

ROAD HIERARCHY IN MASTER PLANS

Conventional vs Alternative Approaches

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To my husband and my entire family.

'The origin of the city is linked to the nature of the places.'

Leonardo Benevolo

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ABSTRACT

Road classification from traffic engineering concepts, developed in a first moment for highways systems, have been applied in urban road systems enforced by national and municipal regulations. The particular application of traffic engineering concepts and the replication of ideas for urban environment resulted in the intensification of private motor vehicles usage incentive leading to traffic congestion problems and overcrowded streets. Also, the lack of infrastructure and space for alternative transport modes leading to insecurity for those users; and the disconnection between legislation, infrastructure spaces, and real demand of users are some issues resulting of the road hierarchy conventional practice.

Meanwhile, alternative practices, such as 'Complete Streets' and 'Link and Place', have been emerging through a new urban policy and streets design approach to redevelop and rebalance the streets spaces, regarding all transport modes, users demands, the activities, functions and the context of each street.

Therefore, this study aims to explore good practices in road hierarchy and classification rising on the international scenario, and verify how Portuguese and Brazilian municipalities classify streets in Master Plans; if they follow the conventional road hierarchy established by traffic engineering or promote alternative approaches oriented to local characteristics and, demands of different users and transportations. For this purpose, the study is based on the conceptual background of road hierarchy, revises the current legislation of both countries, and then analyses a case study that introduces innovative strategies of functional hierarchy.

The analysis makes possible a comparison between the approaches and perceiving the gaps in legislation concerning road hierarchy. Also, clarifies that no model applies to every place; instead, each street or route is unique regarding their functions, adjacent activities, and local context.

KEYWORDS: Road Hierarchy, Street Classification, Street Design, Master Plan, Complete Streets, Link and Place.

RESUMO

A classificação viária, sob os conceitos de engenharia de tráfego e desenvolvida para sistemas rodoviários de estradas, vem sendo aplicadas nos sistemas viários urbanos endossados pelas legislações nacionais e municipais. A aplicação exclusiva dos conceitos de engenharia de tráfego e a replicação destas ideias no ambiente urbano resultaram na intensificação do uso dos veículos motorizados privados que levaram a problemas como o congestionamento e superlotação das ruas. Além disso, a falta de infraestrutura e espaço nas ruas para outros tipos de transportes levam a insegurança para estes usuários; também a desconexão entre a legislação, a infraestrutura e a demanda real dos usuários são problemas resultantes da prática da hierarquia viária convencional.

Práticas alternativas como ‘Complete Streets’ e ‘Link and Place’ vêm se destacando através de novas abordagens nas políticas urbanas e no desenho das ruas para equilibrar os usos dos espaços, considerando todos os meios de transportes, demandas dos usuários, atividades, funções e o contexto em cada rua.

Portanto, este estudo tem o objetivo de explorar as boas práticas de classificação e hierarquização viária que surgiram no cenário internacional. Ainda, verificar como os municípios portugueses e brasileiros classificam seu sistema viário nos Planos Diretores; se seguem a abordagem convencional estabelecida pelos conceitos de engenharia de tráfego, ou promovem técnicas alternativas destinadas às características próprias de cada local e às diferentes demandas dos usuários e dos transportes. Por esta razão, este estudo baseia-se em um enquadramento conceitual da hierarquia viária, revisa as legislações atuais dos dois países, e então, analisa um estudo de caso que introduz estratégias inovadoras de hierarquia funcional.

Esta análise possibilita a comparação das abordagens, bem como a percepção das lacunas entre as legislações tratando-se da hierarquia viária. Ainda, esclarece que nenhum modelo se aplica a todos os lugares; pelo contrário, cada rua é única de acordo com suas funções, atividades adjacentes, e o contexto local.

KEYWORDS: Hierarquia Viária, Classificação das Ruas, Desenho das Ruas, Plano Diretor, Complete Streets, Link and Place.

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1

INTRODUCTION

1.1. BACKGROUND

Faced with a car-oriented scenario, contemporary cities suffer from traffic congestion problems. This can be a result of decades of standard methods application in road planning, replicated by national and municipal legislation.

Marshall (2004) exposed that the traditional road hierarchy does not fit in contemporary cities anymore. The usage of exclusive traffic engineering methods to organise and plan the road system does not match today's agenda of sustainability in mobility that includes diverse ways to commute, variety of streets functions, and many activities occurring in the streets and adjacent lands, as well as different local contexts. Therefore, since ancient cities, the road system follows the growth of cities and changes in the urban layout. Streets, as a rigid established infrastructure, did not change their form, concerning variety functions of streets; however, their functions have been changing, as well as diverse transport modes, users, and ways to commute.

The road hierarchy, then, organised by classes indicating the importance of each road class into the entire system, is divided by a functional classification respecting the hierarchy of movements and the road functions (FHWA, 1989, 2013; AASHTO, 2001), standardised in 'movement and access' functions. Thus, national urban regulations and municipal Master Plans have been applying this conventional concept until alternative approaches began to emerge, as 'Complete Streets' and 'Link and Place', which started in changing urban policy against the limitations of traffic engineering conventional methods that influenced all road planning. Another innovation is the street design as an important tool for rebalancing streets spaces to provide multimodal routes with less infrastructure intervention and improving the sustainability in commutes.

However, alternative approaches are not worldwide applied, many countries still using the conventional techniques in their regulations resulting in a gap between the real streets users demand and the current infrastructure offer.

1.2. OBJECTIVE

This study aims to explore good practices in road hierarchy and classification rising on the international scenario, and verify and evaluate how Portuguese and Brazilian municipalities classify streets in Master Plans; if they follow the conventional road hierarchy established by traffic engineering or promote alternative approaches inspired on recently good practices. In particular, it will be verified a new procedure for road hierarchy in Matosinhos, Portugal, developed for the last review of Master Plan, and discussed which are the contributions for the municipal mobility system, as well the obstacles due being

a pioneering approach in this country, which contributes for a theoretical discussion between conventional and alternative approaches in road hierarchy.

1.3. METHODOLOGY OF INVESTIGATION

The method of study is based essentially on a documental investigation. The first part regards the conceptual background of road hierarchy, defining the state of research. After, the state of practice is determined by a revision of current legislation and Master Plans of chosen cities from Portugal and Brazil. Then, it will be analysed an alternative approach of road hierarchy, which introduces an innovative concept of functional hierarchy.

The background of road hierarchy concepts is divided into three parts. First, the emergence and statement of the road system in the urban environment by urban and architecture perspective. Then, the contextualisation of road hierarchy by traffic engineering and the limitations of these ideas. Next, the introduction of alternative concepts in road planning focused on road hierarchy and their application in contemporary international Street Design Manuals.

Furthermore, considering the conceptual framework, it is analysed the legislation of Portugal and Brazil, to perceive which concepts are being used in national and municipal regulations in road hierarchy. For a review in the current practice of Master Plans, there were chosen the most relevant municipalities of metropolitan areas of both countries, considering mainly the higher demographic density, and then population rate, socio-economic interest, spatial insertion and connections features at the local, regional and national scales.

Table 1: Portuguese and Brazilian Municipalities

	Country	District/ State	Municipality	Demographic Density ¹ ↓ (Pop./Km ²)	Population ¹
1	Brasil	São Paulo	São Paulo	7.387,7	11.253.503
2	Portugal	Lisboa	Amadora	7.376,1	175.136
3	Brasil	Minas Gerais	Belo Horizonte	7.167,0	2.375.151
4	Portugal	Lisboa	Lisboa	6.389,6	547.733
5	Portugal	Porto	Porto	5.686,9	237.591
6	Brasil	Rio de Janeiro	Rio de Janeiro	5.265,8	6.320.446
7	Brasil	Paraná	Curitiba	4.024,8	1.751.907
8	Brasil	São Paulo	Santo André	3.866,4	676.407
9	Brasil	Rio de Janeiro	Niterói	3.640,8	487.562
10	Portugal	Lisboa	Almada	2.477,0	174.030
11	Portugal	Lisboa	Cascais	2.127,1	206.479
12	Portugal	Porto	Vila Nova de Gaia	1.798,5	302.295
13	Portugal	Porto	Maia	1.634,3	135.306
14	Brasil	Rio de Janeiro	Nova Iguaçu	1.527,6	796.257
15	Portugal	Porto	Espinho	1.502,0	31.786
16	Brasil	São Paulo	Campinas	1.358,6	1.080.113

¹ Census: 2011PT/ 2010BR

The documents analysed in this phase comprehend the national urban regulations of both countries, the textual guidelines and graphic pieces of Master Plans and, when applicable, complementary regulation, typical of the Brazilian cases. Municipal Master Plans, then, were analysed according to the similar elements found in each regulation and grouped into two main categories of analysis. The first, Plans

using conventional hierarchy from traffic engineering; and in second, Plans using other methods than conventional. Thus, there were analysed:

- (i) Concern about mobility theme, which indicates the age and stagnation of the regulations;
- (ii) Presence of road hierarchy, which indicates the concern about the road system, and national urban regulation compliance even if it is a generic road classification;
- (iii) The number of road classes, for comparison and understanding the complexity of the road network and its hierarchy;
- (iv) Transportation priority in general network and, in specific classes, which demonstrates if the municipality still has car-oriented planning or promote alternative transportation usage;
- (v) Promotion of alternative transports; and
- (vi) The presence of other classification regarding the roads, which reveal complementary guidelines for this specific theme, or if alternative transports already are included in main road hierarchy considering the two last variables (iv) and (v).

These variables made possible dividing the Master Plans into specific groups of analysis mainly oriented for the type of transportation included in the road hierarchy. In addition, it was possible to compare between the road classes revealing the quantity discrepancy, as well as the similarities between the municipals hierarchies. Besides, the specific features of each Master Plan were identified, which contributed to a description of the main findings in road hierarchy.

Subsequently, to explore the innovative practices and promote comparison and discussion between studied Master Plans and alternative approaches, there were verified the recently reviewed Matosinhos Plan that comprehends different functional classification than found in other Plans and concepts. For this purpose, the Master Plan is also analysed with similar attributes of other Plans; it was grouped in the second analysis group of road hierarchy alternative methods. Therefore, it was compared with alternative approaches in regard to other variables and methods of road classification, which include:

- (i) Variables: usage of streets, urban context, and transport mode priorities; and
- (ii) How the hierarchy is defined and for whom.

With the obtained information in the documental research, it was possible to promote a discussion about the theory and practice of road hierarchy in the Master Plans and distinguish the limitations and the benefits of each practice in alternative and conventional approaches for road planning.

2

ROAD HIERARCHY FRAMEWORK

This chapter intends to elucidate the road organisation since the emergence of ancient cities, passing through the modernist period and the massive incentive for car usage, until contemporary urban and transport planning.

Thus, based on the structure developed with the key events and the relevant concepts for the review, it will be presenting in the following subchapters the architectural, urban design and traffic engineering concepts for the roads and streets organisation into a timeline logical for a comprehensive perception.

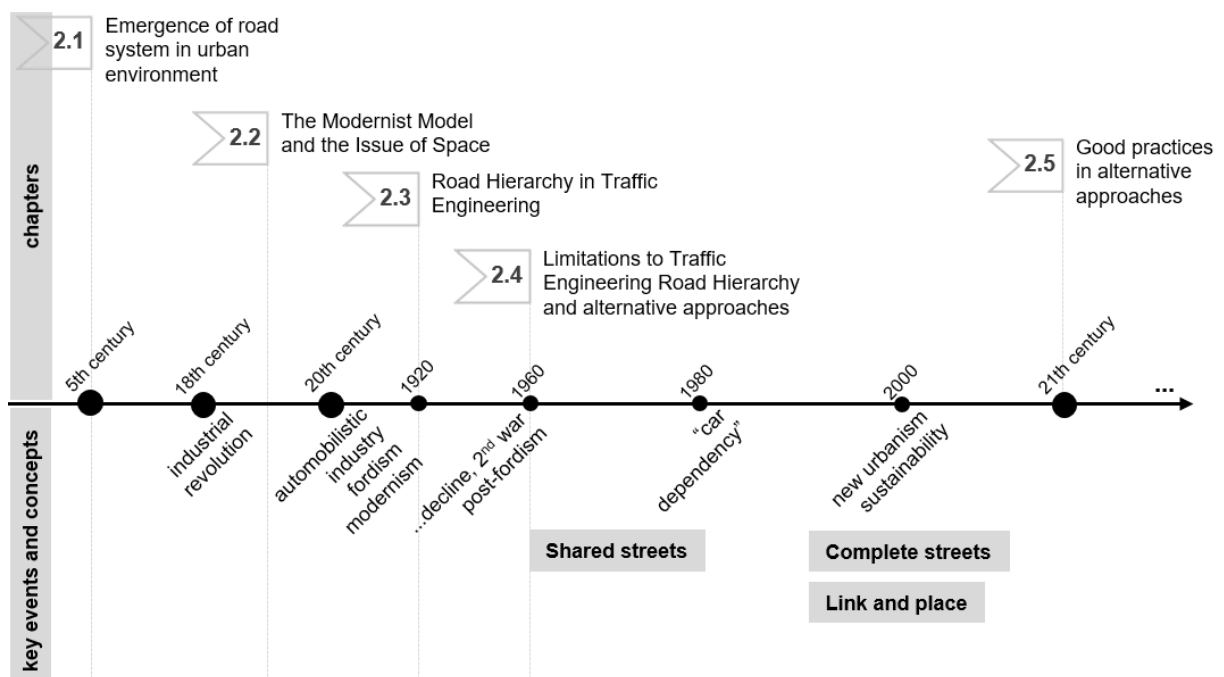


Figure 1: Summary events in urban and road development timeline

2.1. THE EMERGENCE OF ROAD SYSTEM IN URBAN ENVIRONMENT

"The origin of the city is linked to the nature of the places." (Benevolo, 1976). According to the author, in early cities, the structure of roads network was already included in public services. The Roman cities had an efficient road network, which was organised by importance and function: narrow pedestrian streets, *itinera*; streets of passage for one agricultural vehicle, *actus*; and larger streets surrounding the Forum in the central area, *viae*. The Roman legislation established dimensions for the streets; the pedestrian streets, for instance, should have some distance to be able to fit houses saliences, such as balconies. Therefore, it is possible to perceive that the streets were fundamental city structures and,

despite its seemingly primitive preoccupation, it was an introductory concept for the streets organisation. Furthermore, the movement was not the only role of the streets, but access, building fit, and meeting place. The hierarchy was based on street vocation when the most important were the wider streets setting the *plazas*; followed by the streets with movement character, made for connecting places; and finally the building access narrow streets.

On a broader scale, the orthogonal layout was a reference to defining territory boundaries and agricultural lands. This road system, *centuriatio*, was characterised by *limites* which were principal roads and administrative boundaries; secondary roads, *decumani*, parallel to the principal road; and the *cardines*, perpendicular and shorter than others. Two major axes, *decumanus maximus* and *cardo maximus*, crosses a point which was the ideal centre of the city. Even after ancient agricultural system extinction, this pattern had been worldwide replicated, especially in American colonies. (Benevolo, 1976). In this model, the roads diverge from the centre beyond the city boundaries, turning into rural roads, and linking to other places that could be commercial routes or other cities. This road configuration helped defining cities limits and mark the ideal city centre which was distinguished by accommodating the principal public buildings and activities.

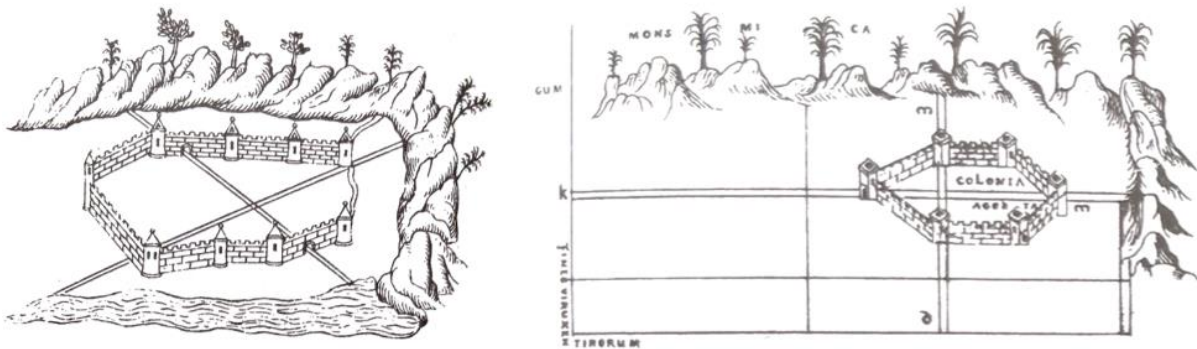


Figure 2: Road system in ancient Roman cities (Benevolo, 1976).

While the population rate increased, the urban environment also had been expanding through adjacent areas, and new structures had been established between old ruins. The old city centres became an urban environment, and the road network was adapted to attempt the new demands of agricultural production, industry and commercial activities. (Benevolo, 1976). Empirical studies and economic theories of location have shown that commercial activities were the impulse for people's displacement. (Puşcaci, 2014). It is evident that residential and business centres had emerged as a result of a necessity brought by commerce activities, the flux of people and goods transportation. Thus, there is a very close relationship between land use, activities and the road network, resulting in the design of each city. Cities were developing and evolving their structure through the growth of the road network, which also contributed to the urban sprawl to rural areas. The roads development provided access to remote areas, creating residential suburbia, logistics and industrial sheds zones, which as a result could also become new urban centres, also creating a hierarchy between the urban systems.

The inherited rural-town road system, from the pre-motor era, induced the contemporary traffic problems. (Minister of Transport, 1963). It happens because of urban and traffic planning processes, which haven't followed the fast automobile industry increase. Also, as analysed by Traffic in Towns (1963), narrow streets from old city centres in conjunction with frequent intervals of intersections and access to buildings, resulted in flow obstruction.

For centuries, from the emergence of road system until Industrial Revolution, the roads were developed to achieve goals that were not suitable for motor vehicles; the cities were based on walking. The

objective of ordinary streets was the accommodation of buildings, citizens' circulation, and houses access; then the main streets had access to the public buildings, and some streets were developed for animal traction vehicles.

2.2. THE MODERNIST MODEL AND ISSUE OF SPACE

During the evolution of modern cities structure, the focus shifted to motor-vehicles inclusion and industrial development. From Fordism era, 20th century, the influence of car use in cities impacted the urban design and people's commuting system. These changes in cities structure and society lifestyle occurred mainly in cities that owned automotive industry and promoted incentive for automobile usage at that time. So how did cities become automobile dependent? According to Newman and Kenworthy (1999) the "automobile dependence" occurs because of (i) the increase of automobile infrastructure caused by transportation prioritization; (ii) economic priorities through the new suburban infrastructure growth; and (iii) cultural priorities involving the importance of automobile transportation system and less prioritization for transit or active transportation.

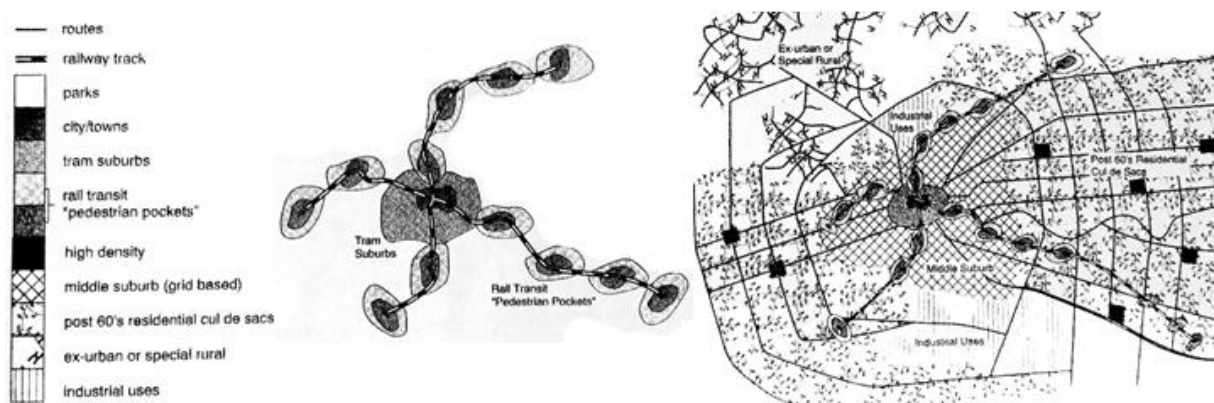


Figure 3: Dispersed cities and separated urban functions (Newman and Kenworthy, 1999).

The modernist criteria of urban development was the automobile incentive objectification. The study "Traffic in Towns" concluded that the streets inherited from old cities have not been suitable for motor vehicles movement. (Minister of Transport, 1963). The urban, traffic and road planning were not synchronised along the cities transformation. Even if the modernist principles, from Le Corbusier, were organising the city according to functions, the traffic planning did not relate to another transportations mode in the same place; there was a segregation of transport modes.

Although the analysis of modern city functions from Athens Charter depicting the cities functions such as living, working, circulation and leisure, the street function was considered mainly for automobile vehicles. The principle of separating the individual and the collective may not fit in contemporary context, according to Marshall (2004). Furthermore, these principles had been used until the New Urbanism movement, which manifested concepts about sustainability and focused on human-scaled urban design (CNU, 1999). The urban road hierarchy until this point was based in street-corridor (Benevolo, 1976) separated by modal paths. The traditional circulation was organised by transport modes and its necessity. This rational functions organisation resulted in congestion increase, and so, for the first time, there was a preoccupation about car dependence consequences, when the "Traffic in Towns", 1963, was developed to study the problems of traffic in urban areas and to propose interventions.

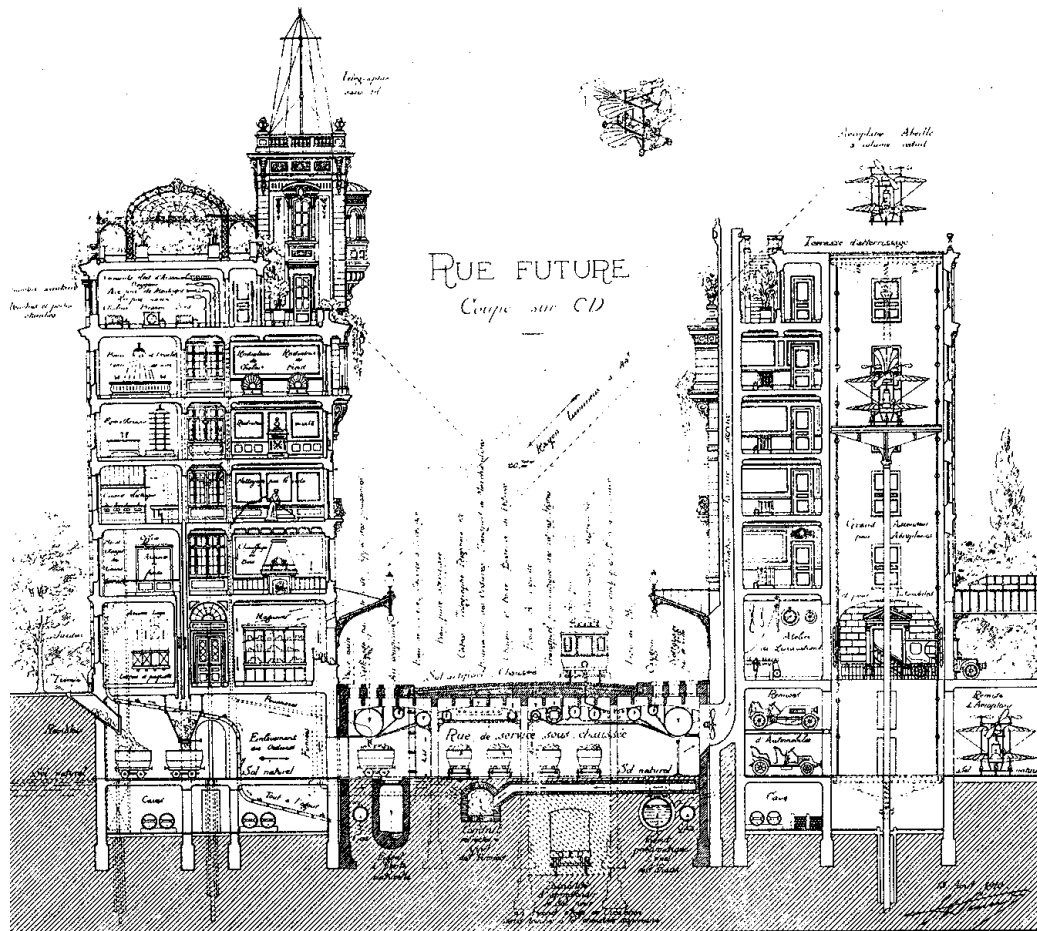
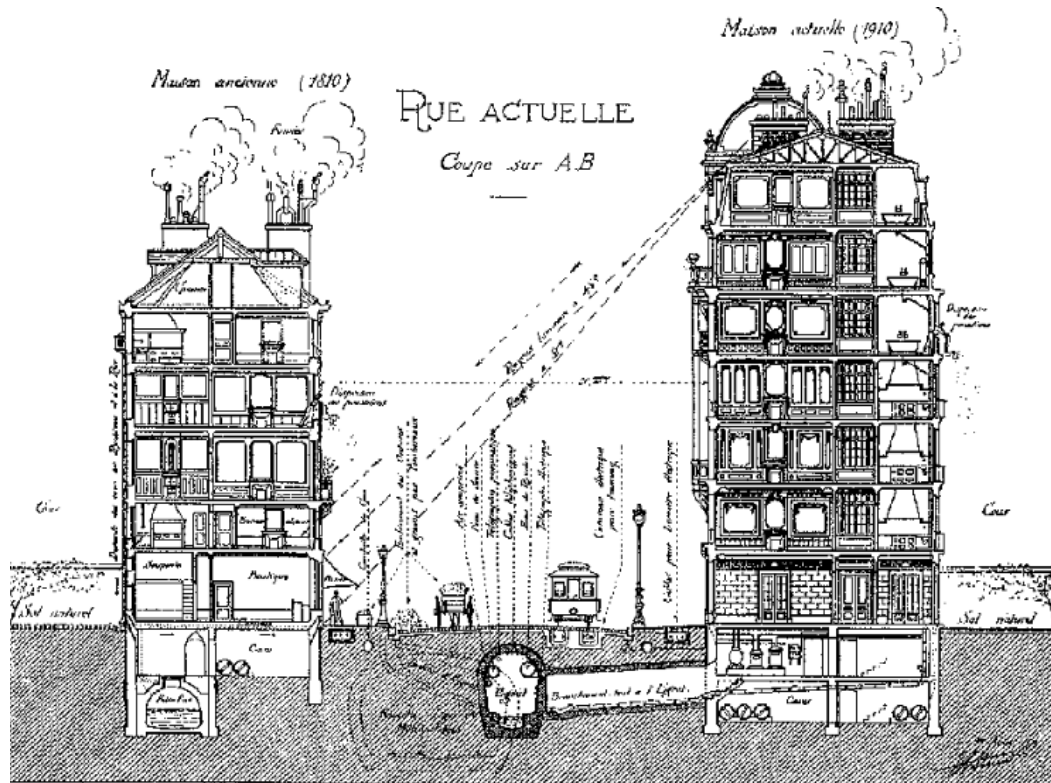


Figure 4: Section of "Current" street and "Future" street according Hénard concept (Hénard, 1910).

Many urbanists developed concepts, some utopic, of new ways of thinking about space in a multimodal transportation city. The precursor of “Traffic in Towns” study methods, according to Françoise Choay (1965), Eugène Hénard (1910) developed the circulation theory in his work “Transformations: Études sur les transformations de Paris”, which divided the circulation into six categories. Each one corresponds to a road type matching with each trajectory and movement densities. Also, he proposed multi-level streets divided proportionally to traffic intensity. The configuration of the multi-level street was designed through traffic classification with overlapping platforms. The upper one was created for pedestrians and cars; then bellow, an intermediate platform for streetcar; and two lower platforms for urban infrastructure and cargo (Choay, 1965), as demonstrated in **Figure 4**. This organisation of spaces and functions supported segregation between transit and all transport modes.

A concrete example of the segregation configuration, developed in the 50’s, the La Défense district, in Paris, France, is a case of applying the Athens Charter principles, separating automobile, transit and pedestrian traffic (Ladefense.fr, 2018). The road network was settled below an enormous pedestrian plaza which also serves for accessing buildings, meeting point and esplanade.

The Report ‘Traffic In Towns’ (Minister of Transport, 1963), developed a study method based on traffic intensity, the same way as Hénard’s concept (Choay, 1965). Also, explained by Stephen Marshall (2004), the study had the road hierarchy principles that resulted in the city shape, ratifying the study methodology, which was formulated considering road and town planning as complementary parts of the planning process. The Report was a “pioneer study of the problem of traffic in towns which is both comprehensive and quantitative” (Minister of Transport, 1963), exploring the consequences of motor vehicles in London and developing traffic solutions. However, the concern was still based on traffic segregation. According to Hamilton-Baillie (2008), “Buchanan argued that the two principal purposes associated with streets and public spaces, those of movement and social interaction, would need to be strictly segregated as traffic volumes increased.”

Another criticism of the Modernist model is the Trancik's (1986) “Lost Space” concept. He proposed that buildings were isolated objects between vast space, without coherent structure involving street and squares. Indeed, the morphology of modern cities had a character of segregation. In an attempt to rationalise the functions, the forms resulting from that concept were spread and were connected by the streets-corridor, ensuring the automobile usage and opposing to functions interaction. The issue of space was largely discussed by earlier urban theories, resulting in a road network demand that may not lead to the ideal city, but utopian places. An isolated scenario was manifested in other urban theories publications, such as “Garden City” by Ebenezer Howard, 1902 and “Broadacre City” by Frank Lloyd Wright, 1932, as well, the land privacy was wider and assured. (Fishman, 1982). As a result, extended roadways gave access to isolated residential properties, emphasising the idea of automobile movement and futuristic technology.

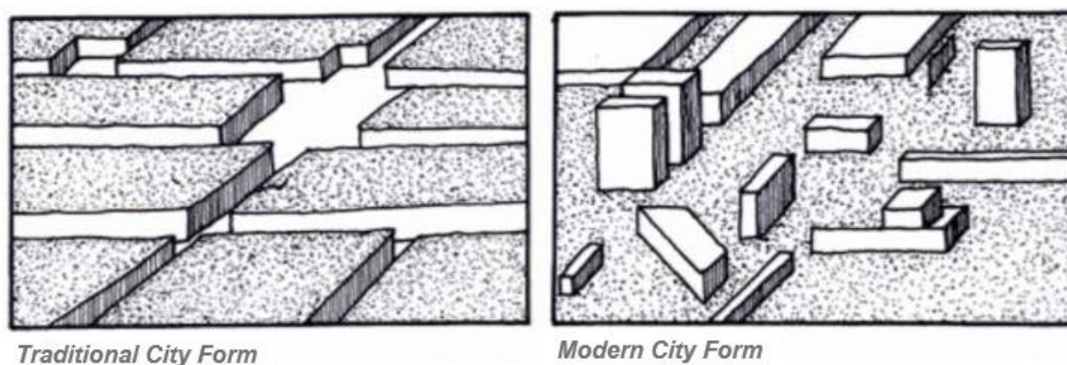


Figure 5: Spatial structure of traditional cities and the fragmentation of modern cities (Trancik, 1986).

Trancik (1986) discussed factors related with the highway, the modern movement in architecture, urban renewal and zoning, competition for the image on the part of the private enterprise, and changing patterns of land use in the inner city, which have created the modern space dilemma. Also discussed by Jones, Roberts and Morris (2007), the “separation between buildings and highways changed the character of streets in each urban context”.

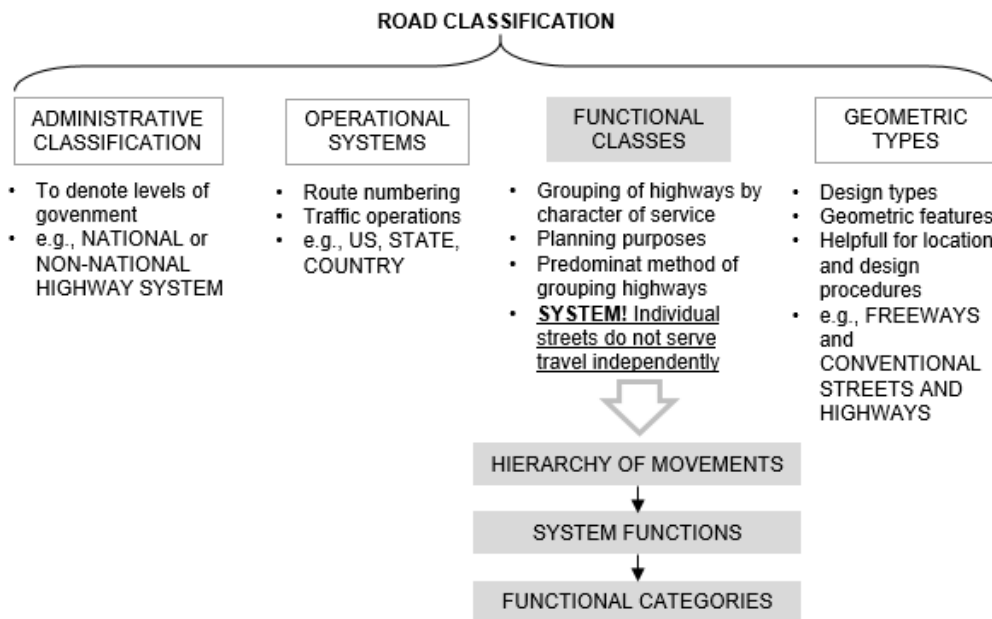
The modern or functionalist urban planning attitude allowed the increase of contemporary urban traffic. The legacy left were the roadways, emphasising the popular idea of street-corridor linking different city functions, and conceding the lost space establishment that does not cooperate with the liveability of cities. It seems that the functions provided by streets had been set apart from the city progress. Also, the public space function did not exist as a role part of the place; public spaces also had a specific designed local, as a park settled in a square, a plaza in the city centre; they were delimited by their functions. However, the streets also play like a public space, as boulevards that contains many activities happening.

