MORE

Multimodal Optimisation of Roadspace in Europe

Deliverable D1.2

Urban Corridor Road Design:

Guides, Objectives and Performance Indicators

Start date of project:	**1st September 2018**	Duration:	**36 months**
		Version:	**1**
		Prepared by:	**TUD (Regine Gerike, Caroline Koszowski, Bettina Schröter, Rico Wittwer, Johannes Weber)** **UCL (Marco Dean, Peter Jones)**
		Checked by:	**Peter Jones**
		Verified by:	**X**
		Status:	**x**
		Dissemination level:	**PU/CO**

The sole responsibility for the content of this document lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither INEA nor the European Commission are responsible for any use that may be made of the information contained therein.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769276

Table of Contents

Copyright © 2019 by MORE

1 Introduction

Urban roads and streets serve manifold functions. As defined within the MORE project,

- ‘roads’ cater only to motorised vehicle movement and have no direct frontage access; vehicle access is usually limited to signalised or grade separated junctions with speed limits typically not exceeding 50 mph / 80 km/h.
- ‘streets’ typically have sidewalks, surface pedestrian crossings, buildings on either side, and often kerbside parking and loading, bus stops, etc; speed limits typically do not exceed 20 – 30 mph (30 – 50 km/h).

The focus of the MORE project is on the most challenging parts of the transport network. The primary aim of MORE is to provide a comprehensive and objective approach to the planning, design, management, and operation of street space on major urban corridors feeding into the Trans European Transport (Ten-T) road networks, where expanding or building new urban roads is not an option. The focus of MORE is thus on streets that have both major link and place functions. These are main streets that both serve as conduits for movement for all different types of user groups including pedestrians, cyclists, buses, trams, cars, lorries, etc., and that also serve as destinations. The street sections investigated and re-designed in the MORE project have buildings on either side and various related sidewalk activities and place functions, such as kerbside parking and loading, window shopping, restaurants, bus stops, intermodal transfers, etc. The MORE corridors also encompass road sections where the link function clearly dominates and where place functions are scarce. In this deliverable, the term ‘street’ is used more prominently because (1) streets with both link and place functions are the core interest of MORE and (2) it avoids the necessity to always use both terms throughout the deliverable.

The MORE objective is to provide knowledge and tools for optimising limited street space and capacities. The basis for such optimisation is gathering knowledge of existing practices in urban street design, identifying objectives and performance indicators, and establishing an overview of road function classification systems across Europe. Guidance and planning philosophies differ greatly, and a systematic overview is lacking due to most publications thereof being provided solely in their national languages. It is therefore difficult to identify and understand the relevant material.

The MORE consortium and project provide the unique opportunity for compiling urban street design material on an international level. Thus, different planning practices are made accessible for a wide multilingual audience; urban and transport planners are able to learn from each other and, through this exchange of knowledge, to develop innovative and improved solutions for the optimisation of limited urban street spaces. Please note that where references are made to left or right turning traffic, these generally apply to mainland European situations, where vehicles drive on the right hand side of the road; these references need to be inverted for UK conditions.

This deliverable is embedded in Work Package 1 (WP1) which, together with the work packages WP2 and WP3, provides the foundation for the subsequent work packages in

Copyright © 2019 by MORE

MORE. This deliverable reviews guidelines and other relevant material for road function classification and urban street design and additionally provides a comprehensive compilation of objectives and performance indicators for the design of urban roads and streets. This deliverable is based on comprehensive research combined with intense discussions with all MORE partners. A questionnaire was sent to each partner asking for material and information concerning their city and country. Partners were highly engaged in providing insights and material on their individual national and/or local guidelines, strategic policy documents, the genesis of these guidelines, their scope and status in terms of whether these are more or less mandatory, etc. Further material was provided by the technical partners of MORE such as ECF, IFP and PTV on their specific perspectives and practices. Discussions in various teleconferences and personal meetings gave background information and helped to better understand the material provided in local languages. As a result, the scope of this deliverable focuses on the MORE partner cities and countries in addition to relevant cities and countries for which there were no local partners in place.

The structure of this deliverable addresses each topic as follows: Systems of road function classification are presented in Chapter 2, followed by an overview of street design objectives in Chapter 3. Chapter 4 is dedicated to guidelines and material on urban street design. First, an overview is given in Chapter 4.1 about what material exists in the different countries, which status this material has for daily practice in urban street design, and about which policies and processes are in place for creating this material. The subsequent Chapters 4.2 to 4.7 provide the synthesis of research for each user group including pedestrians and place users, cyclists, public transport, motorised transport, kerbside activities, etc. Safety considerations have taken a forefront in urban street design as a result of European regulations and legal requirements to identify and resolve accident black spots. Chapter 5 gives an overview of accident reporting and road infrastructure safety management as well as of black spot management and the role these play for urban street design in the different countries. The deliverable concludes with a summary of main findings and an outlook to open questions in Chapter 6.

Copyright © 2019 by MORE

2 Road Function Classification

2.1 Introduction

Roads and streets[1] contribute to the economic, environmental and social functioning of cities by facilitating the transport of goods and people from one place to another and, at the same time, serving and sustaining the daily activities of local communities (Hebbert, 2005; Jones et al., 2007; Marshall, 2005; Marshall et al., 2004). Indeed, the system of roads and streets constitutes approximately 80% of public space in cities and towns so that most urban activities and much urban identity are closely associated with that system (Jones and Boujenko, 2009; Jones et al., 2008)

Road planning has a long history, having emerged from town planning and gradually evolved as an independent discipline, since the first half of the previous century, fuelled by the rise of the automotive industry (Harder, 2003). The earliest modern forms of road classification, devised in those years, were thus mainly oriented towards the resolution of road safety and traffic accessibility problems, created by the introduction of the car into the urban environment (Harder, 2003; Henning Jones, 2014). The first attempt to classify roads in the UK, for instance, dates back to the 1920s, following the formation of the Ministry of Transport in 1919. The original purpose of this classification system was to bring order to traffic movement, helping motorists to identify direct routes and to assist with the allocation of grants for road maintenance and improvement (Emmerson and Bancroft, 2007). The decision to start classifying roads hierarchically was also inspired by several international publications investigating road space allocation and other issues associated with the advent of motor vehicles. Some of the first seminal works in this area, which have since become key references for subsequent research and policy guidelines, include Bouton (1916), Olmsted (1916), Robinson (1916), Bartholomew (1922), Taylor (1924), McClintock (1925) and Tripp (1950).

As highlighted by Marshall and colleagues (2004) the practice of classifying roads and streets has both a descriptive and prescriptive connotation. On the one hand, it is used to describe and acknowledge the role, characteristics and requirements of streets across different contexts (Marshall, 2005). On the other hand, it also serves to indicate the responsibilities of the associated authorities (Paraphantakul, 2014, 2017) and allows consistent decisions to be made with reference to street/road planning, design, construction, funding, management and operation (Jones, 2019; Roads and Traffic Authority, 2004). A good road classification can also help to integrate land use and transport in a coherent way (Committee of Transport Officials, 2012; Eppell et al., 2001; Jing-Xin Dong et al., 2013) and

---

[1] In the literature and more often in everyday life, 'road' and 'street' are used interchangeably as synonyms. However, for the purpose of this report, and in line with what specified by the UK Department for Transport and the Department for Communities and Local Government in the *Manual for Streets* (Department for Transport (2007)) the term 'road' refers to a linear transportation infrastructure whose main function is accommodating the movement of motor traffic, whilst 'street' is employed to indicate an infrastructure link which, besides traffic circulation, supports also accessibility and social and economic activities.

Copyright © 2019 by MORE

improve road safety by inducing intended behaviour of road users (Lu et al., 2006; Malenkovska Todorova et al., 2009).

At present, a variety of systems are used to classify road and street networks. Classification systems are based on many themes and factors, including ownership and management, physical form, traffic function, and urban function (Committee of Transport Officials, 2012; Jones, 2017, 2019; Malenkovska Todorova et al., 2009; Marshall, 2004; Matena et al., 2006; Paraphantakul, 2014, 2017; Vitkienė et al., 2017). However, there is no ‘optimal’ classification approach. The type of classification adopted ultimately depends on the purpose and context of its application (Jones, 2017; Marshall et al., 2004).

This Chapter of Deliverable 1.2 is a review of the road and street classification systems in use in urban areas worldwide, with a more detailed focus on the five MORE case study cities (Budapest, Constanta, Lisbon, London and Malmo). The rest of the report consists of six chapters. Chapter 2.2 provides a general overview of the current approaches to road/street classification and a summary of previous studies and research on this topic. Chapters 2.3 to 2.5 cover some of the most widely adopted classification systems, namely the geometric classification, the administrative classification and the functional classification of roads and streets. Chapter 2.6 illustrates the classification methods currently adopted in the MORE case study cities. Finally, Chapter 2.7 concludes the report by summarising the key findings and discussing their implications in the context of the MORE project.

2.2 Overview of Street and Road Classification Systems

As already highlighted above, there are in principle a number of ways of describing and categorising roads and streets and there is no single correct approach to road and street classification. Indeed, streets and roads present multiple attributes and, in many cases, fulfil different purposes. Any classification system is capable of capturing only some of these aspects. The elements considered by a classification method reflect the general objectives of the categorisation (Marshall et al., 2004).

The Australian Intergovernmental Committee on Surveying and Mapping lists some basic requirements that any road/street categorisation system should comply with (Intergovernmental Committee on Surveying and Mapping, 2006). These include, amongst other:

- Completeness: the classes included in the classification system must cover all the relevant street types present in a region or country;
- Manageability: in order to avoid unnecessary analytical effort, the total number of road/street classes must be as limited as possible;
- Understandability: the definitions that characterise each category must be distinct, clear and concise. Engineers, planners, decision-makers and all the other parties involved in road/street planning and design must have a shared understanding of the assumptions and concepts behind each road/street class. The definition of the road/street classes should also be in line with the expectations and perceptions of the road users.

An analysis of the relevant literature highlights that, despite the variety of names and structures, in general, the road and street classifications adopted across the world exhibit

Copyright © 2019 by MORE

some similarities, which allow them to be compared and grouped together. In this regards, the ARTISTS project, whose main objective was to identify the sustainable functions of urban streets in Europe (Marshall et al., 2004), identified a number of classification criteria (see Table 1). Amongst these criteria, administration, circulation and access, strategic role, road section and traffic speed, trip length, and destination status were found to be the most recurrent ones (Marshall, 2005).

According to another study concerning road categorisation practice in Europe (Matena et al., 2006), in European countries there are three main ways to categorise roads and streets: a functional classification, identifying the specific purpose of the roads and the streets; a hierarchical classification based upon the jurisdiction of the various streets (i.e. administrative classification); and a categorisation system focusing on the major geometric or operational features of the roads and streets.

The Manual on road classification and access management of the South African road network (Committee of Transport Officials, 2012) lists several possible road classification criteria: mobility and access functions; administrative responsibility; route number; traffic signs; geometry design; naming hierarchy, public transport routes; construction and pavement management systems. The Manual, however, points out that the functional classification system based on mobility and access function is the most well established approach to categorising roads.

Paraphantakul (2014, 2017) reviewed road and street classification practice in 25 countries and established eight key classification criteria common to all these countries: access control; road surface; usage; transport mode; administration; link role; place status; and functions. Paraphantakul concluded that geometric, administrative and functional aspects are the most widely used road classification criteria.

A study undertaken by Vitkienė et al. (2017), investigating the classification approaches of 10 countries, adopted the same classification criteria as Paraphantakul's study, highlighting that functional criteria are used by all these countries to define their road classification systems.

As illustrated in Table 1, some of the criteria identified by these studies are highly interrelated and partially overlap each other. There seem to be also some inconsistencies in the use and definition of some criteria. What, however, seems to emerge from the review is that that geometric aspects, administrative status and function are amongst the top classification criteria for roads and streets. The classification systems based on these parameters will be described in detail in the following chapters.

Copyright © 2019 by MORE

Table 1: Main Criteria and Themes Adopted in Road and Street Classification Practice

Studies/ Manuals	Marshall et al. (2004)	Matena et al. (2006)	Committee of Transport Officials (2012)	Paraphantakul (2014, 2017); Vitkienė et al. (2017)
Classifi-cation Criteria	*Main Criteria* 1. Administration 2. Circulation vs Access 3. Strategic Role 4. Road Section & Traffic Speed 5. Trip Length 6. Destination Status *Other Criteria* 7. Access Control 8. Built Frontage 9. Environment 10. Traffic Volume 11. Road Width 12. Transport Mode 13. Other Urban Uses	1. Function 2. Administrative Status 3. Geometric & Operational Features	1. Mobility & Access 2. Administrative Status 3. Route Number 4. Traffic Signs 5. Geometry Design 6. Naming Hierarchy 7. Public Transport Routes 8. Construction & Pavement Management Systems	1. Access Control 2. Road Surface 3. Usage 4. Transport Mode 5. Administration 6. Link Role 7. Place Status 8. Functions
Classifi-cation Themes	▪ Forms and Assets | ▪ Function | ▪ Use | ▪ Administration			

Source: (Based on) Marshall et al. (2004); Matena et al. (2006); Committee of Transport Officials (2012); Paraphantakul (2014, 2017), and Vitkienė et al. (2017)

2.3 Geometric Classification

The geometric classification focuses on the structural standards and the physical dimensions of the roads and streets, so as to provide the basis for their design and construction (Committee of Transport Officials, 2012; Intergovernmental Committee on Surveying and Mapping, 2006). The key parameters of the geometric classification include, amongst others, horizontal and vertical alignment, horizontal curvature, super elevation, carriageway width and design speed, which ultimately affect the safety conditions of the road (Paraphantakul, 2017). Different types of roads adopt different design standards. In general, manuals and

Copyright © 2019 by MORE

guidance indicate only minimum and/or maximum requirements for each of these parameters for different types of roads. Design parameters need then to be adapted according to the specific context and conditions in which each road operates Figure 1 displays, for instance, the design criteria and corresponding standard for urban roads in England as prescribed by the Highways Agency's Design Manual for Roads and Bridges (Highways Agency, 2002).

The key input for determining the structural standards of a road is the purpose of the road itself. Therefore, despite its usefulness, the geometric classification turns out to be dependent by other forms of road classifications, especially functional classifications systems (Committee of Transport Officials, 2012; Intergovernmental Committee on Surveying and Mapping, 2006; Paraphantakul, 2017).

Figure 1: Example of Design Criteria and Correspondent Standard for Urban Roads

DESIGN SPEED kph	120	100	85	70	60	50	V^2/R
STOPPING SIGHT DISTANCE m							
Desirable Minimum	295	215	160	120	90	70	
One Step below Desirable Minimum	215	160	120	90	70	50	
HORIZONTAL CURVATURE m.							
Minimum R* without elimination of Adverse Camber and Transitions	2880	2040	1440	1020	720	520	5
Minimum R* with Superelevation of 2.5%	2040	1440	1020	720	510	360	7.07
Minimum R* with Superelevation of 3.5%	1440	1020	720	510	360	255	10
Desirable Minimum R with Superelevation of 5%	1020	720	510	360	255	180	14.14
One Step below Desirable Minimum R with Superelevation of 7%	720	510	360	255	180	127	20
Two Steps below Desirable Minimum Radius with Superelevation of 7%	510	360	255	180	127	90	28.28
VERTICAL CURVATURE							
Desirable Minimum* Crest K Value	182	100	55	30	17	10	
One Step below Desirable Min Crest K Value	100	55	30	17	10	6.5	
Absolute Minimum Sag K Value	37	26	20	20	13	9	
OVERTAKING SIGHT DISTANCES							
Full Overtaking Sight Distance FOSD m.	*	580	490	410	345	290	
FOSD Overtaking Crest K Value	*	400	285	200	142	100	

Source: Highways Agency (2002)).

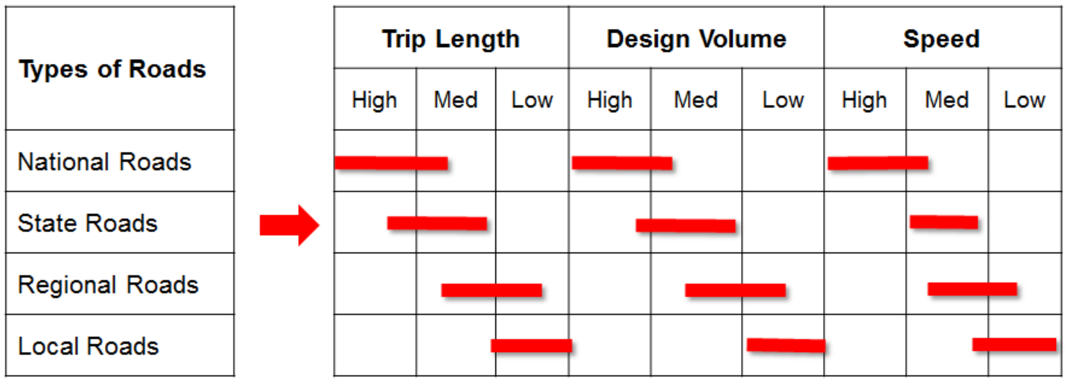
2.4 Administrative Classification

The administrative classification system is used to classify roads according to who is the responsible authority. This type of classification thus conveys important information regarding the road governance structure and funding responsibilities (Paraphantakul, 2014, 2017). A similar form of classification was already used by the Romans and in the course of time has been adapted by many modern societies (Matena et al., 2006). In general and simple terms, roads and streets can be operated by three or four levels of road authorities, typically:

- National;
- Provincial/State;
- Regional/County;
- Local.

As illustrated in Figure 2, the administrative classification may also be used to inform the design standards of roads.

Figure 2: Relationship between Administrative Classification and Design Standards of Roads



Source: (Adapted from) Road Engineering Association of Malaysia (2002)

Recent privatisation, decentralization and devolution trends have increased the level of complexity of the administrative ownership of roads in many countries (Paraphantakul, 2014, 2017). In the UK, for example, Highways England (formerly the Highways Agency) is the government-owned company which is responsible for operating, maintaining and improving the so-called ‘Strategic Road Network’, comprising most motorways and major ‘trunk’ A-roads (Table 2). Although the length of the Strategic Road Network represents only around two per cent of the total length of England’s road network, it carries roughly one-third of the total national motor vehicle traffic, thus playing a critical role for the economy (Butcher, 2015). The rest of the road network, including the Primary Route Network (linking primary destination across the UK and consisting mainly of major A-roads), second-tier roads (B-roads) and other minor and local roads, is owned and managed by different local authorities (Department for Transport, 2012).

Copyright © 2019 by MORE

Table 2: Types of Roads and Administrative Responsibility in England

Road Categories	Type of Network	Responsibility
Motorways	Strategic Road Network	Highways England Company Limited
Class A roads		
Class B roads	Non-Strategic Road Network	Local Authorities
Classified Un-Numbered Roads (Class C roads)		
Local Unclassified Roads		

Source: (Based on) Department for Transport (2012).

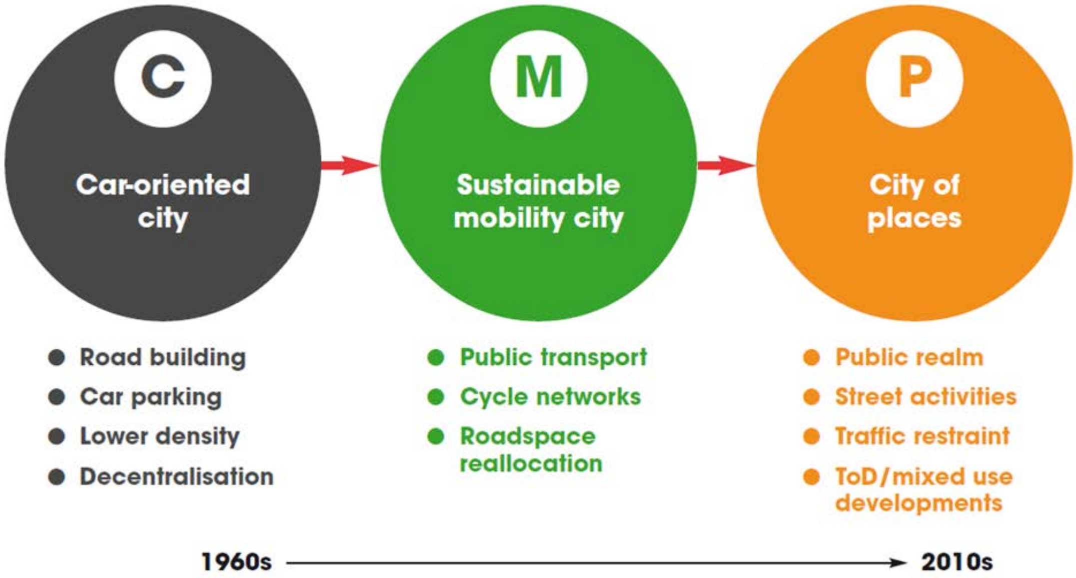
2.5 Functional Classification

2.5.1 Evolving Policy Perspectives on Transport

Functional classifications group roads/streets into classes according to their particular purpose and the character of service they are intended to provide (Roads and Traffic Authority, 2004). Streets and roads can, however, perform different functions at the same time, ranging from motor vehicle circulation to the support of economic vitality and liveability of urban centres. Hence, in the course of time, various functional classification systems, reflecting different schools of thought and focusing on different aspects and issues, have been devised. Indeed, as Marshall et al. (2004) point out, the development of a classification system is to some extent a political act and reveals the policy priorities, development visions and biases of those making the classification.

According to Jones et al. (2018), in transport planning it is possible to identify three main dominant development paradigms and policy perspectives which have shaped the city since the first part of the 20th century: a pro-car perspective, focusing mainly on the need to adapt the urban fabric to accommodate the growing use of the motor car; a sustainable mobility perspective, promoting more efficient and attractive forms of transport systems; and a place based perspective, characterised by a growing interest in urban quality and vitality (see Figure 3). In most western cities, especially in Europe, these perspectives, as described further below, have broadly followed sequentially, as a three-stage evolving process fuelled by internal triggers and emerging global challenges. However, for some economically advanced cities, the shift from one policy to another has not been clear cut, with overlaps and temporary reversals of the trends, or has not taken place at all (Jones et al., 2018).

Figure 3: Dominant Policy Perspectives in Transport Planning



Source: (Adapted from) Jones et al. (2018)

- *Car-Oriented City:* this perspective, which had dominated western transport planning practice from its origin to the 1960s and which is still predominant in some North American cities and developing countries (Banister, 2005, 2011; Curtis, C., and Low, N., 2012), *prioritises* individual motorized movement. Especially towards *the middle* of the previous century, in many western cities, the growth in motor traffic was not perceived as a problem but rather as a beneficial consequence of economic and social development (e.g. increases in household incomes) (Jones, 2009). Therefore, policy measures promoted to cope with the rapid rise of automobile ownership and the growing traffic level were expressly aimed at meeting the requirement of motor vehicles, rather than limiting their use (Henning Jones, 2014; Jones et al., 2018). The main transport solutions devised by traffic engineers during that period consisted of building new roads, increasing the capacity of the existing ones as well as in the provision of additional parking spaces. Limited attention was paid to other types of street uses and the needs of other street users (Jones et al., 2018) - and space was often taken away from footways in order to provide more carriageway space.
- *Sustainable Mobility City:* starting from the 1970s, major congestion problems in urban areas, the practical impossibility of providing unlimited road capacity to accommodate the continuing traffic growth and the 1973/74 oil crisis, which provided a warning of the dangers of becoming a heavily vehicle dependent society, led to a major paradigm shift in transport planning (Jones, 2009). Rather than catering for unlimited car movement in cities, the overarching policy goal thus became ensuring the movement of people in the most efficient way possible – and, more recently, with an emphasis too on promoting more sustainable transport modes. Reductions in the road network capacity, improvements of public transport systems (i.e. buses, underground and trains, all capable of accommodating a higher number of people per unit area than cars), provision of walking and cycling infrastructure and enforcement of restrictions on the use of private

cars in high density areas (e.g. congestion charge, parking fees) represented some of the main instruments to encourage a modal shift from car (Jones et al., 2018).

- *City of Places:* in more recent decades the advent of the sustainable development goals (World Commission on Environment and Development, 1987), growing concerns about unattractive street environments, social exclusion, air and noise pollution, and obesity have led to another major breakthrough in transport planning practice (Jones et al., 2018). There has been a greater acknowledgement of the importance of considering streets as multifunctional places, which provide important public realm functions beyond the vehicle mobility. As a result, instruments such as traffic restraint measures in urban areas, the revitalisations of historic streets, the creation of new streets in new development areas and the promotion of mixed-use transit-oriented development schemes have been increasingly pursued with the view to rebalancing the traffic movement role of streets with other social and economic functions (Svensson and Marshall, 2007)

Along with specific policy measures to address the perceived mobility-related problems at that time, each policy perspective introduced also specific success criteria to evaluate the effectiveness of the policy actions taken (Jones et al., 2018). Hence, for example, according to the pro-car perspective, the level of congestion is the most important parameter, whilst this becomes less relevant in cities which encourage people to use more sustainable transport modes (sustainable mobility perspective) and which place a greater value on high quality places (place based perspective). Different transport planning paradigms are also generally associated with alternative street and road classification systems (Jones et al., 2018). In a car-oriented city, streets and roads tend to be classified based on their traffic function. By comparison, in a sustainable mobility city, where modes of transport other than private car are present, an expanded functional classification system may be necessary. Finally, in a city of places, streets are recognised to have two main roles, namely a movement space and a destination in its own right (see Table 3). These three contrasting systems of classification are discussed in detail in the following chapters.

Copyright © 2019 by MORE

Table 3: Dominant Transport Policy Perspectives and Associated Measures of Success, and Road/Street Classification Systems

Policy Perspectives	*Car-Oriented City*	*Sustainable Mobility City*	*City of Places*
Criteria and Measures of Success	- Average network speeds - Day-to-day variability - Vehicle congestion - Car parking availability - Road traffic accidents - Noise - Air pollution	- PT frequency and reliability - Access to bus stops and stations - Safety and security - Seamless travel - PT modal split - Walking/cycling modal shares - Door-to-door travel times by mode	- Time use in transport modes - Intensity of street activities - Time spent in local area - Quality public realm - Health of the population - Social interaction - Social equity and inclusion - Community severance
Street and Road Classification Systems	Vehicle-based functional road classification system	Expanded functional classification systems	'Movement' and 'Place' functional street and road classification system

Source: Jones (2016) and Jones et al. (2018).

2.5.2 Conventional Vehicle-Based Functional Road Classification System

2.5.2.1 Overview of the System

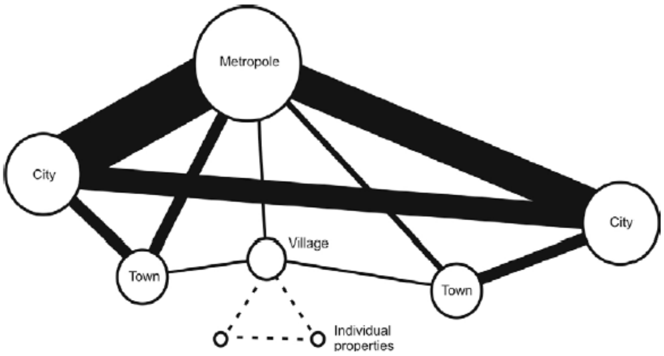
Since the beginning of the motorisation era, for many decades and in many parts of the world, the planning and design of streets in urban areas had focused on meeting the needs of motor vehicles, with a corresponding tendency to encourage the relocation of other traditional street activities to sites off busier urban streets (Jones et al., 2007). As a result, the traditional functional classification system, which emerged in those years, allocates priority to vehicle drivers and the vehicle-based movement function of the street, whilst neglecting other users and street functions (Henning Jones, 2014; Marshall, 2005).

This traffic-oriented approach has become one of the predominant methods among transportation professionals for grouping roads and is still adopted in a number of countries (Committee of Transport Officials, 2012; Jones, 2017, 2019; Malenkovska Todorova et al., 2009; Marshall et al., 2004; Matena et al., 2006; Paraphantakul, 2014, 2017; Vitkienė et al., 2017). It considers the road to be strictly a transport corridor for motorised vehicles with two main functions, namely traffic mobility and access. Mobility is generally understood as the capacity of a road to move vehicles containing people or goods from one place to another, whilst access measures the extent to which a road allows motor vehicles to reach a particular land use (Committee of Transport Officials, 2012; Transportation Association of Canada, 1999).

Copyright © 2019 by MORE

The underlying assumptions of this model are that most trips involve movement through a network of roads and that travellers have different needs during different parts of their trips. Generally speaking, at the beginning and end of a trip, the system of roads should provide access to buildings or land uses which the travellers travel from/to, whereas during the middle part of the trip, the system should enable high travel speeds without the friction of encountering stopping vehicles. Figure 4 includes a schematic representation of a road network in a urban or rural area, and illustrates the need to provide high capacity roads to serve large volumes of travel over long distances between the major nodes whilst access roads are required to serve smaller nodes and individual properties (the relative widths of the lines is directly proportional to the traffic volume between nodes). A well-designed functional road classification system should satisfy these principles by channelling the different trips within the road network in a logical and efficient manner (Eppell et al., 2001; Jing-Xin Dong et al., 2013; Paraphantakul, 2017).

Figure 4: Schematic Representation of a Road Network



Source: Committee of Transport Officials (2012)

The conventional functional classification thus orders the various links in the road network in a hierarchy, according to the character of travel service each carriageway provides (American Association of State Highway and Transportation Officials, 1990, 2001, 2011; Federal Highway Administration, 1982, 1989, 2013). As shown in Figure 5, within this hierarchy three primary classes of roads can typically be identified:

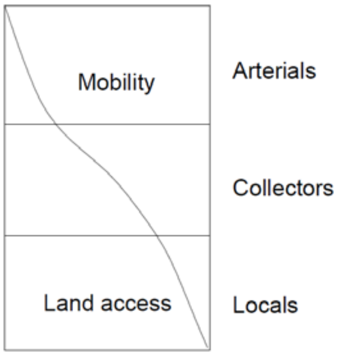
- *Arterial Roads:* strategic routes which serve long distance through traffic, accommodate high traffic volumes and enable high travel speeds. Such roads provide a high level of mobility with minimum access points;
- *Local Roads:* minor roads which tend to be designed for short distance trips, low traffic volumes and low travel speeds. Local roads are primary meant for direct access to residential, commercial or industrial properties and generally present narrow width with some speed reduction mechanisms;
- *Collector Roads*: roads which provide the transition of the traffic from arterial to local roads and vice versa, and present moderate mobility and access levels.

As shown in Figure 5, within this classification system the mobility and access functions are inversely related (Henning Jones, 2014; Marshall et al., 2004). Indeed, a road meant to provide maximum mobility performance should provide a very limited access function, as the

Copyright © 2019 by MORE

latter role directly disturbs the circulation (i.e. to access a place a vehicle stopping can slow down other traffic). Conversely, a road designated as an access street should have a low circulation function (Paraphantakul, 2017) – partly for ‘environmental’ reasons.

Figure 5: Relationship between Mobility and Access and Types of Roads in the Conventional Functional Classification System



Source: Federal Highway Administration (1982) American Association of State Highway Officials, 1964

2.5.2.2 International Examples

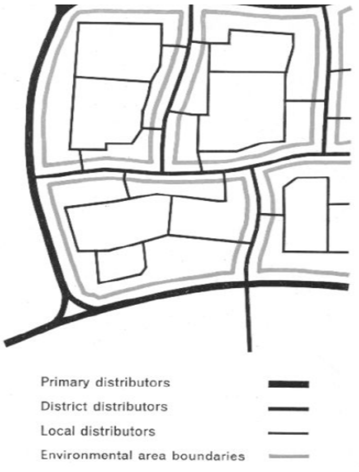
One of the earliest examples of a vehicle-based functional road classification system is represented by the Roads Plan produced by the Metropolitan Town Planning Commission for the City of Melbourne in 1929. In this plan, roads are grouped in four different tiers according to their primary traffic function (Metropolitan Town Planning Commission, 1929):

- Tramline Streets: auxiliaries to arterial road system;
- Outer Suburban Connections: intercept main routes to lead traffic to arterial routes;
- Inter-suburban and Ring Roads: bridge suburban connection roads with arterial roads;
- Parkways: avenues for the lighter types of traffic and to form parkway drives.

In the UK, the diffusion of this classification method can be traced back to the publication of the Traffic in Towns report, also popularly known as the Buchanan Report, prepared by Colin Buchanan for the UK Ministry of Transport (Ministry of Transport, 1963). This report offered some ideas for reducing traffic congestion and reconciling conflicts between the urban form and the movement of motor vehicles, ultimately laying out a comprehensive vision for urban planning for the motor era (Ben-Joseph, 1995; Jones, 2009). The underlying assumption of the Buchanan Report, based in part on a series of earlier studies on safety and traffic control carried out in the UK by Alker Tripp since the late 1930s (Tripp, 1942, 1950), is that in the traditional city there is an irreconcilable conflict between vehicle-based movement and a high quality local urban environment (Goodwin, 1995; Hass-Klau, 1990; Henning Jones, 2014; Marshall, 2005).

Echoing Tripp’s approach, Buchanan believed that this conflict could only be resolved through physical separation (Jing-Xin Dong et al., 2013; Marshall, 2004). Buchanan’s system in the UK thus introduced a basic distinction between a system of ‘traffic distributors’, which comprised three main classes of roads, namely primary, district and local traffic distributors, and a system of ‘environmental areas’, where environmental considerations were prioritised (Figure 6).

Figure 6: The Division between System of Traffic Distributors and a System of Environmental Areas Suggested in the Buchanan Report



Source: Ministry of Transport (1963)

Almost concurrently with the release of the Traffic in Towns report, in the US a publication of the American Association of State Highway Officials introduced the basic ‘mobility and land access’ principles (American Association of State Highway Officials, 1964), thus establishing the basis for the conventional vehicle-based functional road classification system which is still largely adopted in US practice. Figure 5, extracted from that guide and illustrating the inverse relationship between the mobility and access functions of roads has been adopted, with various minor modifications, in almost every report on functional classification ever since (American Association of State Highway and Transportation Officials, 1990, 2001, 2011; Federal Highway Administration, 1982, 1989, 2013).

Nowadays, almost every country adopts a vehicle-based functional road classification (Marshall et al., 2004; Matena et al., 2006; Paraphantakul, 2014, 2017; Vitkienė et al., 2017). As it is noticeable from Table 4, although the classification terminologies and the number of road classes differ from country to country, the various classification systems share the same basic principles and follow the same general pattern, with a spectrum from major roads to minor roads. For example, in the UK, all the roads are grouped into the following categories (Department for Transport, 2012):

- Motorways;
- A Roads: major roads intended to provide large-scale transport links within or between areas;
- B Roads – roads intended to connect different areas, and to feed traffic between A roads and smaller roads on the network;
- Classified Unnumbered Roads (i.e. C roads): smaller roads intended to connect together unclassified roads with A and B roads, and often linking a housing estate or a village to the rest of the network;
- Local Unclassified Roads: local roads intended for local traffic.

Table 4: Vehicle-Based Functional Road Classification System Adopted in some Selected Countries

Countries	UK (Department for Transport, 2012)	US (Federal Highway Administration, 2010)	SOUTH AFRICA (Committee of Transport Officials, 2012)	ITALY (D.Lgs 30/4/192 n.285)
Classes of Roads	- Motorways - Class A roads; - Class B roads; - Classified Un-Numbered Roads (Class C roads); - Local Unclassified Roads	- Interstate Highways - Freeways and Expressways - Other Principal Arterials - Minor Arterials - Major Collectors - Minor Collectors; - Local Roads	- *Urban-Mobility* • U1 Urban principal arterial • U2 Urban major arterial • U3 Urban minor arterial - *Urban-Accessibility* • U4 Urban collector • U5 Urban local street • U6 Urban Walkway - *Rural-Mobility* • R1 Rural principal arterial • R2 Rural major arterial • R3 Rural minor arterial - *Rural-Accessibility* • R4 Rural collector road • R5 Rural local road • R6 Rural walkway	- National Highways Road Surface (A) - Main Non-Urban Roads (B) - Secondary Non-Urban Roads (C) - Urban Arterial Roads (D) - Secondary Urban Roads (E) - Local Roads (F) - Bicycle Road (F-bis) - Service Road

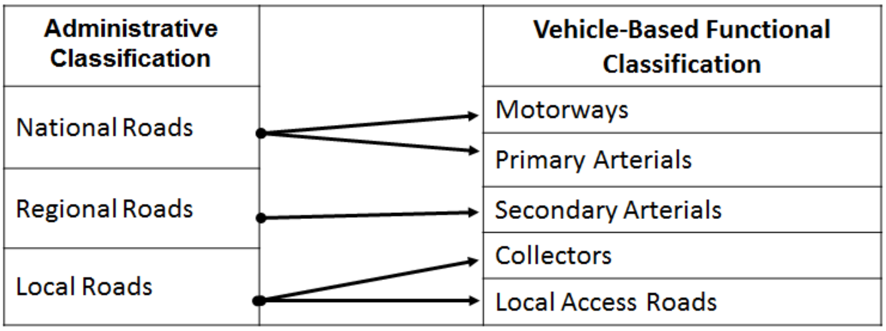
Copyright © 2019 by MORE

2.5.2.3 Relationships with other Systems of Classification

In a country, typically, different classification methods are overlaid on one other and this may generate some interdependencies between the systems. As already highlighted in Chapter 2.3, for instance, the purpose of the road may be conveniently used to define the type of geometric design that meets the requirements (Committee of Transport Officials, 2012).

The vehicle-based functional road classification and the administrative classification also should not be considered as being entirely separate. As highlighted in a report published by the Australian Roads & Traffic Authority, the functional classification system can be used as basis for allocating jurisdictional responsibility for roads (Roads and Traffic Authority, 2004). Figure 7 illustrates a hypothetical alignment of the two classification models.

Figure 7: Relationship between Vehicle-Based Functional Classification and Administrative Classification



Source: Authors' own elaboration.

Notwithstanding such associations, a complete match is unlikely to occur. The Intergovernmental Committee on Surveying & Mapping emphasises that there are many international examples where a mixture of administrative and functional characteristics have been used to define a road hierarchy (Intergovernmental Committee on Surveying and Mapping, 2006).

2.5.2.4 Strengths and Weaknesses of the System

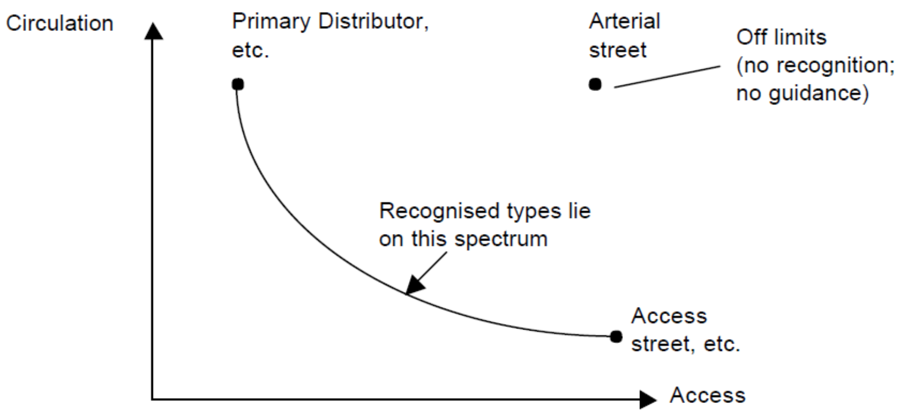
The review above suggests that the conventional vehicle-base functional road classification system is a simple and straightforward approach to the grouping of roads and streets, which has facilitated its diffusion in many countries. On the other hand, this simplicity is also its major weaknesses, for two reasons:

- The conventional functional classification is, as already highlighted, a motor vehicle traffic oriented system. Therefore, in the course of time, this approach has been criticised for its lack of attention to more sustainable travel modes (e.g. walking, cycling) and its inability to support other functions of roads and streets apart from access and mobility (Bochner and Dock, 2005; Forbes, 1999; Greenberg and Dock, 2003; Marshall, 2005; Marshall et al., 2004; Stamatiadis et al., 2017).
- The interpretation of the inverse relationship between mobility and access is also problematic. This inverse relationship means that whilst there are two possible street functions, they are largely seen as incompatible and there is effectively only one possible spectrum, along which any street can fit (Marshall et al., 2004). Indeed, as illustrated in

Copyright © 2019 by MORE

Figure 8, according to this classification system, a street can either have a high mobility function and low access function, or a low circulation and high access function (or a proportionate combination of the two functions). The result is an idealised hierarchy which fails to take into account the diversity of street types with mixed functions, conflicting functions and indeterminate functions (Marshall, 2004; Marshall, 2005; Marshall et al., 2004). Hence, for instance, an arterial street with a significant circulation function and access function cannot fit in the classification system (see Figure 8). Some studies (Goodwin, 2007; Jing-Xin Dong et al., 2013) have also highlighted that the designated role and actual usage of roads do not always match. Indeed, in some contexts, arterial roads are being used more than local roads for short-distance trips.

Figure 8: Implications of the Inverse Relationship between Circulation (Mobility) and Accessibility



Source: Marshall et al. (2004)

The result is that the conventional approach to street classification is not as realistic and comprehensive as it might seem. Attempts to apply it to street planning and design have also resulted in a number of problems. In the UK, for example, the consequences of implementing the recommendations included in the Buchanan's Report in urban locations across the UK has led to the redesign of busier urban streets as high capacity routes, with narrow footways, wide carriageways and pedestrian underpasses or overbridges (Jones et al., 2008; LaPlante and McCann, 2008). This has resulted in unwelcoming streetscapes and poor quality urban environments (Henning Jones, 2014; Marshall, 2004), which has in many cases contributed to the loss of vitality of local business and the gradual demise of traditional street activities (Henning Jones, 2014; Jones et al., 2008)

2.5.3 Expanded Functional Classification Systems

For cities embracing a sustainable mobility paradigm and focusing on the promotion of more efficient and environmentally friendly transport systems, the vehicle-based functional road classification system turns out to be a rather narrow approach as it prioritises motor vehicle traffic and balances only vehicular mobility and access. More recent guidelines and manuals have sought to expand and integrate this conventional framework in a wider framework, in an attempt to take into account the context in which roads and streets operate and the different design requirements of the various transport modes. The Abu Dhabi Urban Street Design

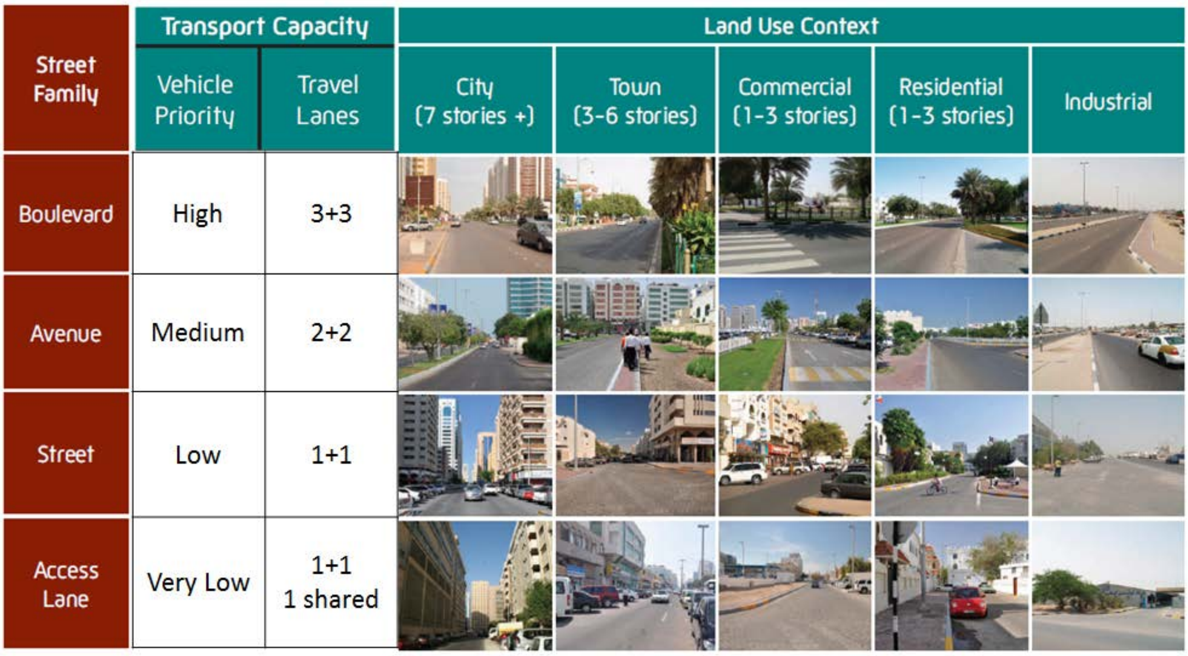
Manual commissioned by the Abu Dhabi Urban Planning Council (Abu Dhabi Urban Planning Council, 2009) represents a good case in point. Whilst previous street design practices in Abu Dhabi and in the United Arab Emirates had been strongly influences by AASHTO's policy documents, the need for supporting the transition from a vehicle trip based society to a multi-modal society and creating more walkable communities has led to the adoption of a new approach to road and street classification. The new system incorporates two main dimensions, namely the land use context (e.g. residential or commercial) and the transport capacity of the street. In terms of land use context, six possible situations are considered:

- City: mixed use central business districts and high density neighbourhoods with high levels of pedestrian activity.
- Town: mixed use areas with medium levels of pedestrian activity;
- Commercial: areas intended to provide a variety of working, shopping, and service options;
- Residential: areas that provide a variety of housing opportunities;
- Industrial: areas for businesses; and
- No Active Frontage: places with no buildings or land uses front onto the street and with very low of pedestrian activity.
- In terms of transport capacity, four street types are included in the framework:
- Boulevard: a high vehicle priority with three lanes in each direction;
- Avenue: a medium vehicle priority with two lanes in each direction;
- Street: a low vehicle priority with one lane in each direction; and
- Access Lane: a very low vehicle priority with one lane in each direction or even a one-lane shared street.

Figure 9, adapted from the Abu Dhabi Manual, illustrates the resulting 24 potential combinations of standard street types.

Copyright © 2019 by MORE

Figure 9: Street Typologies Considered in the Abu Dhabi Urban Street Design Manual



Source: (Adapted from) Abu Dhabi Urban Planning Council (2009)

Another interesting example of this trend towards expanding the traditional functional road classification system is represented by the framework proposed by the Kentucky Transportation Center (Stamatiadis et al., 2017). Like the Abu Dhabi Urban Planning Council's approach, this framework accounts for road functions, context and different transport modes. In this expanded functional classification system, five distinct contexts are identified based on factors such as density (i.e. existence of structures and structure types), land uses (i.e. primarily residential, commercial, industrial, and/or agricultural) and building setbacks (i.e. distance of structures to adjacent carriageways). These five contexts are defined as follows:

- Rural: very low density, agricultural land use, large setbacks;
- Rural Town: low to medium density, commercial use, on-street parking and sidewalks with small setbacks;
- Suburban: low to medium density, mixed residential neighbourhood and commercial cluster, varied setbacks with some sidewalks and mostly off-street parking
- Urban: high density, mixed residential neighbourhood and commercial uses, on-street parking and sidewalks with mixed setbacks; and
- Urban Core: very high density, mixed residential, commercial and institutional uses, small setbacks with sidewalks and pedestrian plazas.

Four distinct carriageway types, namely Principal Arterial, Minor Arterial, Collector and Local Roads are then defined according to their network function and connectivity and the national, regional, and local importance of the carriageway.

In addition to the vehicular carriageway types, network functionality is defined independently for the different transport modes, including bicycle, and pedestrian users. The level of modal

Copyright © 2019 by MORE

priority on the corridor is defined as High, Medium, or Low based on the importance of the link to the individual mode system, as well as on the existing or potential demand in the corridor. Figure 10 displays the resulting functional classification matrix. In every cell of the matrix, the various users (drivers, bicyclists, and pedestrians) are defined and their balancing characteristics are provided.

Figure 10: Expanded Functional Classification System Proposed by the Kentucky Transportation Center

Context / Roadway	Rural	Rural Town	Suburban	Urban	Urban Core
Principal Arterial	H speed H mobility-L access	L/M speed M mobility-H access	M/H speed M mobility-M access	L/M speed M mobility-M access	L speed M mobility-M access
	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC, CC: M separation	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC: M/H separation; CC: H separation	LC: L separation; NC, CC: M separation
	P1: *; P2: Min; P3, P4: Wide	P2: Min; P3: Wide ; P4:Enhanced	P1: *; P2: Min;P3: Wide; P4: Wide	P2: Min; P3: Wide; P4: Enhanced	P3: Wide; P4:Enhanced
Minor Arterial	H speed H mobility-M access	L/M speed M mobility-H access	M speed M mobility-M access	L/M speed M mobility-M/H access	L speed M mobility-M/H access
	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC, CC: M separation	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC, CC: M separation	LC: L separation; NC, CC: M separation
	P1, P2: Min P3, P4: Wide	P2: Min; P3: Wide ; P4:Enhanced	P1: *; P2: Min;P3: Wide; P4: Wide	P2: Min; P3: Wide; P4: Enhanced	P3: Wide; P4:Enhanced
Collector	M speed M mobility-M access	L speed M mobility-H access	M speed M mobility-H access	L speed M mobility-H access	L speed M mobility-H access
	LC: L separation; NC, CC: M separation	LC, NC: L separation; CC: M separation	LC: L separation; NC, CC: M separation	LC: L separation; NC, CC: M separation	LC, NC: L separation; CC: M separation
	P1, P2: Min; P3, P4: Wide	P2: Min; P3: Wide ; P4:Enhanced	P1: *; P2: Min;P3: Wide; P4: Wide	P2: Min; P3: Wide; P4: Enhanced	P3: Wide; P4:Enhanced
Local	M speed M mobility-M access	L speed M mobility-H access	L speed L mobility-H access	L speed L mobility-H access	L speed L mobility-H access
	LC, NC, CC: L separation	LC, NC, CC: L separation	LC, NC, CC: L separation	LC, NC, CC: L separation	LC, NC, CC: L separation;
	P1, P2: Min; P3, P4: Wide	P2: Min; P3: Wide ; P4:Enhanced	P1: *; P2: Min;P3: Wide; P4: Wide	P2: Min; P3: Wide; P4: Enhanced	P3: Wide; P4:Enhanced

■ Vehicular Roadway Types	■ Bicycle		■ Pedestrian Users
Speed, Mobility, Accessibility and Separation Level	H: High	M: Medium	L: Low
Bicycle Connectors	LC: Local	NC: Neighborhood	CC: Citywide
Pedestrian Traffic Levels	P1: Rare / P2: Low	P3: Medium	P4: High
Pedestrian Facility Width	Min: Minimum	Wide: Greater than Minimum	Enhanced: Wide

Source: (Adapted from) Stamatiadis et al. (2017)

2.5.4 ‘Movement’ and ‘Place’ Functional Street and Road Classification System

2.5.4.1 Overview of the System

Although overcoming some of the limitations of the vehicle-based classification system, the expanded functional classification systems do not offer a complete approach to road and street categorisation. As explained in Chapter 2.5.1, over the past two decades there has been an increasing recognition that streets are not only conduits for moving people and goods, but are also destination and public places that contribute to healthy, social and prosperous communities. A number of recent studies and street design guidelines (Abbate, 2005; Duany et al., 2012; Forbes, 1999; Institute of Transportation Engineers, 2006; LaPlante and McCann, 2008; Marshall et al., 2004; Monderman, 2005) have emphasised the necessity of reformulating the conventional vehicle-based functional classification system, which should consider not only traffic but also other street urban activities. The Link and Place approach devised by Jones et al. (2007), in particular, answers to this need by evaluating the movement and place functions of a street in its wider urban context and thus accounting for the competing needs of a wide range of street users.

