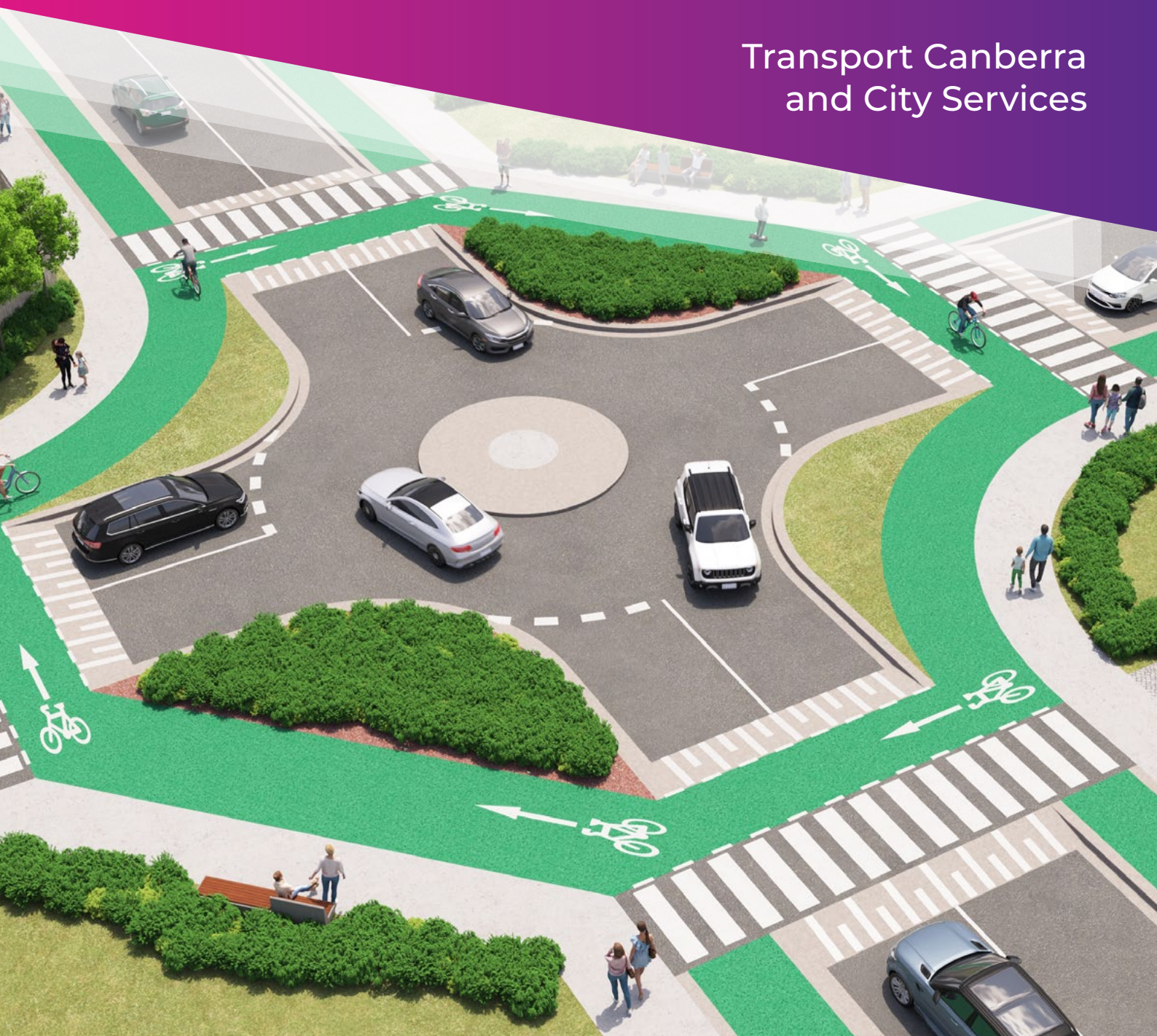
ACT Government

# Design Guide

## Best practices for urban intersections and other active travel infrastructure in the ACT

Transport Canberra and City Services



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Transport Canberra and City Services Directorate,
ACT Government GPO Box 158, Canberra ACT 2601

Telephone: 13 22 81. Website: www.transport.act.gov.au


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# 1. Policy setting

## 1.1. Introduction - Setting the vision for safe and vibrant streets

As we build safe infrastructure, it is important that it reflects best practice to encourage active travel by design. This Design Guide applies the Safe Systems approach to streets and paths in a way that not only makes it safer and more convenient for people walking, cycling and use other forms of active travel, but also makes the street environment safer for all road users.

This guide sets the vision and ambition for safe and people-friendly streets for the ACT. The ACT Government's Municipal Infrastructure Standards (MIS) will be revised based on guidance in this document to make Canberra's streets safer and more vibrant for people who aren't travelling by car. In some cases, this approach applies the right infrastructure standards in a way that is compliant with Safe Systems. In other cases, applying Safe Systems design principles will challenge or exceed current infrastructure standards.

In order to make our streets more adaptable to transport challenges, This guide includes guidance on 'quick-build' treatments that test design solutions in a more flexible, responsive and cost-effective way.

## 1.2. ACT policy framework

The ACT Government has committed to developing best practice active travel design guidance for intersections as detailed in the ACT Transport Strategy 2020:

*'The Government has committed to trial new ways of using roads that most efficiently move people and goods and better support walking, cycling and public transport. This work will also look at the best practice road intersection design from around the world to inform trials of new intersection design, in areas supported by the Movement and Place framework, that prioritise walking and cycling. The ACT Government will develop best practice guidance for industry and stakeholders to inform better design outcomes for active travel infrastructure.'*

This work is aligned with the Movement and Place, and Safe Systems policy frameworks being developed separately by the ACT Government.

