D5.5 Cross-Site Assessment of Case Study Design Packages

Part 1: Street Performance Assessment Scheme: Concept and Specification

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1 Introduction

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 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.

The MORE project convenes urban street designers from all over Europe and gives the unique opportunity to (1) exchange knowledge on current practices in urban street design and (2) to develop innovative solutions for the five MORE-corridors and particularly for the so-called stress sections within these corridors. The state-of-the-art is described in D1.2 including a review of guidelines and other relevant material for road function classification and urban street design, and additionally a comprehensive compilation of objectives and performance indicators for the design of urban roads and streets. D1.2 is based on a comprehensive desk research combined with intense discussions with all MORE partners.

This document is a pre-publication of deliverable D5.5 *Cross-site assessment of case study design packages*. It is embedded in WP5 and focuses on the corridor case studies in the five MORE-partner cities Budapest, Constanta, Lisbon, London and Malmö. It develops, based on the work done in WP1 to WP3, a concept for evaluating alternative design solutions for urban streets. This concept is called *Street Performance Assessment Scheme* (SPAS); it should be generally valid and applicable to any re-design task, it should allow to compare the performance of a street section (1) with the goals formulated for each specific case study, (2) in situations before and after the implementation of a re-design solution, and (3) between different case studies in cross-site assessments.

In the second part of the MORE-project, the developed *Street Performance Assessment Scheme* will be applied to the five MORE-corridors and particularly to the so-called stress sections defined within each of these corridors. The stress sections were chosen by the local partners; these are street sections within the MORE-corridors that are particularly important, interesting and/or challenging in terms of movement and place functions as defined in D1.2 see Chapter 2). Stress sections have major movement and major place functions, they are located in the inner-cities with limited space availabilities and are thus typical examples for the most challenging design tasks that urban street designers face. The MORE-stress sections are also examples for the most important parts of the street network when aiming at liveable future cities. Cities need to find solutions for these parts of the street network that strengthen the place functions and invite city life while at the same time ensuring smooth traffic and movement for all user groups including motorised public and private vehicles, bicycles and other types of micro-mobility, pedestrians and also delivery, loading and parking activities. The application of SPAS to the five stress sections in the MORE-partner cities and the results of developed design packages for these stress sections will be reported in the final deliverable D5.5 in June 2021.

This deliverable builds on the work done in the first tasks of WP5 (T51.-T5.3), namely:

- The detailed design specification for case study corridors as described in D5.1 and D5.2 for current and future conditions:
    (i) Details of feeder route characteristics (spatial extent, interface with the TEN-T Network, current performance characteristics, land use patterns, etc), plus delineation of wider corridor impact area and selection of 'area under stress' for detailed investigation;

    (ii) Identification of stakeholder groups and the agreed local stakeholder engagement framework, including an exercise to identify current problems to be addressed, and

    (iii) Design briefs for current and future conditions, drawing on (i) and (ii), which set out the objectives and conditions for developing design options, for each feeder route.

- The developed optimal street-space management packages for current and future conditions on each stress section as described in D5.3 and D5.4:
    (i) The collation and collection of data for each corridor, as an input to option generation, modelling and appraisal;

    (ii) The generated sets of design options, for current and future conditions;

    (iii) The Vissim scenarios developed for each stress section;

    (iv) Appraisal of design options for each individual case study.

The tools for generating design options, for stakeholder engagement, for the simulation of road user behaviour and for assessing and prioritising street design options created in WP4 are another important input for developing and assessing the proposed design solutions as described in this deliverable.

The remainder of this pre-deliverable of D5.5 is organised as follows: The conceptual framework for SPAS is developed in Chapter 2 as the basis for all subsequent steps. Chapter 3 gives an overview about relevant literature on street performance assessment in the urban context. Based on the conceptual considerations and the literature review, the *Street Performance Assessment Scheme* (SPAS) is developed in Chapter 4. Chapter 5 summarises the main findings so far and gives an outlook on the planned process of creating and assessing alternative design solutions for the five stress sections in MORE in the months to come.

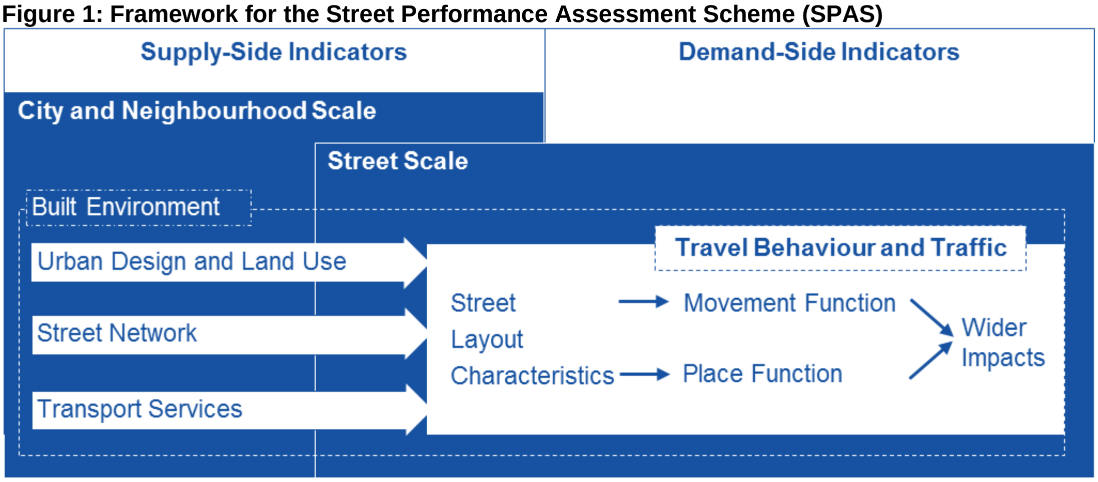
2 Conceptual Framework for Assessing the Design Packages

The *Street Performance Assessment Scheme* (SPAS) to be developed in this deliverable should allow comparing different alternative design solutions for specific street sections and it should also be a suitable basis for before-after comparisons when street design is modified. The three terms objectives, indicators and targets 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 formulated 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 1 shows the conceptual framework that is used as the basis for developing the street performance assessment scheme. 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 1: 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; Garfinkel-Castro et al., 2017). In Figure 1, *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). Also within the street space, public transport stops need to be well accessible e.g. in terms of barrier-free access, suitable crossing facilities and separation from bicycle traffic.

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 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 on these higher level spatial scales.

Demand-side indicators:

Demand-side indicators characterise the usage of the built environment and the transport supply. Indicators for the *movement function* (also called movement function) describe the quality of movements as well as the quality of streets as conduits which allow movements of different user groups in passenger and freight. The overall ambition for the movement function is to achieve safe, fast, reliable and convenient movements (save time). Indicators for the *place function* indicate the quality of place activities and 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. Link and place activities generate various impacts. These are summarised in the category *wider impacts* and include (1) environmental and safety effects of movements that should be minimised, (2) health benefits that result from higher proportions 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 two chapters, tables are provided for demand-side indicators (Chapter 3.1) and supply-side indicators (Chapter 3.2). These tables give an overview of all relevant indicators identified in the process of researching literature and material with relevance for the evaluation in WP5. These tables are the basis for developing the Street Performance Assessment Scheme (SPAS) in Chapter 4. Objectives, targets and indicators are listed in the tables in each one column. 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.

Chapter 3.3 gives an overview about output options provided in Vissim. These are a hard constraint for the evaluation in MORE which will mainly rely on the Vissim simulations of the different developed design solutions. There will hardly be any changes in the physical environment to be assessed. Audits and walkability assessments are a relevant input for evaluating the conditions for pedestrians and place users. These were therefore included in the literature review with the results being presented in Chapter 3.4.

Objectives and 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 indicators are covered in WP2 within the MORE-project.

3 Literature Review: Street Design Objectives, Targets and Indicators

3.1 Demand-Side: Street Users and Usage

3.1.1 Movement Functions

The following Table 1 lists objectives, targets and indicators for the movement function as identified in the research of relevant material. They describe different aspects of the quality of movements for the different user groups of pedestrians, cyclists, innovative micro-vehicles such as electric scooters, busses and trams, cars, vans and medium-sized delivery vehicles, heavy duty vehicles. The objective of maximising the quality of movements is similar for all these 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.