Refuting the Athens Charter and Garden City principles, Appleyard and Jacobs (1982), believed that all activities must be integrated, concluding that the best urban places have a balance of uses. Moreover, they suggested mixed-use projects to promote social integration. These ideas were based on architecture and urban environment, but it also can be moderated and applied in the street setting.

2.3. ROAD HIERARCHY IN TRAFFIC ENGINEERING

The road classification came from a necessity of maintenance and governance after roads were built (Weingroff, 2017), also from political issues. The most usual road classification methods are from the United States with policies that were developed in the mid of 20th century by American Association of State Highway Officials – AASHTO (Weiner, 1997). The concept of classifying the roads into classes first came indirectly, from a political lobby to achieve federal aid, of which the concern was also to improve the rural roads that became the top of the road hierarchy. Thus, for political reasons the federal AASHTO introduced in the bill that “each state to designate 7 percent of its roads, 3 per cent primary and 4 per cent secondary, to be part of the federal-aid system” creating, then, a national highway system (Seely, 1987). Indeed, the departments of transportation in the US were created to ensure the safety in roads and improve the network in large scale – or improve the highways – in the Progressive Era. Surprisingly, a movement for bicyclists interests promoted the first demands for better roads (Seely, 1987). Then, in the following years, the highways policies also become to appear with a political and technical character.

Regarding the planning and design policies, a Committee on Planning and Design Policies was created in 1937 to formulate and recommend highway engineering policies. The 2001’s document version of “Green Book” – A Policy on Geometric Design of Highways and Streets – presents the main highway classification methods and each road function, and explains that “different classification schemes have been applied for different purposes in different rural and urban regions.” (AASHTO, 2001). Also, the policy indicates that different classification methods can appear because of their purpose. By the US, highways can be categorised in (i) Administrative Classification to denote levels of government; (ii) Operational Systems, for traffic operations; (iii) Functional Classes for planning purposes where the highways are grouped in systems; and (iv) Geometric Types for design procedures, summarised in **Scheme 1**. However, the last one presents difficulties for design criteria because some road types can be considered different in the functions they serve, a freeways and arterials roads that can have different functions in urban or rural regions, according to the guidance.



Scheme 1: Summary road classification typologies (FHWA, 1989, 2013; AASHTO, 2001).

The most conventional classification method is the Functional Classes categorisation, which is “the process by which streets and highways are grouped in classes, or systems, according to the character of service they are intended to provide”. The idea of grouping roads in systems means that “individual roads and streets do not serve travel independently.” (FHWA, 1989). In other words, each part of the road system has a function that allows a person to complete a journey, from the initial place to the destination place.

Comparing to Geometric Type categorisation, the Functional Classification method appears to be more efficient for a planning process, achieving a general system overview, then, a more specific approach of each road function. “Under a functional classification system, design criteria and level of service vary according to the function of the highway facility. Volume serves to further refine the design criteria for each class.” (AASHTO, 2001). In other words, the main factor for classifying the roads is the function each road has into the network.

2.3.1. HIERARCHY OF MOVEMENTS AND SYSTEM FUNCTIONS

To achieve the functional road classification, the guide explores the hierarchy of movements into the road system. During travels, several activities can occur under the “Hierarchy of Movements”, which are (i) movement, (ii) transition, (iii) distribution, (iv) collection, (v) access, and (vi) termination. (AASHTO, 2001; FHWA, 1989; Forbes, 1999). Each movement is important for travelling, and there must be a suitable facility for each action occurs; this means roads with different characteristics support each distinct action. Then, these movements can be summarised into two principal functions; the functional classification emerges from a dual role the network plays: (i) the access to property; and (ii) travel mobility, where the access is a fixed condition in both points of any trip, and mobility occurs along the trips and in different levels (FHWA, 1989).

Since the two principal road functions are established, the road classification and hierarchisation follow these principles. There is a relation between road classes and their functions, according to the character of service they provide, there are (i) principal arterials (for main movement), (ii) minor arterials (distributors), (iii) collectors streets, and (iv) local streets (AASHTO, 2001). The **Figure 6** demonstrates the relative importance of movement and access at the different road typologies.

Named as the same as the rural roads, the urban system has different nature and intensity than the rural system, however, in every urban environment there exists a system of highways and streets, varying the scale, quantity and extensions. The urban principal arterial system serves the metropolitan areas with the highest traffic volume and major extensions, combining with the rural systems (FHWA, 1989). Thus, is possible to perceive that the road system both rural and urban, they interconnect and merge in some point, delimiting also the boundaries of the regions.

Indeed, the Green Book explain that “in urban areas there are relatively more arterials with further functional subdivisions of the arterial category whereas in rural areas there are relatively more collectors with further functional subdivisions of the collector category.” (AASHTO, 2001). The **Figure 6**, from a Guide of Functional Classification, elucidates that the same road nomenclatures in different environments do not signify the same functions and the same characteristics.

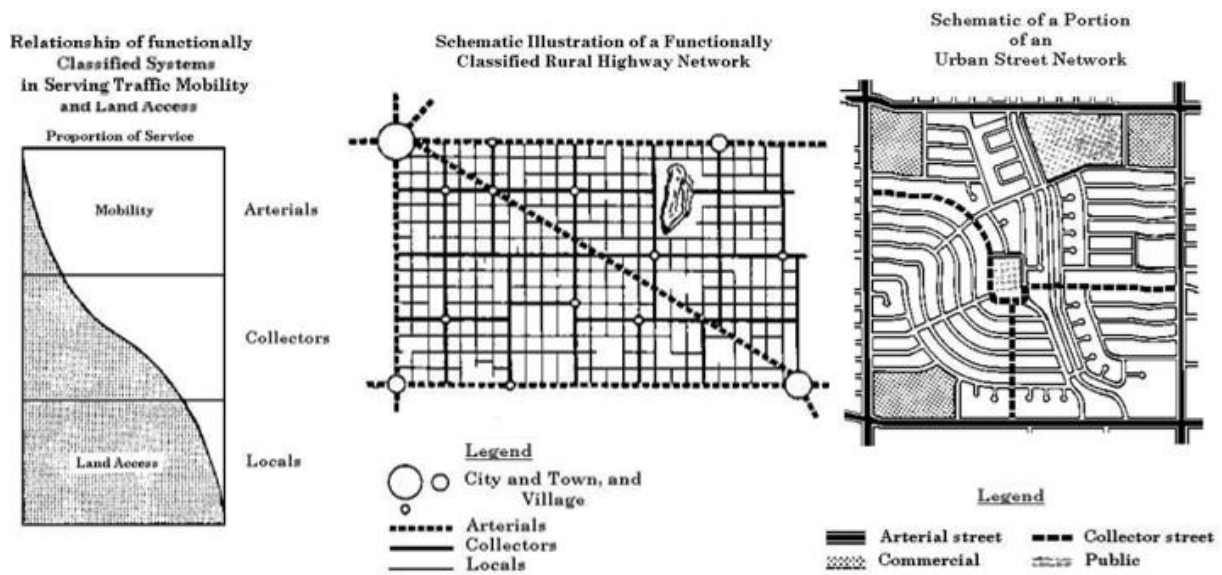


Figure 6: Functionally systems and difference between rural and urban systems (FHWA, 1989).

2.3.2. THE CONVENTIONAL ROAD HIERARCHY MODEL

Regarding the functional classification, the Green Book, then, classifies the urban roads into four systems according to their principal functions in the entire network, summarised in **Table 2**.

These concept and method of dividing roads into functional classes are present in many traffic planning documents and instructions; it is disseminated in international road planning policies. Considering the system and their functions proposed by the Green Book, the road hierarchy regarded the car's movement since the beginning. Thus, the description of the systems did not mention another transport mode beyond cars, and sometimes, buses. Also, the design criteria from this policy were based on two principal elements: (i) the physical characteristics, and (ii) the proportion of vehicles of various sizes using the road infrastructure (AASHTO, 2001), that is, the volume of traffic and the capacity whose roads could absorb.

Table 2: Urban Roads Functional Classification Summary (AASHTO, 2001).

ROAD TYPES	MAIN FUNCTION	RANGE	
		Travel Volume (%)	Length (%)
PRINCIPAL ARTERIAL SYSTEM	- Service for major circulation movements; - Highest traffic volume corridors; - Longest trips; - Bypassing the central city - Carries importante intra-urban/ intercity bus routes; - Provides continuity for all rual arterials that intercept the urban boundaries; - No access to land, only subclasse of other arterials are capable to providing direct access to land.	40 – 65%	5 – 10%
MINOR ARTERIAL STREET SYSTEM	- Interconnects with and augments the urban principal arterial system; Lower level of travel mobility than principal arterials; - Distributes travel to geographic areas smaller than those with the higher system; More emphasis on land access; Lower traffic mobility than higher system; - Local bus routes; - Provide intracommunity continuity but does not penetrate;	65 – 80%	15 – 25%
COLLECTOR STREET SYSTEM	- The facilities penetrates residencial neighbourhood; - Distributes trips from the arterial through the area to their ultimate destinations; - Collects traffic from local streets in residencial neighborhoods and channels it into the arterial system; - May also carry local bus routes; Land access services; Circulation whithin residencial, comercial and industrial areas.	5 – 10%	5 – 10%
LOCAL STREET SYSTEM	- Comprises all facilities not in one of the higher systems; - Permit direct access to abutting lands; - Connections to the higher other systems; - Lowest level of mobility; - No bus routes - Service to through traffic movement usually is discouraged.	10 – 30%	65 – 80%

In Europe, the road classification was formulated by several international committees, resulting in the development of guidelines and regulations associated with each respective national transport agency, but also regarding the conventional road classification. In Belgium the classification was related to the daily volume of all vehicles; the Danish road network applied road categories which are functionally distinguished as follows according to permitted traffic type: level of mobility and level of accessibility; and the German road network was based on groups of road categories, organized according to functions: connection, distribution and residencial, for instance. As explained in the SWOV Report (Ruyters, Slope Wegman, 1994), in Great Britain the road classification was based on the desired function, and not in roads usage. “The transport distance determines the order of ranking of the road functions; transport over short distances should take place over a hierarchically low-ranking road category.” (Janssen, 1994). Therefore, the European countries classified and organised their road network according “to the number of motor vehicles, the traffic speed and the transport distances of those vehicles.” (Janssen, 1994).

In most cases, the road classification has a top-down hierarchy, of which the express and highways occupy the top of hierarchy; below, the collectors and distributors roads; and in lower classes, the local and access streets. In other words, the top is occupied by the high volume roads, and the lower hierarchy level keeps the low volume roads.

A comparison between some types of road hierarchy, demonstrated in the **Figure 7**, ratifies that the kinds of road hierarchy “[they] all appear to be ranked by some kind of ‘traffic function’” (Marshall, 2004), as well as Janssen' report (1994). That is, the conventional “movement and access” functions, associated to roads volume and capacity, resulted in the conventional institutionalised road hierarchy model, as demonstrated in a few international classifications. Also, the typical ranking was from “major

traffic roads such as primary distributors at the top of the hierarchy, down to the intermediate road, to pedestrian-only streets or paths at the bottom of the hierarchy.” (Marshall, 2004).

<i>Traffic in Towns, UK ^(a)</i>	<i>Transport in the Urban Environment, UK ^(b)</i>
Primary distributor	Primary distributor
District distributor	District distributor
Local distributor	Local distributor
Access road	Access road
	Pedestrian street
	Pedestrian route
	Cycle route
<i>City of Copenhagen ^(c)</i>	<i>Belgium, Functional Classification ^(c)</i>
1. Motorway	1. Motorway
2. Regional road	2. Metropolitan Road
3. Primary road	3. Trunk Road
4. Distributor street	4. Inter-District Road
5. Local street	5. Through Street
	6. Local Street
<i>Italy ^(d)</i>	<i>Institute of Transportation Engineers, USA ^(e)</i>
Motorways	Freeway
Principal inter-urban roads	Expressway
Secondary inter-urban roads	Major arterial
Urban roads (connectors)	Collector Street
District urban roads	Local Street
Local roads	Cul-de-sac

(a) MoT (1963); (b) IHT (1997); (c) Marshall (2002); (d) Bartlett (2003); (e) Jacobs *et al.*, (1995). Fuller catalogues are provided in Marshall (2002) and Marshall (2004).

Figure 7: Examples of road hierarchies (Marshall, 2004)

In Portugal, the road network was inherited from ancient roads, and initially was classified for administrative purposes of obtaining financial resources; in 1928 the road system, Basic National Network, was grouped into national highways, municipal roadways, and public paths (DPL, 2011). The urban sprawl and spatial urban organisation conditioned the road hierarchy implementation. Then, the importance of movement and access functions, as the international conventional principles, provided the Portuguese functional road classification: Collectors/Arterials roads and Main Distributor for movement; and Local Distributor and Local Access streets for access purposes (CCDR-N, 2008), described and compared in the **Table 3**. In some cases, the same type of road plays different functions depending on the specific conditions of integration in the network and the surrounding space.

Table 3: Portuguese National Road Hierarchy vs Urban Road Hierarchy (CCDR-N, 2008. Free translation).

Rural Classes (National Network) vs Road Hierarchy					
RURAL Roads Cassification		Road Hierarchy on URBAN environment			
		Collector Roads	Main Distributor Roads	Local Distributor Roads	Local Access Streets
Basic National Network	- Principal Routes (IP)				
Complementary National Netowork	- Complementary Routes (IC)				
	- National Roads (EN)				
Regional Network	- Regional Roads				
Municipal Network	- Municipal Roads (EM)				
	- Municipal Paths (CM)				

The road classification methods in Brazil was inspired by the US Green Book classification approaches and there are different road classification types for different purposes: (i) administrative; (ii) functional; (iii) technical; and (iv) legal (Fajersztajn, 2012), intentionally relating the legal terminology to the technical (Pietrantonio, 2017), for operational reasons.

The Brazilian Transit Code distinguishes (i) Rapid Transit Routes, (ii) Arterial roads, (iii) Collector roads, and (iv) Local streets (Lei 9.503/97; DNIT, 2010). In larger cities with high traffic volume, such as São Paulo, many roads are supported by parallel roads that perform the same structural function, although, functionally, all parallel roads and lanes are the same arterial corridor (Pietrantonio, 2017). The functional classification method was applied similarly to the US road hierarchy; in which the movement and access, the car-oriented road planning provided by the road capacity were the main principles to project and organise the road network.

Finally, in a general manner, the roads planned based on the conventional concepts have similar global characteristics, in which the classes in top of hierarchy tends to carry significant flux of traffic, linking regions; next the classes that distribute the traffic inside the city area; and then the access routes that provide car access to properties. In a global overview, functional classification of road hierarchy prioritises the cars and the network connection (Forbes, 1999), since the hierarchy is established generally by the number of vehicles, speed and distances (Janssen, 1994).

2.4. LIMITATIONS TO TRAFFIC ENGINEERING ROAD HIERARCHY AND ALTERNATIVE APPROACHES

2.4.1. CRITICS TO CONVENTIONAL ROAD HIERARCHY

The road hierarchy has many purposes depending on the context and the subject; as seen before, the classification of streets in the urban environment follows general rules applied to solve initially administrative and political issues of highway systems. Many city streets were inherited before the advent of the Federal Highway System of functional classification, "making the system unsuitable for the diversity of land uses and travel characteristics throughout an urban area." (NACTO, 2012). In addition, the geometric design criteria also have been inappropriately applied the highways dimensions to neighbourhood streets (Igarta, 2012).

Once many hierarchy models were produced for highways in a rural environment, the reproduction of this model on urban streets requires a local context and variations consideration (NACTO, 2012). Indeed, "there is no single correct or optimal way of describing and classifying streets; what kind of classification is chosen will depend on the purpose and context of its application." (Marshall, Jones e Plowright, 2004). The rigid and conventional road hierarchy resulted in "urban roadways dividing neighbourhoods, destroying local businesses in established communities and creating sterile, inhospitable streetscapes in developing suburbs" (Plante, La e McCann, 2008); in other words, the standard classification intended to provide mobility with emphasis on speed and traffic capacity resulting in a streets design intolerant for pedestrians, and with car-oriented character.

Likewise, Marshall, Jones and Plowright (2004) also presumed that conventional tends to effectively manifest itself as a traffic-oriented classification, rather than multimodal transportation, or streets as multifunctional places. The classification models were based on form, use, relation and designation, in which the "functional nature of the classification is most directly related to the network function of a street". Then, the automobile dependence caused by many factors, in special the segregation of activities from the modernist urban model, car-oriented road planning and urban sprawl saturated the cities and caused problems in a variety of sectors. Health and social problems as obesity and stress levels; environmental issues as air pollution and fossil fuels scarcity; road users injuries and high levels of traffic and congestion (Newman e Kenworthy, 1999, 2006).

Therefore, the conventional road hierarchy does not fit in contemporary cities anymore (Marshall, 2004), since the roads have many functions and accommodate many users. Planning in a local context, according to the author, requires the inclusion of elements that were unconsidered when the conventional

approach, such as street functions as public space, the uses and activities in streets and adjacent lands, and multimodal transportation and the connectivity between the different transports mode. According to the author, the primary functions of Distributors and Access roads are inexact in contemporary road system; there is a function mixture happening, and some streets have not only one specific purpose.

Marshall (2004) discussed if the streets had no hierarchy; they “were required to be equally and comprehensively multi-functional, then all streets would be trying to act simultaneously as traffic conduits, as trading places, as play areas, as meeting places, and so on.” However, as exposed by Svensson and Hydén (2004) different functions can be conflicting. Then, also supplemented by Marshall (2004) the policymakers should plan the streets more efficiently, perceiving the street dedication and the “prioritisation of the different potential roles of each street-space relative to the whole system.”

The idea of no establishing road hierarchy opens a precedent for a new classification system, where the street importance regards to not only one transport mode but also the coexistence of different transports in a global context - this is, regards the land use typology where the street is settled.

Also, assuming all functions that streets can have, it also requires another approach than the conventional. Connection purpose still is essential, mainly in a regional or national context; however, the urban streets demand another strategy since they have more complex and different functions because of the environment where they are located, besides the variety of users, differently from national and regional roadways.

Therefore, the environment where the infrastructure is located, combined with the transport users' types denote a necessity for an alternative approach for streets classification and planning.

The road hierarchy may serve for administrative issues, and geographic and spatial organization into a major system; however, urban scale hierarchy does not fit into this context. There were detected other aspects which do not correspond to the conventional road hierarchy method; thereby, the roadways are different from urban streets. These aspects include the (i) street functions into the urban environment; (ii) the local where the infrastructure is located; and (iii) the transport and the users.

2.4.1.1. Urban Street Functions and Land Use

Similar to Roman roads, streets still have many functions and activities, but as much the cities evolve, other different activities happen on the streets. The character of public space did not change too much, but the activities did. The streets configuration is also very similar to the ancient streets in reference of public space, as explained by Jan Gehl (1989), many activities happen in traditional open-air public spaces, making the comparison with the medieval city pattern, like Copenhagen. Empirically, many activities happening on the streets; however, according to the author, “streets life patterns are under heavy pressure from a number of directions as car traffic and parking take up space.”

Indeed, Appleyard (1980) presented the street as a social place. He exposed that some community streets were over-dimensioned for the traffic, and residential street systems had extra space for other uses, that is, for pedestrians, children's play, sitting out and community gardens. Additionally, he explained that street space allocation to other than vehicle use would depend on resident composition, densities, traffic volumes, and available private and public open space in the neighbourhood; introducing the idea of “liveable” places. Additionally, assuming that urban roads and streets have multimodal transportation and serve more than mobility and access functions, Forbes (1999) describes streets as public corridors carrying a variety of transports, and public space with many purposes, such as “places to gather, to socialise, window shop, people watch”, at the same way to Appleyard.

Thus, since the streets are social places into a road system network, they can also have functions beyond traffic accommodation. However, as La Plante and McCann (2008) expose, the rigid road hierarchy

resulted in destroying communities creating inhospitable streetscapes for people, mainly residential and neighbourhood streets that have an intrinsic character of socialising people and functions beyond traffic “movement and access”. Furthermore, the high speed of cars and route zones in Local streets resulted in concern about road safety. Then, these traditional functions may be secondary functions in some road typologies, seen by this point of view, and the conventional road hierarchy method does not appraise streets other purposes.

Besides the Local streets, the Arterial streets also had been seen as a multifunctional; as explained by Marshall, Jones and Plowright (2004), they have no place in the traditional road classification. The Local or residential streets can work as public places, and the Arterial still has the movement and connection character, however, the dimensions, design and environment of this street type is different and attract a variety of activities, as a result, has other functions as well. This street is seen as a very complex typology that did not fit in the conventional “movement and access” functions also.

The conventional traffic engineering approach did not consider the zoning and mixed-use activities in adjacent lands. As exposed, Arterial streets can contain many activities and functions rather than carrying traffic flow, then “the conventional classification has no place for the traditional arterial street. As well as not reflecting existing reality, this system no longer represents a future ideal, which would now include a role for the arterial street” (Marshall, Jones e Plowright, 2004). Furthermore, some these particularities of Arterial streets, as described by Svensson and Hydén (2004), are that they provide a connection and movement for different parts of the city, as a strategic route of the network, usually located into mixed-use areas attracting a mixture of different road users categories. Besides, they represent a cultural mark and importance for social interaction, and they represent “the garden” for residents.

In fact, as demonstrated by Cervero (1996), mixed-use lands affect commuting behaviour, where there are a retail shop and non-residential activities, the non-motorised commute increase until a determined distance. In the same idea, Newman and Kenworthy (2006) explained that urban centres that provide self-sufficiency, or in other words mixed-use centres, can form the basis for a less car-oriented city, giving options for people displacement. Thus, is possible to realise mixed-use lands attract other users in the streets and there is a relationship between land use and commuting. In particular, the Space Syntax methodology studied the relationship between form and function into the built environment, in which building influences in the spatial design (Hillier, 1997). In an earlier work, Hillier *et al.* (1993), achieved the understanding of public space and how it works through the correlation between configuration and pedestrian movement flow; the authors also exposed there were patterns of movement which could attract some uses and activities, and this can happen in areas of diverse activities, as Arterial streets, neighbourhood streets, and mixed-use areas.

Another Arterial streets characteristic is the visual mark, as a identity of some zone or city. These streets, on urbanism aspects, represents a structural character. According to Chapman and Lynch (1962), the image of cities is constituted by overlapping of many individual images. Citizen as an observer creates an image of the city according to the hierarchy of elements in the landscape, and streets categorised into a path element may be the predominant elements in that image. The paths, as predominant elements, are channels along with the observer moves. They are designated streets, walkways, transit lines, channels, railroads. The streets hierarchy reveals an image based not only on functions but on the importance of each street type for the city as a whole, then, exposes the principal activities of each place and their significance.

In resume, Arterial streets functions such as connection and conduction of traffic flow, different road users attraction, the cultural mark of social interaction and public space; and according to Svensson and

Hydén (2004), these various functions, often, can be conflict and not compatible with the conventional road hierarchy principles that regards to only movement and access functions.

Complementing, the conventional approach applies the same method of classification in all roads, regardless the context along the entire route (Lahart *et al.*, 2013). The authors explain that streets “transverse areas with very different characteristics, such as industrial areas, residential areas, mixed use neighbourhoods and city, town and village centres”, ratifying that conventional road classification does not consider the local characteristics and the land use along streets. Therefore, since the context changes, elucidated at **Figure 8**, the authors suggest a need to change the streets design also.

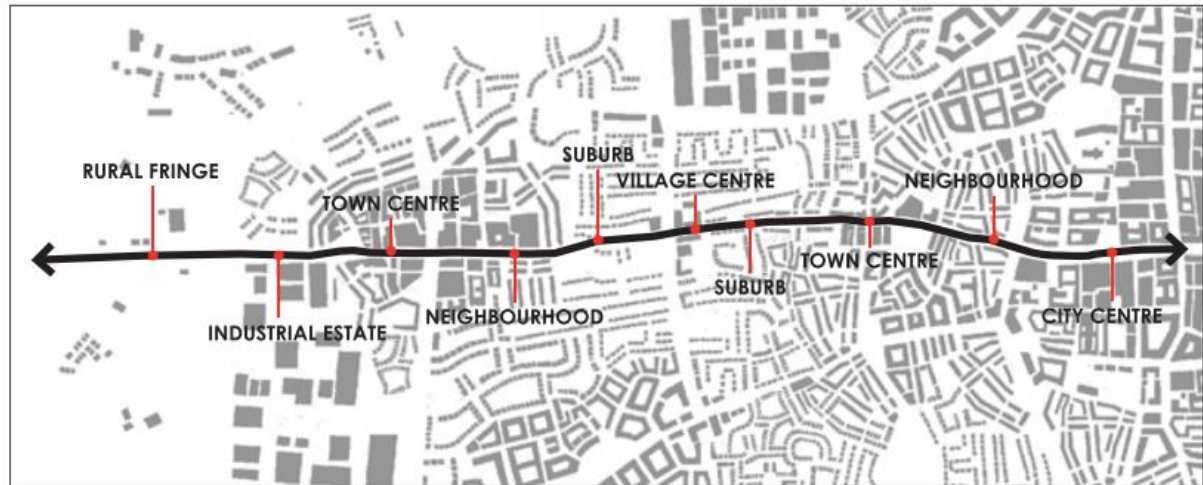


Figure 8: A street or road may pass through a number of different contexts along its route. As context changes, the design of streets and roads will need to change accordingly (Lahart *et al.*, 2013).

2.4.1.2. Multimodal Transportation and Segregation between transport modes

Traffic engineering principles resulted in a car-oriented network under separating functions principles, both urban and on roads, mainly on modernism urban pattern. The separation of transports modes from modernists' theories and traditional planning process was focused on “long-range time horizons, ignoring more immediate problems” criticised for being rigid and not adaptable (Weiner, 1997), considering the traditional highway policies that were adapted for urban systems. Also, this traditional hierarchy has been interpreted as “mono-functional” in which each road type have only one function into the network (Slop, 1994), as well as car-oriented hierarchy as if road users are only private motor vehicles drivers (Plante, La e McCann, 2008).

Supposing the modernist theories, if specific infrastructures and different spaces segregated the many transportation types, would have a high demand for space and a high cost of construction. Besides, the monofunctional channel does not consider another mode in the same channel; it would result in a disconnection of transportation, disregarding that users are pedestrian in some parts of travel, or people use different transports for a commute.

According to Burden and Litman (2011), the transportation problems could be addressed by multimodal transportation systems that allow the users choose for the best mode for each trip; moreover, this system serves for drivers and non-drivers including all users. However, such as Slop (1994), La Plante and McCann (2008) exposed that many roads are being built as if private motor vehicles and freight are the only users, following the standard principles. The road network, as explained by Gerike and Jones (2015), was planned with “desire-lines” between origins and destinations, and this principle did not

considered other transport modes, as well did not fit for all transport modes. The authors explained that a multimodal transportation planning must to contemplate the land use categories, attraction features, in accordance with spatial planning.

Regarding the Traffic in Towns report, some authors interpreted that Buchanan had a first intrinsic idea of mixed-use, or multimodal streets and the consistency of multimodal transportation, however, the policymakers, at the time, supported the segregation of traffic and other transports (Karndacharuk, Wilson e Dunn, 2014; Marshall, 2004). In contrast Forbes (1999) analysed that was lack of planning, that was leaving cyclists and pedestrians behind road planning. As more vulnerable road users, they require safety conditions to circulate on the road network.

Besides, the measurement of performance and offer quality provided by the road system, under the conventional functions by US Highway Capacity Manual, HCM, was initially developed through the study of the capacity of which some road, lane or patch in an established period. However, capacity alone does not fully translate the users' conditions (DNIT, 2006), as well does not translate the urban roads conditions which present functions complexity, differently from highways and rural roads.

2.4.2. ALTERNATIVE APPROACHES

Since the recognising the problems with traditional road planning, resulting from the decades of car-oriented practices, the cities do not accommodate conventional traffic anymore; as exposed by Marshall (2004), the extensive car-oriented planning and the principle of separating the transport modes do not fit in the contemporary context.

Therefore, the multimodal transportation issues, other functions that streets have, and the settlement of diverse activities in streets and adjacent mixed-use lands, are components to be considered in comprehensive planning. Accordingly to Liu, Yan and Wang (2017), the alternative approaches shifted from the car-oriented to “people-oriented” policies; considering the variety of functions and the road users, supplemented by Forbes (1999).

Thus, alternative policies and design tools, they have been introduced as comprehensive concepts and practices, in some cases refuting the entire traditional manner to organise the road system, at least in the urban environment. European cities started to adapt their streets with other techniques that later became an inspiration for US streets policies, applied and disseminated in many urban and transportation international policies.

These approaches can interfere directly or indirectly the road hierarchy, creating other classification system or adding other classes into the traditional road classification. Forbes (1999) resumed that an alternative road classification must to integrate “the road, its design into the urban fabric”. In addition, the same author discuss the issue of multifunctional and multimodal streets must be understood before the design process begins. He explained that was not possible just improve some street with a bike lane in isolated circumstances during the design phase when there were no previews planning. Thus, is important also the manner the regulations and policies establish the guidelines for comprehensive planning.

The alternative approaches also emerge from the idea that streets have functions beyond the traffic carrying and the many functions must be organised to avoid conflict between them, through contextual analysis and application of design solution. Based on the results of years of traffic engineering planning, the alternative approaches makes an effort to consider elements disregarded on conventional principles. These elements or context as a group of elements, in which regard the road hierarchy, are:

- (i) The residential streets are recognised as containing other urban street functions, improved by design principles of Shared Streets;
- (ii) The mixed-use lands and the functions of arterial streets which promotes a variety of activities and have a character that does not fit into the traditional road classification, leading to an approach relating the context and connection status of streets, as Link and Place principles;
- (iii) Multimodal transportation, which has been neglected in car-oriented road planning, and the comprehensive approach introduced in the Complete Streets concept.

Still, the recognition of these elements influences directly in the road hierarchy, which conventional road classification system does not correspond to this reality. Indeed, the classification can guide the multimodal and multifunctional design of a street. (Marshall, 2004), explained the inclusion of different transport modes into a channel space can be guided by the street classification, where there must priorities the potential of each street-space in relation to the entire system. Thus, the hierarchy here will be established for users or potential of each street; and the street will be classified according to all context, including users and location. In addition, ratifying the planning comprehensiveness, the development of classification systems according to the local needs combine some variables that guide the decision-making: (i) street type and usage; (ii) urban design context; and (iii) overlays including modal priorities, special uses, and historic designations (NACTO, 2013).

Thus, **Figure 9** elucidate a type of streets classification in the comprehensive planning of alternative approaches, regarding the variables and specifies of each space. It can recognise a classification for the street as a movement conduit, for the street in the context it is inserted, and for the use as a place, or for special characteristics, or for the priority of transportation modes users.

STREET	CONTEXT	OVERLAY
Avenue	Commercial	Country Route
Boulevard	Industrial	State Route
Street	Residential	
Arterial	City	Sanitation Route
Collector	Town	Snow Route
Local	Village	Truck Route
Alley	Campus	Ceremonial
Lane	Cultural	Economic
Main	Institutional	Historic
		Scenic
Connector	Center	Bicycle Priority
Major	Corridor	Driving Priority
Multi-Way	District	Pedestrian Priority
Thoroughfare	Downtown	Transit Priority
Transit		
Auto-Oriented	Low-Density	Home Zone
General	Marketplace	Pedestrian District
Multi-modal	Mixed-Use	Transit-Oriented
Parkway	Neighborhood	
Paseo	Park	
Pedestrian	Urban	
Shared	Workplace	
Slow		

Figure 9: Example of street classification considering the street type, context, and overlay (NACTO, 2013).

Assuming the functions the streets can have beyond movement and access, some advocates of new urban planning and sustainability issues proposed interventions that could be local or sectoral or an entirely new approach in roads planning procedures. Shared Streets, Complete Streets, and Link and Place are some approaches found in the literature that incited the reorganisation in the road systems influencing directly the road hierarchy. A comparison board (**Appendix I.1**), presents the main information and differences between these principles.

2.4.2.1. Shared Space

Table 4: Shared Space summary (Appendix I.1)

SHARED SPACE					
key: pedestrian - residential streets - streets as place - other street functions - mixed-use street					
Principles	Design tools	In which conventional road type does it apply?	Does it have an influence on road hierarchy?	Which is the road classification approach?	Which is the priority?
Design tool. Design approach depending on local characteristics. Intends to minimise the influence of motor vehicles, and encouraging people using a road space as a “place” instead of a transport access and mobility conventional uses.	Traffic calming; streets layout that do not segregate the transport modes (pedestrian, cyclists, motor vehicles).	Residential neighbourhoods streets; Local distributor or Access streets. (Short streets; with relatively low traffic volumes.)	Does not establish another classification method; however, could be added another road class in the conventional road hierarchy, since there was identify other functions for these streets type, besides the treatment as a “place”.		Pedestrian safety; Transport modes coexistence.