The supporting Active Travel Plan outlines a number of priorities for the ACT Government including:

- Safe infrastructure for walking and cycling;
- A better connected and maintained path network;
- Supporting new and emerging types of active travel;
- Overcoming barriers; and
- Supporting behaviour change and partnering with the community.

## 1.3. The Canberra context

Unless designated, all paths are shared and people can use them for walking, cycling, scooting and riding other devices, including mobility aids. People riding can use pedestrian crossings at low speed (10km/hr). Drivers of motor vehicles must give way to people walking or riding over marked crossings, or at signalised intersections when the lights are green. Drivers must also give way to people walking or riding when those people are crossing a driveway leaving a private property. Some of these rules are poorly understood by the general community which highlights the importance of design treatments that clearly indicate this priority..

As the most vulnerable users, pedestrians (people walking or using devices to assist in pedestrian activity, such as wheelchairs or other mobility aids) have priority in the path environment over people riding bikes or personal mobility devices (PMDs – e-scooter and other e-rideable devices as well as non-motorised devices such as skateboards or rollerblades). The ACT has a significant network of footpaths, on-road bicycle only

lanes, and shared paths designed to support more efficient, longer trips for cycling and micromobility. Since 2019, PMDs have been legal to use on paths, but not on roads. We have seen a significant uptake of privately-owned devices, and the e-scooter share scheme was rolled out to all regions of Canberra at the end of 2022. Canberra streets commonly have footpaths on both sides of residential streets, although some only have them on one side and some have none. Streets in newer suburbs were better designed for lower speeds.

Unless otherwise signposted, the default speed limit on residential streets is 50km/ hour. Major collector streets are generally 60km/hr. Both can be modified by localised treatments such as, but not limited to, school zones and high pedestrian areas in the town centres that are limited to 40km/hr.

## 1.4. Using the best practice examples

The *Auckland Urban Street and Road Design Guide* (Auckland Guide) is widely regarded as a current Australasian best practice example for streets that are safe, functional and healthy for all users, not just motor vehicles. Streets that work in this way are often referred to as 'healthy streets', 'living streets' or 'complete streets'. The Auckland Guide is part of a suite of well researched guidance and policy instruments that broadly fit with the ACT policy and guidance framework. In particular, the document closely aligns with the frameworks and principles of Movement and Place and Safe Systems, currently under development by the ACT Government.

Accordingly, the Auckland Guide has been used as key resource in the development of this document. Many sections and illustrations in this guide have been adopted directly from the Auckland Guide, specifically those relating to intersections (Sections 6-13). Other guides have also been used in the preparation of this guide:

- Austroads – Integrating Safe System with *Movement and Place for Vulnerable Road Users*
- Transport for NSW – *Cycleway Design Toolbox*
- World Resources Institute – *Global Street Design Guide*
- Waka Kotahi New Zealand Transport Agency – *Handbook for Tactical Urbanism in Aotearoa*

This guide also draws on the knowledge sharing and collaboration between jurisdictions, professional practitioners and not-for-profit organisations through the Design Innovations Working Group established by Cycling and Walking Australia New Zealand (CWANZ) who have been reviewing these materials on an ongoing basis.

The ACT Government acknowledges all of these sources and the generosity of the authoring agencies in allowing us to benefit from their work.

## 1.5. Safe Systems framework

Safety is a key element under the *ACT Transport Strategy 2020* and will be used to assess current and future performance of roads, streets, corridors and precincts.

A Vision Zero network is about safety for all modes; no matter their priority. Figure 1 shows the relationship between evidence and science and the systematic approaches that can be taken to create a transport network that protects and improves conditions for walking, cycling and public transport and can lead to a more vibrant and healthier city.

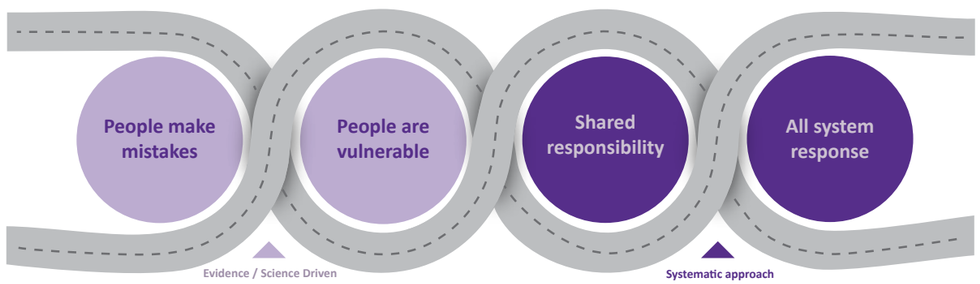



**Figure 1. The interrelation of evidence and approaches we can take in the Safe system approach to designing streets for active travel (Source: *Urban Street and Road Design Guide*, Auckland Transport).**



The *ACT Road Safety Strategy 2020-25* and the and the *ACT Road Safety Action Plan 2020-2023* outline the ACT Government's commitment to Vision Zero. The pathway to Vision Zero follows the Safe Systems approach – integrating safe people, safe vehicles, safe roads and safe speeds (Figure 2.).

