The design of streets has become more complex over time, especially given the rapid growth of the city.

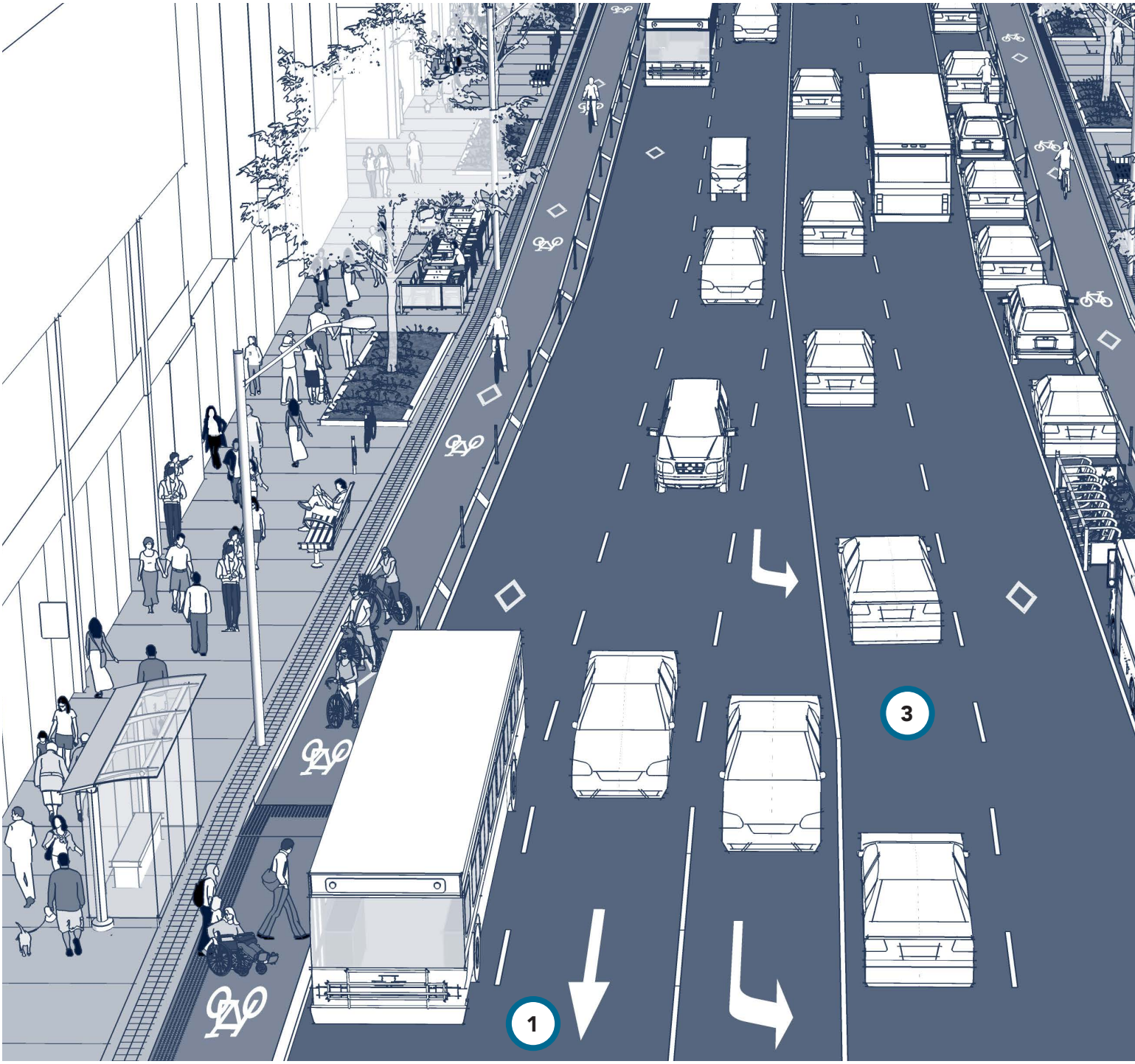
As shown in Chapter 1, the roadway is not just about moving motorized vehicles – its design affects the space adjacent to the roadway, as well as multi-modal access and mobility, public health, economic vitality, environmental sustainability and quality of life.

The roadway (the space between the curbs) needs to serve various modes of travel and their access in an environmentally, socially and economically sustainable manner. Roadway design should provide conditions that foster reliable travel and safety for all road users, particularly for the most vulnerable.

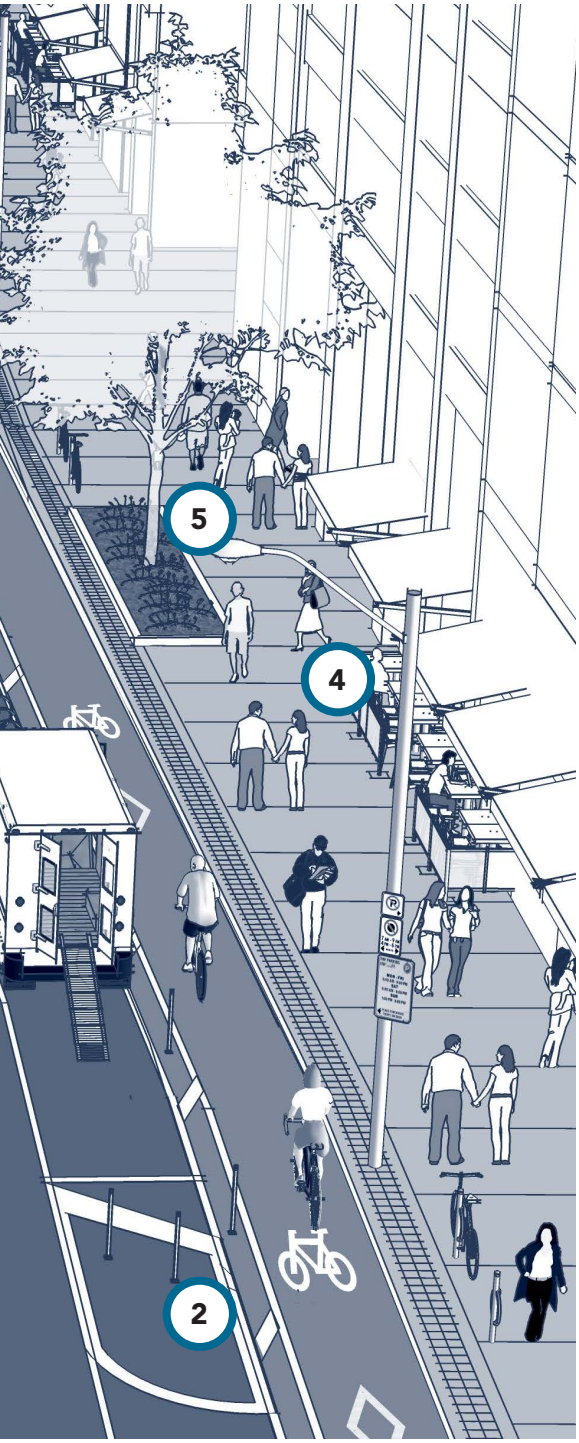
This chapter focuses on designing mid-block portions of roadways. Intersections are dealt with in Chapter 9. Topics related to pedestrians, cycling, transit and green infrastructure are discussed in Chapters 4 to 7.