Table 1: List of Objectives, Targets and Indicators for the Movement Functions

Theme	Objectives	Targets	Indicators	Reference
Traffic Quality	Keep traffic flows stable, increase traffic quality, achieve defined Levels of Service (LOS, usually A-F, derived from quantitative indicators) per user group Minimise congestion	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/h] [ped.-trips/h] 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) (Constanta Municipality, 2015; Mayor of London, 2018; Road Task Force, 2013; Transportation Research Board, 2016)
Speed, Delays	Increase speed for specific user groups, time periods, use cases; decrease delays and waiting times at junctions	For movement 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.	[km/h] [minutes delay per km driven] [km] of street sections with certain speed limits Indicator applicable for sequences of street sections and junctions rather than for single elements (section or junction)	(PTV AG, 2007; Szabo and Schäfer, 2016) (International Federation of Pedestrians, 2012; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2019a) (International Federation of Pedestrians, 2012, 2012; Lisbon Municipality, 2015; Mayor of London, 2018; Transport for London, 2017a, 2017c, 2019b)
Travel Time	Direct corellation 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	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; Constanta Municipality, 2015; Road Task Force, 2013)

Theme	Objectives	Targets	Indicators	Reference
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)
Traffic Volumes, 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	Target values for shares of specific modes in modal split Decrease or increase of traffic volumes per user group	[%] (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; Constanta Municipality, 2015; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2018a)

3.1.2 Place Functions

Place functions are more diverse than movement 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 (also called stationary activities) have different degrees of voluntariness as well as different determinants and requirements:

1. Place activities in the street as destination: Gehl (2010) and Gehl and Svarre (2013) distinguish the following types of place:

    - 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 to what is happening, exchange 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, exchange brief remarks about the weather or when the next bus is due, young people hang out and use 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, based on various examples, convincingly 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 depends on invitation; this holds particularly for place activities in the street as destination.

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. Parking and stopping: Vehicles (busses, 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. 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.

Objectives, targets and indicators for the different types of place functions function, as identified in the research of relevant material, are listed in the below Table 2.

Table 2: List of Objectives, Targets and Indicators for the Place Functions

Theme	Objectives	Targets	Indicators	Reference
Traffic Volumes	Lower volumes of motorised traffic to improve safety and comfort for place users, also ease crossing of the street Increase volumes or achieve specific target volumes for waking/ cycling/ PT	Low volumes of (heavy duty) motorised vehicles High volumes walking, cycling, PT	Number of vehicles/ pedestrians per time at specific locations [veh/h] [ped/h] Peak, off-peak	(Transport for London, 2017b)
Speed of Motorised Traffic	Lower speed levels of motorised vehicles, this allows for re-allocating road space, increases safety levels and quality of urban space	Low speed of motorised vehicles	[km/h]	(Transport for London, 2017b)
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)

Theme	Objectives	Targets	Indicators	Reference
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)
Liveliness Index	Increase the number of people staying in the street and the length of their stay	Composite indicator for overall place activities, might be distinguished by person group (e.g. children, elderly)	Number of people times the duration of their stay (15s to <1min, 1min to <5min, 5min to <10min, 10min to < 15min, ≥ 15 min)	(Mehta, 2007; Mehta and Bosson, 2018)
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, 2017e)
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, 2017e)
Satisfaction of Street Users, Perception of Streetscape	Improve satisfaction of street users with the street environment (demand and supply)	Indicator in between demand- and supply-side indicators; street users and respondents might assess all relevant aspects of the street environment	Subjective assessments of street environments from on-site or remote interviews or surveys	(Gehl Institute, 2019; Mehta, 2014a, 2014b; Transport for London, 2017d)

3.1.3 Wider Impacts

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 3 summarises typical indicators as identified in the researched material.

Table 3: List of Objectives, Targets and Indicators for Wider Impacts

Theme	Objectives	Targets	Indicators	Reference
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 (##)	(Lisbon Municipality, 2015; Mayor of London, 2018)
Economic effects				
Cost (Investment, Operation)	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 severerly 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; Constanta Municipality, 2015; Lisbon Municipality, 2015; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2017a, 2017c, 2018d, 2019b)

Theme	Objectives	Targets	Indicators	Reference
Environmental effects and resource consumption				
Energy Consumption	Reduce energy consumption in total or particularly for fossile 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; 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; 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	(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, 2017a, 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

3.2 Supply-Side: Streetscape, Urban Design and Land Use

Supply-side indicators were introduced in Chapter 2 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 4 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 4: List of supply-side objectives, targets and indicators characterising specific street sections

Theme	Objectives	Targets	Indicators	Reference
Street Network				
Space for Movement 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) (Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2017a, 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	(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	
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	(Constanta Municipality, 2015; Mayor of London, 2018; PTV AG, 2007; Transport for London, 2017c, 2019b, 2019d; Vienna Municipality, 2015)

Theme	Objectives	Targets	Indicators	Reference
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 seating facilities per kilometre, distinguished by private/ commercial seating, formal (e.g. benches)/ informal seating (e.g. stairs) Distance between each two seating facilities 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	(Constanta Municipality, 2015; Mayor of London, 2018; PTV AG, 2007; Transport for London, 2017e; 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)
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; Constanta Municipality, 2015; Lisbon Municipality, 2015; Mayor of London, 2018; Transport for London, 2017a, 2017c, 2018e, 2019b)
Overall Quality of Streetscape	Composite indicator for quality of streetscape	Improve overall quality of street space	Sidewalk coverage x pavement quality x street amenity (as total of benches, bike racks, trees)	(Lai and Kontokosta, 2018)

Theme	Objectives	Targets	Indicators	Reference
Urban Design and Land Use				
Human Scale/ Dimension, Enclosure	Buildings and spaces designed to human dimension Degree to which streets and other public spaces are visually defined by buildings, walls, trees and other vertical elements	Choose proportions and size of buildings according to human dimension and distances for social interaction as introduced by Gehl (2010)	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, Permeability	Provide things to see, open/ transparent usages of buildings, appeal to many senses, interesting texture and details, mixed functions, varied façade rhythms, soft edges, allow people to see or perceive human activity beyond the edge of a street	Suitable façade length of 5-6m (15-20 shops per 100m), vertical façade articulation better than long horizontal lines Personalisation of building façade, entrances, shop-windows (how are these embellished with personal touches such as displays, decorations, signs, banners, planters, flowerboxes, and other wares)	Proportion of facades with active frontage/ soft edges/ windows/ active uses Façade length, proportion of street wall Qualitative assessment of façade designs Articulation of facades (nooks, corners, alcoves, small setbacks, steps and ledges)	(Gehl, 2010; Mehta, 2014b)
Mixed Usages of Adjacent Buildings	Support liveable street 24/7	Achieve diversity in type of usages of adjacent buildings Availability of community places (stores that are places to meet neighbours, friends etc.)	Types of usages in adjacent buildings, particularly in ground floor	(Gehl, 2010; Mehta, 2014b)
Imageability	Quality of the street that evokes a strong image in an observer, that makes the place distinct, recognizable and memorable	Achieve high imageability 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:	(Ewing and Handy, 2009; Gehl, 2010)
Complexity	Visual richness of a place, depends on the variety of the physical environment, the numbers and types of buildings, architectural diversity and ornamentation, landscape elements, street furniture, signage and human activity	Provide many interesting things to see, e.g. building details, signs, people, surfaces, changing light patterns and movement, signs of habitation, trees, greenery, street furniture	Number of people in the street/ pieces of public art/ buildings/ accent colours, presence of outdoor dining (yes/no)	(Ewing and Handy, 2009)
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 themselved 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	(Gehl, 2010; Mayor of London, 2018; Road Task Force, 2013; Transport for London, 2017a, 2017a, 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	(Gehl, 2010; Transport for London, 2017c, 2019b)

Theme	Objectives	Targets	Indicators	Reference
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	(Mayor of London, 2018; Transport for London, 2017a, 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)

3.3 Performing Evaluations in Vissim, Overview of Output Options

The Vissim Manual provides a detailed description of possibilities for comparing and evaluating different Vissim scenarios, it can be found at:

- Introduction on performing evaluations: https://cgi.ptvgroup.com/vision-help/VISSIM_11_ENG/Content/11_Auswertungen/Ausw_a_ausfuehren.htm?TocPath=Performing%20evaluations|_____0
- Overview of evaluations: https://cgi.ptvgroup.com/vision-help/VISSIM_11_ENG/Content/11_Auswertungen/Ausw_a_Uebersicht.htm

Various supply-side data is produced during Vissim simulations, e.g. information on vehicles, links, areas, nodes, traffic jams, green time distribution or PT waiting times. This data is a valuable input for the evaluation of the different design-solutions for the MORE corridors. The following output options for the result data of each evaluation exist in Vissim:

- OD pair data: Result attributes can be shown that are created from traffic data between the origin zones and destination zones of dynamic assignment, e.g.:
    - Average travel time = Total of travel times / number of vehicles
    - Average delay time = Total of delay times / number of vehicles
    - Average relative delay = Average delay time / average travel time
    - Number of vehicles
    - Total distance travelled / number of vehicles
    - The indicators can be aggregated by departure time or by arrival time

  OD pair data can be only used for the evaluation if dynamic assignment has been used, this will rather not be the case in MORE. OD pair data can be therefore not be used for evaluating MORE-scenarios but belongs instead to the input data.