The Link and Place functional classification system recognises that, as a ‘link’, a street provides a conduit which can accommodate a broad range of transport modes, depending on its role within the wider urban transport networks. As a ‘place’, the street is a destination in its own right, which facilitates street-based activities and access to local properties. These encompass all manner of non-movement uses that contribute to the character and identity of the street, including loading and parking. Whereas the ‘link’ dimension denotes the role of a street section within the road transport network and follows the basic principle of conventional road hierarchy (although with a multi-modal emphasis), the ‘place’ status indicates the relative significance of the street as a urban place within the whole urban area (Jones and Boujenko, 2009; Jones et al., 2008; Marshall et al., 2004; Svensson and Marshall, 2007).

The Link and Place system thus provides the basis for developing a more comprehensive two-dimensional street classification, which is not vehicle-dominated and explicitly recognises that the link requirements (in terms of people and goods movement – not vehicle movement per se) need to be balanced against the wide range of place-related functions that streets perform. With this system every kind of urban road/street can be located and represented within a street type matrix.

The Link and Place Guidebook (Jones et al., 2007) lays out four basic steps to develop the link and place road classification:

- The first step is to establish an equal number of link and place categories, reflecting the equal importance of each dimension.
- The second step is to define the characteristics of each link status level, which may be based on an existing road classification system (e.g. from principal routes down to local access roads), but taking into account other modal hierarchies.

Copyright © 2019 by MORE

- The third step is to define the characteristic of each place status level. Place categories may reflect factors such as the size of the catchment area for activities associated with that street (e.g. for shops and services), the intensity of street activities, the cultural or heritage significance of the buildings fronting that section of street, the types of existing use in buildings and on public spaces, the presence of vegetation, and urban furniture.
- Finally, the matrix of the link and place is generated.

Figure 11 displays the link and place matrix included in the guidance of Transport for London (Transport for London, 2016b). This matrix uses a '3 x 3' framework, where the link status of the street segments is assessed along the y-axis against a three point scale and the place role is measured along the x-axis by using the same interval point scale. Side-by-side comparison of the two scores via the matrix allows for the categorisation of segments into street types. In Figure 11, for example, a 'City Place' street segment plays a relatively marginal role in the movement of through traffic, but represents a high significance as an urban place. A 'Core Road' street segment, by comparison, plays a pivotal role for traffic circulation, whilst has much less importance as a destination. Finally, a 'City Hub' street segment is critical for through traffic movement and, at the same time, contains a vibrant streetscape that functions as a citywide destination. This street type is important for both Mobility and Access, so is completely contrary to the AASHO principle.

Whereas a '3 x 3' matrix, with a total of 9 cells, has been used for strategic planning purposes in London, in other larger metropolitan areas, a '5 x 5' or even a '6 x 6' matrix, covering a wider range of street types, may be more appropriate, for more detailed analysis.

Figure 11: Example of a Link/Movement and Place Matrix

Source: (Transport for London, 2016b)

2.5.4.2 Applications

The development of the tools and techniques described in the Link and Place Guide were based on applications and trials in a series of projects primarily in London (Jones et al., 2007). Following publication of the guide, further applications have been carried out in a number of UK cities, including London, Manchester, Belfast and Birmingham, and also in other countries (Jones and Boujenko, 2009; Jones et al., 2008).

In particular, one of the most significant example of application of the Link and Place approach has taken place as part of a study aimed at informing the final White Paper on the Birmingham Mobility Action Plan (Birmingham Connected), which identifies priorities for investment in transport in the city for the next 20 years (Budhiraja et al., 2014). As part of the study a bespoke link and place matrix for the road and street network of Birmingham has been developed. The matrix, illustrated in Figure 12, comprises five link categories (Core Network; Primary Multi-modal Link; District Multi-modal Link; Local Multi-modal Link; and Local Access) and five Place classes (i.e. National/ city region level; Sub-regional level; District level; Neighbourhood level; and Local Level). The framework has helped practitioners to identify the requirements of different street user groups (e.g. bus users, cyclists, freight operators), their street activities (e.g. driving, parking, boarding-alighting, window shopping), and the associated minimum and desirable street design needs (e.g. width of a bus lane, area of a cycle stand).

Figure 12: The 5 x 5 Link and Place Matrix Devised for the Birmingham Street Network

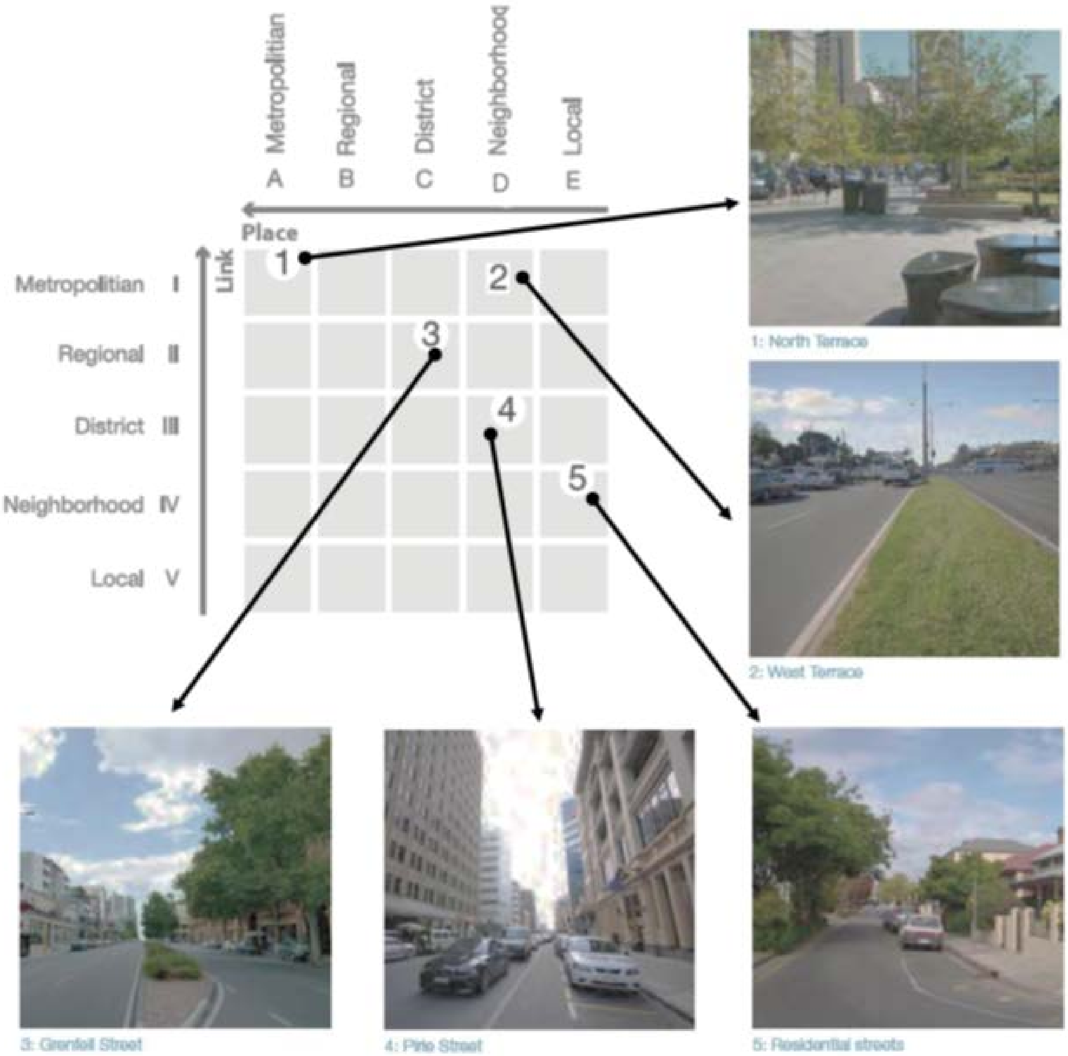
Source: (Adapted from) Budhiraja et al. (2014)

The key principles of this methodology have been adopted in the UK Manual for Streets (Department for Transport, 2007), and in other national guidance documents on street design (Chartered Institution of Highways and Transportation, 2010; Roads Task Force, 2013;

Transport for London, 2016b). Link and Place applications have also been included in the Irish Design Manual for Urban Roads and Streets (Department of Transport, Tourism and Sport and Department of Environment, Community and Local Government, 2013) and in street design guidelines published in China, New Zealand and Australia, New Zealand and China (Adelaide City Council, 2012; Auckland Transport, 2018; VicRoads, 2016).

Figure 13, for instance, illustrates the '5 x 5' link and place matrix which has been developed for the City of Adelaide, Australia, by the Adelaide City Council as part of its Transport and Movement Strategy (Adelaide City Council, 2012). The Strategy, explicitly oriented towards supporting the city's growth and ensuring its long term success, recognises the need for balancing competing street demands between pedestrians, cyclists, public transport, freight and motorists. The 'Link and Place' approach has thus been adopted to establish the strategic role of each street within the Adelaide's road and street network.

Figure 13: The 5 x 5 Link and Place Matrix Devised for the City of Adelaide



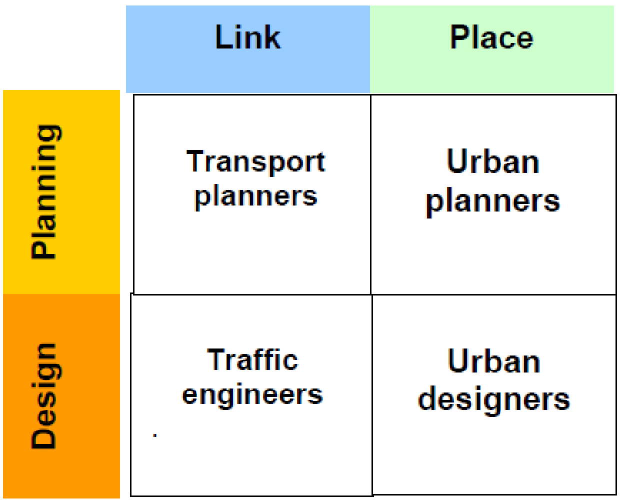
Source: (Adapted from) Adelaide City Council (2012).

2.5.4.3 Main Advantages of the Method

Classifying streets in this way has several advantages over the conventional vehicle-based functional road classification system (Jones and Boujenko, 2009; Jones et al., 2007; Marshall et al., 2004; Svensson and Marshall, 2007). In particular:

- Measuring link status and place status on the same scale helps to ensure that both dimensions are given equal consideration and therefore that all the street user needs are recognised and appropriately taken into account.
- Unlike the conventional vehicle-based functional classification system, the link and place approach can capture all the different streets types, including those one characterised by both significant link and place functions, since the approach assumes that the link and place functions are independent of each other
- The approach also provides a common platform for encouraging a closer dialogue between the different professions involved in street planning and design (Figure 14).
- Finally, the Link and Place approach is an easy-to-understand basis for engaging with the public and business communities during the planning and design of urban streets.

Figure 14: How Link/Place Planning and Design Functions Relate to Different Professional Interests



Source: Jones and Boujenko (2009).

2.6 Classification Systems adopted in the Case Study Cities

2.6.1 Overview

The results of the survey performed in the cities of Budapest, Constanta, Lisbon, London and Malmö show that the five MORE case study cities adopt different road and street classification systems. As illustrated in Table 5, in Constanta different categorisation approaches are employed, whilst in the other four cities only one main classification system appears to be in place. The conventional vehicle-based functional road classification system is adopted, although with some differences in terminologies and number of road classes, in the cities of Budapest and Constanta. By comparison Lisbon, Malmö and especially London employ more comprehensive functional classification systems. Based on this survey and with reference to Chapter 2.5.1, it is possible to conclude that in these cities there seem to be contrasting transport planning paradigms and different dominant policy perspectives.

Table 5: How Link/Place Planning and Design Functions Relate to Different Professional Interests

Classification systems	Cities				
	Budapest	Constanta	Lisbon	London	Malmö
Administrative Classification		✓			
Vehicle-Based Functional Road Classification System	✓	✓			
Expanded Functional Road and Street Classification Approach			✓		✓
Movement' and 'Place' Functional Street and Road Classification System				✓	
Destination Status Classification System		✓			
Strategic Function Classification System		✓			
Construction & Pavement Management Systems		✓			
Dominant Planning Paradigm/Policy Perspective	**Car-Oriented City**	***Car-Oriented City***	**Sustainable Mobility City**	**City of Places**	**City of Places**

2.6.2 Budapest (Hungary)

In Hungary guidelines for road design are developed and published at the national level by MAÚT Hungarian Road and Rail Society. In particular, the national *Road Design Standards* devised by MAUT represent the main document for road planning in this country. This document, covering all types of roads, all aspects of road design and all user groups and usages, is also adopted by the municipality of Budapest. The *Road Design Standards* categorise roads according to a conventional functional classification approach, which, however, accounts also for the specific context and environmental conditions in which each road operates. Table 6 includes an extract of this classification system, which is also used to inform the design standards of roads in terms of design speed and lane widths.

Copyright © 2019 by MORE

Table 6: Vehicle-Based Functional Road Classification System Adopted in Hungary and in Budapest

Urban roads		Design category	Network function	Environment condition	Design speed
Controlled-access highway	Motorway	Rural Roads I		A B, C	130 110
	Expressway	Rural Roads II		A B, C	110 90
Controlled-access highway	Motorway	Urban Roads I		A B, C	110 90
	Expressway	Urban Roads II		A B, C	90 80
Main roads	Primary main road	Urban Roads III	a	A B C	80 70 60
	Secondary main road	Urban Roads IV	b	A B C D	70 60 50 40
Minor roads	Collector road	Urban Roads V	c	A B C D	60 50 40 40-30
	Residential road, Living street, Service road	Urban Roads VI	d	A, B C D	40 30 -
	Bicycle road	Urban Roads VII	Based on ÚT 2-1.203 national road design standard		
	Pedestrian road	Urban Roads VIII			

Environment conditions

A Unbuilt or loosely built area, non-sensitive environment

B Unbuilt or loosely built area, sensitive environment

C Densely built area, non-sensitive environment

D Densely built area, sensitive environment

Network Functions

a Urban parts of primary main roads and secondary main roads; Connection roads among centre of districts; Access roads to commercial and industrial centres; Bypass roads of settlements

b Urban parts of tertiary roads; Connection road among sub centre of districts

c Urban parts of rural roads; Access road to periphery railway station; Connection streets among residential areas; Main roads at city centres; Bypass roads of minor settlements

d Local streets at living areas; Services roads at commercial and industrial areas

Copyright © 2019 by MORE

2.6.3 Constanta (Romania)

In Romania, minimum standards requirements for roads and streets are determined by the national Ministry of Transport and the national Ministry of Regional Development and Public Administration. The city of Constanta is not directly involved in the development of national standards and guidelines, although plans regarding street design and road space allocation in the city have been recently developed as part of the PORTIS Project. In Romania, the road classification is mainly foreseen in the Government Decision no. 43/1997. Different types of classifications exist (Table 7).

Table 7: Classification Systems Adopted in Romania and in Constanta

Classification Systems	Categories of Streets and Roads
Destination Status (adopted at national level)	*Public Roads* - managed by the national Ministry of Transport, county councils or municipalities
	Private Roads - managed by individuals or legal persons
Administrative Status (adopted at national level)	*National Interest Roads* - managed by the national Ministry of Transport
	County Interests Roads - managed by the county councils
	Local Interests Roads - managed by the municipalities
Vehicle-based functional road classification system (adopted at national level)	*Category I Roads* – thoroughfare, which assures the takeover of the major traffic flow of the city on the direction of the national road crossing the city or in the main direction of connection with this road
	Category II Roads – link, which assures the major traffic between functional urban areas and housing areas.
	Category III Roads – collectors, which takeover the traffic flows from the functional urban areas and guides them to linking streets and thoroughfares.
	Category IV Roads – for local use, which assures access to housing and for occasional and day to day services, in areas with very limited traffic
Strategic Function Classification System (adopted by the Constanta Municipality)	*Strategic Highway Network* (Cat I Roads) - European and National roads, including the motorways which are entering the city and transform themselves in urban roads/streets.
	Primary Highway Network (Cat I & II Roads) - assures a big traffic capacity and an optimal speed for connecting the Constanta City territory with the surrounding localities and is composed of the main boulevards and 4 (four) streets with intense car traffic.
	Secondary Highway Network (Cat II & III & IV Roads) - core streets network, granting access to the territory urban functions and also providing alternative routes to those provided by the core network

(Table continued on following page)

Copyright © 2019 by MORE

Classification Systems	Categories of Streets and Roads
Construction & Pavement Management Systems (adopted at national level)	*Refurbished Roads*
	b) *Non-Refurbished Roads*
	c) *Improved/Modernized Roads*
	d) *Paved (with stone) Roads*

2.6.4 Lisbon (Portugal)

In Lisbon, the *Public Space Manual* developed by the Public Space Department of the city administration represents the core guidelines used for urban road/street design, covering all types of roads and streets, all types of users and usages, and all relevant aspects of urban road/street design. In this city an expanded functional road and street classification approach, which builds on the conventional vehicle-based road classification system but accounts also for the requirements of other transport modes, is adopted (see Figure 15)

Figure 15: Classification Systems Adopted in Lisbon

Level		1st level	2nd level	3rd level	4th level	5th level
Road Network designation		Structural road network	Main distribution network	Secondary distribution network	Proximity street network	Local street network
Objectives		Supports long distance routes	Distribution of inter and intra-sectors	Distribution to local network	Neighbourhood distribution	Protection and incentive of pedestrian use
Function	Connects to primary national road network	♦				
	Connects to inter-district and Lisbon' through-traffic roads	♦				
	Connects to metropolitan road network		♦			
	Gathers and distributes urban sector traffic		♦	♦		
	Gathers and distributes neighbourhood traffic				♦	
	Local access street				♦	♦
Specific requirements		Totally independent of surroundings	Protection of surroundings		Traffic calming measures introduction	Traffic calming measures introduction
Pedestrian coexistence		Forbidden	Segregated	Segregated	Segregated or free	Free
Cycling coexistence		Forbidden	Segregated	Segregated or free	Segregated or free	Free

Source: WP 1, Information from Lisbon

2.6.5 London (UK)

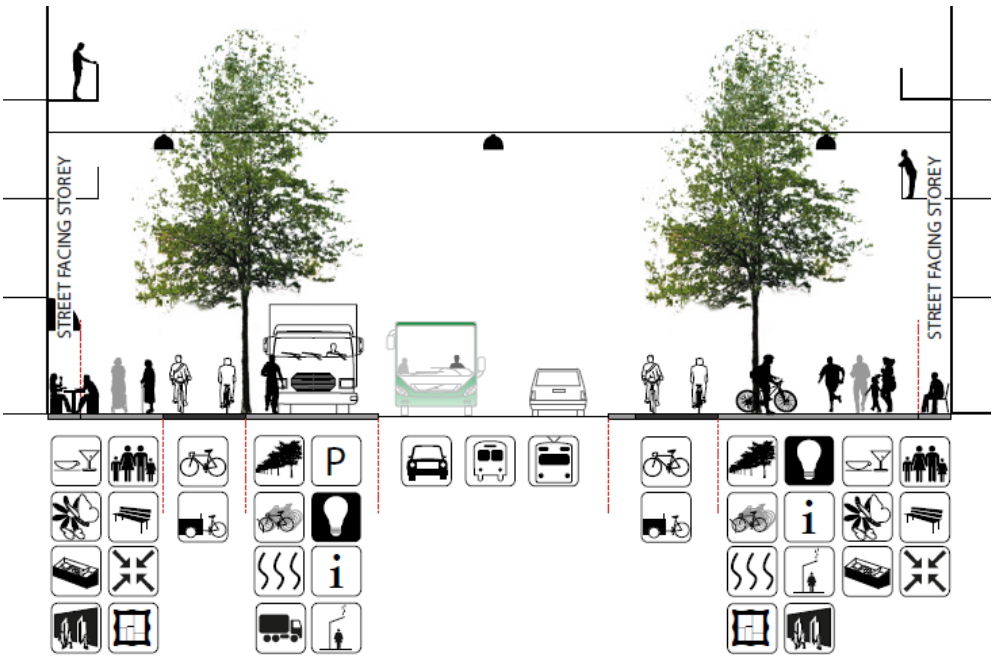
In London, policy document and guidelines on road and street planning and design are produced by the Department of Transport (whose documents are valid mainly in England and Wales) and Transport for London. As already highlighted in Chapter 2.5.4, in London, a

‘Movement’ and ‘Place’ Functional Street and Road Classification System, based on the *Link and Place Guidebook* (Jones et al., 2007) is employed. Key publications on this approach include the already mentioned *Manual for Streets* (Department for Transport, 2007) and *Manual for Streets 2* (Chartered Institution of Highways and Transportation, 2010), the *Vision and Direction for London's Streets and Roads* (Roads Task Force, 2013) and the *Street Types for London* (Transport for London, 2016b).

2.6.6 Malmö (Sweden)

In Sweden, the municipalities of the major cities such as Stockholm, Gothenburg and Malmö tend to develop their own guidelines regarding road and street planning and design. The most relevant documents produced by the city of Malmö on this subject include the Technical Design Manual published by the Estates Streets and Parks Department of the city of Malmö. This comprehensive document discusses urban street design, traffic management, safety, road construction and maintenance, urban infrastructure design, utilities, civil engineering structures and winter maintenance principles. Guidelines on road design at the national level are also published by the Swedish Transport Administration and the Swedish Association of Local Authorities and Regions. Although not explicitly identified during the survey, also the city of Malmö seems to take a rather broad view on road and street design and classification, which clearly supports walking, cycling and public transport as well as environmentally friendly freight and car traffic. Figure 16, extracted from the *Malmö Sustainable Urban Mobility Plan* adopted by the City Council (City of Malmö, 2016) demonstrates a great appreciation of the multiple functions that roads and streets perform.

Figure 16: Street Functions Considered in the Sustainable Urban Mobility Plan of the City of Malmö



Source: City of Malmö (2016)

Copyright © 2019 by MORE

2.7 Summary and Conclusions

In conclusion, the key points of this review can be summarized as follows:

- The earliest modern forms of road classification systems began to be developed in the first half of the twentieth century. Nowadays, a variety of systems are used to classify road and street networks.
- Geometric design, administrative status and especially functional aspects are amongst the most well established, well known and widely adopted approaches to categorise streets and roads
- In the course of time, various functional classification systems, reflecting different transport planning paradigms and schools of thought and focusing on different policy priorities, have been devised.
- The traditional vehicle-based functional road classification system allocates priority to vehicle drivers and the vehicle-based movement function of the street, whilst neglecting other users and street functions. It also only balances mobility and access through an inverse relationship which fails to take into account the existing reality of a diversity of street types.
- In recent years, several expanded functional classification systems have been proposed in an attempt to account for a wider range of road functions, the context in which roads and streets operate and the different design requirements of the various transport modes. However, these systems, although overcoming some limitations of the vehicle-based classification system, do not offer a complete approach to road and street categorisation.
- By comparison, the ‘Movement/Link’ and ‘Place’ Functional Street and Road Classification System presents a greater appreciation of the role of streets as places for activities, for pedestrian, bicycle and transit movement, and as part of the public realm and overall urban environment. This system thus provides the basis for developing a more comprehensive two-dimensional street classification, which is not vehicle-dominated and explicitly recognises that the link requirements have to be balanced against the wide range of place-related functions that streets perform.
- The five MORE case study cities (Budapest, Constanta, Lisbon, London and Malmö) adopt different road and street classification systems. In Budapest and Constanta, a conventional vehicle-based functional road classification system is adopted. These cities seem thus to employ mainly a pro-car perspective. The functional classification systems devised by the city of Lisbon, by comparison, take into consideration also the requirements of other transport modes, thus taking a more sustainable mobility perspective on road and street planning and design. Finally, the cities of Malmö and London appear to adopt a place based perspective, characterized by a growing interest in urban quality and vitality. London, in particular, employ a more comprehensive functional classification systems based on the Link and Place principles.

Copyright © 2019 by MORE

3 Street Design Objectives and Performance Indicators

3.1 Use Cases and Conceptual Framework for Assessing Proposed Solutions

In urban street design, there is rarely one clear preferred solution—superior to all the other alternatives in all Key Performance Indicators (KPIs)—used for assessment. In most cases, the comprehensive satisfaction of all user requirements demands more space than is available and it is rarely possible—at best—to provide the highest performance levels for all user groups. Specific street sections might work very well for one user group but are designed insufficiently for others. The provision of a dedicated cycling lane might, e.g., compete with the provision of a dedicated bus lane. Link users aim at moving fast and reliable whereas place users appreciate low traffic volumes and speeds. The challenging task of balancing the different user needs can only be solved on a case-by-case basis. Local stakeholders often discuss and negotiate possible solutions over long periods of time. Formal and informal procedures for getting relevant stakeholders, such as residents, local interest groups, business representatives or public transport providers, involved into these negotiations exist in all countries and cities and are investigated in MORE in WP2.

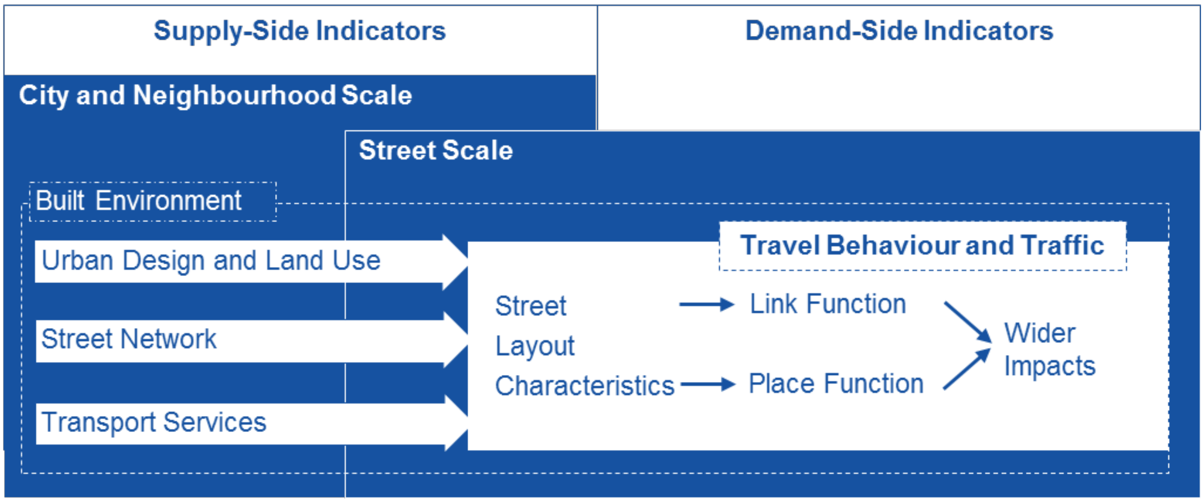
Seeing this difficulty in finding optimal solutions and in balancing the different user needs, it is surprising how little information the researched guidance materials on urban street design contain about objectives and performance indicators. Instead, such information was mainly identified in strategic documents—such as in sustainable urban mobility plans (SUMP), and in publications from NGOs, research projects, public authorities and academic institutions.

The focus of the MORE project and also of this Chapter is on urban street design and on metrics that allow comparing different alternative design solutions for specific street sections and that are also a suitable basis for before-after comparisons when street design is modified. This Chapter provides an overview about which metrics have been identified in the various studied documents. The identified metrics are grouped along the three terms objectives, indicators and targets; these are defined for this deliverable as follows.

- Objectives: Objectives are qualitative goals and visions; this might be, for example, in the case of safety, the improvement of traffic safety as a very general goal on the aggregate level.
- Indicators: Indicators operationalise the qualitative objectives; they make the objectives measurable and thus allow for the measuring of progress towards formulated objectives. Indicators for the objective of improving traffic safety might be, for example, the number of injured or killed persons in traffic.
- Targets: Targets combine objectives and indicators by setting specific values for the chosen indicators that wish to be achieved. For traffic safety this might be Vision Zero: no person killed or seriously injured until, e.g., 2030.

The different objectives, targets and indicators are not independent from each other: There are conflicts and synergies, and also causal relationships. Figure 17 shows the conceptual framework that is used for systemising the identified objective, targets and indicators. The framework focusses on the influence of the built environment on travel behaviour and traffic. The various further determinants such as users' socio-demographic, socio-economic as well as socio-psychological characteristics (see e.g. Koszowski et al., 2019) are purposefully left out because these can be hardly influenced or changed by urban street design.

Figure 17: Framework for the Street Performance Assessment Scheme (SPAS)



The objectives, targets and indicators are grouped into the following two themes:

<u>Supply-Side Indicators:</u>

These indicators characterise the built environment on the city/neighbourhood scale, and on the street scale. For this study, supply-side indicators are grouped into *Urban Design and Land Use*, *Street Network* and *Transport Services* as described below.

The importance of the built environment for travel behaviour is high, particularly for walking and for the place activities. The "5Ds" of *density*, *destination accessibility*, *design*, *distance to public transport*, and *diversity* refer to the neighbourhood scale and have been shown in the literature consistently as more influential on walking than any other variable (Cervero and Kockelman, 1997; Ewing and Cervero, 2010). In Figure 17, *Urban Design and Land Use* include the factors *density* and *diversity*. The dimension *density* is defined as number of residents or workplaces per analysed area unit and determines the spatial structure of the built environment. *Diversity* describes the heterogeneity respectively the homogeneity of land uses in a defined area. A high variety of land uses means a high amount of potential destinations, which can be reached at short distances (*destination accessibility*) (Cervero and Kockelman, 1997; Ewing and Cervero, 2010).

Street Networks contain the "D"-Variable *design* and describe the characteristics of the street networks (e.g. orthogonal vs. radial grids) and of their individual parts (e.g. intersections, streets, or squares). They include the provision of seamless street networks for all users (street network connectivity) and are measured by indicators such as link-node-ratio, intersection density, street network density, connected node ratio, block density, and average block length (Berrigan et al., 2010; Cervero and Kockelman, 1997; Mayor of London, 2018). A highly connected street network is usually formed by a dense urban grid and thus provides many route choice options to each one destination.

Transport Services includes specific services and facilities for each user group. For example, public transport supply is described by its accessibility, this means the distance to the nearest public transport stop from residence or workplace (“D”-variable *distance to public transport*) or the distance between public transport stops (Ewing and Cervero, 2010).

All three groups of variables describing the built environment can be defined on the city and neighbourhood as well as on the street scale. For the street performance assessment scheme to be developed in this chapter, the focus lies exclusively on street scale; these are objectives, targets and indicators that characterise the street environment itself and that are sensitive to changes in the layout of specific street sections and junctions. Indicators on the city- and neighbourhood scale as described above should be added to the street performance assessment scheme if the activities for re-designing streets in the MORE corridors go beyond the specific street sections and include also changes in transport services and networks or in land use.

<u>Demand-Side Indicators</u>

Demand-side indicators describe the usage of the built environment functions and the transport supply. Indicators for the *link function* describe the quality of movements. They describe the quality of streets as conduits which allow movements of different user groups in passenger and freight. The overall ambition for the link function is to achieve safe, fast, reliable and convenient movements (save time). Indicators for the *place function* describe the quality of place activities. They describe the quality of streets as destinations and as public spaces. For the place function, the main objective is to motivate place users to stay and to maximise dwell times in the streets (spend time). Link and place activities generate various impacts. These are summarised in the category *wider impacts* and include (1) all environmental and safety effects of movements that should be minimised, (2) health benefits that result from higher shares of the active modes walking and cycling as physical activity, and (3) economic indicators such as the costs of providing transport services.

In the following Chapters 3.2 and 3.3, tables are provided for each theme. Objectives, targets and indicators are listed in the tables in separate columns. The right-hand column lists the references for where each identified objective was found. For example, many references occur for safety since this was included in all researched documents, either on the strategic level such as SUMPs or on the street level of specific street sections. This clear commitment to safety improvements is a direct result of the prioritisation of this issue in political programmes but also from a legal standpoint. The Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008, on road infrastructure safety management is mandatory for all EU member states. This ensures the establishment of procedures for continuously monitoring accidents in terms of location, type, severity, and involved user groups (e.g., vulnerable road users versus motorised vehicles) and also the implementation of measures for improving safety. Another frequently included objective is the decrease of greenhouse gas emissions; this was mentioned in nearly all researched references.

London gives high priority to health effects and to street designs that support active modes and place functions (Transport for London, 2017b, 2017c). The Healthy Streets Check for Designers is a tool that is compulsory to use on some TfL schemes (over a certain budget and directly affecting the experience of people using the street) but can be used on any scheme affecting the street environment. The topic of health effects is also emerging in the other MORE partner cities but by far not as prominently visible in their objectives, targets or indicators for urban street design. Therefore, an own chapter 3.4 is dedicated to criteria from Transport for London for Healthy Streets and Pedestrian Comfort in addition to the tables provided in chapters 3.2 and 3.3 that also include the TfL criteria.

Objectives and demand-side indicators for the planning processes have also been found, such as the type or number of events during a specific planning task, the number of participants, or the media coverage. These process-related demand-side indicators are covered in WP2 within the MORE project.

3.2 Demand-Side Indicators

3.2.1 Link Functions

The following Table 8 lists objectives, targets and indicators for the link function. They describe different aspects of the quality of movements for the different user groups of pedestrians, bicycles, innovative micro-vehicles such as electric scooters, buses and trams, cars, vans and medium-sized delivery vehicles, heavy duty vehicles. The objective of maximising the quality of movements is similar for all user groups; indicators are straightforward and easy to understand. The difficulty lies in the restricted availability of space and capacity in streets and junctions. It will hardly or never be possible to provide for unhindered movements for all user groups. The task of urban street designers is to find balances that ensure stable traffic flows. Political priorities for selected user groups and/or mandatory minimum LOS might exist as hard constraints for this optimisation task.

Copyright © 2019 by MORE

Table 8: List of Objectives, Targets and Indicators for the Link Functions

Theme	Objectives	Targets	Indicators	Exemplary References
Traffic volumes and quality	Keep traffic flows stable, increase traffic quality, achieve defined Levels of Service (LOS, usually A-F, derived from quantitative demand-side indicators) per user group Minimise congestion For place attractivity: low volumes of (heavy duty) motorised vehicles	Achieve pre-defined LOS target levels, e.g. LOS D as a compromise that acknowledges that highest LOS (LOS A) cannot be achieved for all street users while at the same time keeps traffic flow stable	Traffic volumes (all user groups) [veh.-km] [veh.-trips] [ped.-trips] etc. Examples for quantitative indicators used as the basis for computing LOS: Traffic density [vehicle/km] Utilisation rate [vehicle/hour over capacity] Waiting times at junctions [min]	(Intraplan Consult GmbH, 2017; PTV AG, 2007; PTV Planung Transport Verkehr AG et al., 2016; Szabo and Schäfer, 2016) (City of Malmö - Streets and Parks Department, 2019; Constanta Municipality, 2015; MAUT, 2008; Mayor of London, 2018; Road Task Force, 2013; Transportation Research Board, 2016)
Speed, delays	Requirements for link function: increase speed for specific user groups, time periods, use cases; decrease delays and waiting times at junctions Requirements for place function (see also Chapter 3.2.2): Lower speed levels of motorised vehicles (this allows for re-allocating road space, increases safety levels and quality of urban space)	For link functions: hardly any specific target levels, rather comparisons of speeds in different alternatives In London, the goal is to reduce overall traffic levels while keeping congestion broadly at today's levels during peak periods. For place function see Chapter 3.2.2	[km/h] [minutes delay per km driven] [km] of street sections with certain speed limits	(PTV AG, 2007; Szabo and Schäfer, 2016) (International Federation of Pedestrians, 2012; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2019a) (City of Malmö - Streets and Parks Department, 2019; International Federation of Pedestrians, 2012, 2012; Lisbon Municipality, 2015; Mayor of London, 2018; Transport for London, 2017b, 2017c, 2019b)
Travel time	Direct correlation with speed, objectives: Reduce travel time for specific user groups (passenger versus freight, pedestrians, cyclists, motorised private vehicles, public transport) and trip purposes, reduce related monetary losses Travel times to destinations are influenced by speed and by directness/detour factors (and also distance to the destination)	Absolute values e.g. for maximum travel times to specific destinations or relative targets (e.g. improvement) compared to reference period	[person-h/year] [vehicle-h/year] Might be distinguished in peak vs. off-peak, might be weighted e.g. by the number of affected persons Monetised gains and losses in travel times [€/year]	(Intraplan Consult GmbH, 2017; PTV AG, 2007; PTV Planung Transport Verkehr AG et al., 2016; Szabo and Schäfer, 2016) (Budapest Municipality, forthcoming; City of Malmö - Streets and Parks Department, 2019; Constanta Municipality, 2015; Road Task Force, 2013)
Reliability	Increase reliability, peak/ off-peak	Absolute targets such as percentage of journeys not exceeding specific delay values Relative targets (e.g. improvement) compared to reference periods	Average delay [min] or [€/year], frequency of delays above specific thresholds Might be distance-weighted Breakdowns in PT	(Intraplan Consult GmbH, 2017; PTV AG, 2007; PTV Planung Transport Verkehr AG et al., 2016) (Mayor of London, 2018; Road Task Force, 2013)
Modal split	Change of trip-based modal split towards walking, cycling, PT Objective formulated on city level but also for specific neighbourhoods or street sections	Absolute target values for shares of specific modes in modal split	[%] (e.g. target share of active modes walking and cycling), to be computed based on traffic volumes for each user group	(Budapest Municipality, forthcoming, 2013, 2017; City of Malmö, 2016; Constanta Municipality, 2015; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2018a)

veh = vehicle; ped = pedestrian

Copyright © 2019 by MORE

3.2.2 Place Functions

Place functions are more diverse than link functions. They encompass all types of activities that do not use street as conduits for movements but as destinations. Place users come to streets because they like to spend time and to dwell in the public street space or because they want to carry out activities in the adjacent buildings. These different types of place activities have different degrees of voluntariness as well as different determinants and requirements:

1. Parking and stopping: Vehicles (buses, trams, cars, vans, heavy duty vehicles, motorcycles, scooters) stop in the street for loading or unloading goods or passengers, or for supplying shops and businesses in the adjacent buildings. Drivers do not accept long distances from the parked vehicles to the final destination; they tend to park illegally if no suitable parking space is provided. Demand-side indicators are suggested to monitor these activities in terms of number, type, duration and possible conflicts or interactions that might be caused by these activities.
2. Access to adjacent buildings: Persons and in some cases also vehicles need to access the adjacent buildings. Space needs to be provided and needs be kept clear from other usages even if the access to the adjacent buildings is a rare event. Sufficient ranges of vision are paramount for avoiding conflicts with other street users and usages.
3. Place activities in the street as destination: Gehl (2010) and Gehl and Svarre (2013) distinguish the following types of place activities in streets as destinations:

- Necessary place activities: These activities have to been undertaken, they can be observed under all conditions even when facilities for these functions are poor. A typical example is waiting for the bus.
- Optional place activities: These are activities that people might like and that people do voluntarily, e.g. recreational activities, walking down the promenade, standing up to get a good look at interesting and nice things, sitting down to enjoy the view or the weather.
- Social place activities: These include all types of communication and require the presence of other people. Typical examples for social place activities are watching people and what is happening, exchanging greetings, to talk to and to listen to acquaintances, chance meetings and small talks at market booths, on benches or wherever people wait, people asking for directions, exchanging brief remarks about the weather or when the next bus is due, young people hanging out and using city space as meeting place. More extensive contacts and conversations might result from these short talks, acquaintanceships might sprout. Social place activities happen spontaneously and can hardly be predicted, but they can be invited and encouraged by suitable street layouts. Planned common activities such as markets, street parties, meetings, parades and demonstrations also belong to this category of social place activities.

Gehl (2010) demonstrates convincingly, based on various examples, that, with better conditions in the streets, people emerge from their buildings to stay in city space. Chairs are dragged out in front of houses and children come to play. Versatile city and street life largely depend on invitation, this holds particularly for place activities in the street as destination.

Copyright © 2019 by MORE

Objectives, targets and indicators for the different types of place functions are listed in the below Table 9.

Table 9: List of Objectives, Targets and Indicators for the Place Functions

Theme	Objectives	Targets	Indicators	Exemplary References
Necessary Activities	Meet the needs of place users for carrying out necessary activities such as waiting for a bus	Increase the comfort for necessary place activities	Number, type and duration of necessary activities	(Gehl, 2010; Mayor of London, 2018; PTV AG, 2007)
Optional Activities	Increase the intensity of place usages in the street	Increase the overall duration (number of activities times their duration) of optional activities	Number, type and duration of optional activities: standing/ (in)formal seating/ strolling/ lying down Examples for optional activities: wait, work, eat, drink, window shop, use mobile devices, read, enjoy life/ the weather, smoke, walk pet, take photo, navigate, talk on the phone, feed pigeons, look at others/ something, rest, shelter, queue	(Gehl, 2010; Mayor of London, 2018; PTV AG, 2007)
Social Activities	Increase the intensity of place usages in the street	Increase the overall duration (number of activities times their duration) of social activities	Number, type and duration of social activities (all types of communication and interaction): standing/ (in)formal seating/ strolling/ lying down Examples for social activities: talk, sing, play, work, meet, engage in cultural activities/ performing, skateboarding/ rollerblading in groups, vending / commercial activity	(Gehl, 2010; Mayor of London, 2018; PTV AG, 2007)
Access to adjacent buildings	Allow for safe and smooth access to adjacent buildings and usages	Meet needs for access Minimise conflicts and incidents	Number of access activities to adjacent buildings Interactions and incidents	(FGSV, 2006)
Parking	Provide for parking	Meet parking needs Minimise conflicts, incidents, accidents related to parking (e.g. dooring, crossing) Reduce illegal parking	Number and location of parked cars (observation) over the day/ week/ year, purpose of parking activities (on-site interview), duration of parking activities	(Transport for London, 2017d)
Stopping (un-)loading, delivery)	Provide for delivery, (un-) loading	Meet needs for (un-) loading, delivery Minimise conflicts, incidents, accidents (e.g. dooring, crossing) Reduce illegal stopping	Frequency and location of stopping activities over the day/ week/ year, purpose and duration of stopping activities, proportion of stopping activities during peak hours or other specific time periods, type of vehicle	(Transport for London, 2017d)

Copyright © 2019 by MORE

3.2.3 Wider Impacts

Demand-side indicators on wider impacts operationalise the consequences of any usage of the street space. These indicators are the basis for cost-benefit analysis or other methods used for assessing proposed street design solutions. The below Table 10 summarises typical demand-side indicators as identified in the researched material.

Table 10: List of Objectives, Targets and Indicators for Wider Impacts

Theme	Objectives	Targets	Indicators	Exemplary References
		Health		
Health	Increase in residents' physical activity (overall or in transport), reduce health costs, skim societal benefits from (increased) physical activity	WHO-targets for physical activity, e.g. 150min of moderate physical activity per week To meet certain durations of physical activity per week overall or only from travel Reduction in health cost compared to reference levels	[min moderate/intense physical activity per week], for specific person groups such as children, adults or seniors [min walking/cycling travel per week] [%] reduction in health cost, e.g. computed with WHO HEAT-tool (https://www.heatwalkingcycling.org)	(Lisbon Municipality, 2015; Mayor of London, 2018)
		Economic effects		
Cost (Investment, Operation) (s)	Reduce cost for investment and operation (vehicles, infrastructures), might be distinguished by user group (private versus PT, passenger versus freight transport,	Minimisation of cost	Total investment cost Total annual cost for operation Total annual cost for maintenance [€/year] Proportion cost for operation / investment cost [%] Relative cost, e.g. average cost per kilometre [€/100km]	(PTV AG, 2007; PTV Planung Transport Verkehr AG et al., 2016; Schäfer and Walther, 2008; Szabo and Schäfer, 2016) (Budapest Municipality, forthcoming; Constanta Municipality, 2015)
Economic Success of Adjacent Usages	Ensure economic success of businesses adjacent to the street	Maximise economic success and attractivity of buildings	Number and type of businesses in adjacent buildings Annual turnovers of adjacent businesses Number of customers	(Mayor of London, 2018)
		Safety		
Safety	Improve traffic safety For specific user groups (pedestrians, cyclists, motorised private vehicles, PT) For specific types of infrastructures or accidents (e.g. at junctions, at public transport stops, at pedestrian crossings) Subjective (perceived) vs. objective (measured) safety	Vision Zero (no death, no severely injured) Relative reductions in number and severity of accidents compared to reference level Improvements in user perceptions (e.g. based on intercept surveys)	Total number of accidents/injured per year (per 3 years for accidents with personal injury) Number of accidents/injured per length of infrastructure [km] Number of accidents/injured per length of infrastructure [km] and traffic volume [veh.-km] All the above indicators might be monetised (absolute accident cost, accident cost per km / veh.-km) Percentage reduction of accidents/ accident cost [%]	(Intraplan Consult GmbH, 2017; PTV AG, 2007; PTV Planung Transport Verkehr AG et al., 2016; Schäfer and Walther, 2008; Szabo and Schäfer, 2016) (Budapest Municipality, forthcoming; City of Malmö - Streets and Parks Department, 2015; Constanta Municipality, 2015; Lisbon Municipality, 2015; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2017b, 2017c, 2018d, 2019b)

veh = vehicle; ped = pedestrian
(Table continued on following page)

Theme	Objectives	Targets	Indicators	Exemplary References
Environmental effects and resource consumption				
Energy Consumption	Reduce energy consumption in total or particularly for fossil fuels Improve efficiency of the transport system	Absolute or relative reduction targets for total fuel consumption / fuel consumption per kilometre Absolute or relative increase in the use of renewable energy	Total fuel consumption [t fuels/year] Relative fuel consumption per distance [t fuels/100km] Percentage reduction of fuel consumption [%] Proportion of renewable energy [%] Proportion of electric vehicles or zero emission vehicles in vehicle fleet [%]	(PTV AG, 2007; PTV Planung Transport Verkehr AG et al., 2016) (Budapest Municipality, 2013, 2017; Constanta Municipality, 2015; Mayor of London, 2018)
Air Pollutant Emissions, Air Quality	Improve air quality, reduce air pollutant emissions	Meet air pollution targets e.g. for NO2, PM, ozone Reduce environmental cost Reduce emissions from transport (absolute per year, relative per distance driven)	Number of days with exceedances of legal limit values given by the European Air Quality Directive Mean air pollutant concentration per year, e.g. [g NO2/m³] Tons of specific air pollutants emitted in transport [t NO2/year] [g NO2/veh.-km]	(PTV AG, 2007; PTV Planung Transport Verkehr AG et al., 2016; Szabo and Schäfer, 2016) (Budapest Municipality, 2013; City of Malmö, 2016; Constanta Municipality, 2015; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2019b)
Greenhouse Gas Emissions	Reduce GHG-emissions from transport	Absolute or relative reductions compared to reference levels (e.g. current situation or BAU scenarios) Meet specific absolute targets Zero emission in London by 2050	[t CO2], [t CO2e] (as target values or as reduction values compared to reference levels) [%]-reduction compared to reference levels	(Intraplan Consult GmbH, 2017; PTV AG, 2007; PTV Planung Transport Verkehr AG et al., 2016; Schäfer and Walther, 2008; Szabo and Schäfer, 2016) (Budapest Municipality, forthcoming, 2013; City of Malmö, 2016, 2018; Constanta Municipality, 2015; Lisbon Municipality, 2015; Mayor of London, 2018; Road Task Force, 2013)
Noise Emissions, Noise Exposure	Reduce noise emissions, meet targets for maximum noise exposure	Meet specific noise levels [dB(A)] Reduce number of persons affected by specific noise levels [dB(A)]	[number of persons affected by noise levels dB(A) above certain thresholds] Indicators of European Environmental Noise Directive	(City of Malmö, 2016; Constanta Municipality, 2015; European Commission, 2002; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2019b) (Intraplan Consult GmbH, 2017; PTV Planung Transport Verkehr AG et al., 2016)
Micro Climate	Improve micro climate e.g. in particular hot time periods Monitor and minimise urban heat islands in a spatial and timely breakdown	Usually relative targets compared to reference levels (e.g. current situation)	Number of trees or other street furniture providing shade Temperature difference between unbuilt areas, green areas and built-in areas	(Budapest Municipality, 2013, 2017; Lisbon Municipality, 2015; Transport for London, 2017b, 2017c, 2019b)
Land Use, Space Consumption	Minimise land use, protect soil quality, protect water quality (groundwater, rivers or lakes in proximity), reduce risk of flooding	Reduce sealed surface, provide sufficient space for infiltration	Size or share of sealed surface for specific usages/ user groups [m²] [%] Size of infiltration spaces [m width in street-cross-section], [m²] Per capita green area	(Intraplan Consult GmbH, 2017; PTV AG, 2007; Schäfer and Walther, 2008; Szabo and Schäfer, 2016) (Budapest Municipality, 2013, 2017)
Nature Conservation	Minimise impairment to habitats	Protection of habitats from endangered animal and plant species	Size of affected areas [m²], number of cut (and so far connected) habitat areas for certain species, qualitative indicators	(PTV Planung Transport Verkehr AG et al., 2016) (Constanta Municipality, 2015)
Resilience	Improve resilience to severe weather and climate change or other disruptive changes in societal framework conditions			(Mayor of London, 2018; Vienna Municipality, 2015)
Streets as ecosystems				See WP2

veh = vehicle; ped = pedestrian

Copyright © 2019 by MORE

3.3 Supply-Side Indicators: Characteristics of the Street Section

Supply-side indicators were introduced in Chapter 3.1 as characteristics of the built environment on the city, neighbourhood scale, and on the street scale. For the MORE project, mainly the street scale is relevant including all three groups of supply-side indicators *Urban Design and Land Use*, *Street Network* and *Transport Services* as described above. The below Table 11 lists all objectives, targets and indicators that have been identified as relevant for urban street design. Variables in the group *Street Network* describe the space that is provided to the different user groups, the types of separation between the user groups and the provided street furniture/equipment.

Variables in the group *Urban Design and Land Use* describe the proportions of the different elements of the street layout themselves (e.g. width of carriageway vs. widths of footways) but also the proportions of the street width vs. the type and height of the adjacent buildings. Further variables characterise the buildings, their usage (land use) and the transition spaces between the street and the buildings (soft vs. hard edges). The topics of security and protection are also covered in this group of supply-side indicators.

There are only few variables in the group *Transport Services* that are relevant on the street scale as this group is mainly about the quality, quantity and accessibility of services provided on the city and neighbourhood scale. However, most of these services eventually happen on streets. Therefore, two variables *Multi-Modal Transport Services* and *Innovative Transport Services* are included in the below list; these describe the provision of facilities for changing transport modes within a street or for using innovative services such as scooter sharing.