8.0 STREET DESIGN FOR ROADWAYS

8.1 ROADWAY DESIGN PRINCIPLES



For illustrative purposes - may include a mix of permanent/temporary materials.



1. Multi-modal transportation. Give reliable, convenient and attractive mobility choices to people and support more efficient, active and healthier forms of travel (by foot, bicycle, transit) to reduce vehicular congestion. Provide emergency access and operations. Support goods movement and delivery by different modes. Identify and support existing and planned priority networks for each mode.

2. Safety. Fully consider road users who are particularly vulnerable in a crash or in interactions with other road users, such as pedestrians (especially children, older adults and persons with disabilities) and cyclists. Seek ways to reduce their exposure to risk (e.g., rightsize travel lanes, repurpose underused road space and separate pedestrians from cyclists). Provide visible, clear and predictable travel paths for all road users.

3. Context-sensitive target speed and reliable travel. Create a safer environment for everyone by using design to facilitate the intended speed of travel for drivers based on the street's context. Safer speeds and driver behaviours result in fewer incidents on the roadway that can cause delays and vehicular congestion, which negatively impact emergency access and goods movement. Coordinated signals, along with target speed, can help improve consistency in travel times. Peak-hour restrictions for stopping, parking and turn movements can improve travel times along key routes. This helps to manage demand and road capacity during peak travel times.

4. Placemaking. Consider existing and planned land uses, urban form, and the different uses of the street (e.g., social and economic activities) when making decisions about competing demands for space on the street. Seek ways to provide space, for example, through building setbacks and/or repurposing underused roadway space for streetscaping, street trees, street furniture, café or marketing areas, parklets, bicycle parking, pedestrian lighting, snow storage and removal, etc.

5. Greening and stormwater management. Limit the area of impervious materials. Seek ways to integrate street trees, landscape features, as well as water retention and treatment strategies and snow storage. Promote non-motorized modes to reduce greenhouse gas emissions and air and noise pollution. Use materials that contribute to sustainability, life-cycle performance and reduce the urban heat island effect. See Chapter 7 on Green Infrastructure for design guidance.

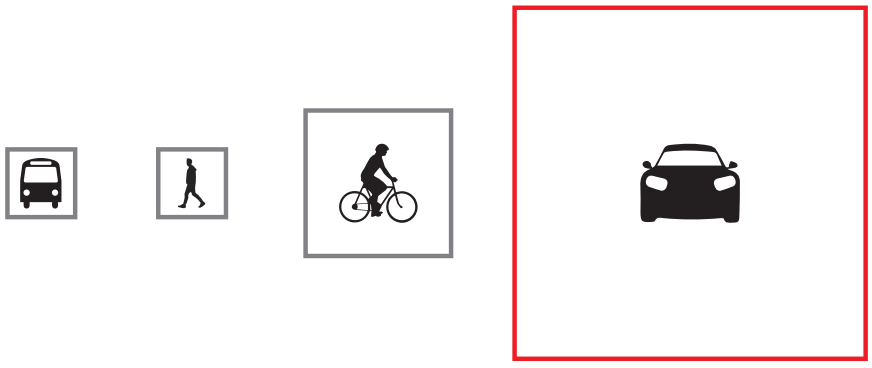
8.2 DESIGN FOR A MULTI-MODAL TRANSPORTATION SYSTEM

In a growing city like Toronto, limited street space is in high demand. Streets become more efficient when the focus is on moving people and goods rather than just moving vehicles.

Transit vehicles carry far more passengers than private automobiles and should be given priority wherever practicable to reduce vehicular congestion. Fewer single occupant motor vehicles will help free up space for other purposes, such as urban goods movement or placemaking. Design streets to encourage and support higher volume and more space efficient modes like walking, cycling and public transit, whenever possible.

An example of the efficient use of space to increase person capacity is the improvement to the Richmond-Adelaide corridor - converting a travel lane to a protected bicycle lane led to an increase to overall person capacity. Evaluations of such projects are important to monitor person capacity, traffic operation and impacts on emergency response.

Figure 8-1: Toronto Version of the famous Munster, Germany graphic illustrating space requirements between autos and transit.



transit
1m²/second

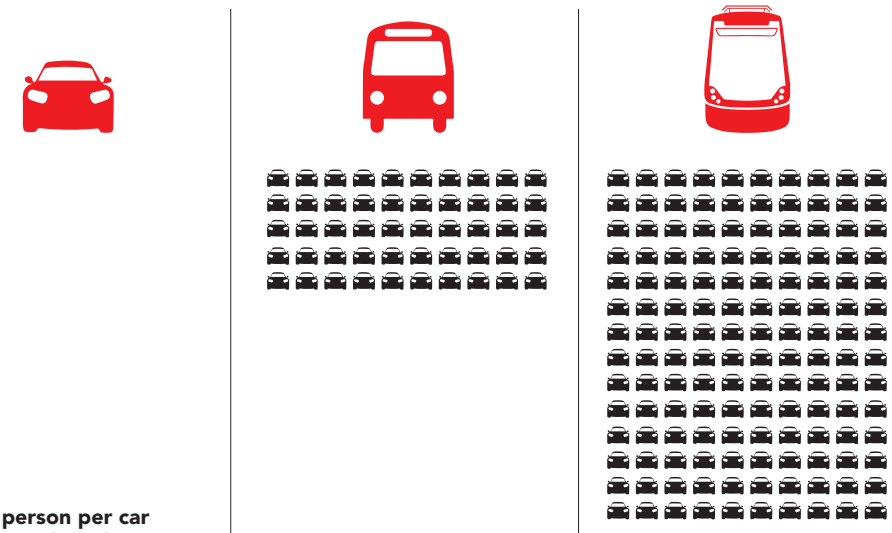
walking
1m²/second

cycling
4m²/second

single occupant automobile
19m²/second

Figure 8-2: Road space required per passenger for various travel modes. Street space requirements increase with vehicle speeds, as faster vehicles require more "shy distance" between them and other objects. Space requirements also decline with more space efficient modes like walking, cycling and taking transit. An automobile on an urban arterial requires about 20 times as much space as a pedestrian or transit passenger, and five times as much as a cyclist.

source: Adapted from Litman, T. August 2015. "Evaluating Complete Streets". Assumes typical dimension and travel speeds of walking (5km/h), cycling (15km/h), transit (25km/h) and auto (30km/h), with bus transit occupancy at 60% or 30 passengers and 1.2 passengers per automobile.



1 person per car (typical single occupant vehicle)

50 people per bus

130 riders per new streetcar

Figure 8-3: Mode Priority and Capacity. For longer trips, transit can move far more people and with greater efficiency than single occupant motor vehicles.

source: Metrolinx, TTC

8.3 DESIGN FOR SAFETY OF VULNERABLE USERS

Vulnerable users such as pedestrians, especially children, the older adults and people with disabilities are the priority. Pedestrians are more vulnerable to serious injury or death in motor vehicle collisions, as well as in interactions with cyclists given the differential in mass, speed and momentum. Pedestrians and cyclists are at greater risk of injury and mortality during a collision than motor vehicle occupants. Reducing speed is a critical aspect to improve safety for the most vulnerable.

Pedestrians are the most vulnerable road users.

Cyclists are also vulnerable road users and have a high risk of injury and mortality during a collision with motor vehicles.