As a design tool for improvement of street space for a particular stakeholder – pedestrian and non-motorised functions in streets in mainly –, the idea was to rethink the street choosing an approach dedicated to the street as “place” rather than a space for car movement.

Woonerf – yard for living or home zones – was the early concept of shared space (Hamilton-Baillie, 2008). There was an uncertain beginning, but some authors explain it was first idealised in the Netherlands, in the 1960s, with “naked streets” idea, as a redesign of residential streets for the community liveability, removing the segregations and traffic control devices from these streets (Karndacharuk, Wilson e Dunn, 2014). In fact applied in Germany in the 1970s by Hans Monderman and his road users safety principles (Hamilton-Baillie, 2008) and in the UK during 1960s and 1970s (Ruiz-Apilánez *et al.*, 2017). Besides, some authors also indicate the Traffic in Towns report as a precursor of the idea, where Buchanan introduced an initial idea of mixing traffic and traffic calming (Karndacharuk, Wilson e Dunn, 2014).

The concept had been not developed as a road policy; instead, were a design practice for some streets that communities requested intervention, or had a high number of injuries. The approach was to minimise the influence of motor vehicles in residential streets, promoting the pedestrian and cycling activities, and providing safety for all users, in particular, a pedestrian (Hamilton-Baillie, 2008). Using the space as “place” rather than conventional vehicular “access and movement”, encouraged communities and planners to invest in the idea (Karndacharuk, Wilson e Dunn, 2014). Also, the safety of the pedestrians was the main concern; Polus and Craus (1988), affirm that safety is achieved “not by segregation between pedestrian and vehicle, but by controlling the vehicle through traffic-restraint schemes”, which meant traffic calming principles. In a way or another, the design approach by vertical or horizontal signalling, changes in the pavement, and the exclusions of physical barriers in streets was the main idea for speed reduction, and coexistence of modes, also leading to a reeducation of motorists regarding the non-motorised street users.

Thus, the neighbourhood residential areas had the potential street type for goals achievement. Streets with low traffic volume, short streets and minimum width of nine meters are some features of shared streets described by Polus and Craus (1988). The approach meant to design low-speed residential roads, which had demonstrated a new relationship between pedestrians and motorists (Jones, Roberts e Morris,

2007). There was not a proposal for a new organisation of streets, but improving local streets for other functionalities and their users. “Shared space is a design approach that seeks to change the way streets operate by reducing the dominance of motor vehicles, primarily through lower speeds and encouraging drivers to behave more accommodatingly towards pedestrians.” (Department of Transport, 2011).

Indeed, also identified by Hamilton-Baillie (2008), the concept had no intention to reclassify the streets or promote an alternative road hierarchy, but this street type fill a lacuna in conventional hierarchy because presents a different characteristics than conventional classes. Therefore, a development of intervention on these streets might create another class on the road hierarchy, since their use, functions and technical characteristics are peculiar. The function “place” was not included in any conventional road classification; even in local streets, the function had been for access in most part, prioritising the motor vehicles access. Instead, shared streets prioritise the pedestrian and the community liveability, as Karndacharuk, Wilson and Dunn (2014) exposed, “shared space diverges from a conventional road where all road users are encouraged to legitimately occupy the same road space with little physical separation.”

In resume, streets as public spaces have a variety of functions (Ghel, 2006; Marshall, 2004), and as social places (Appleyard, 1980) requires design solutions and different approaches than conventional road design as well its hierarchy. Residential, neighbourhood streets traditionally designed for traffic access also have people-oriented functions like children play, an extension of residents’ homes, walking. Many policies, to transform the residential streets in liveable places, included the shared space principles to improve the design of streets for their users and to assist the future creation of new typologies.

The concept had not an intention to reclassify streets hierarchy, but affects the functionality of some street classes and can add new classes as well. Although it fitted better in initially for residential streets, where the concept applied with more accuracy, the procedure can be replicated for other contexts and environments as a complementary instrument making part of a more embracing policy. Other street classes also can receive the alternative design depending on goals established for each road and the network.

Furthermore, shared space design features was a step for rethink space for multimodal transportation where it is possible the coexistence between different modes. Since there is a priority for the more vulnerable user, also contemplating the various functions and other users, the concept also leads to a creation of another hierarchy approach that does not relate to the road types, but its users.

2.4.2.2. Link and Place

Table 5: Link and Place summary (Appendix I.1).

LINK AND PLACE					
key: arterial streets - multifunctional streets - mixed use land - adjacent activities - multimodal transportation					
Principles	Design tools	In which conventional road type does it apply?	Does it have an influence on road hierarchy?	Which is the road classification approach?	Which is the priority?
Multifunctional streets. EU Project developed for alternative street planning through a new road classification approach, analysing related functions for each street section.	Overlays of design elements in the reorganisation of street space on the base plan, as a way of checking for space constraints and possibilities; and thus establishing the design approaches.	Developed for arterial streets, but the method can be applied in all streets.	Yes.	The two-dimensional hierarchy. Classify the streets according to their geographic context and usage context.	Priority may vary according to street type, and each context. Default users' hierarchy: 1. pedestrians; 2. bicyclists, 3. public transport users, 4. service vehicles, 5. other motor vehicles.

What is it?

A concept developed by an international project, “Link and Place” was based on street users regarding the transportation mode and adjacent land activities. The approaching of this project was mainly directed for arterial streets, and their several functions, that were able to enforce the link and place status concept. Considering a street type with particular characteristics, the mixed-use streets – urban arterial streets – provided a wide range of functions, being a complex and challenger case study, the heading of “link” and “place” was developed by the Arterial Streets Towards Sustainability – ARTISTS Project (Jones, Roberts e Morris, 2007).

“Arterial streets have become the focus for the movement of people, goods and service through the city system.” (Marshall, Jones e Plowright, 2004). Arterial streets are at the same time the most important connections between streets in cities, as well as an important commercial and liveable place as a socialising place, as the same way as shared space principles that considered streets and adjacent lands as “places” instead of movement function only. According to the authors, the problem of arterial streets was a mismatch of the conventional principles of urban road management and the existing reality of cities. “The conventional classification has no place for the traditional arterial street. As well as not reflecting existing reality, this system no longer represents a future ideal, which would now include a role for the arterial street.” (Marshall, Jones e Plowright, 2004). The authors explained that there is a need to reconcile conventional theory and existing and future practice. In addition, the existing classification systems are inadequate, since they do not take into account the potential role of combining strategic movement with local frontage use and the numerous uses of the space between buildings.

ARTISTS development, thus, was about a specific street type conventionally classified, in which did not fit into the traditional classification that contemplated "movement and access" functions. Conventional principles did not consider the role of arterial streets functions. Thus, the Project started from diagnoses of the variety these functions of the arterial street. There was related four conflict functions occurring in the arterial streets: (i) connection or traffic channel between different city regions; (ii) access to adjacent lands which contains many commercial and service activities; (iii) they represent a significant public space because their visual, cultural importance, and social interaction; and (iv) they represent the garden for many residents (Svensson e Hydén, 2004).

According to the authors, Jones and Boujenko (2009), the streets had been re-classified by related functions of “link” and “place”. Link as a “street as movement conduit” to save time, and Place as a “street as a destination in its own right” to spend time. The idea of re-organisation of the streets afforded

a more sensible street-space study. This was enabled by the development of a matrix demonstrating the intensity of the functions levels, where each level, from the major arterials down to residential cul-de-sacs, meant a new street category, and status levels were defined by A-E (Place), and I-V (Link) classification, corresponding the **Figure 10**.

Other factors were considered when classifying the streets, as the predominant type of land use as a component of Place status; and modal priorities on the Link side. The definition of the status level also took into account the pre-existing road categories from traffic engineering. However, the new proposal of “two-dimensional” street categorisation provided a more comprehensive classification of the street. While “the Link categories may make use of an existing road classification”, the Place categories “may reflect the size of the catchment area for activities associated with that street or cultural or heritage significance of the building fronting that segment street.” (Jones e Boujenko, 2009), in which, according to the authors, “every kind of urban street is represented by a cell within that matrix”.

ARTISTS street classification table

Link status	National	Ie	Id	Ic	Ib	Ia	Arterial roads/ways Arterial streets Non-arterial roads/ways Non-arterial streets
	City	Ile	Ild	Ilc	Ilb	Ila	
	District	IIle	IIId	IIlc	IIlb	IIla	
	Neighbourhood	IVe	IVd	IVc	IVb	IVa	
	Local	Ve	Vd	Vc	Vb	Va	
		Local	Neighbourhood	District	City	National	

Place status

ARTISTS Functional Classification

Figure 10: Matrix Link and Place (ARTISTS Consortium, 2004).

Thus, as Link and Place classify the streets according to their geographic context and usage context, the two-dimensional hierarchy is overlapped resulting in the complete street layout. The specific functions such link as place are classified separately; however, they are complementing each other. The link status can be classified by modes, also included in the overlapping maps. The final street layout can be developed by overlaying the mode-specific Link functions of each street section with other functions, such as local access and Place functions such as playing in the street (Gerike e Jones, 2015).

The concept demonstrates that the conventional road hierarchy was not entirely discarded, but adapted and improved for the newer necessities to control and predict traffic demand through local scale analysis, identifying the main user demands and developing street design facilities on a micro or local scale. The analysis of street segments cooper to uncover the details of street activities because of each street space requires a particular intervention design. Then, recognising the diversity of street typologies it is possible to choose a method or design solutions for the improvement of the area, as well the entire network, “addressing different users needs and being sensitive to streets’ local and wider strategic context” (Adelaide City Council, 2012).

How does it works?

As being a flexible concept, it has some variations depending on the local or scale that have been studied or applied. The Manual for Streets, UK, and The City of Adelaide SMART MOVE Transport and Movement Strategy 2012-22, Australia, are examples of policies introducing Link and Place ARTISTS principles. In addition, both projects offer new ways of categorising existing roadways that support short-distance mobility and access with design options to accommodate a variety of modes and roadway treatment options (FHWA, 2013). Properly, Adelaide's Strategic plan appoint that "Link and Place street classification system will be used to establish the role of the street and its hierarchy of needs, and to suggest how design strategies will influence street design"(Adelaide City Council, 2012).

At municipal level, the Smart Move Transport and Movement Strategy 2012-22 from Adelaide City Council, Australia, introduce the policy and exemplify the principles in a central area that requires intervention. The example shows a current street status and proposal for its future through design approach (**Figure 11**). The "current" section exhibits the distribution and traffic carrying functions (link status II), and a low level of place activity (place status D). The study by Adelaide City Council (2012), concluded that in this area there were fewer places of significance than link streets, in divergence with the plan strategy that was giving priority to pedestrian on city streets. Also, high levels of vehicle traffic were evident on most streets, and 20-30% of traffic passing through the central area, that did not stop anywhere in the city, that is, it was useless to occupy these streets with accommodation of vehicular traffic, in most part.

The strategy for the future of this area, in particular, the selected section, was slow down the traffic and discouraged driving through and within the city, choosing a lower level of link status (III), still with connection character; and giving a very high place status (A).

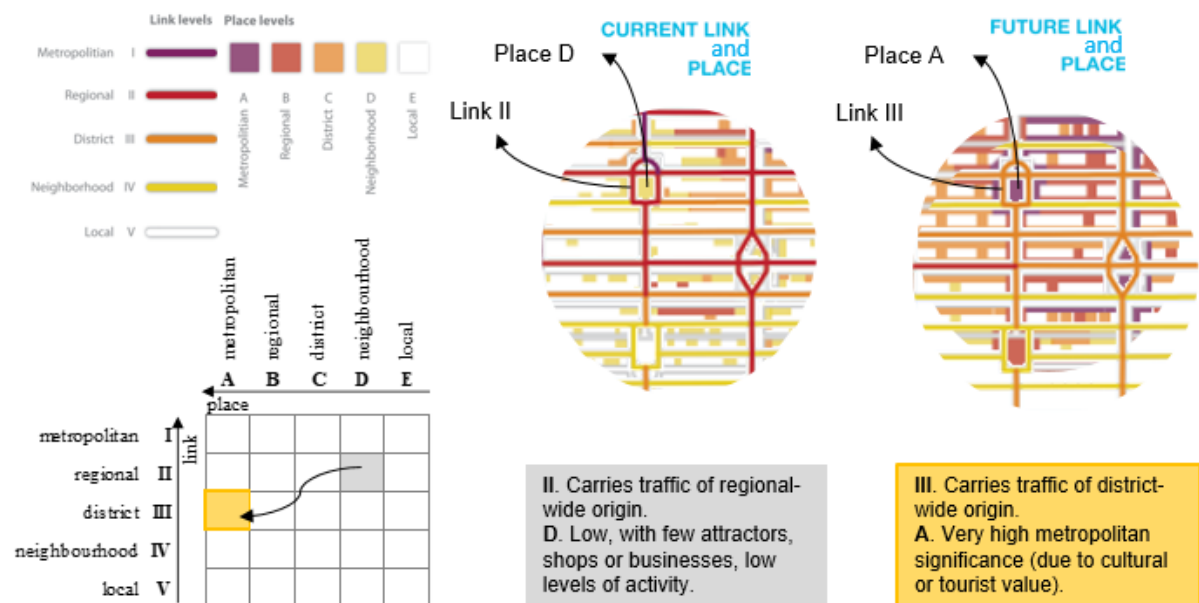


Figure 11: Images from Adelaide Smart Move Plan – Link and Place status from current and future situations.

Combining these recommendations with public transportation, the Plan also increased a level of bus route (**Figure 12**). Where it had a regional link level (II), it was changed to a high level of link status (I). This means, attract more people from different places, giving more options of transport mode, and establishing a public transport system that supports a vibrant economy, according to the Plan.

The hierarchy proposed changed the Regional bus line range from Metropolitan, where the Metropolitan (place status A) has more importance for improvement strategy for this area, as place of vibrant economy mentioned before. Therefore, Link and Place principles are adaptable for each urban street context.

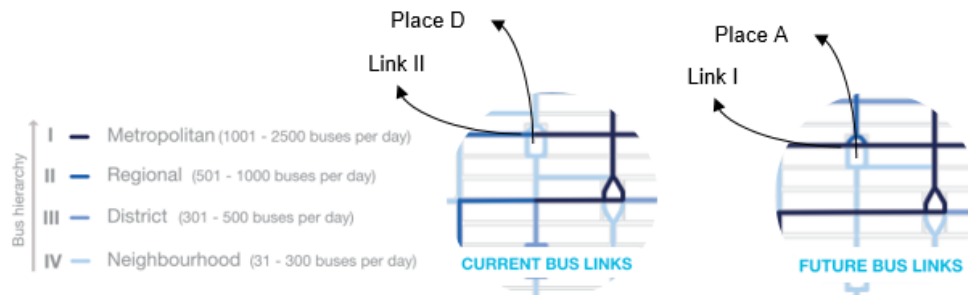


Figure 12: Image from Adelaide Smart Move Plan – Bus Link status.

This example shows how strategic guidance can direct the design of the streets through a sensitive analysis and establishment of goal with accuracy for each street and the whole network. After establishing the roles as link and place status character through the matrix, is possible to perceive the functions that streets perform in different contexts, then the strategies for local improvement can be developed with careful planning and a specific design proposal, respecting economic activity, the movement, and maximising their environmental and aesthetic opportunities (Adelaide City Council, 2012).

Consonant, applying Link and Place concept, the national policy Manual for Streets (MfS) from the United Kingdom, indicates that local traffic authorities should determine specific objectives for different streets of their road network, as well their design strategies. Recognising that the principle does not classify the streets in the same way as conventional classification the policies helps to direct to the alternative approach. While the traditional classification establishes a hierarchy for streets, the MfS policy includes other elements to establish the classification of the street regarding street design typologies. For an integrated design approach, the hierarchy suggested is related to street users; and the streets are classified according to their context (link and place) and the users' hierarchy.

Complementing, the manual suggests the hierarchy is not meant to be rigid; instead, it must consider the main users according to the character of the street and the context. The hierarchy established regarded the streets users and the default scheme consider the first pedestrian; then, bicyclists; next, public transport users; specialist service vehicles; and finally, other motor traffic. However, the policy explains that in each case the hierarchy could be changed, since it considers the pedestrian as a priority, ensuring also that the streets will serve all of its users in a balanced way. Each situation must be analysed especially, for example “buses might not need to be accommodated in a short, narrow section of street where access for cars is required” (DfT e D.C.L.G, 2007).

Then, to establish a design approach in each street type, the policy key for the integrated design included steps in the development process for new and to existing streets:

- Carry out context appraisal;
- Develop a proposed movement framework;
- Prepare outline master plan or scheme layout;
- Develop street character types;
- Design street network;
- Produce detailed master plan or scheme layout;
- Produce a design code. (DfT e D.C.L.G, 2007).

Inside the steps for a embracing development, MfS proposed the development of street types that breaking away from the conventional road hierarchy based on traffic capacity. Considering that the street

character has a relationship to building and other important elements of streets such as parking, trees and lightning, these typologies are not only simply nomenclatures but guidance for the future design approach. MfS in this way, remind the importance of Design Codes and explain that are important mechanism for implementing the masterplan, as a valuable tool for helping local authorities to deliver high-quality design (DfT e D.C.L.G, 2007). Examples of descriptive terminologies that should be enforced by local design guidances to define the character of each street are:

- high street;
- main street;
- shopping street;
- mixed-use street;
- avenue;
- boulevard;
- lane;
- courtyard. (DfT e D.C.L.G, 2007)

The more recent review in MfS policy, the MfS 2 explains with more specificity the link and place status and how it serve to classify the streets according each context. The **Table 6** provides a summary of streets typologies, in which it established the contexts and the commonly street types in each context.

Table 6: Street Types from MfS 2 (CIHT, 2010).

MANUAL FOR STREETS 2	
Contexts	Common Street Types
1. Town and City Centres	1.1. Multifunctional Streets and Spaces
	2.1. Arterial Routes and High Streets
2. Urban and Suburban Areas	2.2. Relief Road/Ring Road
	2.3. Boulevards
3. Urban Extensions	3.1. High Streets, Residential Streets
4. Interchanges	
5. Village Centres	5.1. Village Streets
6. Rural Areas	6.1. Rural Roads and Lanes
7. Urban and rural settlements	7.1. Shared Space

Recognizing the major character of streets types and the main movement function that connect residential, commercial, urban and suburban areas, besides towns and villages, the routes fulfil many functions along them (CIHT, 2010). Thus, there is a necessity of classifying the streets in parts and different contexts. Less specific than MfS, the Smart Move plan from Adelaide proposes the classification according the level of hierarchy of the link and place status, such as the main instructions of the concept, regarding the coverage area.

Table 7: Street Types from Adelaide Smart Move (Adelaide City Council, 2012).

The city of Adelaide SMART MOVE Transport and Movement Strategy 2012-22		
Status label: Coverage area	Link hierarchy level	Place hierarchy level
1. Metropolitan	I. Carries traffic of metropolitan-wide origin.	A. Very high metropolitan significance (due to cultural or tourist value).
2. Regional	II. Carries traffic of regional-wide origin.	B. High, with large numbers of on-street staying users within a large precinct.
3. District	III. Carries traffic of district-wide origin.	C. Moderate, staying activities and concentration of public transport stops.
4. Neighbourhood	IV. Carries traffic of neighbourhood- wide origin.	D. Low, with few attractors, shops or businesses, low levels of activity.
5. Local	V. Carries local traffic from immediate streets.	E. Used by local residents and workers only.

According Marshall (2004) this approach recognises today's streets-oriented agenda, which can include street types not recognised in conventional classification, such as the arterial street, and regards activities relating to the role of the street as an urban place.

"In the two-dimensional system (...), a more definite sense of balance is provided, by explicitly including place status as part of the classification (...) because this is ranked on the same basis as link status – ie, based on a geographical scale of significance – this should allow for treatment that does not allow link status to override place status" (Marshall, 2004).

Thus, the hierarchy of the streets connects the traditional and the alternative multidisciplinary approaches, establishing more flexible planning and providing local improvements for a better road network, attending all users.

2.4.2.3. Complete Streets

Table 8: Complete Streets summary (Appendix I.1)

COMPLETE STREETS					
key: pedestrian - multimodal transportation - comprehensive planning - local context					
Principles	Design tools	Which conventional road type does it apply?	Does it have an influence on road hierarchy?	What is the road classification approach?	Priority/ Hierarchy?
Embracing streets policy with long-term results. Streets for everyone.	Each local policy must develop regarding the hierarchy of users to ensure and provide safe access for all users.	All streets.	Yes.	Classification based on the type of transport users and context (land use) of each street. The hierarchy is established for users, not street types.	All modes coexistence; Safety for all street users.

While the concept of the shared streets is a design tool to achieve specific goals through traffic calming and non-segregation of street space in residential neighbourhoods, Complete Streets mean a comprehensive approach, also to achieve the safety on streets, but it comprehends other elements; "is about policy and institutional change." (McCann e LaPlante, 2010). Such as Link and Place, the policy aims the balance of different transport modes through a context approach also. However, Complete Streets is more embracing policy because actually emphasises the pedestrian and the "place" status, as well as provides more detailed design approach between different transport modes. Besides, contemplates the sustainability issues that also helps to guide the long-term goals.

What is it?

The first approach essay was developed and adopted in Oregon, US, in 1971 (Moreland-Russell *et al.*, 2013), through a "bike bill" law with measures to accommodate bicyclists and pedestrians in the roads. In early 2000s a variety of groups representing different transportation modes users and official institutes created the National Complete Streets Coalition contributing the disseminate and adoption the complete streets policies indeed around US, at community, state or federal level (McCann e Rynne, 2010), because "complete streets policies will look different in different places" (Plante, La e McCann, 2008). Therefore, each level of government should adapt to each reality. Also, as comprehensive and national police, the implementing process guide suggests it should be incorporated into new projects or renewal of streets built by public agents or private (McCann e Seskin, 2013).

According to Burden and Litman (2011), the complete streets policy comprehends strategies to increase the accessibility because “when we consider accessibility, we see how the modes affect one another. (...) Complete Streets policies are aimed at balancing access for all modes.” Then, the same authors described the policy as comprehensive development because it includes a diverse implication between the communities and official agencies, while proposes a new streets design specifying the term “all users” including pedestrians, bicyclists, and transit passengers, buses, and automobiles. Under these circumstances, multimodal transportation through complete streets is not an entirely new concept because “roadways historically were designed to accommodate all modes”. However, the complete streets provide the opportunity to multimodal commutes in neighbourhood level, ensuring that streets “are designed to safety, comfortably, and efficiently accommodate all type of users including motorists, pedestrians, cyclists, children, disabled, the elderly, and public transit travellers”, concluded the same authors.

The multimodal approach has been discussed and has been changed since the Geometric Design of Highways by AASHTO Policy. Mccann and LaPlante (2010) argued that other methods for multimodal transportation planning are directed for roadways improvement, but Complete Streets strategies focus on the roads and its users with the intention to change the practices in which included all modes in the planning process.

The concern about safety appear in the subject many times, indeed, the concept emerges from a recognition of a series of problems related to traffic and its consequences, as fatal accidents and injuries with drives and pedestrian; problems with citizens health, as obesity; air pollution; the non-drivers disadvantage in access the public services; the traffic costs. Still, giving pedestrian priority for achieving safety on streets and getting improvements in other areas, Complete Streets concept suggested equality between traffic groups, and according to Gehl (2010), integrating various types of traffic is not satisfactory until pedestrians are given a clear priority. The central idea focused on pedestrians and their priority in mixed traffic.

This integration of different transport modes influences directly on road hierarchy, in which it shifts from "conventional" that did not provide pedestrian priority, to people-oriented including pedestrian, transit passengers, soft modes users; that is, all street users' demands, not the vehicles' volume. Complete streets policies propose a street classification regarding the contexts these streets are placed. Users, types of transports and type of land use are regarded in the classification of streets, where residential, commercial, and downtown streets are considered different and must to be applied different design strategies for improving each intrinsic character and provide good conditions to these users. There is no mention of conventional classification in policies except to break this inconvenient principle to urban streets.

Regarding the road hierarchy, it is adapted for local reality. Each design guide, then, comprehending Complete Streets principles must adapt their situation and local context for proposals of redevelopment of urban streets. The principle of include and balance all modes and users influences directly on established road hierarchy. If some city followed the conventional classification, it will not be compatible with this alternative approach.

How does it works?

The Transportation System Plan (TSP), from Portland, Oregon, included the Complete Streets policies, where it established very meticulous street types according to some variables as type of users and local context streets. The streets are classified by Design and Policy classifications, in which Streets Design Classification is consistent with land use plans, environmental context, urban design pattern areas, and Neighbourhood and Civic Corridor Urban Design Framework. Street Policy Classification is developed

for types of users, such as pedestrian, bicycle, transit, freight, emergency vehicles, and other motor vehicles, considering also access for all modes, connectivity, adjacent lands uses, and estate and regional requirements. The classification also, indicates how streets should function for each mode of travel (City of Portland, 2015).

Table 9: Portland's street types (City of Portland, 2015). (Appendix I.2).

Transportation System Plan - Portland 2035		
1. Pedestrian	1.1. Pedestrian Districts;	1.4. Off-Street Paths;
	1.2. Pedestrian-Transit Streets;	1.5. Local Service Walkways.
	1.3. City Walkways;	
2. Bicycle	2.1. Major City Bikeways;	2.3. Local Service Bikeways;
	2.2. City Bikeways;	2.4. Bicycle Districts.
3. Transit	3.1. Regional Transitways;	3.4. Local Service Transit Streets;
	3.2. Major Transit Priority Streets;	3.5. Intercity Passenger Rail;
	3.3. Transit Access Streets;	3.6. Passenger Intermodal Facilities.
4. Freight	4.1. Freight Districts;	4.6. Local Service Truck Streets;
	4.2. Regional Truckways;	4.7. Railroad Main Lines;
	4.3. Priority Truck Streets;	4.8. Railroad Branch Lines;
	4.4. Major Truck Streets;	4.9. Freight Facilities.
	4.5. Truck Access Streets;	
5. Design	5.1. Civic Main Streets;	5.7. Urban Throughways;
	5.2. Neighborhood Main Streets;	5.8. Industrial Roads;
	5.3. Civic Corridors;	5.9. Enhanced Greenway Corridors;
	5.4. Neighborhood Corridors;	5.10. Greenscape Streets;
	5.5. Regional Corridors;	5.11. Local Streets.
	5.6. Community Corridors;	
6. Emergency Response	6.1. Major Emergency Response Streets;	
	6.2. Secondary Emergency Response Streets;	
	6.3. Minor Emergency Response Streets.	
7. Traffic	7.1. Regional Trafficways;	7.4. District Collectors;
	7.2. Major City Traffic Streets;	7.5. Neighborhood Collectors;
	7.3. Traffic Access Streets;	7.6. Local Service Traffic Streets.

Inside this classification, the method also includes the land use categories to support the decision of which transport mode should be emphasized on each street. The street classifications are based, in part, upon the underlying land use category and describe which transportation mode should be emphasized on each street. Thus, each part of the city has a specific Master Street Plan, which describes and provide the design approaches, always regarding the strategy for people movement also. The prioritisation of modes is ordered into:

1. Walking;
2. Bicycling;
3. Transit;
4. Fleets of electric, fully automated, multiple passenger vehicles;
5. Other shared vehicles;
6. Low or no occupancy vehicles, fossil-fueled non-transit vehicles (City of Portland, 2015).

Then, to elucidate the classification, the Plan also provide graphic pieces from each street type according to transport mode and the key description of each classification (**Figure 13**). Then, because it is a part of the city's Comprehensive Plan, there is also other plans attached for establish goals and parameters in local scale and for specific subjects. Below TSP, there are the Bicycle Plan, Pedestrian Master Plan, Freight Master Plan, Neighbourhood Area Plans, and Other Plans and Policies. They all follow the TSP guidance, but have more detailed information.

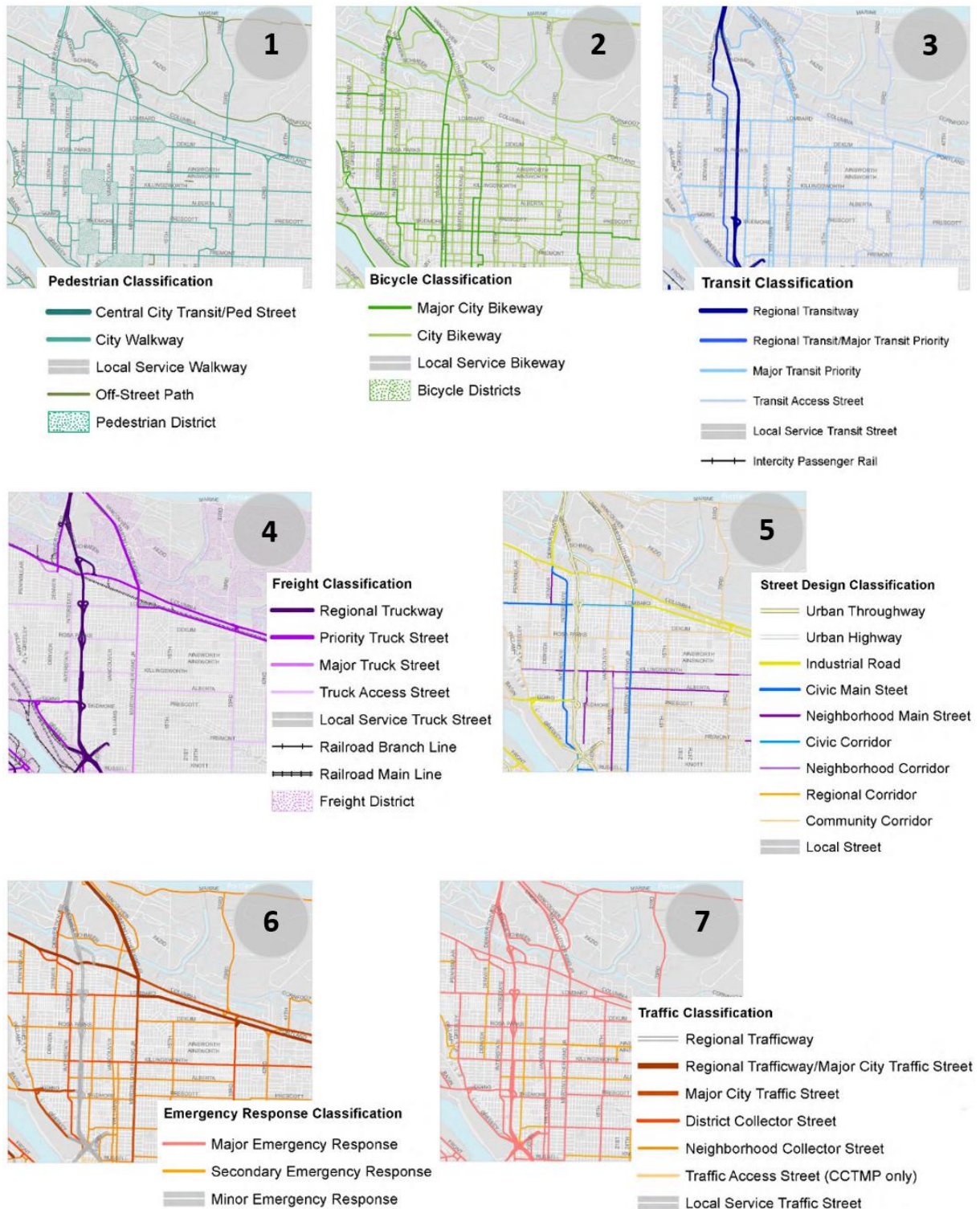


Figure 13: Portland's street types layout (City of Portland, 2015).

For an understanding of how Complete Streets policy can be adapted for each city and context, Toronto and Chicago also adhered it, also establishing the users' priority that changes when it is necessary. Their classifications are less detailed than Portland's street types but also regarded to land use type and transport modes users.

Table 10: Streets Classifications of Toronto and Chicago (Appendix I.2)

TORONTO COMPLETE STREETS GUIDE		
1. Civic Street		8. Scenic Street
2. Downtown & Centres	2.1. Main Street; 2.2. Residential Street.	9. Park Street
3. Avenue & Neighbourhood	3.1. Main Street	10. Employment Street
4. Apartment Neighbourhood	4.1. Residential Street	11. Mixed Use Access Street
5. Neighbourhood	5.1. Residential Street	12. Shared Street
6. Mixed Use Connector Street		13. Residential Shared Street
7. Residential Connector Street		14. Mixed Use Lane
		15. Residential Lane
COMPLETE STREETS CHICAGO		
1. Neighborhood Street		4. Main Street
2. Service Way		5. Connector
3. Pedestrian Way		6. Thoroughfare

2.5. PRACTICES IN ALTERNATIVE APPROACHES

As directed by conceptual policies the further details and standard design will be developed by design guide for each street type or each space or element of the streets, in order to support the application of the strategies. There were selected five design manuals for understanding how they follow the proposals and how they participate in the road hierarchy subject.