Table 11: List of Supply-Side Objectives, Targets and Indicators characterising Specific Street Sections

Theme	Objectives	Targets	Indicators	Exemplary References
		Street Network		
Space for link functions	Provide adequate street dimensions and capacity for all user groups, respect minimum space requirements e.g. because of vehicle widths or geometric tractrix curves	Provide adequate space per user group	Space provision per user group in cross section [m] [m²] Percentage change [%] Share of street sections with dedicated lanes for PT/ cycling	(Szabo and Schäfer, 2016) (City of Malmö - Streets and Parks Department, 2019; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2017b, 2017c, 2019b)
Appropriate facilities and separation of user groups (link and place)	Provide appropriate facilities for each user group as the core prerequisite for quality, safety, comfort, for street sections and junctions	Provide adequate facilities for each user group	Documentation of facilities for each user group, comparison with recommended values in guidance material	(City of Malmö - Streets and Parks Department, 2010a, 2019; Transport for London, 2019c)
Appropriate signalising schemes at junctions	Ensure safe, smooths and comfortable movements at junctions for all user groups Prioritise selected user groups	Increase safety, reliability Decrease waiting time, detours while crossing a junction	Documentation of signalling scheme	(City of Malmö - Streets and Parks Department, 2019)
Space for place functions	Increase space for place functions (static or dynamic): sit, stand, dwell, stroll access to adjacent buildings park, stop	Absolute values or proportions of space dedicated to place functions (not including clear zones of sidewalks), relative targets compared to reference period e.g. increase in space for pedestrians	Width [m] Space [m²] Change in space for specific user groups Indicators might refer to specific time periods in case of dynamic solutions of allocating street space	(City of Malmö - Streets and Parks Department, 2019; Constanta Municipality, 2015; Mayor of London, 2018; PTV AG, 2007; Transport for London, 2017c, 2019b, 2019e; Vienna Municipality, 2015)
Opportunities to stand/stay	Provide attractive zones for standing/ staying considering the edge effect Provide support for standing	Encourage place activities, increase overall dwell time	Width [m], Space [m²] Change in space for specific user groups	(Gehl, 2010)
Opportunities to sit	Provide zones for sitting, utilising advantages such as view, sun, people Provide seating facilities such as benches	Encourage place activities, increase overall dwell time	Number of benches, seating per kilometre Distance between each two seats, Availability of toilets	(Gehl, 2010)
Opportunities for play and exercise	Provide inviting street furniture for creativity, physical activity, exercise and play, day and night, in summer and winter	Encourage place activities, increase overall dwell time	Width [m] Space [m²] Change in space for specific user groups	(Gehl, 2010)
Provision for parking and stopping (loading, delivery)	Meet demand for parking and stopping (short/long-term, for different user groups (e.g. sharing, private) and vehicle types (e.g. delivery vans, bicycles, scooters)	Meet demand with reduced space consumption for parking Reduce illegal parking	Number of parking lots per type Number, location, time of illegal parking activities	(City of Malmö - Streets and Parks Department, 2019; Constanta Municipality, 2015; Mayor of London, 2018; PTV AG, 2007; Transport for London, 2017d; Vienna Municipality, 2015)
Community Severance, crossing facilities	Improve crossing facilities for pedestrians, cyclists and place users	Decrease detours for crossing Decrease waiting times for crossing Increase number of crossing facilities Guarantee high safety of crossing facilities	Number of crossings Suitability of crossing locations (should meet desire lines) Share of street sections with mid-link crossings (in places with high crossing needs) Appropriate detection and optimisation technology for active mode users at traffic lights	(Mayor of London, 2018; Transport for London, 2017c, 2019b)

PT = Public Transport
(Table continued on following page)

Theme	Objectives	Targets	Indicators	Exemplary References
Inclusive Design	Enable all user groups to use public street spaces Guarantee access to transport services to all user groups Ensure accessibility of adjacent usages / buildings for all user groups (pedestrians, delivery, PT users)	Provide seamless guidance systems for visually impaired persons, ensure even surfaces and crossing facilities for physically impaired persons, consequently apply design-for-all principles for all street design tasks Achieve completely accessible PT services	Share of street network and (crossing) facilities that is accessible for all user groups Quality of surface Share of vehicles and PT stations that are accessible also for persons with reduced mobility	(Intraplan Consult GmbH, 2017) (Budapest Municipality, forthcoming; City of Malmö - Streets and Parks Department, 2008; Constanta Municipality, 2015; Lisbon Municipality, 2015; Mayor of London, 2018; Transport for London, 2017b, 2017c, 2018e, 2019b)
Urban Design and Land Use				
Scale, human dimension, enclosure	Buildings and spaces designed to human dimension	Choose proportions and size of buildings according to human dimension	Ratio of widths of footway/ width of carriageway/ widths of footway should be appr. [30 % / 40 % / 30 %] Ratio width of street/ height of adjacent buildings should comply with human dimension Qualitative assessment by users Enclosure: proportion of the section with buildings or other static vertical elements such as trees	(Ewing and Handy, 2009; FGSV, 2006, 2011; Gehl, 2010; Mayor of London, 2018; Transport for London, 2017c)
Attractive and active frontages, transparency	Provide things to see, open/transparent usages of buildings, appeal to many senses, interesting texture and details, mixed functions, varied façade rhythms, soft edges	Suitable façade length of 5-6m (15-20 shops per 100m), vertical façade articulation better than long horizontal lines	Proportion of street section with active frontage/ soft edges Façade length Qualitative assessment of façade designs	(Gehl, 2010)
Mixed usages of adjacent buildings	Support liveable street 24/7	Achieve diversity in type of usages of adjacent buildings	Types of usages in adjacent buildings	(Gehl, 2010)
Further urban design qualities in terms of physical characteristics of streets and their edges	Imageability, and complexity	Achieve high urban design qualities for each street section	Imageability: proportion of historic buildings; number of courtyards/ plazas/ parks; presence of outdoor dining; proportion of buildings with non-rectangular silhouettes Complexity: Number of pieces of public art, number of buildings, number and availability of outdoor dining (yes/no)	(Ewing and Handy, 2009; Gehl, 2010)
Security, protection against crime and violence	Improve security (crime and perception of crime), lighting, visibility of all parts of the street section Lively public realm, eyes on the street, overlapping functions day and night	Relative targets compared to reference period	Qualitative assessment by users e.g. with Likert-Scales (for London: more people should feel safe walking by themselves in their local area, fewer people should say they are deterred from travelling by safety concerns) Monitoring of crime Existence of surveillance of public spaces Number of street lights, distance between street lights	(City of Malmö - Streets and Parks Department, 2010b; Gehl, 2010; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2017b, 2017b, 2017c, 2018e, 2019b)
Protection against unpleasant sensory experiences, opportunities to enjoy the positive aspects of climate	Protection against wind, rain/ snow, cold/ heat, pollution, dust, noise, glare Arrange place activities so that these have sun/shade, heat/coolness, breeze	Shelters, refuges, separation between the different user groups Greenery, trees	Number of shelters, refuges, distance between sheltered areas Assessment of provided greenery Qualitative assessment of the different aspects	(City of Malmö, 2016; Gehl, 2010; Transport for London, 2017c, 2019b)

PT = Public Transport
(Table continued on following page)

Theme	Objectives	Targets	Indicators	Exemplary References
Positive sensory experiences	Good design and detailing, good materials, fine views, trees/ plants/ water Clean surfaces and streets Minimise clutter	Improve overall attractivity of streets and spaces	Subjective assessment of the different aspects	(Gehl, 2010)
Flexibility of Street Use	Improve flexibility of street use	Increase capacity, prepare for future changed user needs/ transport technologies/ vehicles	Type and number of flexible street use elements	(Mayor of London, 2018; Transport for London, 2019a)
		Transport Services		
Multi-Modal Transport Services	Support intermodal trips (> 1 mode per trip) and multimodal travel behaviour (> 1 mode e.g. during 1 week) Provide digital support for routing, ticketing etc.	Provide possibility to transport bicycles on PT vehicles Support for interchange between PT and other modes	Regulation for transporting bicycles in PT vehicles, usage of this service Provision of secure cycling parking close to PT stations Kiss+Ride, Park+Ride facilities Bus/ tram stop accessibility Bus stop connectivity with other public transport services Street-to-station step-free access	(City of Malmö, 2016; Mayor of London, 2018; Transport for London, 2017b, 2017c, 2019b)
Innovative Transport Services	Provide innovative transport services such as car/ bike/ scooter sharing	Increase usage of shared vehicles, reduce usage of private vehicles	Number of car/ bike/ scooter stations or vehicles (in case of free-floating services)	(Budapest Municipality, forthcoming, 2017; Mayor of London, 2018; Transport for London, 2019a)

PT = Public Transport

3.4 Criteria from Transport for London: Healthy Street Checks, Pedestrian Comfort Guidance

In London, pedestrians and place users are considered in urban street design with particular importance. The Mayor of London has adopted the Healthy Streets approach as the core focus of the Mayor's Transport Strategy (Mayor of London, 2018). Pedestrian Comfort Guidance (PCG) is provided for understanding how pedestrian flows, footway widths, street furniture, crossings and islands affect pedestrian movements and static activities of place users (Transport for London, 2019e). The PCG-tool provides a Pedestrian Comfort Level (PCL) grade, based on the density of pedestrians within a given area. This ambition and level of detail for guidance material for pedestrians and place users is unique; no similar concepts have been identified in any other city. Therefore, a chapter is dedicated to the criteria used in London for measuring and improving performance of streets for pedestrians and place users.

3.4.1 Healthy Street Checks

The London Healthy Street approach puts people and their health at the heart of decision making. It covers link and place functions and focuses on creating streets that are pleasant, safe and attractive, where noise, air pollution, accessibility and lack of seating and shelter are not barriers that prevent people from getting out and about. This ambition differs substantially from the other identified demand-side indicator schemes that often focus on smooth and safe movement of motorised vehicles. The London Healthy Street approach contains demand-side indicators that are similar to the ones listed in the above tables (see Chapter 3.2) but their targets differ. For example, a street scores highest in the London Healthy Street Check for Designers when the 85th percentile speed of motorised traffic is less than 32 km/h (Transport for London, 2019b). On the contrary, minimum speed or LOS are required for motorised traffic in many other cities and guidance material as described above. The Healthy Streets Check for Designers is compulsory to use on some TfL schemes (above a certain budget and directly affecting the experience of people using the street), but can be used on any scheme affecting the street environment. TfL provides an Excel spreadsheet to support designers in carrying out the Healthy Street Checks (Transport for London, 2019b).

Ten Healthy Streets Indicators and 31 metrics are defined for scoring healthy street performance of specific street sections (Transport for London, 2019b) with each metric contributing to multiple indicators:

1. Pedestrians from all walks of life: London's streets should be welcoming places for everyone to walk, spend time in and engage in community life.
2. People choose to walk, cycle and use public transport: A successful transport system enables more people to walk and cycle more often.
3. Clean air: Improving air quality delivers benefits for everyone and reduces unfair health inequalities.
4. People feel safe: The whole community should feel comfortable and safe on our streets at all times. People should not feel worried about road danger.
5. Not too noisy: Reducing the noise impacts of traffic will directly benefit health and improve the ambience of our streets.
6. Easy to cross: Making streets easier to cross is important to encourage more walking and to connect communities.
7. Places to stop and rest: A lack of resting places can limit mobility for certain groups of people.
8. Shade and shelter: Providing shade and shelter enables everybody to use our streets, whatever the weather.
9. People feel relaxed: More people will walk or cycle if our streets are not dominated by motor traffic, and if pavements and cycle paths are not overcrowded, dirty or in disrepair.
10. Things to see and do: People are more likely to use our streets when their journey is interesting and stimulating, with attractive views, buildings, planting and street art.

Metrics can be scored from zero or one to three where three is the highest (best) score; ten of the 31 metrics can be scored zero (the lowest score). Overall, the maximum scores of all 31 metrics sum up to 100. However, TfL stresses that the maximum score of 100 will never be reached as compromises and trade-offs need to be made for any one street design. Street designers should seek to increase the score, to have balanced scores in all the ten indicators and to eliminate the zero scores. The below Table 12 list the 10 indicators and the 31 metrics, further detailed information can be found at https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/healthy-streets. Possible data sources are added in the table by the authors of this document in order to prepare data collection in the MORE corridors. Figure 18 shows an example output of the Healthy Street Check for Designers.

Table 12: List of Healthy Street Check Metrics in London

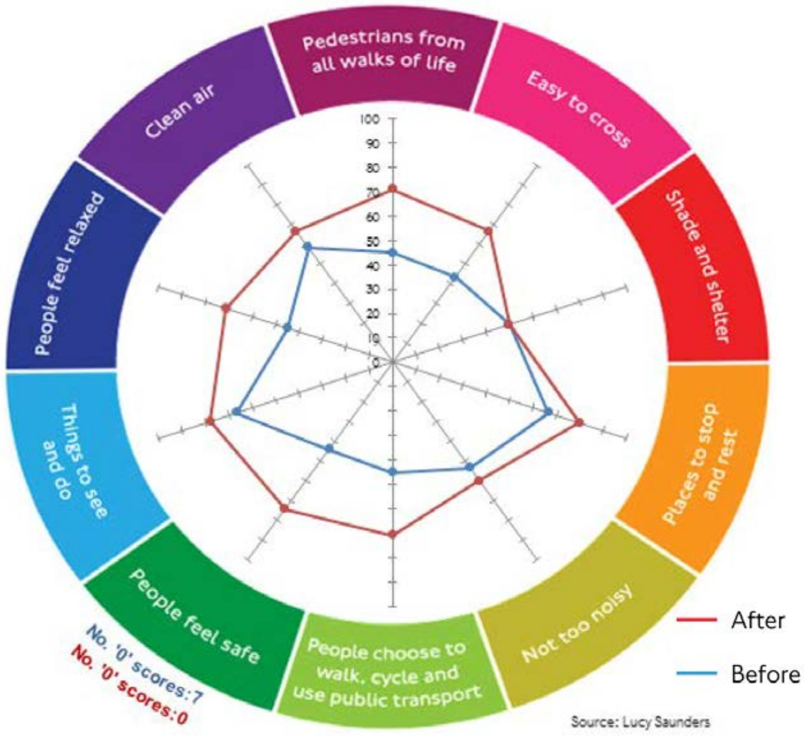
No.	Metric	Scoring System	Possible Data Sources
1	Total volume of two way motorised traffic	Volumes of motorised traffic at peak hour, score 3/2/1/0: <500/ 500-1,000/ >1,000 and dedicated cycling facility/ >1,000 and no dedicated cycling facility	Traffic counts
2	Interaction between large vehicles and people cycling	Volumes of large vehicles, score 3/2/1/0: no / <2 / >5% Score 1/2/3/0: and appropriate cycling facility/ >5% large vehicles and no appropriate cycling facility	Traffic counts
3	Speed of motorised traffic	Score 3/2/1/0: 85th percentile speed <32km/h/ 32-40km/h/ 40-48km/h/ >48km/h	Speed measurements
4	Traffic noise based on peak hour motorised traffic volumes	Score 3/2/1/0: <55vehicles per hour/ 55-450/ >450/ no value	Traffic counts
5	Noise from large vehicles	Proportion of large vehicles, score 1/2/3/0: <5%/ 5-10%/ >10%/ no value	Traffic counts
6	NO2 concentration	NO_2 concentration (if assessing exist), score 3/2/1/0: <32µg/m³/ 32-40 µg/m³/ >40µg/m³/ no value	Roadside NO_2 measurements
7	Reducing private car use	Score 3/2/1/0: no through-movement for motorised traffic (access limited to local residents, public service delivery)/ sometime or movement restrictions for motorised traffic/ no access restrictions for motorised traffic	On-site inspection
8	Ease of crossing side roads for people walking	Score 3/2/1/0: Side roads are one-way out for motor vehicles and have features to encourage drivers to turn cautiously/ side roads are two-way out or one-way without features to encourage drivers to turn cautiously/ side roads have dropped kerbs only/ side roads have no dropped kerbs	On-site inspection
9	Mid-link crossing, to meet pedestrian desire lines	Score 3/2/1/0: All main/ some/ no pedestrian desire lines are provided for with crossings, no value for score 0.	On-site inspection of crossing facilities and ped. behaviour
10	Types and suitability of pedestrian crossings away from junctions	Score 3/2/1/0: Uncontrolled crossing with <200 motorised vehicles per hour or zebra, parallel, signalised crossing / uncontrolled crossing with 200-1,000 vehicles per hour or signalised crossing with suitable crossing distance and speed of motorised vehicles/ uncontrolled crossing with >1,000 vehicles per hour or signalised crossing with high crossing distances and speed/ not value for zero score	On-site inspection of crossing facilities, traffic counts, speed measurements
11	Technology to optimise efficiency of movement (pedestrians, cyclists, buses, general motor traffic)	Score 3/2/1/0: All/ some/ no detection and optimisation technology has been applied to traffic signals, no value for zero score	On-/off-site inspection of signalling schemes
12	Additional features to support people using controlled crossings	Score 3/2/1/0: Controlled crossings have many/ some/ no additional features to enhance their quality, no value for zero score	On-site inspection of crossing facilities
13	Width of clear continuous walking space	Score 3: > 2.00 m width for walking in quiet locations with <600 pedestrians per hour or > 2.50 m for 600-1,000 ped/hour or > 3.00 m for > 1,200 ped/hour Score 2/1: 2,00 m-2,50 m/ 1.50 m-2.00 m for 600-1,200 ped/hour or 2.50 m-3.00 m/ 1.50 m-2.00 m for >1,200 ped/hour No value for zero score	On-site inspection, pedestrian counts
14	Sharing of footway with people cycling	Score 3/2/1/0: no shared footway/ parts of/ all footway is shared with 3.00 m widths and < 200 ped/hour/ parts of/ all footway is shared with < 3.00 m widths or ≥ 200 ped/hour/ no value for zero score	On-site inspection, pedestrian counts
15	Collision risk between people cycling and turning motor vehicles	Score 3/2/1/0: separation of traffic flows or minimal turning movements of motorised vehicles/ low turning movements/ no restrictions on movements/ no separation and high volumes of turning motorised vehicle movements	On-site inspection, traffic counts
16	Effective width for cycling	Score 3: Width of cycle lane/track > 2.00 m (one-way) or ≥ 3.50 m (two-way) or lane width for mixed traffic ≥ 4.50 m Score 2: Width of cycle lane/track 1.50 m - 2.20 m (one-way) or 2.50 m -3.50 m (two-way) or lane width for mixed traffic 4.00 m - 4.50 m Score 1: Width of cycle lane/track < 1.50 m (one-way) or < 3.20 m (two-way) or lane width for mixed traffic ≥ 3.20 m Score 0: No cycling facility and lane width for mixed traffic 3.20 m - 3.90 m	On-site inspection of cycling facilities
17	Impact of kerbside activity on cycling	Score 3/2/1/0: No kerbside activity or physical separation of cyclists from parking and loading facilities/ occasional kerbside activity and ≥ 1.00 m clearance/ frequent kerbside activity and ≥ 1.00 m clearance/ cyclists cannot maintain at least 1.00 m clearance from vehicles parked or loading	On-site inspection of facility for cycling and kerbside activities, observation of kerbside activities

ped = Pedestrian
Source: (Transport for London, 2019b)
(Table continued on following page)

No.	Metric	Scoring System	Possible Data Sources
18	Quality of carriageway surface	Score 3/2/1/0: surface even and smooth/ few minor defects/ many minor defects/ major defects	On-site inspection of surface quality
19	Quality of footway surface	Score 3/2/1/0: surface even and smooth/ few minor defects/ many minor defects/ major defects	On-site inspection of surface quality
20	Surveillance of public spaces	Score 3/2/1/0: constant/ intermittent/ poor surveillance because of many people, no value for zero score	Pedestrian counts
21	Lighting	Score 3/2/1/0: lighting meets standards fully/ partly/ not at all, no value for zero score	On-site inspection of lighting
22	Provision of cycle parking	Score 3/2/1/0: Cycle parking exceeds/ meets/ does not meet existing demand, no value for zero score	On-site inspection of facilities for cycle parking and demand
23	Street trees	Score 3/2/1/0 depending on number of trees and canopies, no value for zero score	On-site inspection of trees
24	Planting at footway-level (excluding trees)	Score 3/2/1/0: substantial/ some/ no planting, no value for zero score	On-site inspection of planting
25	Walking distance between resting points (benches or other informal seating)	Score 3/2/1/0: < 50 m/ 50 – 150 m/ > 150 m distance between resting points, no value for zero score	On-site inspection of resting points
26	Walking distance between sheltered areas protecting from rain (including fixed awning, shelter provided by buildings/ infrastructure)	Score 3/2/1/0: < 50 m/ 50 – 150 m/ > 150 m distance between sheltered areas, no value for zero score	On-site inspection of sheltered areas
27	Factors influencing bus passenger journey time	Score 3/2/1/0: Priority for buses/ mixed traffic/ negative influences on bus journey time, no value for zero score	On-site inspection of measures for prioritising buses
28	Bus stop accessibility	Score 3/2/1/0 depending on wheelchair accessibility of bus stop and kerb height, no value for zero score	On-site inspection of bus stops
29	Bus stop connectivity with other public transport services	Score 3/2/1/0: distance between services < 40 m/ 50 – 150 m/ > 150 m, no value for zero score	On-site inspection of bus stops
30	Street-to-station step-free access	Score 3/2/1/0 depending on the degree of step-free access, no value for zero score	On-site inspection of access to rail/ undergr./ bus stations
31	Support for interchange between cycling and underground/ rail	Score 3/2/1/0 depending on the quantity of cycle parking provided at stations, no value for zero score	On-site inspection of cycle parking facilities at rail/ underground/ bus stations and demand for cycle parking

ped = Pedestrian
Source: (Transport for London, 2019b)

Figure 18: Example Output of the Healthy Street Check for Designers



Source: (Transport for London, 2018b)

3.4.2 Pedestrian Comfort Guidance

The Pedestrian Comfort Guidance (PCG) particularly compares the volumes of pedestrians and place users with the available space and allows determining a Pedestrian Comfort Level (PCL) grade, based on the density of pedestrians within a given area. PCLs should be determined both for footway comfort and crossing comfort.

In the first step, sites are classified based on site visits as one of the following area types: high street, office and retail, residential, tourist attraction, transport interchange. Activity data should be collected and characteristics of footways and crossing facilities should be mapped in detail in the next step. The following pedestrian activity data is required:

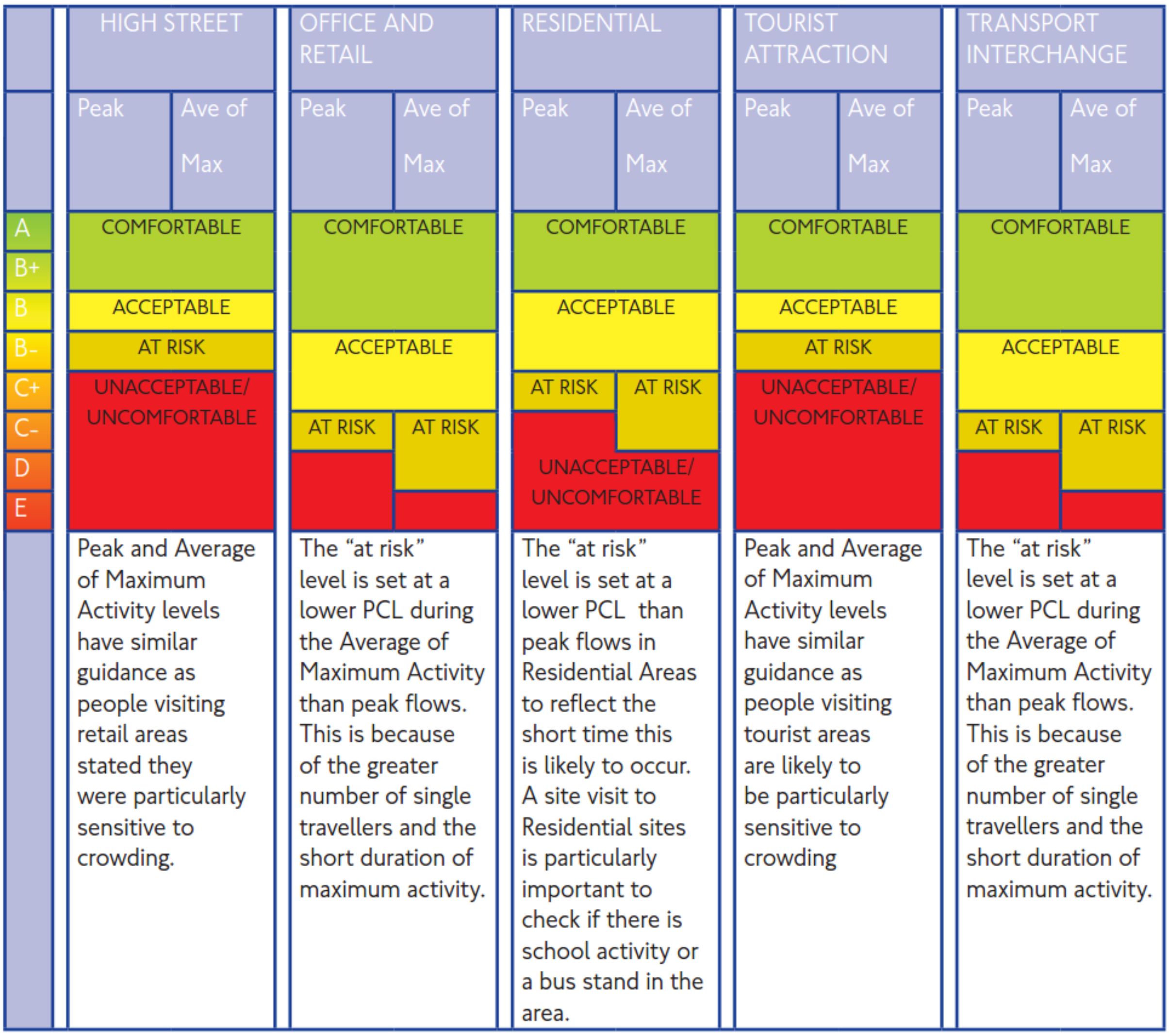
- Pedestrian flow data for footways and crossings.
- A static activity survey to record the reduction in space available for walking from static activity unrelated to street furniture (meeting friends, queuing, taking photographs) is recommended at regional retail centres and tourist attractions as these areas tend to generate a lot of this activity.
- Also note any other relevant activity (e.g. delivery operating times if a loading bay is present).

After all data is entered into the excel spreadsheet, the following criteria is automatically calculated:

- Clear Footway Width - This is the space left for walking after the standard wall and kerb buffers and any street furniture is taken into account
- Crowding - Pedestrian crowding is measured in pedestrians per metre of clear footway width per minute (ppmm) and is calculated using the following formula:
  people per hour ÷ 60 ÷ clear footway width [m]
  This is calculated for average flow, peak hour flow and average of maximum activity
- Pedestrian Comfort Level Categorisation - The crowding level (ppmm) is then categorised according to the Pedestrian Comfort Level scale.
- Clear Footway Width required for PCL B+ - The spreadsheet also calculates the clear footway width required to achieve a PCL of B+. This is to aid decision making, as PCL B+ is the recommended level of comfort for most area types.

Pedestrian densities are provided for all PCLs in Transport for London (2019e). For example, PCL B+ on footways and for crossing arms and space to pass on island means 9-11 pedestrians per square metre (ppmm). For queues on crossing islands, the number of rows of waiting pedestrians determines the PCL. Figure 19 summarises which Pedestrian Comfort Level is suitable for different area types for use in the peak hour, and for the average maximum activity level.

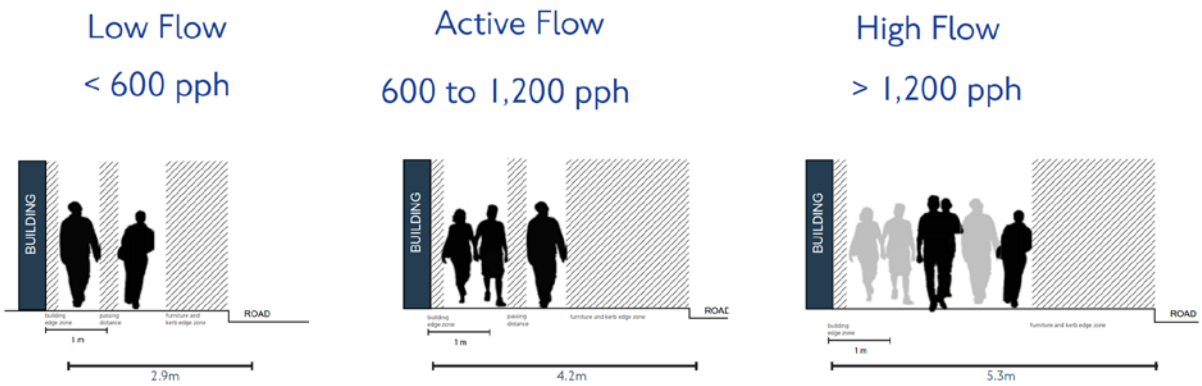
Figure 19: Suitable Pedestrian Comfort Levels for Different Area Types



Source: (Transport for London, 2019e)

Transport for London (2019e) provides detailed guidance on recommended widths and buffer zones for footways with or without furniture with some examples shown in the below Figures.

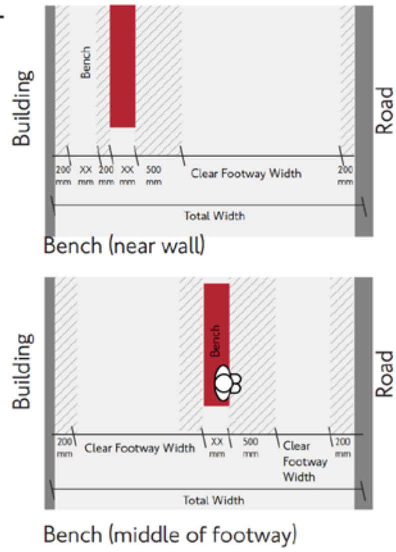
Figure 20: Recommended Footway Width



Source: (Transport for London, 2019e)

Figure 21: Recommended Footway Design with Bench

Benches		
	Benches reduce the clear footway width by the bench width, plus an additional 500mm in the direction of seating when in use (legs, bags etc). Note that for the bench to be attractive to people there needs to be room for two people to pass between the bench zone and the kerb or building line (1500mm clear footway width). If the bench is placed in the middle of the footway, with people able to sit facing one direction only, the reduction is 500mm plus 200mm on the other side. If you can sit facing either way the buffer would be 1,000mm (500mm either side).	500mm from Bench edge for direction of seating, 200mm on non-seating side If seating is in both directions, 1,000mm (500mm either side)



Source: (Transport for London, 2019e)

4 Guidance Material on Urban Street Design

4.1 Structure, Role and Genesis of Guidance Material

Different institutions are responsible for developing guidance material on urban street design in the studied countries:

1. National Transport Authorities, e.g., Portugal, Romania, Sweden, and UK
2. Expert Associations, e.g., Austria, Germany, Hungary, Switzerland, The Netherlands, and U.S.
3. Municipalities, e.g., City of Budapest (with selected supplements to national standards), City of Malmö, City of Lisbon, and Transport for London (TfL) for the Greater London Authority (GLA)
4. Boroughs, e.g., London
5. City Associations, e.g., National Association of City Transportation Officials (NACTO) in the U.S., and Swedish Association of Local Authorities and Regions

National guidance materials on urban street design exist in all studied countries, either provided by the national (transport) authorities or by expert associations where specialists from different private and public institutions and administrative levels convene and develop the guidelines. None of this material appears to be legally binding, but national transport authorities strongly recommend that such guidelines be responsibly applied to roads for countries where guidelines have not been developed by the transport authorities themselves but by expert associations. The application of these materials is also recommended for roads and streets that are not necessarily the direct responsibility of the national transport authorities. In addition, in all countries, regulation with relevance to urban street design exists which carry legislative weight and hence mandatory compliance. Examples for such regulation are the national accessibility laws for disabled persons established in Portugal, the traffic sign regulations and general directions from the UK Department for Transport (DfT), and the standards and compulsory technical parameters for the design, construction, repair, and utilisation of vehicles and of the infrastructure provided by the Ministry of Transport of Romania (MT).

Cities are actively engaged in developing the guidelines at the national level in countries where expert associations are in place. In these countries, only a few cities have their own guidance materials in addition to the national ones. This is different in countries where the national transport authorities are responsible for developing the national guidelines. It seems that those guidelines mainly focus on rural roads with dominating link functions (often without problems of space scarcity), and the solutions provided do not typically fit to the urban context, with differing user requirements and often strict space limitations. In these cases, cities take the initiative and develop their own guidance on urban street design, tailor-made for their specific local context. In London/GLA (the largest of the MORE partner cities), goes one level further, with boroughs that develop their own guidance material in addition to the material provided by the TfL.

Cities in Sweden ascribe particular importance to independently developing their own guidance and solutions. All guidance material in Sweden, including the Malmö Teknisk Handbook (City of Malmö - Streets and Parks Department, 2019) that is created and published by the Malmö city administration and that is prominently used in urban street design in Malmö, are used by planners as inspiration and examples but not as binding guideline that must be complied with.

Special examples for institutions providing guidance on urban street design are the city associations in Sweden and in the U.S. (NACTO), and the American Association of State Highway and Transportation Officials (AASHTO) in the U.S.

The following Table 13 gives an overview about responsibilities, processes and created guidance material in the different studies cities and countries.

Table 13: Responsibilities and Bindingness of Guidelines

Responsibilities, local versus national guidelines	Bindingness	Exemplary references
Budapest (BKK), Hungary		
The Hungarian Road and Railway Society is responsible for developing and publishing guidelines for Hungary (MAUT, http://www.maut.hu/) MAUT convenes experts of various organisations such as highway administrative agencies, research institutes, design and consulting companies, construction enterprises and local governments. The Society prepares technical regulations within 30 working groups, in coordination with the executives of the highway administration and submits them for approval for use in the national highway network. At the same time, the guidelines are recommended to local governments. MAUT has an exclusive right for the publication of such regulations. The present membership is about 500 persons and increasing, there are about 200 legal entities as members. BKK uses the MAUT-standards but supplements these for specific topics such as Tramway construction and maintenance technical specifications etc. (Budapesti Közlekesi Részvénytársaság, 2007)	National road design standards (RDS) are binding for the national highway network and recommended by the transport ministry for lower level roads and streets. Various supplements exist, these are less binding and cover specific topics in more detail than the RDS.	National RDS (MAUT, 2008)cover all types of roads, all aspects of street design, all user groups and usages Example supplements: (MAUT, 2005, 2009b)
Constanta (PMC), Romania		
The National Ministry of Transport (NMT) and the National Ministry of Regional Development and Public Administration (MDRAP) publish guidance material for Romania. The NMT sets the norms and the compulsory technical normatives for the design, construction, repair and exploitation of vehicles and of the infrastructure from its domain of activity. Respectively, the NMT is responsible for setting the rules for national roads and for road safety. MDRAP is managing land use, urbanism, urban mobility and architecture, construction, public works. MDRAP is also the Managing Authority for the Regional Development Programme and provides funds for the local authorities to implement urban mobility projects, including the refurbishment of streets in order to become more inclusive and adopted to the needs of all street users. Currently, MDRAP is working on new design standards for cycling infrastructures. The new rules are looking more in depth at how these facilities must be built; the document is currently under public consultation. The document must not be cited so far. There are no specific standards for the city of Constanta, the national norms and recommendations are used for urban street design in Constanta.	Two types of guidance materials exist: (1) norms and (2) recommendations (called Romanian State Standards, STASs). Norms mainly are about construction, they must be respected.	(Institutul Roman de Standardizare, 2010)

(Table continued on following page)

Copyright © 2019 by MORE

Responsibilities, local versus national guidelines	Bindingness	Exemplary references
Lisbon (CML), Portugal		
National guidelines for street design are provided by the Road Infrastructure Institute INIR that developed a set of normative documents aiming at technical guidance in the road sector, see http://www.imt-ip.pt/sites/IMTT/Portugues/InfraestruturasRodoviarias/InovacaoNormalizacao/Paginas/DivulgacaoTecnica.aspx The INIR documents give a national approach on the subject but, in daily working within the city, the Public Space Manual absorbs most of the concepts that apply for our case. INIR documents are only used to clear doubts in specific situations. For Lisbon, the Lisbon Public Space Manual (LPSM) (http://www.cm-lisboa.pt/viver/urbanismo/espaco-publico) is the core guideline used for urban street design. It includes the national legal framework given e.g. by INIR (2010) and the national accessibility law for disabled persons and develops based on this basis detailed guidance for street design in Lisbon. It covers all types of roads and streets, from motorways down to residential streets; it covers all types of users and usages as well as all relevant aspects of urban street design. It was developed by the Public Space Department of the city administration, as determined by the Public Space Councilman, not by external consultants. The other departments of the city administration were asked to analyse, comment and discuss required changes (December 2015) before the final document was reviewed and came out. The national accessibility law for disabled persons and the national regulation for intervening in underground infrastructure are of high importance as these are binding and provide standards also for street design. The LPSM refers to these documents. The Lisbon master plan (http://www.cm-lisboa.pt/viver/urbanismo/planeamento-urbano/plano-diretor-municipal/pdm-em-vigor) is also relevant; it provides the classification of the road network along the five levels described in Chapter 2. For each of these levels, the objectives, functions and particular rules and parameters are defined for the physical characterisation of the structures associated with each level, namely: - the minimum number of lanes; - the physical separation of the circulation directions; - the minimum dimensions of lanes, buffer zones and sidewalks; - the type of intersections and nodes; - operational attributes (speed and capacity); - possibility of parking and loading / unloading; - relationship with the public transport network; - relationship with pedestrian and cycling networks. The LPSM additionally sets the ground for work to be carried out in other cities of Portugal.	The LPSM is not mandatory but a recommendation and a common view of what the city believes is good practice, it did not require general political validation, but was endorsed by the mayor (documented in the initial message of the document).	(Municipal Chamber of Lisbon, 2018)
London, U.K.		
For urban street design in London, documents from the Department of Transport (DfT; valid for UK, but mainly England and Wales) and from Transport for London (TfL) are relevant. Some DfT documents such as the Traffic Signs Regulations and General Directions (TSRGD) are very important as they carry legislative weight - and hence must be complied with, and the accompanying Traffic Signs Manuals indicate how the DfT interpret these regulations in terms of design and implementation, and can be seen as "best practice". Other DfT documents such as Manual for Streets could be considered less important but nevertheless provide some useful advice. The TfL Streets toolkit (https://tfl.gov.uk/corporate/publications-and-reports/streets-toolkit) is the basis for urban street design in London, for the TfL road network and also for the roads and streets in the boroughs' responsibility. The TfL (2017) Streetscape Guidance (https://tfl.gov.uk/corporate/publications-and-reports/streets-toolkit) is the most comprehensive guidance within the TfL Streets Toolkit. It is binding for the TLRN in relation to the materials that are permitted as standard and is also an important document for TfL; more so than the DfT Manual for Streets. Deviations from these standards in Streetscape Guidance may only be permitted through a formal review process. Streetscape Guidance also acts as guidance for borough streets but is not a requirement. Other TfL SQA and design documents take their cues from National Guidance and adapt these to the London Street Environment based upon research that TfL has undertaken, and provide an evidence base to design decisions. In addition to municipal and national standards exists guidance in some boroughs. For example, Bromley and Haringey published Streetscape Manuals: https://www.bromley.gov.uk/downloads/100011/transport_and_streets, https://www.haringey.gov.uk/parking-roads-and-travel/roads-and-streets/road-care-and-maintenance/streetscape. Those manuals are not binding but give specification of existing municipal guidance. Documents on the Healthy Streets page of the TfL website are also relevant: https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/healthy-streets The Guide to the Healthy Streets Indicators can help designers consider what changes need to be made to improve the street in line with the Healthy Streets Approach. The Healthy Streets Check for Designers is a tool that is compulsory to use on some TfL schemes (above a certain budget and directly affecting the experience of people using the street) but can be used on any scheme affecting the street environment.		(Department for Transport, 2007; Transport for London, 2016a, 2017a, 2017b, 2017d, 2017e, 2019e)

(Table continued on following page)

Responsibilities, local versus national guidelines	Bindingness	Exemplary references
Malmö, Sweden		
In Sweden, municipalities are very strong; they decide on their own what type of infrastructures they want to have and how street layouts should be designed. National regulations, published by the Swedish Transport Administration (Trafikverket, https://www.trafikverket.se/) and also the Swedish Association of Local Authorities and Regions (Sveriges kommuner och landsting, https://skl.se/) which is not a legal authority, hold for the national road network. This includes mainly rural roads, in Malmö only the outer ring road belongs to the national network, all other roads belong to the city of Malmö. Smaller cities might have more roads in national responsibility. Malmö's big ring road marks the boundary of roads within the city's responsibility. Most Swedish cities do not have the capacities to develop their own guidelines, they use the national ones. Bigger cities have the capacity and knowledge, they develop their own guidelines. The three biggest cities in Sweden are Stockholm, Gothenburg and Malmö; they all have their own guidelines (e.g. Teknisk handbook for Malmö). In general, all materials are treated as guidance and not as rules; stakeholders might follow but are not requested to follow the guidance materials. The most relevant documents for urban street design in Malmö are the Teknisk handbook (www.projektering.nu), the SUMP (www.malmo.se/Sa-arbetar-vi-med.../Stad-och-trafik/Trafiksakerhet/Trafik--och-mobilitetsplan.html) and the TRAST-family published by the Swedish Association of Local Authorities and Regions as well as the Swedish Transport Administration (https://webbutik.skl.se/sv/artiklar/transport-for-an-attractive-city.html). The national urban VGU-guide is also relevant (it is the first national guidance for urban roads) but far less used than the above mentioned documents. The Teknisk handbook for Malmö is a comprehensive document including urban street design, traffic management, safety, road construction and maintenance, urban infrastructure design, utilities, civil engineering structures, winter maintenance. It is published by the Estates streets and parks department of the city of Malmö. The Teknisk handbook is constantly updated. There is a group in the city administration that coordinates the process of updating the Teknisk handbook. Experts from the city administration get involved for actually generating the contents for the updates. The initiative to update the Teknisk handbook might come from the coordination group or from experts in the city administration. Contractors need to follow Teknisk handbook; they get told which version they should use. Exceptions are possible; this is aligned in the contract. The Teknisk handbook might refer to the national guidelines such as VGU but it always looks for own solutions for the city of Malmö, these are solutions that really fit to the local context. The TRAST is less focussed on giving detailed guidance for urban street design but has a much broader scope and include also topics on the strategic level of transport planning. Transport topics are the core focus of the TRAST family. The TRAST handbook was developed and financed jointly by the Swedish Transport Administration and The Swedish Association of Local Authorities and Regions. Further documents include detailed guidance in areas such as traffic safety, public transport, walking and sustainable travel. As extra support, there is also a TRAST guidance document (the TRAST-guide). For more information, see https://www.trafikverket.se/contentassets/347f069e6d684bfd85b85e3a3593920f/transport_for_an_attractive_city_introduction.pdf. The city of Malmö works a lot with TRAST. Also, experts from Malmö are involved in developing material from the TRAST-family.		(City of Malmö - Streets and Parks Department, 2019; Trafikverket and Swedish Association of Local Authorities and Regions, 2014)
Austria, Germany, Switzerland		
Similar to the society MAUT in Hungary, national societies exist in the three German-speaking countries: FGSV (www.fgsv.de) in Germany, FSV (www.fsv.at) in Austria, VSS (www.vss.ch) in Switzerland. Experts convene in permanent and temporary committees and develop standards and recommendations. The committee system ensures continuous work on the guidelines. National guidelines published by FGSV/ FSV/ VSS are used for urban street design. City representatives are engaged in various committees in the societies FGSV/ FSV/ VSS and thus actively contribute to developing the guidelines and to make them fitting to the urban context. Bigger cities such as Hamburg publish local guidance on how to directly apply or on how to adapt specific parts of the national guidelines for their particular city (see for Hamburg https://www.hamburg.de/bwvi/restra/).	Documents published by the societies FGSV/ FSV/ VSS have a defined hierarchy: Highest level guidelines go through an extensive coordination process with various stakeholders inside and outside the societies, including federal and state ministries. The ministry mandates their application for roads in its own responsibility and recommends their application for all lower level roads and streets. Second level guidelines are formulated as recommendations, there is no mandate from the ministry for their application but still they are applied widely. First level guidelines cover all aspects; second level guidelines detail specific aspects. In addition, so called knowledge documents are published that give background or describe recent developments not covered so far in guidelines or recommendations.	(FGSV, 2002, 2006, 2010, 2013, 2015b)

(Table continued on following page)

Copyright © 2019 by MORE

Responsibilities, local versus national guidelines	Bindingness	Exemplary references
U.S.		
The American Association of State Highway and Transportation Officials (AASHTO, www.transportation.org/) is the standards setting body in the U.S. which publishes guidelines for street design throughout the United States. Particularly for pedestrian and bicyclists facilities, the National Association of City Transportation Officials (NACTO, https://nacto.org/) Design Guides and the Institute of Transportation Engineers (ITE) guides are of high relevance (Schultheiss et al., 2018; U.S. Department of Transportation and Federal Highway Administration, 2013). These build upon the flexibilities provided in the AASHTO guides and help communities plan and design safe and convenient facilities that meet each specific local situation. AASHTO sets transportation standards and policy for the United States as a whole but is not an agency of the federal government; rather it is an organisation of the states themselves. Policies of AASHTO are not federal laws or policies, but rather are ways to coordinate state laws and policies in the field of transportation. While AASHTO is not a government body, it does possess quasi-governmental powers in the sense that the organisations that supply its members customarily obey most AASHTO decisions. The voting membership of AASHTO consists of the Department of Transportation of each state in the United States, as well as those of Puerto Rico and the District of Columbia. The United States Department of Transportation, some U.S. cities, counties, and toll-road operators, most Canadian provinces as well as the Hong Kong Highways Department, the Turkish Ministry of Public Works and Settlement, and the Nigerian Association of Public Highway and Transportation Officials have non-voting associate memberships. The AASHTO design guides are the primary national resources for planning, designing, and operating street facilities.	In addition to the national guidelines, guidance exists on state level and on municipal level. This leads to a great variety of guidance material within the U.S.	Relevant AASHTO guides: (American Association of State Highway and Transportation Officials, 2004, 2017, 2018) NACTO-Guides: (National Association of City Transportation Officials, 2013, 2014, 2016) Examples for guidance on state level: (California Department of Transportation, 2005, 2010, 2014) Examples for guidance on city level: (City of Saskatoon, 2017; New York City, Department of Transportation, 2015)
The Netherlands		
Guidelines for urban road/ street design are published by CROW (https://www.crow.nl/). Professionals from CROW, the government (government, provinces, municipalities, water boards) and the business community (contractors, transport companies, suppliers) come together in working groups and develop the guidance material. Special advice is offered for cycling at https://www.fietsberaad.nl/		The “ASVV 2012” (CROW, 2012) are the core guidelines for urban street design. They cover all types of infrastructures, users and usages. Guidance on bicycle infrastructure is summarised in CROW (2016).

Copyright © 2019 by MORE

4.2 Infrastructure for Pedestrians and Place Users

4.2.1 Role of Pedestrians in Urban Street Design and Motivation

For many years, spaces for pedestrians were treated as “left-over spaces” in urban street design. In regard to technical geometrical street design, motorised vehicle size was the determiner for minimum lane widths; dedicated lanes for public transport were provided depending on space availability and prioritisation in local transport policy; and defined target values for traffic quality for motorised vehicles, e.g., in terms of Levels of Service for the forecasted traffic volumes, determined the number of lanes in street sections and at junctions. In addition, cycling has recently gained in importance, resulting in the increase in both the quality and quantity of cycling facilities as well as in the integration of such facilities directly into urban street layouts. The accommodation of all these other user needs has not left much room for pedestrians or other possible usages, particularly in inner urban areas with limited street space availabilities.

Additionally, with a width of about 0.75 m, a standard pedestrian does not occupy much space, thus causing pedestrians to be perceived and treated as a more flexible user group.

Spatial structures and land use are also powerful drivers for walking—in addition to the quality of the street environment and accommodation of the space—thus pedestrians will still use streets despite poor conditions (see the “5 Ds” density, diversity, distance to public transport, design, destinations, (Cervero and Duncan, 2003; Ewing and Cervero, 2010; Ewing and Handy, 2009; Götschi et al., 2017; Stead and Marshall, 2001).

Planners do not have reliable information about existing or expected pedestrian volumes, and, even in the current era of digitalisation, pedestrians are still counted by hand in most cases which is burdensome and hardly done. A mixture of all these arguments with different intensities has been occurring in many discussions about urban street design tasks and has led to various newly planned street layouts with overly narrow or absent sidewalks.

Interest in walking as well as in improving the quality of street environments to be more walkable is actively increasing all over the world. Cities such as New York are redesigning major parts of their street networks and urban spaces with primary focus on the increased quality of pedestrian and dense urban areas; the City of Malmö places pedestrians at the highest level of their street-user hierarchy (City of Malmö, 2016); in London, the healthy street approach takes highest priority in the Mayor’s Transport Strategy (Mayor of London, 2018); and also at the national level, more and more pedestrian strategies are being put in place (Austrian Ministry for Transport, Innovation and Technology, 2015). As research interest in walking and in walkability dynamically increases, new insights surface about why people walk and about the various benefits of walking (Koszowski et al., 2019; Litman, 2003). The Health Economic Assessment Tool (HEAT-Tool, see https://www.heatwalkingcycling.org/), provided by the WHO/Europe, allows cities to compute, in advance, the monetised health effects of anticipated behavioural change and increased walking and cycling levels. It is consensual that walking contributes to a healthier population as well as to environmentally friendlier travel behaviours and is a core ingredient of liveable cities. Thus, it also supports the UN Sustainable Development Goals, specifically Goal 11:

Copyright © 2019 by MORE

Sustainable Cities and Communities (see https://www.un.org/sustainabledevelopment/sustainable-development-goals/). All these arguments make clear that spaces for pedestrians must not be treated as “left-over spaces”. They should be the focus of attention.

Designing pedestrian facilities is a challenging task as they are both (1) link users who want to move safely and comfortably from A to B and (2) place users who want to rest, wait, communicate, shop, eat, and enjoy their life in a pleasant environment. These two characteristics present a challenge when accommodating place functions into streets (according to their road-function classification) and increase the tension between link and place functions (with their very different goal functions of minimising travel times versus maximising the length of stay); this is particularly visible when it comes to the provision made for pedestrians. Providing for pedestrians is thus an interdisciplinary task that needs support from both transport and urban planning as well as from traffic engineering and urban designers (see Figure 14). It concerns the sufficient widths of pedestrian facilities and safe crossing facilities but also the proportions of street widths versus the height of adjacent buildings, the proportions of the width of carriageways versus sidewalks, the land marks, orientation, lines of sight, shade and sun, and overall wellbeing within the urban environment.

The review of guidance material on urban street design shows that urban street designers are advanced in measuring space requirements for pedestrians but less in planning pleasant urban environments that fit to human dimensions, are inviting, and offer advanced place functions such as communicating with one another (Gehl, 2010). Literature from urban planning about basic principles of designing cities and urban spaces for people was therefore added to our review and is summarised in Chapter 4.2.3.

4.2.2 Synthesis of Recommendations for Pedestrian Facilities

The following table combines the information taken from the researched guidance material on urban street design in a manner with which the reader can easily see what type of information is given and how the standards in the different countries and cities compare to one another. The following aspects are analysed:

- Space requirements for moving pedestrians (link function): What width is assumed/set for standard pedestrians and also for pedestrians with increased space requirements such as wheelchair users? Space requirements for two or more pedestrians are also provided in some references and included into the table. The reason for this is that sidewalks are never used in only one direction. Pedestrians are free to move in either direction on either side of the street and extensively make use of this freedom. This needs to be considered when designing pedestrian facilities.
- Space requirements for street equipment (place function): What width is assumed/set for the various items that might be placed on sidewalks such as street furniture or greenery?
- Standards widths of sidewalks: How are the space requirements for the link and the place function translated into sidewalk widths? Which widths are recommended for sidewalks under differing conditions?
- Components/zones of sidewalks: Some references distinguish different zones of sidewalks, these are also summarised in the table.

Copyright © 2019 by MORE

- Recommendations on place function: This part of the table summarises recommendations for supporting place functions of sidewalks.
- Crossing facilities: Besides the sidewalks, crossing facilities are very important for pedestrians as a vulnerable and highly detour-sensitive user group; recommendations on this topic were therefore also included into the table.