Street design teams shall consider the safety of vulnerable users throughout every stage of the street project delivery process and design strategies that take into account street context such as:

- Lowering speeds to reduce severe injuries and deaths in the event of a crash.
- Rightsizing travel lanes to meet target speeds for the street's context.
- Prioritizing the safety of pedestrians, who are the most vulnerable of road users, especially children, older adults and persons with disabilities (e.g. mobility, vision, cognitive, and balance issues). Assess risks for the most vulnerable users, ensure dedicated space and reduce exposure to faster modes that may harm or injure pedestrians.
- Shortening crossing distances and exposure of vulnerable users to vehicles in the roadway.
- Increasing and ensuring the visibility of pedestrians and cyclists to drivers.
- Curb extensions and rightsizing intersection corners to address turning speeds.
- Separation between different users, and greater separation with increasing speeds.
- Bicycle facilities designed according to context and to make cyclists more visible to turning motor vehicles.
- Placement and design of elements to reduce the opportunity for crime and fear of crime, such as the principles in the Safer City Guidelines and Crime Prevention Through Environmental Design (CPTED).

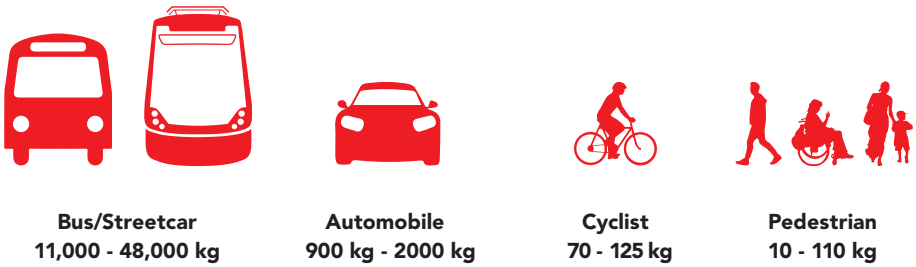


Figure 8-4: Mass of Various Street Users. The severity of a crash increases as the mass and/or the speed increases. The lighter of the two objects will always sustain the more severe injuries or damage.

source: Adapted from NACTO Urban Street Design Guide.

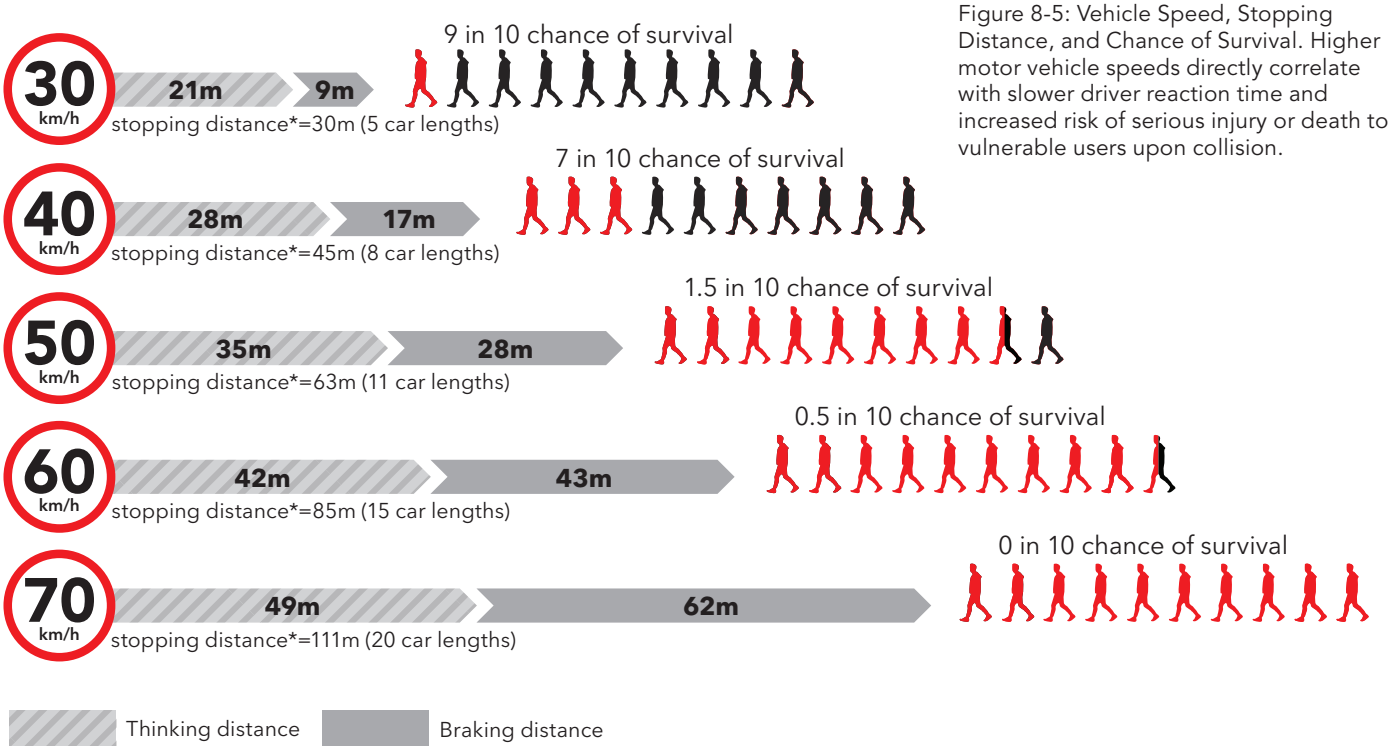


Figure 8-5: Vehicle Speed, Stopping Distance, and Chance of Survival. Higher motor vehicle speeds directly correlate with slower driver reaction time and increased risk of serious injury or death to vulnerable users upon collision.

*Stopping distances during wet conditions. Single car length=5.6m. Based on a 2.5s reaction time, representing 90th percentile of drivers.

source: Adapted from World Health Organization, 2008. Speed management: a road safety manual for decision-makers and practitioners.
Transportation Association of Canada, 2011. Geometric Design Guide for Canadian Roads Part 1. 1.2.5.2 - 1.2.5.4.

8.4 DESIGN USING A TARGET SPEED FOR THE STREET CONTEXT

The speed at which vehicles are travelling is a central factor in the ability to avoid collisions and the severity of crashes should they occur. Target speed is the intended speed of travel for drivers based on the street's context.

Reduced corner radii help to slow turning traffic.

Mid-block curb extensions help reduce vehicle speeds.

Lower speeds increase a driver's field of view and decrease their stopping distance. For example, safe speeds around schools or busy pedestrian areas will need to be lower than on wide streets with large setbacks or land uses that do not generate many trips.

Street design is always more effective in shaping behaviour than posted speed limits. Incorporate context sensitive design feature when redesigning streets to achieve the intended target (posted) speed for the context. More consistent travel speeds support reliable and smooth traffic flows for all road users, and can help reduce incidences on roadways which cause delays and traffic congestion.

Examples of mid-block design measures to achieve target speed based on street context include:

- Rightsizing lane widths mid-block and rightsizing turning radii.
- Mid-block curb extensions to rightsize roadway (e.g., pinch points to reduce vehicular speeds).
- On-street bicycle or motor vehicle parking.
- Trees and other vertical elements ("cause visual friction").
- Presence of pedestrians and cyclists, and facilities that support them.
- Signals synchronized to target (posted) speed.