Table 11: Summary information of Design Manuals (Appendix II.1)

		general	conventional hierarchy	alternative approach for street classification			
		Streets Design Principles	Does it consider the conventional road hierarchy based on 'movement and access' functions?	Street Classification System	Which road functions/ variables are considered?	There is any priority or hierarchy guiding the streets classification?	Number of Street Classes
1	Design Manual for Urban Roads and Streets (DMURS) (Lahart et al., 2013), Ireland.	Balance between streets place and movement fuctions, focused on pedestrian. (Link and Place)	In parts.	It is established the importance (higher; lower) for each street type vs their function.	Movement; Place Context.	1. Pedestrian; 2. Cyclists; 3. Public Transport; 4. Private Motor vehicles.	7
2	Urban Street Design Guide (NACTO, 2013), USA.	Streets are public spaces for people as well as arteries for traffic and transportation. A street design must meet the needs of people walking, driving, cycling, and taking transit, all in a constrained space. (Complete Streets)	No. The guide indicates that cities may choose to alternative street's classification, respecting the local variables.	Context is a crucial parameter in designing streets. Street design should both respond to and influence the desired character of the public realm.	Street type and usage; Urban design context and built environment; Overlays, including modal priorities, special uses, and historic character.	Prioritises walking, bicycling, and transit.	13
3	Global Street Design Guide (NACTO and GDCI, 2016), USA.	Balance the needs of different transportation modes within the given context and culture. (Complete Streets)	No. The guide shifts from a system of functional classification to a context-based approach to street designs.	It is established streets typologies; based on local context, the needs of multiple users.	Users needs; Place demands.	Yes. Users priority. 1. Pedestrians; 2. Cyclists and transit riders; 3. People doing business and providing city services; 4. People in personal motor vehicles.	21
4	O Desenho da Rua - Manual do Espaço Urbano (Lisboa, 2018)	Adoption of design principles for an integrated street, to improve living conditions, promoting the appropriation of streets as spaces. It includes the principles of space sharing between the various modes of transport.	In parts.	Maintains the conventional functional classification, but includes other steets spaces as of equal importance.	Pedestrian circulation spaces; Road traffic spaces; Cycling spaces; Shared spaces; Parking spaces.	Compatibility of the simultaneous presence of pedestrians and other vehicles in different situations.	5 levels of convention al hierarchy
5	Streetscape Guidance (Mayor of London, 2019)	Balancing the diverse needs of these users will ensure better and safer places to support the variety of activity on our streets.	No.	Place and Movement functions (Link and place)	Accommodating movement; Understanding competing demands; Recognising place; Function, performance and form.	Users priority according each context.	18 (Street Type Policy)

The Design Manual from Ireland and the both USA's manuals present the streets typology, to clarify which type of intervention, functions, and users they accommodate.

The Design Manual for Urban Roads and Streets, from Ireland, classifies the streets according to their movement function and place context. Does not regard to road hierarchy, but the importance in each context. From higher to lower the level of connectivity is given to the streets that are a significant role in the movement network. Then, the levels of place context are established by the importance of attraction of diverse activities, mixed land uses, and in particular, pedestrian activities. This approach considers the context because a street can present different characteristics depending on the local context. Thus, the guide emphasises the place function rather than vehicles movement, because it is focused and prioritises the pedestrian needs.

To encourage safer streets, the manual indicates the pedestrian as a priority user — next, cyclists, public transport, and finally the private motor vehicle drivers.

The traffic hierarchy established to search the balance between the movement and place functions in order to minimise the traffic speed and volume on the street. However it made clear that it may necessary a comprehensive approach including the analysis of network too, because of decrease the traffic flow of on street, it may be necessary maintain through other streets – or provide options for the commuters (Grey e Siddal, 2012).

Inspired on Manual for Streets, UK, the guidelines reference link and place status, or movement and context for each street type, which influence the layout and design of streets in different areas. Also, the design guide presents a comparison between the conventional hierarchy and the alternative description.

DMURS Description	Roads Act/NRA DMRB	Traffic Management Guidelines	National Cycle Manual
Arterial	National	Primary Distributor Roads	Distributor
Link	Regional (see note 1)	District Distributor Local Collector (see Notes 1 and 2)	Local Collector
Local	Local	Access	Access

Notes

Note 1: Larger Regional/District Distributors may fall into the category of Arterial where they are the main links between major centres (i.e. towns) or have an orbital function.

Note 2: Local Distributors may fall into the category of Local street where they are relatively short in length and simply link a neighbourhood to the broader street network.

Table 3.1: Terminology used within this Manual compared with other key publications.

Figure 14: Terminology used DMURS compared with other key publications (Lahart et al., 2013).

		PEDESTRIAN PRIORITY		VEHICLE PRIORITY	
FUNCTION	ARTERIAL	30-40 KM/H	40-50 KM/H	40-50 KM/H	50-60 KM/H
	LINK	30 KM/H	30-50 KM/H	30-50 KM/H	50-60 KM/H
	LOCAL	10-30 KM/H	10-30 KM/H	10-30 KM/H	30-50 KM/H
		60 KM/H			
		CENTRE	N'HOOD	SUBURBAN	BUSINESS/ INDUSTRIAL
					RURAL FRINGE
CONTEXT					

Table 4.1: Design speed selection matrix indicating the links between place, movement and speed that need to be taken into account in order to achieve effective and balanced design solutions.

Figure 15: Design speed selection matrix indicating the links between place, movement and speed that need to be taken into account in order to achieve effective and balanced design solutions (Lahart et al., 2013).

Urban Street Design Manual considers the urban context which is (i) the needs of people (walking, driving, cycling, and taking transit) all in a constrained space; and (ii) the land use and activities, the value of the business, offices, and schools located along the roadway. (NACTO, 2013).

As other manuals, it is established the priority for pedestrian activity in the first place, however, the hierarchy of users changes according to the principal activity or function in the streets. The improvements recommendations for Streets located ate residential areas are directed mainly for pedestrian first. Also, the large and high-traffic streets in downtown areas also require pedestrian enhance because of their mixed activity character in adjacent lands. These streets play the network role,

however also contained many walking activities. In transit corridors, for instance, the priority is also for the pedestrian because sometimes the public transport passengers will be a pedestrian too. Thus, only connector roads that do not have the activities value along them will have recommendations for public transport mainly.

The Global Street Design Guide, a more recent manual than the previous, approaches are based on the local context for streets design because of every street is unique and require a balancing of many activities and demands; also part to the principle that all streets, as parts of cities, are places for people. Intended to minimise the automobile dependency, promote safety to all street users, incorporate the urban centres that became isolated, and grow sustainability (NACTO e GDCI, 2016). Recognising the importance of considering context and culture in the design of streets, the approach embraces the local situation of spaces regarding people and place.

First, identifying the people's needs; then, who are the users; next, how they use the streets; and finally, the number of users. For identify the place demands, the guide orient the examination of how the context defines the physical scale and character of the space; or how the surrounding land-uses, densities and networks influence mobility and use patterns.

The traditional functional classification then was shifted into streets typology oriented for people, which includes varied functions and users; and the hierarchy is based on stakeholder importance, establishing the priority of users on streets. The traditional road classification that classified according to the automobile volume and roads capacity is shifted into a sustainable people-oriented approach (NACTO e GDCI, 2016).

The typologies of streets are established to promote a balance of the needs of different transportation modes within the given context and culture; also, ensure the designs serve social, environmental, and economic needs and functions. While the Urban Streets Design Guide has thirteen typologies, the Global Streets Design Guide creates the major typologies (5) sub typologies (21) of streets to refine the design approach for each type. In addition, it helps to choose the better design tools for each context.

Table 12: Streets Classification from Design Guides.

URBAN STREET DESIGN GUIDE		GLOBAL STREET DESIGN GUIDE			
1	Downtown 1-Way Street	Pedestrian-Priority Spaces	Pedestrian-Only Streets	14	Elevated Structure Improvements
2	Downtown 2-Way Street		Laneways and Alleys	15	Elevated Structure Removal
3	Downtown Thoroughfare		Parklets	16	Streets to Streams
4	Neighbourhood Main Street		Pedestrian Plazas	17	Temporary Street Closures
5	Neighbourhood Street	Shared Streets	Commercial Shared Streets	18	Post-Industrial Revitalization
6	Yield Street		Residential Shared Streets	19	Waterfront and Parkside Streets
7	Boulevard	Neighbourhood Streets	Residential Streets	20	Historic Streets
8	Residential Boulevard		Neighborhood Main Streets	21	Streets in Informal Areas
9	Transit Corridor	Avenues and Boulevards	Central One-Way Streets		
10	Green Alley		Central Two-Way Streets		
11	Commercial Alley		Transit Streets		
12	Residential Shared Street		Large Streets with Transit		
13	Commercial Shared Street		Grand Streets		

The street design manual from Lisbon considers the conventional classification for road circulation spaces, however there is a major classification that establishes the components of public spaces in two major groups divided into (i) pedestrian circulation spaces and (ii) vehicle circulation spaces. Under these two spaces, the manual exhibit the elements that constitute them: Pedestrian circulation spaces, Bicycle circulation spaces, Road circulation spaces, Shared spaces, Parking spaces, Urban Furniture and Equipment, and cultural value elements. Thus, into Road circulation spaces, there is reproduced the

official road hierarchy. These guide do not indicate another road hierarchy, but presents the streets in parts relating to type of usage.

London's Streetscape Guidance proposes a more specific conditions for streets design improvements. It follows the hierarchy and street types from Street Types policy (**Figure 16**), and indicates the elements of each part of streets.

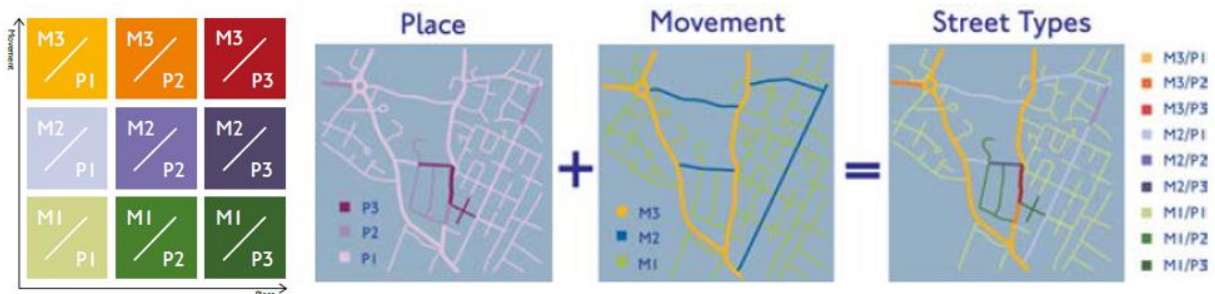


Figure 16: The Street Types Matrix (Mayor of London, 2019).

For a functional diversity of different places, the guide recommends levels of intervention:

- Tidy up – look to remove unnecessary road markings or broken furniture which is simple to clear up and will not damage the footway;
- De-clutter – requires a more strategic justification for every individual piece of equipment in the street, with the presumption of removal unless a clear reason for retention is given;
- Relocate or merge functions – any remaining features should be rationalised to combine signage and lighting or better locate street furniture to fulfil its intended use;
- Rethink traffic management options – by considering user priority, changes to carriageway widths, or removal of traffic signals;
- Recreate the street – complete remodelling of the street may be suitable if a new set of objectives or character is desired, for example, by creating a shared surface. (Mayor of London, 2019)

Ireland's, London's and Lisbon's design manuals, do not interfere in the established road hierarchy; they propose a punctual approach in the streets elements; treats the street as a public space that contains spaces dedicated to each use and function.

The balance of all street users and pedestrian priority, as the more vulnerable mode of travel, are unanimous in the manuals principles; and hierarchy in these cases is given to transport users, always putting the pedestrian as principal. By these rules, do not make sense classify the road hierarchy, once the movement function does not have the main importance as the conventional road hierarchy does. In alternative approaches, streets are settled by all functions they serve, and accordingly the users' priority.

Also, the balance of transport modes is regarded in some streets' classifications or design guidance. The analysis and design approach in individual transportations according to the demand of users reveals a comprehensive approach that overlaps the many layouts to conclude a global implementation design. Besides, a careful intervention and the steps are settled for each element recognised.

3

ROAD HIERARCHY IN MASTER PLANS: CURRENT PRACTICE IN PORTUGAL AND BRAZIL

Comprehensive national urban policies precede the municipal regulation and specific design guides and instructions for urban development. The road system is a subject to be treated by the national, regional, and the municipal levels, since the regions have roads for connections between other areas or cities; and the cities have their system for inner connections.

Regarding the road system, as part of the rural and urban environments connecting all scales – from national to local – besides the urban development laws, there are specific traffic regulations and official manuals by infrastructure national departments that give other attributes of the road hierarchy; providing parameters, classification, and concepts explanation relating to the road functions. Thus, the municipalities follow the guidelines and develop instructions for each purpose.

The analysis of the national regulations search the infrastructure subjects where the road system is described to understand the rules and concepts established in a general manner. Also, it must clarify the kind of guidelines and goals the national regulation established for the municipalities. The analysis of Master Plans will provide specific parameters of road hierarchy in the urban system, such as how each municipality classifies the streets and which elements are involved, as well the concepts regarded.

3.1. LEGAL FRAMEWORK FOR ROAD HIERARCHY IN URBAN PLANNING

The Portuguese Law nº 31/2014¹, establishes general bases for land public policies, spatial organisation and urbanism, as a comprehensive urban regulation. Some purposes, regarding the subjects of infrastructure, urban systems, accessibility and spatial organisation, are the coherence of the systems of urban and rural areas; spatial organisation to contain the urban expansion and ensuring the access to infrastructures; and promotion of accessibility to all citizens to buildings, public spaces and equipment.

Complementary laws related to this first are the Legal Regime of Spatial Management and the Legal Regime of Building and Urbanism. The first one, Decree-Law 80/2015², develops the bases of the land policies and spatial management, as well as defines the general regime for land use, legal building approval, evaluation and execution of land management instruments. These instruments can be national,

¹ Lei de Bases Gerais da Política Pública de Solos, de Ordenamento do Território e de Urbanismo – Lei nº 31/2014. (Portugal)

² Regime Jurídico dos Instrumentos de Gestão Territorial – RJIT – DL nº 80/2015. (Portugal)

regional, inter-municipal and municipal, and each authority must develop programs and plans according to the respective administration level.

Concerning the building legislation, the second law mentioned, Law 555/99³, provides rules, parameters and obligations for constructions and urbanisation. It also gives instructions for licensing building, that municipalities are responsible for. The instructions including the road system issues are the building parameters and urban development, which must obey the minimum dimensions established by ordinance P 216-B/2008⁴, attached to this law. It assumes that urban development projects must provide public utilisation spaces, green areas, and road infrastructures which parameters are established by Municipal Plans. However, the minimum dimension parameters are provided by this national ordinance according to the chart contained in the Ordinance.

QUADRO II	
Parâmetros de dimensionamento	
Tipos de ocupação	Infra-estruturas — Arruamentos (b)
Habitação a. c. hab. > 80 % a. c.	Perfil tipo $\geq 9,7$ m. Faixa de rodagem = 6,5 m. Passeio = 1,6 m ($\times 2$). Estacionamento = [(2 m) ($\times 2$)] (opcional). Caldeiras para árvores = [(1,0 m) ($\times 2$)] (opcional).
Habitação (se a. c. hab. < 80 %), comércio e ou serviços.	Perfil tipo ≥ 12 m. Faixa de rodagem = 7,5 m. Passeios = 2,25 m ($\times 2$). Estacionamento = [(2,25 m) ($\times 2$)] (opcional). Caldeiras para árvores = [(1,0 m) ($\times 2$)] (opcional).
Quando exista indústria e ou armazéns.	Perfil tipo $\geq 12,2$ m. Faixa de rodagem = 9 m. Passeios = 1,6 m ($\times 2$). Estacionamento = [(2,5 m) ($\times 2$)] (opcional). Caldeiras para árvores = [(1,0 m) ($\times 2$)] (opcional).

Figure 17: Table II contained at P 216-B/2008. Dimension parameters of road infrastructure according to the occupation typology (Portaria 216-B/2008).

Attending the land occupation typologies (left column), the dimensions of the public spaces as road infrastructure (right column), must obey the minimal indicated measures. In other words, depending on the variation of typology, such as residential, service or industrial occupations, the road infrastructure minimum values are established on the right column, and it is divided into measures of road profile, carriageway, sidewalk, parking, and arborisation space.

Thus, each road has a minimum measure given by national legislation. However, the municipalities have the autonomy to restrict the values according to the local characteristics. On the one hand, these values provide a minimum parameter for urban infrastructure implementation, assuring the coherence and the quality for urban spaces, as described by the law. However, the parameters are generic because they are following just the land occupation typology. It does not take into account the particularity of each area and the roads functions. Besides, the restrictive dimensions for the carriageway, sidewalks, parking and

³ Regime Jurídico da Urbanização e Edificação – RJUE – DL nº 555/99. (Portugal).

⁴ Portaria n.º 216-B/2008 de 3 de Março – Quadro II: Parâmetros RJUE DL nº 555/99. (Portugal).

trees tend to result in a monotone city pattern and non-oriented streets to all users and all transport modes. The dimensions parameters do not consider the street as an urban space with many functions, besides traffic accommodation.

This perception indicates the legislation consider the traffic volume for each street classification versus the estimated measurement of traffic by the type of land use and activities. Thus, general rules do not take into account the local specificities of the streets as a public space, giving the local planning responsibilities for the Master Plans and local programs to develop and manage the road infrastructure space. Another factor is that the national parameters of roads dimensions are related to the land occupation typology. In that case, the building regulations are mandatory, and the road infrastructure development must follow these rules because it is calculated also by the number of users in buildings in adjacent lands.

Both laws did not assure the road hierarchy guidelines, they only ensure the global urban system organisation and its management. However, the Decree-Law 80/2015 is precise about how can each region manage their urban system. The article 20, around the Transport System and Mobility, establishes that the National and Regional road network, as well as their interfaces with local transport and mobility networks, must be identified and defined at the local programs and spatial plans. Also, establishes contents of the Regional and Municipal plans, according to the articles 55 and 64, which are the regulations and graphic pieces of urban systems network. On both geographic scales, regarding the road network, they are establishing the development of the graphic representation of transport and mobility networks and public equipment.

At the national level also, the Portuguese road system is organised by a macro road plan – National Road Plan⁵ (PRN2000), which is a regulatory instrument for the organisation of national road infrastructure with the goal of optimising the conditions of land use and planning. It takes into account the Highway Capacity Manual instructions, regarding the level of service, and the Green Book concepts regarding the functional classification. The proposal includes the increase of road system density in frontier zones and towns, in order to improve the accessibility and connection between these areas and neighbouring towns. New roads were created as a result, emerging the necessity for a road system reclassification, including new regional roads category, structuring the connection of the road network between cities clusters.

According to PRN2000, hierarchy of National Road Network in Portugal consists in (i) Fundamental Network, which integrates the main routes of significant national interest and serves as a support for the entire national road network; and the (ii) Complementary Network that ensures the connection between the Fundamental National Network and the urban centres. At the national context, is established the connections of greater regional interest, as well as the main routes surrounding, and access in metropolitan areas. Lastly, the (iii) Regional Roads ensure the communication of supra-municipal roads, complementing to the National Road Network. The regulation also establishes technical information, as the number of lanes each road type must have.

According to articles 13 and 14, the roads not included in the PRN2000 and roads classified as municipal networks roads will integrate the Municipal Networks, through protocols to be celebrated between the roads autarchy and the municipal councils. In other words, the Plan considers, at the national level, the road network connecting significant regions, and the municipality must plan, regulate and manage the

⁵ Plano Rodoviário Nacional – PRN2000 – Decreto-Lei 222/98 de 17 de julho. (Portugal).

urban road network. Also, as established by the Roads Statute⁶, when a national road is declassified and does not belong to the national system anymore, it must be integrated at the municipal road network.

The Roads Statute assure the articulation between the National Road Plan and other spatial programs. Indeed, it establishes that the national network from Road Plan must be followed by other programs, as well as its goals and interventions priority. Also, this regulation indicates that the guidance and technical instructions from national institutes are official and must be followed since they are approved and published by the official national publisher. Furthermore, the Institute for Mobility and Transport elaborates a technical guidelines for the road system projects.

The Brazilian national regulations proceed similarly to the Portuguese. Ensuring the right to housing, accessibility and access to urban infrastructures, the City Statute, Law 10.257/2001⁷, regulated by the Brazilian Federal Constitution, determines that each city with more than twenty thousand inhabitants must have their Master Plan. Also, in case of more than five hundred thousand inhabitants, the city must have an Urban Transportation Integrated Plan compatible with Master Plan or insert in it, according to article 41 from City Statute. In case of a land subdivision, the parameters are not specified at the Master Plan and the municipality must have its complementary regulations, as well the zoning ordinance that sometimes is a complementary document to the Master Plan.

The City Statute can be compared to the Portuguese Law n° 80/2015 (RJIT) establishing the general bases for urban planning and the urban policies. The road system subject appears a few times, in which, at article 42-B, determines that cities in expansion must provide specific guidelines for areas that will be used for infrastructure, road system, public and urban facilities; then, transferring to the municipalities the responsibilities particular rules development. In some cases, the city already has a Master Plan, and then the complementary regulations are developed. For this reason, the Brazilian Master Plans tend to have other regulations attached to them.

Finally, the Brazilian Law 6.766/1979⁸ provides regulation and the national general parameters for land subdivision projects in urban areas, likewise the Portuguese RJUE. Some areas, object of the subdivision, must be allocated for the construction of new road infrastructure or just augmentation of existing streets, and public places. Before designing the project, the builder must require the municipality for the basic infrastructure projects designated for the area. Therefore, based on official guidelines provided by cities, according to the Article 9, the project must contemplate the proposal of the new road system or complementary one, and its respective hierarchy, besides the specific project with technical information of streets and their profile.

Formerly, the minimum percentage of the areas for public equipment and infrastructure was provided by this national regulation. However, a recent review transferred the responsibility of defining parameters to the municipal ordinances, making this law more generic than Portuguese RJUE. In summary, in a first moment, the Law 6.766/79 defined the percentages for public space donation, including the road space, in case of land subdivision; and the law review transferred the responsibility to the municipalities.

The concern for mobility is present in urban policies of both countries to link the regional areas, mainly, resulting in a spatial structuration development, regarding a spatial organisation. The laws strategies include the urban infrastructure and collective facilities as tools for mobility increase in a general manner. The concern for mobility also appears in discussion at the accessibility subject. On these two national regulations, the road system is cited as a part of the urban system; however, the theme is not

⁶ Estatuto das Estradas – Lei n° 34/2015. (Portugal).

⁷ Estatuto da Cidade – Lei n° 10.257/2001. (Brasil).

⁸ Lei de Parcelamento do Solo Urbano – Lei n° 6766/1979. (Brasil).

developed. The road classification, parameters and measures, as a technical device, will be emphasised at the local Plans and specific traffic regulation, according to both National constitutions.

The Brazilian classification divides the roads into urban and rural roads, as well as AASHTO's Green Book, which is the conceptual base for the Brazilian Transit Law⁹. The road classification is divided into administrative, legal, technical and functional including the movement and access concept. According to article 60, the road system is classified corresponding to the utilisation. The urban roads are (i) Rapid transit roads, (ii) Arterial road, (iii) Collector road, and (iv) Local street; and the Rural roads are classified as (v) Highways and (vi) Roadways, described in **Appendix IV**.

As the Portuguese specific road guidance, the National Transportation Infrastructure Department (DNIT) manual IPR-742¹⁰ divides the road system into a major system and a subsystem classification. According to each road function and in compliance with “mobility and accessibility” into the whole system, the subsystem is classified by functional classification.

In both cases, either Portugal or Brazil there is a major law about traffic disciplines, which classifies the main Road Network, at a national level. Then, each lower level traffic infrastructure departments applies sub-classifications – or functional classification – for the urban road system, always based on AASTO concepts such as Arterial, Collector and Local Streets. Regional Commissions composed of traffic authorities and officials research institutes, provide detailed instructions of mobility planning, management and establish the Portuguese and the Brazilian functional classification. These documents establish levels of road hierarchy based on system functions. Besides, the instructions denote which type of transportation can or cannot circulate into each road type, the geometric criteria for road construction, the facilities and the complementary issues as urban furniture, street design and landscaping.

Once the national urban policy was established in both countries, each municipality must regulate its urban policies by a spatial plan, in which consists of a comprehensive and long-term document that determines the municipal organisation in many aspects. Also, they have the function to install the spatial development strategies and integrate the national instructions into a spatial organisation model of land classification and qualification.

According to RJIT (Decreto-Lei nº 80/2015), the Portuguese urban plans are instruments for defining the municipal and inter-municipal strategies for the spatial development in a local level; and they are performed by the (i) Master Plan, (ii) Urbanisation Plans, and the (iii) Detail Plans.

The Master Plan lays the foundations of a strategy of spatial development articulating the guidelines set by the national and regional scope, and provides the organisation model of the territory, at the level of the municipality. The municipal road hierarchy is in this document, since it encompasses comprehensive proposals for the municipalities' structure, including the infrastructures. Also, this document is obligatory in all cities except in cases where they opt for an inter-municipal plan (Decreto-Lei nº 80/2015).

The Urbanisation Plan develops in a specific area, the urban planning policy, building a reference framework for the application of urban policies and defining the urban structure, the land use regime and the territorial transformation criteria. And the Detail Plan develops and concretises the proposals, in a local level, establishing rules and design guidance for the execution of infrastructure, public spaces and equipment as well as their location, and spatial organisation of other activities (Decreto-Lei nº 80/2015).

⁹ Lei nº 9.503 de 23 de setembro de 1997 – Código Brasileiro de Trânsito. (Brasil).

¹⁰ Publicação IPR-742 de 2010 – Manual de Implantação Básica de Rodovia. (Brasil).

The contents of the Master Plan are the regulation, the Land Use maps and Land Use Restriction maps; and complementing the characterization studies of municipal territory, environment report and execution schedule. Still, the plan has also complementary elements, specifically the Regional map with the indication of main urban centres and main connecting roads, relevant infrastructures and equipment. Coinciding with the Land Use map, both contain the main road infrastructure, with regional connection character; however, there is no mention about the local scale streets representation (Decreto-Lei nº 80/2015).

The Brazilian urban regulation established by general national law, City Statute (Lei 10.557/2001), distributes the urban planning management to municipalities, as well as the Portuguese regulation. The municipal instruments guided by this law comprehends of (i) Master Plan, (ii) Land Use and Occupation Regulation, (iii) Zoning Ordinance, and other economic and social plans.

Each municipality which has more than twenty thousand inhabitants must provide the Master Plan, as well as the cities with more than five hundred thousand inhabitants must provide a comprehensive plan of transport integration. Besides, there is specific guidance for local scale projects, the Urban Operations, which consists of a set of interventions, managed by the municipality, with the participation of citizens, users, owners, and private investors of a specific area from the city. In the case of Urban Operation development, it must be contained at the Master Plan regulation (Lei 10.557/2001).

According to the national regulation, the Master Plan must contain in its documents the specific projects – Urban Operations – and delimitation of urban areas objects of land subdivision or building, as well as the current infrastructure. Also, regarding the road system theme, the municipalities that will expand their territory, must provide the delimitation of new perimeter and put the guidelines in place for areas that will be used for infrastructure, road system and public spaces.

The Brazilian instructions are more superficial than the Portuguese as the first do not request specific maps neither indicate elements besides conditioning parameters.

3.2. ROAD HIERARCHY IN PORTUGUESE AND BRAZILIAN MASTER PLANS

Once analysed Master Plans, it was possible to perceive two main groups of concept application of road hierarchy. First, there is a group (Group A) that provides a road system oriented for motor vehicles only, enforcing the roads as infrastructure for cars movement, planned by the capacity it can receive. Therefore, these Master Plans replicate the national road distribution nomenclatures and classification for municipalities' streets, according to the general guidance of US' Green Book and the measurement features of Highway Capacity Manual.

Then, other models of road classification can be arranged in Groups B, C and D, which contemplates other variables when defining road hierarchy. These Master Plans consider a variety of transport modes such as private motor vehicles, public transportation, and soft modes.

This does not mean that the road classification system is oriented for these alternative transports only. There are cases that they are included in the conventional hierarchy, or have separated hierarchy from the main road system. Still, to combine different transport modes in the same infrastructure, previously designed for cars, the Master Plans apply entirely or some ideas of the Shared Space, Complete Streets, and Link and Place concepts.

The groups were developed to concise the analysis of the Master Plans information. Then, based on the subjects reported to the charts, the groups are:

- **Group A:** Road Hierarchy

Master Plans included at this group have only road hierarchy cited in the regulation. They may present the conventional concepts of traffic engineering in order to classify the roads.

- **Group B: Road Hierarchy + Public Transport**

This group contains the Master Plans that have the road hierarchy, as Group A but add the public transportation hierarchy as well. As a complementary mobility tool, these regulations may include the Interfaces classification, depending on public transportation type and facilities location.

- **Group C: Road Hierarchy + Soft Modes**

The group C includes the Master Plans that have a classification for the soft transportation modes – as bicycle paths and pedestrian streets – included at the road hierarchy classification. If the subject of the soft modes is cited in another chapter as general guidelines, it will be disregarded.

- **Group D: Mixed Hierarchy**

The Mixed Hierarchy signifies the Master Plans, besides the conventional road hierarchy, contain the complementary hierarchies for public transport and soft modes also, as the groups B and C subjects.

3.2.1. GROUP A: ROAD HIERARCHY

Table 13: Group A Summary (Appendix III)

City	Concern for Urban Mobility	Municipal Road Hierarchy	Number of Road Classes	Transportation priority according to road classes description	Promotion of Alternative Transport Modes	Other classification	Group of Analysis
ALMADA	✗	✓	3	Motor vehicles.	✗	National Road Hierarchy (PRN); Motor vehicles.	A 
AMADORA	✗	✓	3	Motor vehicles.	✗	National Road Hierarchy (PRN).	
MAIA	✗	✓	3	Motor vehicles; Public transport.	Bicycle.	National Road Hierarchy (PRN).	
ESPINHO	✗	✓	4	Motor vehicles.	✗	National Road Hierarchy (PRN).	
VILA NOVA DE GAIA	✓	✓	4	Motor vehicles; Public transport.	Bicycle; Pedestrian.	National road hierarchy; Passenger interfaces.	
NITERÓI	✓	✓	4	Motor vehicles.	✗	✗	
SANTO ANDRÉ	✓	✓	6	Motor vehicles.	Public Transport; Bicycle.	✗	
CAMPINAS	✓	✓	9	Motor vehicles; Public transport; Bicycle.	Bicycle.	✗	

The Master Plans included in this group have the fundamental road hierarchy indicated at regulation, comprehending the municipalities of Almada, Amadora, Espinho, Vila Nova de Gaia and Maia from Portugal; and Niteroi, Santo André and Campinas from Brazil.

Essentially, this group consists of road hierarchies oriented for motor vehicles circulation, and do not have road classes for other transport modes, also they are not included at the road classes' descriptions. The laws follow the national traffic manuals and guidance from departments of infrastructure that produce regulations according to the conventional concepts of road classification, based on U.S. concepts by Green Book. In other words, the road organisation by functions – movement and access – into the entire road system do not consider other aspects and elements, like other users, transport modes and land use. Still, some Plans include general guidelines for public transport and cycling paths system improvement, but it is not incorporated at the main hierarchy.

The mobility theme is included in some regulations, but some additional policies indicated have no connection with the hierarchy subject. Also, the indication of incentive for public transport and bicycle are included in some articles of the laws. However, there is no connection between the established road hierarchies and the alternative transport incentive; or it is described at other documents of which there is no citation in the Master Plan; or it is just guidelines that have not been developed yet, neither specified.

Occasionally, the road hierarchy is also classified just to establish the land use parameters, to improve developing areas; and sometimes it has more relevance in the planning process than the coherence between the road and adjacent lands.

A particularity detected in this analysis is that the municipalities are settled around the major metropolis; they have a similar or simpler road classification than the main cities. The dormitory-town character demands a road system with regional connection function, and the development of these road types may be more important than the urban streets in urban planning. The **Table 14** appraises the roads nomenclatures from Master Plans which hierarchy classification is noticeably similar. The “Regional”, “Metropolitan”, “High Capacity” attributes mean that these cities are located surrounding the major cities and they need to be connected by roads, and those are the main commute between them.

Table 14: Group A Road Classes Summary (Appendix IV)

	ALMADA	AMADORA	MAIA	ESPINHO	VILA NOVA DE GAIA	NITEROI	SANTO ANDRÉ	CAMPINAS
1	Regional Roads	Main Roads	Main Distributor Roads	Regional Road System	High Capacity Routes	Main Arterial Roads	Metropolitan Roads	Rapid Transit Routes
2	Municipal Roads	Secondary Roads	Secondary Distributor Roads	Main Distributor Roads	Structural City Routes	Secondary Arterial Roads	Primary Arterial Roads	Arterial I
3	Primary Roads (urban roads)	Local Streets	Local Arterial Streets	Secondary Distributor Roads	Complementary City Routes	Collector Roads	Secondary Arterial Roads	Arterial II
4	-	-	-	Local Access Streets	Local Streets	Local Streets	Primary Collector Roads	Collector I
5	-	-	-	-	-	-	Secondary Collector Roads	Collector II
6	-	-	-	-	-	-	Local Street	Local Street
7	-	-	-	-	-	-	-	Frontage Road
8	-	-	-	-	-	-	-	Rapid Transit and Arterial I Frontage Road
9	-	-	-	-	-	-	-	Infrastructure Paths

Amadora, Maia and Espinho contemplate the national roadways by the National Road Plan (PRN), and they have a similarity of the roads functions into the system. Also, they establish the road hierarchy straighter than others. Amadora and Maia classify three road types resulting in a minimum hierarchy,

but all these cities follow the national criteria, like Main and Distributor roads, which have the regional and municipal connection functions including the national highways; and the local streets with the purpose of internal urban circulation. However, there is no mention of the development of the road hierarchy in local scale, still, express that inferior plans – as PU and PP – must review the classification corresponding to the municipal categories by Master Plan.