Table 14: Recommendations for Pedestrian Facilities

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Space Requirements (Width)								
Standard Pedestrian	0.55 m + 0.10 m buffer on each side = 0.75 m	No recommendation	0.655 m x 0.368 m	0.75 m	0.70 m	0.80 m (value is given but only in a figure where 2 pedestrians are shown)	No recommendation	0.55–0.80 m
Two and More Pedestrians	- Adult + child: 1.30 m + 0.10 m buffer on each side = 1.50 m - Family (2 adults + 2 children): 2.80 m + 0.10 m buffer on each side = 3.00m	No recommendation	Two pedestrians: 1.50 m	- Two pedestrians: 1.50 m - Adult + child: 1.20 m	No recommendation	Two pedestrians: 1.80 m (each pedestrian 0.80 m + 0.20 m buffer in between)	No recommendation	- Adult + child: 1.20–1.50 m - Two pedestrians: 1.50–1.80 m - Family: 3.00 m
Increased Space Requirements (width)								
Blind Person with Assistance	No recommendation	No recommendation	No recommendation	1.20 m	1.20 m	1.20–1.30 m	No recommendation	1.20–1.30 m
Person with Walking Cane	0.80 m + 0.10 m buffer on each side = 1.00 m	0.95 m	No recommendation	0.75 m	No recommendation	0.85 –1.20 m	No recommendation	0.75–1.20 m
Person with Crutches	0.80 m + 0.10 m buffer on each side = 1.00 m	0.90 m	No recommendation	0.90 m	No recommendation	1.00 m	No recommendation	0.90–1.00 m
Person in a Wheelchair	0.80 m + 0.10 m buffer on each side = 1.00 m	0.80 m	- 0.90 m x 1.20 m, - Two Persons with wheelchair ≥ 1.80 m	0.90 m	0.80 m	0.90 m	No recommendation	0.80–1.00 m
Person in Wheelchair with Assistance:	1.65 m	No recommendation	No recommendation	1.50 m	No recommendation	1.00 m x 2.50	No recommendation	1.00–1.65 m
Person with Luggage	0.80 m + 0.10 m buffer on each side = 1.00 m	No recommendation	No recommendation	No recommendation	No recommendation	No recommendation	No recommendation	1.00 m
Person with Pram	0.55 m + 0.10 m buffer on each side = 0.75 m	No recommendation	No recommendation	Plus one adult beside: 1.50 m	0.70 m	1.00 m x 2.00 m	No recommendation	0.75–1.50 m
References								
	(MAUT, 2009c)	(City of Constanta: Lupascu, George and Dumitrescu, 2019; Institutul Roman de Standardizare, 2010)	(Municipal Chamber of Lisbon, 2018)	(Department for Transport, 2005, 2007; Transport for London, 2016c)	(City of Malmö - Streets and Parks Department, 2006; Trafikverket and Swedish Association of Local Authorities and Regions, 2015)	(FGSV, 2002, 2006)	(National Association of City Transportation Officials, 2013)	

(Table continued on following page)

,

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Space Requirements for Street Furniture (Width)								
Benches	No recommendation	No recommendation	≥ 1.20 m	≥ 0.50 m (minimum bench requirement)	2.00 m	≥ 1.00 m	No recommendation	0.50–2.00 m
Green Space without Trees	No recommendation	No recommendation	No recommendation	No recommendation	No recommendation	≥ 1.00 m	No recommendation	≥ 1.00 m
Green Space with Trees	No recommendation	0.75–1.00 m	≥ 1.20 m	No recommendation	> 2.50 m	2.00–2.50 m	No recommendation	0.75–4.00 m
Waiting Area at PT Stops:	≥ 1.50 m	≥ 2.00 m or ≥ 2.80 m depending on guidance of cyclists	≥ 2.60 m	Wide enough for waiting passengers while still allowing for pedestrian movement along the sidewalk.	2.30 m	≥ 1.50 m	1,83–3.05 m	1.50–2.80 m
Standard Width of Sidewalks								
Width and Conditions	- Min. width 1.50 m, recommended width 3.00 m - Useable width of sidewalk: 1,5 m + n x 0.75 m (n = number of pedestrians) - Width of sidewalk depends on street type, available space and volume of pedestrians. - Recommended width of sidewalks: • Living/ residential street: 1.50–3.00 m • Major street: ≥ 3.00 m • Commercial street: ≥ 4.50 m • PT stop area: ≥ 3.00 m	1.00–4.00 m depending on pedestrian volumes	Min. width: - General (including trees, lighting, etc.): 3.00 m - Usable" width in new streets: 2,00 m - Usable" width in pre-existing streets: • ≥ 1.20 m on 4th/ 5th level streets • ≥ 1.50 m on 2nd/ 3rd level streets • ≥ 1.50 m in every other situation	- Min. width: 2.00 m in lightly used streets (such as those with purely residential function) - The width of the sidewalk varies depending on pedestrian volumes	- Min. width: 2.00 m - In inner city environment next to higher buildings the sidewalk should not be less than 2,50 m	- Standard width: 2.50 m (1.80 m for two persons + buffer to adjacent buildings and carriageway) - Wider sidewalks for average daily traffic volume (mot. veh.) AADT > 5,000 veh/ 24 h, higher density/ height of adjacent buildings, commercial usage of adjacent buildings, high frequency PT - Wider sidewalks also in the vicinity of specific destinations such as retirement homes, schools shopping centres	- Desired minimum through zone of 2.13 m and an absolute minimum of 1.52 m. - Where a sidewalk is directly adjacent to moving traffic, the desired minimum is 2.44 m, providing a minimum 0.61 m buffer for street furniture and utilities	- Width: 1.00–4.50 m - Dependencies: • Land use and height of buildings • Street type • Available space • Pedestrian volume • Frequency of PT
References								
	(MAUT, 2009c)	(Institutul Roman de Standardizare, 2010), Questionnaire	(Municipal Chamber of Lisbon, 2018)	(Department for Transport, 2005, 2007; Transport for London, 2016c)	(City of Malmö - Streets and Parks Department, 2006, 2019; Trafikverket and Swedish Association of Local Authorities and Regions, 2015)	(FGSV, 2002, 2006)	(National Association of City Transportation Officials, 2013)	

PT = Public Transport; Veh= Vehicles; Min = Minimum; AADT = Annual Average Daily Traffic (Table continued on following page)

,

Copyright © 2019 by MORE

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Components/Zones of Sidewalks								
Clear Zone	≥ 1.50 m	- Street category I: 2.00 m - Street category II: 1.50 m - Street category III: 1.00–1.50 m	- Min. 1.5 m on 2nd/ 3rd level streets - Min. 1.80 m in new streets min. 1.80 m - Min. 1.20 m on 4th/ 5th level streets	≥ 2.00 m (preferred minimum, unobstructed width)	Yes, but no information on width	1.80 m	- 1.52–2.13 m in residential settings - 2.44–3.66 m in downtown/ commercial areas	1.00–3.66 m
Buffer to Adjacent buildings	0.50 m	≥ 1.00 m	≤ 0.60 m	0.30 m	Yes, but no information on width	0.20 m (0.00 m in case of no buildings or low fences)	No recommendation	0.00–0.60 m
Buffer to Carriageway/ Kerb Zone	- 0–30 km/h: 0.00 m - 31–50 km/h: 0.25 m - 51–70 km/h: 0.50 m - 71–100 km/h: 1.00 m	0.25 m	0.30 m	0,45–0.60 m	Yes, but no information on width	- 0.50 m in standard busy streets - 0.30 m in case of low goods traffic and residential streets	- 0.61 m - Otherwise enhancement zone with bike lanes, parklets or kerb extensions	0.10–1.00 m
Furniture Zone	1.00 m	No recommendation	- For benches: ≥ 1.20 m; - For parklets: 2.00–2.50 m; - For terrace/ gastronomy: ≥ 2.00 m • if terrace is provided, clear zone ≥ 2.00 m	0.50–2.00 m with detailed information on space requirements of different types of street furniture	Yes, but no information on width	≥ 1.00 m Reference values for width for specific place functions, higher widths for specific street types, next to specific POIs	- Yes, but no information on width - For parklets: 1.68 m	0.50–2.00 m
Frontage Zone	1.00–1.50 m	No recommendation	- Shop displays and showcases: 1.00 m - Terrace/gastronomy: ≤ 3.00 m • if terrace is provided, clear zone ≥ 2.00 m	Yes, but no recommendation	Yes, but no information on width	≥ 1.00 m	Yes, but no information on width	1.00–3.00 m
References								
	(MAUT, 2009c)	(City of Constanta: Lupascu, George and Dumitrescu, 2019; Institutul Roman de Standardizare, 2010)	(Municipal Chamber of Lisbon, 2018)	(Department for Transport, 2005, 2007; Transport for London, 2016c)	(City of Malmö - Streets and Parks Department, 2006, 2019; City of Malmö: Brodde Makri, Maria and Nordlund, 2019; Trafikverket and Swedish Association of Local Authorities and Regions, 2015)	(FGSV, 2002, 2006)	(National Association of City Transportation Officials, 2013)	

Min = Minimum

(Table continued on following page)

,

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Recommendations on Place Function								
Place Function	- Staying, waiting, leaning alone at the wall: 0.70–1.00 m - Two to three persons chatting/sitting: 1.50–2.00 m - Places to stay (e.g. gastronomy, benches) or to play: 2.50–3.00 m - Spacious places to stay or to play: ≥ 4.00 m	No recommendation	Installation of benches at appropriate intervals: 50.00–150.00 m	- Seating on key pedestrian routes should be considered every 100 m to provide rest points and to encourage street activity - Maximum recommended spacing interval on high streets, city places: 50.00 m - Places to stay/chat: ≥ 2.50 m - Places to play: ≥ 4.00 m	- Installation of benches every 25.00 m in pedestrian zones • otherwise every 50.00 m - Next to benches, garbage bins should be installed	- Installation of benches at appropriate intervals - Public spaces should primarily be created by widening a section of sidewalk in addition to the area provided for moving along. This also includes the creation of play spaces.	Street space can be reused for different purposes, such as parklets, bike share, and traffic calming	- Benches: 25.00–150.00 m - Places to stay/chat: 1.50–2.50 m - Places to play: ≥ 4.00 m
References								
	(MAUT, 2009c)		(Municipal Chamber of Lisbon, 2018)	(Department for Transport, 2005, 2007; Transport for London, 2016c)	(City of Malmö - Streets and Parks Department, 2006, 2019; Trafikverket and Swedish Association of Local Authorities and Regions, 2015)	(FGSV, 2002, 2006)	(National Association of City Transportation Officials, 2013)	

(Table continued on following page)

,

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Recommended Crossing Designs								
Crossing Designs	- Central median - Physical without priority (plateau/raised block-paved area) - Pedestrian crossing (Zebra Crossing) - Pedestrian crossing with physical measures - Traffic signal - Under-/Overpass	No recommendation	- Central median - Pedestrian crossing (Zebra Crossing) - Traffic signal	- Central median - Physical without priority (plateau/raised block-paved area) - Pedestrian crossing (Zebra Crossing) - Pedestrian crossing with physical measures - Traffic signal - Under-/Overpass	- Central median - Physical without priority (plateau/raised block-paved area) - Pedestrian crossing (Zebra Crossing) - Pedestrian crossing with physical measures - Traffic signal	- Central median - Physical without priority (plateau/raised block-paved area) - Pedestrian crossing (Zebra Crossing) - Pedestrian crossing with physical measures - Traffic signal - Under-/Overpass	- Central median or central island - Pedestrian crossing (e.g. Zebra Crossing) - Traffic signal	- Central median - Physical without priority (plateau/raised block-paved area) - Pedestrian crossing (Zebra Crossing) - Pedestrian crossing with physical measures - Traffic signal - Under-/Overpass
Criteria for Selecting Types of Crossing Facilities								
Criteria	- Crossing facilities are necessary if • There is a distinct crossing need; • Traffic volume > 1,000 motorised vehicles per hour, speed limit 50 km/h; or • Traffic volume > 500 motorised vehicles per hour and speed limit > 50 km/h.	No recommendation	Zebra crossings should be used - Whenever no traffic lights could be provided, - To reduce speed and - To avoid accidents	- Zebra crossings are only recommended for low speed environments, 35 mph or less - Underpass only under exceptional circumstances with high pedestrian demand	- Crossing design depends on: • Traffic safety • Whether a carriageway or a cycle path should be crossed	- Crossing facilities are necessary if • There is a distinct crossing need; • Traffic volume > 1,000 motorised vehicles per hour, speed limit 50 km/h; or • Traffic volume > 500 motorised vehicles per hour, speed limit > 50 km/h.	- On streets with higher volume (> 3,000 AADT), higher speeds (> 20 mph), or more lanes (2+), crosswalks should be provided - At places with high pedestrian demand marked crossings may be beneficial regardless of traffic conditions.	Criteria: - High traffic volume - Speed - Crossing need for pedestrians - High pedestrian demand
References								
	(MAUT, 2009a)		(Municipal Chamber of Lisbon, 2018)	(Transport for London, 2016c)	(City of Malmö - Streets and Parks Department, 2008)	(FGSV, 2002, 2006)	(National Association of City Transportation Officials, 2013)	

,

4.2.3 Design Recommendations with Positive Impact on Pedestrians and Place-Users

In this chapter, recommendations and criteria for urban street design are presented (not from guidance material but from the literature in the disciplines of urban design, transport planning and public health). The starting point of these recommendations for street design is human-centric and thus cover both street and place-user needs.

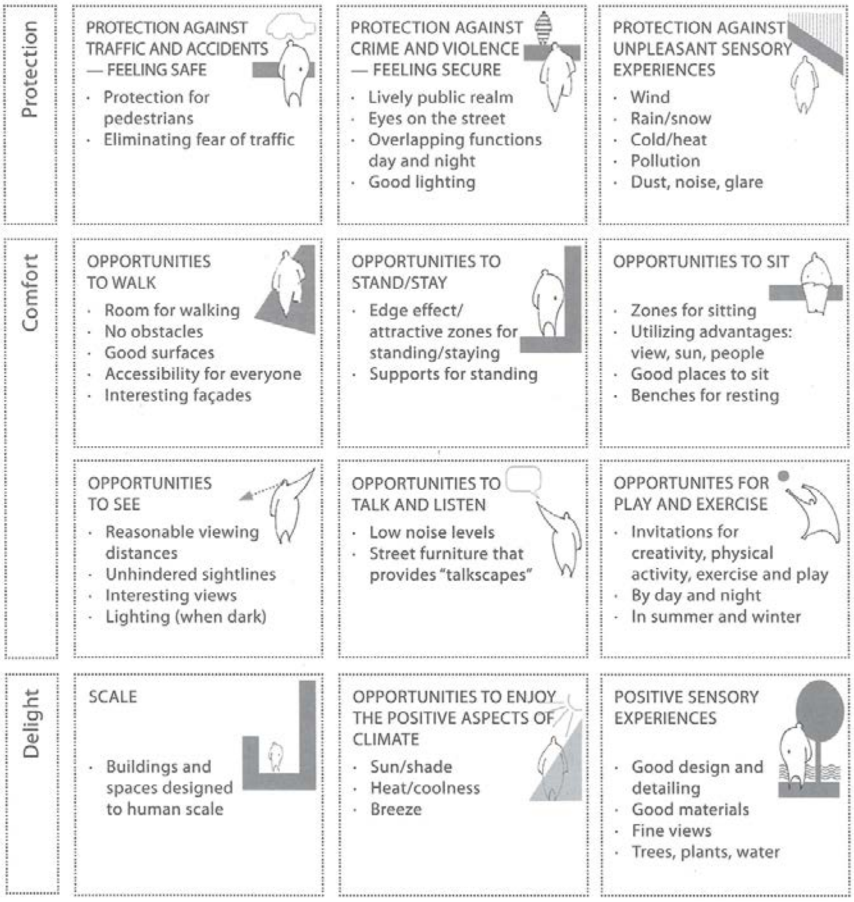
As previously mentioned, pedestrians are characterised by (1) a linear and frontal movement with slow speed up to maximum five km/h and are also (2) place users who, e.g., want to sit, stay, have social interactions, and enjoy their life in well-designed public spaces. Gehl (2010) finds that the low-speed movement of pedestrians leads to mobility behaviours which are highly influenced by the subjective perception of human senses. In particular, sight is one of the most developed senses and is horizontally aligned — Cognition is limited mostly by what persons can see and experience in this horizontal field of vision. Thus, the key to high quality street spaces are those which are built with respect to human senses and human scale (Gehl, 2010).

Gehl (2010) composed twelve quality criteria for high quality street spaces for pedestrians. The criteria are grouped into to the following categories:

- Protection: Objective and subjective (perceived) safety against traffic and traffic accidents as well as security against crime are prerequisites and motivating factors for walking and for place activities. In addition, "protection against unpleasant sensory experiences" (see Figure 22) is to be considered.
- Comfort: After taking safety issues into account, the provision of comfortable public spaces has to be ensured in order to invite people into different link-and-place-activities. For pedestrians, sidewalks should offer sufficient space void of obstacles (e.g., a dedicated footway zone) and good surface quality. Providing space for different place-activities invites place users to spend time in public spaces.
- Delight: To ensure quality maintenance and the well-being of pedestrians and place users, the human scale (in regard to adequate street and building dimensions) must be taken into account. The delight of design with respect to details and materials and green structures promote walking and the enjoyment of public spaces by place users.

Copyright © 2019 by MORE

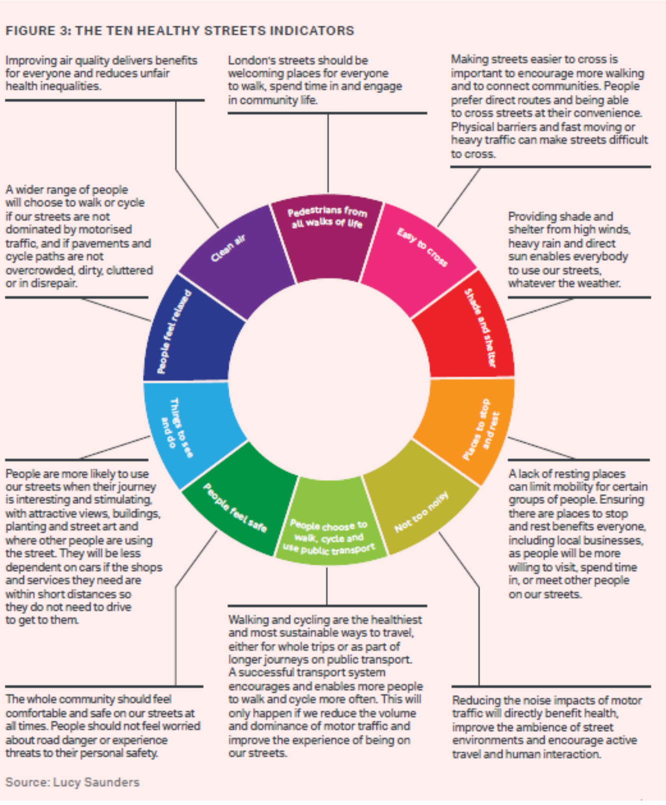
Figure 22: 12 Quality Criteria



Source: Figure cited from: Gehl (2010, p. 239);
Gehl et al. (2006); Further developed: Gehl Architects–Urban Quality Consultants, 2009;

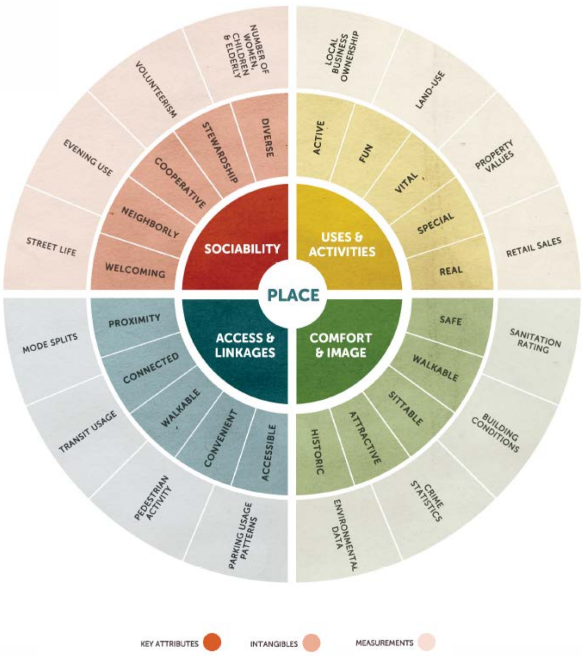
Another approach for urban street design is the Healthy Street Approach. This application supports implementing the vision of creating a "City for All Londoners", in which the streets are designed as "healthy, safe and welcoming" (Transport for London, 2017b, p. 4). The recommendations include ten indicators in total. Eight of them, from the disciplines of public health and urban and transport planning, promote the two main indicators by accommodating "pedestrians from all walks of life" and by motivating them to walk, cycle, and use public transport in their daily lives (Transport for London, 2017b, p. 4). The choice for active modes such as walking and cycling and for public transport can be positively influenced by improving the built environment and, thus, applying the indicators. These include increasing the design quality of street spaces; providing commercial facilities, services, and space for activities; creating safe and secure streets for all street users; and offering an attractive transport system (see Figure 23). These factors play an integral role in decreasing traffic as well as noise and air pollution.

Figure 23: Healthy Streets Indicators



Source: (Transport for London, 2017b, 2018c)

Figure 24: "The Place Diagram"



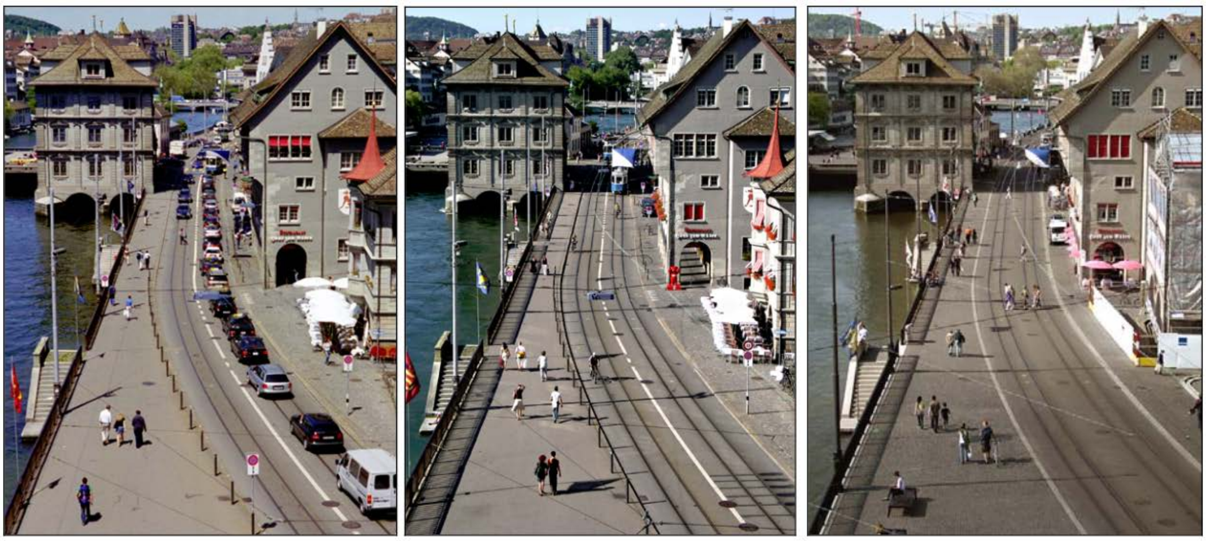
Source: (Project for Public Spaces, p. 5)

The “Project of Public Spaces” focuses on places which should be regarded in a multidimensional manner. These should be comfortable, attainable, and social places which include the placement of uses and activities and are accessible and linked to the surrounding sidewalk network. To evaluate the efficacy of such a place, the non-profit organisation “Project for Public Spaces” has developed “The Place Diagram” which shows objective and qualitative criteria (intangibles)—next to the key attributes of a place in the centre of the diagram—as prerequisites of “well-working” public spaces (Project for Public Spaces, p. 5). Adequate measurements (indicators) are listed at the outer side of the diagram to evaluate the quality of a place.

Amongst the many urban street design projects worldwide, the re-design of the Limmatquai in Zurich, Switzerland, is one of the more successful, best-practice examples. In 2004, the street segment between two bridges—Rudolf Brun Bridge in the north and the Münsterbrücke in the south—has been traffic calmed by removing motorised through traffic. Only public transport, taxis, and local inhabitants are permitted to use this street segment with a maximum speed limit of 30 km/h. The delivery of goods is also allowed (City of Zurich, 2004).

In addition to traffic calming, the street layout of the Limmatquai has been changed from 2006 to 2008. A priority route for cyclists was established, and wider, attractive spaces for pedestrians and place users were built, particularly with improved access to the river Limmat (City of Zurich, 2013) (Figure 25).

Figure 25: Situation at Limmatquai in 2004, 2005 and 2008 (from left to right)



Source: (Urban Mobility Research, City of Zurich, 2009, p. 6)

,

Copyright © 2019 by MORE

The impact of the Limmatquai redesign was evaluated in three phases – before (2004), during (2005) and after reconstruction (2008) (Urban Mobility Research, City of Zurich, 2009), through

- tracking daily pedestrian and cycling volumes,
- a video survey on behaviour and interactions in 2008, and
- a survey on place-using activities.

Both the redesign and traffic calming had a substantial impact on pedestrian volumes. The direct comparison of the amount of pedestrians between 2004 and 2008 shows a relative volume increase of pedestrians per day of about 17%, an increase of about 2,000 pedestrians per day; the amount of cyclists increased by 18% with up to 3,730 cyclists per day (Urban Mobility Research, City of Zurich, 2009, p. 5).

There is a doubling of place users within this project. In 2004, 707 pedestrians per day were spending time within the public space; after the opening of the redesigned street in 2008, the amount raised up to 1,562 pedestrians (+121%) (Urban Mobility Research, City of Zurich, 2009, p. 5). More place users also mean more potential users of commercial facilities. The occupancy rate of cafés (counted without the “Zunfthaus zur Zimmerleuten”) increased from 21% in 2004 to 30% in 2008.

After reconstruction of the Limmatquai, the amount of seating within the space increased almost tenfold (2004: about 20 sitting places; 2008: up to 212 sitting places) (Urban Mobility Research, City of Zurich, 2009, p. 46).

Overall, this example shows the strong effect of a user-friendly design of streets on the volume of pedestrians and cyclists per day as well as on the amount of place using persons. This is also beneficial for commercial facilities located along the redesigned street segment.

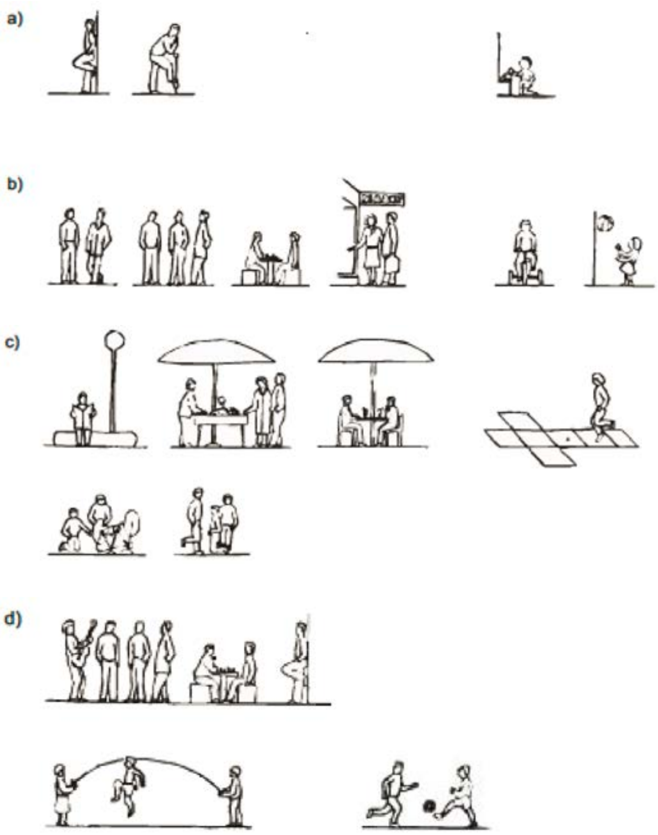
Consequently, designing pedestrian infrastructure is not simply limited to upgrading sidewalks in a sufficient way; it means evaluating and redesigning places in a user-friendly manner with the objective to promote walking and to create liveable public spaces.

Copyright © 2019 by MORE

4.2.4 Examples of Good Practice

Selected examples for visualisations of recommendations for pedestrian facilities in the researched guidance material are shown below.

Figure 26: Residential and Entertainment Functions in Public Areas (Budapest)



17. ábra – Tartózkodási és szórakozási funkciók közterületen
a) 0,70–1,00 m
b) 1,50–2,00 m
c) 2,50–3,50 m
d) 4,00 m vagy nagyobb

Figure 17. Residential and Entertainment Functions in Public Areas

a) 0.70–1.00 m

b) 1.50–2.00 m

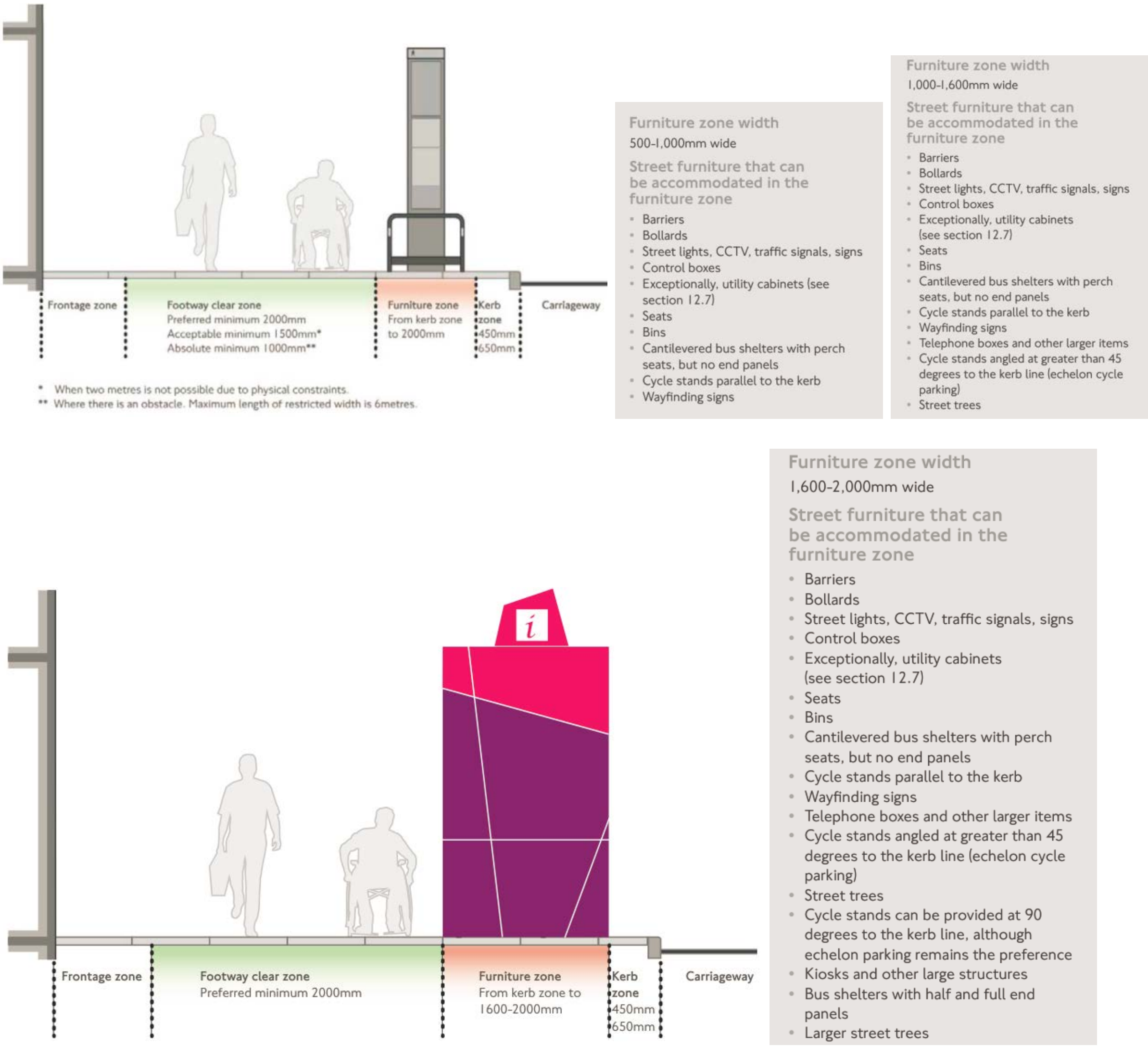
c) 2.50–3.50 m

d)4.00 m or more

Source (MAUT, 2009a)

Copyright © 2019 by MORE

Figure 27: Sidewalk Components (London)



Source: (Transport for London, 2016c)

Copyright © 2019 by MORE

Figure 28: Planning Pedestrian Crossings (Budapest)

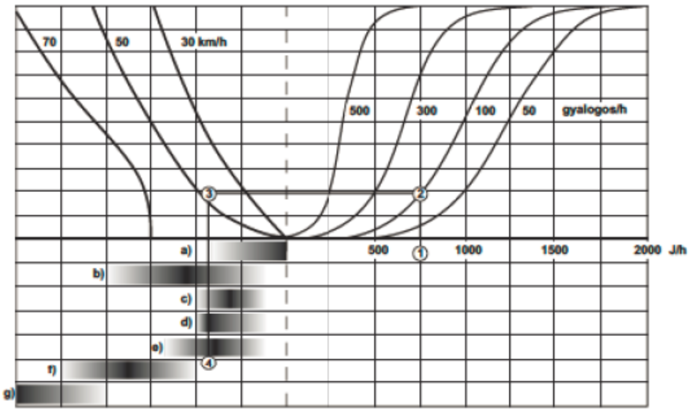


Figure 19. Planning Pedestrian Crossings at Two-Lane Roads in Urban Area.

Usage of Figure: Starting from cross-sectional vehicle traffic (e.g., 750 vehicle/h)

2) Trimming based on pedestrian traffic (e.g., 100 pedestrians/h)

3) Trimming based on permitted speed (e.g., 50 km/h)

4) Selecting a pedestrian facility:

a) No pedestrian crossing required

b) Pedestrian crossing

c) Middle separation (refuge island)

d) Construction intervention without priority (full / partial level increase)

e) Pedestrian crossing with construction intervention

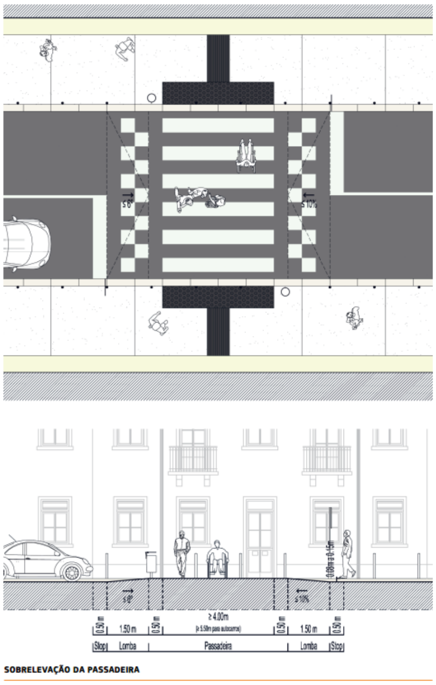
f) Traffic light

g) Underpass / overpass

Source: (MAUT, 2009a)

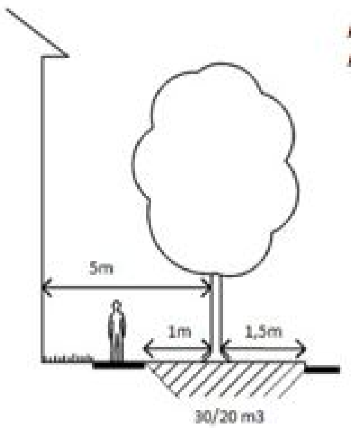
,

Figure 29: Pedestrian Crossing (Lisbon)



Source: (Municipal Chamber of Lisbon, 2018)

Figure 30: Plantzones in Malmö



Source: (City of Malmö - Streets and Parks Department, 2019)

Copyright © 2019 by MORE

4.2.5 Summary and Recommendations

This chapter summarises the findings gathered from the guidance material and additional literature and, based on the insights gained, develops recommendations for designing pedestrian facilities.

The combined research material shows that standards for space requirements of pedestrians are provided in most references and are comparable to one another. The width of a standard pedestrian varies between 0.55 m and 0.80 m; values for two pedestrians are given with few exceptions and vary between 1.50 m and 1.80 m. Only the German guidelines on urban street design are clear and exacting that sidewalks should generally be scaled based on space requirements for two pedestrians. This specification is based on the fact that pedestrians walk on either direction on each sidewalk and that sidewalks should be generally designed in a way that allows two pedestrians walking in opposite directions to meet each other.

Measurable differences were identified among buffer zones; these ranged from 0.00 m to 1.00 m. The criteria used for choosing buffer zone widths for each design task are consistent; these depend on speed and volumes of motorised traffic for buffers to the carriageway and on the type and size of adjacent buildings for buffers to the edge of the street. However, the values themselves differ greatly.

The quite similar space requirements for pedestrians summarised above translate in the researched guidance material into very different recommended sidewalk widths ranging from 1.00 m upwards. This wide range shows the difficulty of actually integrating adequate sidewalk widths into urban street layouts. A sidewalk of 1.00 m means that one standard pedestrian with an assumed width of 0.75 m can walk on this sidewalk with about 0.12 m buffer on both sides. One pedestrian needs to leave the sidewalk if two pedestrians walking in opposite directions meet each other. A wheelchair user with a width of 0.90 m can use this sidewalk with 0.05 m buffer to both sides. This is on the one hand not very comfortable; on the other hand, it is also a safety issue when pedestrians using the carriageway meet each other. The authors of the guidance material are definitely aware of pedestrian space requirements and of the problems that might result from very narrow sidewalks. Nevertheless, they include these low values for sidewalk widths into their recommendations. The main reason for this is space scarcity. Particularly in historic city centres, it is rarely possible to accommodate all user requirements into the limited available street space. Low minimum values, e.g., for sidewalk width, could help finding compromises for such challenging design tasks; and these low values can be applied for pedestrians more easily than, e.g., for buses; these simply cannot pass a cross-section when lanes are too narrow.

Some references provide specific guidance for bottlenecks; these might help in such cases. For example, Transport for London (2016c) allows for a minimum width of the footway clear zone of 1.00m for a maximum length of 6 m. Two pedestrians cannot meet each other here but they might wait at a passing point until the bottleneck is free and can be passed. Municipal Chamber of Lisbon (2018) recommends coexistence streets in case of limited

,

Copyright © 2019 by MORE

space availability; further references recommend to take out selected functions completely and to thus allow for regular widths for the remaining elements in the street (FGSV, 2006).

Criteria for choosing sidewalk widths beyond minimum values are (1) the street type (Budapest, Lisbon, London, Malmö, Germany) or (2) pedestrian volumes (Budapest, Constanta, London). The second criterion of pedestrian volumes is difficult to apply because of problems in counting and forecasting pedestrians. Discussions with city partners revealed that this criterion is therefore hardly applied even when it is clearly mentioned in the local or national guidance material. The first approach to choose sidewalk widths based on street types seems to be more suitable in the context of unknown pedestrian volumes. Criteria for distinguishing street types are based on road-function classification, such as the link and place approach in London (see Chapter 2) or on defined street characteristics; this is for example AADT, density/height and usage of adjacent buildings and the proximity of public transport stations or stops. In addition to these street types, the German guidelines on urban street design recommend the widening of sidewalks based on actual quantified pedestrian demands in the vicinity of specific destinations such as retirement homes, schools or shopping centres. Some references work with pictograms for visualising possible sidewalk usages for specific sidewalk widths; for example, groups of pedestrians should be able to chat on the sidewalk in a street section, thus recommendations are provided for sidewalk widths.

More sophisticated references provide not only recommendations for the overall sidewalk width but give additional recommendations for different zones of the sidewalk (FGSV, 2006; MAUT, 2009c; Municipal Chamber of Lisbon, 2018; National Association of City Transportation Officials, 2013; Transport for London, 2016c). This approach allows for a clear separation of link and place functions. The footway clear zone (also called pedestrian through zone) is the part of the sidewalk that should be kept clear from all obstacles and that is dedicated to the link function; it should allow pedestrians to move safely and comfortably. The recommended minimum width for footway clear zones is 1.20m (in Lisbon on existing 4th or 5th level streets); in Budapest, London (acceptable minimum) and the U.S. 1.50m; in Germany and Lisbon (for new streets) 1.80m and in London 2.00m as the preferred minimum. The frontage zone, furniture zone, and the kerb zones are spaces that are dedicated to place functions or that serve as buffer zones.

Recommendations for place functions are very technical in the researched guidance material and include mainly space requirements for street furniture such as benches, parklets, terraces, gastronomy tables/seating, waiting areas at public transport stops, or parking facilities for bicycles. Malmö is most advanced in providing space requirements for greenery. Transport for London (2016c) lists possible place activities for different widths of the furniture zone (see Chapter 4.2.4). Provision for place functions is additionally included in the increased sidewalk width for specific street types. For example, MAUT (2009c), recommends widths of 1.50 m-3.00m for residential street sidewalks and ≥ 4.50m for shopping streets. These recommendations are based on the fact that higher pedestrian volumes can be expected in shopping streets and higher level place activities should be possible in shopping streets when persons, e.g., not only stop for a moment to write a text message but stay for a while, chat, window shop, or sit in a café.

,

Copyright © 2019 by MORE

Overall, the focus of the researched guidance material is clearly on the link function as well as for pedestrians; rarely any information is given about how to design pleasant spaces for pedestrians that fit to the human dimension and that invite users to stay, sit, chat, etc. On this topic, Gehl (2010) and Transport for London (2017b) have developed human-based approaches for street and urban design which also include health-related aspects. On the street level, the key factor for increasing the odds for pedestrian activities is to meet street-user needs and thus design comfortable and safe street spaces (see Chapter 4.2.3).

Based on the above summary of findings from the researched guidance material, the following conclusions and recommendations have been developed:

Link Function:

- In a supply-oriented approach, adequate standard width for sidewalks should be provided in the guidance material a basis value, independent of expected pedestrian volumes; and as simple standard values. These should include a footway clear zone that allows two pedestrians to meet each other and buffer zones to adjacent usages.
- For the footway clear zone that should be kept free of any obstacles, a minimum value of 1.70m seems to be suitable. This is the width that allows two standard pedestrians to meet each other (0.75m + 0.20m + 0.75m); this value would be 1.85m if the goal were to allow one standard pedestrian and one wheelchair user to meet each other (0.75 m + 0.20 m + 0.90 m).
- Buffer zones to buildings and the carriageway should be scaled depending on the height of the buildings and the usage of the carriageway. For residential streets with low traffic volumes and speed, small buffer values are sufficient. For busy streets with higher speeds for motorised vehicles, buffer zones between the pedestrians and the moving motorised traffic are necessary (≥ 0.30 m).

Copyright © 2019 by MORE

Place Function:

- The street type approach seems to be a suitable starting point for providing for place functions. It allows for implicitly considering differences in place functions resulting from different types and usages of the adjacent buildings and the vicinity to public transport stops for determining sidewalk widths.
- Road function classification is of great importance also for pedestrians. A clear concept for pedestrian networks including a hierarchy of main and secondary pedestrian facilities is the basis for deciding on extra space beyond standard values and also on the equipment of sidewalks (e.g., benches or public toilets).
- The human dimension is of great importance for pedestrians as link and place users. Pedestrians are the slowest transport users; they are directly impacted by their environment. In particular, place activities are only carried out when pedestrians feel comfortable, when they perceive their environment as pleasant and as inviting. Thus far, guidance for designing pleasant and activating spaces for pedestrians are hardly included into guidance material on urban street design but are urgently needed. Urban planning literature can provide valuable input for adding such information to the guidance material on urban street design.

Bottlenecks:

These are a major problem in planning for pedestrians. Clear guidance should be provided about how to deal with bottlenecks, but standard values for sidewalk widths and characteristics should not be established for bottlenecks. These should instead be values that allow pedestrians to at least move safely and comfortably in both directions.

4.3 Universal Design, Design for All, Inclusive Design

4.3.1 Role of Universal Design in Urban Street Design

In December 2006, the “Convention on the Rights of Persons with Disabilities” and its “Optional Protocol” was adopted by the General Assembly of the United Nations and came in into force in 2008 (United Nations, 2008a). All EU Member States ratified the UN Convention.

Prior to the adoption of the UN Convention by the European Union, the Council of Europe had developed an action plan for 2006–2010. To ensure the effective implementation of the UN Convention within the EU Member States, the “European Disability Strategy 2010–2020” has been established (European Commission, 2010). The following chapter refers to passages from the European Union and the UN Convention documents.

All EU Member States declare within the UN Convention “to promote, protect and ensure the full and equal enjoyment of all human rights and fundamental freedoms by all persons with disabilities, and to promote respect for their inherent dignity” (United Nations, 2008b Article 1). This means the inclusion of persons with disabilities in all aspects of (public and societal) life. The “Charter of Fundamental Rights of the European Union” states within Articles 1 and 26 the preservation of human dignity and equality (The European Parliament, the Council and the Commission, 2000).

,

In order to guarantee independence and ensure mobility in daily life, full access to all users within the built environment (e.g. buildings and facilities/institutions/services, roads and transportation) must be provided, which directly corresponds with the elimination of obstacles and barriers (European Commission, 2010; United Nations, 2008b, Article 9).

Provision of accessibility has direct implications for street design. In this respect, the UN Convention defined the term “Universal Design” in Article 2 as follows: “Universal Design” means the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design.” (United Nations, 2008b, Article 2). The EU uses for emphasis the term “Design for All” (European Commission, 2010, p. 9).

In the MORE project, the terms “Universal Design”, “Design for All”, and “Inclusive Design” will be used interchangeably.

4.3.2 Synthesis of Recommendations for Persons with Disabilities

The guidance material used by the MORE cities all allude to the concept of universal design. Table 15 below gives an overview of the recommendations regarding urban street design.

- Elements and dimensions of tactile paving: The most important senses used while moving are seeing, hearing, and feeling. If one of these senses is physically reduced, compensating mobility aids need to be implemented within the street space (FGSV, 2011). For visually impaired persons, audible and tactile measures are required to ensure orientation within street spaces and to enable independent mobility.
- Concerning tactile paving, different types of layouts are used to signal changes within street spaces. The elements and the dimensions of tactile paving for these different situations are shown in the table.
- Additional requirements for visually impaired persons: In addition to the elements and dimensions of tactile paving, information of kerb heights, materials or audible and tactile signals at crossings are given in the guidance material.
- Requirements for persons with impaired mobility: Adequate sidewalks gradients and ramps as well as dropped kerbs at crossings and access to all levels are required. The following overview focusses, in particular, on gradients of sidewalks and heights of kerbs at crossings.

,

Copyright © 2019 by MORE

Table 15: Recommendations for Persons with Disabilities

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Elements and Dimensions of Tactile Paving								
At Crossings and Junctions	- Dropped kerbs: maximum gradient of 8% - Kerbs with a reduced height of 0.02 m, - Width: ≥ 3.00 m - On re-designed and new streets: • Tactile paving orthogonal to crossing with ribbed structure(one unit) • Blister surface (two units)	- Tactile paving orthogonal to crossing with ribbed structure (two units) - Blister surface: • Width: 1.50 m (recommended) - Dropped kerbs/access ramps: recommended gradient of 8%(max. 15%)	Tactile paving orthogonal to crossing with ribbed structure - At orthogonal crossings: width: 0.80 m (two units) - At crossings with radial curves: width: 0.40 m (one unit) - On central islands: • 1.50–3.00 m surface covered by blister surface • > 3.00 m tactile paving, width: 0.40 m (one unit) • central island with a change of direction on it: tactile paving width: 0.80 m (two units), in addition field with blister surface as signal for direction change Blister surface: - At orthogonal crossings and at crossings with radial curves: • Width: ≥ 3.00 m, two units of blister paving: 0.80 m	- Red blister surface at controlled crossings only - At controlled crossing points: tactile surface arrangement in "L" pattern: • 0.80 m from the kerb • The stem/tail end of tactile paving in direction of crossing direction: max. 4.80 m	Tactile paving orthogonal to crossing, ribbed structure0.70 m - On sidewalk: tactile paving from building to crossing - On central islands: • < 2.00 m: no tactile paving, but four units blister surface • > 2.00 m with adjacent kerb: no tactile paving • > 2.00 m without adjacent kerb: tactile paving with ribbed structure width: 0.70 m Blister surface: - Crossing of carriageway • From sidewalk: kerb with a height of 0.06 m; one unit blister paving • From central island: no kerb, level of carriageway, white, structured beton plates, two units blister paving - Crossing of cycle path: • From sidewalk: no kerb, level of cycle path, two units blister paving	Tactile paving at kerb and orthogonal to crossing with ribbed structure - Gives advice for crossing direction ("Richtungsfeld") - 0.60 x 0.90 m Tactile paving with blister surface ("Auffindestreifen"): - At controlled crossings - Orthogonal from building to crossing width 0.60 m	- In general: Crossing points and shall be designed for visually as well as mobility-impaired people - Blister surface and dropped kerb	Tactile paving orthogonal to the crossing with ribbed structure or with blister surface

(Table continued on following page)

,

Copyright © 2019 by MORE

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
				Elements and Dimensions of Tactile Paving				
Along the Sidewalk or in Complex Locations (e.g. Airports, Train Stations, Pedestrian Zones, Squares)	Tactile guidance path with direction/ orientation fields	Tactile guidance path with direction/ orientation fields	No recommendation	Blister paving as a guidance path	No recommendation	- Tactile guidance path ("Leitstreifen"), ribbed structure • 0.30–0.60 m - Blister surface ("Abzweigefelder") for changing directions;: • 90 x 0.90 m	No recommendation	- Tactile guidance path - Orientation Fields
Hazardous Situations (e.g. Steps, Ramps):	Tactile paving should cover the full width of the hazard	Tactile paving should cover the full width of the hazard (two or three units)	Tactile paving should cover the full width of the hazard (two units)	Tactile paving should cover the full width of the hazard, depth: 0.80 m	First step with a strong visual contrast	Blister surface ("Aufmerksamkeitsfeld") should cover the full width of the hazard, depth: 0.60 m or 0.90 m	No recommendation	- Tactile paving covering the full width of the hazard - First step with a strong visual contrast
Public Transport:	- Access to platforms/tram stops with a max. gradient of 8% - Access point to public transport vehicle	No recommendation	No recommendation	Tactile paving should cover the full width of the platform, parallel to the platform edge; depth: 0.40 m, min. of 0.50 m back from the edge	Blister surface and tactile paving to access point	Ribbed structure ("Einstiegsfelder") and tactile paving with blister surface ("Auffindestreifen") to access point	No recommendation	- Access to platforms - Access points to the PT vehicle
				Additional Requirements for Visually Impaired Persons				
Additional Requirements	- Dropped kerbs: maximum gradient of 8% and width: 1.50–2.00 m - Kerbs with a reduced height of 0.02 m	Dropped kerbs/access ramps: recommended gradient of 8%(max. 15%)	- Dropped kerbs - Materials of tactile paving elements with a strong visual contrast	- Dropped kerbs: maximum gradient of 8% (1 : 12) - Audible and tactile signals - Raised tactile strip between cycle path and footpath	- Dropped kerbs or same level - Crossing points and consistent pedestrian crossings shall be designed for visually as well as mobility-impaired people.	- kerbs with a reduced height of 0.03 m - materials of tactile paving elements with a strong visual contrast - Provision of additional facilities at traffic signals - safety separating strip with different surface along parallel to parking bays - tactile strip between cycle path and footpath	No recommendation	- Dropped kerbs and access ramps - Material with strong visual contrast - Audible and tactile signals

(Table continued on following page)

,

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Requirements for Persons of Impaired Mobility								
Requirements	Same as visually impaired persons: - Dropped kerbs: maximum gradient of 8% and width: 1.50–2.00 m - Kerbs with a reduced height of 0.02 m	Same as visually impaired persons: - Dropped kerbs/access ramps: recommended gradient of 8%(max. 15%) - Waiting bays	Dropped kerbs, maximum gradient of 8%	Dropped kerbs offer convenient, step-free access and are especially beneficial for users with impaired mobility	Dropped kerbs on level of the carriageway: maximum gradient of 3,5% and width: 0.90–1.05 m	At all crossing facilities, there should be a kerb with reduced height of 0.03 m	Dropped kerbs at crossings	Dropped kerbs and step-free access
References								
	(MAUT, 2009c), own observations in field visits	(Ministry of Regional Development and Public Administration, 2013)	(Municipal Chamber of Lisbon, 2018)	(Department for Transport, 2005; Department of the Environment, Transport and the Regions, 1998; Transport for London, 2016c)	(City of Malmö, 2005a, 2005b, 2005c, 2005d, 2005e; City of Malmö - Streets and Parks Department, 2008)	(FGSV, 2011)	(National Association of City Transportation Officials, 2013)	

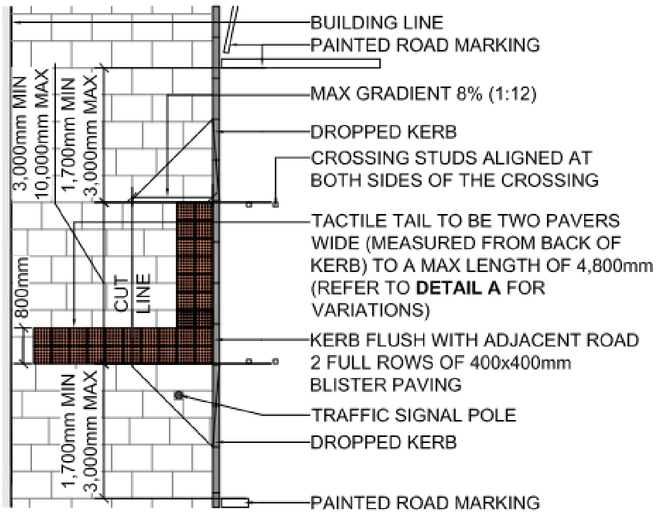
,

Copyright © 2019 by MORE

4.3.3 Examples of Good Practice

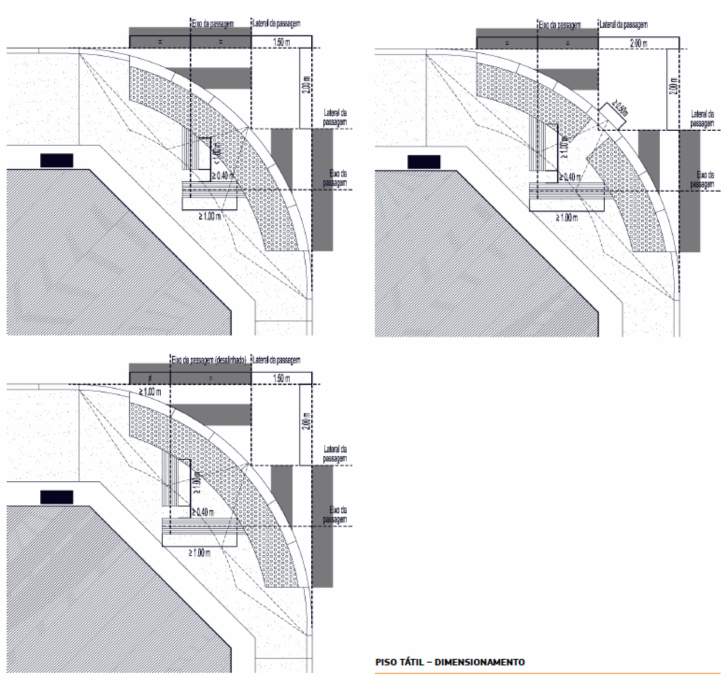
In the following chapter, selected examples of recommendations on universal design are shown.