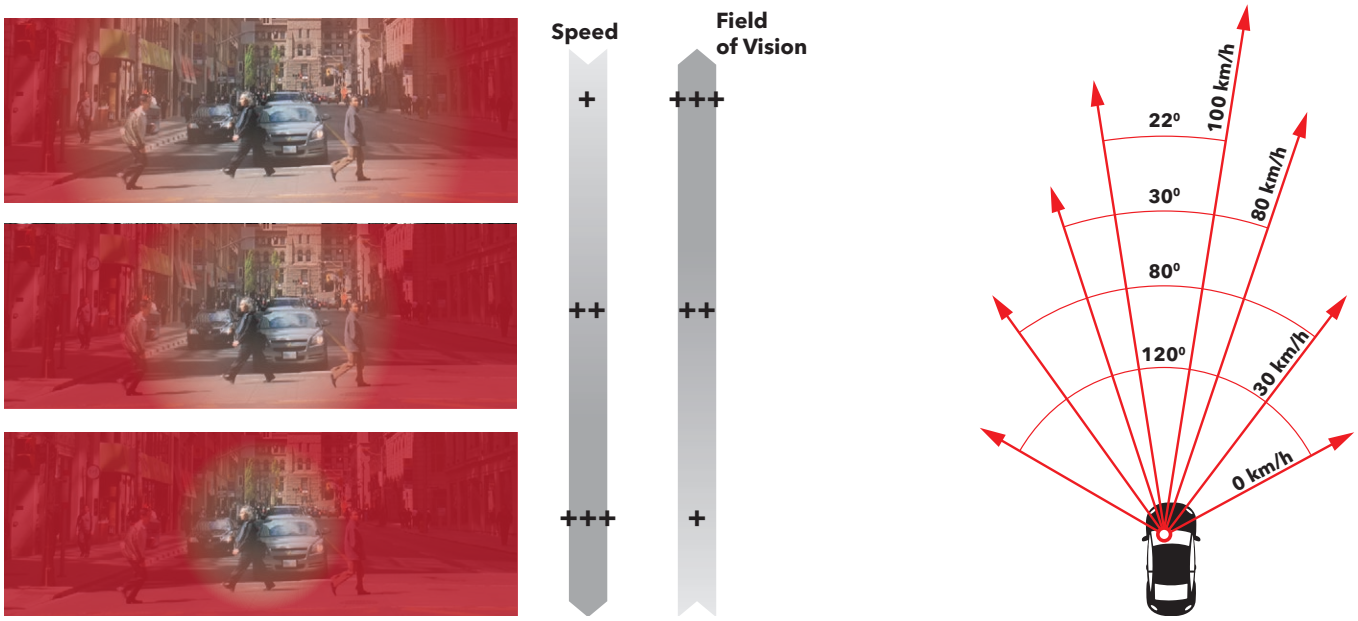


Figure 8-6: Speed and Field of Vision
Speed is especially lethal to vulnerable users like people walking or riding a bicycle. The risk of severe injury increases as a driver's field of vision narrows and misses potential hazards. Field of vision is the area a person sees when their eyes are fixed in one position.

source: base image: mark.watmough flickr: cc.2.0; Federal Motor Carrier Safety Administration; DTAH

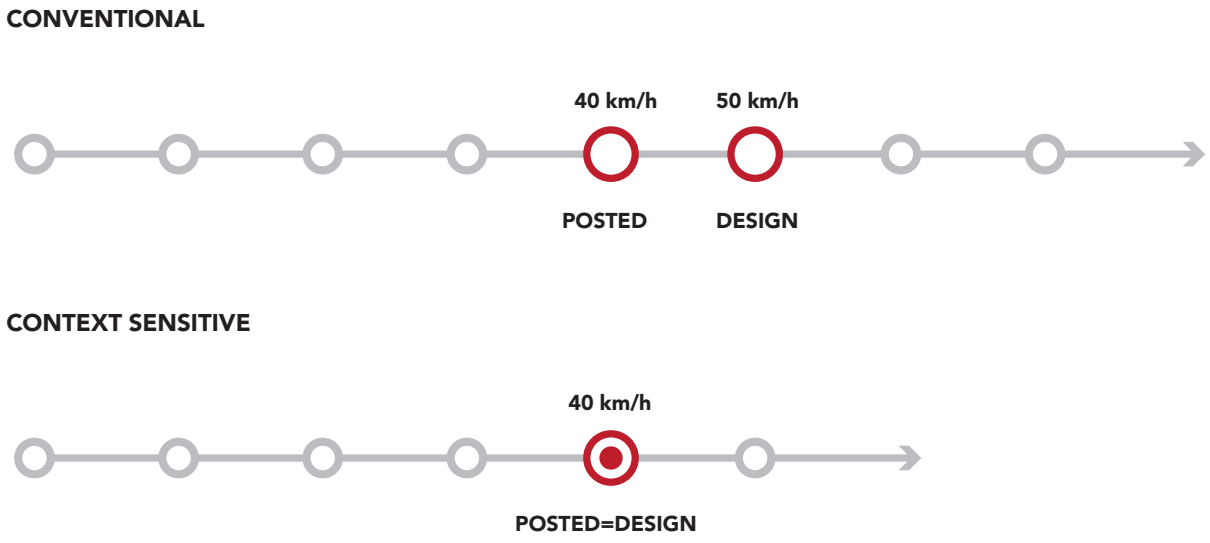


Figure 8-7: Target Speed
Conventional street design considers a posted maximum speed as lower than the design speed. Context-sensitive design promotes that the street includes elements so that both are the same, so that drivers are not comfortable exceeding the intended posted speed.

source: NACTO ; ITE; FHWA; DTAH

8.5

DESIGN TO SUPPORT PLACEMAKING AND STREET CONTEXT

Placemaking is the act of creating public spaces that contribute to the location's unique character. It often involves diverse tactics such as streetscape improvements and event programming to attract social and economic activities to an area like a Main Street. When redesigning Toronto streets, respond to the existing and planned context— taking into account the land uses, buildings, front yard setbacks, activities on the street, and public spaces adjacent to the street itself.

Roadways contribute to placemaking when their design responds to an area's unique social and cultural importance.

Some underutilized roadways in Toronto have been repurposed to meet an area's placemaking, mobility and safety objectives.

c: Courtesy of Waterfront Toronto

Traditional roadway design focused on a "centreline-out" approach where the basis of street design began from the center of the roadway, meeting the vehicle needs first without an understanding of the context that the street exists within. A best practice for transportation engineering is to take a more holistic approach – one that looks at the whole street from building face to building face. Taking a holistic view of streets means applying a "building in" perspective that first looks at the adjacent land uses and users of the street, and then the curb to curb portion of the street. Street context informs the priority functions and uses of the street, as well as details such as choice and quality of materials, need for furnishings, user amenities and greening schemes.

Local context becomes a critical input. Context can range from industrial employment areas to mixed use areas to residential. Street context will inform the priority functions and uses of the street, as well as details such as choice and quality of materials, need for placemaking and furnishings and user amenities, and greening schemes.