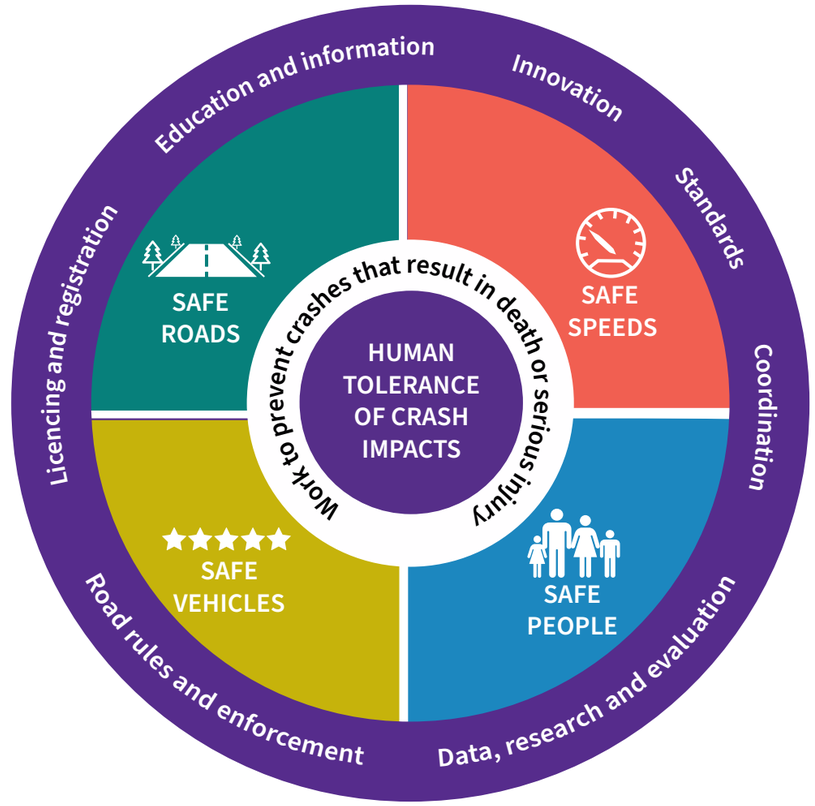



**Figure 2. Safe Systems Model (Source: Safer Roads, Safer Queensland: Queensland's Road Safety Strategy 2015-2021)**

This guide delivers on this commitment by providing best practice guidance on safe roads. The Safe Systems Framework promotes safe and appropriate speeds on our roads, and street designs that are consistent with Movement and Place principles.

## 1.6. Movement and Place framework

The Movement and Place Framework is one of a series of policy frameworks being developed under the *ACT Transport Strategy 2020.*

The Movement and Place approach in street planning and design is a concept that originated in the 1980s in the UK (where it is known as 'Link and Place') and continental Europe. Since then, several authorities in Australia and across the globe have produced guides and frameworks on how to implement the Movement and Place concept in the planning, design, and infrastructure delivery. The concept is highly scalable to suit local, regional or national transport needs.

In Canberra, the ACT Planning Strategy 2018 adopted the Movement and Place Framework. The ACT Transport Strategy 2020 subsequently applied the concept to further integrating land use and transport planning for our future transport network. A Movement and Place decision-making tool is being developed and is currently being tested on a number of ACT Government projects and in the development of a multi-modal network plan.

Once a street is classified it makes it easier to identify appropriate treatments (such as intersections) that support the existing functions of a street, or move it toward more desirable functions.


**Figure 3.** The Movement and Place conceptual framework (Source ACT Transport Strategy 2020)

## 1.7. National Capital Plan

Special treatments are required for 'Designated Areas' under the National Capital Plan. Conserving and enhancing the Griffin's symbolic design and landscape setting for Canberra is important in retaining the special characteristics of the National Capital.

Within Designated Areas, the National Capital Authority (NCA) has responsibility for determining detailed planning policy, and for works approval.
The Designated Areas include:

- Lake Burley Griffin and its foreshores
- The National Triangle (or Parliamentary Triangle); and
- The road reservations of identified Main Avenues and Approach Routes.

More detail about these design treatments can be found on the NCA website https://www.nca.gov.au/planning/plans-policies-and-guidelines

## 1.8. Scope and use of this guide

This Design Guide provides guidance and examples to help practitioners aspire to best practice in a given context, rather than strict technical compliance with standards. Too much attention to the latter can lead to outcomes that do not work for some or, at worst, all users. This Guide incorporates the intent of the ACT Safe Systems and ACT Movement and Place Frameworks and includes two distinct elements:

- Best practice design guide for urban intersections - *This document*
- Draft updates to MIS documentation to reflect this work – *A separate piece of work which will commence once the Design Guide is finalised.*

Section 13 of this guide contains specific guidance on the best practice for designing select intersection types. Each intersection design type includes **Recommended Treatments** for achieving the intersections **Design Objectives**. Detailed dimensions have not been provided to encourage a more lateral and holistic approach to the design of urban intersections at locations where movement and place functions are both of great importance. All example images are illustrative, and the final design will be determined by the context and with due consideration of the requirements of standards.

The intersection designs include different urban street types and suitable treatments for both new estate developments (greenfield) and retrofits of existing intersections (brownfield).

## 1.9. The role of intersections and crossings

Most conflicts and crashes occur at intersections and crossings because this is where different users come together.

Intersections and crossings must be designed in a way that ensures they can be seamlessly and intuitively navigated, safely and easily, and are predictable to all users passing through. This is a result of a holistic approach where the design is uniform and consistent. Safe urban intersections allow all users to make eye contact with one another, and are places where people who are walking, riding and driving are aware of each other. They encourage people to approach with care and at safe speeds, so that any collisions caused by user errors are survivable.

Equally important to intersections being places where people pass through, is that intersections are also public places where people meet and linger or conduct business. Excellent intersection designs have the potential to unlock a city's economic and civic potential, and revive under-utilised areas with street life.