Figure 31: Controlled Crossing Tactile Layout (London)



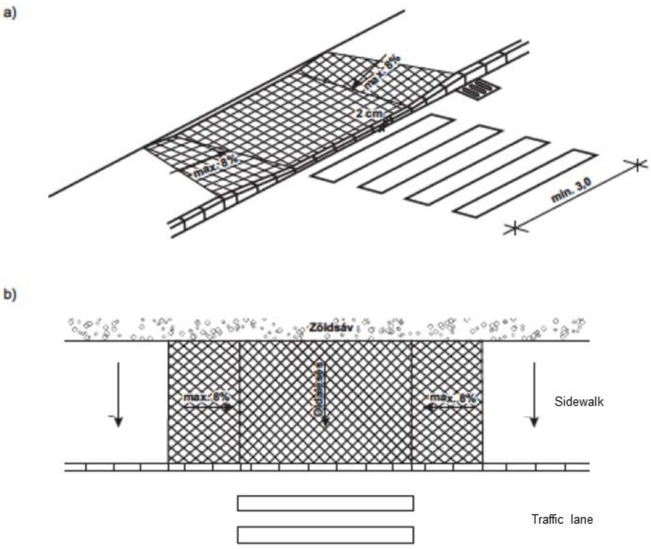
Source: (Transport for London, 2017e, p. 134)

Figure 32: Dimensions of Tactile Paving at Crossings with Radial Curves (Lisbon)



Source: (Municipal Chamber of Lisbon, 2018, chapter 1.1, p.17)

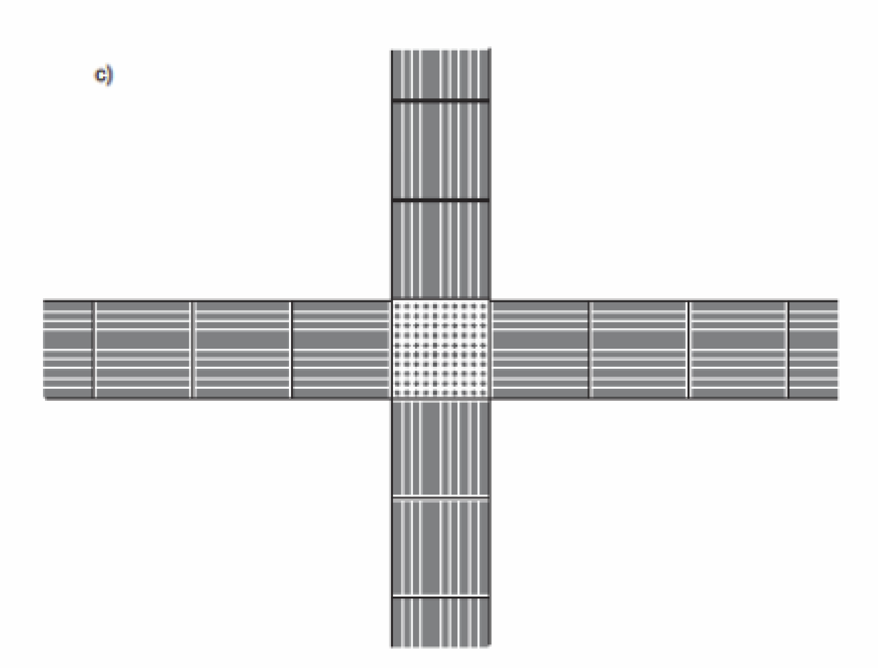
Figure 33: Total Lowering of the Sidewalk at Crossings (Budapest)



a) front view, b) top view

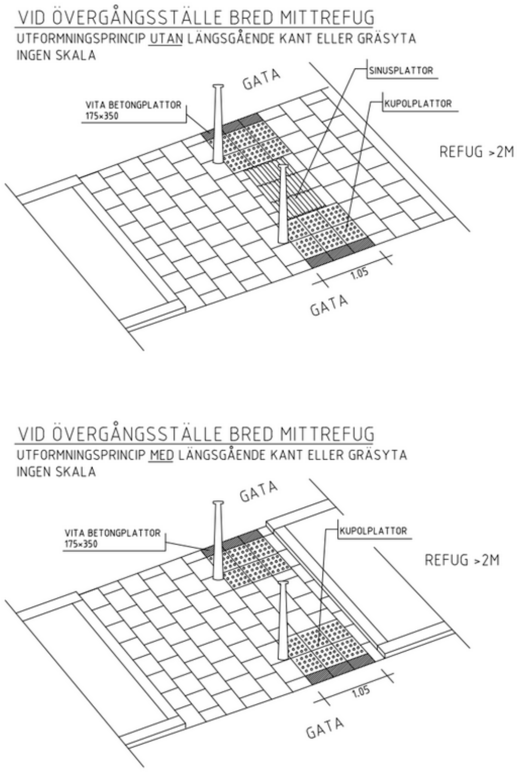
Source: (MAUT, 2009c, p. 11)

Figure 34: Tactile Paving with "Orientation Field" (Budapest)



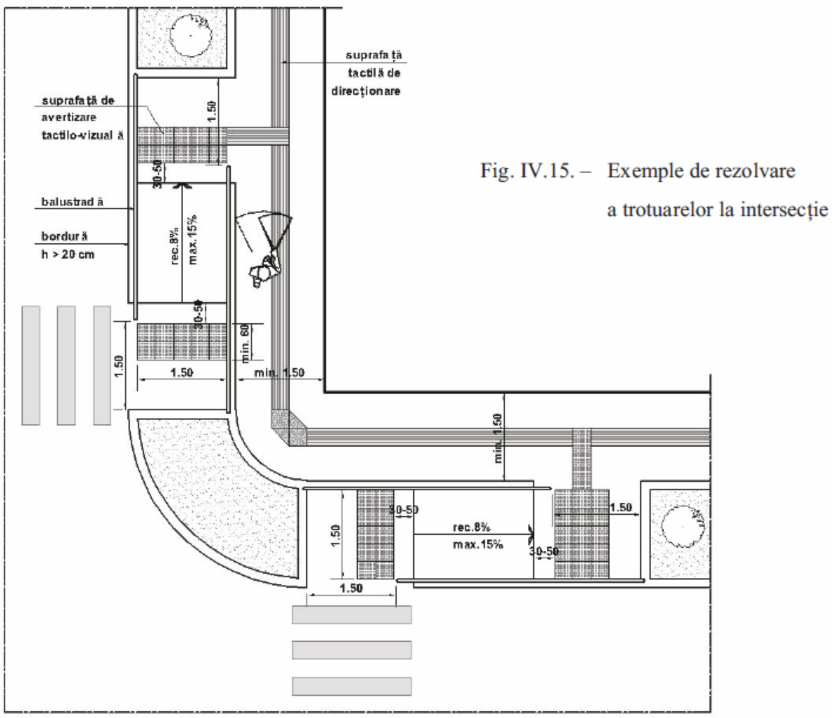
Source: (MAUT, 2009c, p. 17)

Figure 35: Design of Crossing Point with Wide Refuge >2m (Malmö)



Source: (City of Malmö, 2005f)

Figure 36: Tactile Paving at Crossings (Constanta)



Source: (Ministry of Regional Development and Public Administration, 2013, p. 34)

4.3.4 Summary of Recommendations

This chapter provides a summary of the recommendations on universal design researched in the guidance material.

In general, in all MORE cities, tactile paving has been given, but the layout of the tactile paving is handled differently.

At crossings and junctions, the tactile paving in nearly all MORE cities consists of two parts. The first part of the tactile paving is placed orthogonal to the crossing, which guides the person, e.g. from the building line directly to the crossing. In Budapest, Constanta, Lisbon, and Malmö, these tactile elements contain a series of raised, flat-topped bars in "ladder-pattern" (forming a ribbed structure), which indicate the direction to the crossing and how to cross the carriageway safely by the shortest route. Second, in these cities blister surface is placed between the kerb and the orthogonal tactile paving. The blister surface indicates to the pedestrian that the crossing is directly ahead (City of Malmö, 2005f; MAUT, 2009c; Ministry of Regional Development and Public Administration, 2013; Municipal Chamber of Lisbon, 2018). In Germany, the use of tactile paving elements with ribbed structure and blister surfaces is inverted. The blister surface is used as a tactile paving which guides the persons directly to controlled crossings, and the tactile element with ribbed structure is placed between kerb and the tactile paving and defines the direct way to the other side of the crossing (FGSV, 2011). Only in London is the tactile pacing designed with a blister surface in an “L”-pattern, e.g., from the building line to the crossing (see Figure 31) (Transport for London, 2017e).

In Budapest, Constanta, London, and Germany, a tactile guidance path is recommended to lead the way along the sidewalk or in complex situations (e.g., squares, pedestrian zones, train stations, airports) (FGSV, 2011; MAUT, 2009c; Ministry of Regional Development and Public Administration, 2013; Transport for London, 2017e). To indicate directional changes or options for changing directions, quadratic tactile elements function as direction or orientation fields.

Most MORE cities indicate hazardous situations (e.g., steps, ramps) with tactile paving. Malmö emphasises the first step with a strong visual contrast (City of Malmö - Streets and Parks Department, 2008). Also, access points to the public transport vehicles or to the platforms are identified in most of the MORE cities (see Table 15).

In general, the “Urban Street Design Guide” by NACTO recommends no layout for tactile paving in detail but shows that crossings should provide tactile elements as indicators (National Association of City Transportation Officials, 2013).

Additional requirements in the guidance material of the MORE cities are dropped kerbs and audible signals at crossings as well as strong visual contrasts between materials. For example, guidance material of London, Malmö, and Germany provide for a clear separation of sidewalks and cycling paths by raised strips or the changing of materials.

Copyright © 2019 by MORE

For persons with impaired mobility various aspects in street design should also be considered, such as adequate gradients of sidewalks and ramps as well as dropped kerbs at crossings and the provision of step-free access. In this chapter, the gradients and the height of kerbs are listed. All MORE cities provide dropped kerbs at crossings with a maximum gradient of 8% (Malmö 3.5%). For example, in Budapest, the reduced height of the kerb at pedestrian crossings is given by 0.02m. In the German guidelines, the height of the kerb is 0.03m, which is a compromise between providing for visually impaired persons and persons with impaired mobility. Here, the kerb is high enough that it can be detected by visually impaired persons and low enough that, e.g., persons in a wheelchair still have access.

It is important to state that all researched guidance material of the MORE cities include the necessary universal design aspects which enable persons with disabilities to move independently. The MORE cities have made great efforts within the last years to improve the conditions for disabled persons within their street spaces. The consequent implementation of these inclusive design elements to the whole sidewalk-network presents a challenging task.

4.4 Infrastructure for Cyclists

4.4.1 Motivation to Cycle and the Role of Cyclists in Urban Street Design

Cycling is trending in research and in practice. The dynamically growing literature on cycling demonstrates how integral the establishment of safe and convenient cycling facilities are for increasing cycling levels (Mueller et al., 2018), besides socio-demographic/ -economic/ -psychological variables, land-use and external factors such as climate and topography (Gerike et al., 2019; Gerike and Parkin, 2016). Cycling infrastructures need to be seamless and perceived as safe as well as provide appropriate levels of safety which directly correspond to evaluated risk and usage levels. Literature also consistently shows that cycling causes various positive effects on the efficiency and environmental performance of transport systems as well as on the health and well-being of individuals (Gerike and Parkin, 2016).

Cyclist volumes are increasing in many cities and countries all over the world. Many stakeholders agree that cycling, along with other active modes such as walking, should be regarded as a vital feature of transport systems which create attractive, comfortable, safe and healthy communities. They are working hard to promote cycling as a mode of transport and to improve cycling conditions; ambitious goals are being established in strategic urban and transport planning – for example the Sustainable Urban Mobility Plans (SUMPs) – which target cycling either as a sole means of transport or in combination with walking and public transport. Examples for the latter are the cities of London and Vienna which aim for modal split proportions of 80 to 20 percent (walking/cycling/public transport to car) (Mayor of London, 2018; Vienna Municipality, 2015). Lobby groups, such as national cycling associations or the European Cyclists' Federation (ECF) have increased their activities and influence substantially in the last decades and are much stronger in terms of membership and political influence for cycling compared to associations for walking. In summary, there is a pressure on planners to pay particular attention to cycling, both from the demand side (as a result of increasing cycling volumes) and from the policy side (resulting from the positive image of cycling).

These developing and multifaceted incentives toward an increase in the use and awareness of cycling have led to a dynamic collection of guidance material which was researched for this study. The guidance material on cycling was, in most cases, more recently updated than for the other user groups and it was more often in the active process of being updated (e.g. in Budapest, Constanta, Germany, London, Malmö).

In addition, heterogeneity in types, scope of application, and in characteristics of cycling infrastructures was found to be much higher compared to the other user groups. One possible reason for this might be the relatively recent developments and changes in this area. Countries such as The Netherlands have a long history of making provisions for cycling, but many cities all over the world have begun only in recent years to systematically provide for cycling; additionally, the first standards and recommendations for cycling were set subsequent to others, i.e., motorised modes. Another reason for the wide variety of cycling infrastructure types in the researched guidance material might be that cycling is the only transport mode that can not only exist on a dedicated cycling facility along the carriageway, but also be coupled with motorised modes or placed on independent infrastructures separated from the carriageway.

Table 16 shows the classification of cycling infrastructures chosen for the MORE project. The classifications are denoted along the horizontal and vertical locations of the cycling facility regarding the carriageway: The horizontal separation describes whether cyclists are put on or off the carriageway, whereas the vertical separation describes whether or not there is a difference in height between the carriageway and the cycling facility. In addition, information is given about whether or not the cycling facility can be used by other street users and whether or not (and how) it is segregated from motorised traffic. The distinction does also implicitly describe the grade of separation from pedestrians: on-carriageway facilities are vertically separated from pedestrians; facilities with vertical separation from motorised traffic can be halfway between the carriageway and sidewalk level (separation of cyclists and pedestrians) or be on sidewalk level (no vertical separation from pedestrians). The table shows that a clear classification is difficult, particularly for cycle lanes and cycle tracks/paths. The dividing line between these two can be indistinct because both may have physical separation from the carriageway, e.g., in the case of segregated cycle lanes (see below). The terms track and path are used synonymously in this document, as both are horizontally separated from the carriageway. Tracks are dedicated for cyclists and physically separated from pedestrians and can be on half sidewalk or sidewalk level whereas paths are clearly on sidewalk level.

In some references, special versions of the below-listed standard cycling infrastructure types are recommended. Specifications of cycle lanes or tracks/paths concern the grade of separation from motorised traffic so that buffered lanes, segregated lanes, or stepped tracks are recommended. Those facilities are usually implemented as mandatory bike lanes which can be applied to higher volumes of motorised traffic and cyclists as well as provide higher comfort and safety for cyclists. The National Association of City Transportation Officials (2014) recommends buffered cycle lanes: Such lanes have a buffer zone that is marked by two lines (wide buffers with diagonal hatching). Transport for London (2016a) recommends cycle lanes with either light or full segregation. Light segregation is produced by

,

Copyright © 2019 by MORE

discontinuous pre-formed separators, planters, or flexible posts along the cycle lane and have buffer markings in some cases. Fully segregated cycle lanes have a raised curb, separating strips, islands, grass verges or lines of planting which create a continuous physical barrier between motorised traffic and cyclists; these lanes are also physically segregated from the sidewalk. Located usually on an intermediate level between the carriageway and the footway, stepped tracks are vertically separated from general traffic as well as from pedestrians. Special attention should be paid to junctions for all off-carriageway cycling facilities as visibility of cyclists might be restricted at junctions, e.g., for cyclists going straight with cars simultaneously crossing the lane and turning right (see Chapter 4.7)

Dedicated facilities for cyclists are only well received and safe if they are clear of other users. In countries with less effective enforcement of traffic rules, cycle lanes and tracks/path are prone to illegal parking or even driving. Physical separation can help preventing illegal behaviour even without traffic enforcement.

Advisory cycle lanes are introduced in the table below as one standard type of cycling infrastructure but, technically, they are a sub-type of mixed traffic because the advisory cycle lane is not exclusively dedicated to cyclists and may also be used by general traffic. Malmö lists an adaptation of advisory cycle lanes called marked shoulders that operate like advisory cycle lanes but allow vehicles to stop at the kerbside (inside the shoulder).

Other variations of mixed traffic are sharrows or service roads. Sharrows (shared-lane markings) are non-contiguous lane markings (pictograms) on the carriageway that indicate the shared use of the space. These sharrows aim to make clear that cyclists are allowed and welcome in the carriageway; these markings also give direction about where to cycle, to maintain safe distance from parked cars or to discourage overtaking by cars in narrow sections. They are mainly used where space is too narrow to provide a dedicated cycle facility. The use of sharrows is recommended by the Municipal Chamber of Lisbon (2018, 58 ff.) without particular operational criteria. MAUT (2019) recommends Sharrows only as additional measure with other facilities for cyclists. The National Association of City Transportation Officials (2014, 133 ff.) recommends the use of sharrows with speeds less than 56km/h and volumes of motorised traffic less than 3,000 veh/24h. These thresholds correspond well to the ones used for cycling in mixed traffic (see Chapter 4.4.2). Service roads are additional streets to high-level main carriageways, where cycling may be prohibited due to high speed limits or volumes of motorised traffic. Cyclists and residential motorised traffic share the carriageway. Service roads are mostly combined with sharrows or bicycle street signage. Another example for shared facilities is part time cycle lanes with limited hours of operation. E.g. Transport for London (2016a, Ch.4) does recommend usage in streets with high level of kerbside activities but not in busy streets with high volumes and speeds.

The city of Constanta is a special case: Recommendations in approved guidance material are rare, and dedicated cycling facilities are limited with an overall 6.2 km of infrastructure established thus far 1.2 km of which is in the city centre (European Commission). Planning for a new cycling infrastructure is in the near future, and the Ministry of Regional Development and Public Administration drafted the *Methodological Guide for the Regulation*

,

of the Bicycle Infrastructure Works Design, Construction, Usage and Maintenance which is currently under public review. Substantial changes can be expected for Constanta in the coming years through the provision of new guidance material and the establishment of ambitious goals such as those in the Sustainable Urban Mobility Plan (Constanta Municipality, 2015).

Table 16: Classification of Cycling Infrastructures

Type	Horizontal Location	Vertical Location	Dedicated to Cyclists	Segregation from motorised traffic	Example
Mixed traffic	On carriageway	Carriageway	No (shared with general traffic)	None	 FGSV (2010)
Advisory cycle lanes	On carriageway	Carriageway	No (shared with general traffic)	Stripped line or coloured surface	 FGSV (2010)
Mandatory cycle lanes	On carriageway	Carriageway	Yes	Solid/stripped line (optionally with horizontal segregation)	 Transport for London (2016a)
Bus/cycle lanes	On carriageway	Carriageway	No (shared with buses)	Solid line	 Transport for London (2016a)
Cycle track/path	Off carriageway (adjacent to the carriageway)	Half sidewalk or sidewalk	Yes	Physical	 Municipal Chamber of Lisbon (2018)
Cycleway	Off carriageway (alignment independent from the carriageway)	-	Yes	Physical	 Municipal Chamber of Lisbon (2018)

Copyright © 2019 by MORE

4.4.2 Synthesis of Recommendations for Cycling Facilities

The following Table 17 gives an overview on the recommendations for designing cycling infrastructures that were identified in the researched guidance material. The synthesis of findings is organised along the following aspects:

- Space Requirements: This specifies which width is assumed for a standard cyclist in each city and country; together with the buffer zone width, this is the basis for dimensioning cycling facilities.
- Buffer Zones: In addition to the various possible types and locations of cycling infrastructures, there is also a wide variety of possible neighbouring users and usages. Providing sufficient buffer zones to these adjacent usages is of highest relevance for both the objective and subjective/perceived safety of cyclists. Buffer zones between cyclists and cyclists or cyclists and other users describe the required space for overtaking or meeting events. Buffers to static obstacles describe the space required to manoeuvre along high kerbs or other objects. Buffers to parking/loading facilities are provided in order to avoid dooring accidents with cars opening their doors while being passed by a bicycle.
- Scope of Application: Different criteria are used for deciding which type of cycling infrastructure should be recommended for specific applications; these are listed in the table and allow for the comparison of different approaches and thresholds chosen in the various guidance materials.
- Width of Cycling Infrastructures: Space requirements for cyclists are combined with buffer zone widths to form recommendations for cycling infrastructure dimensions and parameters; these are listed per type of cycling infrastructure in order to account for the differences in recommended widths.
- Mixing and Separating Cyclists and Pedestrians: Particularly in inner-urban contexts with limited space, the provision of a combined space off the carriageway for pedestrians and cyclists was frequently discussed as a solution that would allow for cyclists to travel safely while at the same time saving space for an extra cycling facility. Shared cycle and pedestrian facilities have different applicable rules: cycle and pedestrian tracks/paths, sidewalks with cycling allowed (non-compulsory), cycle tracks/paths with walking allowed (priority for cyclists). Various conflicts and accidents might result from mixing cyclists and pedestrians on the sidewalk due to their varying speeds and manner of movement. Recommendations for the scope of application of such a solution are therefore also included into the table. Solutions for separated cycling and pedestrian facilities are found with combined recommendations in Chapter 4.2 as well as in this Chapter 4.4

It should be noted that only recommendations for street sections but not for junctions are included in the table below; the latter are discussed in Chapter 4.7.3.

Copyright © 2019 by MORE

Table 17: Recommendations for Cycling Facilities

	Budapest	Constanta	Lisbon	London	Malmö	CROW	Germany	NACTO	Summary
					Space Requirements				
Standard Cyclists	1.00 m	No recommendation	0.75 m	1.00 m	0.75 m	0.75 m	1.00 m	0.76 m	0.75–1.00 m
					Buffer Dimensions (Recommended, Not Required)				
Between Cyclists	0.00 m	No recommendation	0.50 m	≥ 0.50 m	No recommendation	0.25 m/0.50 m	0.00 m	No recommendation	0.00–≤ 0.50 m
General Traffic	No recommendation	No recommendation	2.50 m to roads with speed limits > 50 km/h 0.70 m to roads with speed limits ≤ 50 km/h	≥ 0.50 m	0.50–1.00 m	1.00 m to roads with speed limits of 50 km/h 0.80 m to roads with speed limits < 50 km/h	0.00 m for on-carriageway cycle facilities 0.50–0.75 m for cycle facilities alongside the carriageway	No recommendation	0.00–2.50 m depending on position of cyclists and speed limit
Pedestrians	-	-	-	-	0.30–0.40 m	-	0.00 m for on-carriageway cycle facilities 0.25 m for cycle facilities alongside the carriageway	No recommendation	0.00–0.40 m
Obstacles	0.25 m to kerbs, 0.35 m to obstacles on bridges and in exceptions 0.50 m to other obstacles	No recommendation	0.20 m to obstacles < 0.15 m e.g. kerbs, drainage grids 0.30 m to obstacles from 0.15 m to 0.90 m e.g. benches, railings, fences, 0.30–0.60 m to obstacles > 0.90 m e.g. traffic signs, public lighting 0.60 m to obstacles > 0.90 m e.g. bus stop shelters, trees 0.90–1.20 m to build elements e.g. walls, facades	≥ 0.50 m	No recommendation	0.25 m to obstacles < 0.05 m e.g. kerbs 0.50 m to obstacles > 0.05 m e.g. kerbs 0.70 m to fixed object e.g. railings, lamp posts, traffic signs, trees 1.00 m to build elements e.g. walls, facades (Measures exclude space requirements of cyclists)	0.25 m to e.g. walls, trees, traffic signs	No recommendation	0.20–1.20 m depending on obstacle height and type
Parking/ Loading	0.80 m	No recommendation	0.70 m	≥ 0.50 m	0.80–1.00 m (where stopping is allowed)	0.50 m	- 0.25–0.75 m to longitudinal parking for on-carriageway cycle facilities - 0.75 m in any other case	No recommendation	0.25–1.00 m depending on parking angle
Other	-	-	0.70 m to watersides	-	-	-	-	-	

(Table continued on following page)

	Budapest	Constanta	Lisbon	London	Malmö	CROW	Germany	NACTO	Summary
				Application of Cycling Infrastructure					
Criteria	v & SL	None	v & SL & street type	v* & 85th percentile speed & street type	Network function & v*	v & SL & c & number of lanes	v* & SL	v & SL	v & SL (& street type)
Mixed Traffic	v ≤ 4,000 and SL ≤ 30 or v ≤ 2,000 and SL ≤ 50	Generally applied	v ≤ 3,000 and SL ≤ 30 (Local street)	v ≤ 10,000 and 85th percentile speed ≤ 48 At Local streets, High streets, Town squares, City hubs, City streets, City places (bicycle street: analogous)	In residential network with v ≤ 3,000	v ≤ 5,000 and SL ≤ 30 and c ≤ 2500 bicycle street: SL = 30 km/h, c > v, c ≥ 500 and/or v ≤ 2,500	v < 8,000 and SL = 30 or v < 4,000 and SL = 50 or v < 2,000 and SL = 70 with additional non-mandatory off carriageway facility: see criteria of advisory cycle lanes (bicycle street: SL ≤ 30 km/h)	Not recommended	Up to v = 10,000 or Up to SL = 70
Advisory Cycle Lane	v > 6,000 and SL ≤ 30 or v > 5,000 and SL ≤ 40 or v > 4,000 and SL ≤ 50	Not recommended	Not recommended	At Connectors, Local streets, High roads, High streets, Town squares, City hubs, City streets	Not recommended	Not recommended	v < 18,000 and SL = 30 or 4,000 < v ≤ 10,000 and SL = 50 or v < 3,000 and SL = 70	Not recommended	Up to v = 18,000 or Up to SL = 70
Mandatory Cycle Lane	v > 6,000 and SL ≤ 40 or v ≤ 4,000 and SL ≤ 50	No recommendation	3.000 < v ≤ 8.000 and SL = 50 (Local street)	At Arterial roads, Connector roads, High roads, High streets, City hubs	Not recommended	v ≤ 2,000 and SL ≤ 30 and c ≥ 2000 or v ≤ 4,000 and SL ≤ 30 and c < 750 or SL = 50 and c < 75 (2-lane carriageway)	v > 18,000 and SL = 30 or v > 10,000 and SL = 50 or v > 3,000 and SL = 70	v ≤ 3.000 SL ≤ 40	Up to v = 18,000 or Up to SL = 70
Segregated Lane/Stepped track	v > 15,000 and SL ≤ 40) or v > 8,000 and SL ≤ 60	No recommendation	3.000 < v ≤ 10.000 and SL = 50 (Distributional street)	Minimum: light segregation with v > 10,000	Not recommended	Not recommended	Not recommended	No recommendation	From v = 3,000 or From SL = 40
Bus/Cycle Lane	No recommendation	No recommendation	No recommendation (has not been implemented yet)	Connectors, Local streets, High roads, High streets, Town squares, City hubs, City streets	Not recommended	Not recommended	SL ≤ 50	Not recommended	-
Cycle Track/Path	> 8,000 and SL > 60 also used with lower SL	No recommendation	3.000 < v ≤ 8.000 and SL = 50 (Local street) or v > 10.000 and SL ≥ 50 (distributional or structural street)	Arterial roads, Connector roads, High roads	Anywhere in main network (standard solution: bidirectional)	SL ≥ 50or v ≥ 2,000 and SL ≤ 30 and c > 2000 or v ≤ 4,000 and SL ≤ 30	v > 18,000 and SL = 30 or v > 10,000 with SL = 50 or v > 3,000 and SL = 70	No recommendation	From v = 2,000 or From SL = 30

Volume of motorised traffic v [vehicles/ 24 h]; speed limit of motorised traffic SL [km/ h]; volume of cyclists c [cyclists/24h];* Where volumes v are defined in veh/h. The daily volume is tenfold the volume/hour.

(Table continued on following page)

Copyright © 2019 by MORE

	Budapest	Constanta	Lisbon	London	Malmö	CROW	Germany	NACTO	Summary
Width of Cycling Infrastructure									
Mixed Traffic	3.50–4.50 m lane width (depending on speed limit and design vehicle)	No recommendation	3.80 m lane width if adjacent building high < 5 floors 4.50 m lane width if adjacent building high ≥ 5 floors	≤ 3.20 m lane width or ≥ 4.00 m lane width (no operational criteria)	5.50 m carriageway width	5.80 m carriageway width c' ≤ 100 or v' ≤ 200 and c' ≤ 400	≤ 6.00 m carriageway width v' ≤ 500 ≥ 7.00 m carriageway width v' ≤ 1,000	-	≤ 3.20 m or ≥ 4.00 m lane width (Avoid medium values)
Advisory Cycle Lane	1.25 m Min. 3.5 m remaining carriageway width	-	-	≥ 2.00 m	-	-	1.50 m Min. 4.5 m remaining carriageway width	-	1.25–2.00 m with recommendations on remaining carriageway width
Mandatory Cycle Lane	1.25 m	≥ 1.00 m	≥ 1.50 m	≥ 2.00 m	-	2.00–2.25 m	≥ 1.85 m	1.83 m	1.25–2.25 m
Bus/Cycle Lane	4.25 m	-	3.20–3.25 m	3.00–3.20 m with ≤ 20 buses/hour or ≤ 100 buses and taxis per hour ≥ 4.50 m with > 20 buses/hour or > 100 buses and taxis per hour	-	-	3.00–3.50 m with c ≤ 200 ≥ 4.75 m with c > 200	-	3.00–3.50 m or ≥ 4.25 m
Cycle Track One-Way	2.00 m	≥ 1.00 m	≥ 1.50 m	≥ 1.50 m	≥ 1.50 m	2.00–4.00 m	2.00 m	1.99 m	1.50–4.00 m
Cycle Track Two-Way	2.50 m	≥ 2.00 m	≥ 2.60 m	≥ 2.0 m	2.50–3.50 m	2.50–4.50 m	2.50 m	3.66 m	2.50–4.50 m
Cycleway	-	-	≥ 2.60 m	1.20–3.50 m	-	-	2.50–4.00 m	-	1.20–4.00 m
Mixing and Segregating Cyclists and Pedestrians									
Criteria for Shared Facility	ca. 60–420 ped/h and ca. 60–420 cyclists/h	Not recommended	max 250 ped/h	Alongside the carriageway: to avoid Off-road: preferred for all traffic situations	Not recommended	max 250 ped/h/m of profile width	Only where separated provision cannot be used Max 1/3 cyclists in total volume of pedestrians + cyclists	Not recommended	Acceptable with low volumes of pedestrians and cyclists
Width of Shared Facility	3.50–4.25 m	-	2.70–3.00 m	2.20–4.50 m	-	No recommendation	> 2.50 m	-	2.20–4.50 m
References									
	(MAUT, 2005, 2019)	(Institutul Roman de Standardizare, 2010)	(Municipal Chamber of Lisbon, 2018)	(Transport for London, 2016a)	(City of Malmö - Streets and Parks Department, 2006, 2010a, 2019; City of Malmö: Brodde Makri, Maria and Nordlund, 2019)	(CROW, 2016)	(FGSV, 2006, 2010)	(National Association of City Transportation Officials, 2014)	

Volume of motorised traffic v' [vehicles/ h]; volume of cyclists c' [cyclists/ h]

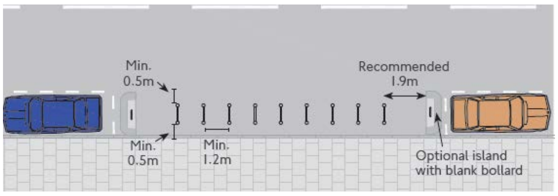
Copyright © 2019 by MORE

4.4.3 Bicycle Parking

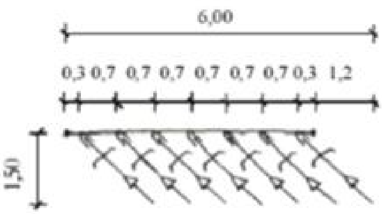
Public bicycle parking facilities are an important part of a cycling infrastructure. A network of bicycle parking stands at interchanges, public spaces, and in residential areas promotes the safety, attractiveness, and accessibility of cycling, thus encouraging cycling as a modal choice. The demand for bicycle parking increases with a modal shift toward cycling, and a high quality infrastructure may encourage more people to choose cycling as a mode of transport.

Bicycle parking stands can be placed on the footway or along the carriageway. Carriageway parking stands support the integration of bicycle parking with other functions, reduce car parking, create a “daylighting” zone before pedestrian crossings and junctions, reduce clutter on the sidewalk, reduce the illegal sidewalk cycling and do not require mitigation for visually impaired people, thus they are preferred over footway facilities for mixed traffic and cycle lanes/tracks on the carriageway. With separated cycle facilities on intermediate or footway level, cycle stands on the footway are the better option, if there is enough space to be provided for pedestrians and place users. Recommendations for carriageway bicycle parking mostly include the installation of bollards to prevent vehicles from parking in bicycle-designated spaces and to provide adequate space to secure the bicycle. Figure 37shows example layouts of carriageway bicycle parking stands.

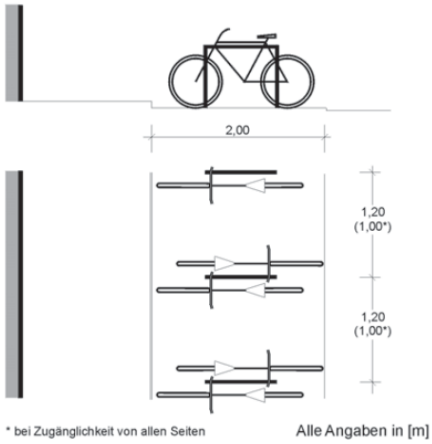
Figure 37: Exemplary Layouts of Carriageway Cycle Stands



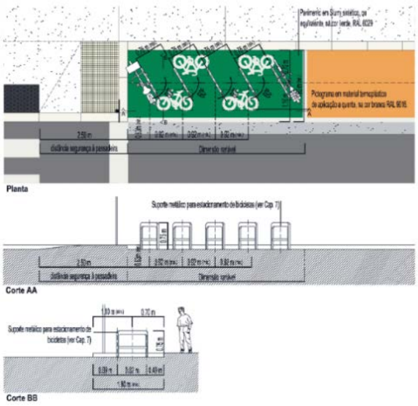
Source: (Transport for London, 2016a, Ch.8:13)



Source: (City of Malmö - Streets and Parks Department, 2006, p. 58)

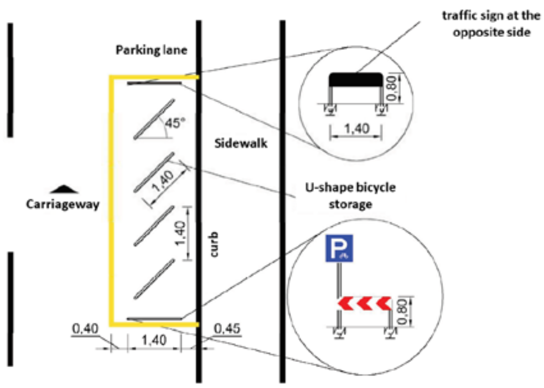


Source: (FGSV, 2006, p. 84)



Source:

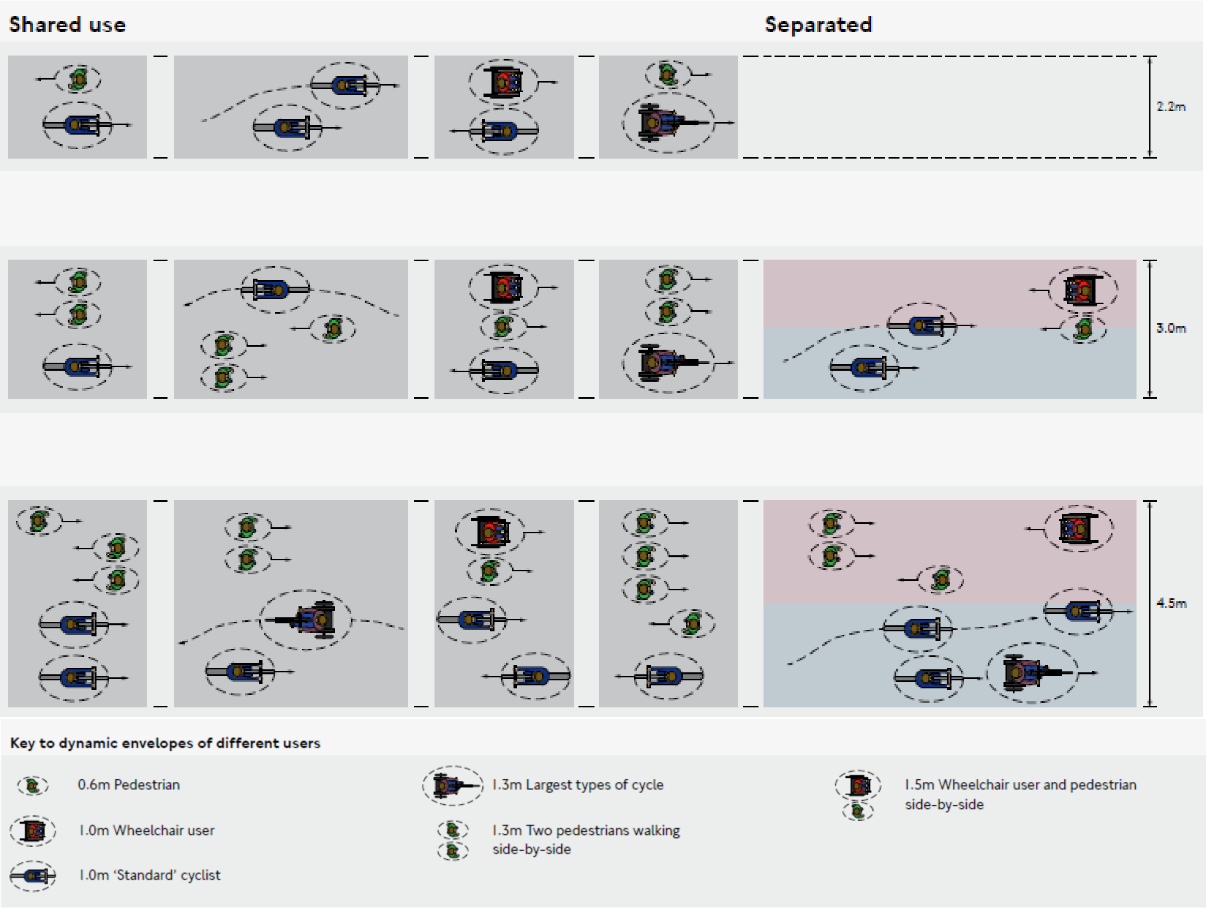
(Municipal Chamber of Lisbon, 2018, p. 228)



Source:(MAUT, 2019, p. 56)

4.4.4 Examples for Good Practice

Figure 38: User Interactions Depending on Path Width



Source: (Transport for London, 2016a)

Figure 39: Field of View to Cyclist

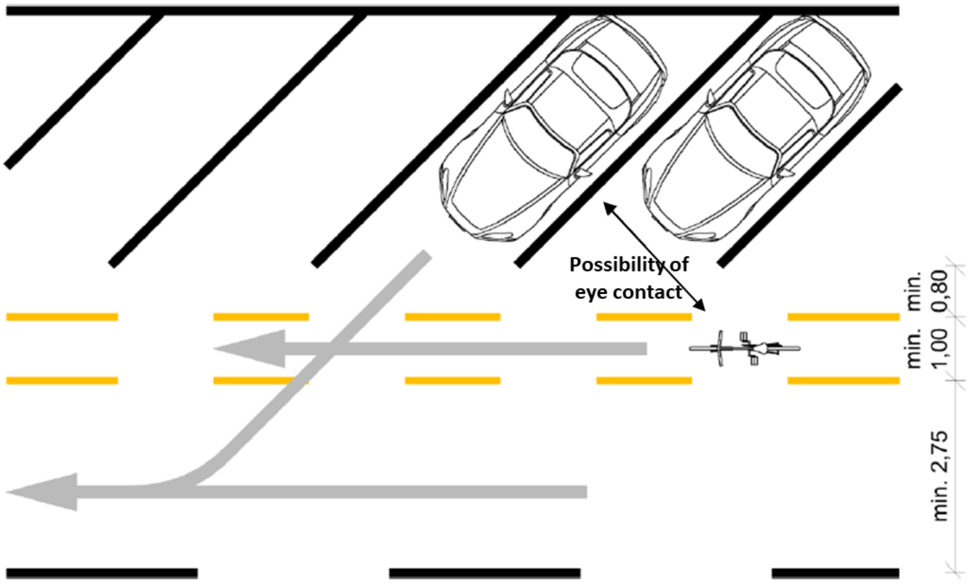


Figure 12: Angle parking and bike lane in one- or two-way streets

Source: (MAUT, 2019, p. 27)

Figure 40: Selection Plan for Cycle Facilities (Budapest)

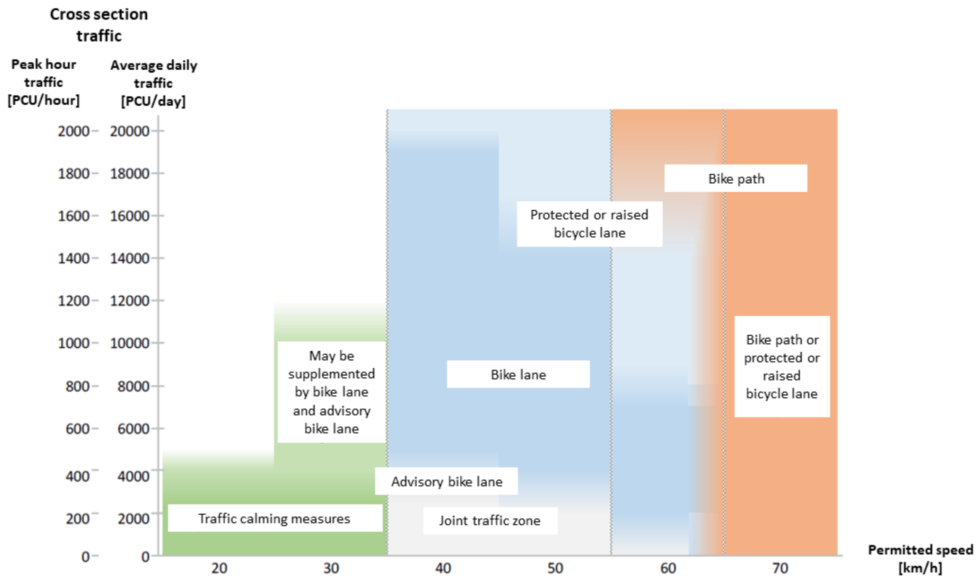


Figure 3: Minimal levels of bike-friendly infrastructure in the urban area depending on planned car traffic and permitted speed

Source: (MAUT, 2019)

London has an additive approach to control whether or not cyclists can be in mixed traffic (Transport for London, 2019d). Therefore, they define six quality criteria:

- Criteria 1: The degree of separation for people cycling is appropriate for the total volume of two-way motorised traffic: mixed traffic for < 500 motor vehicles per hour (vph – two-way) at peak times, and preferably fewer than 200 vph; the grey absolute minimum is a light segregated cycle lane where there are > 1,000 motor vehicles per hour, lane widths should be ≥ 4.50 m for 500 - 1,000 motor vehicles per hour
- Criteria 2: The speed of motorised traffic is appropriate for people cycling: mixed traffic for 85th percentile speed < 40 km/h, separation required for 85th percentile speed > 48 km/h
- Criteria 3: An appropriate width for cycling is provided to suit the local context: for mixed traffic: width of nearside lanes should be ≤ 3.20 m for < 500 vehicles per hour (two-way) and proportion of HGV < 5 % OR ≥ 4.50 m; for separated cycling facilities preferred minimum 2.20 m (one-way cycle lane) and 3.00 m (two-way cycle lanes or tracks) (absolute minimum 1.50 m / 2.00 m), for mixed traffic nearside lanes will not be 3.20 m - 4.00 m (for > 500 vph), widths of cycle facilities should correspond to expected cyclists' volumes
- Criteria 4: Collision risk between people cycling and turning motor vehicles is minimised: for priority junctions with > 200 vph, volumes and speed of turning movements should be reduced, dedicated signals for cyclists should be provided
- Criteria 5: Kerbside activity has a minimal impact on people cycling: 85th percentile speed should be < 40 km/h and remaining lane width should be at least 2.00 m to the nearside lane marking / carriageway centre point (unless vehicle flows are < 200 vph), for separated cycling facilities at least 1.00 m clearance should be provided to stationary parked vehicles and also to oncoming vehicles
- Criteria 6: Interaction between HGVs and people cycling in mixed traffic is minimised along a link: mixed traffic for 200 – 500 vph and proportion of HGV < 5 % (HGV < 10 % for < 200 vph), Where the proportion of HGVs* is 5 % or more for any level of two-way flow above 500 vph, measures will be put in place to reduce HGV flows and/or people cycling on new routes will be provided with at least a 4.5 m nearside general traffic lane, bus lane, or cycle lane combined with the adjacent general traffic lane with no kerbside activity or provision must be made for people cycling to be fully separated from general traffic. Where the peak hour HGV flow is 50 vehicles or more, provision is required for people cycling to be fully separated from general traffic (Transport for London, 2019d, p. 17). Where motor vehicle flows are between 500 vph and 1000 vph and the proportion of HGVs is less than 5 %, it may in exceptional circumstances be acceptable to allow for people cycling to be mixed with general traffic, which is calculated by the Criteria Review Process.

The following scheme shows the acceptable solutions. None of the criteria is allowed to miss the target grey level. If, e.g., one criterion on flows or speed misses the target green level, there are restrictions on width, turning risks, kerbside activities and HGV to meet the target green level (see Figure 41).

Figure 41: Criteria Review Process for Application of Mixed Traffic (London)

Scenarios considered acceptable for people cycling to mix with general traffic	*Criteria 1 Flows*	*Criteria 2 Speed*	*Criteria 3 Width*	*Criteria 4 Turning risk*	*Criteria 5 Kerbside activity*	*Criteria 6 HGVs*
Scenario 1	*All target green levels met*					
Scenario 2	*Falls below the target green level*	*Target green level met*	*At least 2 out of 3 criteria achieve the target green level of provision, with turning risk mitigation measures at junctions required where there is a known safety issue*			*Proportion of HGVs* is less than 5%**(except where width requirements are met)*
Scenario 3	*Target green level met*	*Falls below the target green level*	*At least 3 out of 4 criteria achieve the target green level of provision, with turning risk mitigation measures at junctions required where there is a known safety issue*			
Scenario 4	*Target green level met*	*Target green level met*	*At least 2 out of 4 criteria achieve the target green level of provision, with turning risk mitigation measures at junctions required where there is a known safety issue*			

** Heavy Goods Vehicle (HGV) – defined as lorries and trucks over 3.5 tonnes*

*** Based on the peak hour HGV % as a proportion of the corresponding motor vehicle traffic flow, 7am to 7pm*

Source: (Transport for London, 2019d)

The below selection plan for cycle facilities in Malmö (Figure 42) is provided in the latest guideline for urban street design in Malmö but has no significance for actual transport policies and urban street design in the city. Since 2013, the speed limit is 40 km/h almost everywhere inside the inner ring road of Malmö. Since 2018, the speed limit of 40 km/h was expanded to all residential areas. The general approach now is to build dedicated cycle facilities (separated cycle tracks/paths) adjacent to main streets. Outside the main network, cyclists cycle in mixed traffic.