Street projects will account for placemaking and context by:

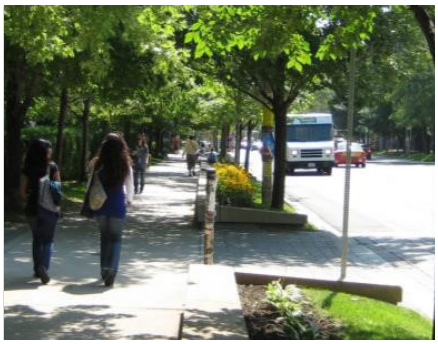
- Assessing the street from a holistic perspective (building face to building face), taking into account the adjacent land uses, ground floor uses and setbacks of a street together with designing the roadway or curb-to-curb portion of the street.
- Using information in Chapter 2 on Street Types and data inputs such as maps and overlays to identify and understand a project area's context (both existing and planned land uses and priority networks, e.g., for transit, cycling and goods movement).
- Using consultation and engagement, as outlined in Chapter 3 on the steps to designing streets to obtain input on a project's street context.
- Developing a full profile of the street's current and future context, uses and various users of the street and developing a priority for space allocation for the street.
- Seeking ways to enhance and support the unique character, e.g., social and cultural aspects of the location of a street, such as designing public spaces for lingering and respite, not just movement. For example, curb extensions on side streets enable seating and plantings to enhance local character. Street furniture, pedestrian scale lighting and public art will also contribute to the identity of a street.
- Looking at strategies that include use of building setbacks and/or repurposing underutilized roadway space for placemaking objectives for a street's context.

8.6

RIGHTSIZING & REPURPOSING ROADWAYS AS COMPLETE STREETS

On many streets, a key objective is to observe what space is not being used effectively and to rightsize and repurpose the space to achieve complete streets goals.

Curb extensions provide space for green infrastructure and street furniture.



St. George Street lanes were repurposed to widen sidewalks, add green infrastructure, and improve safety for all.

Rightsizing and repurposing roadway space essentially involves the following approach:

- Observing and thinking critically about the required space needed by various road users to enable safe mobility and access (see Chapters 4 to 9 on each component related to pedestrians, cycling, transit, green infrastructure, roadways and intersections).
- Ensuring that excess space is not provided for any one mode to the detriment of the safety of other modes and/or street project objectives such as safety and target speed, active and sustainable transportation options, placemaking, greening or universal design and accessibility.
- Gathering all of the relevant background information on a street's context and evaluating design options against the complete streets goals and street project objectives developed through the street design process outlined in Chapter 3.
- Developing and evaluating street design options, and finalizing the reallocation of space in the roadway.

Rightsizing and repurposing roadway space involves redesigning the physical space and using geometric design to improve safety conditions for everyone using the street. Design techniques include:

- Curb extensions mid-block or at intersections.
- Chicanes (or road narrowings) such as using on-street parking, or curb extensions, that alternate on a street.
- Reconfiguring four lanes into three, with the shared turn lane as the middle lane.
- Reviewing for adequate corner radii for truck routes or transit vehicles.
- Rightsizing vehicular lanes and repurposing space to on-street parking and/or bicycle lanes and/or widened sidewalks and boulevards.
- Rightsizing pavement and repurposing space to add or widen a sidewalk and/or boulevard where there is none to provide for safe space for pedestrians and universal accessibility.
- Repurpose or redesign sidewalks and boulevards to ensure that the pedestrian clearway is not cluttered or obstructed, such as by moving a

transit shelter to the back of a sidewalk onto private property through an easement or providing outdoor café patio seating using a parklet.

Potential co-benefits of rightsizing and repurposing roadway space include opportunities for landscaping and stormwater management if the features enable greening or the use of permeable surfaces. All of the above and previously described design techniques will also take into consideration the accommodation of emergency vehicles and year-round operations and maintenance. By increasing perceptions and experiences of safety and repurposing space to other uses such as placemaking, more people may walk and cycle in the neighbourhood or frequent local businesses to support local economic development.

Repurposed roadway space to improve cycling facilities on Sherbourne Street.

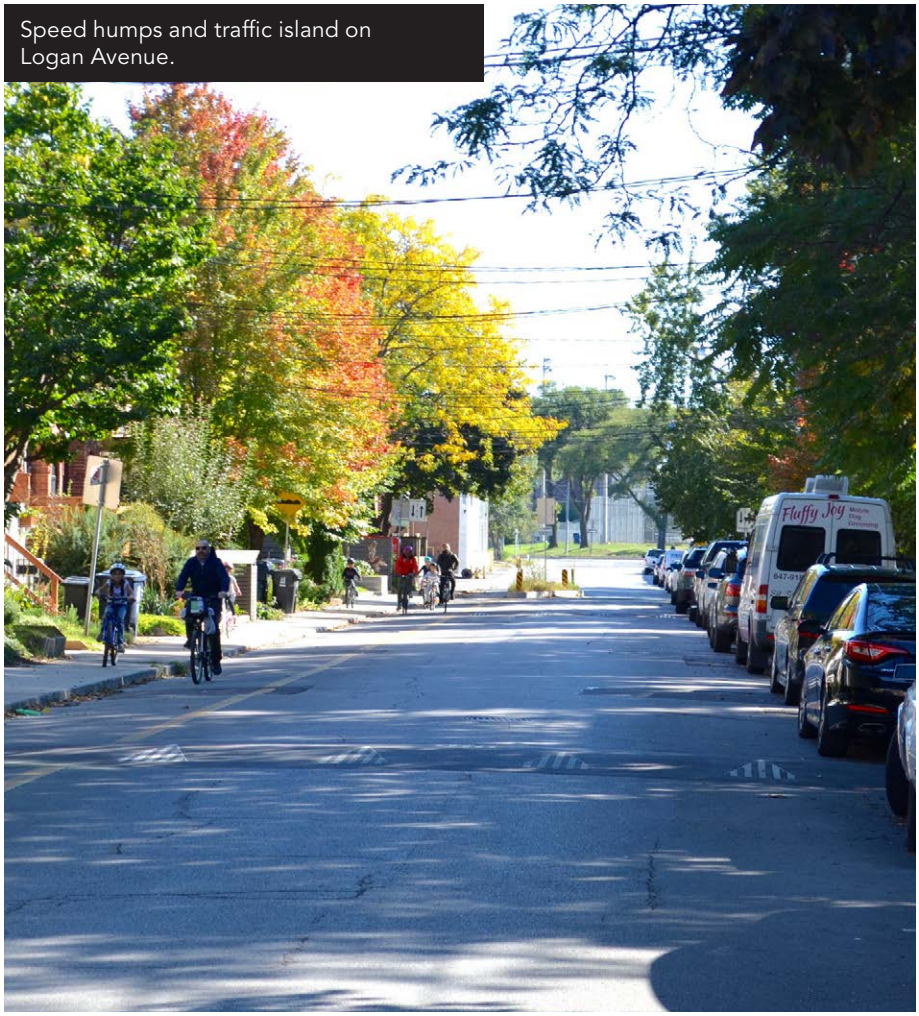
8.7

TRAFFIC CALMING

In Toronto, traffic calming measures, such as speed bumps or diverters may only be used on local and collector roads. The City's Traffic Calming Policy (2010) defines traffic calming measures as well as the criteria and process for applying them to streets. The purpose of traffic calming devices is to alter drivers' behaviour and to improve road safety. The need for these devices is often an indication that the street is not well-designed to achieve its desired target speed for vehicles. The better approach is to seek opportunities through street redesign projects to rightsize and repurpose street space to achieve complete streets objectives. When implementing traffic calming, treatments intended to curtail motor vehicles should exempt cyclists, not be located on transit routes and should accommodate emergency vehicles and winter maintenance requirements.