In urban contexts, intersections become the most complex and challenging part of street design. As pinch points in the road network, they are often overbuilt and tend to prioritise vehicle traffic and throughput, making them difficult to negotiate for people who are walking and riding. To guarantee safety for all users, a number of principles should be considered when designing intersections, not only to make them convenient to navigate, but to also to ensure they work well as public places. These principles do not always align, requiring considered approaches to every context.

## 1.10 The importance of context and collaboration

Successful designs will depend on the context. What works in one location may not work in another depending on the volumes and types of users amongst other things. It is crucial that practitioners observe and collaborate with users, municipalities, developers and local institutions to ensure that their designs respond to this context. These key design principles are discussed further in Section 6.

# 2. Principles of safe design

## 2.1. User-centred

This guide recognises that active travel networks and intersections with roads are used by a broad range of users who travel for similar reasons, whether that is for work, shopping, education or leisure.

At the human scale there are people who:

- make different types of active trips (walking from the carpark to the office or cycling long distances between regions);
- use a diverse range of active modes (by foot; small and large wheels; devices designed for high and low speed; and devices with different manoeuvrability);
- have different abilities (a child who is unable to judge safe road environments, a person with mobility challenges who needs more time to cross the road, a person with a sensory impairment who reads the environment using different cues); and
- are more and less predictable or responsive in their behaviour (children, animals, people who may be easily startled).

All of these people share the same path environment.

Similarly, the road environment includes motor vehicles of different configurations used for different purposes:

- Professional drivers in public transport (buses and light rail);
- Emergency workers in a range of specialised vehicles (cars, trucks, ambulances);
- Commercial drivers for delivery (small and large cars and trucks);
- Travel between work sites to do their work (i.e.: builders, community services workers);
- Services provided by specialised vehicles (waste removal, mowers, tractors);
- Commercial cars (ride share); and
- Private travel (privately owned cars).

## 2.2. Safe roads and streets

One of the principles of the Safe Systems Framework is Safe Roads. This guide provides five design principles to ensure that roads and streets are consistent with Safe Systems:

- **Functionality:**
  - A functional hierarchy is used to determine priority at junctions and intersections of both roads and paths, and the design elements reinforce this hierarchy.
- **Speed of the road or path environment:**
  - Equality in speed between modes and users on shared paths or roads, or separate facilities in areas where speed differential is greater.
- **Forgiveness:**
  - Road and path users make mistakes, but mistakes should not result in serious injury or death.
  - Limit injuries through a forgiving road environment and anticipation of road user behaviour.
- **Self-explaining streets and paths:**
  - Predictable and consistently designed infrastructure which provides users with a clear indication on travel behaviour and direction.
- **State of awareness of road users:**
  - Ability of the road user to process information from the road/path environment and adapt their responses to suit.

### Functionality

Within the Movement and Place Framework, there are functional hierarchies for walking, cycling and road traffic. The design of intersections and junctions between different road classifications should clearly show change from one function to another.

| Movement class | Functional hierarchy |
|---|---|
| **Road** | Arterial/Orbital<br>Collector<br>Local |
| **Cycling** | Principal<br>Main<br>Local |
| **Walking** | Central<br>Primary<br>Secondary |

**Table 1. Functional hierarchies for movement classes**

### Speed of the road or path environment

Achieving safe speeds is a critical component in for safe street and intersection design.

Where people who are walking, cycling and driving share road space, the road or street environment should be designed to achieve equitable travel speeds (30km/h or less). If equitable travel speeds are not achievable, then separate facilities should be provided.

At intersections, people driving yield more frequently to people walking and riding when speeds are low, making it safer for path users to pass in front of turning cars. Lower speeds give drivers more time to stop if needed and reduce the severity of collisions when they occur. Other design considerations that can reduce driver speed are smaller turn radii, centreline hardening, turn speed bumps, and raised crossings and bike paths.

Speed also needs to be considered in path environments where there are faster moving bikes and micromobility devices, and people walking and lingering. Depending on the movement and place classification separated facilities, or other design considerations to slow speeds between path users in shared environments, may be required.

### Forgiveness

Path facilities should be designed to eliminate path-side hazards such as bollards, railings, poles, fences, overhanging vegetation, drainage grates, slippery or longitudinally grooved surfaces, ramp lips above 100mm, and inadequate clearances from moving traffic.

### State of awareness of road users

Providing predictable and consistently designed infrastructure which provides users with a clear indication on travel behaviour and direction.

### Self-explaining

Walking, cycling and other forms of active travel have differing needs and require different infrastructure solutions. Cycleways should be separated from footpaths where feasible particularly in busy areas.

People on bikes crossing busy intersections need clear priority over the turning movements by motor vehicles. Yielding behaviour can be improved by implementing bike-friendly signal strategies.