Amadora and Almada have a more straightforward graphic piece of spatial organisation with low quality of roads representation. Similarly, the Niterói's Master Plan does not develop the theme; the hierarchy is also simplistic to categorise the roads as the national guidelines and provides other classification related with the technical characteristics, as carriageway widths. The Master Plan of Almada describes the national road system and roadways, of which composes the network with regional connection character. Then, the regulation distinguishes the municipal road classes in order to stipulate the width for *non aedificandi* areas. The map of the spatial planning also contemplates the national and the municipal classes as well their representation, though there is no classes' detailed description in the text.

Maia's Road Hierarchy graphic piece, **Figure 18**, represents the road classes; however, is perceivable the map does not include all the municipality road classes. Although the Master Plan describes the national and the municipal roads, there is no mention of the other streets – in white – in the key legend neither in the text. The colours key blue, red, brown and pink are the National, Main Distributor, Secondary Distributor, and Arterial roads, respectively; also regarding a regional connection network. The local streets are not indicated as well as Almada hierarchy.



Figure 18: Clipping from Maia's Road Hierarchy map. (Maia, 2013).

Santo André and Campinas hierarchies are described as the same as other municipalities, with regional connection character. The difference is in the number of road types. Usually, the Brazilian road classifications include two or more Arterial or Distributor roads at the hierarchy, according to the national guidance, because of the large spatial extensions compared to the Portuguese cities.

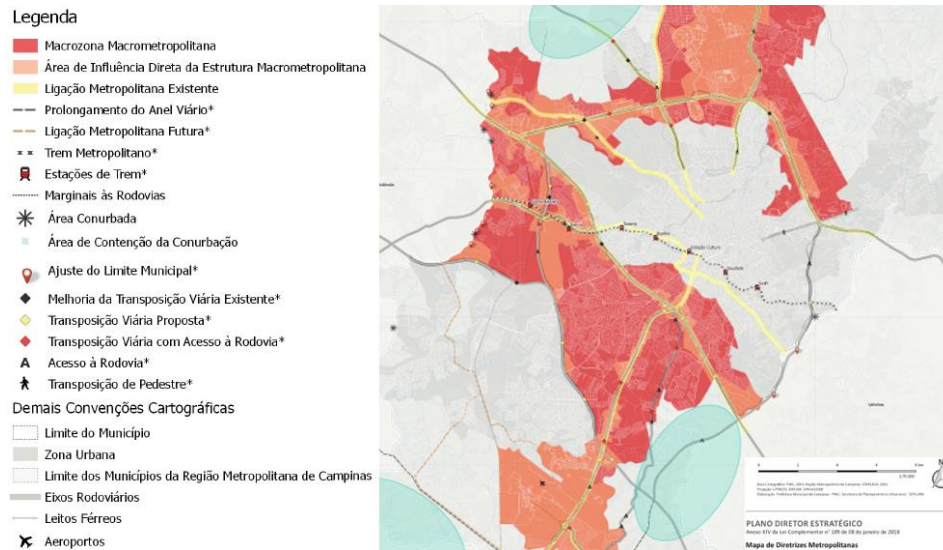


Figure 19: Campinas Master Plan - Map of Metropolitan Directrix (Anexo XIV da Lei Complementar nº 189/2018) (Campinas, 2018).

Additionally, as the other municipalities, Campinas also demonstrates the Road Hierarchy as regional connection importance. The yellow line at **Figure 19** represents the metropolitan connection by roads and the influence area in red and orange, which condition the urban development in the city. The surrounding areas in grey represent the urbanised and bordering cities, that constitute a continuously urbanised area, denominated *conurbação*. This explains the importance of metropolitan and regional roads for this city, as well as the road hierarchy as regional connection importance.

Campinas goes further, includes the “Frontage Roads” and “Infrastructure Paths” at the hierarchy, confirming the magnitude of roadways and the significant number of “Rapid Transit Routes”. Also, the “Mobility Structure System” map points mobility prevalent by roads. The green, red and yellow lines from **Figure 20** are part of the road system, as a Structural System for motor vehicles. The “mobility” in that case meant to be just for cars and buses. There is no other transport mode connections and facilities. The train rail indicated at the black and white dotted line is the metropolitan line beginning in São Paulo until the inner cities. It connects the major metropolis until the large municipalities of the countryside, but its management belongs to São Paulo State and depends on state policies. The fragmentation and disconnection between different transport modes are visible.

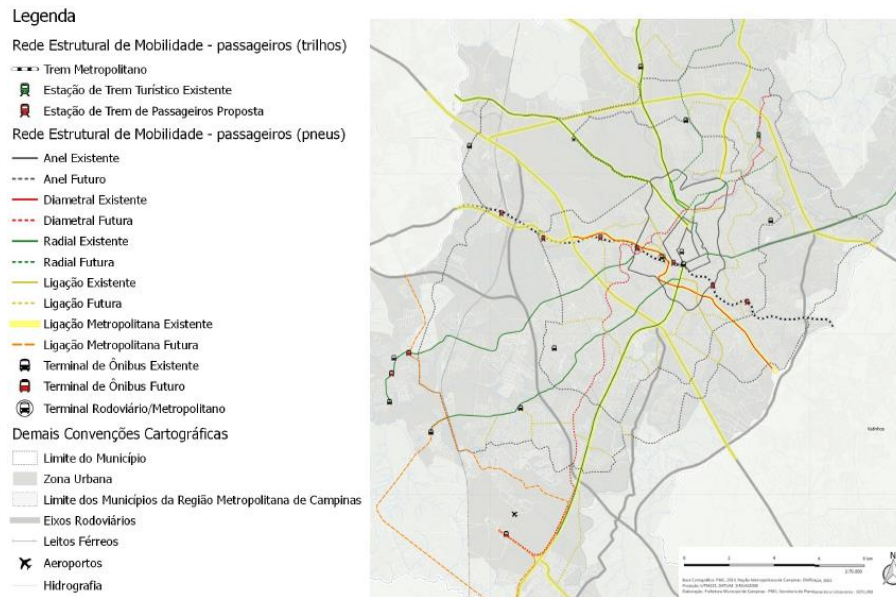


Figure 20: Campinas Master Plan - Map of Mobility System Structure (Anexo XV da Lei Complementar nº 189/2018) (Campinas, 2018).

Santo André is located at São Paulo's metropolitan region, so the regional connection is essential for the municipality as well as Campinas. The Master Plan does not classify the roads but gives the responsibility to Land Use Regulation, which does not establish the geometric features or more information besides the function of the roads. The mobility subject appears when it indicates the guidelines for the development of Municipal Mobility Plan, and even so, the road hierarchy is not mentioned. There are stated general guidelines from the national policy, City Statute. Even though, regarding the municipality spatial disposition, there is an importance for the metropolitan connection for the integration of Transport System with other frontier cities, which will be developed by São Paulo State Urban Transportation Company.

The Master Plans are not persuasive about mobility and accessibility in its instructions; they are limited at road classification, according to the national hierarchy, emphasising the roadways and regional roads, adding the municipal roads in a conventional way: Main Distributors, Secondary Roads, and Local Streets. Espinho and Maia show a very similar road hierarchy chapter with traffic calming recommendation in the guidelines, but there is no specification, unless it must be done at local streets.

Almada, Amadora, Espinho and Niterói's Master Plans do not promote alternative transportation, and they are explicit motor-vehicle-oriented, including the classes from PRN and giving focus to rapid transit routes.

Similarly to Maia, the Espinho and Vila Nova de Gaia's charts also do not represent the Local Streets in the key legend. The Espinho's Accessibility map, **Figure 21**, represent the public transport axis, some bicycle routes and a pedestrian path, although the text does not mention or includes the public transport and soft modes theme at the road system subject. Also, the pedestrian path represented in green is more like a promenade along the beach, and do not have a connection with the road system. Instead, Gaia's Local Streets description indicates that they admit the compatibility of pedestrian and bicycle in the common street space based on shared streets concepts when it is possible. However, these streets are only for development purpose, also indicated in the maps as predicted infrastructures.

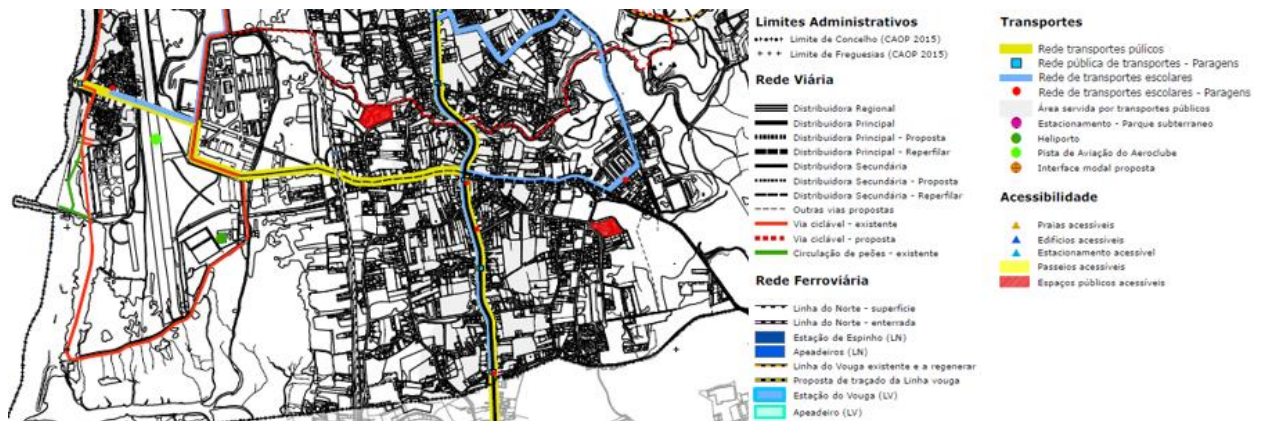


Figure 21: Clipping from Espinhos's Accessibility Map (Espinho, 2016).

Although both Master Plans charts represent some complementary elements of public transportation and soft modes, the regulations do not include the themes in the road hierarchy, as if they are separated subjects.

At the same way of Campinas, Maia's Master Plan is more concerned with the regional connection than the issue of mobility and transport systems. According to article 12 from Master Plan (Maia, 2013), the Plan privileges:

- “a) The execution of the main distribution network, as a link between the main urban agglomerations and their connection with the motorways network of the national system;
- b) The collective transport system as a preferential mode of transport in urban and interurban space.” (Maia, 2013, free translation).

Although there is a priority for public transport, the hierarchy is aimed at cars in general, as seen by the number of road nodes provided in the Master Plan chart, as well as the importance that is given to the Main Distributors Routes execution. The road hierarchy prioritises the motor vehicle circulation, by encouraging the inter cities connection and these road types.

Maia has more detailed guidelines regarding public transport and interfaces. However, there is no other classification complementing the road hierarchy, neither linking between the subjects. The public transport is mentioned when the Master Plan defines the roads characteristics chart, in article 97; it establishes the bus corridor allowance on – main and secondary – Distributors Roads, but there is no more specification about the transports. Also, Maia has a transport interface chapter that indicates the function of connection between two or more transport modes. The guidelines indicate the organisation by the train and metro stations and they must be dimensioned based on traffic impact studies, according to article 99. (Maia, 2013).

The recently revised Master Plan of Campinas includes the national Mobility and Transportation Policy guidelines, with the goal to promote the urban-oriented development related to public transportation and non-motorised transports. Such as the national policy determines, the municipality must develop their Mobility Plan, described in Master Plan guidelines, mainly for integrated land use and mobility planning, enabling the compatibility of public transportation offer with spatial planning. The concept behind the guidelines is a Transport-oriented development which allows the spatial and traffic planning integration. Chapter III of the Master Plan about Mobility and Transportation establishes the guidelines for spatial and traffic planning integration, which considering a transit-oriented development concept, called DOT – *Desenvolvimento Orientado pelo Transporte*.

Campinas promotes mobility and incentivises transportation-oriented development, with actions to land policies and mobility integration. Despite this, the road classification is, in the recently Master Plan revision, oriented for motor vehicles typology. The Master Plan indicates the implantation of a bicycle path on two road types: Collector I and II, but there is no indication of them on the graphic pieces.

Regarding soft modes, some guidelines are not innovative. The bicycle lane implementation is mandatory in the Collector I, and the Collector II can support a cycle path. According to article 53, Campinas must provide the Municipal Cycling Plan allied with the Mobility Plan and the Road System Plan to structure the whole system, but there are no design criteria for a bicycle path established or integration between the systems until this point. Considering the pedestrian and other transport modes, the Plan assured the development of public policies that promote the sidewalks qualification and pedestrian circulation spaces with safety and comfort, prioritising the pedestrian and non-motorised mobility. Besides that, the regulation does not indicate any other guidelines about alternative transport mode, or how the road hierarchy structures the mobility system. The hierarchy points to motor vehicle and public transport modes, distinguishing the bicycle path system from them, only.

Santo André' Master Plan, same as Campinas, instruct the mobility development, indicate the incentive to bicycle paths and pedestrian priority, and transportation modes integration. However, the guidelines are segregated. There is an instruction to develop the Municipal Mobility Plan, as well as other Brazilian Master Plans, but specifically, this Plan does not indicate any other relation with existing road classification, it just identifies the origin and destination areas, transportation modes, and volume versus an hour, according to article 22. (PDM Santo André).

This can be interpreted as a conventional road hierarchy, as well as Maia's. Although Maia's Master Plan includes the regulation for transport interface, assuming the incentive of mobility, there is no text with relevance about this theme. Also, the transport interfaces, according to article 99 (PDM Maia), must be organised in order to promote the existing train and metro stop, always based on traffic impact on the proximity.

3.2.2. GROUP B: ROAD HIERARCHY + PUBLIC TRANSPORT

Table 15: Group B Summary (Appendix III)

City	Concern for Urban Mobility	Municipal Road Hierarchy	Number of Road Classes	Transportation priority according to road classes description	Promotion of Alternative Transport Modes	Other classification	Groups of Analysis
CASCAIS	✓	✓	5 + 3 PT classes	Motor vehicles; Public transport.	Soft transport modes.	National Road Hierarchy; Public Transport.	
CURITIBA	✓	✓	5 + 6 PT classes	Public Transport; Motor vehicles.	Bicycle; Pedestrian.	Public Transport.	B 
RIO DE JANEIRO	✓	✓	6 + 3 PT classes	Motor vehicles; Public transport (Bus, BRT, BRS, LVT).	Bicycle.	Public Transport (BRS).	

As a complementary mobility tool for the urban mobility, the Master Plans included at “Group B” have the Public Transport (PT) classification contained in the regulation, and it is integrated to the current road hierarchy. The Master Plans of Cascais¹¹ and Curitiba¹² have mention of PT in the road hierarchy description; and also it can be mentioned in another chapter or complementary document as Rio de Janeiro that has the classification established by the Land Use regulation¹³, complementing its Master Plan¹⁴. Mostly, the classification consists in dividing the TP by transport types, levels of influence, regarding the space and the activities in the proximity, sometimes including the transport interfaces classification as well.

The principal road hierarchy of Cascais and Rio de Janeiro follows the conventional classification with regional roads of connection character, the following classes destined for traffic distribution within the cities, and the access streets to local circulation, as the same way of municipalities of “Group A”.

Instead, Curitiba’s Master Plan do not classify the access and local streets. It establishes other classification for a particular sector of the city, and the Land Use Regulation indicates other classes according to the zone vocation, adding sub classification at the Macro-hierarchy of Master Plan. The subclasses from Basic hierarchy “priority connection, sectoral roads”, and “collectors 1, 2 and 3”, follow the macro-hierarchy functions, as exposed in the summary tables (**Appendix IV**).

The difference between the Macro and Basic hierarchies is that the basic hierarchy is settled in a special expansion area from the city centre, as commercial, services and transport corridors designed into a trinary circulation system. Still, there is a particular area of zoning, the “Preferential Pedestrian Sector”, which comprehends the margin lands of public streets, partially or entirely blocked for motor vehicles, but it is a special area described at the zoning chapter and is not included in the road hierarchy like the PT is (Curitiba, 2000). The zoning subject affects the road classes and their structure in local scale and special areas, but the Macro-hierarchy established by the Master Plan regards the system with more importance influencing the road system structuration, integrating also to PT hierarchy.

Thus, Curitiba's road hierarchy, associates both classifications, the Macro and the Basic road hierarchy relating each other, as well as the compatibility with the PT structural system, summarised at **Appendices IV** and **V**. At the **Figure 22**, clipped from the Road and the PT Network charts, is perceivable the agreement between the systems, according to the regulation description. The hierarchy

¹¹ Plano Diretor Municipal de Cascais – Aviso nº 7212-B/2015.

¹² Plano Diretor de Curitiba – Lei nº 14771/2015.

¹³ Define Uso e Ocupação para Ordenamento Territorial da Cidade do Rio de Janeiro – PLC nº 33/2013.

¹⁴ Plano Diretor de Desenvolvimento Sustentável do Município do Rio de Janeiro – PLC nº 11/2011.

classes correspond each other; and the PT class “PT Complementary Routes” is combined with metropolitan roads, constituted by the infrastructure function implanted in selected routes. This means the integration of diverse transport modal and coherence in their planning. Still, the land use subject is mentioned many times to ratify the link between different elements of urban planning, in particular, the land use and the PT incentive in areas of diverse activities.

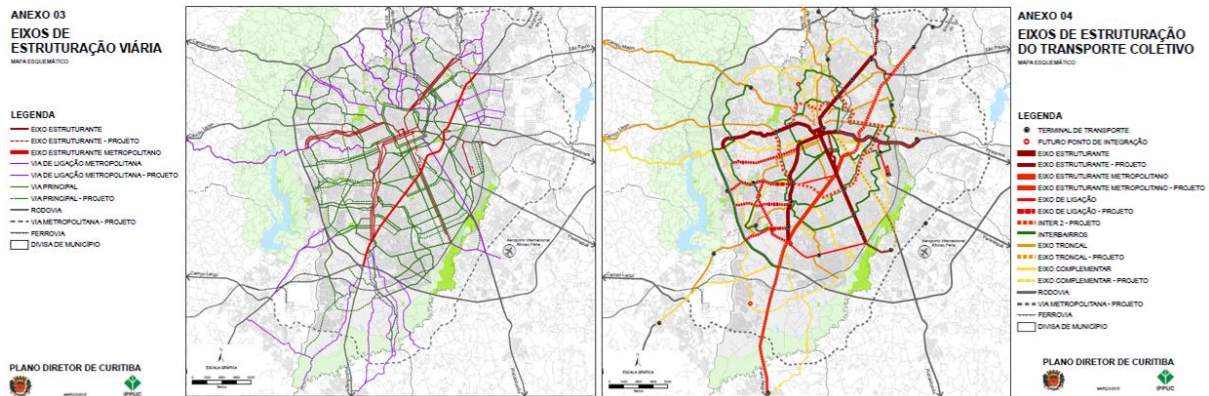


Figure 22: Graphic pieces from Curitiba's Master Plan. (Left: Structural Road System/ Right: PT System). (Curitiba, 2000).

The PT system, in Cascais, is categorised according to the public transport type and its function. Three levels correspond to (i) the current train line; (ii) the PT in an exclusive lane, on a proposal; (iii) and private collective transportation network, which make connections within the municipality and between municipalities with high importance. In particular, the PT in an exclusive lane requires intervention at the road level and implies a readjustment of sharing space between different modes of transport. (Cascas, 2015).

The lines are demonstrated in the Mobility and Accessibility maps where are also represented the road classes, interfaces, railway line, water and air mobility infrastructure and bicycle routes. However, the PT system is more related to the road system subject than another transport mode. The bicycle route is not integrated with the road hierarchy; indeed the soft modes system are included at the interface subject, which provides the transfer of passengers between different transport modes.

Regarding the street space and the compatibility with different transports, the Master Plan emphasises the promotion of PT in an exclusive lane. The Cascas' Master Plan indicates that the new roads must be developed for PT in order to promote the exclusive lanes in the system. Also, depending on its functions and characteristics, the space to be affected by the roadway may include lanes, sidewalks, parking areas, bicycle lanes, and public transport stops. In the case of new PT infrastructure development, it must provide the street space according to the pre-defined measurement parameters (Cascas, 2015).

Although the Cascas' road hierarchy contain supra-municipal routes and distributors roads that are oriented for motor vehicles, the Plan conditions the street for PT, which includes the space reserved for Public Transport in an exclusive lane, in the following situations, according to Article 107:

- “a) In an existing road, the space for PT in exclusive lane coincides with the existing road;
- b) In roads on a proposal, the PT in exclusive lane coincides with the proposal street space;
- c) In a road of PT exclusive lanes, the respective street space is defined by a corridor with 15,00m for each side of the axis.” (Cascas, 2015, free translation).

While Cascais stipulate the PT classification by modal (train and bus) and the exclusive transport lanes are in development stage, Curitiba establishes the PT classes according to the macro road hierarchy, which already contemplates the lanes just for PT. Curitiba's Bus Rapid Transit system, have a dedicated lane and it is an intrinsic system into the conventional road network. Also, Curitiba's PT system consists of the trinary system and the exclusive lanes, mostly, included at the road system for passage of high capacity transports always integrated with the land use. The trinary system is composed of the middle lane exclusive for PT, and the two parallels external roads are destined for general vehicles traffic combined with the land use and activities bordering, indicated at Structural Routes of road hierarchy. (Curitiba, 2015).

In the case of Rio de Janeiro, the Land Use Regulation, in chapter 25, classifies the municipal public transport in order to expose the many types of PT, like Rail, Metro, Light Rail Vehicle, Bus Rapid Transit, Conventional bus lines. However, only the Bus Rapid System (BRS) have a hierarchy corresponding to the respective road classes, as described in **Appendix IV**. The other PT modes are specified in the text and demonstrated at the map, but there is no description of them and the relation between them and the current road system. Also, there is a difficulty to understand the lines in the annexed maps because of the low-quality image. As well as Curitiba, Rio de Janeiro also has a map of the road system and other of the public transport system, differently from Cascais, which is compatible to the PT with the roads in the Mobility and Accessibility Map (**Figure 23**).

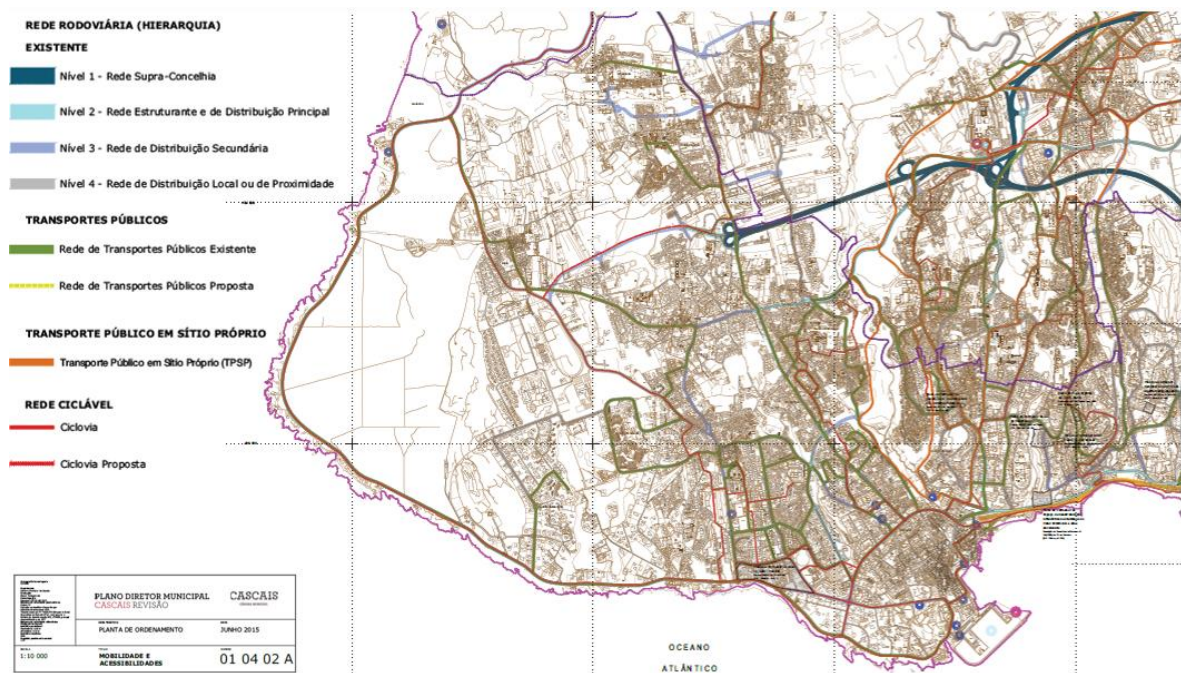


Figure 23: Graphic piece clipping from Cascais' Master Plan, including the Road Hierarchy, PT system and cycling routes (Cascais, 2015).

In order to promote a connection of different transport modes and the mobility improvement, the Master Plans indicate complementary transport infrastructures – the interfaces.

Cascais' and Curitiba's Master Plans present the interfaces subject, which means concern about the transport connection when pedestrians as users have the priority in these facilities. The facilities are designed as a connection tool; when the passenger makes the transfer between transport modes, they are a pedestrian at some point of the journey. Therefore, the Master Plans have stipulated a specific hierarchy for this facility. This shows the concern for connections between different transport modes,

mainly public transportation. In some cases, the interface hierarchy is oriented to transportation, and Cascais have the interfaces oriented for passengers.

Cascais' Master Plan includes the passenger interface subject; express that it is important that the interfaces ensure the transfer of passenger for different transport modes, through incentive to change the use of private transportation for the public mode. Also, they might be developed at specific projects, according to article 115, because the interface hierarchy is not included at the road one. They must be established according to levels of service and the offer intensity, and the type of land use (Cascais, 2015).

Curitiba proposes plans for a walking and cycling system, which induces the improvement of mobility in the city, but there is no specific classification for them in the road hierarchy. While the bicycle path is included at Structural Metropolitan Routes inaccurately, the pedestrian subject is not mentioned in any classes.

As well as Curitiba, Cascais identifies the soft mobility network, but it is not included in the road hierarchy. Differently, the network indication is only by guidelines, and there is no specification of the inclusion of these modes in road classes. The Master Plan indicates that it must be detailed in the "Detail Plan", as well the interfaces indication, and the road system organisation promotion by the "30km/h" zones for traffic calming introducing, according to article 116 (Cascais, 2015). The indication of the soft modes equipment, in this case, the bicycle paths, appear in the graphic piece of mobility, annexe to the Master Plan. However, road classification does not express these modes. The cycling paths are represented in a few streets, but there is no relation with roads typology.

Although these municipalities bring the soft modes indications in order to improve mobility, they are not developed yet. The road classes do not include alternative modes, and there are not more specification about the theme. And differently from both cities, Rio de Janeiro does not mention the interfaces in the regulation text although present some train and BRS stations at the Map.

3.2.3. GROUP C: ROAD HIERARCHY + SOFT MODES

Table 16: Group C Summary (Appendix III)

City	Concern for Urban Mobility	Municipal Road Hierarchy	Number of Road Classes	Transportation priority according to road classes description	Promotion of Alternative Transport Modes	Other classification	Groups of Analysis
PORTO	✓	✓	6	Motor vehicles; Public Transport (Bus); Pedestrian; Bicycle.	Soft transport modes.	National road hierarchy; Passenger interfaces.	C 
BELO HORIZONTE	✓	✓	7	Motor vehicle; Pedestrian; Bicycle.	Bicycle; Public Transport.	Categories for purposes of land use classification: residential, non-residential, mixed streets.	

The "Group C" includes the Master Plans that have classes for the soft transportation modes – as bicycle paths and pedestrian streets – added at the road hierarchy classification. If the soft modes subject was cited in other chapters as general guidelines, it was disregarded for this analysis.

Porto's road hierarchy, established by the Master Plan¹⁵ contains the road hierarchy that includes the soft mobility classes; it does not have another separated classification, unlike Belo Horizonte's road

¹⁵ Plano Diretor Municipal do Porto – Aviso nº 14332/2012.

hierarchy, where is established by the Land Use¹⁶ regulation with the responsibility described at the Master Plan¹⁷.

Both municipalities have a concern for mobility in their regulation, as well as the road hierarchy that is fundamentally oriented for motor vehicles circulation, as the conventional hierarchy. The transportation priority in the roads classes' descriptions (**Table 17**) is mainly for motor vehicles like individual cars. However, they have categories into the road hierarchy for the soft transport modes and the pedestrian circulation, not only in the description of the general guidelines, but also as part of the road hierarchy, described at **Appendices IV** and **V**.

Table 17: Group C Road classification summary (Appendix IV)

MUNICIPAL ROAD HIERARCHY (Road Categories)		
	PORTO	BELO HORIZONTE
1	Structural Intermunicipal Routes	Regional Route
2	Interconnection Routes	Arterial Roads
3	Complementary Urban Routes or Local Structuring	Collector Roads
4	Complementary Urban Routes of Sequential Importance	Local Streets
5	Local Streets	Mixed Streets
6	Shared Streets	Pedestrian Streets
7	-	Bicycle Path

Although Porto and Belo Horizonte include these streets categories, there is no indication at the maps annexes of both regulations. In addition, the Road Hierarchy chart from Porto is more straightforward than other; there is a representation of the first four categories and the national road network that is included in all analysed Portuguese municipal road hierarchy.

Similarly, Belo Horizonte's hierarchy chart indicates the first four road categories destined for motor vehicles circulation, and do not represent the mixed, pedestrian streets, and the bicycle path. The difference is that Belo Horizonte hierarchy map also indicates the zoning and special areas for development.

Even though Porto's Master Plan informs the passenger interfaces, they are not indicated at the map also, as well as the PT network. They are mentioned in the regulation text and are classified through transport modes considered at each interface level. The interfaces consider some PT types, as well as the soft modes and the interconnection between them; and the three interfaces levels specified are just for knowledge of the currently transports included at them. A peculiarity is that the interfaces are named "Passenger Interfaces", tend to be destined for the users, targeting the primary users of each transport in the range. Even so, the Master Plan regulates the road network, the PT, and the interface infrastructure in a separately way; the last two are not mentioned at the road hierarchy, and there is no linking with the road network. The way they are cited is perceptible the segregation between the road system theme.

¹⁶ Normas e Condições para Parcelamento, Ocupação e Uso do Solo Urbano no Município de Belo Horizonte – Lei nº 7.166/96.

¹⁷ Plano Diretor do Município de Belo Horizonte – Lei nº 7.165/96.

Except, at the Porto's case, the PT is only mentioned in the "Complementary Urban Routes of Sequential Importance" description; they "connect the Structuring Routes between them and the urban sectors making compatible the local traffic and the activities (...) a decisive role in the future restructuring of the urban bus network." (Porto, 2012, free translation), denoting a future integration between the systems; however, it does not have more specification about the coexistence of different transport modes in the road system.

Still, Belo Horizonte does not mention the theme at the road hierarchy chapter from Land Use regulation. The Master Plan introduces the subject for improvement of PT structuration, but it is just general guidelines. Also, there is no citation about the interfaces, denoting a discrepancy between the road network planning, as well as Porto's regulation.

None regulations include the PT and the soft transport modes in the hierarchy and their graphic pieces. Is understandable that Master Plans transferred the development responsibility for the Detail Plans on a local scale, however, no references were found of this in the legislation.

Both municipalities have this particularity of infrastructure promotion for the soft transport modes and pedestrian in their regulation.

Porto's Master Plan establishes six roads categories while the last two favour the pedestrian and soft modes, but the last class – Shared Streets – is more precise when it is available just for alternative transportation. Although the Belo Horizonte Master Plan does not classify the same street typology, there are other two, established at the Land Use regulation: the "Pedestrian Street" and the "Bicycle Path" that are indicated for been executed in case of new subdivision projects.

It is straightforward to notice the road hierarchy classified for motor vehicles circulation in Porto's Master Plan. However, the "Shared Streets" classification, according to article 52, serve the pedestrian circulation and admit, as a simultaneous secondary function, the corridors of alternative transport modes, such as electric bicycle, and access for cars to private property. The "Local Streets" are destined to attend the activities in the adjoining lands, favouring the pedestrian and the bicycle to the detriment of traffic (Porto, 2012). Even so, the Local and the Shared Streets are not represented at the Hierarchy Map; then there is a difficulty in understanding which roads are programmed to include this concept.

Belo Horizonte does not purpose the shared streets; instead, the regulation indicates the Bicycle Path category in their road hierarchy. As the same way of Porto, there is no indication of the cycling paths at the map, and this results in a disagreement of bicycle network in the road system since the systems are not compatible.