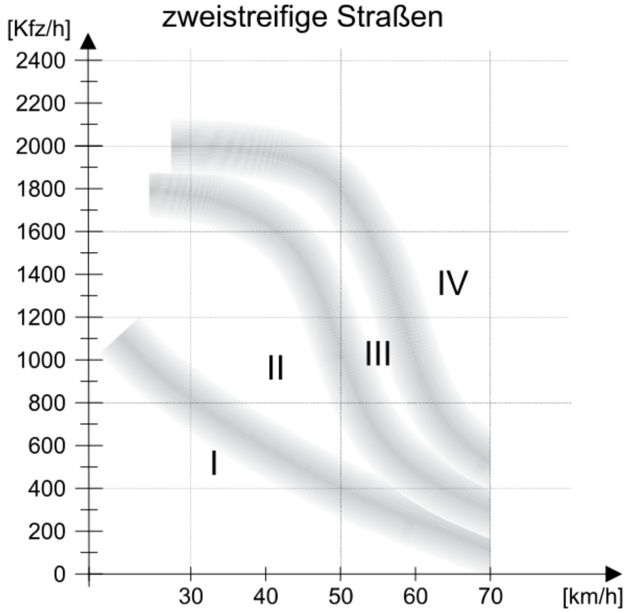
Figure 42: Selection Plan for Cycle Facilities Malmö

Quality	Reference Speed	Separation Form for given car traffic flow		
Good	50 km/h	Mandatory cycle lane		
Less good		Advisory cycle lane	Mandatory cycle lane	
Low		Mixed traffic	Advisory cycle lane	Mandatory cycle lane
Good	< 30 km/h	Mixed traffic		Advisory cycle lane
Less good				Mixed traffic
Low				
Car traffic flow cars/dim h		0	100	300

Source: (City of Malmö - Streets and Parks Department, 2006, p. 36)

Copyright © 2019 by MORE

Figure 43: Selection Plan for Bicycle Facilities (Germany)



Selection plan for bicycle facilities depending on the volume of motorised vehicles [veh/24h] and their allowed speed [km/h] for two-lane streets with one lane per direction (FGSV, 2010)

Type I: Mixed traffic, no dedicated cycling facilities

Type II: The following types of cycling facilities are possible: (1) advisory cycle lane, (2) combination of mixed traffic or advisory cycle lane with cyclists being allowed to cycle on the sidewalk

Type III: Cycle lane, cycle track/path, joint sidewalk for pedestrians and cyclists

Source: (FGSV, 2010)

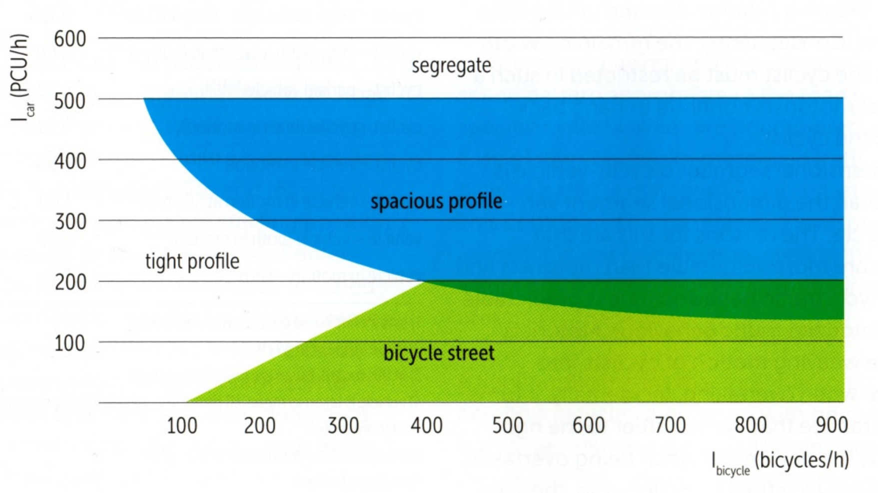
Figure 44: Selection Plan for Cycle Facilities in the Case of Road Sections in Built-Up Areas(CROW, 2016)

Road category	Speed limit motorized traffic (km/h)		Volume of motorized traffic (PCU/24-hour period)	Cycle network category: Basic structure ($I_{bicycle}$ < 750/ 24-hour period)	Main cycle network ($I_{bicycle}$ 500-2,500/ 24-hour period)	Bicycle highway ($I_{bicycle}$ > 2,000/ 24-hour period)
Residential road	walking pace or 30		< 2,500	mixed traffic	mixed traffic or bicycle street	bicycle street (with right of way)
			2,000-5,000		mixed traffic or cycle lane	cycle path or cycle lane (with right of way)
			> 4,000	cycle lane or cycle path		
Distributor road	50	2×1 lane	not relevant		cycle path	
		2×2 traffic lanes				
	70			cycle/moped path		

Source: (CROW, 2016)

When mixed traffic is recommended, (CROW, 2016) distinguishes between a tight street profile where motorised vehicles cannot overtake cyclists with oncoming traffic and a spacious profile (allows overtaking cyclists even with oncoming traffic). When cyclists dominate traffic volumes, a bicycle street is recommended (see Figure 45)

Figure 45: Suggested Solutions (indicative) for Profile Choice When Mixing Motorised Traffic and Bicycle Traffic (CROW, 2016)



Source: (CROW, 2016)

4.4.5 Summary and Recommendations for Urban Cycling Facilities

The following paragraphs summarise the findings from the guidance material research and develop recommendations for the different aspects of providing for cyclists. A variety of cycling infrastructures was identified in the researched materials and, together with the local MORE partners, integrated into the classifications which were introduced for the MORE project in Chapter 4.4.1. The principal cycling infrastructure may be categorised into two types. Lanes or tracks/paths that are mostly used on busier streets and provide an adequate degree of segregation. On more quiet streets, mixed traffic (optionally with advisory lanes or sharrows) or bicycle streets may be used. Cycleways have an independent track alignment away from the carriageway and may complement the cycle network. Some references recommend only a few types of cycling infrastructures. This is, for example, the case for The Netherlands where recommendations are given for accommodating cyclists in mixed traffic as well as in mandatory cycle lanes and cycle tracks/paths but not for advisory cycle lanes or combined bus/cycle lanes (CROW, 2016). Other cities, such as Budapest and TfL in London, provide recommendations for all identified types of cycling infrastructures listed in Chapter 4.4.1 and, in addition, even introduce subgroups (MAUT, 2019; Transport for London, 2016a). For example, the Hungarian guidelines for cycling facilities distinguish the following types of mixed traffic: wide traffic lane, sharrows, and service roads/residential streets.

Differences were also found for the criteria used for selecting suitable cycling facilities for each individual design task. The two criteria, volume of motorised traffic (v) and speed limit of motorised traffic (SL), are used in all references. This means that the decision of whether or not to provide a dedicated cycling infrastructure is taken, in most cases, in a supply-oriented approach, based on how many motorised vehicles drive in a street and how fast they are allowed to drive. The expected cycling demand, measured as the volume of cyclists (c), is only considered in The Netherlands. London takes a completely different approach: In London, decisions about suitable types of cycling infrastructures are taken based on the street type as classified in the link and place matrix (as described in Chapter 2) and based on a complex set of criteria provided in Transport for London (2019d) (see Chapter 4.4.4). In Lisbon, the street type is considered in addition to the volume of motorised traffic and the speed limit. For example, mixed traffic of cyclists and motorised vehicles should be only chosen for local streets with v ≤ 3,000 veh/24h and SL < 30 km/h. All references use the speed limit as criterion for selecting types of cycling infrastructures, but some additionally give the recommendation that measures should be implemented for making sure that drivers respect speed limits. CROW (2016) recommends taking the actual speed as the point of departure for selecting types of cycling infrastructures if speed limits are exceeded en masse.

Criteria for accommodating cyclists in mixed traffic together with motorised vehicles in the carriageway differ substantially. Recommendations in The Netherlands are the most stringent and only allow mixed traffic with cars driving with SL = 30 km/h or slower (CROW, 2016). In Budapest, mixed traffic, including advisory cycle lanes, are possible up to SL = 50 km/h (MAUT, 2019). The allowed volumes of motorised traffic for mixed traffic are highest in Germany with around 8,000 veh/24h (SL = 30 km/h) and between 3,000 and 5,000 veh/24h in the other references. Bicycle streets are a special type of mixed traffic frequently used in The Netherlands (CROW, 2016). This is a functional concept for a residential street with a low link function for motorised traffic but with a high link function for bicycle traffic. Bicycle traffic should be dominant in bicycle streets and higher in volume than car traffic. Bicycle streets could be also planned if current bicycle volumes are lower than volumes of motorised traffic, but extra quality should be produced with cyclists in mind. In these cases, CROW (2016) recommends the reduction of motorised traffic volumes in order to achieve the required volume ratios. Absolute bicycle volumes should be at least 1,000 cyclists/24h in bicycle streets and volume of motorised traffic should not exceed 2,500 veh/24h. Dominance of bicycle traffic is not considered important in situations involving low volumes of motorised traffic up to 500 veh/24h. Similar concepts to the Dutch bicycle street also exist in London, Germany and in Malmö.

Carriageway widths for bicycles in mixed traffic should be kept either low so as to cause cars to remain behind a bicycle when faced with oncoming traffic, or kept wide so cars can safely overtake cyclists even in the face of oncoming traffic. Medium carriageway widths of around 6.00 m to 7.00 m (FGSV, 2010), that might lead to situations of doubt for car drivers on whether or not to overtake a bicycle, should be avoided particularly for higher volumes of motorised traffic (> 4,000/5,000 veh/24h according to (CROW, 2016; FGSV, 2010)). This principle of either narrow or wide profiles for mixed traffic is recommended in literature from London, The Netherlands, and Germany. Malmö only recommends the narrow profile; Budapest only recommends the wide profile; and Lisbon recommends different wide carriageway widths for cycling in mixed traffic depending on the height of the adjacent buildings. Narrow profiles only work with low volumes of motorised traffic; higher volumes will cause irritation and might eventually result in risky overtaking manoeuvres. Maximum volumes of motorised traffic for advisory lanes are slightly higher than for mixed traffic in Budapest and substantially higher in Germany where advisory cycling lanes can be arranged up to 18,000 veh/24h if the speed limit is 30 km/h.

Mandatory carriageway bicycle lanes and off-carriageway bicycle tracks/paths are recommended for high volumes of motorised traffic and high speed limits. The Netherlands and Malmö clearly prefer off-carriageway cycle tracks/paths: “Although it is preferable for segregated cycle paths to be used alongside distributor roads, cycle lanes are also an option on sections of distributor roads with a speed limit of 50 km/h and low volumes of bicycle traffic.” (CROW, 2016, p. 108).This preference for cycle paths off the carriageway is justified with results from early safety research which showed that cycle paths alongside urban arterial roads are safer for cyclists than cycle lanes (CROW, 2016). Cycle paths are generally recommended by CROW (2016) for cyclist volumes > 500 cyclists/24h. CROW (2016) recommends reducing the speed limit to 30 km/h when cycle lanes are provided; in case of a speed limit of 50 km/h, lanes for motorised traffic must be sufficiently wide so that cars and lorries do not have to use the cycle lane. CROW (2016) recommends a lane width of 2.90 m in these cases plus 0.50 m of space between the cycle lane and driving lane; this is in total a width of 6.80 m in between the two cycle lanes on each side of the carriageway. The German recommendations are more neutral and provide an assessment scheme that is intended to support the decision between making a cycle lane versus a cycle track/path in cases where both solutions are an option (FGSV, 2010). Off-carriageway cycle tracks/path have advantages in situations involving low car parking/loading activities, high volumes of motorised traffic, and, particularly, heavy duty traffic and steep slopes; these are, in addition, perceived to be safer than cycle lanes by many cyclists. Carriageway cycle lanes have advantages over cycle tracks/paths when there are necessary pedestrian/place activities on the sidewalks, several access points to adjacent properties, and high numbers of vehicles turning particularly to the right at junctions. The combination of cycling lanes and car parking is always problematic, it is strongly discouraged by CROW (2016). A critical reaction strip of 0.50 m should otherwise be provided or reverse parking at an angle should be arranged as this presents less risk for cyclists than parallel parking.

Segregation of cyclists from motorised traffic is possible on tracks/paths and lanes (vertically or horizontally). Recommendations on segregation refer to speed and volumes of motorised traffic. The Hungarian guidelines recommend segregation with speed limits from 40 km/h and volumes of motorised traffic > 15,000 veh/24h or higher speed limits (60 km/h) and lower volumes of motorised traffic (> 8,000 veh/24h). Recommendations in Municipal Chamber of Lisbon (2018) have stronger restrictions regarding volumes (speed limit: 50 km/h; volumes of motorised traffic: 3,000 – 10,000 veh/24h). According to Transport for London (2019d), volumes of motorised traffic higher than 1,000 veh/peak hour (10,000 veh/24h) does at least require a light segregation of cyclists from motorised traffic. Report for Transport for London (2014) marks out, that cities that already have high cycling levels, and those that have successfully grown cycling levels over relatively short periods, generally secure cyclists from motor traffic by segregated facilities, unless traffic speeds and volumes are low.

Combined bus and cycle lanes are possible in Budapest, Lisbon, London, and Germany. However, they are not recommended in other cities/countries because of possible conflicts between buses that drive faster than cyclists in between their stops or cyclists who do not like to stop at the bus stops and wait behind the bus until boarding has been completed. For example, this type of cycling facility is only possible in Germany if strict conditions are adhered to, e.g. lane widths should be either ≥ 4.75 m or ≤ 3.50 m (up to 150-200 cyclists/h) in order to clearly indicate to both cyclists and bus drivers whether or not the other one can be overtaken; distances between two bus stops should not exceed 300 m; speed limits

Copyright © 2019 by MORE

should be maximum 50 km/h; no driving lane next to the shared bus/cycle lane should exist on the right hand side; there should be no steep slopes; and special care should be taken for cyclists where the shared bus/cycle lane arrives at junctions (FGSV, 2010).

The space requirement of a standard cyclist is either 0.75 m or 1.00 m over all countries. This 1.00 m value appears to already include a certain buffer zone, while the 0.75 m does not. For example, in Germany and Budapest, there is no buffer needed between two cyclists in contrast to most other countries: space requirements for two cyclists are defined in (FGSV, 2006) with 2.00m. This indicates that the necessary buffer between two cyclists is already included into the individual cyclist's space requirement of 1.00 m.

Various recommendations concerning buffer zones for the different possible adjacent usages exist. Buffer zones between two cyclists range from 0.25 m to 0.75 m and are, together with the cyclist space requirements, highest in London with 2.50 m for two cyclists and a buffer zone in between. Buffer zones for static obstacles are recommended in most researched guidance material; their size differs with the type and height of these obstacles. Buffer zones for the general traffic are given as approximate values which are to be applied in all cases or are dependent on speed. These buffer zones vary between 0.00 m for carriageway cycling facilities in Germany and 2.50 m for streets with speed limits higher than 50 km/h in Lisbon. Having no buffer zones particularly between carriageway cycling facilities and motorised traffic might lead to low distances between cars that overtake bicycles, which could increase related safety issues. Buffer zones to parking/loading facilities vary between 0.25 m and 1.00 m with the medium values of around 0.75 m being the most frequently applied.

Space requirements for the different street users taken together with the buffer zones result in the recommendations for the width of cycling facilities. In general, dedicated cycling facilities need to fit the space requirements of minimum one cyclist and buffers to adjacent traffic or objects and must offer enough space to allow passing events (one-way) or meeting events (two-way). The variance of recommended widths for the different types of cycling facilities is quite low in the researched guidance materials. These range from 1.50 m to 2.00 m for one-way cycling facilities and are ≥ 2.00 m (London) or ≥ 2.50m for two-way-facilities (Budapest, Lisbon, Malmö, The Netherlands, Germany, and the U.S.).

Overall, various similarities were identified in the researched guidance materials. Differences mainly exist in the types of recommended cycling facilities and in the criteria for deciding about which type is recommended for specific design tasks. Space requirements for cyclists, buffer zones, and also widths of cycling facilities are quite similar in each of the different cities and countries. Based on the insights gained from summarising the various guidance materials on cycling provision, the following recommendations were developed:

- Keep it simple: "Starter countries" in terms of cycling tend to offer many more types of cycling facilities in their guidance materials than countries with a longer history in cycling provision. A variety of solutions might be necessary in starter countries because the optimal solutions might not have enough political support (e.g. would require taking too much space from cars). This is a critical point because (potential) cyclists are not familiar with participating in traffic as cyclists nor are car drivers and other street users used to cycling infrastructure or expect cyclists in the streets. With this in mind, the first

Copyright © 2019 by MORE

recommendation is to keep cycling provision simple, wherever possible. The three basic options for accommodating cyclists in the streets are a solid basis and, in most cases, sufficient; these are (1) mixed traffic, (2) on-carriageway mandatory cycle lanes, and (3) off-carriageway cycle tracks/paths. Too many types of cycling infrastructure might cause confusion for users. Though there are many different types of cycling infrastructure available, this disadvantage might outweigh the advantage of having the opportunity to provide tailor-made solutions for each design task.

- Mixed traffic or dedicated cycling facilities: The balance between accommodating cyclists in mixed traffic with motorised vehicles on the one hand and dedicated cycling facilities on the other is of special importance. Slow speed of motorised cars of maximum 30 km/h and low volumes of motorised vehicles appear to be the two key deciding factors. Dedicated cycling facilities should be provided if either of these two is exceeded. Bicycle volumes should also be considered if these reach relevant levels. Profiles for cycling in mixed traffic should be either narrow or wide in order to clearly indicate whether or not the overtaking of bicycles is safely possible for cars. Bicycles should be prioritised over motorised traffic, particularly if their current or expected number exceeds car volumes, e.g., by providing bicycle streets.
- Dedicated cycling facilities on or off the carriageway: Once the decision for a dedicated cycling facility has been made, these might be placed on the carriageway as cycle lanes or off the carriageway as cycle tracks/paths. Both of these options have pros and cons which can be evaluated on a case-by-case basis or addressed in a general manner as is done in Malmö and The Netherlands for off-carriageway cycle tracks/paths. Both options are good choices for safe and convenient cycling networks if these are sufficiently wide and well designed.
- Mixing buses and cyclists: Combined bus/cycle lanes should only be used if there is no suitable alternative. One case is kerb-side bus-lanes and no space for segregated cycle facilities: not allowing cyclists in the bus lane means they would have to use the middle lane, while being overtaken on the left by private cars and on the right by busses. Lane widths should be either narrow or wide in order to clearly indicate whether or not buses can overtake cyclists and vice versa.
- Mixing pedestrians and cyclists: This is a popular solution for limited space and high volumes (and speed) of motorised traffic but might lead to conflicts between pedestrians and cyclists and also with other street users at junctions. Dedicated and separated facilities for cyclists and pedestrians should therefore be implemented whenever possible, even if that requires taking space from motorised traffic.
- Width of cycle lanes and tracks/paths: With high cycle volumes, it is desirable to offer a width of minimum 2.00 m to allow passing events without leaving the cycle lane/track. Smaller facilities should only be provided where a low number of cyclists is expected (e.g., due to alternative attractive routes in the network) but a high volume of motorised traffic requires the cycle lane or cycle track/path. Wide facilities might demand physical separation to discourage other road users from driving or parking within the cycle infrastructure.
- Bottlenecks: Selected functions such as car parking might be removed completely from the street in these situations. Profiles with two lanes for motorised traffic per direction might be changed into one extra wide lane per direction plus a cycling facility. The

Copyright © 2019 by MORE

recommended widths for the individual elements of each profile must be met; either the necessary width, e.g., for a cycling facility can be provided or it should not be included at all into a profile. Too narrow widths of cycling facilities or other parts of the street might cause substantial problems for safety and also for traffic quality. If it is not possible to provide the necessary space, one option is lowering speed limits for general traffic (e.g. 30 km/h) and implementing speed reducing measures to accommodate cyclists safely despite limited space requirements.

- Future needs: In general, cycling infrastructure should cover current and future needs. Due to an increasing number of cargo bicycles (higher space requirements) and electric bicycles (higher speeds) and the fast developments in Personal Light Electric Vehicles (PLEV), infrastructure should provide enough space for non-standard and standard users. One such example would be the provision of lane widths which make is easy for faster cyclists to pass slower cyclists even though the slower bike has extended dimensions.

All references reiterate that, when deciding which type of cycling infrastructure to implement, all street user needs and the overall specific street context should always be considered. Various suitable solutions are possible in most cases: none of the provided thresholds and limits should be treated as hard limits. The most important recommendation derived from this research is that all possible solutions and combinations should be investigated and evaluated as the basis for stakeholder engagement.

4.5 Infrastructure for Buses and Trams

4.5.1 Role of Public Transport in Urban Street Design

Public transport is an environmentally friendly transport mode which ensures mobility for all groups of persons.

Public transport in urban streets might be combined into the same lanes as individual motorised traffic, or, alternatively, dedicated public transport lanes might be provided. The latter is strongly recommended and, in some places, even compulsory for trams, as their quality is measured in bus/tram travel times and reliability. Public transport lanes can be operated around the clock or only during certain time periods; at complete sequences of streets sections including in-between junctions or only at particular bottlenecks such as specific junctions where local bus/tram lanes are provided for prioritising public transport vehicles over the individual motorised vehicles.

Dedicated public transport lanes are particularly recommended for public transport services with high importance and operating frequency (e.g., in Budapest, 30 buses/hour/direction). In addition, they are recommended for street sections

- with many disturbances from individual motorised traffic including parking/loading,
- with sufficient space availability for accommodating all street users' requirements,
- with sufficiently long distances between adjacent junctions and good possibilities for prioritising public transport at these junctions.
- Public transport lanes in the middle of the street have no disturbances from parking/loading or other activities at the edge of the carriageway or on the sidewalk but

might cause safety problems with crossing pedestrians getting on or off the public transport vehicles at stops.

4.5.2 Recommendations for Public Transport

The following Chapter gives an overview on the recommendations regarding public transport in urban street design researched in the guidance material of the MORE cities.

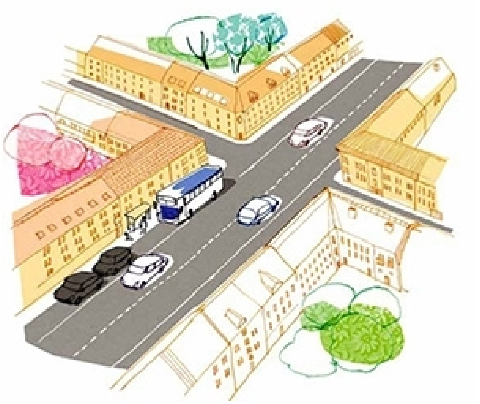
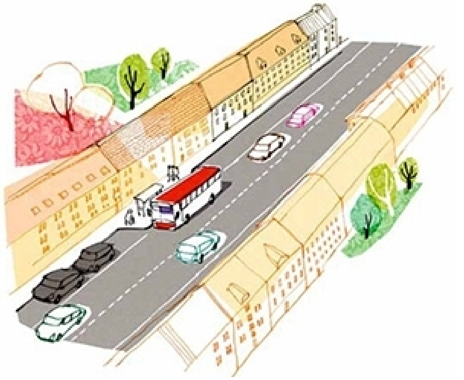
First, Table 18 shows the classification of public transport stops for the MORE project, including explanations about their characteristics and scope of application. The subsequent Table 19 and Table 20, give an overview of infrastructure recommendations for buses and trams. The following aspects are analysed:

- Types of bus and tram stops: The types of public transport stops applied in the street spaces of the MORE cities are shown in the upper part of the table. To have consistent and comparable types of public transport stops, the listed designs are based on the definitions and characteristics of Table 18. In general, the choice of the design of bus stops depends on the conditions such as the availability of space, the traffic volume, and the frequency of buses. In some guidelines, even specific criteria for the choice of a certain bus stop design are given. These are summarised in the table below.
- Space requirements for buses and trams: Here, the standard bus lanes and the space requirements for trams as well as the width of the track infrastructure are shown. The compliance with the specific space requirements is the basis for urban street design.
- Space requirements for platform waiting areas: Regarding tram stops, Table 20 shows the space requirements for waiting areas for passengers. Table 14 already includes this information with respect to the place function of the sidewalk.

Guidance of cyclists at bus stops: To avoid any conflicts with waiting passengers at bus stops and to ensure comfortable routes for cyclists, the guidance of cyclists is an important topic. The different types of guidance at bus stops are listed in Table 19.

Copyright © 2019 by MORE

Table 18: Classification of Public Transport Stops for the MORE Project

<table>
<tr><th>Visualisation of Public Transport Stop</th><th>Explanations</th></tr>
<tr><td colspan="2">Curbside Stop, In-Lane Stop</td></tr>
<tr><td>
Source: (Trafikverket and Swedish Association of Local Authorities and Regions, 2012, p. 91)</td><td>- Applied mainly for buses, rarely for trams
- Applicable for low to moderate volumes of motorised transport (FGSV, 2006, 2013): up to 750 veh/h and direction) and operating frequencies for buses/trams (FGSV, 2006, 2013): headway ≥ 10 min)
- Can be easily implemented at low cost
- Parked cars at the stop might cause problems
- Waiting areas for passengers might be not sufficient if sidewalks are not wide enough</td></tr>
<tr><td colspan="2">Bus/Tram Bulb</td></tr>
<tr><td>
Source: (Trafikverket and Swedish Association of Local Authorities and Regions, 2012, p. 93)</td><td>- Suitable for buses and for trams
- Applicable for low to moderate volumes of motorised transport (FGSV, 2006, 2013): up to 750 veh/h and direction) and operating frequencies for buses/trams (FGSV, 2006, 2013): headway ≥ 10 min with an assumed duration of stay at the stop of 16 s)
- Public transport vehicle is the first in the row of motorised vehicles, vehicles behind it need to wait, the public transport vehicle can directly continue its journey when leaving the stop
- Can be easily kept free from parked cars, this is an advantage over kerbside stops and particularly beneficial in cases of high parking demand
- Enlarge the sidewalks and thus provide more space for the equipment of the stop, for waiting public transport passengers but also for passing pedestrians and cyclists
- Can be approached straight ahead without any curves or weaving
- Can be easily made accessible for all user groups including persons with reduced mobility
- Are less costly than bus bays but more expensive than kerbside stops
- Provide good opportunities for guiding cyclists</td></tr>
</table>

(Table continued on following page)

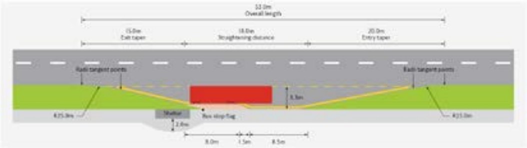
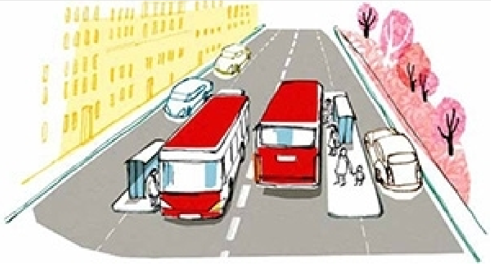
Visualisation of Public Transport Stop	Explanations
Bus Bay, Pull-Out Stop, Bus Lay-By	
 Source:(Transport for London, 2017a, p. 35)	- Only applied for buses - Need much space and length because buses must leave the driving lane/pull out of traffic and at the same time park parallel at the stop - Buses might have difficulty merging back into traffic particularly in case of high volumes of motorised traffic; buses might pull out of the driving lane only partially to avoid being blocked when merging back, this might disturb traffic flows - Are less comfortable for passengers than the other alternatives because bus bays cannot be approached straight ahead - Far-side from junctions only recommended if no other alternative is available, e.g. in case of high volumes of motorised vehicles or long durations of stay at the stop, might be beneficial at junctions for prioritising public transport vehicles and letting other motorised vehicles passing while passengers board the bus - Parked cars at the stop might cause problems - Sidewalk widths are narrowed down, insufficient space might be left for waiting areas and for passing pedestrians Are difficult to handle for winter maintenance
Bus/Tram Stop in Central Position	
 Source: (Trafikverket and Swedish Association of Local Authorities and Regions, 2012, p. 95)	- Stops in central position are mainly applied for tram stops or for stops that are served by buses and by trams, these are usually combined with dedicated public transport lanes in the middle of the carriageway - Are suitable for tram tracks or bus lanes in the middle of the carriageway - No disturbances from activities at the roadside and on the sidewalks - Special attention should be paid to safe crossing from the waiting areas to the sidewalks on both sides - Widths of waiting areas should not fall below 2.50 m

Table 19: Recommendations for Bus Infrastructure

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
				Types of Bus Stops				
Applied Types	- Kerbside stop - Bus bulb - Bus bay	- Kerbside stop - Bus bay (is recommended)	- Kerbside stop • With standard lane or • Dedicated bus lane - Bus bulb - Bus bay	- Kerbside stop (recommended by TfL) - Bus bay - Bus bulb	- Kerbside stop - Bus bulb	- Kerbside stop - Bus bay - Bus bulb	- Bus bulb with a dedicated bus lane - Bus bay - Bus stop in central position	- Kerbside stop - Bus bulb - Bus bay
				General Dependencies for the Choice of the Type of Bus Stop				
Dependencies	- Availability of space - Parking - Traffic volume	-	- Availability of space - Traffic volume	- Availability of space: • Sidewalk width • Pedestrian flows • Location of adjacent building entrances	- Local priorities - Passenger volume - Traffic safety	- Frequency of Public Transport - Traffic volumes - Duration of stay at the stop	-	Different Dependencies: - Availability of street space - Traffic volumes - Bus frequencies/capacity - The local environment - Pedestrian flows
References	(MAUT, 2009b)	(City of Constanta: Lupascu, George and Dumitrescu, 2019)	(Municipal Chamber of Lisbon, 2018)	(Transport for London, 2016c, 2017a)	(City of Malmö: Brodde Makri, Maria and Nordlund, 2019; Skånetrafiken; Trafikverket and Swedish Association of Local Authorities and Regions, 2012)	(FGSV, 2006, 2013)	(National Association of City Transportation Officials, 2013)	-

(Table continued on following page)

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Specific Criteria for the Choice of the Type of Bus Stop (if available)								
Kerbside Stop	- Street with heavy traffic - Street without parking - If parallel parking, stop is between parking spots	-	-	Recommended by TfL	-	≤ 750 veh/h and direction with bus frequencies ≥ 10 min	-	- Traffic volumes - Parking - Frequency of Public Transport
Bus Bulb	- Street with heavy traffic - Street without parking	-	-	Street with parallel parking	-	≤ 750 veh/h and direction with bus frequencies≥ 10 min	- Street with heavy traffic - Dedicated waiting area for passengers	- Traffic volumes - Streets without parking - Frequency of Public Transport
Bus Bay	- Street without parking	Recommended	-	- Only use, when there are • Compelling safety or • Capacity reasons	-	- On main roads - in case of lengthy dwell times - Operating limits of kerbside stops or bus bulbs are exceeded - Sufficient width of sidewalk	- Streets without parking - Wide sidewalk width - Pulling back into traffic must be possible	- Traffic volumes - Streets without parking - Frequency of Public Transport - Traffic safety - The local environment
References	(MAUT, 2009b)	(City of Constanta: Lupascu, George and Dumitrescu, 2019)	(Municipal Chamber of Lisbon, 2018)	(Transport for London, 2016c, 2017a)	(Skånetrafiken)	(FGSV, 2006, 2013)	(National Association of City Transportation Officials, 2013)	

Veh= Vehicles

(Table continued on following page)

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Specific Criteria for Choosing Type of Bus Stop (if available)								
Bus Stop in Central Position	- Street with heavy traffic - Street without parking	-	-	-	-	- Availability of tramways - Dedicated lane for buses and tramways with shared stops	-	- Traffic volumes - Streets without parking - If tramway, Dedicated lane for buses and tramways with shared stops
Space Requirements								
Width of Bus Lane	3.50 m	-	- 3.25 m	- 3.00–3.20 m or 4.50 m	> 3.00 m	-	3.25–3.50 m	3.00–4.50 m
Guidance of Cyclists at Bus Stops								
Possible Types of Guidance	If allowed to use bus lane by bike, cyclists are able to pass bus stops.	Cyclists are not be allowed to use bus lanes. Dedicated cycling facilities will be provided in future.	- Together with the bus on the carriageway (speed limit 30 km/h) - On a separate cycling track behind the bus stop - pedestrians have priority - On a raised cycle lane (plateau) in front of the bus stop pedestrians have priority - On a shared space for pedestrians and cyclists in front of the bus stop	- Together with the bus on the carriageway - On a separate cycle track behind the bus stop	On a separate cycle track on or off the carriageway	- Together with the bus on the carriageway - On a separate cycle track behind the bus stop - On a raised cycle lane (plateau)	On a separate cycle track behind the bus	Different types of guidance: - If allowed, together with the bus on the carriageway - On a separate cycle track behind the bus stop - On a raised cycle lane (plateau) Ensure conflict-free access for passengers
References	(MAUT, 2005, 2008, 2009b)	(City of Constanta: Lupascu, George and Dumitrescu, 2019)	(Municipal Chamber of Lisbon, 2018)	(Department for Transport, 2007; Transport for London, 2016c, 2017a)	(City of Malmö - Streets and Parks Department, 2006; City of Malmö: Brodde Makri, Maria and Nordlund, 2019)	(CROW, 2016; FGSV, 2006, 2013)	(National Association of City Transportation Officials, 2013, 2016)	

Copyright © 2019 by MORE

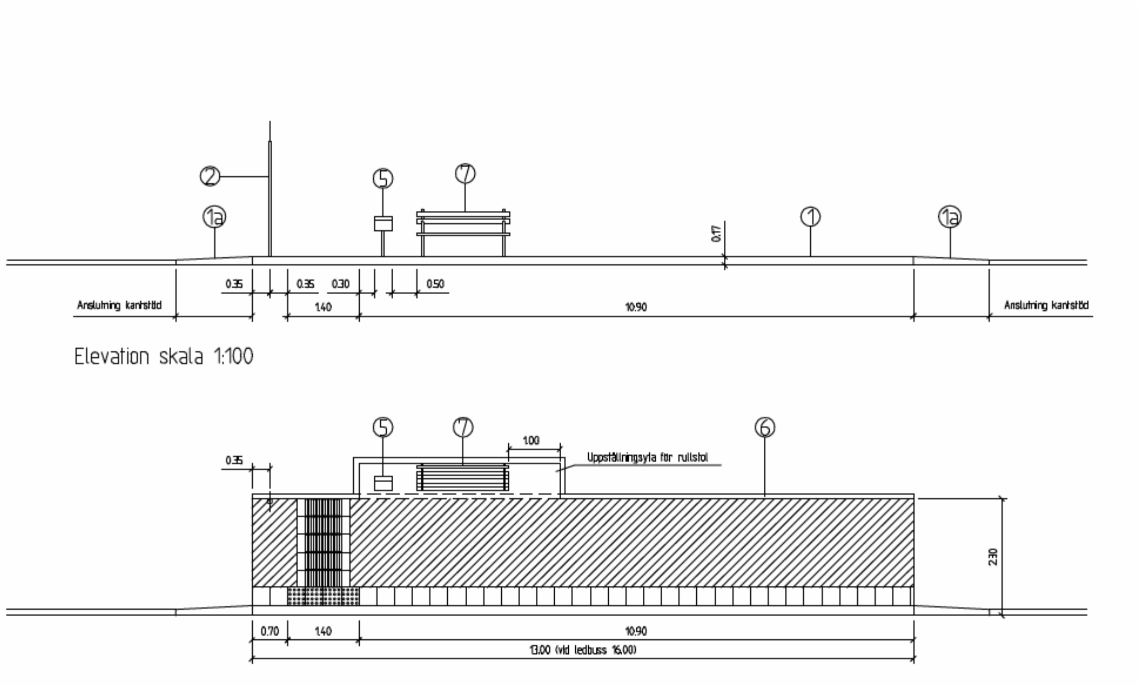
Table 20: Recommendations for Tramway Infrastructure

	Budapest	Constanta	Lisbon	London	Malmö	Germany	NACTO	Summary
Types of Tramway Stops								
Types of Tramway Stop	- Kerbside stop - Tram bulb	No tramways in Constanta	Stops in side position, along the kerbside, sometimes in tram bulbs	- Kerbside stops - Platforms in central position	No tramways in Malmö	- Tram bulb - Kerbside stop with raised carriageway (plateau) - Central position with platform on both sides or in centre	Reference to bus stops – these may also be applied	- Kerbside stop - Tram bulb - Platforms in central position
Space Requirements of Tram Vehicles								
Width of Vehicle	- 2.30 m - 2.48 m	No tramways in Constanta	- 2.40 m - Historical vehicles: 2.378 m	3.00 m	No tramways in Malmö	- 2.40–2.65 m	No recommendations	2.40–3.00 m
Length of Vehicle	15,64-56.00 m		- 24.02 m - Historical vehicles: 8.385 m	-		-		8.385–56.00 m
Width of Infrastructure	Dedicated lane: app. 2,60 m for one standard tramway		Lane: 3.00 m	Lane: 3.65 m		- Dedicated lane: 3.25 m for one standard tramway - For two: 6.30 m		Lane; 2.60–3.65 m
Space Requirements of Platforms or Waiting Areas								
Width	1.80 m	No tramways in Constanta	No recommendations	- Kerbside stop: 3.00 m - Stop in central position: 5.00 m	No tramways in Malmö	≥ 1.50 m	Reference to bus stops – these may also be applied	1.50–5.00 m
References								
	(Budapesti Közlekesi Részvénytársaság, 2007; MAUT, 2009b)		(Municipal Chamber of Lisbon, 2018)	(Office of Rail Regulation, 2006, p. 21; Transport for London, 2017e)		(FGSV, 2006, 2013)	(National Association of City Transportation Officials, 2013)	

Copyright © 2019 by MORE

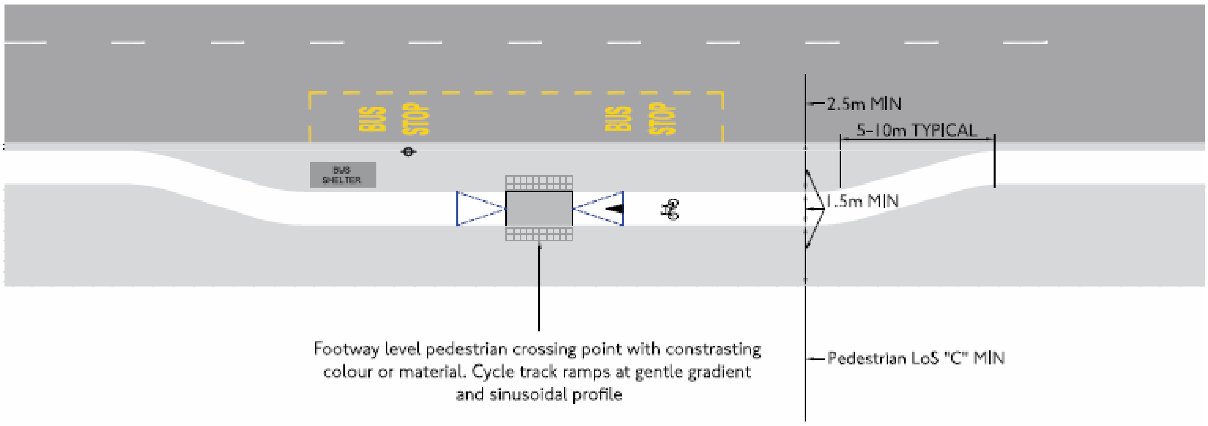
4.5.3 Examples of Good Practice

Figure 46: Kerbside Stop (Malmö)



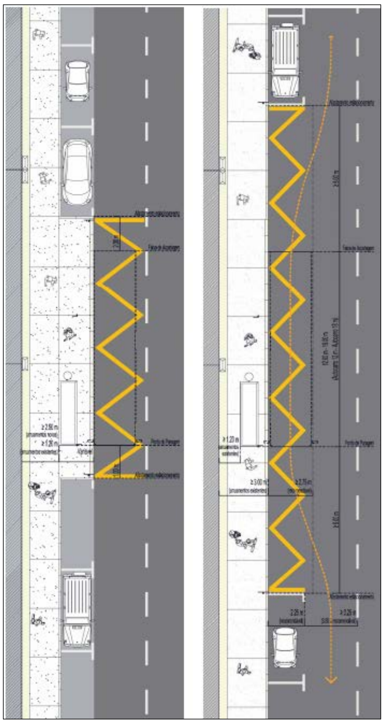
Source: (Skånetrafiken, 2016)

Figure 47: Guidance of Cyclists

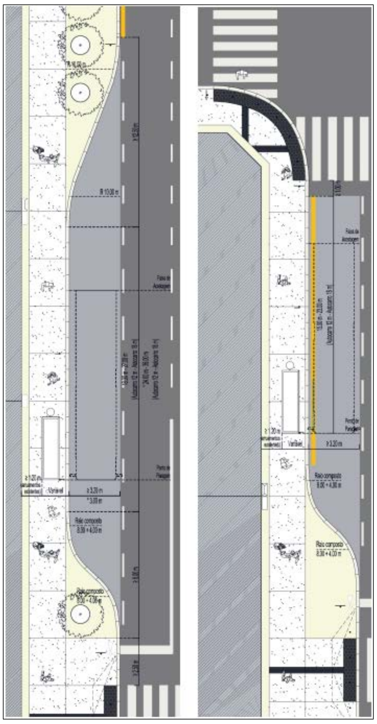


Source: (Transport for London, 2017a, p. 41)

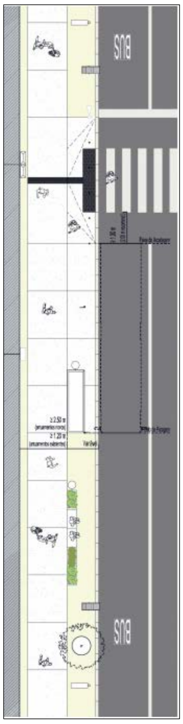
Figure 48: Types of Bus Stops in Lisbon



(Municipal Chamber of Lisbon, 2018, p. 248)

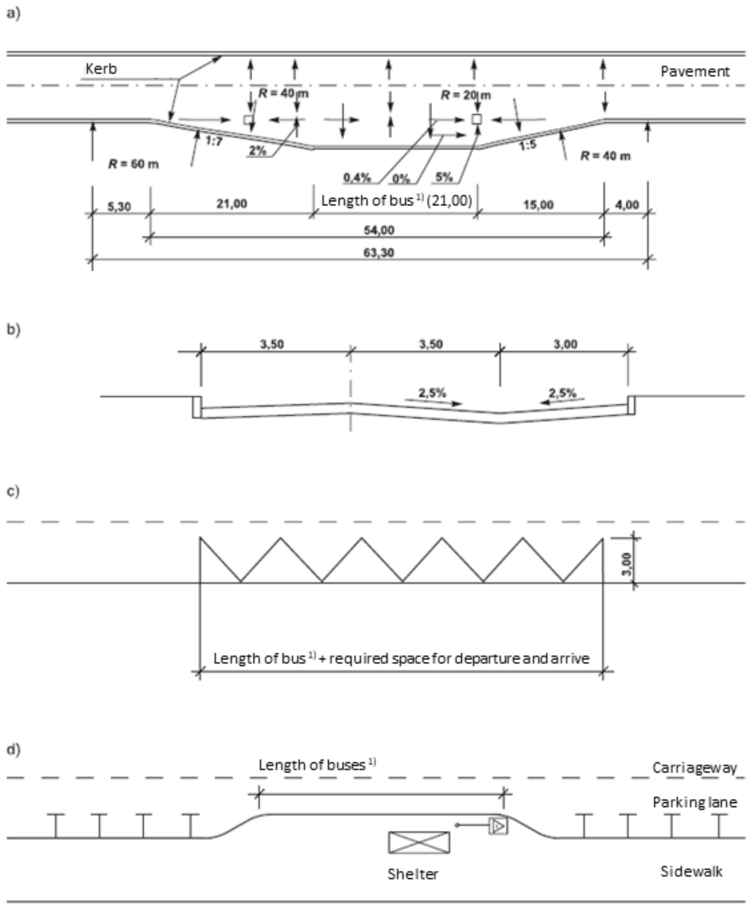


(Municipal Chamber of Lisbon, 2018, p. 249)



(Municipal Chamber of Lisbon, 2018, p. 250)

Figure 49: Types of Bus Stops in Budapest



a)Bus bay in urban area

b) Cross section of bus bay

c) In-lane Bus stop

d) Bus bulb

Source: (MAUT, 2008, p. 108)

4.5.4 Summary and Recommendations

This chapter provides a summary of the recommendations for accommodating buses and trams in urban street design as identified in the guidance material.

Public transport stops are one important element in urban street design to be considered for buses and trams. The placement and design of public transport stops present a challenge: They need extra space in addition to the space requirements which must be considered for the entire street section, and these stops are of particular importance for achieving high attractiveness for public transport. People choose public transport as their preferred travel mode only if this option is safe, convenient, fast, and reliable for the duration of the entire trip, including all stages such as walking to the stop, waiting at the stop, sitting in the bus or tram, and walking from the final stop to the destination.

The location of public transport stops need to be determined on a case-by-case basis; passengers should be able to reach public transport vehicles quickly, conveniently, and safely. Malmö follows a very structured approach for the establishment of public transport

Copyright © 2019 by MORE

stops: Stops are classified into five categories from the biggest transit stops with a minimum of 17,000 boarding/alighting passengers per workday to minor transit stops with less than 15 alighting passengers per workday. Each public transport stop is equipped according to its category.

The guidance material of the MORE cities all utilize kerbside stops for buses. There are three options for the position of buses at stops: (I) in lane—together with motorised vehicles on the carriageway; (II) on a separate lane when traffic volumes are high; and (III) between parking stands at the kerbside. Kerbside stops are placed on the regular sidewalk and no further physical or structural extensions of the sidewalk are required. TfL highly recommends this type of bus stop.

Bus bulbs and bus bays are also possible designs within the analysed guidance material of most MORE cities. Bus bulbs as an extension of the sidewalk between parking stands offer the possibility to stop in-lane and thus avoid illegal parking at the bus stop. On streets with a high frequency of buses, the National Association of City Transportation Officials (2013) recommends a dedicated bus lane.

In contrast to bus bulbs, bus bays decrease the width of the sidewalk but offer a comfortable means of driving the vehicle into the bus stop. A sufficient remaining width of the sidewalk should be kept in consideration. In London, only special safety or capacity reasons justify this layout (Transport for London, 2017a). In Germany, this design is recommended when high traffic volumes (>750veh/h) as well as high bus frequencies exist. A smooth remerging into traffic must be guaranteed. This design is also beneficial when lengthy dwell times are necessary (FGSV, 2006).

In general, the designs of the public transport stops depend on:

- Availability of street space
- Traffic volumes
- Bus frequencies/capacity
- The local environment
- Pedestrian flows

Usually applied types of tram stops are kerbside stops, tram bulbs, and tram stops in the central position with dedicated tram lanes. However, though dedicated tram lanes, which can also be used by buses, ensure timely public transport operations, they are space consuming in the cross section.

Public transport lane width is, besides public transport stops, the second element in urban street design and depends on space requirements of buses and trams. The dimensions of these might differ even within a country between different cities so that public transport operators should always be involved in all projects for (re-)designing urban streets when these are served by buses or trams. Recommended widths for bus lanes range in the researched guidance materials from 3.00m as minimum values (Malmö, Budapest, Germany, Lisbon, London) to 3.50m (Budapest, Germany, Lisbon). Regarding tramways, the width of the tramway tracks as dedicated tramway lanes depends on the tramway model used. In Budapest, the width for one standard tramway is approximately 2.60m at the stop (Budapesti

Közlekesi Részvénytársaság, 2007). In Lisbon and in London the width of the lanes are 3.00 and 3.65m (Office of Rail Regulation, 2006).

Public transport lanes should only be opened for other street users such as taxis or bicycles if their main purpose is still guaranteed; this is the provision of fast and reliable public transport services.

The space requirements for waiting areas at bus stops are listed in Table 14 and range between 1.50m and 2.80m. Depending on the design of the tramway stop, the waiting areas are wider than those of bus stops and differ between 1.50m and 5.00m.

Because of potential conflicts between cyclists and waiting or boarding passengers, the guidance of cyclists is an important aspect when designing public transport stops. In respect to a universal design, direct and comfortable access for persons with disabilities should always be considered.

If allowed, cyclists can use the bus lane or the carriageway together with the buses (Budapest, Lisbon, London, Malmö, Germany). Common is also a separate cycling track around the bus stop (Lisbon, London). Hereby, accessibility of the bus stop is ensured. In Lisbon and Germany raised plateaus between the public transport and the waiting area function as cycle lanes. In Lisbon shared spaces for pedestrians and cyclists is a possible form of "guidance".

All MORE cities have similar standards for the design of public transport stops. The choice of the type depends on many criteria, such as available space, traffic volumes and speed limits, frequency of public transport services, and the local environment. These should be considered in sustainable urban street design processes. To ensure the reliability of public transport and thus increase the comfort of using public transport, dedicated lanes with separate and ahead switched signalisation should be considered whenever street space is available. Otherwise, a shared lane with a widening of space for pedestrians and cyclists is a suitable option. In this manner, sustainable transport modes are promoted and become more attractive, while the travel speed for motorised vehicles is reduced.

Copyright © 2019 by MORE

4.6 Infrastructure for Motorised Vehicles

4.6.1 Infrastructure for Moving Vehicles

The MORE project focusses on streets with major link functions and not on residential streets. Heavy-duty vehicles, buses, trams, fire service vehicles or emergency vehicles serve as design vehicles for these major streets but not private cars. Consequently, lane widths for major streets in the researched guidance materials are derived from the above listed bigger vehicles. The standard widths of lorries and buses range from 2.25 m in Constanta as the only and generally applicable standard design vehicle to 2.60 m for lorries in Malmö and in The Netherlands. This difference of 0.35 m might have a big impact on the final street layout as it determines the necessary widths for motorised vehicle lanes. For a standard carriageway with two lanes (one per direction), this means that two times 0.35 m, this is 0.70 m, of space more or less is needed for the two driving lanes. Taken together with the differences in buffer zones as described in Chapter 4.2 and Chapter 4.4, these at a first glance seemingly minor deviations in the widths of the individual design vehicles might lead to substantial differences in the overall space requirements for the driving lanes and thus also to substantial differences in available space for the other street users including place functions. Standard vehicle widths for buses and trams (see Chapter 4.5 for trams) are provided in all guidance material but it should be noted that these might be different in each individual city as particularly trams are often purchased on individual request with tailor-made characteristics and solutions for each specific application.

Lane widths for standard lanes range from 3.00 m to 3.50 m respectively 6.00 m to 7.00 m for two-lane carriageways with few exceptions. It should be checked carefully whether carriageway widths of 7.00 m are really needed as not all elements of a single driving lane double and need to be considered for the two-lane carriageway. The following Table 21 gives an overview of the design parameters identified in the researched guidance material.

Copyright © 2019 by MORE

Table 21: Infrastructure for Motorised Vehicles

	Budapest	Constanta	Lisbon	London	Malmö	The Netherlands	Germany	NACTO	Summary
Standard Width of Vehicles (Excluding Mirrors)*									
Standard Car	1.75 m/ 1.60 m-1.80 m	Standard design vehicle 2.25 m	1.70 m	1.80 m	1.80 m	1.83 m	1.75 m	1,68 m	1,68 m-1,83 m
Lorry	2.50 m		2.30 m - 2.50 m	2.50 m	2.60 m	2.60 m	2.55 m	2.45 m	2.25 m-2.60 m
Bus	2.50 m		2.55 m	2.50 m	2.55 m	No information	2.55 m	2.59 m	2.50 m-2.59 m
Standard Lane Width									
Main Network	3.00 –3.50 m	3.00–3.50 m	3.00–3.25 m	3.00 m	3.00–3.50 m	-	3.00–3.50 m (min. 3.25 m with buses)	3.05 m	3.00–3.50 m
Residential Network	2.75–3.00 m	3.00–3.50 m	3.00 m		≥ 2.75 m	-	2.25–3.25 m		2,25–3.50 m
Bus Lane	3.50 m	No information	3.25 m	3.00 m - 3.20 m or 4.50 m	> 3.00 m	-	3.25 m – 3.50 m	3.35 m	3.00 m-3.25 m
Standard Width of Carriageway (Main Network)									
2-Lane-Carriageway	5.50 m - 7.00 m	6.00 m - 7.00 m	6.00 m	No information	6.00 m - 7.00 m	-	6.00 m - 6.50 m	6.70 m	5.50 m - 7.00 m
4-Lane-Carriageway	#	14.00 m (4 x 3.50 m)	12.50 m (4 x 3.00 m + 0.50 m buffer)	Not recommended; give place to other users	13.00 m	-	12.00 m – 13.00 m	#	12.50 m-14.00 m
Carriageways with more than Two Lanes									
Max. Number of Lanes	#	3+3	3+3	Not recommended; give place to other users	2+2	-	2+2	-	2+2 to 3+3
Segregation of Circulating Directions	No information	Not required	Required/ recommended on 1st to 3rd level streets	Common on multi-lane inner-city streets	Not required	-	Segregation required, no segregation only allowed in cases of very limited space availability	-	-
References									
	(MAUT, 2005, 2008)	(Ministry of Transport, 1997, 1998)	(Municipal Chamber of Lisbon, 2018)	(Department for Transport, 2007)	(City of Malmö - Streets and Parks Department, 2006; City of Malmö: Brodde Makri, Maria and Nordlund, 2019)	(CROW, 2016)	(FGSV, 2006)	(National Association of City Transportation Officials, 2013, 2016)	

*Where width is given including mirrors, the width is reduced by 0.30 m.