## 2.3. Design principles for roads and streets

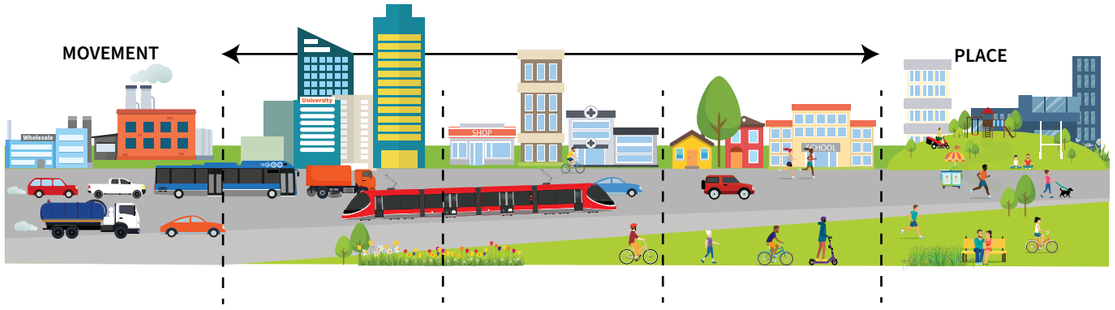
| Design principle | Response | Application in street and path design |
|---|---|---|
| Forgiveness | On new or rebuilt roads and streets, design for safe and appropriate speeds where vulnerable road users are present | Design speed:<br>• Residential streets should be designed for 20k/h speeds regardless of the posted speed.<br>• Central corridors and roads with posted speeds of 60k/h or under should be designed for 10k/h less than the posted speed.<br>• Orbital corridors (traditionally referred to as arterial roads), rural roads and roads with a posted speed of 70k/h and above should be designed for 10k/h over posted speeds.<br>• On-road shared environments (riding and driving) should be designed to achieve equitable travel speeds between modes.<br>Posted speed:<br>• 50k/h on collector streets.<br>• 40k/h may be considered for suburban local streets. |
| | Manage existing roads and streets to encourage safe and appropriate speeds where vulnerable road users are present | Management of residential streets in existing suburbs is guided by the safe systems ambition for safe and appropriate speeds. Existing streets need to be assessed on an individual basis and require traffic calming if current speeds exceed survivable speeds. |
| State of awareness | Compact intersections | Use signalisation instead of slip lanes and high-speed roundabouts to minimise intersection footprint, pedestrian crossing times and distances as well as conflict points.<br>Minimum number of lanes and lane width. On non-orbital corridors, a lower level of service for motor vehicles may be acceptable in order to achieve a more compact footprint. |
| | Visibility of people walking, cycling and other forms of active travel | Design should aim to provide good lines of sight without encouraging higher speeds of vehicles.<br>Setting back bikeway crossings, installing recessed stop lines for motor vehicles, and building raised bikeway crossings all make it easier for drivers to see people using the bikeway. |
| | Crossing points | Safe crossing points (zebra crossing, school crossings, median refuges) provide safety and convenience for people walking. They should be assessed on a balance of factors, which include but are not limited to, warrants based on walking and motor vehicle volumes. |
| Self-explaining | Path widths | Shared path designs should consider the volume and speeds of waking and cycling, with mode separation provided in high volume locations.<br>Path widths in Primary walking areas should be wider to accommodate larger volumes of people accessing destinations or public transport. |
| | Integrate of space and time | Signalisation of intersections allows them to be altered instantly and temporarily. This means the same space can be opened up to some users, while access is restricted to others, alleviating the need to widen the intersection to address delays and congestion concerns. |
| | Flexible designs to accommodate changes over time | Use pop-up treatments to test new designs.<br>Provide separation for painted on-road cycle lanes and shortened crossing distances particularly at conflict points to provide direct connections for people on bikes.<br>Consider as part of upgrades or new works. This could utilise surface mounted kerbs, painted buffers or a ‘road diet’ where road space is reduced and reallocated for other uses (traffic calming and walking and cycling).<br>Temporal application of speed zones could be considered, for example special events. |

# 3. Street types

To guide future developments and road, street or placemaking projects, the *ACT Planning Strategy 2018* contains a set of street types that classify roads and streets based on the adjacent land uses (place) and transport function (movement) using the Movement and Place Framework (See 3.1 below). These street types can be enhanced with design solutions that meet the aim of the street. Section 4 of the guide shows how the strategic direction of the street types outlined in the Movement and Place Framework can be translated into design solutions that meet the aim of the street.

The detailed illustrations of intersections used in different street types in Section 8 are not prescriptive or intended to be used as templates, but are used to guide design thinking and discuss particular aspects. Many streets will vary from commonplace functions. Some special cases are described in the sub-types included later in this guide, with discussion of design issues. Where street space is limited by existing development or other fixed features, the design will have to respond and adapt to these constraints.

## 3.1. Street types and classifications






## 3.2. Urban street zones

In urban areas, the cross-section of all street types can be segmented into different zones. From the property boundary, these include:

1. **Frontage zone** - the space adjacent to the building edge where ground-floor uses spill out onto the public realm, such as outdoor dining. It can be an extension of the active land uses found along a street. The frontage zone is where the features found along the edge of a street interact with the street use.
2. **Clear footway zone** - provides a movement zone for people on foot, e-scooters or other mobility devices (including prams) to travel side by side and pass each other in either direction, that is clear of any obstacles. This facilitates through access for people walking or riding along a street, regardless of age and abilities. Frequent safe crossings provide continuity for people on foot.
3. **Street furniture zone** - the designated area for a variety of features, not limited to street furniture. It provides space for signs, light and signal poles, street trees, public transport stops, rubbish bins, and any additional underground infrastructure.
4. **Kerbside zone** - sitting between the street furniture zone and the roadway, this area offers opportunities for flexible use of the urban realm including walking improvements (such as kerb build-outs), patios and parklets, separated cycleways, parking for cars and micromobility, loading zones, taxi stands, pick-up/drop-off zones and public transport stops.
5. **Roadway** - provides space for through movement for motor vehicles, public transport and for the delivery of goods. In off-peak hours, this space may be partially used for parking and loading. On occasions, access to vehicles might be restricted to provide space for events and festivals.