- Vehicle record: The vehicle record outputs the attribute values for each vehicle as raw data in one row per time step. The evaluation can be restricted to selected vehicle classes and individual vehicles.
- Vehicle network performance: Specific attributes of the entire network can be compiled in lists, e.g.:
  - Total number of vehicles in the network at the end of the simulation
  - Vehicles arrived
  - Average speed [km/h] or [mph], defined as total distance / total travel time
  - Total number of vehicle stops (excluding scheduled stop times of buses and trains at public transport stops, parking times in parking lots)
  - Average number of stops per vehicle defined as total number of stops / (number of veh in network + number of veh that have arrived)
  - Fuel consumption
  - Latent demand: Number of vehicles from meso origin connector edges, vehicle inputs and parking lots that could not be used, number of vehicles that were not allowed to enter the network from vehicle inputs and parking lots until the end of the simulation.
  - Total travel time: Total travel time of vehicles travelling within the network or that have already left the network.
  - Total delay: Total delay of all vehicles in the network or of those that have already exited it, includes stop times at stop signs, excludes scheduled stop times of buses and trains at public transport stops, passenger service times, parking times in parking lots
  - Latent delay: Total delay of vehicles that cannot be used (immediately)
  - Average delay per vehicle: Total delay / (number of vehicles in the network + number of vehicles that have arrived)
  - Total stopped delay: Total standstill time of all vehicles that are in the network or have already arrived, Standstill time = time in which the vehicle is stationary (speed = 0), excluding scheduled stop times of buses and trains at public transport stops as well as parking times
  - Average stopped delay: Average standstill time per vehicle, Total standstill time / (Number of vehicles in network + number of vehicles that have arrived)
  - Total distance: Total distance of all vehicles in the network or of those that have already exited it
- Vehicle & travel times, vehicle travel times (raw data): A vehicle travel time measurement consists of a From Section and a To Section. The mean travel time from traversing the From Section up to traversing the To Section, including the waiting time and/or holding time, is calculated as well as the distance travelled between the start section and destination section.
- Vehicle input data: Attributes can be assigned to vehicles and pedestrians by defining vehicle types, vehicle data can be reported for all vehicles in the network.
- Areas & ramps: Density and speed of pedestrians can be analysed:
  - Maximum, minimum, average number of pedestrians that were in the area, on ramp or stairs

  - Maximum, minimum, average number of pedestrians waiting for a PT vehicle in the area, on the ramp or stairs
  - Number of pedestrians leaving the construction element or walking on it (excluding pedestrians from pedestrian inputs and pedestrians alighting from PT vehicles)
  - Pedestrian density in area, on ramp or stairs
  - Pedestrian density experienced within the perception radius of a pedestrian: Number of other pedestrians within a radius around the pedestrian.
  - Average pedestrian speed, all pedestrian types, calculated as the harmonic mean
  - Vectorial speed differences of all pedestrians within the personal environment radius of their own speed
  - Length and time information on any queues
- Aggregated analysis and visualisation are possible for pedestrian grid cells (density and speed of pedestrians), entire networks, pre-defined areas
- Pedestrian record (only for Viswalk): This record outputs the attribute values for each pedestrian in one row per time step, the evaluation can be restricted to selected pedestrian classes.
- Pedestrian travel times: With the evaluation of the pedestrian travel time, pedestrians are recorded when they are added in the start areas until they enter the associated destination areas.
- Pedestrian travel times (OD data): From a simulation based on a pedestrian origin-destination matrix, the following aggregated data can be generated:
  - Travel time: Average of all travel times of relevant pedestrians per OD relation.
  - Delay: Average of all total delay values per OD relation. For each pedestrian, the delay in each simulation step results from: $\text{Time step length} - \text{Distance walked during time step}/\text{Desired speed of pedestrian}$, Example: The delay is 25% of the length of the time step for a pedestrian at 75% of his desired speed. These values are added up over the entire measured distance of the pedestrian.
  - Relative delay: Average of all relative delays per OD relation, this value is determined separately for each pedestrian as a percentage of the delay in the travel time.
  - Volume: Number of pedestrians on the basis of which the other result attributes were determined.
- Green time distribution: The absolute frequencies of the occurrence of green durations and red durations for each signal group can be evaluated. The evaluation also includes the calculated averages of both.
- Nodes: Data from nodes of microscopic and mesoscopic simulation in the Vissim network can be evaluated.
- Managed lanes: Attribute values of managed lanes, general purpose lanes and other attribute values of managed lane facilities in the Vissim network can be saved, e.g. toll lanes.
- Public transport waiting times: This record contains the duration of each stop, which is not due to boarding and alighting or due to a stop sign, for each PT vehicle.
- Data and collection measurements: At least one data collection point on a link must be defined in the network. The following result attributes refer to all vehicles in the network that have been recorded during data collection measurement:

  - Acceleration: Average acceleration of the vehicles
  - Distance: Distance covered [m] by the vehicles
  - Length: Average length [m] of the vehicles
  - Vehicles: Total number of vehicles
  - Persons: Total number of occupants of the vehicles
  - Queue delay: Total time in [s] that the vehicles have spent so far stuck in a queue, if the queue conditions are met.
  - Speed: Average speed of the vehicle at the data collection point
  - Speed (arithmetic mean): Arithmetic mean of speed of the vehicles
  - Speed (harmonic mean): Harmonic mean of speed of the vehicles
  - Occupancy rate: Share of time [0% bis 100%] in the last simulation step, during which at least one data collection point of this data collection measurement was busy.
- Signal time table: The current signal states and detector states during a simulation or during interactive tests of signal control logic can be shown in a window. Therein, the green times, yellow times and red times are represented graphically along a horizontal time axis for each selected signal control.
- SSAM: A binary file with trajectories can be saved. Trajectories describe the course of vehicle positions through the network. The file can be uploaded to the Surrogate Safety Assessment Model (SSAM) of the Federal Highway Administration Research and Technology of the U.S. Department of Transportation. SSAM is used to evaluate the road safety of transport routes. [This might be interesting if safety predictions should be done. SSAM can be downloaded and used free of charge. Vissim produces input data for SSAM (vehicle record with specific attributes).]
- Queue counters: Queue characteristics such as queue length and number of queue stops can be analysed.
- Links: Using the Link evaluation, the result attributes of vehicles based on segments or lanes of links and connectors for the defined time interval can be recorded. A link evaluation contains the following data:
  - Volume [veh/h]: In mesoscopic simulation, for link segments outside the sections of microscopic simulation, the average number of vehicles is displayed that have entered and exited the sections on the meso edge.
  - Vehicle density
  - Average speed
  - Emissions (for add-on module API package only)
  - Delay (relative): Total delay divided by total travel time of all vehicles in this link segment during this time interval
- Delays: In a delay measurement, the average delay is calculated for all observed vehicles compared to a trip without any other vehicles, signal controls or other required stops. A delay measurement may include the following attribute values:
  - Stop Delay: Average stopped delay per vehicle in seconds without stops at PT stops and in parking lots
  - Vehicle delay: Average delay of all vehicles. The delay of a vehicle in leaving a travel time measurement is obtained by subtracting the theoretical (ideal) travel time

from the actual travel time. The theoretical travel time is the travel time which could be achieved if there were no other vehicles and/or no signal controls or other reasons for stops. Delay time does not account for deceleration in reduced speed areas (Using reduced speed areas to modify desired speed). To calculate the loss time caused by a desired speed decision, Vissim calculates a theoretical speed and compares it with the current speed (Using desired speed to modify desired speed decisions). The actual travel time does not include any passenger service times of PT vehicles at stops and no parking time in real parking lots. The delay due to braking before a PT stop and/or the subsequent acceleration after a PT stop are part of the delay.

- Stops: Average number of vehicle stops per vehicle without stops at PT stops and in parking lots
- Number of vehicles
- Person delay: Average delay [s] of all occupants of the vehicles
- Persons: Number of occupants in the vehicles: number of vehicles * average occupancy rate

3.4 Audits and Assessments of Walkability and Public Space

In the following section relevant audit and assessment tools are introduced. References are provided so that the interested reader can easily find more information on each of the tools. Various further tools are provided at the website of Active Living Research Consulting (https://activelivingresearch.org/search/site/content_tools_and_measure?f[0]=bundle%3Acontent_tools_and_measure). 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). Various tools are available or currently developed by TfL to support the efforts of achieving the ambitious goals, these seem to be of special relevance for MORE and are therefore described in particular detail.

3.4.1 Overview of Relevant Audit- and Assessment-Tools

The Pedestrian Environment Review System (PERS) includes a quantitative assessment of design elements such as the width of pavements and steepness of dropped kerbs, as well as qualitative assessments of their general look and feel (Transport for London, 2015). The below Table 5 gives an overview of the PERS review parameters.