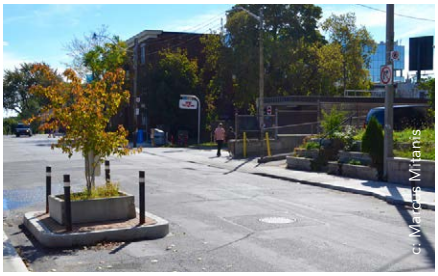
Traffic calming on Armadale Avenue in Etobicoke using a raised concrete island.

Speed humps on Falstaff Avenue in Etobicoke.



Speed humps and traffic island on Logan Avenue.

Treatments curtailing motor vehicles should exempt cyclists.

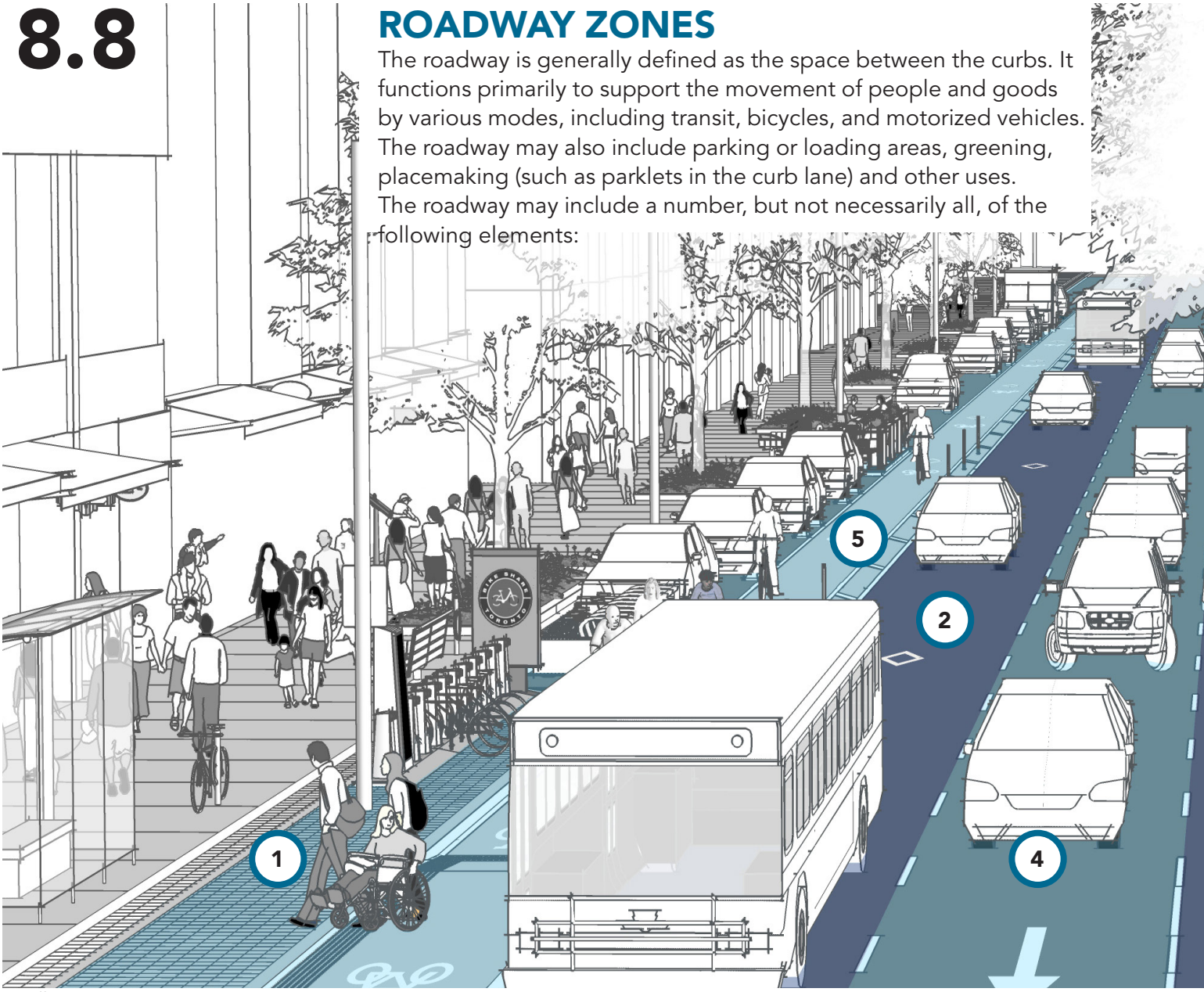


Traffic island on Armadale Avenue.

8.8

ROADWAY ZONES

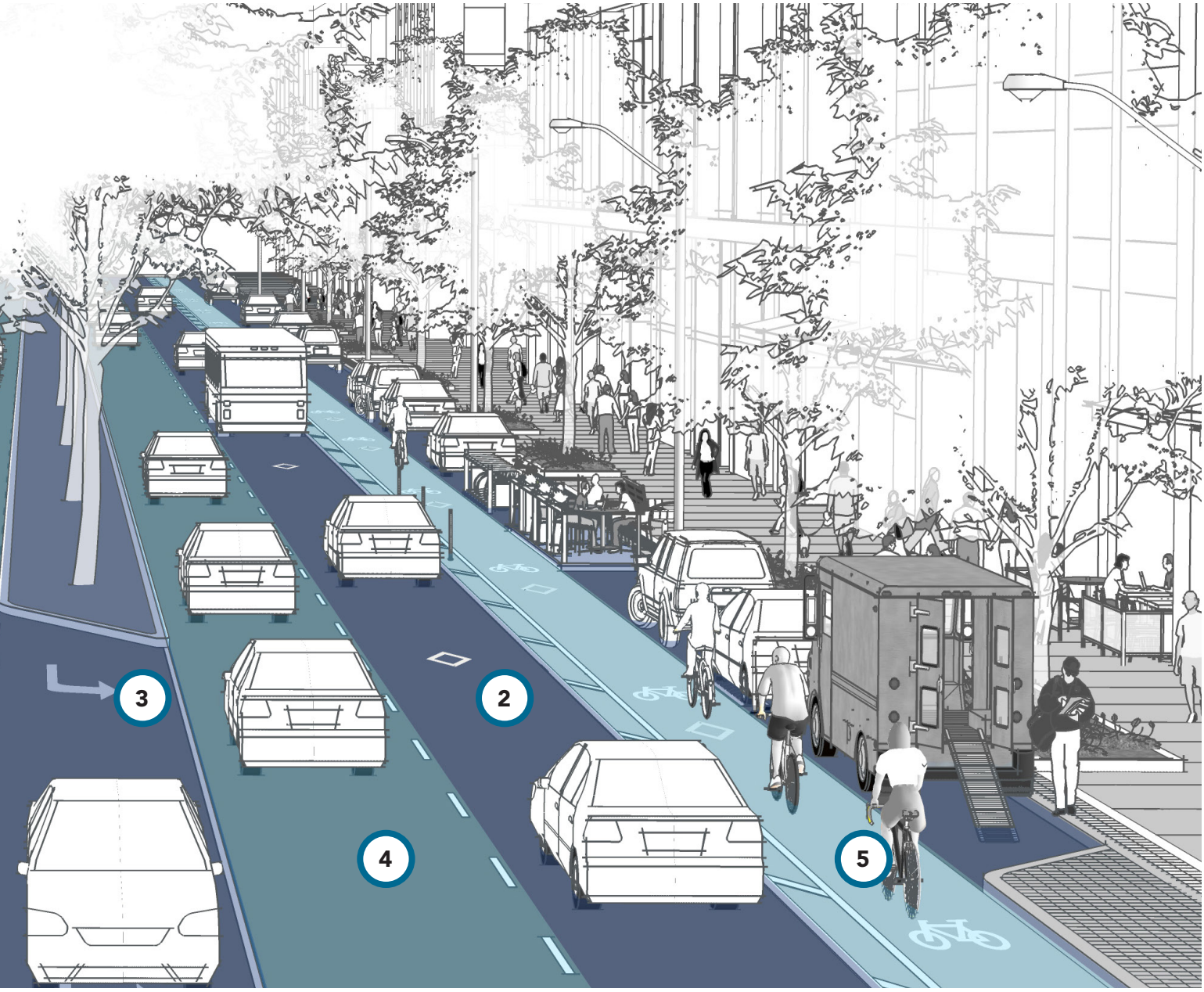
The roadway is generally defined as the space between the curbs. It functions primarily to support the movement of people and goods by various modes, including transit, bicycles, and motorized vehicles. The roadway may also include parking or loading areas, greening, placemaking (such as parklets in the curb lane) and other uses. The roadway may include a number, but not necessarily all, of the following elements:



For illustrative purposes.

1. Curbside Space. The area next to the curb is the space that is often in high demand by diverse and competing uses, such as cycling facilities, public transit (boarding/disembarking), accessible parking, parking/pick up/drop-off, delivery vehicles, driveways, access to buildings, on-street parking of various types, parklets or curb extensions, waste/recycling collection and snow storage.

2. Transit Lanes. These lanes, if present, could share a centre or curb lane with other vehicles (for example High Occupancy Vehicle Lanes) or act as fully dedicated transit only lanes or facilities. The width of these lanes will need to accommodate transit vehicles (buses, streetcar, or light rail transit). See Chapter 6 on Transit for design guidance.



3. Turn Lanes and/or Medians. If present, painted or built medians in the centre of the roadway may provide for a number of different uses including lane separation, Left Turning Lanes, Pedestrian Crossing Islands, and space for streetscape elements on wider medians such as planting, public art and public space (e.g. University Avenue).

4. Vehicle Lanes. These lanes serve vehicular movement, including thru and turning movements. The width of the lanes depends on many factors and is informed by street context and priority network requirements such as transit routes or routes with high truck volumes.

5. Cycling Infrastructure. Depending on the street's context (including vehicular speeds and volumes), there may be cycling facilities in the roadway that are demarcated by pavement or physical separation from moving motor vehicles. Depending on the context, these cycling facilities may be located curbside, or separated from the curb by a row of on-street parking. See Chapter 5 on Cycling for design guidance.

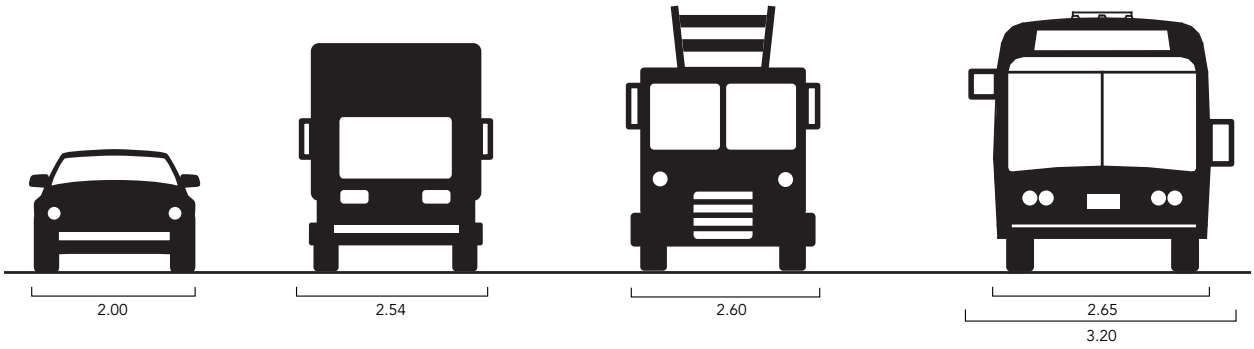


Figure 8-8: Drawing of Typical Road User Dimensions for four different types of vehicles: cars, delivery trucks, fire trucks and TTC buses.

Context is a key factor in the City's approach to vehicle lane widths.

Signal retiming is an important part of the City's Congestion Management Plan.

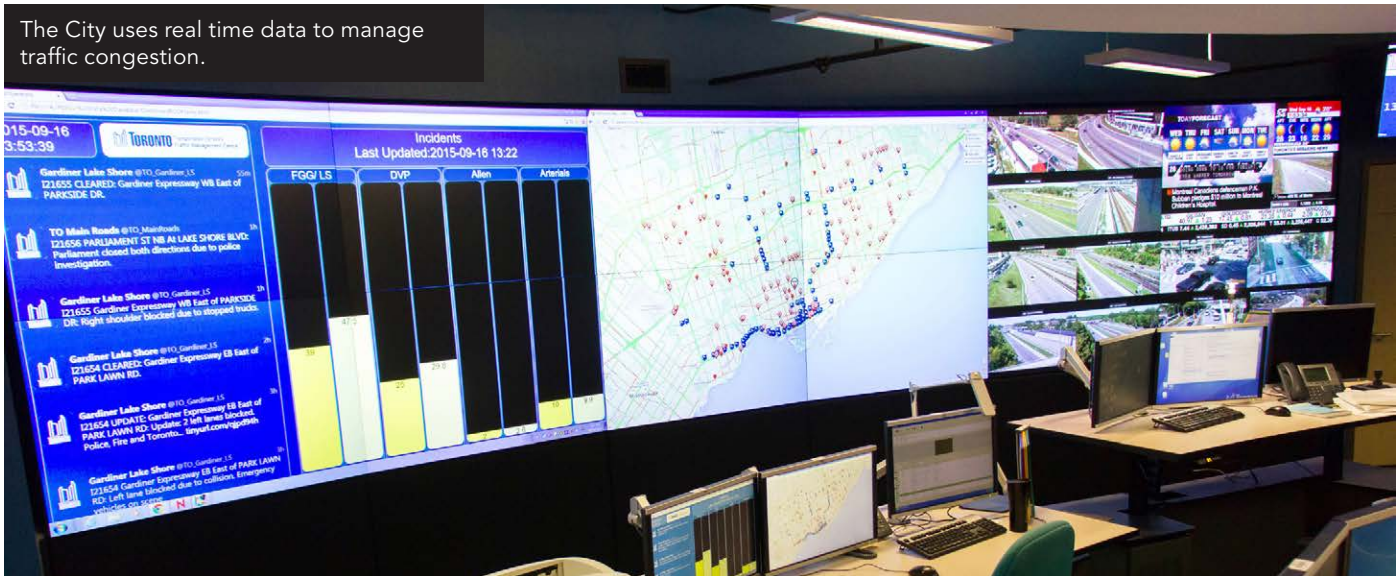
VEHICLE LANES

Vehicle lanes are typically striped to delineate the path of travel for vehicles along a street. They serve the movement of people and goods by various modes. The City of Toronto's Lane Width Guidelines provide guidance on selecting the context-appropriate lane widths in order to improve safety, consider all road users, and balance roadway space for other competing uses.