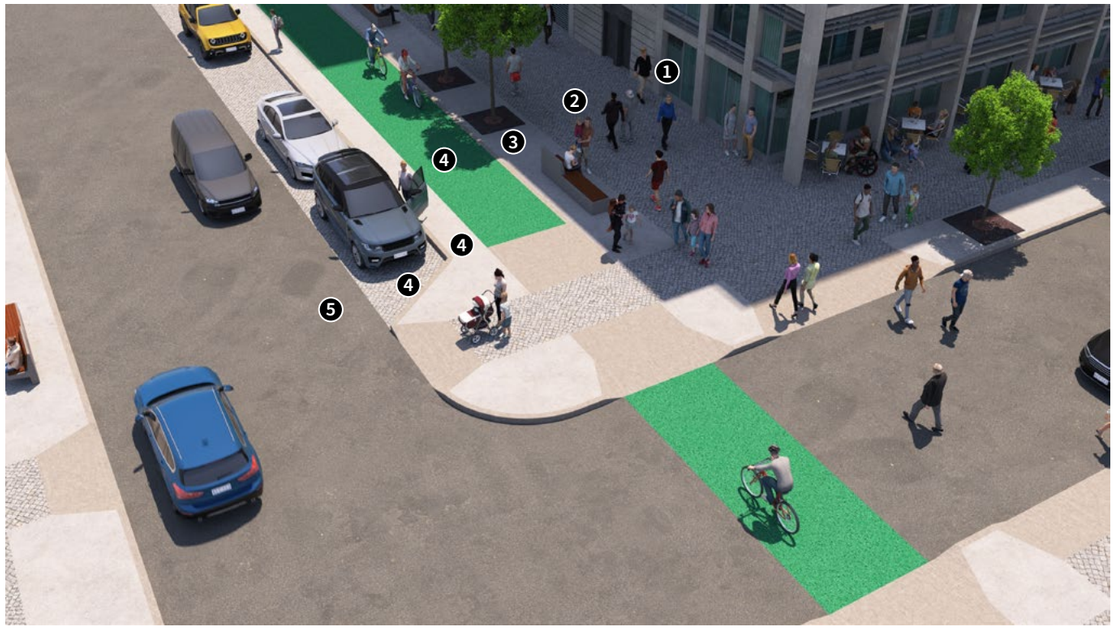



**Figure 4.** **Street zones [adapted from the *Urban Street and Road Design Guide* (Auckland, 2022)].**

### More information:

*The Urban Street and Road Design Guide* (Auckland, 2022) provides more detail about street types.

# 4. Walking

Walking is the most accessible, affordable and equitable form of transport. Within the movement hierarchy and street types, people on foot are prioritised in the design of *Vibrant Streets, Local Streets and Places for People. Walking* is the most intense experience of streets due to the slow speeds and short distances at which people move when on foot or using pedestrian devices. Enriching that sensory experience and making it safe and more comfortable will make it more attractive. A person walking with crutches, a person in a wheelchair and a young parent with a pram all have an equal right to reach any destination accessed by public streets in a city. Priority should be given to designing for the most vulnerable users in mind, such as the elderly, the young and people with mobility impairments. Every street must be accessible by people of any age and ability.

Walkable cities are places that are easily and safely navigable on foot and offer a sense of equity and independence. Walking has the capacity to promote equality and reduce social exclusion.

Walking is good for health both physically and by creating social connections that benefit psychological health. Street design should enable many trips, especially shorter ones, up to 10 or 20 minutes, to be made by walking rather than motor vehicle.

A street environment that encourages walking should:

- enable comfortable flow
- promote social interaction
- provide a sense of safety
- improve accessibility for people with limited mobility
- move large numbers of people efficiently (*Vibrant Streets and Places for People*), and
- enhance the liveability and sustainability of the city.

## 4.1 Walking cross-sections

This section should be used to design according to the intensity of walking use predicted for the life of the infrastructure using the movement and place classifications outlined in Figure 3..

**Local streets – residential, low activity (M1/P1)**

- Verges and footpaths in residential neighbourhoods vary in width, depending on their context.
- Where footpaths exist, they must be at least 1.5m in width.
- Designing for low activity, this is appropriate where people walking are unlikely to pass people coming the other way.
- This layout is appropriate for low-activity areas only– it does not enable people to pass each other coming the other way or walk side-by-side.
- A clearance of 1m between the footpath and property boundary is recommended.

**Local streets – medium activity (M1-2/P1-2)**

- Designing the walking environment on local streets for medium activity is appropriate where people walking are more than likely to pass people coming the other way.
- 1.8m wide footpaths support two people walking side-by-side, and passing when people are walking single file.
- 2m – 3m wide footpaths support two people walking abreast, or two people walking together past another person.

**Local streets – residential, low activity (M1/P1-2) shared street option**

- Local streets with low traffic volumes should be low speed to allow the space to be shared by all users, particularly where there are no footpaths.
- Traffic calming measures are typically necessary to achieve safe speeds.

**Vibrant streets – medium activity (M2/P2)**

- People walking are almost certain to pass people coming the other way.
- Paths should support two people walking next to each other without having to walk in single file when passing others.
- For neighbourhood main streets, various configurations are possible depending on the circumstances:
    - Where the clear path sits directly adjacent to the building edge, a width of at least 2.4 m is ideal.

- Commercial activity (such as outdoor seating) is likely to need about 2.1 metres of this space, so additional width may be required.

- On narrower streets, where it might not be possible to provide tree pits, the buffer strip adjacent to the kerb might be used to provide planters or other landscaping features and should be at least 1 metre wide.
- Where the clear path is not situated directly adjacent to the building's edge, a small zone (1.5 metre) of commercial activity might be situated directly in front of the building.
- On busier neighbourhood main streets, a clear path width of at least 3 m is suggested, as are street trees to provide a buffer between higher pedestrian volumes and traffic.
- A furniture zone of 2.4 m would provide for bus stops and other uses.