The Belo Horizonte Master Plan indicates the traffic calming adoption in the centre of the city to benefit the pedestrian. Differently, from Porto, Belo Horizonte regulation has the "Mixed Street" destined to pedestrian circulation, recreation, and cargo access. Also, there is the "Pedestrian Street" for pedestrian, and bicycle when it is possible. The subject of leisure or recreation was only found in this regulation but was not detailed information about it, where or how it will be implanted.

Although the classification is established for land subdivision when of the opening of new roads, the city centre also has a pedestrian priority because of old city character.

3.2.4. GROUP D: MIXED HIERARCHY

Table 18: Group D Summary (Appendix III)

City	Concern for Urban Mobility	Municipal Road Hierarchy	Number of Road Classes	Transportation priority according to road classes description	Promotion of Alternative Transport Modes	Other classification	Groups of Analysis
NOVA IGUAÇU	✓	✓	5 + 4 PT classes 1 SM class	Motor vehicles; Public Transport; Bicycle.	Public Transport; Bicycle.	Public Transport; Bicycle; National Road Hierarchy (CTB).	D 
LISBOA	✓	✓	5 + 5 SM classes 3 PT classes	Motor vehicle; Public Transport; Pedestrian; Bicycle.	Soft transport modes.	Public Transports; Transport Interfaces; Soft Mobility; Restric Zones.	
SÃO PAULO	✓	✓	7 + 4 SM classes 6 PT classes	Motor vehicle; Public Transport; Pedestrian; Bicycle.	Bicycle; Public Transport.	Public Transport (Bus); Bicycle; Pedestrian.	

The Mixed Hierarchy signifies the Master Plans, besides the conventional road hierarchy, containing the public transportation and the soft modes hierarchy also.

Although being three municipalities included at this group of analysis their Master Plan and the regulations of the system's hierarchy are different. Both Brazilian municipalities have included the bicycle path in their road hierarchy. Lisbon has and a different section for other modes hierarchy, as well as São Paulo, that establishes some features in the main road hierarchy and then indicates other hierarchy at other sections, and describe them in another document.

The road hierarchy in Nova Iguaçu Master Plan is described as the conventional classification, with an indication of vehicular flow per road type and the number of carriageways and lanes in each direction. Also, the road functions are linking the extreme regions and the city centre, and the distribution to local roads where the traffic is more restricted. As well as the road hierarchy, the Master Plan indicates other hierarchies for PT and bicycle system. Meanwhile, there is no mention of these modes in the road hierarchy descriptions; it only establishes the conditions and the road functions.

Then, Nova Iguaçu does not represent the road classes at the Master Plan maps; there are seven annexes maps, in which, one indicates a metropolitan route that crosses the city and a rapid transit road stretch; another map contains some interventions at the road system that includes some street opening, cycling paths, and railway. Another chart indicates the principal road axes and the railway too; and lastly, one with a zoning type and the principal road axis as well. Clearly, the road hierarchy is not fully demonstrated, as well as the integration between the transport modes indicated at the Master Plan text. The poor quality of the graphic pieces and the lack of information do not represent the guidelines exposed. However, the PT and bicycle paths guidelines, summarised at **Appendices IV** and **V**, are more developed than other Master Plans, which include Nova Iguaçu in this group of analysis.

The bicycle path network is regulated through exclusive subsection into the section “Nova Iguaçu Circulate Program”. Although been indicated guideline for Mobility Plan development, Nova Iguaçu already specified the roads for the inclusion of the bicycle paths. Also, they are represented at an annexe map of priority road system interventions, but there is not the entire system development. In addition, the Master Plan identifies the two bicycle infrastructures as cycling paths and cycling lanes; which the first one are exclusive lanes totally segregated from the motor vehicles traffic; and the second, are part of carriageway delimited by signalling. There are six specific roads indicated by the Master Plan to receive the intervention of bicycle paths execution. Then the regulation specifies the concept of the

bicycle parking and the location for the execution that is along of the main commute nucleus and the PT facilities, besides the city centre.

Regarding the PT, as the same of the bicycle guidelines, the municipality stipulates the development by the Mobility Plan for the TP network and have advanced proposals, which includes a PT lines classification. They are classified by their function into the urban structure, and not by their inclusion into the road system network. Nevertheless, they are classified at Radial, Diametric, Perimeter, and Feeding Lines, and their description is related to the activities and uses of the areas they will be implanted indeed. However, the PT lines are not linked with the road hierarchy, even in their description and maps, is difficult to understand which are the linking between them and establish the connection between the classes.

Although Nova Iguaçu is classified at Group D, the TP and SM guidelines are disconnected from the road hierarchy, which follows the Brazilian national traffic regulation. Besides, the Master Plan indicates in its guidance, bicycle paths organisation; and both transport modes classification should be included in the Municipal Mobility Plan development. In resume, currently, there is no relation between the road classification and the transportation modes incentive. One is related to national road hierarchy, and the other modes typologies and classes are going to be stipulated in another document, to be developed.

Lisbon has a particular road hierarchy because contains a specific chart, at annexe VI from regulation, with detailed geometric criteria per road type. The road hierarchy is classified according to the functions and characteristics of the routes, according to article 70. Besides each road type has a description in the text, the chart exposes the specification of them, summarised at **Appendix V** from this study (Lisboa, 2012).

The first three roads categories represent the structuring and distributor roads that receive and distribute the most significant traffic flow between them. According to the attribute chart, the coexistence with PT (Bus and PT in exclusive lane) is allowed, but the coexistence of the bus stops with bicycle and pedestrian is forbidden in the first level and segregated at the two respective levels. Thus, the regulation indicates other technical characteristics like number of lanes in each direction, segregation between directions, and sidewalk width; and the first level routes are totally segregated of the surrounding, also the minimum width for the sidewalk do not apply in these road types, meaning that there is no place for pedestrian in Level 1 Routes.

The Local Distributors and Local Access Routes structure the neighbourhood networks, so have more availability for other users besides motor vehicles. Indeed, the PT transit is not desirable in these street types and is not applicable to the Local streets.

Another aspect is the segregation of lanes, in the case of the three first levels, the segregation between different carriageway directions is desirable and obligatory; meanwhile, it must avoid this type of segregation in the last levels, considering the priority for pedestrian circulation and crossing.

Regarding the Soft Modes, Lisbon Master Plan determines a network to promote the circulation by soft modes, in particular, the bicycle and walking, guaranteeing the access to the transport interfaces and connection with density areas regarding population, activities, traffic. Then, the Detail Plan and the Urbanization Plan must foresee their network and the geometric criteria, like the proposal of the type of segregation about motor vehicles; and for this reason, there is no indication of the SM network at the Master Plan maps. Still, there is an indication of three types of cycling network to predefine future typologies.

Also in the SM chapter, the Master Plan describes in another article about traffic calming zones to moderate the transit of vehicles in these areas through “30km/h Zones” and “Mixed Zones”. The article

72 then, explain that in the “30 Zones” must promote the traffic calming by physical alterations in the urban space with signalling of maximum speed, decreasing of the streets width and curves radius, carriageway elevation, and discontinuity of the street, in order to difficult the car transit. As the shared space concept, the street of the “Mixed Zones” must be shared with pedestrian and motor vehicles through adequate signalling, the absence of space delimitation for the different modes, and maximum speed delimitation. Although the same nomenclature, the Belo Horizonte “mixed streets”, from “Group B”, contemplated at the road hierarchy do not mention other transport modes, only do respect to pedestrian and leisure. Different from Lisbon that introduces the concept for traffic calming and sharing the street space. They have the same terminology, however, the usage can be different, and even so, they still include the soft modes issues at the road hierarchy.

The PT network also is divided into three categories, by the type of transport and function into the road system. At least, the PT is linked with the road hierarchy, and the description does mention the structuring roads when describing the functions of PT Level 1. This category includes the metro and train lines, and according to the Master Plan, these lines are located along with the structuring network, making connections between suburban areas and competing with automobiles. The other two categories respect to common buses and PT in exclusive lines, and they do not mention the link with road hierarchy in their description. The Master Plan also indicates the existence of interfaces to promote the integration of different transport modes; however, it does not establish the connections and coexistence with road hierarchy. The exclusive lane in Level 1 is obvious because of transportation mode in mention, the metro and train, even if the metro can share the street with other modes, but it is not specified.

The disagreement between road, PT, and soft modes network levels is visible in the analysis of the maps. While they meant to be indicated together, as part of the main road network, there is an indication in diverse maps with different intentions. The road hierarchy is demonstrated at two graphic pieces of Lisbon Master Plan: the Land Qualification, and Accessibility and Transports maps.

The first one indicates the zoning of consolidated urban areas and areas to consolidate, the archaeological and geological heritage, the building and landscape heritage, the current metro and train stations, the first three road network levels as the national too, and tunnels and railway viaducts.

The Accessibility map also represents the first three road levels and the national road network, besides parking zones, interfaces levels, and metro and train stations.

Then, there is a third map, for infrastructures conditioning, that indicates some metro lines, metro and train stations, and other, in order to provide a protected area around these infrastructures. However, the regulation text indicates that the road Levels 1, 2 and 3, are represented in the “Accessibility and Transports” map, whose routes can be adjusted in the Detail Projects, according to article 70. And regarding other modes, a Detail and Urbanization Plan, according to article 71 of the Lisbon Master Plan, must develop the connection between the soft modes network, which are pedestrian and bicycle routes (Lisboa, 2012). This means that though the regulation establishes the road and transportation network hierarchy, they must to be detailed on the local scale in another municipal project.

São Paulo Master Plan¹⁸ establishes the road hierarchy including the bicycle routes and pedestrian routes, besides the conventional road classes. Among the guidelines and goals, it explains the importance of the connection between the transport modes for mobility improvement, the promotion of soft modes, the priority of PT beyond cars, and others. Then the determination of Mobility Plan¹⁹ development

¹⁸ Plano Diretor do Município de São Paulo – Lei nº 16.050/2014.

¹⁹ Plano de Mobilidade de São Paulo (PlanMob/SP 2015) – Decreto nº 56.834/2016.

includes the national mobility policy with general guidelines like transport integration, promotion of alternative modes of transport, and the increase of PT system, again.

The alternative transport is mentioned a few times, mainly when the Master Plan regulates about Mobility Policies at chapter V. The article 226 indicates the components of the Mobility System as complementary systems: (i) Road System; (ii) Pedestrian Routes; (iii) Public Transportation System; (iv) Private collective transportation system; (v) Bicycle Routes System; (vi) Waterway; (vii) Logistics and Cargo; and (viii) Air System. At the first moment, the organisation and connection between the systems seem to be coordinated in the regulation, also because there is a section for each system description.

Thus, the definition of the Mobility System is a group of different transport modes, services, equipment and infrastructure necessary for the citizen's commute. Besides the road one, each system of Mobility System is defined as a set of elements; and their components are summarised below.

Table 19: Summarised information from São Paulo Master Plan articles, 231, 244 and 249. (São Paulo, 2014, free translation)

Pedestrian Circulation System components	Public Transport System components	Bicycle System components
I – Sidewalks;	I – Public transport vehicles;	I – Bicycle paths;
II – Pedestrian streets (<i>promenades</i>);	II – Interfaces, transport stops and terminal stations;	II – Bicycle lanes;
III – Pedestrian paths;	III – Roads, segregated or not;	III – Bicycle routes;
IV – Transpositions and footbridges;	IV – Maintenance space and parking;	IV – Bicycle and other urban support facilities;
V – Signalling.	V – Facilities and buildings supporting the system.	V – Cycling signalling;
		VI – Bicycle sharing system.

Since the components from each system are described, is perceived as a connection from Pedestrian and the Road systems, which they are part of the road infrastructure. Besides, the Mobility System also includes the Bicycle and PT systems, which are classified with more specification in the Mobility Plan.

The road hierarchy is divided into two macro systems: (i) the structural and (ii) the non-structural roads, in which the first includes the structural road that connects the city with other municipalities and has regional and metropolitan character. Then, the non-structural roads are divided into four levels, corresponding to Collectors, Local, Bicycle, and Pedestrian streets to provide a connection between the first and second macro systems and access to buildings, besides the pedestrian and bicycle streets that are defined in other systems, as components of Mobility System. In addition, the Master Plan exposes the bicycle routes shall not be restricted in reason of road classification. Although the text describes the type of vehicle in each road class, this paragraph indicates the bicycle preference and promotion in all road types. Also, in the same chapter indicates that the roads, in general, shall receive adaptations to promote the sharing the street with different transport modes, motorised or non-motorised.

The inclusion of alternative transports or soft modes in the road hierarchy description shows the concern and the progress in the theme, at least in the guidelines.

At the characterisation of the PT and the bicycle systems, there is always an indication that Structuring Roads must include the respective infrastructures in their space. However, the functions and characteristics of this road type are not cited in the other systems descriptions. Even the descriptions are

separated into sections; the road hierarchy text might contain the specification of other complementary systems in order to lead to comprehensive and concise information.

Still, there is no connection between the systems at the Master Plan's graphic pieces. The graphic pieces do not indicate the road classes; only establish the priority actions into the road system that is related to future urban projects to be developed in another complementary document.

Soft Modes Hierarchy

Regarding the soft modes, the Master Plan includes the Pedestrian and Cycling Systems, which summarised at charts into **Appendices IV** and **V**. It points to the general guidelines while the Mobility Plan indicates the specific guidelines and its characteristics for the cycling infrastructures.

The structural cycling network system is composed of a set of interventions in the road system and must be interconnected. They correspond to the specific infrastructure in the road system, as well as the planning in the road infrastructure.

Among the general guidelines, the mobility plan exposes the road hierarchy theme, in which the roads of a structural function must be a priority for the bicycle paths inclusion, besides the insertion of the cycling infrastructure in other urban elements like PT routes, transpositions, services paths, and linear parks. Also, all new roads to be opened must include the cycling infrastructure. Thus, the plan introduces the classification for the cycling infrastructure, summarised at **Appendix V**, at São Paulo's chart.

The classification of bicycle infrastructure defines the type of facility and provide some geometrical criteria for the implementation. Also, the plan exposes the priority routes to receive the infrastructure like structuring roads and PT axes, besides the other urban elements mentioned.

The Mobility Plan also indicates that structural roads must have priority in the bicycle infrastructure implementation, and classifies the denominations, described in **Appendix V**. The article 5.2.4 indicates the Structural Cycling System must be included at the existing road system and the new to be planned, through specific infrastructure development. The components for implementation are: "a) Structural Road System; b) Collective Public Transport System; c) Transpositions; d) Service Paths; e) Linear Parks; f) Urban Development Areas." (São Paulo, 2014).

Although the Bicycle system is classified in categories, the Master Plan and Mobility Plan graphic pieces do not indicate the systems as the regulation descriptions. The network is demonstrated without the indication of the different classes. This occurs in the PT maps too, some lines are demonstrated, but not all are represented. Also, there is no indication of the road hierarchy as well.

Public Transports Hierarchy

São Paulo's Master Plan has a hierarchy for bus lanes types, but it is described in another document – the Municipal Urban Mobility Plan. The Master Plan points subjectively the "bus-lane-hierarchy" at the road functional classification descriptions and indicates the Mobility Plan as part of road system planning. Then, São Paulo has a different hierarchy for bus-corridor, classifying the system by bus size and type, as well as their demand. The plan informs the technical features like the number of lanes, physical segregation from ordinary carriageways. São Paulo's bus-corridor system tends to adjust a pre-existing road into an infrastructure for collective transportation so that it will generate competition between motor vehicles lanes and bus lanes in the same infrastructure. The problem with massive traffic in São Paulo might decrease with public transportation incentive, according to the Master Plan.

The link between road and PT hierarchies is described in chapter 241, when the Master Plan indicates which road classes are allowed to receive the public transport exclusive lanes. Although the regulation does not relate to the existing road hierarchy to buses classes, it establishes some connection as

example, must be a priority on structural roads, as mentioned before; however, the graphic pieces are demonstrating the relation between the roads and the bicycle routes implementation. The bicycle system nomenclatures are destined to establish the typology and the exercised function, but they are not linked to the entire road system yet; it is a guideline for future development. As well as the PT system, the classification regards to the operational functions of the buses types, although there are established geometrical criteria of lanes segregation and its position into the roads.

3.3. MAIN FINDINGS

- Road Hierarchy for Regional Connection

The dormitory town character detected in Group A analysis demands a road system with regional connection function, and the development of these road types may be more important than the urban streets in urban planning. Furthermore, car dependency is so intrinsic in these cities that some regulations do not even introduce another hierarchy different from the national described by the respective transit departments. The Master Plans disregard the other transport modes from the roads classifications as if they did not need a specific design and measurement criteria.

- Mobility and Accessibility, just for the record

Although mobility and accessibility subjects appear in most Master Plans, it was detected that in cases of Group A the theme was cited, but not explored either connected to road hierarchy. These regulations were not persuasive, they are limited at road classification according to the national hierarchy, emphasising the roadways and regional roads, adding the municipal roads in a conventional way: Main Distributors, Secondary Roads, and Local Streets. Furthermore, the replication of national highway classification incentive private motor vehicles usage, opposing the mobility and accessibility premises.

- Public Transport: corridor and exclusive lanes as urban structuration tool

Master Plans from Group B and D tend to relate the land use theme to PT infrastructure settlement. Besides the establishment of PT hierarchy following the road system, the PT system also is developed according to the land use type or the type of incentive the municipality wants to propose in each area. Therefore, the city structure is related with PT system.

- Transport interfaces and mobility improvement

In order to promote a connection of different transport modes and the mobility improvement, the Master Plans indicate complementary transport infrastructures – the interfaces. Master Plans from Group C have stipulated a specific hierarchy for this facility. The hierarchy can be oriented to transportation or oriented for passengers, depending on goals. The facilities are designed as a connection tool; when the passenger makes the transfer between transport modes, they are a pedestrian at some point of the journey. Therefore, they are an important tool for soft modes usage.

The mobility and accessibility subjects are present when there are transport interfaces, promotion of alternative transport modes and incentive of pedestrian movement priority. It can be directed for two situations: (i) connection of many transport modes, independently from the user type, releasing the transport lines connection; or (ii) interfaces for users. The second situation takes into account the user convenience, considers the diversity of the urban environment, as well as land use and different activities surrounding; it is not limited to transport connections only. An interface located at strategic points where

there is a diversity of activities and uses, results in an inviting and diverse environment, oriented to mobility and providing tools and options to users.

- Shared Streets, Complete Streets and Pedestrianisation

In cases of Groups C and D, the alternative concepts approaches were detected in guidelines when the inclusion of other hierarchies (e.g. traffic calming, shared streets, controlled speed zones). Such as PT as soft modes classification, there was possible to perceive an encouragement for walking and a particular concern for the pedestrian. The last was mentioned in Master Plans guidelines as a priority element; however, the Plans did not indicate with accuracy the how to prioritise pedestrian into the different systems. Still, Master Plans of cities that have an old centre, like Lisboa, or vocation for pedestrian areas, presented indication for pedestrian restricts areas; that is, putting pedestrian in the top of the hierarchy, whatever the hierarchy mode considered.

4

CASE STUDY: ROAD HIERARCHY IN THE MATOSINHOS MASTER PLAN

4.1. THE MUNICIPALITY AND THE MASTER PLANS

Matosinhos is located in the Metropolitan region of Porto, Portugal, which boundaries with Porto, Maia and Vila do Conde municipalities. The municipality is subdivided in four administrative local units, *freguesias*:

- União das Freguesias de Leça do Balio e Guifões;
- União das Freguesias de Matosinhos e Leça da Palmeira;
- União das Freguesias de Perafita, Lavra e Santa Cruz do Bispo;
- União das Freguesias de São Mamede de Infesta e Senhora da Hora (DGT, 2019).

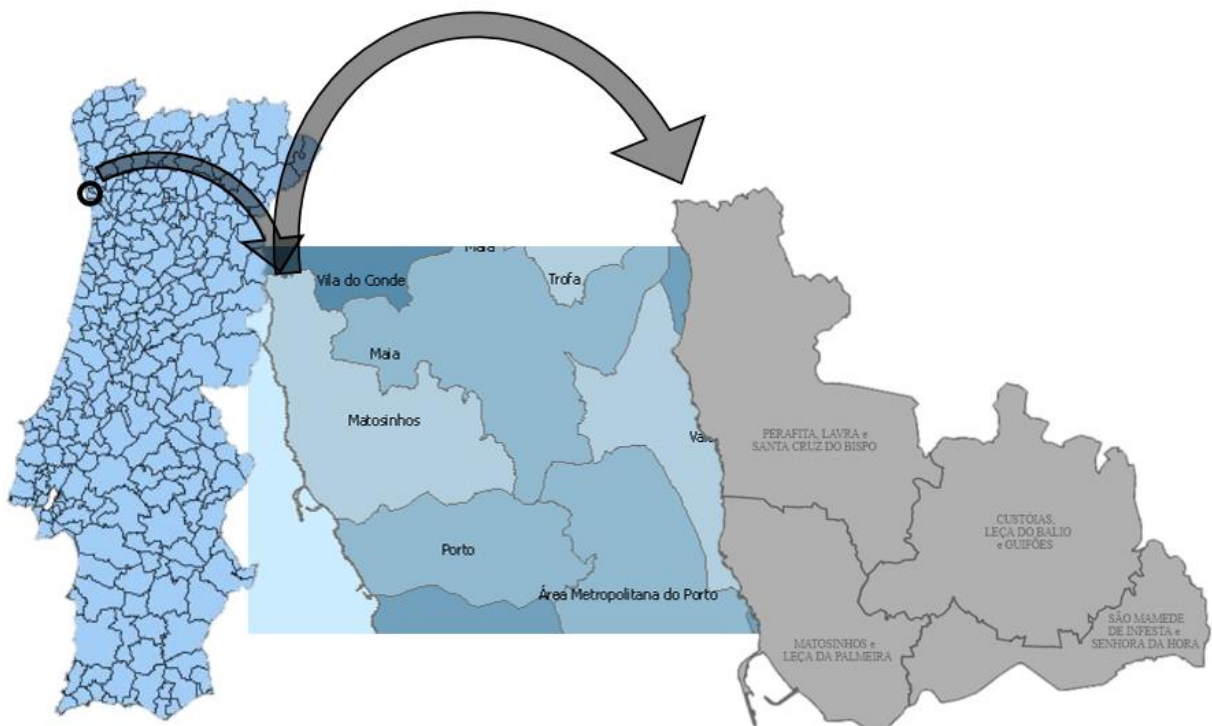


Figure 25: Matosinhos in Portuguese territory (INE, 2019).

With an estimated population of 175.478 distributed over 62,43 Km², Matosinhos also has the one of highest demographic density in the country (Pordata, 2011). Also, from 2001 to 2011 the population increased almost 100 inhabitants per km². Among other municipalities, Matosinhos fits in the average demographic density; thus, there is a favourable scenario for the Master Plans analysis and comparison between them.

Table 20: Matosinhos population statistics among the other selected municipalities.

	Country	District/ State	Municipality	Demographic Density ¹ ↓ (Pop./Km ²)	Population ¹
1	Brasil	São Paulo	São Paulo	7.387,7	11.253.503
2	Portugal	Lisboa	Amadora	7.376,1	175.136
3	Brasil	Minas Gerais	Belo Horizonte	7.167,0	2.375.151
4	Portugal	Lisboa	Lisboa	6.389,6	547.733
5	Portugal	Porto	Porto	5.686,9	237.591
6	Brasil	Rio de Janeiro	Rio de Janeiro	5.265,8	6.320.446
7	Brasil	Paraná	Curitiba	4.024,8	1.751.907
8	Brasil	São Paulo	Santo André	3.866,4	676.407
9	Brasil	Rio de Janeiro	Niterói	3.640,8	487.562
	Portugal	Porto	Matosinhos	2.803,7	175.478
10	Portugal	Lisboa	Almada	2.477,0	174.030
11	Portugal	Lisboa	Cascais	2.127,1	206.479
12	Portugal	Porto	Vila Nova de Gaia	1.798,5	302.295
13	Portugal	Porto	Maia	1.634,3	135.306
14	Brasil	Rio de Janeiro	Nova Iguaçu	1.527,6	796.257
15	Portugal	Porto	Espinho	1.502,0	31.786
16	Brasil	São Paulo	Campinas	1.358,6	1.080.113

¹ Census: 2011PT/2010BR

Table 21: Evolution of demographic density and population in Matosinhos.

Municipality	Demographic Density ¹ (Pop./Km ²)		Population ¹	
	2001	2011	2001	2011
Matosinhos	2.704,6	2.803,7	167.026	175.478

¹ Census: 2011PT

In terms of socio-economic interest, Matosinhos has one of the largest port infrastructure in the country, Porto de Leixões; it also contains logistics services, manufacturing industries and agricultural and fishing activities (AMPorto, 2019). Besides, the city has an international airport that serves all North region, attracting a considerable number of people. The predominance of industrial activities resulted in disorderly urban growth, giving a priority for connection routes because manufacturing, logistics services and the airport demand large transportation infrastructures, occupy considerable space, and generate saturation in near roads (C.M. Matosinhos, 2015).

The situation of urban planning of Matosinhos stagnated for years, and since the national urban regulation established that municipalities must review the Master Plans until 2020 (CCDRN, 2019), Matosinhos and the coloured municipalities in the map of **Figure 26** have their revision in progress.

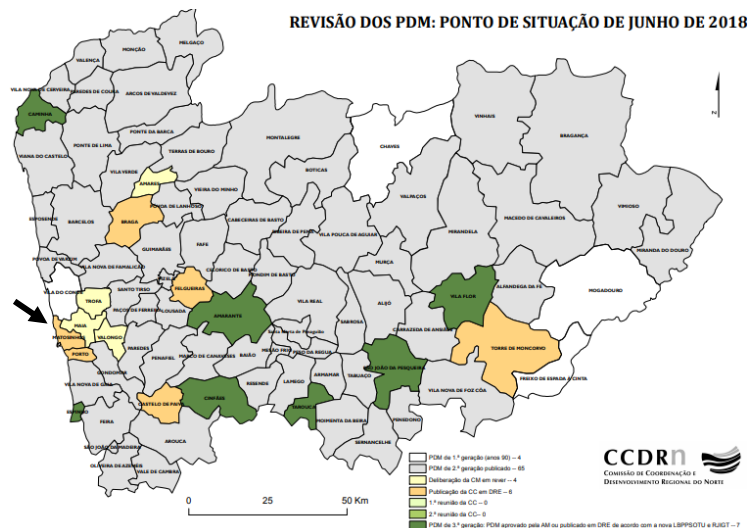


Figure 26: Master Plans (coloured) in revision in the North Region of Portugal. (CCDRN, 2019)

The initial report for revision of 1992' Matosinhos Master Plan indicates the road hierarchy developed for the municipality: (i) Fundamental Road Network, and (ii) Main Distributor Road Network. The main functions exerted by these routes involve the metropolitan connection between adjacent cities and distribution of municipal roads to national roads (C.M. Matosinhos, 2015). Therefore, having only two classes, the road hierarchy from 1992' Plan can be considered as a conventional approach, but simpler than the default hierarchy studied in other Master Plans. The strategy in road planning regarded to the main economic interests, as described before.

In addition, it was verified that the two categories of roads were insufficient for complete road planning. In order to connect the National network and the distributor roads, some roads were implemented without being described in the 1992' Plan guidelines. Thus, the report, as an initial study, promoted guidelines for the redefinition of Matosinhos road system, based on empirical analysis. It was described as restricting the execution of new major roads, since they were the focus in the past thirty years, and incentive of local and inner-municipal streets. Still, the Report presents initial improvements for the future road planning, promoting a Shared Street subcategory in Local Streets, considering the priority for pedestrian, and focusing on the inner streets (C.M. Matosinhos, 2015).

The recent review of Matosinhos Master Plan, currently in approval process, contemplates the concern indicated in the initial report, however it goes beyond including the Mobility Plan development and highlighting the mobility concern.

In order to rebalancing Matosinhos road network, since it was underdeveloped by the old Plan, the new Plan had a support from investigation team from FEUP, University of Porto, which introduced a new perspective 'More Accessible and Closer' (C.M. Matosinhos, 2019. Free translation.) for the mobility and transportation development. Also, it was possible to include good practices in alternative approaches, since a research team was involved.

Under the 'More Accessible and Closer' guidelines, the accessibility and opportunities for commuting by all transport modes are strategic goals developed by the Plan. To accomplish this goal, several proposals are established regarding the road hierarchy and the way that the transport modes are provided for the citizens' demands, as well as the competition between them (Pinho *et al.*, 2017). The strategies defined for improvement quality of mobility include:

- “Priority for active modes circulation, especially in neighbourhood areas;

- Increase of quality of commercial areas, planning in local and neighbourhood scale;
- Solutions for sustainable mobility and incentive of alternative modes rather than private motor vehicles;
- Create conditions for bicyclists circulation and interchanges between modes;
- Priority for public transport and high-frequency service;
- Identify and solve the conflicts between transport modes that tend to share the same road type.” (Pinho *et al.*, 2017. Free translation.)

Since the strategies were defined, the approach for achieving the goals and the sustainability mobility, was based on rebalancing the transport modes to increase the users’ choices between the different modes, as well to redistribute the private motor vehicle traffic to superior hierarchy streets that support a higher volume of traffic flow (Pinho *et al.*, 2017). Besides, the authors also justify that users need opportunities to change the commute behaviours, creating then, a competition between the different transport modes, and suitable options for all users.

As identified by the authors, the active modes and public transportation are the keys to rebalancing the usage of the street resulting in cars circulation decrease. Therefore, the approach proposes a redefinition on road hierarchy, this is, classifying the streets according to transport mode and “identifying the priority mode for each path of streets” (Pinho *et al.*, 2017. Free translation).

4.2. THE ROAD HIERARCHY IN NEW MATOSINHOS MASTER PLAN

The new Matosinhos Master Plan classifies the network based on transport mode (walking, cycling, public transportation and individual transport). Called as ‘Functional Hierarchy’ (Pinho *et al.*, 2017), it starts from a reclassification of streets based on the multi-functional streets, like an infrastructure that accommodates many different transport modes. Each transport mode has its priority in each hierarchy, and they can have overlapped hierarchies also. The hierarchies were defined as:

- Pedestrian Network Hierarchy;
- Cycling Network Hierarchy;
- Public Transportation Network Hierarchy;
- Road Network Hierarchy (Individual Transport);
- Transport Modes Overlapping Hierarchy.

Inspired by the conventional road hierarchy, the proposed hierarchies are more comprehensive because embrace all transports into the carriageway of the street, establishing a hierarchy based on priority that each transport mode have into the streets.

Each transport mode has its particularity respecting the kind of users, main purpose, technical and geometric features and design patterns. However, there are some situations that the hierarchies will coexist, and the Plan specifies that the conflicts will be solved in a future phase of planning (Pinho *et al.*, 2017). Still, there are some cases the Plan instructed to considering the prevalence of higher class of hierarchy in case of more than two hierarchies in the same carriageway, as well as the application of official minimum dimensions established by the Portuguese transportation agency, IMT.

Table 22 summarises the information of the different hierarchies as well as their relationship when regards to combined modes.

Table 22: Functional Hierarchy Characteristics from Matosinhos Plan (Appendix VI)

	(P) PEDESTRIAN Network Hierarchy	(AM: Active Modes) BICYCLING Network Hierarchy	(PT) PUBLIC TRANSPORT Network Hierarchy	(IT) INDIVIDUAL TRANSPORTATION Network Hierarchy	(O) Transport Modes Overlapping Hierarchy
Functional Hierarchy	1. Main Network 2. Priority Complementary Network 3. Complementary Network 4. Secondary Network	1. Main Network 2. Priority Complementary Network 3. Complementary Network 4. Network of Coexistence 5. Secondary Network	1. Railway network 2. Main Road Routes 3. Secondary Road Routes 4. No service (+3) Interfaces	1. Municipal Network 2. Main Distribution Network 3. Local Distribution Network 4. Local Access Network	1. Exclusive: Public Transport 2. Priority: all modes 3. Priority: IT & PT 4. Priority: IT & AM 5. Priority: PT & AM 6. Priority: IT 7. Exclusive: IT 8. Priority: AM 9. Exclusive: AM 10. Non-priority
type of land-use of major prevalence	Residential and commercial areas	Coast route, linking the population density areas	Municipal connection	unoccupied areas; new urbanised areas.	to resolve conflicts between transport modes.
relationship with other functional hierarchy	Inverse relation to the individual transport network. Coincide with last level of IT hierarchy (local access network)	TP Network (metro) favouring the intermodality	Road hierarchy	Municipal and inter-municipal connection.	specific solutions will be defined in the later phase of planning however, in the existence of conflicts, the mode with the higher functional hierarchy will prevail.
compatible transport modes	Pedestrian; Active Modes.	compatible with all categories, except in roadways	Public Transport: Bus, Metro.	all mode, however in residential neighbourhoods the prevalence will be for pedestrian	
design/technical features	Shared streets, traffic calming, crossing in any street point.	Segregated cycling infrastructure or shared spaces with signalling, reinforcing visual signals.	Dedicated corridor for bus; Restricted channel for metro.	traffic calming in residential neighbourhoods;	Dimensioning of carriageway elements according to the minimum stipulated by IMT

In summary, the functional hierarchy assumes all network and is related to connection function through demand interpretation and the environment along with the infrastructure. The transport modes used to commuting correspond to different distances and places. Thus, there are preferential transport modes that harmonise to different routes and areas, as well as other modes.