Table 5: PERS Review Parameter, Weight Bands and Default Weightings for Each Parameter

Table 2-1: PERS review parameters, weight bands and default weightings for each parameter

Link review			Crossing review			Route review		
Factor	Weight Band	Default weighting	Factor	Weight Band	Default weighting	Factor	Weight Band	Default weighting
Effective width	C	5	Crossing provision	C	5	Directness	C	5
Dropped kerbs	H	3	Deviation from desire line	H	3	Permeability	H	3
Gradient	B	1	Performance	C	5	Road safety	C	5
Obstructions	H	3	Capacity	B	1	Personal security	C	5
Permeability	H	3	Delay	H	3	Legibility	H	3
Legibility	B	1	Legibility	B	1	Rest points	B	1
Lighting	H	3	Legibility for sensory impaired people	H	3	Quality of the environment	B	1
Tactile Information	H	3	Dropped kerbs	H	3	Link Audits and Crossing Audits	C	5
Colour contrast	H	3	Gradient	B	1			
Personal security	C	5	Obstructions	B	1			
Surface quality	H	3	Surface quality	H	3			
User conflict	C	5	Maintenance	B	1			
Quality of the environment	B	1						
Maintenance	B	1						

Public transport waiting areas review			Interchange space review			Public space review		
Factor	Weight Band	Default weighting	Factor	Weight Band	Default weighting	Factor	Weight Band	Default weighting
Information to the waiting area	H	3	Moving between modes	C	5	Moving in the space	C	5
Infrastructure to the waiting area	H	3	Identifying where to go	H	3	Interpreting the space	H	3
Boarding public transport	C	5	Personal safety	C	5	Personal safety	C	5
Information at the waiting area	H	3	Feeling comfortable	H	3	Feeling comfortable	H	3
Safety perceptions	C	5	Quality of the environment	B	1	Sense of place	H	3
Security measures	C	5	Maintenance	B	1	Opportunity for activity	B	1
Lighting	H	3	Link Audits and Crossing Audits	C	5	Link Audits and Crossing Audits	C	5
Quality of the environment	B	1	Route Audits	C	5	Route Audits	C	5
Maintenance and Cleanliness	B	1	PT Waiting Area Audits	C	5	PT Waiting Area Audits	C	5
Waiting area comfort	H	3						

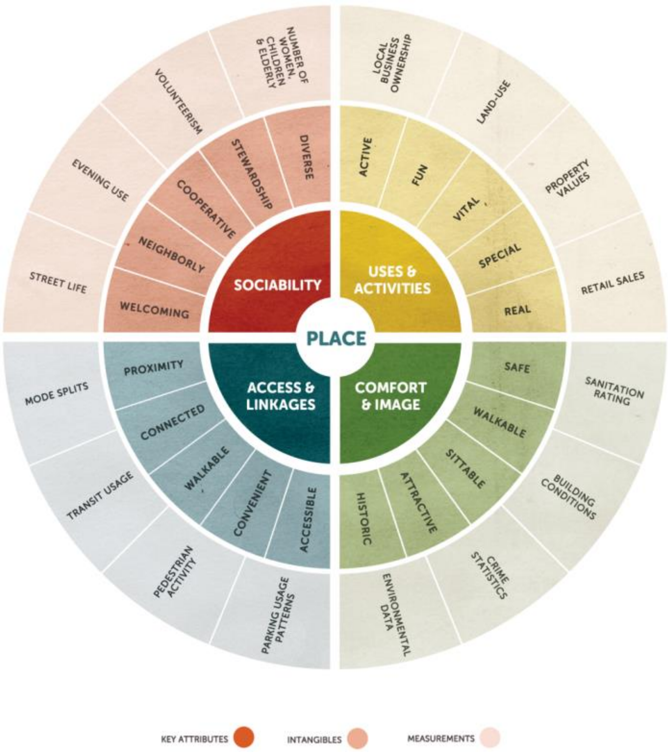
Microscale Audit of Pedestrian Streetscapes (MAPS) is a comprehensive assessment of environmental features on microscale, which have influence on physical activity (see https://activelivingresearch.org/microscale-audit-pedestrian-streetscapes). Three versions of the MAPS tool exist with varying degrees of complexity: 120-item audit survey, 60-item audit survey and MAPS-Mini with 15 items. The items are organised along the following themes: route (land use/destinations, streetscape, aesthetics/social), walkway/sidewalks, crossings.

Mehta (2014a) and Mehta (2019) present a Public Space Index (PSI) with 46 variables for the five dimensions inclusiveness, meaningful activities, comfort, safety and pleasurability. For example, criteria for inclusiveness include the presence of people in different ages/ genders, range of activities, opening hours of public spaces, presence of posted signs to exclude certain persons or behaviours etc.

The Project for Public Spaces (PPS) includes four key principles: (1) sociability, (2) uses and activities, (3) access and linkages, (4) comfort and image with each a list of questions. The approach is not as detailed as for example the Public Space Index (PSI) developed by

(Mehta, 2014a, 2019) or the twelve quality criteria provided by Gehl (2010)but is a widespread approach used mainly in the U.S. (Project for Public Spaces, 2018)

Figure 2: "The Place Diagram" (Project for Public Spaces, 2018, p. 5)



Moura et al. (2017) present the IAAPE tool (Indicators of Accessibility and Attractiveness of Pedestrian Environments), which is a GIS-based and participative assessment framework for measuring walkability on different scales (city, neighbourhood and street scale) for different pedestrian groups and trip purposes according the 7 C's (Connectivity, Convenience, Comfort, Conviviality, Conspicuousness, Coexistence, Commitment). The replicability of the tool helps urban planners to design more walkable environments in their spatial unit.

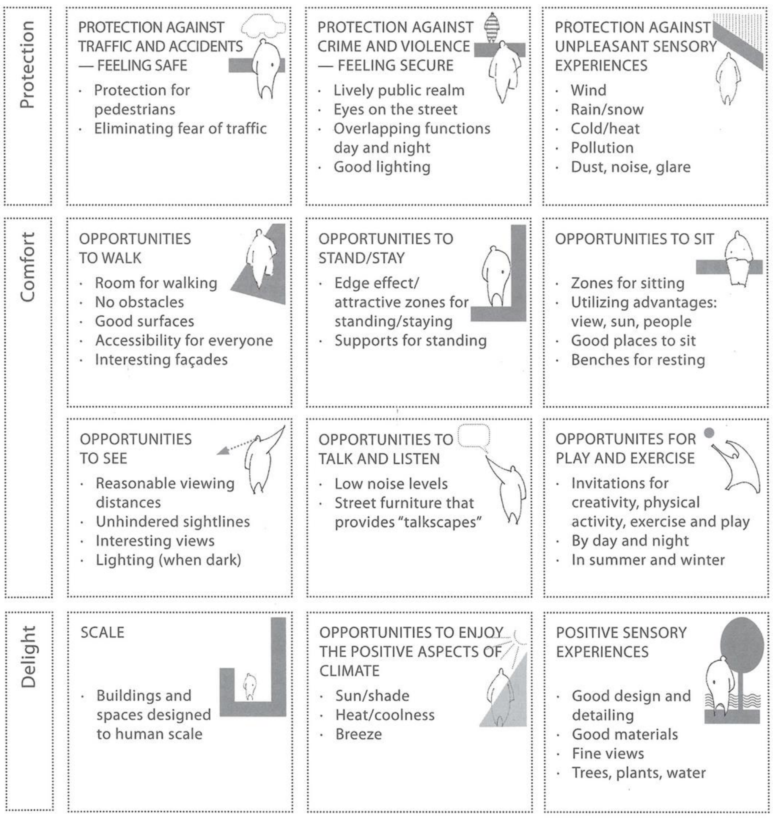
3.4.2 Twelve Quality Criteria, Gehl Institute

Gehl (2010) composed twelve quality criteria for high quality street spaces for pedestrians. The criteria are grouped into to the following categories as shown in Figure 3:

- 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” 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 considered. The delight of design with respect to details and materials and green structures promote walking and the enjoyment of public spaces by place users.

Detailed guidance on how to assess the twelve quality criteria and also various further tools are provided at https://gehlinstitute.org/.

Figure 3: Quality Criteria for High Quality Street Spaces for Pedestrians (Gehl, 2010)



3.4.3 Healthy Street Checks, Transport for London

The London Healthy Street approach puts people and their health at the heart of decision making. It covers movement 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 indicator schemes that often focus on smooth and safe movement of motorised vehicles. The London Healthy Street approach contains indicators that are similar to the ones listed in the above tables (see e.g. Chapter 3.1.1) 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.