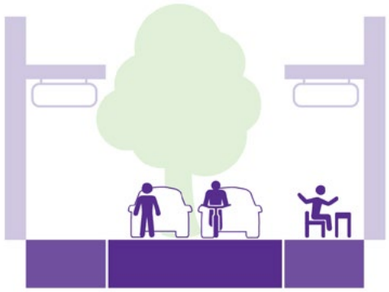
**Vibrant streets – high activity (M2-3/P2-3)**

- Busy commercial streets need multiple zones to provide for on-street commercial activities, a clear path or footway and a distinct buffer between people walking and cycling and motor vehicles.
- Commercial activity that transitions out from the building line onto the footpath in a dedicated area requires about 3.0m.
- Depending on the total width of the footpath and the street, a clear path of 3.0 to 4.2m for higher volume pedestrian paths is appropriate for city and town centres.

- A buffer from traffic of 1.5 to 1.8m is suggested to cater for tree pits, public transport stops and street furniture (such as benches and planters) in the buffer between the clear path and the kerb.

**Places for people – medium to high activity (M1/P3) shared zone option**

- Within shared zones, the entire realm between buildings on both sides of the street effectively becomes the footpath, as it is level throughout.
- People on foot have priority and can walk freely anywhere on the street, only needing to circumnavigate street furniture and street trees.
- The geometry depends greatly on the total width of the street and these environments should be designed on a case-by-case basis.
- However in all cases, the clear footway zone still exists and it is important to provide a clear and accessible path of travel that is safe and protected from vehicles.



## More information:

Section 3 of the *Urban Street and Road Design Guide* (Auckland, 2022) provides more detail about the general needs of people walking, including different walking users (wheelchairs, prams etc), and design features for different street types.

The *NSW Guide to Walkable Public Spaces* (NSW, 2022) identifies 10 characteristics that support places to be more walkable in safety, scale, comfort and interest. https://www.movementandplace.nsw.gov.au/design-principles/guides-and-tools/nsw-guide-walkable-public-space



# 5. Cycling and micromobility

Riding a bike is an affordable, low emissions, healthy mode of transport. The use of cycling facilities is expanding to include scooters, skateboards and other forms of active travel, as well as electrically powered versions of these devices. Safe and attractive cycling infrastructure may also be more appealing for people using mobility scooters. The cycling facilities in this guide follow the Safe Systems approach and the Design Principles listed in Section 2.

## 5.1. Cycling and micromobility cross-sections

This section should be used to design according to the intensity of cycling and micromobility use predicted for the life of the infrastructure. In all options, cyclist movements are protected from vehicle movements by a built kerb height separator or buffer area.

### One-way v. two-way operation

Options for one-way and two-way facilities are provided. Typically, one-way facilities are preferred in urban environments where all users are moving in the same direction as adjacent motor vehicle traffic. The benefit is less complexity of traffic signal operation, greater predictability of movements and less delay.

Two-way facilities may be used where signalised intersections can be avoided (or complexity/delays minimised) or when changing from two-way to one-way operation would be indirect or inconvenient for users.

## Cycling and micromobility cross-sections

**One-way protected cycleway at roadway level.**
*Refer to MIS-05 Bicycle-only path (one-way pair)*

The cycleway width should be more generous than on-road cycle lanes, or off-road paths at kerb level, to allow clearances from vertical elements.

A cycleway width of 2.0m – 2.5m is desirable and allows overtaking or riding side by side. The minimum width is 1.8m. If they are narrower it becomes difficult to manoeuvre different configurations such as cargo bikes and trailers.

**Two-way protected cycleway at roadway level.**
*Refer to MIS-05 Bicycle-only path (two-way)*

The cycleway width should be more generous than on-road cycle lanes, or off-road paths at kerb level, to allow clearances from vertical elements.

A cycleway width of 2.5m – 3m is desirable and allows overtaking or riding side by side, with a minimum width of 2.5m.

Buffers should be a minimum 0.4m in retrofit situations and 1.0m in estate developments. The height of the buffer will be determined by the environment to avoid pedal strike and damage to motor vehicles where there is a tight turning radius. Bevelled profiles may help to address this issue.

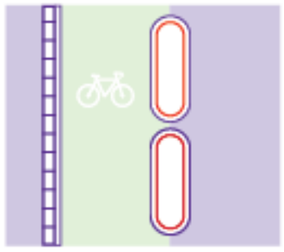
**Protected cycleway at verge level.**
*Refer to MIS-05 Bicycle-only path (one-way pair)*

A cycleway width of 2.0m – 2.5m is desirable and allows overtaking or riding side by side, with a minimum width is 1.8m (or 1.5m at an absolute minimum in constrained situations).

**Separator and buffer dimensions**

The design of the buffer area, on the verge between the cycle path and the roadway, should consider whether it will be used by people walking to cross the roadway or cycleway.

A width of 0.6m or more is desirable, which allows it to be used by pedestrians to pause when crossing the road and cycleway. A wider width of 0.8m - 1.0m should be used where on street parking or loading is present. In these instances, the separator will allow vehicle passengers to alight while minimising the risk of having the door of a parked car opened in the path of a person riding a bike. At a minimum, separator kerbing should be no less than 0.4m wide, or 0.3m for pop-up kerb-and-bollard separators.



Buffers used between parked cars may be castellated and positioned so that passengers alighting from a car do not step onto the buffer, but between blocks.




**Figure 5.** **Example of a movement corridor / suburban arterial cross-section including a footpath, protected cycleway at verge level (one-way), street trees, landscaped buffer and indented on-street parking and roadway with a median. (Pro Hart Avenue, Strathnairn).**


**Figure 6.** **Example of a town centre collector/ *Vibrant Street* including a clear footway, furniture zone with plantings, protected cycleway at road level (two-way), raised pedestrian crossing, indented on-street parking and castellated buffer. (Furzer Street, Phillip).**

## 5.2. Quick-build separator treatments

### Quick build protected bike lanes

Many people do not feel safe using on-road cycle lanes where motorised traffic is busy or fast moving. Quick-build separator treatments are a cost effective and efficient method for providing physical separation between people on bikes and people in cars. They can also be used to quickly enclose pre-existing on-road lanes or to test demand on roads where no current provision exists, prior to installing permanent infrastructure. Some examples of the types of treatments are listed below.