Travel lane widths can range from 3.0m to 3.5m depending on context and constraints, including land uses; presence of pedestrians, cyclists, and transit; truck volumes; emergency services; posted speed; on-street parking; etc.. Curb lane widths depend on whether there are cycling facilities – if there are not dedicated cycling facilities, the curb lane width should still be designed to enable a car to safely pass a cyclist on the roadway.

HIGH OCCUPANCY VEHICLE (HOV) LANES

Lanes marked with signs and markings to indicate which vehicles are permitted to travel in the lanes. HOV lanes are intended to provide travel time incentives to people who carpool, use public transit or ride taxis, motorcycles or bicycles, so that limited space on city streets is optimized by moving more people in HOV lanes as well as reducing emissions and air pollution. HOV lanes are accompanied by hours of operation (typically during morning and afternoon peak travel times) and occupancy requirements that consider efficiency and use of the lanes. The City's Congestion Management Plan includes reviewing HOV lane locations and ways to improve their use and benefits.



The City uses real time data to manage traffic congestion.

CONGESTION MANAGEMENT

The City of Toronto's Congestion Management Plan 2014-2018 sets out numerous activities to manage traffic congestion to benefit travellers, businesses and the environment. These include traffic management on arterial roads (e.g., Main Streets, Mixed Use Connectors, etc.) and using different technologies (e.g., intelligent transportation systems, upgrading the city's signal system) and partnerships to improve efficiency and coordination on the City's transportation network.

EMERGENCY SERVICES AND OPERATIONS

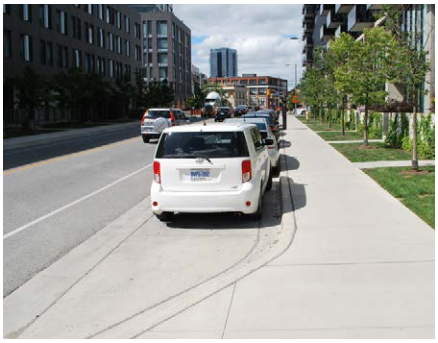
Roadway design must consider the space and operational needs of first responders such as fire, paramedics and police. Fire trucks are the largest emergency response vehicles and need accommodation in the design of roadways. They must have adequate space in the roadway to access structures and fire routes; deploy apparatus, equipment, and personnel safely and efficiently; and provide passable (drivable) space to ensure effective, timely and safe emergency response. For example, in some instances, the transitway may be used as a route for first responders.

One of the potential benefits of the complete streets approach is to improve safety of all road users and to reduce the incidence and severity of crashes to which paramedics, police and fire must respond. Collaborative and innovative efforts exist among city departments to address response times, including system planning for dispatch locations, use of real-time data for traffic congestion, navigation technologies, signal operations and street design considerations.

Space efficient modes help to reduce motor vehicle congestion.

Designs must consider the space and operational needs of fire services and paramedics.

Taxi stands are one of the many potential curbside uses. Curbside space will vary based on context, and may be flexible by time of day, season, or location on the block.



On-street parking in a lay-by.

Seasonal bike parking corral.

CURBSIDE SPACE

The area next to the curb is in high demand for many different uses including access and movement. The uses will vary widely depending on street context and span transit lanes; on-street parking for bicycles, motorcycles, and automobiles; loading/unloading for goods; pick up and drop off including accessible boarding and disembarking; taxi stands, food trucks; parking for film, music and tourism; and collection and storage of snow and solid waste/recycling. It can also be used for an extension of the sidewalk and boulevard zone, for example for parklets. Depending on street context, it can also be space that is used for mobility options for dedicated cycling facilities, transit lanes and stops or high occupancy vehicle lanes. This space can also be treated in a flexible manner through regulation (time of day restrictions for parking) and/or street design (e.g. curb extensions, parklets or laybys).

Since there are many demands from many users for the limited space in this zone, curbside design and management often involves making collaborative trade-offs. It begins with an understanding of the competing demands for its use and the overall context, including the use and design of the whole street such as the adjacent buildings and public spaces.

PARKING

Parking serves an important need for motorists, persons with disabilities and cyclists as well as for the film, music and tourism industries, accessing destinations and can be supplied off-street (e.g., parking lots or garages) and on-street (e.g., temporary, pick up/drop off spots, metered or permitted parking).


Medians help to manage access and provide space for green infrastructure. It is critical to consider impacts on emergency access, maintenance access and costs.


Landscaped mid-block curb extensions.


Traffic island with seating for transit users and new tree plantings.

CURB EXTENSIONS (MID-BLOCK)

A curb extension is where the curb extends out and expands the sidewalk beyond the typical curb alignment. Curb extensions should be considered where on-street parking exists, as the extensions can be on either side of the on-street parking and provide street space for features such as benches, trees and plantings (for stormwater management), surface transit stops, and multi-unit bicycle racks to increase parking. Curb extensions also provide an unobstructed location for fire hydrants that do not have the risk of access being blocked by illegally parked cars. When street elements are installed in curb extensions, it is important to plan and design to maintain sightlines for safety.

PEDESTRIAN CROSSOVERS, MID-BLOCK CROSSWALKS, AND PEDESTRIAN REFUGE ISLANDS

These are discussed in Chapter 4 on Pedestrians.

MEDIANS OR RAISED ISLANDS

Medians or raised islands separate lanes or directions of traffic within the roadway using pavement markings or raised concrete islands. Medians may be applied for different reasons – they can be used to manage or restrict access, provide space for turn lanes (and turning vehicles), facilitate pedestrian crossings, placemaking and provide space for greening. Their application and dimensions depend on many considerations. Since medians typically require a wider right-of-way, the practitioner needs to weigh the benefits of a median against using the space to support other uses and facilities (e.g., curb extensions, cycling facilities, sidewalk and boulevard widening for pedestrians and streetscaping). In addition, medians or raised islands can impact emergency vehicles accessing properties and intersecting side streets, which should be considered in design options.

The design and installation of "soil cells", the underground system to help trees grow, must be coordinated with the location and access of any underground utilities.

Street lighting supports road safety and personal security.

LIGHTING

Street lighting is directed towards roadways and also sidewalks, and is critical at intersections and crosswalks. Lighting supports road safety for all users and enables road users to see each other. Streets with higher intensity of use, such as Civic Streets and Main Streets, will have higher illumination levels than lower intensity streets, such as Park Streets and Residential Streets, which receive lower illumination levels.

UTILITIES AND THE ROADWAY ZONE

Utilities in the roadway can be found at the surface (e.g., catch basins) and below ground (e.g., pipes, ducts, conduits and chambers for water, wastewater, stormwater, electric, telecommunication, and gas). Proactive planning and coordination among various city partners, external organizations and developers will help identify opportunities to site utility elements where they will support design objectives and operational expectations. It is essential to address utility design and engage utility companies early in the street design process.

MORE INFORMATION

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