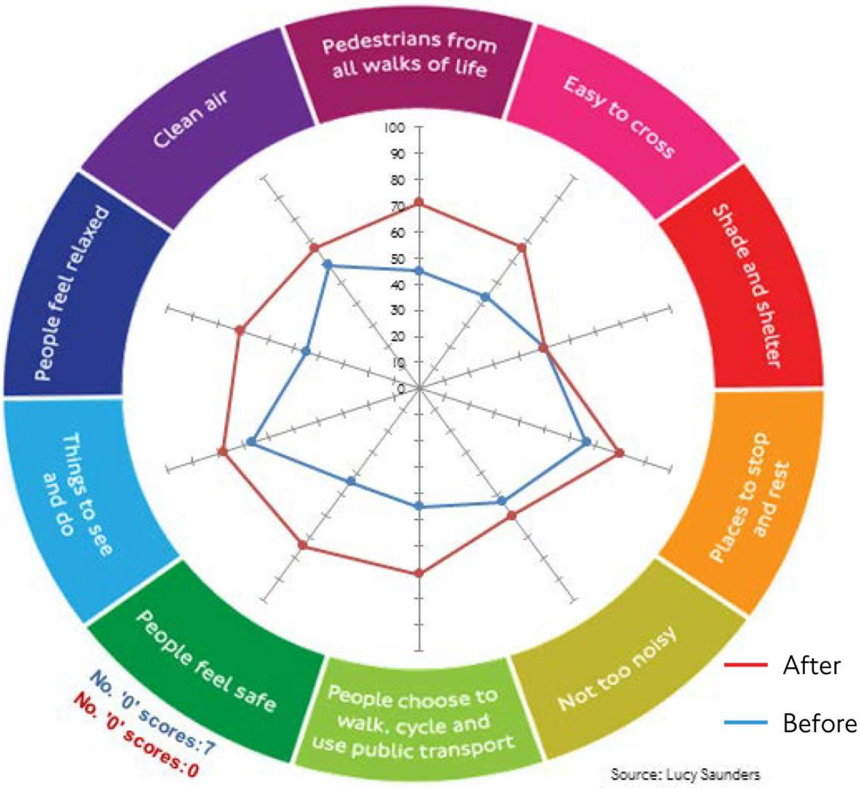
Metrics can be scored from zero or one to three where three is the highest (best) score; ten of the 31 metrics can be scored zero (the lowest score). Overall, the maximum scores of all 31 metrics sum up to 100. However, TfL stresses that the maximum score of 100 will never be reached as compromises and 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 6 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 4 shows an example output of the Healthy Street Check for Designers.

Table 6: List of Healthy Street Check Metrics in London (Transport for London, 2019b)

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 Voncentration	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)/ some time 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, Private/ Shared Motorised 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

No.	Metric	Scoring System	Possible Data Sources
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/ frequen 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
18	Quality of Carriageway Surface	Score 3/2/1/0: surface even and smootg/ 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 smootg/ 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 ligthing
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 busses/ mixed traffic/ negative influences on bus journey time, no value for zero score	On-site inspection of measures for prioritising busses
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

Figure 4: Example Output of the Healthy Street Check for Designers (Transport for London, 2018b)



3.4.4 Healthy Street Tracker Surveys, Transport for London

Healthy Street Tracker Surveys were piloted at 48 sites in August 2018 (Saunders and Groot, 2019; Transport for London, 2018c). The aim of this new survey is to reliably track the performance of London's streets against the Healthy Streets Indicators capturing qualitative and quantitative data, both at the pan London scale, as well as locally in relation to specific improvements. Trained surveyors complete a questionnaire at selected locations using a tablet device. The questionnaire consists of six key sections relating to nine of the 10 Healthy Streets Indicators. Each item in each of these sections is scored between zero and ten, overall 106 items are to be assessed. Below are the six sections and examples of what is assessed in each:

- Context (date, weather, pavement/road conditions, building or construction works, short pedestrian and cycle count)
- Road features (traffic calming, traffic restrictions, parking, signage, side street features)
- Ambience (street façade, greenery, graffiti, litter, noise, street lighting)
- Crossings and traffic (formal and informal crossings, crossing features, volume and flow of traffic, driver and cyclist behaviour)
- Seating and people (formal and informal seating, seating features, social activity and space, shade and shelter)
- Pavement and cycleway (width and evenness of footway, trip hazards, cycle infrastructure)

Questions are scored to reflect positive and negative factors present on a street, mostly on a scale of 0 to 10 (10 being the highest score). Positive factors on street score well and negative factors lower the scores for each question. Once the weighting is applied (accounting for influence of each factor) this allows TfL to see how well each indicator is scoring. The below example shows how the answer categories from each question are converted into scores:

94	Considering the pavement overall, how far would you agree that the paving material provides an even and level footway for people walking?	Single choice response	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree	10 8 6 4 2	Max available score 10

Each question has also been assigned a weighting, according to the relative importance of that factor in contributing to a Healthy Street, using evidence from the Healthy Streets documentation (see: https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/healthy-streets). This allows a weighted percentage score for each indicator to be calculated, which can be stratified by street type or region.

3.4.5 Pedestrian Level of Service Measures

Karatas and Tuydes-Yaman (2018) provide an overview of studies on sidewalk pedestrian level service measures (PLOS) and rating. The authors demonstrate the heterogeneity of the existing concepts and conclude that PLOS ratings should be merged with walkability assessments in order to reduce the variety of the different approaches and to achieve more standardisation and comparability for the assessment of quality of pedestrian facilities.

The Pedestrian Comfort Guidance (PCG) provided by Transport for London is described in more detail as one example approach for PLOS assessments. The 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 (2019d) (see Figure 6). 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 5 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 5: Suitable pedestrian comfort levels for different area types (Transport for London, 2019d)

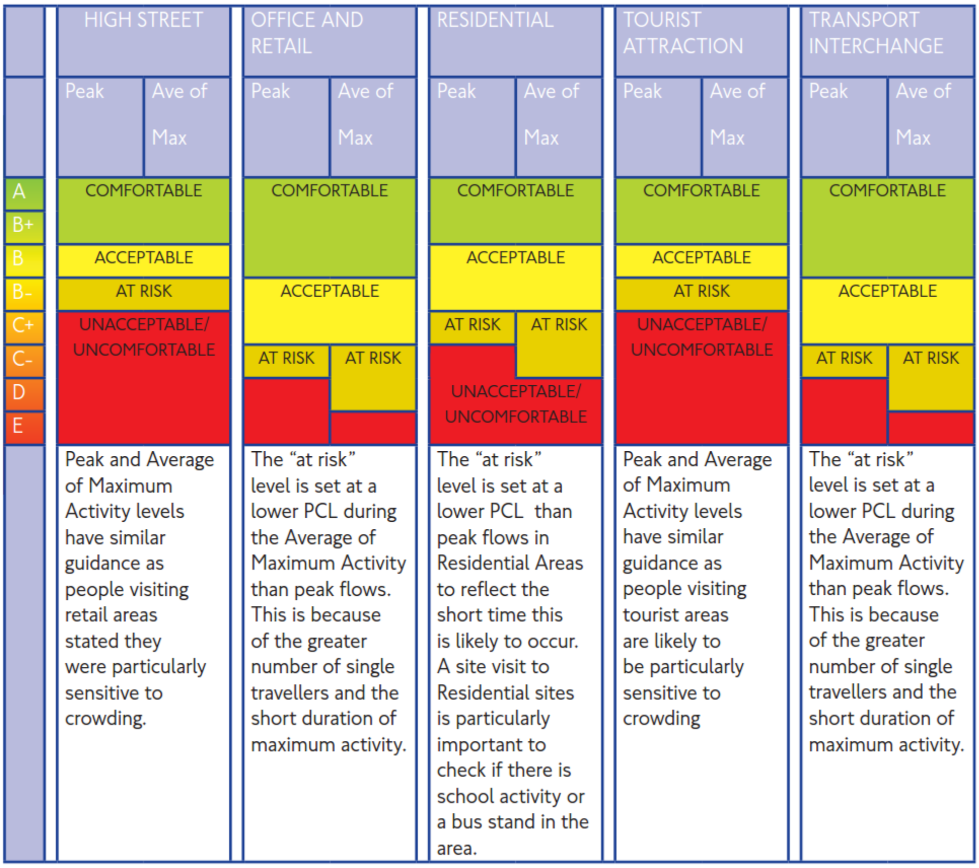


Figure 6: Pedestrian Densities and Comfort Levels (Transport for London, 2019d)

Figure 8 Pedestrian Comfort Levels on Footways

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

Figure 7: Recommended footway width (Transport for London, 2019d)