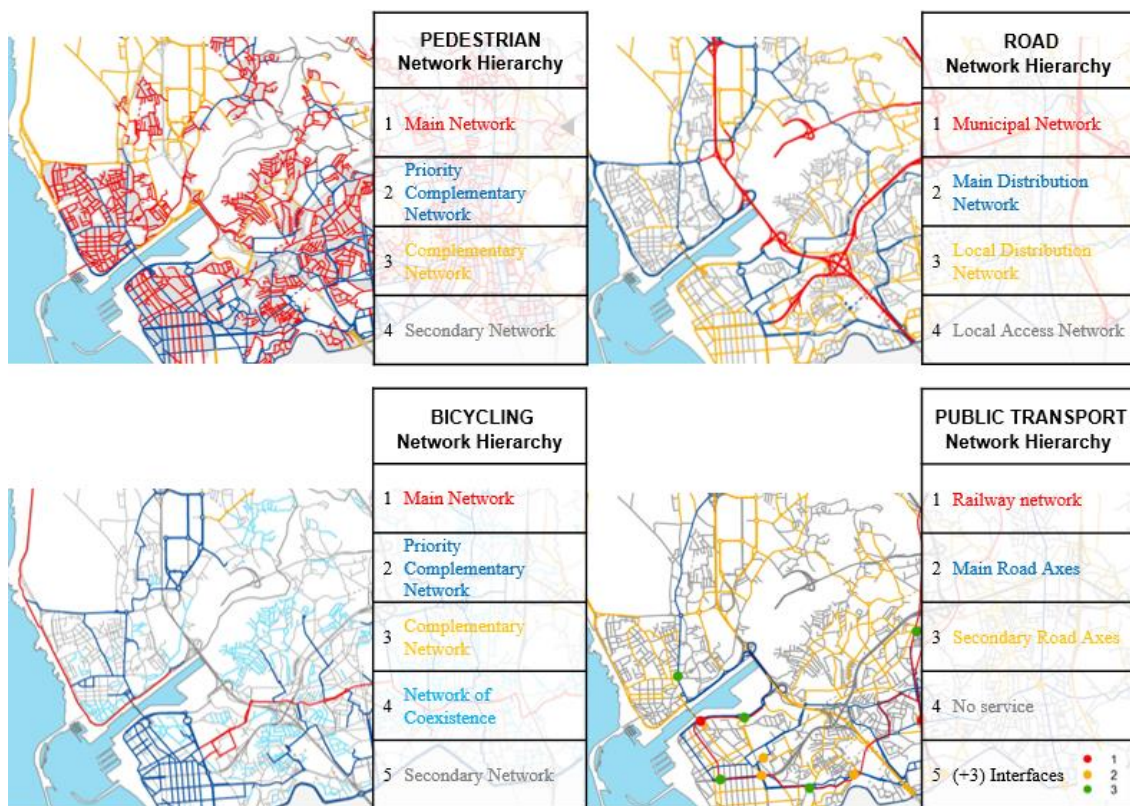


Figure 27: Matosinhos Network Hierarchies (Pinho et al., 2017).

The Pedestrian Network has four hierarchy classes mainly associated with residential areas (grey hatch along the routes), which maintain the principal walking function. The Main Network coincides to the Individual Transportation Local Access Network; they are settled inversely, giving a proper environment for pedestrian circulation through shared space and traffic calming measures. Also, another instruction introduced was this network must provide safe pedestrian crossing in any point of streets from the Main Network.

According to the Master Plan, the Bicycle Network hierarchy is settled where there is more population density by a transversal route and in the coastal route where there is a larger demand for cycling. Allied to this, there is a close relationship with Public Transportation Network and Interfaces. The Plan settled interfaces coinciding to bicycle routes and public transport, encouraging intermodality in commutes.

The Coexistence Routes from Bicycling Network matches also to Pedestrian Main Network in which can be applied the shared space principles. In another hand, the Public Transportation hierarchy does not coincide to Pedestrian Main Network, respecting the quality and safety of both modes. Other pedestrian classes, then, can correspond to the Main and Secondary PT Network.

Finally, the overlapping of hierarchies (**Figure 28**), introduces a comprehensive approach that modes can be simultaneous, but there are situations that one overlap other. Also, this hierarchy shows that two modes can coexist at the same space with equal importance; actually, they are complementary or competitor depending on the situation and level of the hierarchy. The Plan establishes in case of conflict between modes, prevalence the mode with higher hierarchy; the pedestrian and road hierarchies attested this principle when the levels of their classes were inversely established. Besides, the infrastructure adjustment must follow the official standard measurement regarding the design parameters and dimensions. In the case of modes coexistence, the minimum dimensions of streets' elements can be changed according to new Master Plan provisions.

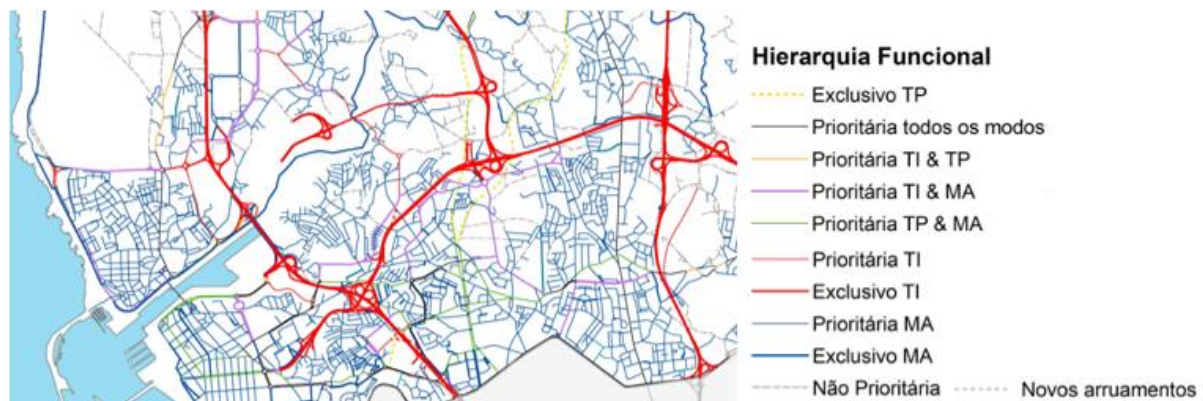


Figure 28: Matosinhos Combined hierarchies (Pinho et al., 2017).

4.3. CRITICAL ANALYSIS AND REFLECTIONS

As being inspired by conventional functional hierarchy, the proposed 'Functional Hierarchy' considers all transport modes used by Matosinhos' citizens and classifies the streets by levels of transport priority. However, unlike the conventional approach, it does not classifies by infrastructure capacity of accommodating the automobile volume, but by the importance of different transports in streets, as well as in the entire network. The functional hierarchy from this Plan includes other ways to commute than private cars. Regarding other transport modes, the road infrastructure must consider these other demands, as well as provide them with proper functioning. This includes sizing, technical characteristics, interchange facilities, pavement, signalling, and other interventions.

Examining under the parameters from Groups of Master Plans, the Master Plans of Matosinhos can be classified in Group D, which considers complementary classification for other modes besides cars; however, the hierarchy is treated as Road Hierarchy in studied Master Plans. In Matosinhos case, the hierarchies are all principal and oriented for all modes; they all are treated with the same importance and detail, being parts of the entire network, differently from Plans from Group D that include the other modes in the main road hierarchy.

Still, this alternative approach establishes separated hierarchies for different transport modes. Each one has its classes and respective graphic pieces containing the classification of all network, whose conventional approach does not demonstrate as verified in other studied Master Plans. Their graphic pieces do not exhibit all road network, least of all the local access streets, that appear without importance although goals of Master Plans involving pedestrian and improvements for all citizens in their general guidelines. Differently, Matosinhos Master Plan includes all streets of the municipality and all transport modes, defining a priority between them in the streets. Therefore, the functional hierarchy here regards to all movement functions of street space, such as walking, cycling, taking public transportation, or driving a private car. The functions are directed to commute modes.

Regarding the hierarchy system, the separated classification allows planners to define more assertive strategies and improvements for each street or route. Related to Link and Place classification method, the final layout of streets emerge from overlapping the different modes. In Matosinhos case, the 'Link' function defined the role for reclassification of streets, establishing it by transport modes and then, resulting in overlapping classes both description and graphic piece. The 'Place' function was not considered for this classification; indeed the land use and principal activities were considered to identify the main users' demands, however, the classification regards only to transportation type.

With reference to Complete Streets, Matosinhos Plan, considers pedestrian and active modes with attention. Both goals and strategies are directed towards these modes, and the Pedestrian and Active Modes hierarchy are included in the entire network. Complete Streets regards to all modes; however, the active modes are the peculiarity inclusion because it was disregarded by the traditional planning until then. Reminding the conventional approach, it considers only cars and at most to public transportation as well. Even the global guidelines from studied Master Plans that established sustainability, improvement of mobility and accessibility; they did not, in practice, promote instructions of how it should be put in practice nor it determined with accuracy the intervention areas, transfer the responsibilities to other regulation or law revisions, giving less importance to the active modes.

Matosinhos Plan, considering pedestrian and active modes with attention and simultaneous with other motorised transports, creates competition and gives importance to all modes in the same intensity. Each one has its priority in some part in the mobility network. In particular, the Plan establishes yet some measures to enforce the quality of pedestrian routes, such as crossing in any point of streets in case of Pedestrian streets with higher hierarchy. In addition, regarding the Bicycle Network hierarchy, the Plan introduces the shared space concept in a hierarchy level, also determining based guidelines to future interventions. Thus, the essential guidelines are already established at this legislation level, not transferring the subject to be discussed in the future in detailed plans. The importance of each transportation mode in the streets is already assured by having fixed the rules in this Plan, as well as assertive interventions.

It is also conscious of the conflicts between different transport modes. Although pedestrians are preferential users according to the alternative approaches, there are some conflict situations where pedestrians should not have priority because either the environment, adjacent functions and activities do

not favour this mode. The combined hierarchy, which includes priority modes in the same street, anticipates and deals with the conflicts that may appear when operationalising the hierarchy system.

Still, regarding pedestrian streets, or restricted streets, it is essential to caution in existing infrastructure and future interventions. Some transport modes are compatible with pedestrian areas, but it is important to notice the exceptions, such as Portland's Transportation Plan that defined the Emergency Response classification. It is necessary to provide access to services' motor vehicles, which occasionally should access these restricted areas, like fire trucks, emergency cars, infrastructure maintenance cars, etc. Thus, overlapping the hierarchies also allows careful planning that examines all coincidences into streets, as well as current and future infrastructure. The Matosinhos Plan did not regard this hierarchy type; however, by overlapping the hierarchies, it also ensures perceiving the possibilities, coexistences and exceptions in all streets.

In contrast to other alternative approaches, Matosinhos Plan defines the network classes as 'Main Network', 'Distributor', 'Complementary' and 'Local', being inspired by conventional methods of classification; while the alternative approaches defined the street types according to the context (residential, neighbourhood or commercial streets, boulevards, corridor). The context in Matosinhos Plan does not have the same importance than in other approaches. The local context is seen in all new methods studied, however, it will need a further refined study to be applied in Matosinhos.

Finally, as Marshall (2014) exposed, it does not matter the nomenclatures or hierarchies; he presented that is essential the diagnosis of the real necessity of streets users, regarding also the surroundings, land use and activities, and connections and movement within cities. Then, the method of classification, being directed for link status or place status, must be developed in accordance with each city or each particularity of the regions. Indeed, each reality is different from another; the urban systems and demands are different respecting local characteristics, and therefore one must choose or develop a method that fits better to each reality.

5

CONCLUSION

According to the goals proposed, this investigation contributes to an overview of road hierarchy theories and practices through documental research.

The study involved a conceptual framework in urbanism and traffic engineering disciplines, defining the conventional e alternative approaches in road hierarchy. Also, the practices in Master Plans of Portugal and Brazil and the analysis of the new concept applied in Matosinhos elucidate how the municipalities are implementing the road hierarchy.

Therefore, this investigation provides:

- an overview of the good practices in alternative approaches,
- the evaluation of the road hierarchy in the Portuguese and Brazilian contexts compared to the good practices, and
- exploration of the new approach recently developed in Matosinhos Master Plan, to perceive the contributions and limitations compared with good practices.

5.1. MOTIVATIONS FOUND IN ALTERNATIVE APPROACHES

The revision of the conceptual background of road hierarchy in traffic engineering and urbanism scenarios provided an overview of how road hierarchy has been evolving in past years. Indeed, there is a gap between these two disciplines. While urbanists attempted to solve space issues, leaving the road planning to engineers, traffic engineering concepts became more usual and used as a pattern to be replicated in any road system. Land use planning and road planning did not evolve together; and as parts of the urban environment, road systems did not follow the changing in cities behaviour. The growth of population size and buildings, new outside activities, changed citizens commute behaviour, and new transport modes emerged. Therefore, alternative approaches, as Complete Streets, Link and Place, and Shared Space, involving urban policy and street design, were introduced to mitigate problems resulting from car-oriented road planning.

- Multimodal Transportation and Rebalancing of Street Space

The consciousness of multimodal transportation was presented in Traffic in Towns report (MoT, 1963), however, policymakers at the time, supported the segregation of traffic and other transports (Marshall, 2004; Karndacharuk, Wilson and Dunn, 2014), leaving cyclists and pedestrians behind road planning (Forbes, 1999).

Besides multimodal transportation and the street space issue, there was detected another limitation on conventional road hierarchy. ARTISTS Project identified some road types did not fit into the traditional

road classification (Arterial, Collector and Local road systems). Arterial streets were identified as a unique street type that did not correspond to the traditional road functions (movement and access); indeed this street type performs these two functions but not only, they are usually located into mixed-use areas attracting a mixture of different road users categories (Marshall, Jones and Plowright, 2004). Four functions occurring in the arterial streets are related: (i) connection or traffic channel between different city regions; (ii) access to adjacent lands which contains many commercial and service activities; (iii) they represent a significant public space because their visual, cultural importance, and social interaction; and (iv) they represent the garden for many residents (Svensson and Hydén, 2004). Knowing that, Marshall (2004) exposed that streets could be equally multi-functional “prioritising the different potential roles of each street space relative to the whole system”, and as multi-functional places requires design solutions and different approaches than conventional road design as well its hierarchy. The idea of no hierarchy in road system opens a precedent for new approaches on the classification system, where the street importance regards to not only one function or transport type, but also the coexistence of different transports regarding also the local context – this is the land use in adjacent lands, users and modal priority.

- Streets Classification and Users Hierarchy

Complete Streets and Link and Place are different practices but have in common the reclassification of streets and the recognition of diverse transportation occupying the same street. Complete Streets is related to institutional change, promotes a revision in municipal regulations to readjust the streets to each context in the long term. It emphasises the pedestrian and the 'place' status, as well as provides detailed design approach between different transport modes, similarly to Link and Place that reclassify streets in a two-dimensional approach: link and place status, considering the land use and the connection function of the route in the entire network. Manuals that adopted these methods used to classified the streets by nomenclatures according to the context, not by a hierarchy of movements (e.g. residential, commercial, or neighbourhood streets, bikeways or walkways), and the hierarchy indeed was stipulated for the users of each street or route.

Pedestrian was considered in the higher priority when establishing a hierarchy in Street Design Manuals by the alternative concepts. The equality between traffic groups, according to Gehl (2010), integrates different types of transports and is not satisfactory until pedestrians are the priority. Thus, the hierarchy changes from road functions to types of users. The default users hierarchy found in Streets Design Manuals is (1) Pedestrians, (2) Bicyclists, (3) Public transport users, (4) Service vehicles, and (5) Other motor vehicles.

5.2. CONCLUSIONS OF PRACTICES IN MASTER PLANS

The national regulations in either Portugal or Brazil did not advance in the entire road hierarchy process; they are following the conventional method. As seen in Group A (half of studied Master Plans) the municipalities are using the conventional road hierarchy; and in other cases, municipalities include alternative approaches, in parts, in the main road hierarchy. Groups B, C, and D included different modes in the road hierarchy, such as public transportation and soft modes. Thus, the Master Plans still applies the conventional road classification, nomenclatures and functions according to national regulations; however, the inclusion of other transport modes in some Master Plans opens a discussion of which transport have priority in each context of the entire network, which leads to the Matosinhos approach.

As an alternative approach, the review of Matosinhos Master Plan exhibited a different form to classifying streets establishing hierarchy of network according to transport modes. Pedestrian, Bicycling, Public Transport, Individual Transport, and Combined Modes hierarchies were defined separately, inspired by the conventional and innovative approaches in the international scenario.

Differently from Master Plans studied, Matosinhos Plan promotes a new classification of streets, being the first of its kind in Portugal.

The limitations of Plans and new approaches of Matosinhos Plan found in the review are described in the following.

- Policies and Road Hierarchy

In terms of national regulation, alternative approaches are less evident than conventional approaches in Master Plans. Most cities use the conventional road hierarchy, developed for a connection purpose, for their urban streets organisation. When the municipalities develop other classification, it still follows the traditional method from international practices. It is necessary a systematisation in urban streets hierarchy. Although national laws define the road hierarchy in macro scale and transfer the responsibility of local scale to the municipal level, there is no mention or guide for cities develop their road hierarchy according to their intrinsic character and demands. The guidance appears in complementary manuals promoted by official agencies; however, national urban laws are not reviewed to adjust the alternative approaches in their regiments.

Complete Streets policies are an example of governance of regulations, where there is assistance at the national level, and there is a difficulty in approving exceptions at the municipal level, obligating to municipalities to adjust their regulations to alternative approaches.

- Graphic Representation

The graphic representation is a powerful tool for the understanding of the road network classification. According to the analysis of Master Plans, there was found a discrepancy between text guidelines and maps contents. The Master Plans do not represent all road classes of hierarchy in their maps. The higher hierarchy roads used to be represented in almost all Plans; this shows the importance that the regulation gives to major routes with connection character than local streets within the municipality. Also, the Plans do not represent the other transportation modes in the network. Public transportation used to be represented; however, the routes for soft modes, which are an alternative for short-distance commute, were not represented in graphic pieces. In contrast, the new Matosinhos Plan provided maps with all network represented, including the local streets that do not appear in the Studied Master Plans.

- Mobility Network

The Master Plan of Matosinhos introduces the ‘Mobility Network’ terminology instead of the traditional Road Network. This demonstrates the concern about mobility and diverse transport modes. The terminology denotes that the network is not oriented only to roads as car accommodation; instead, the roads are used to accommodate a variety of transports users.

- Hierarchy of Users

The pedestrian subject appears with frequency in the studied Plans. Master Plans identify in the guidelines the concern about pedestrians as the most vulnerable users of streets; however, the concern was not substantial about their priority in the road hierarchy in Master Plans. In most cases, it only appeared in descriptions of Local streets.

Instead of establishing a road hierarchy, the Design Manuals appoint hierarchy for streets users; therefore they are classified in top of the hierarchy; however, each authority must analyse the context the street is settled and establish the appropriate hierarchy approach. Matosinhos Plan follows this approach when developing a hierarchy for the pedestrian. In case of a conflict between other transports, there were presented the Combined Hierarchy.

- Combined Hierarchy

As seen in Master Plans the hierarchy is oriented especially to the circulation of private motor vehicles; the road classes are categorised according to conventional methods. Following this, when public transportation and soft modes are included in the main road hierarchy it is expected that they would have the same importance; however, in most cases, they were included just in classes description without relevance in the hierarchy.

The multimodal transportation issues, other functions that streets have and the settlement of diverse activities in streets and adjacent mixed-use lands, are components to be considered in road planning. The alternative approaches shifted from the car-oriented to 'people-oriented' (Liu, Yan and Wang, 2017), considering the variety of functions and the types of road users.

The Matosinhos Master Plan, considering this idea, introduced the hierarchies for each transport mode, developing a final layout combining all networks overlapping the hierarchies, such as seen in the alternative approach in Portland. There are cases the transport modes will have inverse relation (e.g. Pedestrian Network vs Individual Network). The higher class in Pedestrian Network coincides in many cases to the last level of Individual Transportation Network. This occurs because pedestrian circulation does not match to cars movement; therefore, when the pedestrian has priority, private transportation will have less relevance. The theory fits for default users hierarchies defined in alternative approaches; however, there are conflicts to be solved at the operational level. The combined hierarchy was developed to avoid conflicts and facilitate decision-making when establishing a priority in the paths.

5.3. FUTURE RESEARCH

The road hierarchy aspects have a multidisciplinary approach that comprehends various scopes among urban policies, design, traffic and infrastructure engineering and urban planning. Also, they contain many elements such as the streets, people, transportation, urban equipment and buildings. Therefore, for a comprehensive understanding, it must be evaluated all aspects that involve road hierarchy theme.

- Evaluate the design of multi-functional streets;
- Evaluate the post-occupation and the real functionality in streets of the municipalities that already transformed their road system;
- Study of good practices of alternative approaches in other cities with different characteristics.

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APPENDIX I

1. Alternative Approaches Summary Table

	SHARED STREETS	COMPLETE STREETS	LINK AND PLACE
key issues	Residential streets - streets as public space - other street functions - pedestrian	Multimodal transportation - comprehensive planning - pedestrian and multimodal transp.	Arterial streets - mixed use land - adjacent activities - multimodal transp.
Principles	Design tool. Design variations depending on local characteristics. Minimise the influence of motor vehicles and encouraging people using a road space as a “place” instead of a transport access and mobility conventional uses.	Policy. Global streets policy with long-term results. Streets for everyone. To ensure and provide safe access for all users.	EU Project developed for alternative street planning through a new road classification approach, analysing related functions for each street section.
Design tools	Traffic calming; streets layout that do not segregate the transport modes (pedestrian, cyclists, motor vehicles).	Each local policy must develop regarding the	analysing related functions for each street section.
Which conventional road type does it apply?	Residential neighbourhoods streets; Local distributor or Access streets. (Short streets; with relatively low traffic volumes.)	All streets.	Developed for arterial streets; but can be applied in all streets.
Does it have an influence on road hierarchy?		Yes.	Yes.
What is the road classification approach?	Could be another road class in the conventional road hierarchy, since there was added another function for these street type, the place use.	Classification based movement function and context of each streets. The hierarchy is classified for users, not street types.	Classification do not starts from movement and access conventional functions. Matrix of link and place status. Analysis of street sections, according the "Link" and "Place" functions.
Priority/ Hierarchy?	Pedestrian safety; Transport modes coexistence.	All modes coexistence; Safety for all street users.	Multimodal transportation.
References	(Polus and Craus, 1988; Karndacharuk, Wilson and Dunn, 2014)	Smart Growth America	MfS, ARTISTS, Marshall

APPENDIX I

2. Streets Classification by Complete Streets Policies

TRANSPORTATION SYSTEM PLAN - Portland 2035		
1. Pedestrian	1.1. Pedestrian Districts;	1.4. Off-Street Paths;
	1.2. Pedestrian-Transit Streets;	1.5. Local Service Walkways.
	1.3. City Walkways;	
2. Bicycle	2.1. Major City Bikeways;	2.3. Local Service Bikeways;
	2.2. City Bikeways;	2.4. Bicycle Districts.
3. Transit	3.1. Regional Transitways;	3.4. Local Service Transit Streets;
	3.2. Major Transit Priority Streets;	3.5. Intercity Passenger Rail;
	3.3. Transit Access Streets;	3.6. Passenger Intermodal Facilities.
4. Freight	4.1. Freight Districts;	4.6. Local Service Truck Streets;
	4.2. Regional Truckways;	4.7. Railroad Main Lines;
	4.3. Priority Truck Streets;	4.8. Railroad Branch Lines;
	4.4. Major Truck Streets;	4.9. Freight Facilities.
	4.5. Truck Access Streets;	
5. Design	5.1. Civic Main Streets;	5.7. Urban Throughways;
	5.2. Neighborhood Main Streets;	5.8. Industrial Roads;
	5.3. Civic Corridors;	5.9. Enhanced Greenway Corridors;
	5.4. Neighborhood Corridors;	5.10. Greenscape Streets;
	5.5. Regional Corridors;	5.11. Local Streets.
	5.6. Community Corridors;	
6. Emergency Response	6.1. Major Emergency Response Streets;	
	6.2. Secondary Emergency Response Streets;	
	6.3. Minor Emergency Response Streets.	
7. Traffic	7.1. Regional Trafficways;	7.4. District Collectors;
	7.2. Major City Traffic Streets;	7.5. Neighborhood Collectors;
	7.3. Traffic Access Streets;	7.6. Local Service Traffic Streets.
TORONTO COMPLETE STREETS GUIDE		
1. Civic Street		8. Scenic Street
2. Downtown & Centres	2.1. Main Street;	9. Park Street
	2.2. Residential Street.	10. Employment Street
3. Avenue & Neighbourhood	3.1. Main Street	11. Mixed Use Access Street
4. Apartment Neighbourhood	4.1. Residential Street	12. Shared Street
5. Neighbourhood	5.1. Residential Street	13. Residential Shared Street
6. Mixed Use Connector Street		14. Mixed Use Lane
7. Residential Connector Street		15. Residential Lane
COMPLETE STREETS CHICAGO		
1. Neighborhood Street		4. Main Street
2. Service Way		5. Connector
3. Pedestrian Way		6. Thoroughfare

APPENDIX I

3. Streets Classification by Link and Place Policies

MANUAL FOR STREETS 2	
Contexts	Common Street Types
1. Town and City Centres	1.1. Multifunctional Streets and Spaces
	2.1. Arterial Routes and High Streets
2. Urban and Suburban Areas	2.2. Relief Road/Ring Road
	2.3. Boulevards
3. Urban Extensions	3.1. High Streets, Residential Streets
4. Interchanges	
5. Village Centres	5.1. Village Streets
6. Rural Areas	6.1. Rural Roads and Lanes
7. Urban and rural settlements	7.1. Shared Space

The city of Adelaide SMART MOVE Transport and Movement Strategy 2012-22		
Status label: Coverage area	Link hierarchy level	Place hierarchy level
1. Metropolitan	I. Carries traffic of metropolitan-wide origin.	A. Very high metropolitan significance (due to cultural or tourist value).
2. Regional	II. Carries traffic of regional-wide origin.	B. High, with large numbers of on-street staying users within a large precinct.
3. District	III. Carries traffic of district-wide origin.	C. Moderate, staying activities and concentration of public transport stops.
4. Neighbourhood	IV. Carries traffic of neighbourhood-wide origin.	D. Low, with few attractors, shops or businesses, low levels of activity.
5. Local	V. Carries local traffic from immediate streets.	E. Used by local residents and workers only.

APPENDIX II

Street Design Manuals Summary Table

	general	conventional hierarchy	alternative approach for street classification			
	Streets Design Principles	Does it consider the conventional road hierarchy based on 'movement and access' functions?	Street Classification System	Which road functions/ variables are considered?	There is any priority or hierarchy guiding the streets classification?	Number of Street Classes
Design Manual for Urban Roads and Streets (DMURS) (Lahart et al., 2013), Ireland.	Balance between streets place and movement functions, focused on pedestrian. (Link and Place)	In parts.	It is established the importance (higher; lower) for each street type vs their function.	Movement; Place Context.	1. Pedestrian; 2. Cyclists; 3. Public Transport; 4. Private Motor vehicles.	7
Urban Street Design Guide (NACTO, 2013), USA.	Streets are public spaces for people as well as arteries for traffic and transportation. A street design must meet the needs of people walking, driving, cycling, and taking transit, all in a constrained space. (Complete Streets)	No. The guide indicates that cities may choose to alternative street's classification, respecting the local variables.	Context is a crucial parameter in designing streets. Street design should both respond to and influence the desired character of the public realm.	Street type and usage; Urban design context and built environment; Overlays, including modal priorities, special uses, and historic character.	Prioritises walking, bicycling, and transit.	13
Global Street Design Guide (NACTO and GDCI, 2016), USA.	Balance the needs of different transportation modes within the given context and culture. (Complete Streets)	No. The guide shifts from a system of functional classification to a context-based approach to street designs.	It is established streets typologies; based on local context, the needs of multiple users.	Users needs; Place demands.	Yes. Users priority. 1. Pedestrians; 2. Cyclists and transit riders; 3. People doing business and providing city services; 4. People in personal motor vehicles.	21
O Desenho da Rua - Manual do Espaço Urbano (Lisboa, 2018)	Adoption of design principles for an integrated street, to improve living conditions, promoting the appropriation of streets as spaces. It includes the principles of space sharing between the various modes of transport.	In parts.	Maintains the conventional functional classification, but includes other streets spaces as of equal importance.	Pedestrian circulation spaces; Road traffic spaces; Cycling spaces; Shared spaces; Parking spaces.	Compatibility of the simultaneous presence of pedestrians and other vehicles in different situations.	5 levels of conventional hierarchy
Streetscape Guidance (Mayor of London, 2019)	Balancing the diverse needs of these users will ensure better and safer places to support the variety of activity on our streets.	No.	Place and Movement functions (Link and place)	Accommodating movement; Understanding competing demands; Recognising place; Function, performance and form.	Users priority according each context.	18 (Street Type Policy)

APPENDIX III

1. Road hierarchy and relevant topics in the Master Plans

	Country	City	Master Plan	Concern for Urban Mobility	Municipal Road Hierarchy	Number of Road Classes	Transportation priority according to road classes description	Promotion of Alternative Transport Modes	Other classification	Groups of Analysis
1	Portugal	ALMADA	Resolução nº 5/97	✗	✓	3	Motor vehicles.	✗	National Road Hierarchy (PRN); Motor vehicles.	A 
2	Portugal	AMADORA	Resolução nº 44/94	✗	✓	3	Motor vehicles.	✗	National Road Hierarchy (PRN).	A 
4	Portugal	MAIA	Aviso nº 9751/2013	✗	✓	3	Motor vehicles; Public transport.	Bicycle.	National Road Hierarchy (PRN).	A 
5	Portugal	ESPINHO	Aviso nº 10906/2016	✗	✓	4	Motor vehicles.	✗	National Road Hierarchy (PRN).	A 
7	Portugal	VILA NOVA DE GAIA	Aviso nº 9505/2018	✓	✓	4	Motor vehicles; Public transport.	Bicycle; Pedestrian.	National road hierarchy; Passenger interfaces.	A 
10	Brazil	NITERÓI	L nº 1157/1992; L nº 1470/1995	✓	✓	4	Motor vehicles.	✗	✗	A 
14	Brazil	SANTO ANDRÉ	L nº 8696/2004; L nº 9394/2012	✓	✓	6	Motor vehicles.	Public Transport; Bicycle.	✗	A 
15	Brazil	CAMPINAS	LC nº 189/2018	✓	✓	9	Motor vehicles; Public transport; Bicycle.	Bicycle	✗	A 
3	Portugal	CAS CAIS	Aviso nº 7212-B/2015	✓	✓	5 + 3 PT classes	Motor vehicles; Public transport.	Soft transport modes.	National Road Hierarchy; Public Transport.	B 
9	Brazil	CURITIBA	L nº 14771/2015; L nº 9800/2000	✓	✓	5 + 6 PT classes	Public Transport; Motor vehicles.	Bicycle; Pedestrian.	Public Transport.	B 
11	Brazil	RIO DE JANEIRO	LC nº 111/2011; PLC nº 33/2013	✓	✓	6 + 3 PT classes	Motor vehicles; Public transport (Bus, BRT, BRS, LVT).	Bicycle.	Public Transport (BRS).	B 
6	Portugal	PORTO	Aviso nº 14332/2012	✓	✓	6	Motor vehicles; Public Transport (Bus); Pedestrian; Bicycle.	Soft transport modes.	National road hierarchy; Passenger interfaces.	C 
8	Brazil	BELO HORIZONTE	L nº 7165/96; L nº 7166/96	✓	✓	7	Motor vehicle; Pedestrian; Bicycle.	Bicycle; Public Transport.	Categories for purposes of land use classification: residential, non-residential, mixed streets.	C 
12	Brazil	NOVA IGUAÇU	L nº 4092/2011	✓	✓	5 + 4 PT classes 1 SM class	Motor vehicles; Public Transport; Bicycle.	Public Transport; Bicycle.	Public Transport; Bicycle; National Road Hierarchy (CTB).	D 
13	Portugal	LISBOA	Aviso nº 11622/2012	✓	✓	5 + 5 SM classes 3 PT classes	Motor vehicle; Public Transport; Pedestrian; Bicycle.	Soft transport modes.	Public Transports; Transport Interfaces; Soft Mobility; Restrict Zones.	D 
16	Brazil	SÃO PAULO	L nº 16.050/2014; PlanMob/SP 2015.	✓	✓	7 + 4 SM classes 6 PT classes	Motor vehicle; Public Transport; Pedestrian; Bicycle.	Bicycle; Public Transport.	Public Transport (Bus); Bicycle; Pedestrian.	D 
SM: Soft Modes PT: Public Transport										