Copyright © 2019 by MORE

4.6.2 Provision for Kerbside Activities, Parking and Loading

The widths of the standard design car are of minor importance for choosing lane widths in major streets but it is of highest importance for the space needed if parallel parking at the roadside should be provided. Standard design cars in the researched guidance material range from 1.70 m in Lisbon to 1.80 m in Budapest, London, Malmö and 1.83 m in The Netherlands (see Chapter 4.6.1). The widths of the standards design car in Germany is 1.75 m but recent investigations of the German car fleet revealed that the actual width (85 %-percentile) is with 1.85 m 10 cm wider and is in addition increasing. These 10 cm matter for the design of parallel parking lanes. The often applied 2.00 m width for parking lanes is not sufficient if car widths are equal to 1.85 m. Parked cars do not stay in their lanes, they might hamper driving street users in the adjacent lanes, be it cyclists in on-carriageway cycle lanes or private/public motorised vehicles that might have problems in passing the parked cars.

With parallel parking, buffer zones that cover the dooring-zone next to cycle facilities are of highest importance (see Chapter 4.4.2). Sufficiently large dimensioned buffer zones, (optionally with physical separation) prevent dooring accidents while cyclists have enough space to ride on their facility and abruptly opening doors do not hit them or force them to change on general traffic lanes.

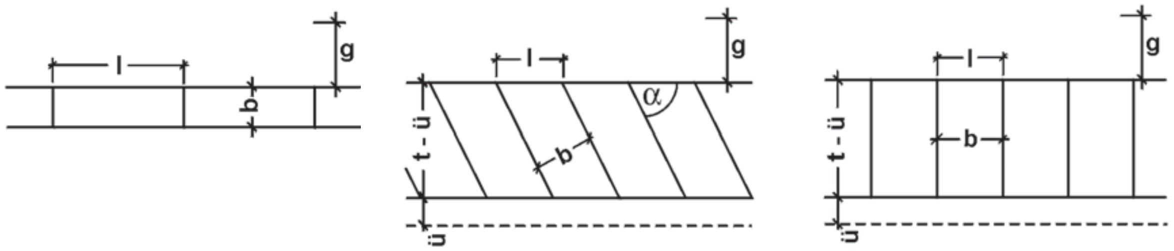
Transport for London (2017e) provides recommendations on the street context of parking and loading bays: Loading bays should be provided adjacent to commercial or industrial premises which require regular deliveries and collections. The transfer distance should be minimised in order to maximise acceptance of the bays. This could be achieved by aligning delivery doors with destination doors wherever possible. Minimised proximity to delivery points also reduces lorry dwell times. Parking bays (including parking for car clubs) can be provided in a wide range of circumstances including residential streets, commercial and industrial streets. Blue badge bays or other facilities reserved only for residents should be located adjacent to local amenities.

The researched guidance material rarely provides information or standards on how to deal with the increasing amount of kerbside activities, e.g. by dynamically assigning space to different types of street activities. This topic of innovative approaches to provide for kerbside activities will be covered in WP3 of the MORE project.

Figure 50 gives an overview of the different possible schemes of parking facilities alongside the carriageway and the notation used in the subsequent Table 22. This Table gives an overview of the dimensions of parking facilities identified in the guidance material.

Copyright © 2019 by MORE

Figure 50: Scheme of Parking Facilities alongside the Carriageway



Source: (FGSV, 2006)
With
l = length
b = width
g = lane width
t = depth
ü = overhang
α = angle

Copyright © 2019 by MORE

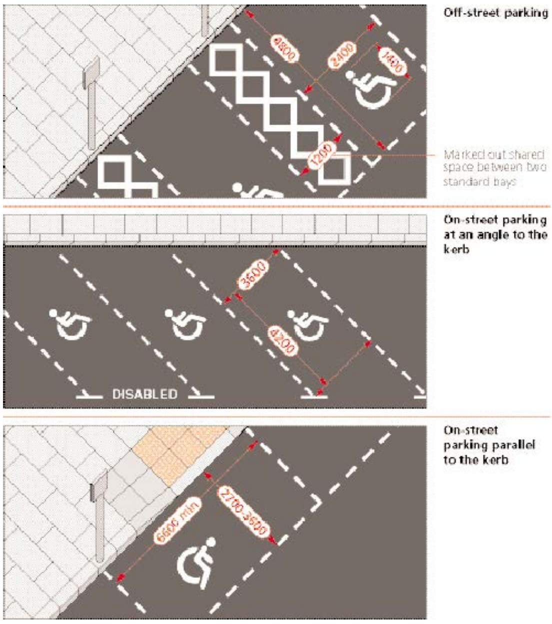
Table 22: Kerbside Activities, Parking and Loading

	Budapest	Constanta		Lisbon		London		Malmö	Germany		Summary
Parallel Parking Facilities											
Width b	2.50 m	2.50 m		> 1.80 m		2.00 m		2.00–2.50m	2.00 m		> 1.80 m-2.50 m
Length l	5.50 m	5.00 m		5.00 m		6.00 m		6.00 m	6.70 m/5.70 m		5.00 m-6.00 m
Lane width g	3.00 m	-		-		-		≥ 3.50 m	3.25 m/3.50 m		3.00 m-≥ 3.50 m
Requirements for Persons of Impaired Mobility	l = 6.50 m width of adjacent sidewalk ≥ 1.50 m	-		l = 5.50–6.00 m b = 2.00–3.50 m		b = 2.70–3.60 m l ≥ 6.60 m		l = 7.00 m	-		-
Width of Loading Bays	3.00 m	No information		2.50 m		3.00 m		No information	2.30–2.50 m		2.30 m-3.00 m
Perpendicular Parking Facilities											
Length l	2.50 m	2.50 m		2.30 m		2.40 m		2.50 m	2.50 m		2.30 m-2.50 m
Depth t-ü	4.50 m	5.00 m		4.50 m		4.80 m		5.00 m	4.30 m		4.30 m-5.00 m
Overhang ü	0.70 m	-		-		-		-	0.70 m		No overhang to 0.70 m
Lane Width g	5.00 m	-		> 2.25 m with a two-lane carriageway		> 2.25 m with a two-lane carriageway		> 3.05 m with a two-lane carriageway	3.00 m/2.25 m with a two-lane carriageway		-
Requirements for Persons of Impaired Mobility	l = 3.50 m (or l = 2.50 m + 1.40 m adjacent space or 1.10 m between two parallel parking bays) t-ü = 5.50 m	t = 5.00 m width between two parking bays ≥ 1.20 m		-		Width between two parking bays ≥ 1.20 m		b ≥ 3.60m			-
Echelon Parking Facilities											
Angle α	45 °	30 °	60 °	45 °	60 °	45 °	60 °	60 °	45 °	63 °	-
Length l	3.50 m	5.00 m*	2.90 m*	3.25 m	2.65 m	3.40 m*	2.77 m	2.90 m	3.54 m	2.8 m	-
Width b	2.50 m	2.50 m	2.50 m	2.30 m	2.30 m	2.40 m	2.40 m	2.50 m	2.50 m	2.50 m	-
Depth t-ü	5.10 m	t = 4.87 m	t = 5.93 m	4.20 m	4.20 m	-		5.30 m	4.15 m	4.60 m	-
Overhang ü	0.70 m	Included in t		-	-	-		-	0.70 m	0.70 m	-
Lane Width g	3.00 m	-		> 1.85 m	> 2.10 m	> 1.80 m	> 2.10 m	> 3.50 m	3.00 m	4.00 m	-
				With a two-lane carriageway		With a two-lane carriageway					-
Requirements for Persons of Impaired Mobility	-	Width between two parking bays ≥ 1.20 m		-		Usable area: 3.60 m * 4.20 m		b ≥ 3.60m t-o = 5.30 m			-
References											
	(MAUT, 2005)	(Ministry of Regional Development and Public Administration, 2013)		(Municipal Chamber of Lisbon, 2018)		(Department for Transport, 2005, 2007; Transport for London, 2017d)		(City of Malmö - Streets and Parks Department, 2006)	(FGSV, 2006)		

Copyright © 2019 by MORE

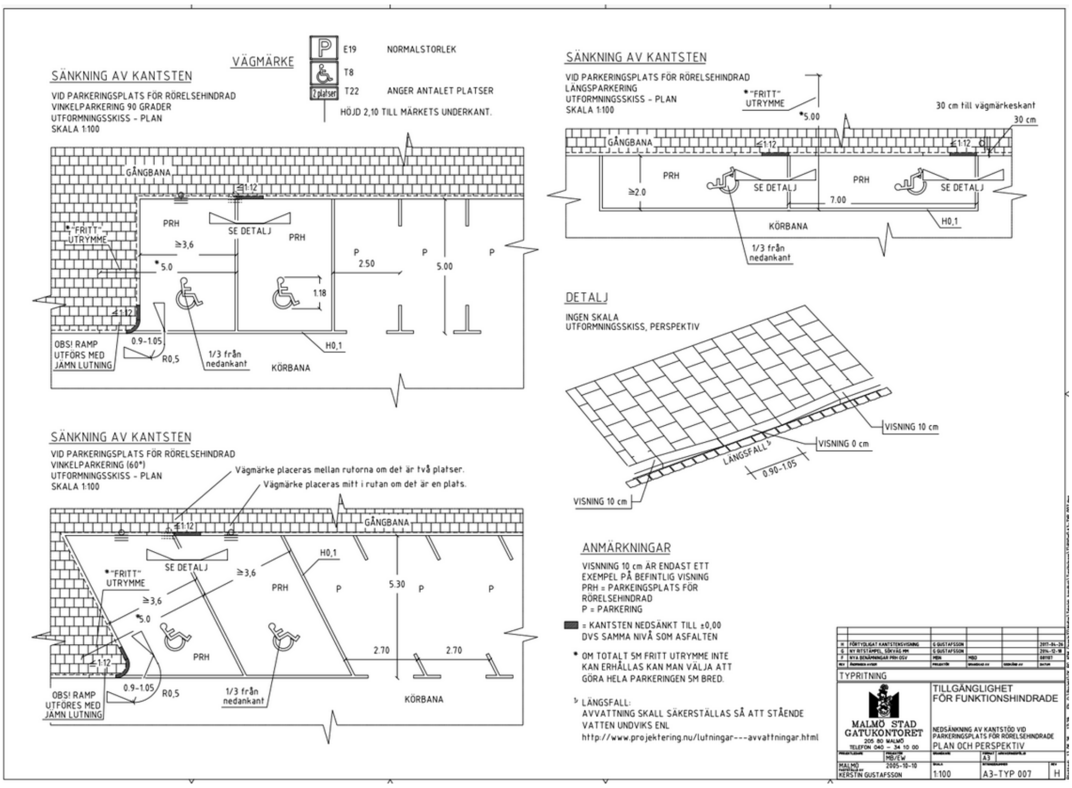
4.6.3 Examples of Good Practise

Figure 51: Parking Spaces for Persons with Reduced Mobility (London)



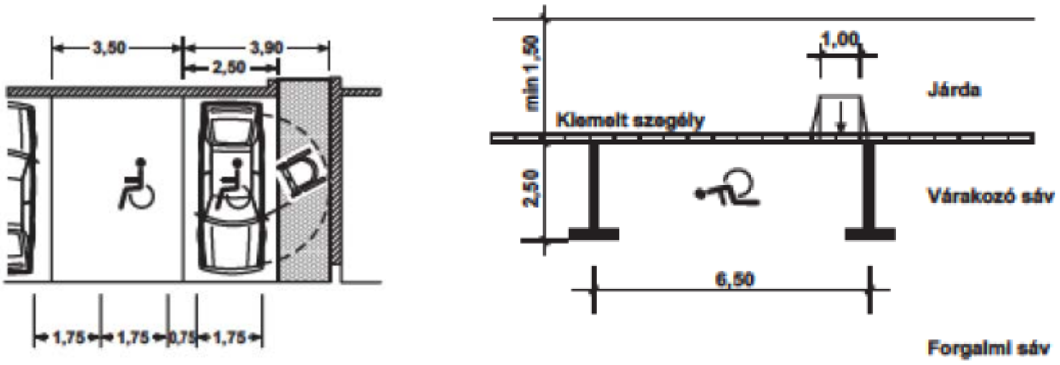
Source: (Department for Transport, 2005)

Figure 52: Parking Spaces for Persons with Reduced Mobility (Malmö)



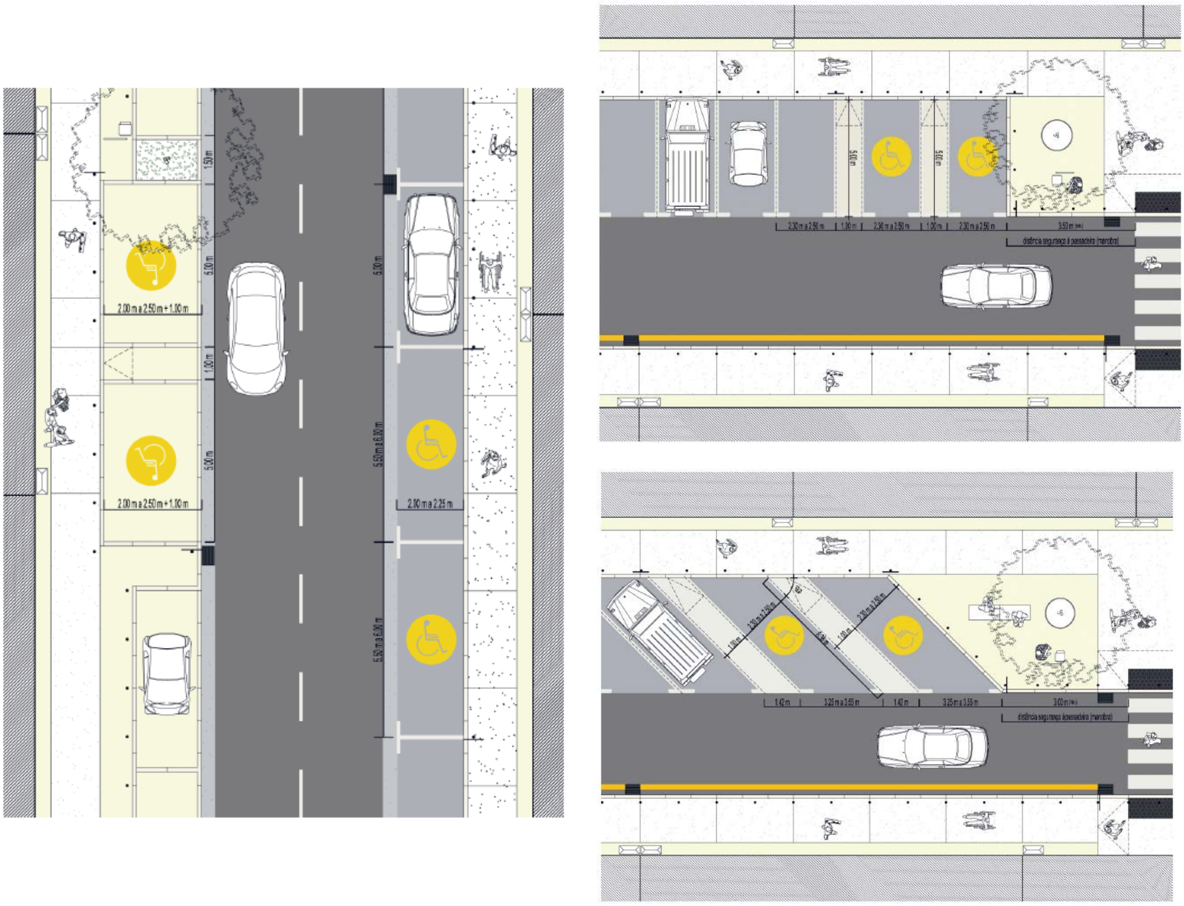
Source:(City of Malmö - Streets and Parks Department, 2019)

Figure 53: Parking Spaces for Persons with Reduced Mobility (Budapest)



Source: (MAUT, 2005)

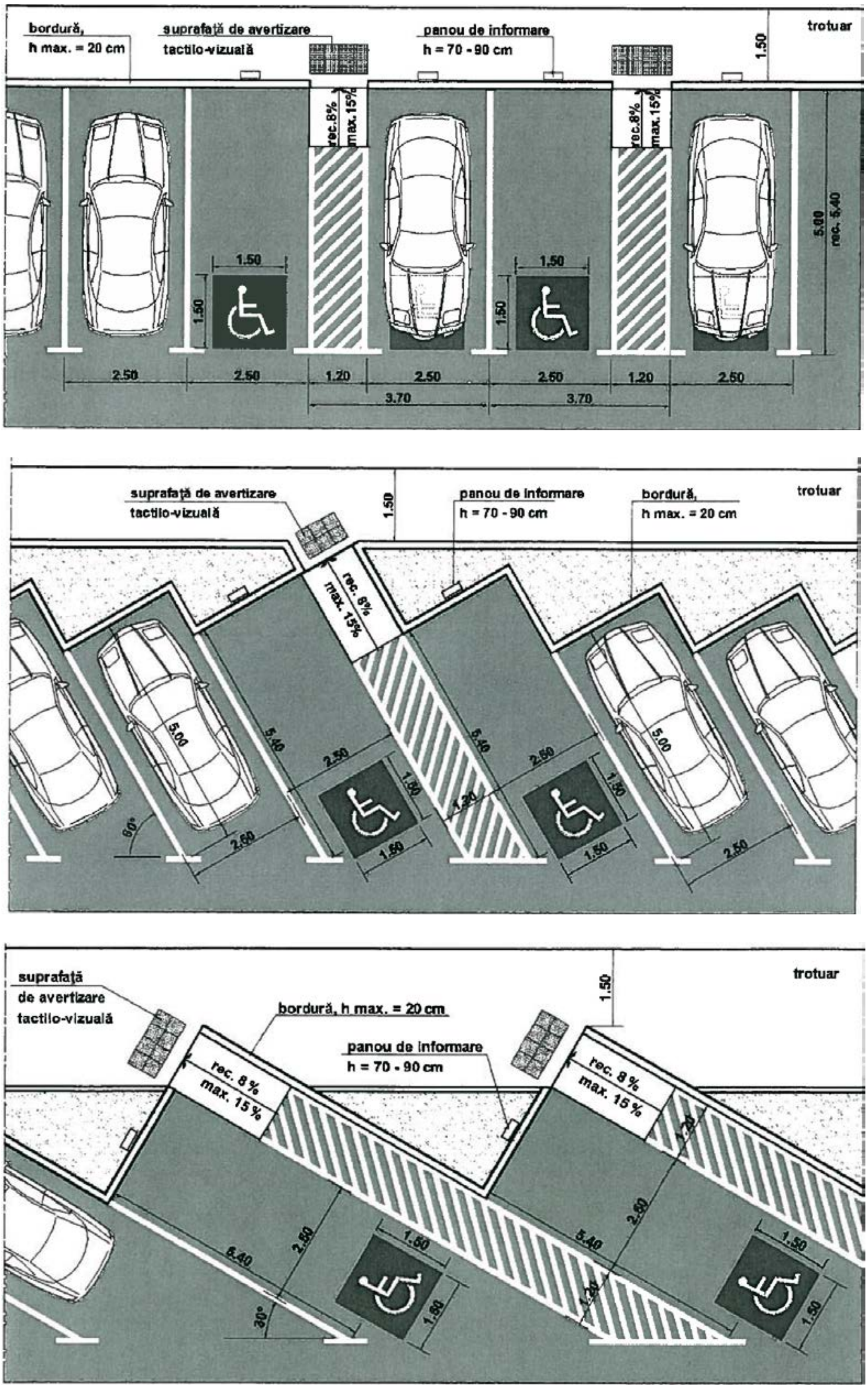
Figure 54: Parking Spaces for Persons with Reduced Mobility (Lisbon)



Source: (Municipal Chamber of Lisbon, 2018)

Copyright © 2019 by MORE

Figure 55: Parking Spaces for Persons with Reduced Mobility (Constanta)



Source: (Ministry of Regional Development and Public Administration, 2013)

4.7 Junctions

4.7.1 General Planning Principles

Junctions are a central element in urban street networks because they allow street users to move from one street section to another. Designing junctions is the most challenging task in urban street design. Junctions are critical points in the network and determine the capacity of the whole network. In addition, they generate the most complex traffic situations and require the highest attention from all user groups. Traffic accidents in urban contexts occur much more often at junctions than at the street sections in between.

Requirements for junctions differ widely which leads to a high variety in junction types and design. Junction types range from grade-separated junctions to junctions on the same level and from signal-controlled junctions to right-of-way junctions. Selecting the suitable type and dimensions for each junction is dependent on several criteria, such as:

- network function of the streets being linked (link & place)
- traffic (turning) volumes of relevant user groups (including public transport vehicles)
- accident statistics, and
- types of adjacent buildings and their usages (urban design).

For MORE corridors, junctions of two major streets or of a minor street crossing a major street are the most common, and the traffic volumes on such streets are high for all user groups. Signal-controlled junctions are a recommended solution for this design situation (FGSV, 2006; Municipal Chamber of Lisbon, 2018; National Association of City Transportation Officials, 2013). Therefore, these are the focus of the following explanations.

Signal-controlled junctions guarantee road safety by separating conflicting traffic flows in a timed manner. They allow for arranging the necessary number of lanes because lines of sight do not need to be respected for conflicting traffic flows as comprehensively as is the case for junctions without traffic signals, and can thus manage high traffic volumes. They can also prioritise certain street user groups, steadily or with varying priorities over time. Signalling at neighbouring junctions can be coordinated to allow for, e.g., public transport vehicles to pass a sequence of signalled junctions without stopping. The interaction between the signal programme and geometric design must be considered when planning signal-controlled junctions. General design principles for signal-controlled junctions are safety, visibility, accessibility, comfort, and short cycle times. Further objectives of junction design are directness and attractiveness.

Visibility of the junction must be ensured in all approaches. Stopping sight distance needs to be guaranteed in accordance with speed limits for approaching vehicles. Waiting pedestrians, cycles, and vehicles need to have a good view of the traffic lights. In addition, (potentially) conflicting street users need to have view of one another. Banning parking and/or stopping at and near junctions can enhance visibility for approaching users as well as waiting/crossing users.

Junctions need to be accessible, safe and comfortably functional for all user groups, including persons with reduced mobility (see also Chapter 4.3). Cyclists need an

Copyright © 2019 by MORE

understandable, continuous, and unobstructed guidance through junctions in all cases, also when the type of cycling infrastructure changes in the junction, e.g., from off-carriageway to on-carriageway. Safety of pedestrians and cyclists must be considered when selecting curve radii: Larger radii tend to lead to higher vehicle turning speeds, whereas small curve radii shorten the crossing distance for pedestrians (see Chapter 4.7.2). For motorised vehicles, swept paths need to be analysed on all turning relations; this ensures sufficiently wide curve radii for heavy goods vehicles.

Waiting and queuing areas should be dimensioned to accommodate all arriving vehicles and users within the blocking time. This requires general traffic turning lanes to be long enough and cycling facilities to be long and wide enough to queue. In coherence, green times should be long enough to allow all vehicles which have been stopped by the red light to pass through the junction.

Short cycle times are advantageous over longer ones as these reduce delays for all user groups and lower the probability of stops. Short cycle times are often difficult to achieve because of high traffic volumes for all street user groups in all approaches including pedestrians, cyclists, buses, trams, and individual motorised vehicles. The recommended maximum cycle time is 90s and should never exceed 120s (CROW, 2016; FGSV, 2015a; Transport for London, 2016a). Cycle times depend on lengths of green times, inter-green periods, blocking time for all phases and number of phases. Length of green time is determined by minimum green time (depending on crossing distances and user-group design speeds), and traffic volumes. Inter-green periods are defined as the periods between one phase losing right of way and the next phase gaining right of way. An inter-green period is highly dependent on the size of the crossing; therefore, compact junctions (avoiding unnecessary lanes, narrow lanes, pedestrian and cycle crossings close to the junction) generate fewer losses on inter-green period. Minimum green time and inter-green time are highly relevant for safety, particularly for the vulnerable street users.

Furthermore, comprehensibility is a general design requirement for any junction. This requires junctions to be clearly understandable, make all users aware of priorities, potential conflicts with other road users and any available filtering and turning option. Signal-controlled intersections are mostly applied where comprehensibility cannot be guaranteed without signalisation due to high volumes of traffic or disadvantageous visibility.

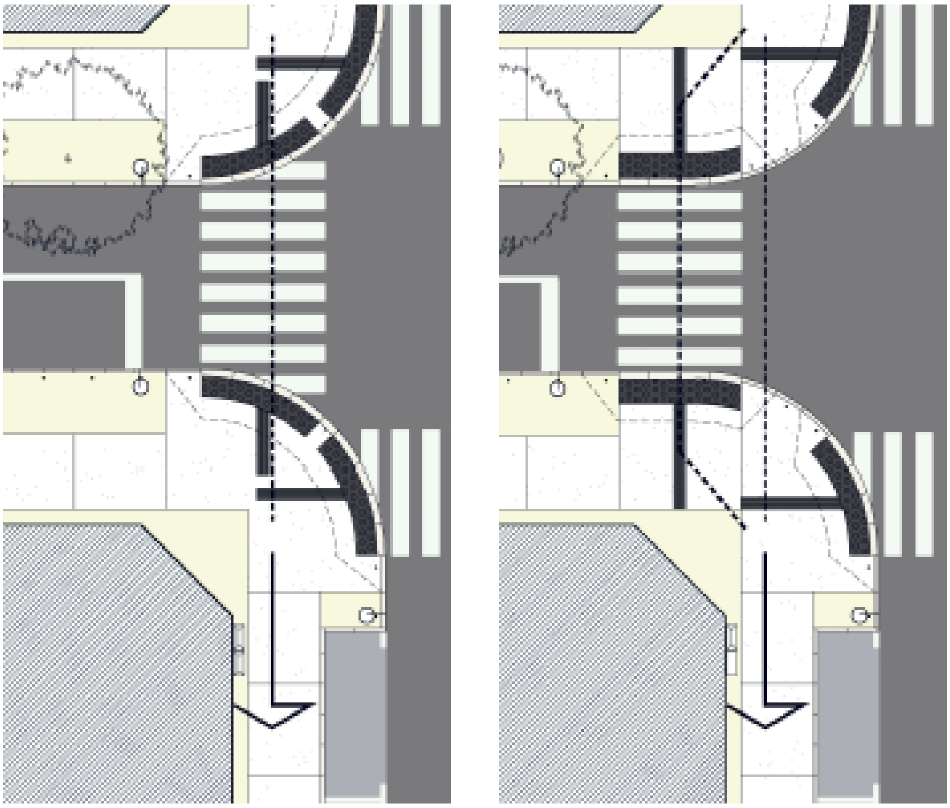
To save energy, some countries operate traffic lights just by day and inactivate them at night, due to lower traffic volumes. To secure comprehensibility, it is recommended to have operational signal control at all times of the day and year.

4.7.2 Guidance for Pedestrians

Pedestrian crossings should be established wherever the need exists. Pedestrians are extremely distance sensitive and avoid even minor detours whenever possible. In the urban context, crossing facilities for pedestrians should be provided at every junction and approach. The amount of measures for pedestrians always depends on the size of the crossing/junction.

In order to offer the most direct crossing opportunity, facilities should be placed in a direct continuation of the sidewalks (Figure 56, left). At junctions with large curve radii, the guidance in direct line would lead to long crossing distances; in this case, it is beneficial to inset the crossing beyond the limits of the curve radius to minimise the crossing distance (Figure 56, right).

Figure 56: Position of Pedestrian Crossings at Signal-Controlled Junctions



Source: (Municipal Chamber of Lisbon, 2018)

On wide carriageways, the provision of a central island is preferred. Central islands offer space for pedestrians to wait if they cannot cross the whole carriageway within one signal phase. Central islands should be wide enough to accommodate pedestrians with a pram or a wheelchair. Recommendations range from a minimum of 1.50m (Municipal Chamber of Lisbon, 2018; The Highways Agency, 2004) to 1.82m (National Association of City Transportation Officials, 2013) and 2.50m (FGSV, 2006).

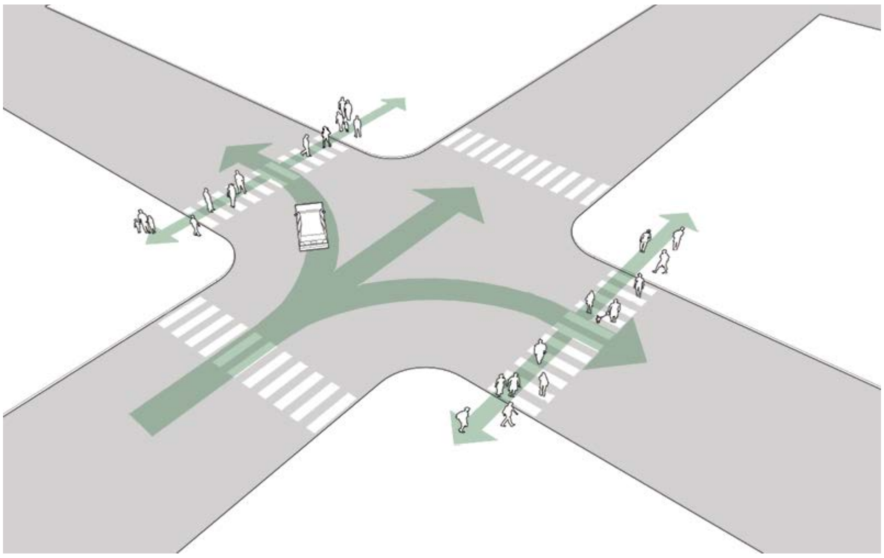
The green time for pedestrians should enable a standard pedestrian to cross the whole carriageway in one phase such that the central islands are simply present to provide the opportunity for slower (e.g., impaired) users to rest and to wait for the next green light. In addition to crossing distance, the next determining variable for pedestrian green time is the pedestrian design speed. Design speeds vary from 0.4m/s in Portugal (Ministry of Labour and Social Solidarity, 2006) up to 1.2m/s in the United States/Germany (FGSV, 2015a; Texas Transportation Institute, 2009). Low speeds might lead to unreasonably long cycle times and encourage planners to implement shorter times. High speeds may lead to safety issues because pedestrians cannot completely cross during the green time. Within aging

Europe, there are numerous studies which strongly indicate that the pedestrian design speed must be decreased to values that are more acceptable (Asher et al., 2012; Crabtree et al., 2014). For example, Living Streets (2014) assumes 0.8m/s as a balanced value. Installation of buttons that requests for longer green times can be useful for elderly and impaired users. Other considerations for impaired users include the application of acoustical green time signals for visually impaired users. For general considerations, see Chapter 4.3.

As mentioned in 4.7.1, short cycle times are desirable. This is of special importance for pedestrians in order to keep red/waiting times short. This increases the acceptance of signals and infrastructure and discourages pedestrians from walking during a red light.

In order to keep the cycle time as short as possible, pedestrians usually have a corresponding green signal in the same direction of traffic. Pedestrians have the right of way over turning vehicles while crossing, thus visibility between pedestrians and drivers must be ensured. To improve visibility and demerge pedestrian and turning vehicle flows, a head start should be given to the pedestrians. This advantage in time allows pedestrians to cross safely while motorised vehicles are still waiting on their stop line. When the flow of turning vehicles reaches the pedestrian crossing, the pedestrians should have already passed the conflict point (see Figure 57). The amount of time given in advance depends on the junction geometry (e.g., crossing distance, vehicle entering time).

Figure 57: Leading Pedestrian Interval



Source: (National Association of City Transportation Officials, 2013)

If a Leading Pedestrian Interval is given to pedestrians, it is appropriate to give cyclists this time advantage as well. Alternatively, separate green times can be provided for pedestrians (either at individual arms or as green phases for pedestrians at all approaches); this is beneficial for crossings which have a high volume of children, elderly or impaired users, or a high proportion of HGV in right turning flows.

Copyright © 2019 by MORE

4.7.3 Guidance for Cyclists

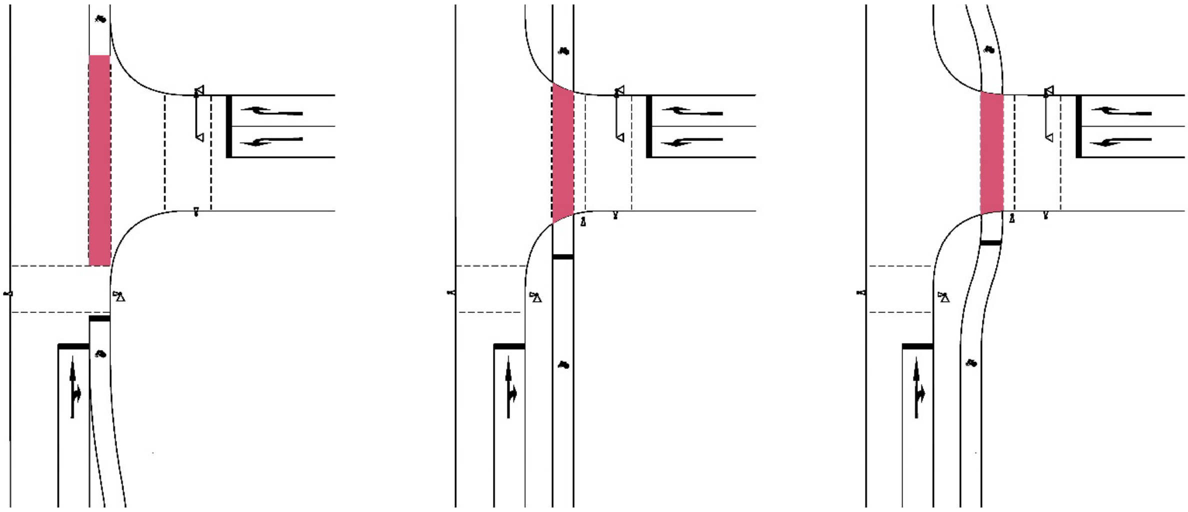
General Street Design Layout

The design of cyclist routing at junctions is strongly connected to the type of cycling infrastructure leading up to and after the junction; it is also affected by the volume of motorised traffic and the local traffic conditions. Even though the transition between section and junction may require changes in the location and layout of the cycling infrastructure, the guidance of cyclists needs to be seamless and comfortable.

Cyclists approaching in mixed traffic are usually guided with motorised traffic and do not need dedicated signalisation at junctions. In situations of mixed traffic, speeds of cyclists must be considered for inter-green time calculations. It may be beneficial to implement advisory lanes at the approach to provide cyclists the room the pass motorised vehicles—especially with advanced stop lines (see below). At high level link function sections (on MORE corridors) cyclists will mainly approach intersections on dedicated cycling facilities. Those may be located on or off the carriageway and with or without segregation (see Chapter 4.4). At junctions, it is favourable for safety reasons to guide cyclists on the carriageway level to allow for better visibility by other users. Where cyclists approach the junction adjacent to general traffic (advisory/mandatory cycle lane), it is recommended to continue the facility through the junction. In places where the cycling infrastructure before the junction is physically (vertically/horizontally) segregated, visibility and right of way need to be ensured. For unidirectional facilities, this can be achieved by 'bending in' the cyclists: ending the separation and transitioning into a standard cycle lane on the carriageway before reaching the junction. A second option is continuing the track through the junction 'without deviation', either on the same plane as the carriageway or raising the track above the carriageway level (Transport for London, 2016a, Ch.5). A third option is 'bending out' the cyclists, which routes the cycle facility away from the major road adjacent to the pedestrian crossing facility. The application of bending-out designs differs greatly between countries. It is a typical solution in Sweden and The Netherlands but never the first solution in London and Germany. 'Bending out' has shown a negative impact on road safety (see, e.g., Kolrep-Rometsch et al., 2013) it is less direct for cyclists as well as for pedestrians and requires more space.

Copyright © 2019 by MORE

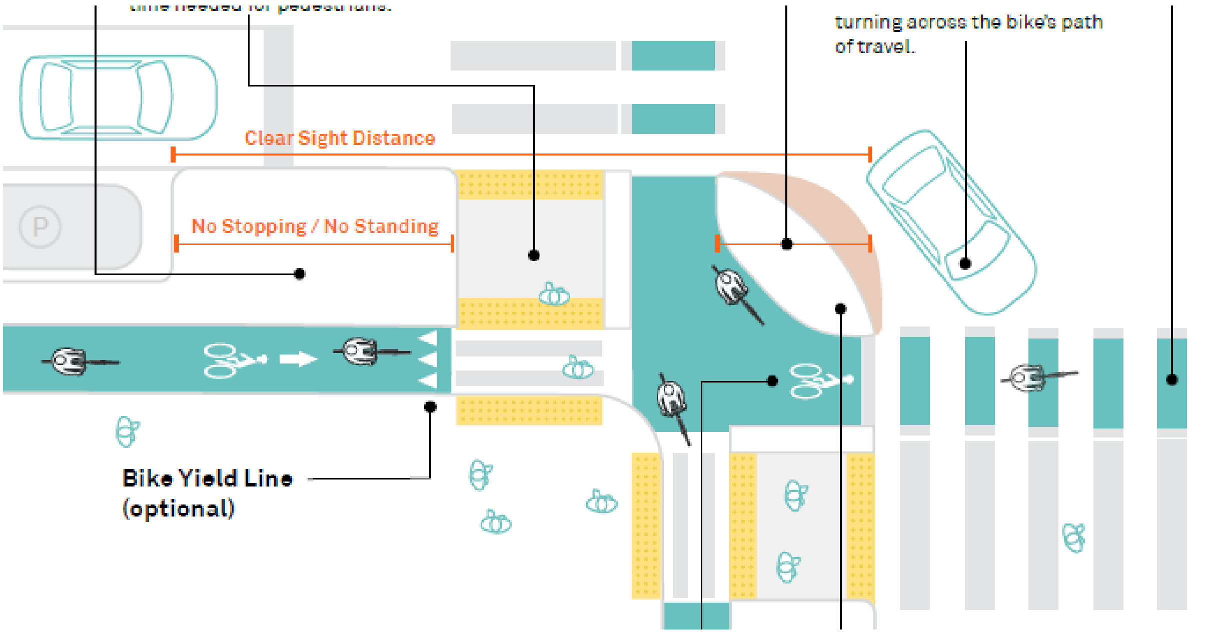
Figure 58: Guidance of Cyclists: Bending In, Without Deviation, Bending Out



In places where the cyclists change from the sidewalk to the carriageway level and/or the cycle facility is bending, the transition needs to be properly designed with a smooth, gradual (not abrupt) ramp. To clearly mark the route for cyclists, it is recommended to have continuous markings in the inner junction area as well as use a colour system to highlight the potential conflict points with other users.

For off-carriageway guidance, the National Association of City Transportation Officials (2019) promotes a layout of protected intersections by using setback bikeways. The corner island as a central element creates the setback area, ensuring visibility of users and providing motorists space to wait while giving way.

Figure 59: Protected Intersections



Source: (National Association of City Transportation Officials, 2019)

Signalisation of Cyclists

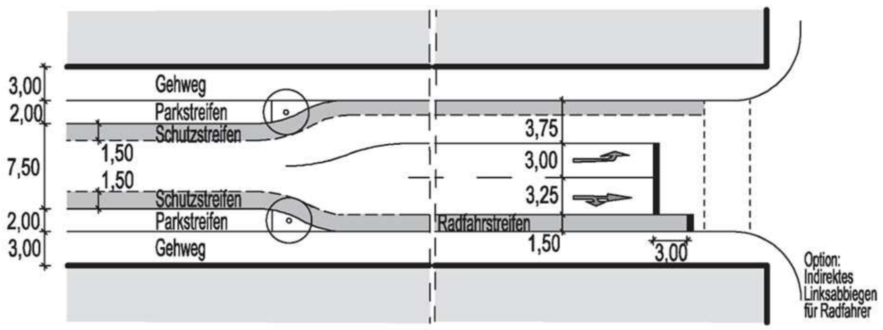
At signal-controlled junctions with separated signalisation for cyclists, all conflicting movements with other users can be eliminated. This signalisation leads to long cycle times and might not be appropriate in all situations. In situations with two-way cycle facilities, separated signalisation of cyclists is recommended. In most cases, cyclists have a corresponding green signal in the same direction of traffic which might potentially lead to conflicts between cyclists and motorised traffic. Typical conflicts at signal-controlled junctions occur between:

- Cyclists who cycle straight ahead and motorised vehicles turning right and
- Cyclists turning left and motorised vehicles driving straight ahead.

The collision risk is even higher if cyclists drive on two-way facilities or they cycle illegally in the opposite direction as prescribed. The risk of conflicts or collisions between cyclists and right-turning vehicles can be mitigated by an advantage in time or space for cyclists.

Advanced Stop Lines (ASL) give cyclists the advantage in space. Cyclists approaching at a red light pass the waiting vehicles and wait at the advanced stop line within the visual range of the waiting vehicles. The stop line for cyclists should, for example in Germany, be a minimum of 3.00m in front of the general stop line (Figure 60) (FGSV, 2010). This measure ensures the visibility of cyclists for all motorised vehicles including heavy-duty vehicles and allows cyclists to clear the junction before the other vehicles.

Figure 60: Advanced Stop Lines for Cyclists

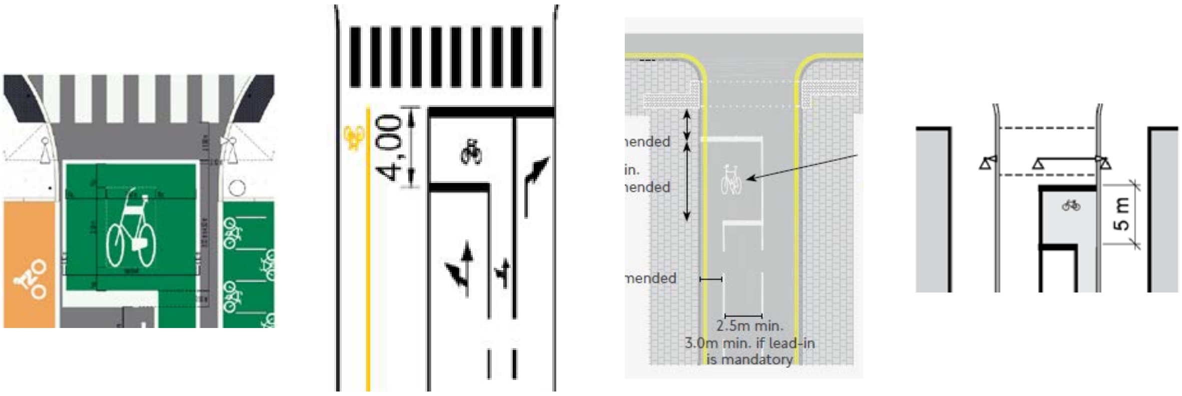


Source: (FGSV, 2010)

Advanced Stop Lines are useful when the guidance of cyclists is adjacent or segregated from general traffic. Where no cycle facility exists, a nearside lead-in lane gives cyclists the space to pass motorised traffic. This lane may be narrower than a mandatory cycle lane (e.g., in London 1.50m instead of 2.00m).

A common implementation of ASL is a bike box. At junctions with on-carriageway routing, a bike box covers the whole cycling lane width. Bike boxes give cyclists extra space at the stop line, enable them to position ahead of the other waiting vehicles and clarify the right of way over turning vehicles. Example layouts of ASL with boxes are shown in Figure 60.

Figure 61: Bike Boxes for Cyclists



Source: (Municipal Chamber of Lisbon, 2018, p. 117)

Source: (MAUT, 2019, p. 49)

Source: (Transport for London, 2016a, Ch5, p.44)

Source: (FGSV, 2010, p. 45)

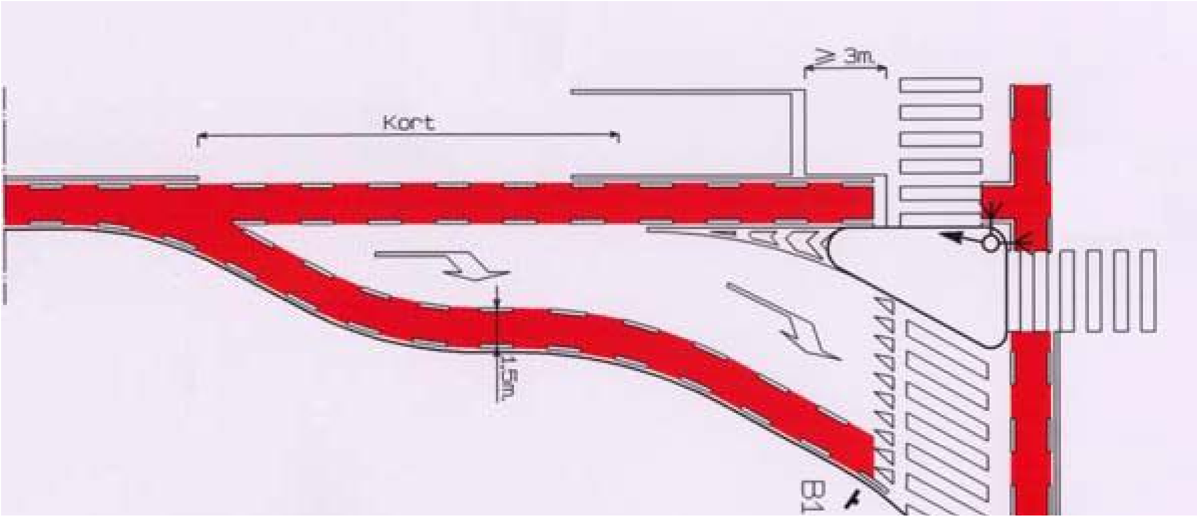
Advantage in time is given by signalised early cycle releases (analogous to Leading Pedestrian Interval, Chapter 4.7.2). This signalisation can only be applied when cyclist signalisation is separated from general traffic. At on-carriageway routings this measure might come with or without an ASL. When cyclists routing is off-carriageway, early releases are of higher importance for clarifying right of way.

The amount of time given to cyclists depends on the dimensions of the junction and signal operation. Transport for London (2016a, Ch5:32) recommends a minimum of 3 seconds in advance and a maximum of 5 seconds in usual conditions. According to FGSV (2015a, p. 28), cyclists have to be released in enough time in advance to make sure they reach the conflict point 1 or 2 seconds before any turning vehicles do. It is also possible to give combined advantage in time and space, e.g., with cycle gates (see Transport for London, 2016a, Ch.5).

Right-turning general traffic lanes should be avoided with on-carriageway cycle facilities due to safety issues. With this, the conflict point between motorised vehicles and cyclists is shifted ahead of the junction when vehicles have to cross the cycle facility. Where right-turning general traffic lanes are unavoidable, low speed of general traffic needs to be ensured through the use of an undynamic design (small radii). Cycle lanes should not be deviated and need to be marked prominently in advance of the conflict point.

Copyright © 2019 by MORE

Figure 62: Guidance of Cyclists at Right-Turning General Traffic Lanes



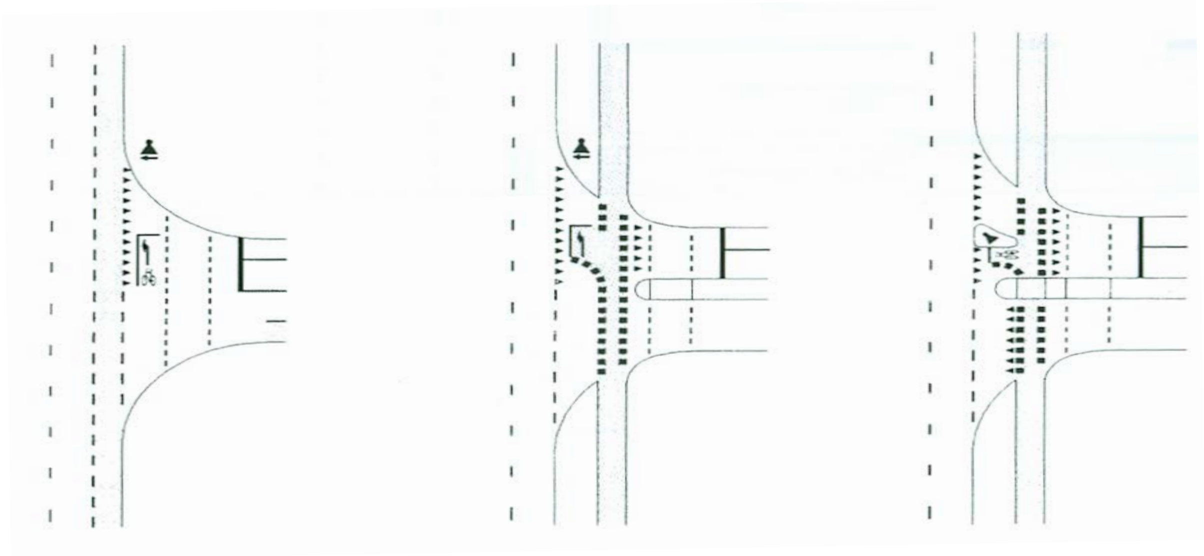
Source: (Department of Mobility and Public Works Flanders, 2017)

Left-turning cyclists have conflict points with vehicles within their same approach as well as with opposing traffic. Cyclists might turn directly or in two stages. Direct guidance of left-turning cyclists is not recommended if cyclists do not approach the junction on on-carriageway facilities, if cyclists have to cross more than one lane to reach the left-turn lane, and if the 85th percentile speed of motorised traffic is max. 50 km/h (FGSV, 2010).

Junctions on MORE corridors will, in most cases, have at minimum two general traffic lanes with high volumes of motorised traffic and high speeds which makes a two-stage left turn the preferable solution. This approach splits the left turn into two straight movements while cyclists first cross one arm of the junction then queue at the end of the cycle crossing to continue the journey with a green light in their direction. Two-step left turns are possible informally without specific infrastructure in some countries (depending on the legal framework). In the face of expected or existing high cycling volumes on the corridor, it would be useful to offer formal two-step left turns. Those require marked waiting areas (usually between the pedestrian crossing and cycle facility/carriageway) and cycle signals to give a green light to cyclists. As in every consideration, the waiting area needs to be dimensioned in a manner that accommodates all waiting cyclists to fit within one phase.

Copyright © 2019 by MORE

Figure 63: Formal Two-Stage Left-Turn Layouts



Source: (CROW, 2016)

Where conflicts cannot be banned sufficiently, selected turns of motorised traffic might be banned. This method has a wider impact on the network level and might transfer conflict points to other locations.