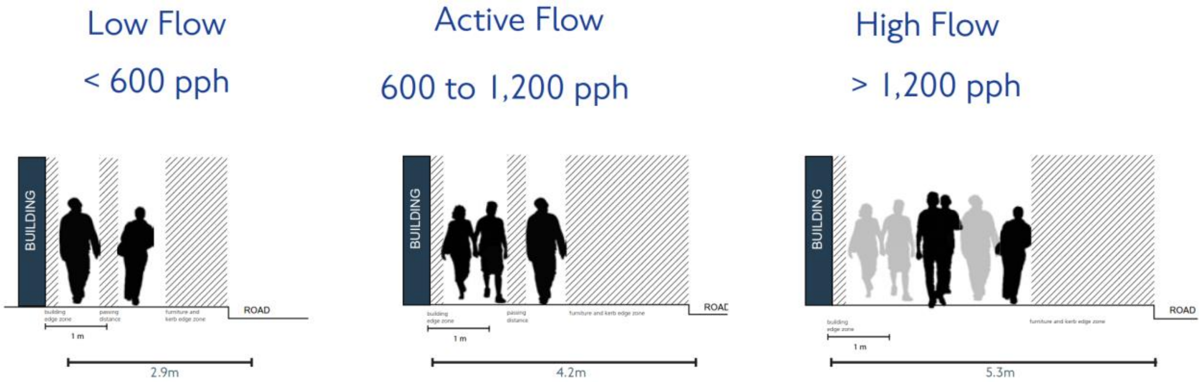
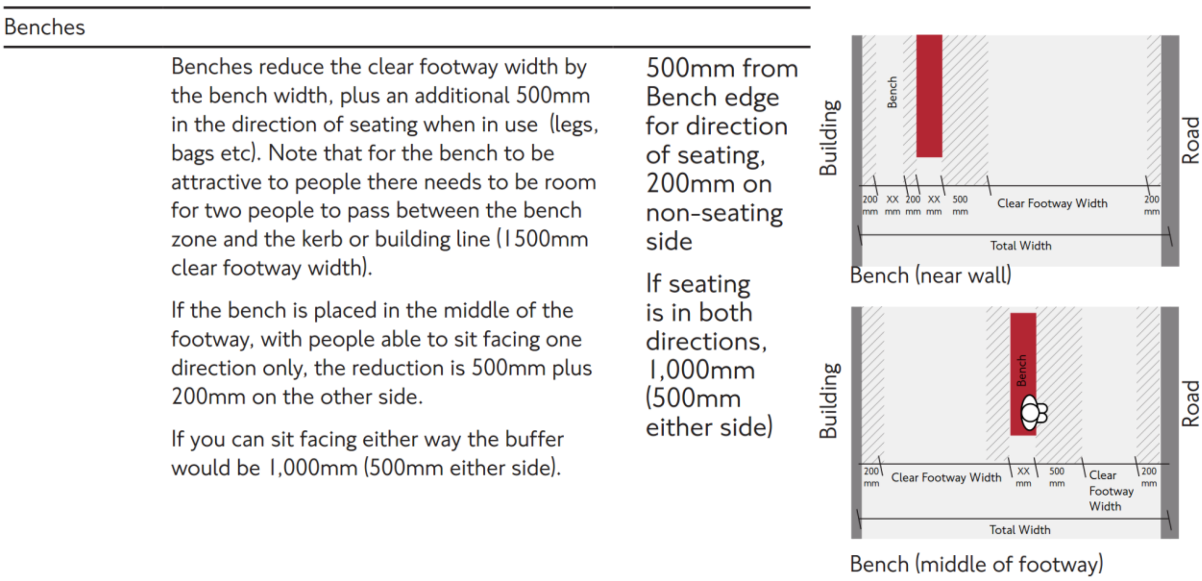


Figure 8: Recommended footway design with bench (Transport for London, 2019d)


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)

Bench (near wall)

Bench (middle of footway)

4 Street Performance Assessment Scheme (SPAS) for the MORE Stress Sections

4.1 General Principles and Considerations

Based on the conceptual framework described in Chapter 2 and the lists of objectives, targets and indicators presented in Chapter 3, the *Street Performance Assessment Scheme* (SPAS) is developed in the next step to be applied for the before-after comparisons and also for the cross-site assessments of the existing and the newly developed design solutions for the stress sections in each of the five MORE-cities. For these purposes, the street performance assessment scheme should meet the following requirements:

- It should be sensitive to street design so that different sites can be compared and also before-after studies as planned in WP5 can be evaluated with SPAS.
- It should include supply-side indicators and demand-side indicators. Place functions should have particular weight as their improvement is a common goal in all MORE-stress sections.
- The SPAS should contain standardised indicators and thus allow for comparisons between the MORE-case studies. At the same time, it should be flexible and open for specific indicators that might be suitable only for some of the MORE-case studies.

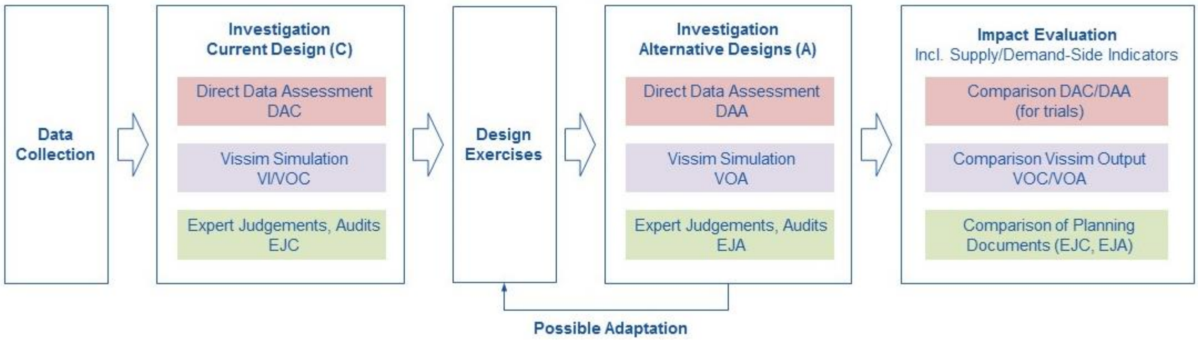
Seeing these requirements, we suggest a modular approach for the SPAS in MORE:

- Key indicators are arranged in the *core module*; this module is ident for all MORE-cities. It ensures comparability across the MORE-cities.
- The *city-specific complementary module* includes individual indicators for each city in order to meet the city-specific requirements and framework conditions. These indicators are not comparable between MORE cities but can be compared for the different possible design solutions within each city.

In this Chapter 4, only the core module will be described in detail. City-specific complementary modules might be developed individually for each MORE-case study based on the overview of possible street design objectives, targets and indicators provided in Chapter 3; these city-specific modules will be explained and applied in the final deliverable D 5.5 for each MORE-case study individually.

The evaluation in MORE will rely heavily on the outcomes of the Vissim models as these are the basis for simulating the effects of the different developed design solutions, and as hardly any physical implementation of the developed design solutions will be possible within the lifetime of the MORE-project. Direct assessment will be carried out for pilots that might be implemented in selected case studies when e.g. selected lanes will be temporarily blocked or parking spaces are taken out for a limited time period. In addition, expert judgements will be seeked as third pillar of the evaluation approach. This leads to a multi-data and multi-method approach used for impact evaluation as shown in Figure 9.

Figure 9: Multi-Method and Multi-Data Approach for Impact Evaluation



DAC Direct Assessment Current Design; VI/VOC Vissim Input/ Vissim Output Current Design; EJC Expert Judgements Current Design; DAA Direct Assessment Alternative Design, VOA Vissim Output Alternative Design, EJA Expert Judgements and Audits Alternative Design

In the following, the core module of the SPAS is described. Chapter 4.2.1 gives an overview of the demand-side key performance indicators chosen for the evaluation. The proposed types of data to be collected for computing these indicators and for setting up the Vissim simulation are listed in Chapter 4.2.2. This data is also the basis for developing the alternative design solutions. The supply-side indicators for characterising the streetscape, urban design and land use in the stress sections is introduced in Chapter 4.3.

4.2 Demand-Side Indicators and Wider Impacts

4.2.1 Key Performance Indicators

Table 7 to Table 9 list the demand-side indicators chosen for the core module in SPAS. The performance indicators are grouped along the three dimensions (1) movement functions, (2) place functions and (3) wider impacts. Indicators describing the pure quantity of movement and place activities are the basis of the core module. This might sound simple but is potentially challenging for the MORE partners as volumes of all user groups including pedestrians, place users, and activities for parking and stopping should be quantified. For vehicles, turning movements are necessary for setting up the Vissim models. Changes in the volumes of specific user groups are an important goal for the stress sections that can be monitored based on these indicators; this information allows also computing modal split values specifically for the stress sections, for the current situation and the different design solutions.

Besides the user volumes, key indicators for characterising street users' movement and place activities are considered. This includes e.g. speed, travel times, waiting times, and acceptance of infrastructure and traffic rules (do cyclists accept their facilities or do they actually cycle on different parts of the street, are red lights and crossing facilities accepted, etc.) for the movement functions. Place functions distinguish between (1) stationary activities of place users who use the street as destination and not as conduit for facilitating their movements and (2) kerbside activities (parking, loading/ delivery and drop-off/ pick-up). Similar to the indicators for the movement function, number and characteristics should be measured for the different place activities. Different to movement functions, information on activity duration is needed for place activities.

For the wider impacts, indicators on air pollutant emissions, safety, healthy street performance and security are included into the core module of the street performance assessment scheme. Increasing safety is a key and often mandatory objective in any urban street design; it was included with high priority in all the researched documents. The reduction of air pollutant and also GHG-emissions is another key objective for transport in all MORE cities. Further indicators e.g. for quantifying other environmental or health effects such as noise could be evaluated in the city-specific supplementary modules.

Possible output options in Vissim are presented in an extra column in order clearly show the opportunities for evaluating different proposed scenarios to be simulated in Vissim. The tables thus list not only the performance indicators chosen for the core module in SPAS but also explain whether these indicators can be used for direct assessment and/or for the simulation in Vissim. Direct assessment might mean the comparison of different sites e.g. in the different MORE-cities or before-after studies in case of temporary modifications of the physical environment.