Road Hierarchy Classes in Master Plans and National Regulations

GROUP A						GROUP B						GROUP C						GROUP D
ALMADA	AMADORA	MAIA	ESPINHO DE GAIA	NITEROI	SANTO ANDRÉ	CAMPINAS	CASCAIS	RIO DE JANEIRO	OURTIBA	PORTO	BELo HORIZONTE	NOVA IGUAÇU	LISBOA	SÃO PAULO				
Regional Roads	Main Roads	Main Distributor Roads	Regional Road System	Main Arterial Roads	Metropolitan Roads	Rapid Transit Routes	Supra-municipal Routes - Level 1	Structural Expressways and Main Roads - Non-Express	Structural Connecting Routes	Structural Inter-municipal Routes	Regional Route	Rapid Transit Routes	Structuring Network (Level I)	Structuring Roads (Level 1)				
	Secondary Roads	Secondary Distributor Roads	Main Distributor Roads	Secondary Arterial Roads	Primary Arterial Roads	Arterial I	Structuring and Main Distribution	Structural Connecting Routes	Metropolitan Connecting Routes	Interconnectio n Routes	Arterial Roads	Arterial Roads	Distributors Routes (Level 2)	Structuring Roads (Level 2)				
Primary Roads (urban roads)	Local Streets	Local Arterial Streets	Secondary Distributor Roads	Collector Roads	Secondary Arterial Roads	Arterial II	Secondary Distribution	Main Arterial Roads	Structural Metropolitan Routes	Complementa ry Urban Routes or Complementa	Collector Roads	Collector Roads	Secondary Distributor Routes (Level 3)	Structuring Roads (Level 3)				
-	-	-	Local Access Streets	Local Streets	Primary Collector Roads	Collector I	Local Distribution Routes - Level 5	Secondary Arterial Roads	Major Roads	Local Streets	Local Streets	Local Streets	Local Distributor Routes (Level 5)	Collector Roads				
-	-	-	-	-	Secondary Collector Roads	Collector II	PT Network Level 1	Collector Roads	Collector Roads	Local Streets	Mixed Streets	Bicycle Paths	Routes (Level 5)	Local Streets				
-	-	-	-	-	Local Street	Local Street	PT Network Level 2	Local Streets	Public Transp. Structural	Shared Streets	Pedestrian Streets	PT Radial Lines	Bicy de Lane Common Route	Bicycle Paths				
-	-	-	-	-	-	Frontage Road	PT Network Level 3	PT Main Bus Rapid System (BRS)	PT Structural Metropolitan Routes	-	Bicycle Paths	Diametrical Lines	Bicy de Lane	Pedestrian Street				
-	-	-	-	-	-	Rapid Transit and Arterial I	-	Bus Rapid System(BRS)	PT Connecting Routes	-	-	PT Perimeter Lines	Bicy de Path (Ciclovía)	Bicy de Path (Ciclovía)				
-	-	-	-	-	-	Frontage Road Infrastructure Paths	-	PT Collector Bus Rapid System(BRS)	PT Trunk Routes	-	-	PT Feeding Lines	30km/h Zones	Bicy de Lane (Ciclofaixa)				
-	-	-	-	-	-	-	-	-	PT Inter-neighborhood Routes	-	-	-	Mixed Zones	Bicy de Route (Ciclorrotas)				
-	-	-	-	-	-	-	-	-	PT Complementa ry Routes	-	-	-	PT Level 1	Shared Sidewalks (Common Shared)				
-	-	-	-	-	-	-	-	-	-	-	-	-	PT Level 2	Sidewalks (exclusive)				
-	-	-	-	-	-	-	-	-	-	-	-	-	PT Level 3	PT Exclusive Bus-Corridor - Class I				
-	-	-	-	-	-	-	-	-	-	-	-	-	-	PT Exclusive Bus-Corridor - Class II				
-	-	-	-	-	-	-	-	-	-	-	-	-	-	PT Exclusive Bus-Corridor - Class III				
-	-	-	-	-	-	-	-	-	-	-	-	-	-	PT Exclusive Bus-Corridor - Class IV				
-	-	-	-	-	-	-	-	-	-	-	-	-	-	PT Exclusive Bus-Corridor - Class V				
-	-	-	-	-	-	-	-	-	-	-	-	-	-	PT Exclusive Bus-Corridor - Class VI				

Road hierarchy	xxx
Soft modes included at main road hierarchy	xxx
Soft modes hierarchy	xxx
Public transports hierarchy	xxx

PORTUGUESE NATIONAL ROAD CLASSES (PRN2000)		FUNCTIONAL HIERARCHY FOR URBAN ROADS			BRAZILIAN NATIONAL ROAD CLASSES (CBT)	National Roads Nomenclatures	
Fundamental Network	Main Routes	Collector Roads			Rapid Transit Roads	Arterial Roads	
	Complementary Routes						
Complementary Network	National Roads	Main Distributor Roads			Local Streets	Collector Roads	
	Regional Roads						
	Municipal Roads (Rural)	Local Distributor Roads					Highways (Rural)
	Municipal Roads (Urban)	Local Access Roads					

APPENDIX V

Road Hierarchy description in Master Plans

GROUP A

ALMADA - AMADORA - MAIA - ESPINHO - VILA NOVA DE GAIA - NITERÓI - SANTO ANDRÉ - CAMPINAS

ALMADA Lisboa Portugal		MUNICIPAL ROAD HIERARCHY Master Plan (Resolução nº 44/94)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Regional Roads	-	-	Non aedificandi paths width.
2 Municipal Roads	-	-	
3 Primary Roads (urban roads)	-	-	

AMADORA Lisboa Portugal		MUNICIPAL ROAD HIERARCHY Master Plan (Resolução nº 44/94)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Main Roads	Transport/ mobility functions ensuring the connections within the Municipality, and the top-level networks - national/ regional.	Motor vehicles.	Lanes and sidewalks width, parking and building restriction.
2 Secondary Roads	Transport and local accessibility functions; ensure distribution and collection of urban traffic to and from the main network.		
3 Local Streets	Local access function to the activities. Streets that can be shared indistinctly by vehicles and pedestrians in interior of urban areas.	Motor vehicles; Pedestrian.	

MAIA Porto Portugal		MUNICIPAL ROAD HIERARCHY Master Plan (Aviso nº 9751/2013)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Distributor Main Roads	connection between main urban centers, national roads and secondary roads.	Motor vehicles; Public Transports.	Width, quantity of lanes, parking, bus-corridor facilities, bus stop, pedestrian and bicycle routes facilities.
2 Distributor Secondary Roads	complementary to main roads. connection between main routes and local roads.	Motor vehicles; Public Transports.	Width, quantity of lanes, parking, bus-corridor facilities, bus stop, pedestrian and bicycle routes facilities.
3 Local Arterials Streets	access to buildings	Motor vehicles; Public Transports; Bicycle; Pedestrian.	Width, quantity of lanes, parking, bus-corridor facilities, bus stop, pedestrian and bicycle routes facilities.

GROUP A

ALMADA - AMADORA - MAIA - ESPINHO - VILA NOVA DE GAIA - NITERÓI - SANTO ANDRÉ - CAMPINAS

ESPINHO Aveiro Portugal		MUNICIPAL ROAD HIERARCHY Master Plan (Aviso nº 10906/2016)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Regional Road System	Regional character; they supply the Main Distributors roads directly. This system include the roadways from national road system.	Motor vehicles.	Number of lanes, widths; parking; Public transportation stops.
2 Main Distributors Roads	This system includes the roadways from the national road system which have structuring character. Establish a connection between the preview class.		Number of lanes, widths; parking; Public transportation stops, <i>non-aedificandi</i> spaces.
3 Secondary Distributors Roads	They are supported by the Main Distributor network; guarantee accessibility to urban centers and municipal areas.		
4 Local Access Streets	Correspond the streets that connect the Distributor Network to the buildings they serve.	Motor vehicles; Pedestrian.	Number of lanes, widths; parking; Public transportation stops.

VILA NOVA DE GAIA Porto Portugal		MUNICIPAL ROAD HIERARCHY Master Plan Aviso nº 9505/2018	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 High Capacity Routes	nacional character, connetion between metropolitan areas	Motor vehicles	Lanes width
2 Structuring City Routes	nacional character, connetion between metropolitan areas	Motor vehicles; Public Transport.	
3 Complementary City Routes	municipal character, access municipality regions, medium volume of traffic. can receive bicycles, and pedestrians.	Motor vehicles; Public Transport; Bicycle;	Lanes, sidewalks width
4 Local Streets	municipal character, access municipality regions, medium volume of traffic. Privilege bicycles and pedestrians.	Bicycle; Pedestrian.	

NITERÓI Rio de Janeiro Brazil		MUNICIPAL ROAD HIERARCHY Master Plan and Land Use Regulation (L nº 1157/1992; L nº 1470/1995)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Main Arterial Roads	-	-	-
2 Secondary Arterial Roads	-	-	-
3 Collector Roads	-	-	-
4 Local Streets	-	-	-

GROUP A

ALMADA - AMADORA - MAIA - ESPINHO - VILA NOVA DE GAIA - NITERÓI - SANTO ANDRÉ - CAMPINAS

SANTO ANDRÉSão Paulo
Brazil**MUNICIPAL ROAD HIERARCHY**
Master Plan and Land Use Regulation
(L n° 8696/04; L n° 9394/12)

Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Rapid Transit Routes	Interconnection between regions, highways, and arterial roads.	Motor vehicles	-
2 Arterial I	Redistributes the rapid transit routes traffic to their destinations, up to next hierarchy level.	-	-
3 Arterial II	Receives the Arterial I and Collector traffic. Interconnects the structuring system, with a lower level of mobility and capacity than the Arterial I.	-	-
4 Collector I	Collects traffic from Local roads and channels it to Arterial roads and vice versa.	Motor vehicles. Public and collective transportation.	-
5 Collector II	Collects traffic from Local roads and channels it to Arterial roads and vice versa.	Public and collective transportation.	-
6 Local Street	Direct access to lots and buildings.	-	-

CAMPINAS São Paulo Brazil		MUNICIPAL ROAD HIERARCHY Master Plan (LC nº 189/2018)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Rapid Transit Routes	Interconnection between regions, highways, and arterial roads.	Motor vehicles	Widths, transpositions and crossings.
2 Arterial I	Redistributes the rapid transit routes traffic to their destinations, up to next hierarchy level.	-	Widths, transpositions and crossings.
3 Arterial II	Receives the Arterial I and Collector traffic. Interconnects the structuring system, with a lower level of mobility and capacity than the Arterial I.	-	Widths, transpositions and crossings.
4 Collector I	Collects traffic from Local roads and channels it to Arterial roads and vice versa.	Motor vehicles. Public and collective transportation.	Widths, transpositions and crossings. Bicycle lanes required at some street types. (obrigatorio)
5 Collector II	Collects traffic from Local roads and channels it to Arterial roads and vice versa.	Motor vehicles. Public and collective transportation.	Widths, transpositions and crossings. Bicycle lanes required at some street types. (pode ter...)
6 Local Street	Direct access to lots and buildings.	-	Widths, transpositions and crossings.
7 Roadway Frontage Road	Collects and avoid the conflict between road traffic and local traffic.	-	Widths, transpositions and crossings.
8 Rapid Transit Road and Arterial I Frontage Road	Collects and avoid the conflict between traffic and access.	-	Widths, transpositions and crossings.
9 Infrastructure Paths	Routes along infrastructures that preserve the <i>non aedificandi</i> areas. Functions within the road system according to the context in which they are.	-	Widths, transpositions and crossings.

GROUP B
 CASCAIS - RIO DE JANEIRO - CURITIBA

CASCAIS Lisboa Portugal		MUNICIPAL ROAD HIERARCHY Master Plan (Aviso Nº 7212-B/2015)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Supra-municipal Routes - Level 1	Ensure the main accesses to the municipality, as well as the intra-municipal journeys of greater distance.	Motor vehicles.	-
2 Structuring and Main Distribution Routes - Level 2	Ensure distribution of the main municipal traffic flows, as well as the medium distance routes and access to level 1.		-
3 Secondary Distribution Routes - Level 3	Comprises the internal roads to the urban agglomerations, ensures the near distribution, as well as channels the traffic flow to the superior levels.		-
4 Local or Proximity Distribution Routes - Level 4	Comprise the structuring routes at the neighbourhood level, with a few flow capacity, and the pedestrian has greater importance.	Motor vehicle; Pedestrian.	-
5 Local Access Streets - Level 5	Guarantee the road access to the buildings, privileging the pedestrian circulation.		-

CASCAIS Lisboa Portugal		MUNICIPAL PT HIERARCHY Master Plan (Aviso Nº 7212-B/2015)	
1 PT Routes Level 1	Corresponds to the existing rail network (Cascais Line) at the south coast, and promotes the connection between Cascais, Oeiras and Lisbon.	Train.	-
2 PT Routes Level 2	Corresponds to the proposed Public Transport in an exclusive channel or lanes, which promotes the connection between Cascais and Carcavelos in the interior of the municipality.	PT in exclusive lane/ channel space.	- In an existing road or in a proposal, the PT space coincides with the road; - In exclusive PT route, the respective channel space is defined by a corridor with 15,00m for each side of the axis.
3 PT Routes Level 3	Comprises the existing PT network, which provides connections between the Municipalities of Cascais, Sintra, Oeiras and Amadora.	PT (Bus).	

GROUP B
 CASCAIS - RIO DE JANEIRO - CURITIBA

RIO DE JANEIRO Rio de Janeiro Brazil		MUNICIPAL ROAD HIERARCHY Master Plan and Land Use Regulation (LC n° 111/2011; PLC n° 33/2013)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Structuring Roads - Expressways	High capacity to attend the long distance displacements with a high volume of vehicles. They do not have connection with adjacent lands.	Motor vehicles.	-
2 Structuring Roads - Non-Express	High capacity to attend the long distance displacements with a high volume of vehicles. They have connection with adjacent lands and have traffic lights.		-
3 Main Arterial Roads	Connections between the centres, municipal and inter-municipal, and the routes of superior hierarchy. Medium access control, to minimise the effects conflicts points forming a continuous way.	Motor vehicles; Public Transport (Bus Rapid System).	-
4 Secondary Arterial Roads	Connection between the regional and the municipal centres; and the routes of superior hierarchy. Medium access control, to minimise the effects conflicts points forming a continuous way.		-
5 Collector Roads	Collect and distribute the internal traffic of the neighbourhoods, feeding the arterial system.		-
6 Local Streets	Direct access to residential buildings or for economic activities, with exclusively local traffic.	Motor vehicles.	-

RIO DE JANEIRO Rio de Janeiro Brazil		MUNICIPAL PT HIERARCHY Master Plan and Land Use Regulation (LC n° 111/2011; PLC n° 33/2013)	
1 Main Bus Rapid System (BRS)	Compatible with Main Roads.	Bus.	Exclusive lanes.
2 Secondary Bus Rapid System (BRS)	Compatible with Secondary Roads.		
3 Collector Bus Rapid System (BRS)	Compatible with Collector Roads.		

GROUP B**CASCAIS - RIO DE JANEIRO - CURITIBA**

CURITIBA Paraná Brazil		MUNICIPAL ROAD HIERARCHY "MACRO-HIERARCHY" Master Plan (L n° 14.771/2015)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Structuring Routes	Main road axes, with diverse functions of mobility and urban accessibility. Compatible with Priority Connecting Roads (*1), allowing commerce and service uses of the special sectors.	Public Transport; Motor vehicles.	Trinary road system, combining the PT exclusive lanes, slow access traffic, and mixed rapid traffic.
2 Metropolitan Connecting Roads	Promote the main connections with metropolitan region, enabling the exchange of travel between the urban areas of neighbouring municipalities; compatible with the Sectoral Routes (*2).		-
3 Structuring Metropolitan Routes	Green Line (*3): integration route of the Metropolitan Region of Curitiba. It has exclusive management through an urban development approved by law specific.	Public Transport; Motor vehicles; Bicycle.	PT line in an exclusive lane, marginal roads, local access roads and a bicycle lane.
4 Major Roads	Main connections between the different areas of the city; traffic distribution; acting as a high-capacity road corridor and a PT corridor, supporting the commerce and the service uses.	Public Transport; Motor vehicles.	-
5 Collector Roads (*4)	Roads that may or not have a connection to the main road system. Concentrates the local traffic, having vicinal commerce and service uses.	Motor vehicles.	Small and medium extension roads.
CURITIBA Paraná Brazil		MUNICIPAL ROAD HIERARCHY "BASIC HIERARCHY" Land Use Regulation (L n° 9800/2000)	
1 Priority Connecting Roads (*1)	Corridors with high traffic volume, linking the Structuring Special Sectors and important routes of the main road system.	Public Transport; Motor vehicles.	Parameters of land use and occupation must provide traffic flow.
2 Sectoral Roads (*2)	Connecting axes between regions, neighbouring municipalities, central and peripheral areas; articulation with the main road system, coinciding sometimes with routes of access to Curitiba.		Admit mainly the sectorial uses.
3 Collector Roads 1 (*4)	They are integrated into the main road system; concentrates local traffic and commerce and service.		Medium extension routes.
4 Collector Roads 2 (*4)	Small roads within the neighbourhoods, and may or not have a connection with the main road system; where small and medium-sized activities are located to serve the region.		Small roads.
5 Collector Roads 3 (*4)	They structure the areas of the social housing interest; may concentrate the uses directed to the region interest, favouring the generation of employment and income.		Small and medium-sized roads.
CURITIBA Paraná Brazil		MUNICIPAL PT HIERARCHY Master Plan (L n° 14.771/2015)	

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CURITIBA Paraná Brazil		MUNICIPAL PT HIERARCHY Master Plan (L n° 14.771/2015)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 PT Structuring Routes	Main urban public transportation for the high capacity transport system, which may include metropolitan service coverage.	Public transport.	Corridors with exclusive lanes.
2 PT Structuring Metropolitan Routes	Green Line (*3): PT corridor with urban character and metropolitan integration. Exclusive lanes to the medium and high capacity system.		
3 PT Connecting Routes	Medium and high capacity urban transport routes that interconnect and/or complement the structuring routes.		Exclusive lanes or tracks.
4 PT Trunk Routes	Main routes of PT urban and/or metropolitan integration that start or pass through a terminal towards the city centre.		Preferably exclusive lanes.
5 PT Inter-neighborhood Routes	Collective, circular or pendular transport axes that interconnect several neighbourhoods and integrate structuring and trunks routes.		
6 PT Complementary Routes	Connection between the neighbourhoods and the city centre, where the concentration of itineraries of different lines of collective transportation occurs.		Axes constituted by the infrastructure function implanted in selected routes.

GROUP C
 PORTO - BELO HORIZONTE

PORTO Porto Portugal		MUNICIPAL ROAD HIERARCHY Master Plan (Aviso nº 14332/2012)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Structuring Intermunicipal Routes	Establish the link between the main city sectors, and those to the national network structuring the metropolitan and regional territory; greater traffic flows.	Motor vehicles.	Carriageway, sidewalks and bicycle lanes width.
2 Interconnection Routes	Traffic weakening (absorb) between the municipal and the national road system, as their use is fundamentally associated with the 'exit' and 'entry' functions in the urban road network.		
3 Complementary Urban Routes or Local Structuring	Connects the Structuring Routes to each other, and the urban sectors making compatible the local traffic and the activities; a decisive role in the future restructuring of the urban bus network.		
4 Complementary Urban Routes	or Local Structuring of Sequential Importance: crosses, where possible, different urban sectors as a complement to the main network. Circulation of road transport, and inter-municipal connections.	Motor vehicles; Public transport (Bus).	
5 Local Streets	Attend the uses of housing, commerce and other activities, to the detriment of traffic crossing favouring pedestrian and bicycle circulation; compatible with parking and loading/unloading.	Pedestrian; Bicycle; Cars.	
6 Shared Streets	Serve the pedestrian circulation; admit as a simultaneous secondary function the corridors of alternative modes of transport, and in an adequate regime, car access to private property.	Pedestrian; Bicycle; Electric vehicles; Cars.	

BELO HORIZONTE Minas Gerais Brazil		MUNICIPAL ROAD HIERARCHY Master Plan and Land Use Regulation (L nº 7.165/96; L nº 7.166/96)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Regional Route	Regional connection; connection with the neighboring cities. Access to the near roads.	Motor vehicles.	Dimensioning, streets minimum width, type of paving declivity.
2 Arterial Roads	Significant traffic volume; urban displacements of greater distance. Access to the near roads.		
3 Collector Roads	Circulation of vehicles between Arterial or Regional routes and Local streets.		
4 Local Streets	Low traffic volume; direct access to buildings.		
5 Mixed Streets	Intended for pedestrians and leisure; low traffic volume; eventually, an entrance of cargo vehicles.	Pedestrian; Cars; Cargo.	Type of paving.
6 Pedestrian Streets	Pedestrians and, where appropriate, bicycles.	Pedestrian; Bicycle.	
7 Bicycle Routes	A side lane, physically segregated from other lanes, intended exclusively for the bicycles transit.	Bicycle.	Type of paving, lanes segregation.

GROUP D

NOVA IGUAÇU - LISBOA - SÃO PAULO

NOVA IGUAÇU Rio de Janeiro Brazil		MUNICIPAL ROAD HIERARCHY Master Plan (L nº 4.092/2011)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Rapid Transit Roads	Set the main municipal road structure, receive the vehicular flows of the Collector and Local Routes; articulation between the extreme points of the municipality, where the traffic is predominant.	Motor vehicles.	Double/single runway , two or more lanes in each direction; the vehicular flow is uninterrupted.
2 Arterial Roads			Allow access to adjacent lands; the vehicular flow is interrupted.
3 Collectors			Allow access to the adjacent lands.
4 Local Streets			Double/single runways, two or more lanes per direction; the vehicular flow is interrupted.
NOVA IGUAÇU Rio de Janeiro Brazil		SOFT MODES Master Plan (L nº 4.092/2011)	
1 Bicycle Paths	To be implanted at six roads indicated + along the railway . Also to be implanted along the new roads to be opened, or qualified by the Municipal Mobility Plan as routes for bicycle.	Bicycle.	Exclusive lanes totally segregated from the motor vehicles traffic.
2 Bicycle Lanes			Part of carriageway, delimited by signalling.
NOVA IGUAÇU Rio de Janeiro Brazil		PUBLIC TRANSPORTS Master Plan (L nº 4.092/2011)	
1 PT Radial Lines	Connection with the Nova Iguaçu central area.	The PT types were not specified.	-
2 PT Diametrical Lines	Connection between the main centralities, through the central area, strengthening the internal integration.		-
3 PT Perimeter Lines	Connection between the main centralities, without passing through the centre, strengthening the internal integration without unnecessarily overloading the road system of the central area.		-
4 PT Feeding Lines	Connection of the various neighbourhoods to the central areas without reaching the central area.		-

GROUP D

NOVA IGUAÇU - LISBOA - SÃO PAULO

LISBOA Lisboa Portugal		MUNICIPAL ROAD HIERARCHY Master Plan (Aviso nº 11622/2012)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Structuring Network (Level 1)	Inter-municipal connections; link to the National Road Network; support for long distance routes.	Motor vehicles; Public Transport (Bus + PT in exclusive lane).	Number of lanes, width, physical separation, parking, public transportation facilities, coexistence with soft transport modes; road nodes.
2 Main Distributors Routes (Level 2)	Distribution of the most significant internal traffic flows to the municipality. Collection and distribution of traffic in urban sectors; inter- and intra-sectoral distribution.		
3 Secondary Distributor Routes (Level 3)	Composed of internal routes and ensures the distribution of proximity, as well as the referral of traffic flows to the higher level. Collection and distribution of traffic in urban sectors.		
4 Local Distributor Routes (Level 4)	Structural routes of the neighbourhood level, with some capacity of flow, but the pedestrian has greater importance. Collection and distribution of neighbourhood traffic; Local Access.	Pedestrian; Bicycle; Motor vehicles; PT not desirable.	
5 Local Access Routes (Level 5)	Motor vehicles access to the building but must provide privileged conditions for pedestrian circulation. Encouragement and protection of pedestrian; local access.	Pedestrian; Bicycle; Motor vehicles; PT not allowed.	
LISBOA Lisboa Portugal		SOFT MODES HIERARCHY Master Plan (Aviso nº 11622/2012)	
1 Bicycle Commom Route	Bicycle route bicycles in coexistence with road traffic; it is unidirectional, following the direction of the traffic flow.	Bicycle.	Vertical and horizontal signalling.
2 Bicycle Lane	A delimited lane, at the level of the road pavement; it is unidirectional, following the direction of the traffic flow.		Horizontal signalling; without physical barriers (it is not segregated, but also it is not shared).
3 Bicycle Path	Path in own channel, segregated from road traffic. It can be bidirectional or unidirectional.		Can be parallel to the street following the sidewalk or have an independent route.
4 "30 Zones"	Zones with character to promote the traffic calming; moderation of the automobile circulation by physical modification in the channel space.	Pedestrian; Motor Vehicles.	Maximum speed 30km/h; vertical signalling; reduction of the road width; road elevation and discontinuity.
5 "Mixed Zones"	The channel space is shared between pedestrians and motor vehicles, with priority to non-motorized modes.	Pedestrian; SM; Motor Vehicles.	Vertical signalling; maximum speed 20km/h; absence of delimitation for the different modes.
LISBOA Lisboa Portugal		PUBLIC TRANSPORTS Master Plan (Aviso nº 11622/2012)	

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LISBOA Lisboa Portugal		PUBLIC TRANSPORT HIERARCHY Master Plan (Aviso nº 11622/2012)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 PT Level 1	Along to the Structuring road network; connection between different sectors and interfaces; suburban commuting flows; connection to the long-distance networks defined by the railway and airport offer.	Train; Metro.	Exclusive lane; operational characteristics, velocity, frequency.
2 PT Level 2	Connection between different 1st level corridors; and links to the collective tourist equipments.	PT exclusive lane (VLT, Electric); Common Bus; Express Bus.	Operational characteristics, velocity, frequency.
3 PT Level 3	Promote connections between districts not served (or incompletely served) by the 1st and 2nd level; neighbourhood internal connections and between adjacent neighbourhoods.	Common Bus; Mini Bus;	

GROUP D

NOVA IGUAÇU - LISBOA - SÃO PAULO

SÃO PAULO São Paulo Brazil		MUNICIPAL ROAD HIERARCHY Master Plan (L nº 16.050/2014)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Structuring Roads (Level 1)	Link the municipality with others municipalities of São Paulo's State.	Public Transport; Motor vehicles.	Priorisation of PT circulation; Bicycle infra allowance.
2 Structuring Roads (Level 2)	Those not included at the previous level; link between the municipalities of the São Paulo Metropolitan Area and the level 1 routes.		- Bicycle lanes/ paths allowance.
3 Structuring Roads (Level 3)	Those not included at the previous level; link between districts, neighborhoods and central areas of São Paulo Municipality.	Public Transport; Motor vehicles; Bicycle; Non-motorized modes.	- Parking, taxi stand facilities; - Bicycle lanes/ paths allowance.
4 Collector Roads	Connection between local and structural routes.	Public Transport; Motor vehicles. Bicycle path.	- Parking, taxi stand facilities; - Bicycle lanes/ paths allowance.
5 Local Streets	Provide access to properties; not classified as collecting or structural.		- Parking, taxi stand facilities; - Bicycle lanes/ paths allowance.
6 Bicycle Routes	The bicycle circulation shall not be restricted due to road classification. Also described at "Bicycle Route System".	Bicycle.	-
7 Pedestrian Streets	Described at "Pedestrian System".	Pedestrian.	-
SÃO PAULO São Paulo Brazil		SOFT MODES HIERARCHY Master Plan; Municipal Mobility Plan (L nº 16.050/2014; PlanMob/SP 2015)	
1 Bicycle Path (Ciclovía)	Exclusive path for bicycles exclusive use; segregated; can be at the same level of carriageway or sidewalks, but in different pavement. Can be Unidirectional or Bidirectional.	Bicycle.	Physical segregation to motor vehicles or pedestrian transit; specific signalling.
2 Bicycle Lane (Ciclofaixa)	Lane at the same level of the carriageway, exclusive for bicycles; Unidirectional or Bidirectional.		Visual or physical segregation of motor vehicles traffic.
3 Bicycle Route (Ciclorrota)	Shared lanes in the carriageway between bicycles and motor vehicles. Located in road that have characteristics of volume and speed of traffic where the other transport modes can share the	Bicycle; Motor Vehicles.	Specific signaling at the lane.
4 Shared Sidewalks - Common space (Calçadas Compartilhadas)	Common space into the sidewalk. This solution is used when is not possible the connection with other cycling treatment.	Bicycle; Pedestrian and wheelchair.	Shared space, specific signaling.
5 Shared Sidewalks - exclusive space (Calçadas Partilhadas)	Exclusive space for bicycle circulation in the sidewalk. As "bicycle lane", but in the sidewalk.	Bicycle.	Exclusive space; segregated; visual signaling; different pavementation.

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SÃO PAULO São Paulo Brazil		PUBLIC TRANSPORT HIERARCHY Master Plan; Municipal Mobility Plan (L n° 16.050/2014; PlanMob/SP 2015)	
Classification	Function	Transport Mode	Geometric Criteria/ Technical Specification
1 Exclusive Bus Corridor Class I	Structural lines integrated with terminal or intermediate stations, and other lines. Do not share the lane with inferior hierarchy classes. Dedicated lane, similar to the Bus Rapid Transit (BRT).	Articulated Bus.	Segregation between other traffic lanes. System structure physically linked and integrated.
2 Exclusive Bus Corridor Class II	Structural lines integrated with terminal or intermediate stations, and other lines. Do not share the lane with inferior hierarchy classes.	Articulated Bus; Conventional urban bus.	Corridor in a dedicated centre lane with; High level of segregation between general traffic.
3 Exclusive Bus Corridor Class III	Structural lines integrated with terminal and other lines, sharing the lane with those who enter or exit from the corridor. Do not share the lane with inferior hierarchy classes.		Corridor in the left lane segregated, signalised, without physical separation of the general traffic.
4 Exclusive Bus Corridor Class IV	Preferential structural lines can be operating with schedules in some cases.	Buses of any size; Motor vehicles (general traffic).	Exclusive right lane can share the space between general traffic; segregation by signalling.
5 Exclusive Bus Corridor Class V	Operation with structural or local lines.		Preferential right lane shared with general traffic; indication by signalling.
6 Exclusive Bus Corridor Class VI	The category includes all roads without any priority treatment for buses, but which are important axes for PT; overlapping of structural or local lines.	PT; Buses of any size, avoiding articulated.	General roads; any priority treatment for buses circulation.

APPENDIX VI

1. Network hierarchy in Matosinhos Master Plan

	(P)	(AM: Active Modes)	(PT)	(IT)	(O)
	PEDESTRIAN Network Hierarchy	BICYCLING Network Hierarchy	PUBLIC TRANSPORT Network Hierarchy	INDIVIDUAL TRANSPORTATION Network Hierarchy	Transport Modes Overlapping Hierarchy
Functional Hierarchy	1. Main Network 2. Priority Complementary Network 3. Complementary Network 4. Secondary Network	1. Main Network 2. Priority Complementary Network 3. Complementary Network 4. Network of Coexistence 5. Secondary Network	1. Railway network 2. Main Road Routes 3. Secondary Road Routes 4. No service (+3) Interfaces	1. Municipal Network 2. Main Distribution Network 3. Local Distribution Network 4. Local Access Network	1. Exclusive: Public Transport 2. Priority: all modes 3. Priority: IT & PT 4. Priority: IT & AM 5. Priority: PT & AM 6. Priority: IT 7. Exclusive: IT 8. Priority: AM 9. Exclusive: AM 10. Non-priority
type of land-use of major prevalence	Residential and commercial areas	Coast route, linking the population density areas	Municipal connection	unoccupied areas; new urbanised areas.	to resolve conflicts between transport modes.
relationship with other functional hierarchy	Inverse relation to the individual transport network. Coincide with last level of IT hierarchy (local access network)	TP Network (metro) favouring the intermodality	Road hierarchy	Municipal and inter-municipal connection.	specific solutions will be defined in the later phase of planning; however, in the existence of conflicts, the mode with the higher functional hierarchy will prevail.
compatible transport modes	Pedestrian; Active Modes.	compatible with all categories, except in roadways	Public Transport: Bus, Metro.	all mode, however in residential neighbourhoods the prevalence will be for pedestrian	
design/technical features	Shared streets, traffic calming, crossing in any street point.	Segregated cycling infrastructure or shared spaces with signalling, reinforcing visual signals.	Dedicated corridor for bus; Restricted channel for metro.	traffic calming in residential neighbourhoods;	Dimensioning of carriageway elements according to the minimum stipulated by IMT

APPENDIX VI

2. Network hierarchy classes in Matosinhos Master Plan

	PEDESTRIAN Network Hierarchy	BICYCLING Network Hierarchy	PUBLIC TRANSPORT Network Hierarchy	ROAD Network Hierarchy	Transport Modes Overlapping Hierarchy
1	Main Network	Main Network	Railway network	Municipal Network	Exclusive: Public Transport
2	Priority Complementary Network	Priority Complementary Network	Main Road Axes	Main Distribution Network	Priority: all modes
3	Complementary Network	Complementary Network	Secondary Road Axes	Local Distribution Network	Priority: IT & PT
4	Secondary Network	Network of Coexistence	No service	Local Access Network	Priority: IT & AM
5	-	Secondary Network	(+3) Interfaces	-	Priority: PT & AM
6	-	-	-	-	Priority: IT
7	-	-	-	-	Exclusive: IT
8	-	-	-	-	Priority: AM
9	-	-	-	-	Exclusive: AM
10	-	-	-	-	Non-priority