4.7.4 Public Transport Issues

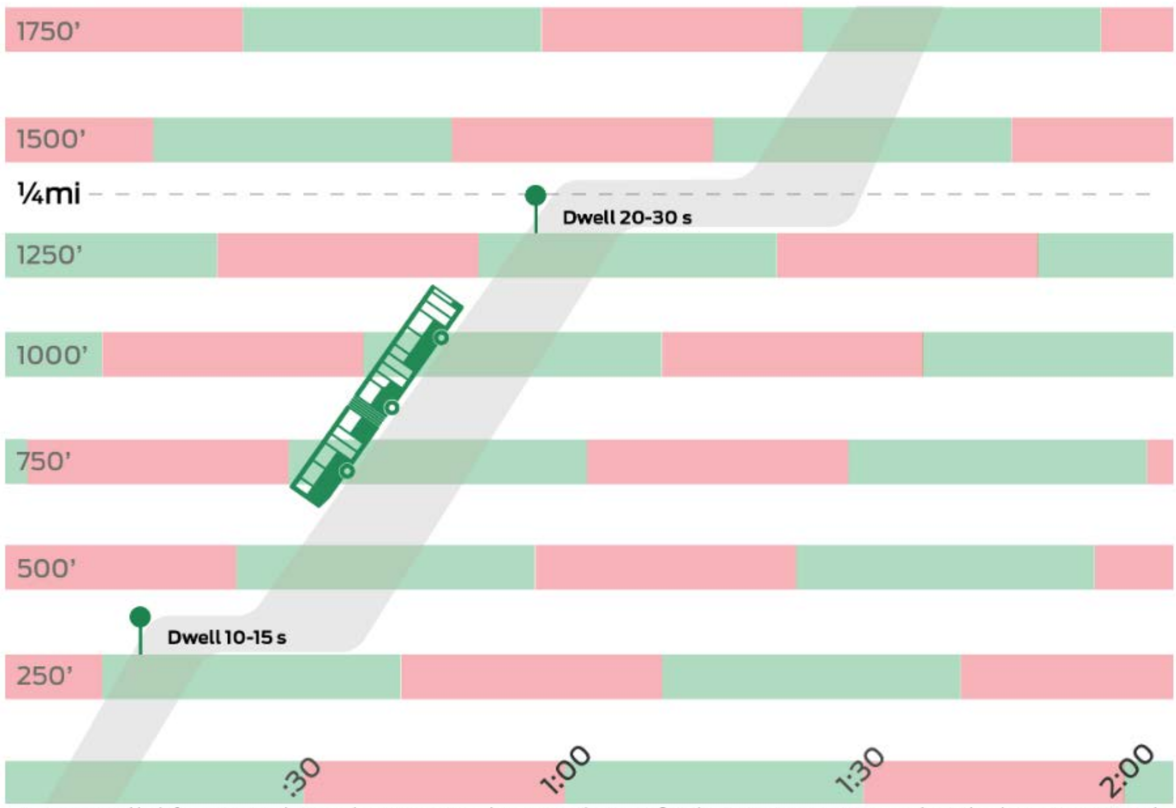
Junctions can perform different functions for public transport. They do on the one hand offer space for public transport stops and on the other hand give the opportunity to prioritise public transport in signal programmes.

Public transport stops are (in many situations) preferably located near junctions so that they are situated at more than one pedestrian route or near well-frequented destinations. Locating public transport stops at junctions ensures the findability of stops and availability of safe pedestrian crossings. Public transport stops can be located in the approach or behind the junction depending on the signal operation. The location of the stop depends on various criteria, such as the transport stop type, distance to the next stop, and frequent interchange relations. Application of all bus stop types is possible at junctions. In many cases, it is beneficial to install partial public transport lanes in order to support prioritisation of public transport.

Prioritisation of public transport is grouped into ‘active’ or ‘passive’ priority (Gardner et al., 2009). Passive priority is given by weighting in signal timings (green times) and general optimisation of signals for public transport. One example for passive prioritisation is signal progression which is the implementation of a green wave for public transport (see Figure 64). The speed should be set to realistic travel speeds including deceleration, dwell, and acceleration time. Alternating bus stop locations (before and after the junction) may contribute to this measure. (National Association of City Transportation Officials, 2016)

Copyright © 2019 by MORE

Figure 64: Scheme of Signal Progression



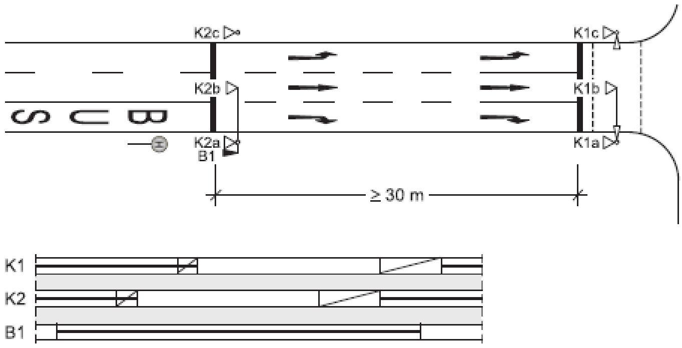
Source: (National Association of City Transportation Officials, 2016)

Active prioritisation affects individual public transport vehicles and hence requires equipment in the infrastructure and on the vehicles to detect arrivals. Priority might be given generally (e.g., to all buses) or conditionally (e.g., to delayed buses or other pre-defined criteria). Priority to all buses can cause excessively long delays for other user groups, especially with high public transport volumes, which can then lead to a large number of traffic signal recalls. A common strategy is to give conditional priority to buses that are behind schedule. This approach provides balanced travel-time savings and passenger waiting-time savings and has a lower impact on general traffic delays. General methods of prioritisation that do not require dedicated infrastructure for public transport are:

- Extending the green signal for buses when arriving at the end of green light
- Giving buses a green light (earlier than in standard signalisation) when arriving at a red light.

Integrated prioritisation combines physical and signal measures which is especially beneficial at junctions with bus stops. One example are bus filters, where the partial public transport lane ends before the junction and goes into the general traffic lane. With this solution, pre-signals for general traffic may hold back traffic while the public transport vehicle enters the empty lane where every turning movement is possible (see Figure 65).

Figure 65: Bus Advance Area Using Pre-Signals and Bus Filter



Source: (Gardner et al., 2009)

Source: (FGSV, 2015a)

5 Accident Reporting and Black-Spot Management

The EU-Directive 2008/96/EC (European Parliament, 2008) has been the core basis for any road infrastructure safety management in the European Union and had a substantial impact in all member states. It is currently in the process of being updated; therefore, this chapter provides information on the original Directive but also the recent amendment.

The Directive mainly regulates road safety impact assessment, road safety audits for infrastructure projects, safety ranking and management of the road network in operation, safety inspections and data management. According to the Directive, every member state in European Union has to:

- Analyse the impact of a new road or a substantial modification to the existing network on the safety performance of the road network
- Check safety independently relating to the design characteristics of a road infrastructure project and covering all stages from planning to early operation
- Identify, analyse and rank sections of the road network which have been in operation for more than three years and upon which a large number of fatal accidents in proportion to the traffic flow have occurred
- Identify, analyse and classify parts of the existing road network according to their potential for safety development and accident cost savings
- Verify the characteristics and defects that require maintenance work for reasons of safety periodically and
- Ensure accident reports for each fatal accident and calculate average social cost of fatal and severe accidents.

The Directive applies to roads that are part of the Trans-European Road Network and is thus only partly relevant for the five MORE corridors. However, many member states also apply the Directive on their national road infrastructure. Each member state was requested to translate the Directive into national law; this has been completed in all the countries of the MORE partner cities. All MORE project city/country partners work with the Directive and have guidelines that focus on road safety. The recent amendments on the Directive (European Parliament, 2019) include the following decisive changes:

- Extension of the scope: The new Directive will not only be applicable to motorways but also to primary roads
- New Guidance for the design of “forgiving roadsides” and “self-explaining and self-enforcing roads”: Such guidance will be provided for the initial audit of the design phase e.g. for quality requirements regarding vulnerable road users. Buczynski (2019) marks out that quality requirements for vulnerable road users should be provided for all audit phases, not just for the initial audit.
- Training curricula for road safety auditors: This should include aspects related to vulnerable road users and the infrastructure for such users.

- Safety classification: Member states shall report the safety classification of the entire network assessed and if applicable a list of provisions of national updated guidelines, including in particular the improvements in terms of technological progress and of protection of vulnerable road users.

As all MORE cities are obliged to apply the Directive and have adopted documents on safety management, their methodologies on accident reporting, black spot management and measures for mitigating black spots are highlighted in this report.

Accidents are recorded systematically in all MORE cities. In Budapest, Constanta, Lisbon, (London) and Malmö, the police is recording the accident data, including the location. The location of accidents is usually recorded via geo-codes and sometimes with additional descriptions of the place, but some cities report inexactness in geo-code locations. This inexactness either leads to additional work in verifying locations or causes problems in identifying black spots. Accidents do not necessarily need to be reported to the Police in London if involved parties exchange data, even with involvement of injury. Most countries focus on accidents with personal injuries in their data collection. In some countries accident data is recorded additionally by other institutions e.g. transport operators (Budapest) or hospitals (Malmö).

Accident data for single accidents is not made public in Budapest, Constanta, London and Malmö, but in Lisbon (http://geodados.cm-lisboa.pt/). In Budapest, London and Malmö, street planners have access to accident data. Accident data is used in decision making and planning. Black spot management helps identifying and prioritising accident-stressed junctions and street sections in each city. The thresholds for black spots are defined based on national standards. Most countries use the number and severity of accidents as criteria (Constanta, Lisbon, London, Malmö). Budapest identifies black spots by types of collision. Time periods for black spot analysis range from one to five years in the MORE countries. There is a high dynamic a black-spot methodology, e.g. the national Hungarian and the Romanian Guidelines are currently under revision.

For reports, accidents are classified in different types (e.g. single vehicle accidents, rear-end accidents, etc.). This distinction is set by national standards. Some cities implemented standard measures to reduce specific types of accidents. The Romanian “General Masterplan for Transport” recommends e.g. the implementation of left-turn-lanes at junctions with a high rate of side accidents, and video surveillance in locations with a high rate of accidents caused by speeding. In London, conflicts between turning vehicles and crossing pedestrians are mitigated by segregating traffic through lane separators or traffic signals. “Manual do Planeamento de Acessibilidade e Transportes” has some standardised measures for Lisbon. Malmö is currently working on a new strategic document.

Most accidents in Constanta and Lisbon occur between pedestrians and vehicles, e.g. by disregarding right of way or illegal crossing or in general at pedestrian crossings.

In general, accidents and conflicts are strongly connected to infrastructure and for that reason need to be analysed periodically to mitigate systematic conflicts with appropriate measures.

6 Summary and Outlook

This deliverable provides a comprehensive compilation of planning principles for urban street design, based on an extensive review of relevant material and various inputs from MORE partners. The deliverable shows similarities and differences between the different cities and countries. Guidance for link functions of streets and particularly for motorised vehicles are more consistent and clearer than guidance for the active modes walking and cycling. Guidance on cycling provision is characterised by particular dynamics; new cycling guidelines have been discussed or approved in all MORE cities/countries in the time period of preparing this deliverable. This shows the high priority that the promotion of cycling has in all the researched cities and countries. Pedestrians are positioned high in the hierarchy of street users but have the lowest levels of detail and consistency in the researched guidance material. Particularly for place functions, little information was found.

This deliverable contributes to the development of tools for urban street design in WP4 and also to the city case studies in WP5. It is intended to support the MORE partners and further the engagement of stakeholders in urban street design. It should enable the mutual understanding and exchange of practices and experiences for improving approaches for urban street design in each individual context and study area. The task of (re-)designing urban streets is highly context dependent: there will never be a clear ‘one-design-fits-all solution’ - individual optimisation and balancing of user requirements needs to be done anew for each individual design task.

The summaries in Chapters 4.2.5, 4.3.4 and 4.4.5 clearly show preferred solutions to satisfy each user group’s needs and to provide the best conditions for the various link and place functions of urban streets. The task of comparing necessary space for optimally providing for each user group with the available space, and to find design solutions also for cases when space is not sufficient for optimally providing for all user groups, is left with local experts and planners. This deliverable aims to provide inspiration and ideas about how this could be done and to show how others have worked in similar contexts—thus contributing to the development of ever-improving solutions. Clear priorities in strategic documents such as SUMPs are helpful for the discussions with stakeholders and for finding solutions that are optimal given the limited space and the local preferences.

Copyright © 2019 by MORE

References

Abbate, A., 2005. Broward County County-wide Community Design Guidebook. Broward County Board of County Commissioners, Fort Lauderdale, Florida (English).

Abu Dhabi Urban Planning Council, 2009. Abu Dhabi Urban Street Design Manual. Abu Dhabi Urban Planning Council. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwjrvKr5247iAhXSJFAKHYQoBgMQFjAAegQIARAC&url=https%3A%2F%2Fnelsonnygaard.com%2Fwp-content%2Fuploads%2F2014%2F04%2FAbu-Dhabi-StreetDesignManual.pdf&usg=AOvVaw0c-yrEN0_6L-yahNRJwHOQ. Accessed 9 May 2019 (English).

Adelaide City Council, 2012. Smart Move: The City of Adelaide's Transport and Movement Strategy 2012-22, 92 pp. https://www.cityofadelaide.com.au/assets/Policies-Papers/docs/STRATEGY-smart-move-2012-22.pdf. Accessed 2 May 2019 (English).

American Association of State Highway and Transportation Officials, 1990. A Policy on Geometric Design of Highways and Streets. American Association of State Highway and Transportation Officials, Washington, D.C.

American Association of State Highway and Transportation Officials, 2001. A Policy on Geometric Design of Highways and Streets, 4th ed. American Association of State Highway and Transportation Officials, Washington D.C., 942 pp. (English).

American Association of State Highway and Transportation Officials, 2004. Guide for the planning, design, and operation of pedestrian facilities, Washington, D.C. (English).

American Association of State Highway and Transportation Officials, 2011. A Policy on Geometric Design of Highways and Streets, 6th ed., Washington, D.C. (English).

American Association of State Highway and Transportation Officials, 2017. Guide for development of bicycle facilities, 4th ed., Washington, D.C. (English).

American Association of State Highway and Transportation Officials, 2018. A policy on geometric design of highways and streets, 7th ed., Washington, D.C., 1 volume (various (English).

American Association of State Highway Officials, 1964. A Guide for Functional Highway Classification. National Association of Counties, Washington D.C., 22 pp. (English).

Asher, L., Aresu, M., Falaschetti, E., Mindell, J., 2012. Most older pedestrians are unable to cross the road in time: a cross-sectional study. Age and ageing 41 (5), 690–694 (English). 10.1093/ageing/afs076.

Auckland Transport, 2018. Roads and Streets Framework. Auckland Transport, 136 pp. https://at.govt.nz/media/1976084/roads-and-streets-framework-webcompressed.pdf. Accessed 2 May 2019 (English).

Copyright © 2019 by MORE

Austrian Ministry for Transport, Innovation and Technology, 2015. Masterplan Walking: Strategy for Supporting Walking in Austria. https://www.bmvit.gv.at/service/publikationen/verkehr/fuss_radverkehr/downloads/masterplangehen.pdf. Accessed 30 April 2019.

Banister, D., 2005. Unsustainable Transport: City Transport in the New Century. Taylor & Francis, London, 292 pp. (English).

Banister, D., 2011. Cities, mobility and climate change. Journal of Transport Geography 19 (6), 1538–1546.

Bartholomew, H., 1922. The Principles of City Planning. American City (26(5)), 457–461.

Ben-Joseph, E., 1995. Changing the Residential Street Scene: Adapting the shared street (Woonerf) Concept to the Suburban Environment. Journal of the American Planning Association 61 (4), 504–515 (English).

Berrigan, D., Pickle, L.W., Dill, J., 2010. Associations between street connectivity and active transportation. International Journal of Health Geographics (9) (English).

Bochner, B., Dock, F.C., 2005. Street Systems and Classifications to Support Smart Growth. 2nd Urban Street Symposium: Uptown, Downtown, or Small Town., 2005, Anaheim, California , United States (English).

Bouton, E.H., 1916. Local and Minor Streets. In: Nolen, J. (Ed.) City Planning. A Series of Papers Presenting the Essential Elements of a City Plan. D. Appleton and Company, New York, London, pp. 88–102English.

Buczynski, A., 2019. Key changes in the directive on road infrastructure safety management. ECF, 5 pp. https://ecf.com/sites/ecf.com/files/key_changes_in_the_rism_directive_20190520.pdf. Accessed 30 July 2019 (English).

Budapest Municipality, forthcoming. Budapest Mobility Plan 2030. http://budapest.hu/sites/english/Lapok/2017/budapest-urban-development-plans.aspx (English).

Budapest Municipality, 2013. Budapest 2030 - Long-Term Urban Development Concept. http://budapest.hu/sites/english/Lapok/2017/budapest-urban-development-plans.aspx (English).

Budapest Municipality, 2017. Smart Budapest – The smart city vision of Budapest. http://budapest.hu/Documents/V%C3%A1ros%C3%A9p%C3%ADt%C3%A9si%20F%C5%91oszt%C3%A1ly/Smart_Budapest_summary_ENG.pdf (English).

Budapesti Közlekesi Részvénytársaság, 2007. Tramway construction and maintenance technical specifications (Hungarian).

Copyright © 2019 by MORE

Budhiraja, H., Croucher, M., Jones, P., 2014. Birmingham Mobility Action Plan. Technical Study Group Report: Birmingham Connected Package One - Road Space Allocation. Birmingham City Council, 82 pp. (English).

Butcher, L., 2015. Strategic Road Network (SRN), 35 pp. https://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN01448#fullreport. Accessed 2 May 2019 (English).

California Department of Transportation, 2005. Pedestrian and Bicycle Facilities in California: A Technical Reference and Technology Transfer Synthesis for Caltrans Planners and Engineers. http://www.dot.ca.gov/trafficops/ped/docs/technical-reference.pdf. Accessed 30 March 2019 (English).

California Department of Transportation, 2010. Complete Intersections: A Guide for Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians. http://www.dot.ca.gov/trafficops/ped/docs/intersection-guide-bicycles-pedestrians.pdf. Accessed 30 March 2019 (English).

California Department of Transportation, 2014. California Manual on Uniform Traffic Control Devices: FHWA's MUTCD 2009 Edition, including Revisions 1&2 as amended for use in California. http://www.dot.ca.gov/trafficops/camutcd/docs/2014r4/CAMUTCD2014_rev4_hires.pdf. Accessed 30.3.3019 (English).

Cervero, R., Duncan, M., 2003. Walking, Bicycling, and Urban Landscapes: Evidence From the San Francisco Bay Area. American Journal of Public Health 93 (9), 1478–1483 (English).

Cervero, R., Kockelman, K., 1997. Travel Demand and the 3 Ds: Density, Diversity, and Design. Transportation Research Part D: Transport and Environment (3), 199–219 (English).

Chartered Institution of Highways and Transportation, 2010. Manual for Streets 2: Wider Application of the Principles. Chartered Institution of Highways and Transportation (English).

City of Constanta: Lupascu, George, Dumitrescu, D., 2019. Transport Infrastructure in Constanta, Telco, Paris (English).

City of Malmö, 2005a. Norm drawings. Accessibility for persons with impaired mobility. A3-TYP 001. http://www.projektering.nu/typritningar.html. Accessed 26 April 2019, 1 p. (Swedish).

City of Malmö, 2005b. Norm drawings. Accessibility for persons with impaired mobility. A3-TYP 002. http://www.projektering.nu/typritningar.html. Accessed 26 April 2019 (Swedish).

City of Malmö, 2005c. Norm drawings. Accessibility for persons with impaired mobility. A3-TYP 003. http://www.projektering.nu/typritningar.html. Accessed 26 April 2019 (Swedish).

Copyright © 2019 by MORE

City of Malmö, 2005d. Norm drawings. Accessibility for persons with impaired mobility. A3-TYP 004. http://www.projektering.nu/typritningar.html. Accessed 26 April 2019 (Swedish).

City of Malmö, 2005e. Norm drawings. Accessibility for persons with impaired mobility. A3-TYP 005. http://www.projektering.nu/typritningar.html. Accessed 26 April 2019 (Swedish).

City of Malmö, 2005f. Norm drawings. Accessibility for persons with impaired mobility. A3-TYP 006. http://www.projektering.nu/typritningar.html. Accessed 26 April 2019 (Swedish).

City of Malmö, 2016. Sustainable Urban Mobility Plan: Creating a more accessible Malmö. City of Malmö, Malmö, 68 pp. https://malmo.se/download/18.16ac037b154961d0287b3d9/1491303430464/MALM_TROMP_210x297mm_ENG.pdf. Accessed 6 March 2019 (English).

City of Malmö, 2018. Comprehensive Plan for Malmö. City of Malmö, Malmö. https://malmo.se/Service/Var-stad-och-var-omgivning/Stadsplanering--strategier/Oversiktsplan-for-Malmo.html. Accessed 30 April 2019 (Swedish).

City of Malmö - Streets and Parks Department, 2006. Street Sections: Recommendations and examples for street environment design. City of Malmö - Streets and Parks Department, Malmö, 104 pp. http://www.projektering.nu/files/Gatusektioner.pdf. Accessed 6 March 2019 (Swedish).

City of Malmö - Streets and Parks Department, 2008. Accessibility programme for Malmö: Requirements and recommendations for good accessibility for people with reduced mobility in terms of construction and conversion on public space. City of Malmö - Streets and Parks Department, Malmö, 60 pp. http://www.projektering.nu/files/Tillganglighetsprogr.pdf. Accessed 8 March 2019 (Swedish).

City of Malmö - Streets and Parks Department, 2010a. Bicycle Programme for the city of Malmö 2012-2019. City of Malmö - Streets and Parks Department. https://malmo.se/download/18.4cc94c3815be8cd0d0b1bd32/1497268366591/Cykelprogram%2Bf%C3%B6r%2BMalm%C3%B6%2Bstad%2B2012-2019%2B2012-10-30.pdf. Accessed 30 April 2019 (Swedish).

City of Malmö - Streets and Parks Department, 2010b. Security programme. City of Malmö - Streets and Parks Department, Malmö, 44 pp. http://www.projektering.nu/files/Trygghetsprogram.pdf. Accessed 8 March 2019 (Swedish).

City of Malmö - Streets and Parks Department, 2015. Traffic Safety Strategy: Malmö 2015-2020. City of Malmö - Streets and Parks Department, Malmö, 88 pp. https://malmo.se/download/18.41768749161d675215aae90/1520352069340/tss_korrad+20160929_utanskartillwebb.pdf. Accessed 8 March 2019 (Swedish).

City of Malmö - Streets and Parks Department, 2019. Technical Design Manual. City of Malmö - Streets and Parks Department, Malmö. Accessed 16 July 2019 (Swedish).

City of Malmö: Brodde Makri, Maria, Nordlund, J., 2019. Transport Infrastructure in Malmö, Telco, Malmö (English).

City of Saskatoon, 2017. Complete Streets Design & Policy Guide. https://www.saskatoon.ca/sites/default/files/documents/complete_streets_design_and_policy_guide_.pdf. Accessed 30 March 2019 (English).

City of Zurich, 2004. New quality of life at Limmatquai. https://www.stadt-zuerich.ch/pd/de/index/dav/medien/archiv/medienmitteilungen2004/neue_lebensqualitaetamlimmatquai.html. Accessed 20 May 2019 (German).

City of Zurich, 2013. The riviera of the Zurich Old Town. https://www.stadt-zuerich.ch/ted/de/index/departement/medien/medienmitteilungen/2013/juni/130613a.html. Accessed 20 May 2019 (German).

Committee of Transport Officials, 2012. South African Road Classification and Access Management Manual: Technical Recommendations for Highways. Committee of Transport Officials, 89 pp. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwjRt9rD_PzhAhVNMewKHbCFAz4QFjAAegQIABAC&url=https%3A%2F%2Fwayleave.tshwane.gov.za%2Fdocument%2Fdownload%2F335975%2F&usg=AOvVaw1O09w6KShDdQqUwYokMeuP. Accessed 2 May 2019 (English).

Constanta Municipality, 2015. Sustainable Urban Mobility Plan Constanta Growth Pole.

Crabtree, M., Lodge, C., Emmerson, P., 2014. A review of pedestrian walking speeds and time needed to cross the road, 1st ed. Transport Research Laboratory, Wokingham, 16 pp. (English).

CROW, 2012. Guidelines for urban roads and streets (ASVV), 6th ed.

CROW, 2016. Design manual for bicycle traffic, 300 pp.

Curtis, C., and Low, N., 2012. Institutional Barriers for Sustainable Transport, Farnham (English).

Department for Transport, 2005. Inclusive mobility, London, 79 pp. https://www.gov.uk/government/publications/inclusive-mobility. Accessed 8 April 2019 (English).

Department for Transport, 2007. Manual for streets, London, 144 pp. Accessed 26 April 2019 (English).

Department for Transport, 2012. Guidance on Road Classification and the Primary Route Network. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/315783/road-classification-guidance.pdf (English).

Department of the Environment, Transport and the Regions, 1998. Guidance on Guidance on the use of Tactile Paving Surfaces, 108 pp.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/289245/tactile-paving-surfaces.pdf. Accessed 26 April 2019 (English).

Department of Transport, Tourism and Sport, Department of Environment, Community and Local Government, 2013. Design manual for Urban Roads and Streets. http://www.dttas.ie/sites/default/files/publications/corporate/english/design-manual-urban-roads-and-streets/design-manual-urban-roads-and-streets-ultra-low-resolution.pdf (English).

Duany, A., Sorlien, S., Wright, W., 2012. SmartCode: v 9.2. https://www.dpz.com/uploads/Books/SmartCode-v9.2.pdf (English).

Emmerson, A., Bancroft, P., 2007. A, B, C and M: Road Numbering Revealed, Harrow (English).

Eppell, V.A., Bunker, J.M., McClurg, B.A., 2001. A Four Level Road Hierarchy for Network Planning and Management, Melbourne. https://eprints.qut.edu.au/2349/1/2349.pdf (English).

European Commission. Constanta | CIVITAS. https://civitas.eu/portis/constanta. Accessed 11 April 2019 (English).

European Commission, 2002. Environmental Noise Directive (Directive 2002/49/EC). http://data.europa.eu/eli/dir/2002/49/oj. Accessed 29 April 2019.

European Commission, 2010. European Disability Strategy 2010-2020: A Renewed Commitment to a Barrier-Free Europe: SEC(2010) 1324 final (English).

European Parliament, 2008. Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on road infrastructure safety management, 9 pp. (English).

European Parliament, 2019. European Parliament legislative resolution of 4 April 2019 on the proposal for a directive of the European Parliament and of the Council amending Directive 2008/96/EC on road infrastructure safety management: P8_TA-PROV(2019)0346, 61 pp. (English).

Ewing, R., Cervero, R., 2010. Travel and the Built Environment. Journal of the American Planning Association 76 (3), 265–294 (English). 10.1080/01944361003766766.

Ewing, R., Handy, S., 2009. Measuring the Unmeasurable: Urban Design Qualities Related to Walkability. Journal of Urban Design 14 (1), 65–84. 10.1080/13574800802451155.

Federal Highway Administration, 1982. Highway Functional Classification: A Management Tool, Washington, D.C. (English).

Federal Highway Administration, 1989. FHWA Functional Classification: Concepts, Criteria and Procedure, Washington, D.C. (English).

Federal Highway Administration, 2010. Guidance for the Functional Classification of Highways (Updated), Washington, D.C. (English).

Federal Highway Administration, 2013. Highway Functional Classification: Concepts, Criteria and Procedures, Washington, D.C. https://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/fcauab.pdf (English).

FGSV, 2002. Recommendations for Pedestrian Traffic Facilities, Cologne, 38 pp. Accessed 26 April 2019 (German).

FGSV, 2006. Directives for the Design of Urban Roads: Translation 2012. German Road and Transport Research Association, Cologne. http://www.fgsv-verlag.de/catalog/index.php?cPath=21_107. Accessed 4 April 2019 (English).

FGSV, 2010. Recommendations for Cycle Facility Design. FGSV R2 - Regelwerke FGSV-284. FGSV, Cologne, 95 pp. (German).

FGSV, 2011. Recommendations for the Design of Accessible Traffic Facilities. FGSV W1 - Wissensdokumente FGSV 212, Cologne, 90 pp. (German).

FGSV, 2013. Recommendations for Public Transport Traffic Facilities: EAÖ, 2013rd ed. FGSV-Verl., Köln, 100 pp. (German).

FGSV, 2015a. Directives for traffic signals: RiLSA : Traffic lights. FGSV R1 - Regelwerke FGSV-321. FGSV, Cologne, 90 pp. (German).

FGSV, 2015b. Guidelines for Dimensioning Road Traffic Facilities: HBS, 2015th ed. FGSV-Verl., Cologne, 31 pp. (German).

Forbes, G., 1999. Urban Roadway Classification: Before the Design Begins, Dallas, Texas.

Gardner, K., D'Souza, C., Hounsell, N., Shrestha, B., 2009. Review of Bus Priority at Traffic Signals around the World, Burssles, 68 pp. http://content.tfl.gov.uk/interaction-of-buses-and-signals-at-road-crossings.pdf. Accessed 25 June 2019.

Gehl, J., 2010. Cities for people. Island Press, Washington, Covelo, London, 269 pp. (English).

Gehl, J., Gemzoe, L., Kirknaes, S., Sternhagen, B., 2006. New city life, 1st ed. Danish Architectural Press, Copenhagen, 180 pp. (English).

Gehl, J., Svarre, B., 2013. How to study public life. Island Press, Washington, DC, 193 pp. (English).

Gerike, R., Nazelle, A. de, Wittwer, R., Parkin, J., 2019. Special Issue "Walking and Cycling for better Transport, Health and the Environment". Transportation Research Part A: Policy and Practice 123, 1–6. 10.1016/j.tra.2019.02.010.

Gerike, R., Parkin, J., 2016. Cycling futures: From research into practice. Routledge, London, New York, 1 online resource (xxxiii, 287).

Copyright © 2019 by MORE

Goodwin, P., 1995. End of Hierarchy: New Perspective on Managing the Road Network, University of Oxford (English).

Goodwin, P., 2007. The Rise and Fall of a Roads Hierarchy. Local Transport Today (English).

Götschi, T., Nazelle, A. de, Brand, C., Gerike, R., 2017. Towards a Comprehensive Conceptual Framework of Active Travel Behavior: a Review and Synthesis of Published Frameworks. Current environmental health reports 4 (3), 286–295 (English). 10.1007/s40572-017-0149-9.

Greenberg, E., Dock, F., 2003. Design Guidance for Great Streets: Adressing Context Sensitivity for Major Urban Road Streets, San Francisco (English).

2017. Handbook of cycle provisions, 229 pp. https://www.mobielvlaanderen.be/pdf/vademecum/2017-vf-integraal.pdf. Accessed 24 June 2019.

Harder, H., 2003. A "Network" and a "Dictum": Shaping the Urban Landscape, Leuven, Belgium. https://vbn.aau.dk/en/publications/a-network-and-a-dictum-shaping-the-urban-landscape.

Hass-Klau, C., 1990. The pedestrian and city traffic. Belhaven Pr, London, 277 pp. (English).

Hebbert, M., 2005. Engineering, Urbanism and the Struggle for Street Design. Journal of Urban Design. https://www.tandfonline.com/doi/abs/10.1080/13574800500062361?needAccess=true#aHR0cHM6Ly93d3cudGFuZGZvbmxpbmUuY29tL2RvaS9wZGYvMTAuMTA4MC8xMzU3NDgwMDUwMDA2MjM2MT9uZWVkQWNjZXNzPXRydWVAQEAw (English).

Henning Jones, I., 2014. Road Space Allocation: The Intersection of Transport Planning, Governance and Infrastructure. School of Global, Urban and Social Studies, College of Design and Social Contest, RMIT University, Melbourne. https://researchbank.rmit.edu.au/eserv/rmit:160985/Jones.pdf (English).

Highways Agency, 2002. Design Manual for Roads and Bridges - Volume 6: Road Geometry.

Institute of Transportation Engineers, 2006. Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities: An ITE Proposed Recommended Practice, Washington, D.C. https://www.epa.gov/sites/production/files/2015-11/documents/rp036.pdf (English).

Institutul Roman de Standardizare, 2010. Streets: sidewalks, footways and bicycle tracks, Design specifications: STAS 10144/2-91 (Romanian).

Intergovernmental Committee on Surveying and Mapping, 2006. Assessing the Feasibility of a National Road Classification: Report to ICSM on National Road Classification Developments, Australia, 47 pp.

http://www.icsm.gov.au/sites/default/files/Assessing_Feasibility_National_Road_Classification.pdf. Accessed 3 May 2019 (English).

International Federation of Pedestrians, 2012. Primer to promote walking: Policy Paper. https://docs.google.com/document/d/1ykhoPQkzYztqLN-tSp6m3YtZJHcru8XFKoWhXABkuY4/edit. Accessed 1 June 2019.

Intraplan Consult GmbH, 2017. Standardised assessment of investments in infrastructures for public transport, Munich. https://www.worldcat.org/title/standardisierte-bewertung-von-verkehrswegeinvestitionen-des-ffentlichen-personennahverkehrs-und-folgekostenrechnung-verfahrensanleitung/oclc/1075116271?referer=di&ht=edition (German).

Jing-Xin Dong, Tao Cheng, Jingjing Xu, Jianping Wu, 2013. Quantitative assessment of urban road network hierarchy planning. https://online.liverpooluniversitypress.co.uk/doi/pdf/10.3828/tpr.2013.24 (English).

Jones, P. (Ed.), 2009. Changing Perspectives: Challenges for Research and Practice, 14 pp.

Jones, P., 2016. Understanding Steets for Life: Leading through street re-classification. Presentation to UDL meeting, 24 May 2016.

Jones, P., 2017. Road and Street Classification. Lecture for the Course Module in Urban Street Planning and Design, 16 January 2017.

Jones, P., 2019. Urban Street Classification and Implication for Street Space Allocation, 4 February 2019, London.

Jones, P., Boujenko, N., 2009. 'Link' and 'Place': A new approach to street planning and design, 18th ed.

Jones, P., Boujenko, N., Marshall, S., 2007. Link & Place: A Guide to Street Planning and Design // Link & place: A guide to street planning and design. Local Transport Today Ltd, London (English).

Jones, P., Marshall, S., Boujenko, N., 2008. Creating more people-friendly urban streets through 'Link and Place' street planning and design. IATSS Research 32 (1), 14–25. 10.1016/S0386-1112(14)60196-5.

Jones, P., Paulo, A., Buckingham, C., Cavoli, C., Cohen, T., Cristea, L., Gerike, R., Halperm, C., Pickup, L., 2018. Urban Mobility: Preparing for the Future, Learning from the Past: Project Summary and Recommendations for Cities. http://nws.eurocities.eu/MediaShell/media/CREATE-ProjectSummaryReccommendations.pdf (English).

Kolrep-Rometsch, H., Leitner, R., Platho, C., Richter, T., Schreiber, A., Schreiber, M., 2013. Accidents between turning motorised vehicles and cyclists. GDV, Berlin, 148 pp. (German).

Koszowski, C., Gerike, R., Hubrich, S., Götschi, T., Pohle, M., Wittwer, R., 2019. Active Mobility: Bringing Together Transport Planning, Urban Planning, and Public Health. In: Müller, B., Meyer, G. (Eds.) Towards User-Centric Transport in Europe. Challenges, Solutions and Collaborations, vol. 26. Springer International Publishing, Cham, pp. 149–171eng.

LaPlante, J., McCann, B., 2008. Complete Streets: We Can Get There from Here. ITE Journal 78 (5), 14–25.

Lisbon Municipality, 2015. City Governing Program 2017-2021. http://www.cm-lisboa.pt/.

Litman, T.A., 2003. Economic Value of Walkability. Transportation Research Record 1828 (1), 3–11 (English). 10.3141/1828-01.

Living Streets, 2014. Living Streets Research Briefing: Pedestrian crossings – extending the time to cross, 3 pp. https://www.livingstreets.org.uk/media/2158/living-streets-research-briefing-pedestrian-crossings-extending-the-time-to-cross-september-2014.pdf. Accessed 24 July 2019 (English).

Lu, M., Wevers, K., Bakiaris, E. (Eds.), 2006. Traffic safety principles and physical road infrastructure measures (English).

Malenkovska Todorova, M., Donceva, R., Bunevska, J., 2009. Role of Functional Classification of Highways in Road Traffic Safety. Transport Problems (4), 97–104.

Marshall, S., 2004. Building on Buchanan: Evolving Road Hierarchy for Today's Streets-Oriented Design Agenda: Conference Proceedings. European Transport Conference, France.

Marshall, S., 2005. Streets & Patterns. Spon, London, 318 pp. (English).

Marshall, S., Jones, P., Plowright Ian, 2004. A Framework for Classification and Assessment of Arterial Streets. Arterial Streets Towards Sustainability, 101 pp.

Matena, S., Weber, R., Louwerse, R., Drolenga, H., Vaneerdewegh, P., Pokorny, P., Gaitanidou, L., Hollo, P., Moksari, T., Elvik, R., Cardoso, J., 2006. Road Categorisation and the Design of Self-Explaining Roads. European Commission, Directorate-General for Transport and Energy, Brussels.

MAUT, 2005. Geometric Design of Parking Places and Facilities. e-UT 03.02.31, 43 pp. https://ume.kozut.hu/dokumentum/44. Accessed 6 May 2019 (Hungarian).

MAUT, 2008. Road Planning. e-UT 03.01.11, 140 pp. https://ume.kozut.hu/dokumentum/40. Accessed 6 May 2019 (Hungarian).

MAUT, 2009a. Design of Public Road Facilities for Pedestrian Traffic. e-UT 03.07.23, 53 pp. http://ume.kozut.hu/dokumentum/56. Accessed 26 April 2019 (Hungarian).

MAUT, 2009b. Design of Public Transport Facilities. e-UT 03.07.24, 89 pp. http://ume.kozut.hu/dokumentum/57. Accessed 26 April 2019 (Hungarian).

MAUT, 2009c. Traffic Facilities in Roads for Disabled Persons. e-UT 03.05.12, 27 pp. http://ume.kozut.hu/dokumentum/49. Accessed 26 April 2019 (Hungarian).

MAUT, 2019. Design of Bikeable Public Roads. e-UT_03_04_13, 66 pp. https://ume.kozut.hu/dokumentum/479. Accessed 25 June 2019 (Hungarian).

Mayor of London, 2018. Mayor's Transport Strategy. https://tfl.gov.uk/corporate/about-tfl/the-mayors-transport-strategy (English).

McClintock, M., 1925. Street Traffic Control, New York.

Metropolitan Town Planning Commission, 1929. Plan of General Development. Metropolitan Town Planning Commission, Melbourne, Australia.

Ministry of Labour and Social Solidarity, 2006. Decree Law Nr 163/2006, 20 pp. (Portuguese).

Ministry of Regional Development and Public Administration, 2013. Minister’s Order no. 189/2013 for approving the 'Norms regarding the adaptation of civil buildings and urban space to the needs of persons with disabilities, indicative NP 051-2012 – Revisiting NP051/2000'. Official Journal of Romania (121) from 05.03.2013. https://www.mdrap.ro/userfiles/reglementari/Domeniul_XVII/17_23_NP_051_2012.pdf. Accessed 6 August 2019 (Romanian).

Ministry of Transport, 1963. Traffic in towns: A study of the long term problems of traffic in urban areas. Her Majesty's Stationery Office, London, 223 pp.

Ministry of Transport, 1997. Law regarding the road regime: no.43/1997 (Romanian).

Ministry of Transport, 1998. Law for the approval of the Technical standards for urban streets design and construction: no. 49/1998 (Romanian).

Monderman, H., 2005. Shared Space: Room for Everyone: A New Vision for Public Spaces, Leeuwarden, Netherlands.

Mueller, N., Rojas-Rueda, D., Salmon, M., Martinez, D., Ambros, A., Brand, C., Nazelle, A. de, Dons, E., Gaupp-Berghausen, M., Gerike, R., Götschi, T., Iacorossi, F., Int Panis, L., Kahlmeier, S., Raser, E., Nieuwenhuijsen, M., 2018. Health impact assessment of cycling network expansions in European cities. Preventive medicine 109, 62–70 (English). 10.1016/j.ypmed.2017.12.011.

Municipal Chamber of Lisbon, 2018. Lisbon Street Design. Manual of Public Space. http://www.cm-lisboa.pt/viver/urbanismo/espaco-publico. Accessed 3 April 2019 (Portuguese).

National Association of City Transportation Officials, 2013. Urban street design guide. Island Press, Washington, 180 pp. (English).

National Association of City Transportation Officials, 2014. Urban bikeway design guide. National Association of City Transportation Officials, New York, 242 pp. (English).

Copyright © 2019 by MORE

National Association of City Transportation Officials, 2016. Transit street design guide. Island Press, Washington, 223 pp. (English).

National Association of City Transportation Officials, 2019. Don't Give Up at the Intersection: Designing All Ages and Abilities Bicycle Crossings. Island Press, Washington, 40 pp. (English).

New York City, Department of Transportation, 2015. Street Design Manual. https://www1.nyc.gov/html/dot/downloads/pdf/nycdot-streetdesignmanual-interior.pdf. Accessed 30 March 2019 (English).

Office of Rail Regulation, 2006. Guidance on Tramways: Railway Safety Publication 2, 82 pp. https://webarchive.nationalarchives.gov.uk/20130903205236/http://www.rail-reg.gov.uk/upload/pdf/rspg-2g-trmwys.pdf. Accessed 21 May 2019 (English).

Olmsted, L., 1916. Introduction. In: Nolen, J. (Ed.) City Planning: A series of papers presenting the essential elements of a city plan. D. Appleton and Company, New York, London, pp. 1–18.

Paraphantakul, C., 2014. Review of Worldwide Road Classification Systems: Conference Proceedings, National Transportation Conference, Bangkok. National Transportation Conference.

Paraphantakul, C., 2017. Establishing the Importance of Non-National Roads and Its Applications to Road Project Planning.: Supplementary documents for the PhD upgrade report.

Project for Public Spaces. Placemaking: What if we built our cities around places?, 1–24.

PTV AG, 2007. Procedures for the economic evaluation of long-term strategies in municipal transport planning, Karlsruhe (German).

PTV Planung Transport Verkehr AG, PTV Transport Consult GmbH, TCI Röhling –Transport Consulting International, 2016. Masterplan Strategic Transport Networks for Germany 2030: Technical Report, Karlsruhe, Berlin, Waldkirch, Munich. https://www.bmvi.de/SharedDocs/DE/Anlage/VerkehrUndMobilitaet/BVWP/bvwp-2030-methodenhandbuch.pdf?__blob=publicationFile. Accessed 1 March 2019 (German).

Report for Transport for London, 2014. International Cycling Infrastructure Best Practice Study, 108 pp. http://content.tfl.gov.uk/international-cycling-infrastructure-best-practice-study.pdf. Accessed 24 June 2019.

Road Engineering Association of Malaysia, 2002. A Guide on Geometric Design of Roads. Road Engineering Association of Malaysia.

Road Task Force, 2013. The Vision and Direction for London's Streets and Roads. https://tfl.gov.uk/corporate/publications-and-reports/roads-task-force (English).

Roads and Traffic Authority, 2004. New South Wales (NSW) Road Classification Review.: Information Paper & Invitation for Submissions. Roads and Traffic Authority.

Roads Task Force, 2013. The vision and direction for London’s streets and roads. Mayor of London, London, 12 pp. https://tfl.gov.uk/corporate/publications-and-reports/roads-task-force#on-this-page-0. Accessed 13 March 2019 (English).

Robinson, C.M., 1916. City Planning With Special Reference to the Planning of Streets and Lots. American Journal of Sociology 22 (1), 96. 10.1086/212579.

Schäfer, T., Walther, C.(P.), 2008. Cost-Benefit Analysis - Assessment of Cycling-Measures, Denzlingen/Karlsruhe. https://nationaler-radverkehrsplan.de/de/aktuell/nachrichten/veroeffentlichung-der-forschungsergebnisse-des (German).

Schultheiss, W., Sanders, R.L., Toole, J., 2018. A Historical Perspective on the AASHTO Guide for the Developement of Bicycle Facilities and the Impact of the Vehicular Cycling Movement. http://tooledesign.com/wp-content/uploads/2018/10/TRB_Paper18-05962_HistoryofAASHTO_BikeGuide_TRB_rev.pdf. Accessed 1 June 2019.

Skånetrafiken. Classification. http://www.skanetrafiken.varumarkesmanual.se/sv/hallplatser/klassificering. Accessed 18 March 2019 (Swedish).

Skånetrafiken, 2016. Norm drawings transit stops. Accessibility aligned curbside stop. http://www.skanetrafiken.varumarkesmanual.se/userfiles/16458.pdf. Accessed 18 March 2019 (Swedish).

Stamatiadis, N., Kirk, A., Hartman, D., Jasper, J., Wright, S., King, M., Chellman, R., 2017. Developing an Expanded Functional Classification System for More Flexibility in Geometric Design.: NCHRP Research Report, Washington, DC, US.

Stead, D., Marshall, S., 2001. The Relationships between Urban Form and Travel Patterns. An International Review and Evaluation. European Journal of Transport and Infrastructure Research (EJTIR) 1 (2), 113–141.

Svensson, A., Marshall, S., 2007. Arterial Streets: Towards An Integrated Approach. In: Marshall, S., Banister, D. (Eds.) Land use and transport. European research towards integrated policies. Elsevier, Amsterdam, Boston, pp. 276–292English.

Szabo, N., Schäfer, T., 2016. FLOW Impact Assessment Tool – Guideline D2.4: FLOW project (Furthering Less Congestion by Creating Opportunities For More Walking and Cycling). PTV AG. http://h2020-flow.eu/fileadmin/user_upload/FLOW_D2.4_Guidelines_PTV_FINAL_20180309.pdf (English).

Taylor, E.S., 1924. The plan of chicago in 1924 with special reference to traffic problems and how they are being met. The Annals of the American Academy of Political and Social Science 116 (1), 224–231. 10.1177/000271622411600137.

Texas Transportation Institute, 2009. Traffic Signal Operations Handbook. FHWA/TX-09/0-5629-P1, 162 pp.

Copyright © 2019 by MORE

https://nacto.org/docs/usdg/traffic_signal_operations_handbook_bonneson.pdf. Accessed 24 July 2019 (English).

The European Parliament, the Council and the Commission, 2000. Charter of fundamental rights of the European Union: (2000/C 364/01) (English).

The Highways Agency, 2004. Design Manual for Roads and Bridges: VOLUME 6 SECTION 2 PART 3 - TD 50/04: The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts. The Highways Agency. http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol6/section2/td5004.pdf. Accessed 5 May 2019.

Trafikverket, Swedish Association of Local Authorities and Regions, 2012. PT-TRAST.: Manual for an attractive and effective Public Transport, 160 pp. https://webbutik.skl.se/bilder/artiklar/pdf/7164-842-6.pdf. Accessed 24 July 2019 (Swedish).

Trafikverket, Swedish Association of Local Authorities and Regions, 2014. Transport for an attractive city: An introduction to TRAST, 24 pp. https://webbutik.skl.se/bilder/artiklar/pdf/7585-146-4.pdf. Accessed 31 July 2019 (English).

Trafikverket, Swedish Association of Local Authorities and Regions, 2015. Road and Street Design: Terms and basic values. Trafikverket, Borlänge, 82 pp. (Swedish).

Transport for London, 2016a. London Cycling Design Standards. Mayor of London, 22 pp. https://tfl.gov.uk/corporate/publications-and-reports/streets-toolkit#on-this-page-2. Accessed 18 March 2019 (English).

Transport for London, 2016b. Street Types for London. https://tfl.gov.uk/info-for/boroughs/street-types. Accessed 23 May 2019.

Transport for London, 2016c. Streetscape Guidance. Mayor of London, 335 pp. https://tfl.gov.uk/corporate/publications-and-reports/streets-toolkit#on-this-page-2. Accessed 15 April 2019 (English).

Transport for London, 2017a. Accessible bus stop design guidance, 64 pp. https://tfl.gov.uk/corporate/publications-and-reports/streets-toolkit#on-this-page-2. Accessed 30 March 2019 (English).

Transport for London, 2017b. Guide to the Healthy Streets Indicators: Delivering the Healthy Streets Approach. http://content.tfl.gov.uk/guide-to-the-healthy-streets-indicators.pdf. Accessed 17 April 2019 (English).

Transport for London, 2017c. Healthy Streets for London: Prioritising walking, cycling and public transport to create a healthy city. http://content.tfl.gov.uk/healthy-streets-for-london.pdf (English).

Transport for London, 2017d. Kerbside loading guidance, London, 44 pp. https://tfl.gov.uk/corporate/publications-and-reports/streets-toolkit#on-this-page-2. Accessed 21 March 2019 (English).

Transport for London, 2017e. Streetscape guidance. Mayor of London, 336 pp. https://tfl.gov.uk/corporate/publications-and-reports/streets-toolkit#on-this-page-2. Accessed 15 April 2019 (English).

Transport for London, 2018a. Cycling Action Plan. http://content.tfl.gov.uk/cycling-action-plan.pdf (English).

Transport for London, 2018b. Healthy Streets Explained. https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/healthy-streets (English).

Transport for London, 2018c. Travel in London. Report 11. http://content.tfl.gov.uk/travel-in-london-report-11.pdf. Accessed 27 July 2019.

Transport for London, 2018d. Vision Zero Action Plan. http://content.tfl.gov.uk/vision-zero-action-plan.pdf (English).

Transport for London, 2018e. Walking Action Plan. http://content.tfl.gov.uk/mts-walking-action-plan.pdf (English).

Transport for London, 2019a. Freight and Servicing Action Plan. http://content.tfl.gov.uk/freight-servicing-action-plan.pdf (English).

Transport for London, 2019b. Healthy Street Checks for Designers. https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/healthy-streets (English).

Transport for London, 2019c. New cycle route quality criteria: Accompanying technical note to the Quality Criteria spreadsheet tool. http://content.tfl.gov.uk/cycle-route-quality-criteria-technical-note-v1.pdf. Accessed 2 July 2019.

Transport for London, 2019d. New Cycle Route Quality Criteria: Accompanying technical note to the Quality criteria spreadsheet tool v1, London, 19 pp. http://content.tfl.gov.uk/cycle-route-quality-criteria-technical-note-v1.pdf. Accessed 8 July 2019.

Transport for London, 2019e. Pedestrian Comfort Guidance for London. Mayor of London, London, 41 pp. https://tfl.gov.uk/corporate/about-tfl/what-we-do/walking. Accessed 25 April 2019 (English).

Transportation Association of Canada, 1999. Geometric Design Guide for Canadian Roads., Ottawa, Ontario, Canada.

Transportation Research Board, 2016. Highway capacity manual, 6th ed., Washington, D.C., 3 volumes (loose leaf) (English).

Tripp, H.A., 1942. Town planning and road traffic. Arnold, London, 118 pp.

Copyright © 2019 by MORE

Tripp, H.A., 1950. Road traffic and its control, 2nd ed. Arnold, London, 416 pp.

U.S. Department of Transportation, Federal Highway Administration, 2013. Memorandum, Subject: Bicycle and Pedestrian Facility Design Flexibility. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_flexibility.pdf. Accessed 1 June 2019.

United Nations, 2008a. Convention on the Rights of Persons with Disabilities (CRPD). https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html. Accessed 15 May 2019 (English).

United Nations, 2008b. Convention on the Rights of Persons with Disabilities and Optional Protocol, 37 pp. (English).

Urban Mobility Research, City of Zurich, 2009. Limmatquai before and after redesign: Place-using activities, walking and cycling volumes in camparison 2004-2005-2008 (German [Swiss]).

VicRoads, 2016. A Guide to Movement and Place Framework Victoria.

Vienna Municipality, 2015. Urban Mobility Plan Vienna. https://www.wien.gv.at/stadtentwicklung/studien/pdf/b008444.pdf (English).

Vitkienė, J., Puodžiukas, V., Žilionienė, D., 2017. New approach to the Lithuanian road classification based on worldwide experience. In: 10th International Conference on Environmental Engineering, ICEE 2017English.

World Commission on Environment and Development, 1987. Report of the World Commission on Environment and Development: Our Common Future. Transmitted to the General Assembly as an Annex to document A/42/427 - Development and International Cooperation: Environment. United Nations, 247 pp.

Copyright © 2019 by MORE