Table 7: Demand-Side Indicators, Movement Functions, Core Module of SPAS

Theme	Indicator (peak-hour, off-peak periods, working days)	Output options in Vissim	Type of assessment	Data basis, unit
Vehicle Volumes Cars, LGV, HGV, Motorcycles, Bicycles, Buses, Trams	• Volumes [veh/h] per cross-section, per turning movement at junctions • Vehicle density at street sections [veh/m]	• Total number of vehicles in the network at the end of the simulation • Number of vehicles arrived in the simulation period • Volume [veh/h] per link/lane segment at each point in time during simulation • Vehicle density [veh/m] • Number of vehicles per OD-relation, PT passengers entering / leaving the area in a PT vehicle • Latent demand: Number of vehicles from meso origin connector edges, vehicle inputs and parking lots that could not be used, number of vehicles that were not allowed to enter the network from vehicle inputs and parking lots until the end of the simulation.	Direct assessment, before-after: Vehicle volumes might change due to possible temporary modifications of the streetscape (e.g. blocking one lane or parking space) or of traffic regulation (e.g. changes in signalling or speed limit). Vissim simulation, different scenarios: Vehicle volumes change if capacity of a link or a junction are modified.	Counts of vehicle turning movements at junctions [veh./15min]
Pedestrian Volumes Walking along the Footway	• Volumes [ped/h] at street sections between two junctions (by age group, with/ without mobility aid) • Pedestrian density [ped/m^2] • Experienced pedestrian density [ped/m²]	• Maximum, minimum, average number of pedestrians (area, ramp, stairs) • Number of pedestrians leaving the construction element or walking on it (excluding pedestrians from pedestrian inputs and pedestrians alighting from PT vehicles) • Pedestrian density (area, ramp, stairs) • Pedestrian density experienced within the perception radius of a pedestrian: Number of other pedestrians within a radius around the pedestrian.	Direct assessment, before-after: pedestrian volumes might change if sidewalk characteristics, street furniture or the characteristics of the adjacent buildings are (temporarily) modified during project lifetime Vissim simulation: pedestrian volumes are defined as input so far	Pedestrian counts [ped./15min]
Pedestrian Crossing Volumes	• Volumes [ped/h] per arm of each junction and at street sections between two junctions (by age group, with/ without mobility aid) • Average pedestrian delay at crossings	• See pedestrian volumes walking along the footway	Direct assessment: only possible for current situation as cities hardly will physically change the street elements with relevance for pedestrian crossing Vissim simulation: overall crossing volumes defined as input but location of crossing activities might change with different crossing facilities provided in the alternative scenarios	Pedestrian counts [ped./15min] Delays [min/ person]

Theme	Indicator (peak-hour, off-peak periods, working days)	Output options in Vissim	Type of assessment	Data basis, unit
Public Transport Passengers	Number of passengers boarding/alighting busses/trams, for each PT stop	• Maximum, minimum, average number of pedestrians who were waiting for a PT vehicle (area, ramp, stairs)	Direct assessment: only possible for current situation as cities hardly will physically change the street elements with relevance for PT demand Vissim simulation: PT passengers defined as input	Data to be provided by PT operator
All Street User Groups	• Total number of people moved within the section [users/h] • Percentage values of vehicle/ pedestrian volumes as modal split [%]	• See Vehicle volumes (cars, LGV, HGV, motorcycles, bicycles, buses, trams) and pedestrian volumes (walking along the footway) plus mean number of persons per vehicle	Direct assessment, before-after: User volumes might change due to possible temporary modifications of the streetscape (e.g. blocking one lane or parking space) or of traffic regulation (e.g. changes in signalling or speed limit). Vissim simulation, different scenarios: Vehicle volumes change if capacity of a link or a junction are modified.	Data basis: counts of vehicle turning movements at junctions, pedestrian counts [persons/ 15min]
Travel Times, Delay, Reliability, Motorised Traffic, Bicycles	• Average travel time/ delay • Travel Time Index = (Actual travel time / travel time at reference speed)-1 as percentage increase of travel time compared to reference speed • Variance / distribution of speed/ delay, percentiles • Waiting times at junctions [s] Cars, LGV, HGV, motorcycles, buses, trams	Output options in Vissim[1]: • Average travel time = Total of travel times / number of vehicles • Average delay time = Total of delay times / number of vehicles • Average speed [km/h] or [mph], defined as total distance / total travel time • Waiting times at junctions and for PT at stops, ratio of waiting time over total travel time including also deviations from desired speed	Direct assessment, before-after: Vehicle travel times might change due to possible temporary modifications of the streetscape (e.g. blocking on lane or parking space) or of traffic regulation (e.g. changes in signalling or speed limit). Vissim simulation: Travel times change with changes in demand or supply	Measure-ments [s] FCD-data
Travel Times, Delay, Reliability, Pedestrians	• Waiting times at junctions [s] • Average total walking time [s] • Ratio of waiting times over total walking time [%] (within the modelled area, trip could be longer), including also deviations from desired speed	Pedestrian travel times (OD data): From a simulation based on a pre-defined pedestrian origin-destination matrix, the following aggregated data can be generated: • Travel time: Average of all travel times of relevant pedestrians per OD relation. • Delay: Average of all total delay values per OD relation. For each pedestrian, the delay in each simulation step results from: Time step length-(Distance walked during time step)/(Desired speed of pedestrian), Example: The delay is 25% of the length of the time step for a pedestrian at 75% of his desired speed. These values are added up over the entire measured distance of the pedestrian. • Relative delay: Average of all relative delays per OD relation, this value is determined separately for each pedestrian as a percentage of the delay in the travel time. • Ratio of waiting time over total walking/ cycling time Volume: Number of pedestrians on the basis of which the other result attributes were determined.	Direct assessment, before-after: Travel times and waiting times might change due to possible temporary modifications of traffic regulation (e.g. changes in signalling). Vissim simulation: Travel times and waiting times change with changes in demand or supply	Measure-ments [s]

[1] OD pair data can be only used for the evaluation if dynamic assignment has been used, this will rather not be the case in MORE. OD pair data can therefore probably not be used for evaluating MORE-scenarios but belongs instead to the input data.

Theme	Indicator (peak-hour, off-peak periods, working days)	Output options in Vissim	Type of assessment	Data basis, unit
Spot Speed	• [km/h], at specific locations • in addition to travel times, for vehicles and pedestrians	Output options in Vissim for pedestrians: • Average pedestrian speed, all pedestrian types, calculated as the harmonic mean • Vectorial speed differences of all pedestrians within the personal environment radius of their own speed • Length and time information on any pedestrian queues Mean speed can be also computed for bicycles and motorised vehicles	See travel times, speed of pedestrians might change with changed sidewalk design	Measure-ments [km/h] FCD-data
Acceptance of Infrastructure (Only if Sufficient Resources are Available)	• Red light running rate at signalised junctions [%] • Utilisation rate of dedicated facilities for cyclists [%] • Utilisation rate of formal crossing facilities for cyclists and pedestrians [%]	None	Direct assessment, before-after: Behaviour might change due to possible temporary modifications of traffic regulation (e.g. changes in signalling, changes in cycle facilites). Vissim simulation: no assessment	Measure-ments [%]

Table 8: Demand-Side Indicators, Place Functions, Core Module of SPAS

Theme	Indicator (peak-hour, off-peak periods, working days)	Output options in Vissim	Type of assessment	Data basis, unit
Number and Duration of Stationary Activities	Number and duration of stationary activities Liveliness index (number of people times the duration of their stay) By age/ gender/ mobility aids, by type of activity as indicated in the forms	• Suggestion TUD: Number of people and time spent on place activities, by type of activity.	Direct assessment, before-after: number and duration of stationary activities might change if sidewalk characteristics, street furniture or the characteristics of the adjacent buildings are (temporarily) modified during project lifetime Vissim simulation: Pedestrian activities (number, characteristics, type of their activities) are defined as input so far.	Video recording Manual observations
Number and Duration of Kerbside Activities	Number and duration of parking, loading, drop-off/ pick-up events, by location, time, type of event and vehicle, type of parking space (legal vs. illegal, paid vs. unpaid etc.)	• Suggestion PJ: Kerbside supply efficiency: % of time that parking/loading/drop off (etc..) bays are occupied, by time of day, individually or for defined stretches of road • Suggestion PJ: Kerbside demand efficiency: probability of a driver being able to find a space (within X metre) of his/her desired destination • Suggestion PJ: Financial profile: income from payments for parking (and loading, drop off, etc) • Suggestion TUD: Turnover of parked vehicles (inverse of parking duration, a parking space is better used when more vehicles use it over the day)	Direct assessment, before-after: number and duration of kerbside activities might change if parking supply is (temporarily) modified during project lifetime Vissim simulation: kerbside activities might change if parking supply changes (#or also demand?)	Video recording Manual observations

Table 9: Demand-Side Indicators, Wider Impacts, Core Module of SPAS

Theme	Indicator	Output options in Vissim	Type of assessment	Data basis, Unit
Accidents	Accidents with personal injuries for a 3-year period for the whole stress section should be included: • Location, date, time of accidents, number of injuries (with precise location) [-] • Accident severity [fatality, serious injury, minor injury] • Users involved in the accident (cars, LGV, HGV, motorcycles, cycles, scooters, buses, trams, pedestrians)	None	Direct assessment, before-after: number and severity of accidents might change if infrastructural or regulatory characteristics change or number of users changes, (ATTENTION: no short-term assessment possible) Vissim simulation: no assessment	Police statistics for units see column indicator
Air Quality	Air pollutant concentration on the MORE-corridor: • NO_2, • PM10, • PM2.5	A number of results may be generated with COM Interface (see Link)	Direct assessment, before-after: Emissions might change if street design or user behaviour is (temporarily) modified during project lifetime Vissim simulation: Emissions might change if supply /demand changes	Measurements Computation with Vissim
On-Street Crime (Security)	Number of street crimes on the whole section [-]	None	Direct assessment, before-after: number street crimes might change if infrastructural characteristics change Vissim simulation: no assessment	Official statistics

4.2.2 Proposed Types of Data to be Collected

Data from the stress section is collected for three primary purposes:

1. Inputs to D5.1, the current situation, to help identify street use patterns, extent of problems, etc., and guide the development of the Design Brief and the generation of street design options.
2. Inputs to the Vissim model, so that the impacts of different designs can be simulated.
3. Inputs for the direct assessment of street quality and performance of the current and the alternative designs.

The following Table 10 lists the data that needs to be collected for computing the performance indicators as introduced above. The types of data to be collected are in some cases similar to the performance indicators. For example, data on speed can be directly used to quantify the indicator speed. In addition, data on speed is the basis for computing further indicators such as delays or reliability.

Detailed instructions for data collection and data provision are provided by TUD in a separate document.

Table 10: Proposed Types of Data to be Collected for Demand-Side Indicators

Theme	Type of Data
Link/Movement Function	
Turning Vehicle Movements and Pedestrian Flows at Junctions (Every Single Junction in the Modelled Area)	Turning movements, by direction and arm, by vehicle type and time of day (15-minute intervals): cars, motorcycles, LGV, HGV, cycles, buses, trams
	Pedestrian flows on each footway approaching the junction, walking along the footway and crossing the carriageway, by direction
	Vehicle saturation flows on key approaches to signalised junctions (max. number of vehicles passing at green in over-saturated conditions)
	Vehicle queue lengths on major approaches to junction
Traffic Volumes in between two Junctions	Vehicle flows, by lane and direction; by vehicle type and time of day (15 minute intervals) (to be derived from counts of turning movements at adjacent junctions)
	Pedestrian flows (walking along the sidewalk) by footway, direction and time of day (15-minute intervals), by age group, gender and mobility aids
Pedestrian Crossing Volumes in between two Junctions	Pedestrian flows crossing the carriageway in between two junctions for formal crossing facilities (if possible also informal crossings), by direction, 15-minute intervals, by age group, gender and mobility aids
Public Transport	Total number of people entering the stress section in a public transport vehicle
Travel Times between Junctions	Travel times in both directions along the whole modelled corridor
And/or Spot Speed	Spot speeds at mid-points between junctions
Place Function	
Number and Duration of Stationary Activities	Number and duration of stationary activities, by age, gender, mobility aids, by posture (standing, formal/informal sitting, lying down, multiple movement) and activity type (waiting, consuming etc.)
Kerbside Stopping Activities: Bus/Tram	Frequency of service Number of people boarding and alighting at each bus/tram stop (and railway station entrance), information to be provided for each bus/tram stop
Kerbside Stopping Activities: Parking, Loading, Passenger Drop Off and Pickup, etc.	For each street segment or individual parking space: arrival and departure time for each parking/loading event (to estimate durations), by location, type of event and vehicle type
Wider Impacts	
Accidents	Number, type and severity of accidents Number of injured persons, severity of their injuries By specific location, where possible
Air Quality	Air pollutant concentration on the corridor (e.g. NO2, PM10, PM2.5)
On-Street Crime (Security)	Number of on-street crimes in the stress section (desirable) By specific location, where possible

4.3 Supply-Side Indicators

The careful description of the street layout and its environment is the basis for the evaluation and for understanding changes in the demand-side indicators. The supply-side indicators describe the space provision for each user group in the street, the type of separation between user groups, crossing facilities, inclusive design and the operation of the street (e.g. signalling schemes at traffic lights). Variables for urban design and land use are also included into SPAS even though these will be hardly changed in the process of re-designing the stress sections in the MORE corridors. All researched references show consistently the high importance of urban design and land use for traffic and user behaviour in the street, particularly for the place activities that are of special interest in the MORE project. Their careful documentation is the basis for understanding and purposefully shaping link and place activities in each street section.

Methods for data collection include for all the supply-side indicators mainly GIS-data or on-site inspections, the following Table 11 lists the proposed types of data to be collected for the supply-side indicators for the chosen stress sections.

Table 11: Proposed Types of Data to be Collected for Supply-Side Indicators

Theme	Data and Indicators
Street Network	
Movement and Place Categorisation	Classification of each street segment in the stress section along movement and place functions
Number, Width and Designation of Lanes for Each User Group in the Carriageway	Number and width of lanes in street section between junctions Number and width of lanes/pocket lanes in junction approaches Length of pocket lanes at junctions [m] Turning restrictions at junctions for each user group Allowed user groups on each lane, allowed direction of travel (e.g. for bidirectional cycle facilities)
Gradients of the Street Segment	Gradient [°]
Facilities and Separation of User Groups on Footways	Description of facilities for pedestrians and possible also cyclists, buffer zones if applicable
Signalising Schemes at Junctions	Signal control programs (external controllers if available), Signal control layouts (detector positions if actuated or pre-empted)
Space for Stationary Activities	Extra space beyond standard footway width: location, width [m], space [m²], short description
Opportunities to Sit	Location, width/length [m] of benches and further formal/ informal, commercial/ non-commercial seating facilities Presence of outdoor dining, amount of seating and space [m²]
Opportunities to Play, Exercise	Location, space [m²], width/length [m] of facilities for playing or exercise
Further Street Furniture	Location and characteristics of further street furniture such as street art, drinking fountains, water fountains, public toilets
Trees and Greenery	Location and type of trees and all different possible kinds of greenery
Bus/Tram Stops and Related Facilities	Location, width/length [m] of bus/tram stops and shelters Characteristics of bus/tram stop facilities
Provision for Parking and Stopping (Loading, Delivery, Drop-Off/Pick Up)	Documentation of all parking facilities and restrictions: parking bays, loading bays, prohibited stopping areas, etc. hours of operation and any limits on stopping duration (where appropriate); details of any charges (amount per unit time, hours of operation) Location of bike parking stands; stands for scooters etc. Kiss+Ride, Park+Ride, taxi, shared services facilities
Speed Limit	Speed limit at street section, further legal aspects of traffic regulation
Community Severance, Crossing Facilities	Location of each pedestrian crossing, by type of crossing facility Detection and optimisation technology for active mode users at traffic lights
Inclusive Design	Extent to which each crossing facility is suitable for pedestrians with reduced mobility Quality of footway and crossing surfaces, description and localisation of obstacles at the footway Extent to which each vehicle and PT stop/station is accessible to persons with reduced mobility
Urban Design and Land Use	
Density and Diversity of Land-Use in the Neighbourhood	Number of residents and work places per km² within around 500m radius Proportions of different types of land-use
Usage of Adjacent Buildings, Land Use	Proportions of ground floor usages in adjacent buildings (e.g. residential use or types of non-residential uses such as restaurant, bar, café, supermarket, retail store, bakery, pharmacy and drugstore, bank and ATM, health-related use, educational institution, religious site, public institution, theatre, museum) Estimated types of usage of adjacent buildings for higher-level floors
Scale, Human Dimension, Enclosure	Height of adjacent buildings (number of floors)
Attractive and Active Frontages, Transparency	Proportion of active frontages or soft edges in contrast to inactive walls Qualitative assessment of façade designs

Theme	Data and Indicators
Security, Protection against Crime and Violence	Sufficiency of surveillance and street lighting
Protection Against Unpleasant Sensory Experiences, Opportunities to Enjoy the Positive Aspects of Climate	Location and type of shelters and refuges Cleanliness
Positive Sensory Experiences	Subjective assessment of aspects that positively impact on the quality of street space (might be even scents and smells)

Detailed instructions for data collection and data provision are provided by TUD in a separate document.

5 Summary and Outlook

This document develops the *Street Performance Assessment Scheme* (SPAS) which will be used for the appraisal of the alternative design solutions for the stress sections in each of the five MORE-partner cities. Data collection is ongoing in all MORE-partner cities. Design days and further activities for preparing the alternative design solutions for the MORE-stress sections will follow in early 2020, also the Vissim simulations will be set up.

All these inputs will be the basis for the appraisal of the alternative design solutions and for the cross-site assessments. These will be integrated into this document as further chapters including a brief description of each stress-section (with reference to D5.1, for the current situation and the alternative design solutions), the goals and ambitions for the alternative design solutions, the processes and stakeholders involved and finally the appraisal of the alternative solutions.

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