**Bollards only with line marking**

A very quick and inexpensive installation that provides visual separation.

They don't provide physical protection.

An ideal solution for a short-term pilot in urban settings to quickly test demand and the impact on traffic.

**Separator and bollards (Type 1)**

Separator bollards provide strong visual separation, combined with a kerb, and deter vehicles from straying into the bike lane.

They can be installed quickly to provide a short term solution.

**Separator and bollards (Type 2)**

A more robust installation with more robust bollards for medium term trials for the conversion of existing on-road lanes.

**Separator buffers with line marking**

Provide significant protection, suitable for situations where a lane is continuous and there is little pedestrian activity or where pedestrian activity should be directed to controlled crossings, such as arterial roads connecting regions and town centres

Can be purchased as pre-fabricated units.



**Separator buffers only**

Provide significant protection as well as an intermediate pedestrian refuge. Can be built to a range of widths and used as a buffer between a cycle lane and kerbside parking zone or where pedestrian permeability is high.

Can be purchased as pre-fabricated units.

**Planters and other barriers**

Suitable for low speed, low volume environments over short distances

Suitable for temporary placemaking and special events, particularly community delivered and managed installations.

Could use repurposed materials (car tyres, pallets etc.)

Potential WHS issues as they require a high level of maintenance.

### Tactical urbanism for placemaking and walkability

These treatments can also be used for placemaking and to make places more walkable. The range of possible treatments and options are endless and generally determined through a co-design process with local stakeholders. See the resources below for more details.

### More information:

The *Urban Street and Road Design Guide* (Auckland, 2022) provides more detail about the general needs of people on bikes in Section 3 including different configurations of bikes and infrastructure needs for different traffic conditions.

The NSW *Cycleway Design Toolbox* (2020) is an extensive resource which also includes guidance on quick build considerations.

The Vic Roads websites displays a range of treatments to support pop up and quick build cycling facilities https://www.vicroads.vic.gov.au/traffic-and-road-use/cycling/suite-of-treatments.

The *Tactical Urbanist's Guide to getting it done* (2016) provides information about materials and installations as well as case studies from the US. http://tacticalurbanismguide.com/

# 6. Intersection principles

## Make intersections safe for all users

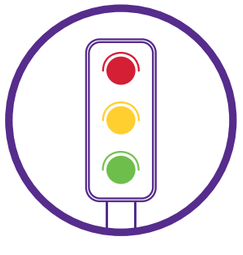
Intersections are safer when users can see each other, are aware of each other, and are able to anticipate and respond to each other's actions and movements. The goal of the intersection should be to not strictly reduce the number of conflicts, but to ensure a space where street users are visible and predictable in their actions. Where users' paths cross, they should do so at safe, survivable speeds and with separation in time and space if needed. A Safe System Assessment must be used in the design.

## Design for context

The design of intersections should account for both the existing and the future land use of the surrounding area. Land use is a key determinant of walking, cycling, public transport and vehicle volumes. Medium/high-density, mixed-use areas will generate more trips than lower-density single-use areas. Walking generators (schools, shops, workplaces, public transport stops etc) located in the area should inform the decisions that are made in intersection design and are as important as matters such as vehicle throughput.

## Part of a multi-modal network

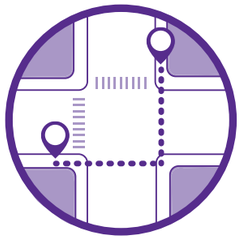
Intersections cannot be designed in isolation. It is possible to achieve a balance of a road network's role in providing traffic capacity and an intersection's role in providing a safe and comfortable crossing for people on foot and by bike. To support a multi-modal network, intersection design should balance and prioritise spatially efficient modes with vehicular traffic.



## Integrate time and space

The use of an intersection may be altered instantly and temporarily through signalisation. This allows for the same space to be opened up to some users, while access is restricted to others, alleviating the need to widen the intersection to address delays and congestion concerns. Signalisation allows regulation of the time taken to enter and cross the intersection, and the capacity of each movement for all users. It is still necessary to ensure survivable approach speeds in case of user mistakes.





## As compact as possible

Compact intersections reduce exposure, slow traffic where crashes are mostly likely to occur, and increase visibility for all users. Complicated and over-sized intersections deter people who are walking and riding, because of the distance and time that is needed to cross, as well as the number of potential conflicts. Oversized intersections take up valuable land, and compromise land economics and street life.

## Protect public transport crossings and stops

All users are vulnerable where they interact with public transport vehicles. Rail and bus vehicles are heavy, fast and quiet, and cannot stop quickly. Within the movement hierarchy, the objective is to provide a high level of service for walking, cycling and public transport at light rail and rapid bus stops as well as crossings of principal and main cycle routes. In this context, consideration should be given to default green for people walking and cycling. Canberra light rail already receives priority as they approach intersections to ensure consistent travel times and improved passenger comfort.

## Speed, observation and decision

The geometry of an intersection affects the speed at which users will choose to pass through it. A safe system requires that any mistake by a user should not result in death or serious injury, so where user paths conflict at an intersection, it is vital that each point of conflict should be approached at a speed suitable for a safe encounter. Mistakes can include misjudgement, distraction or inattention. They may result in failing to give way to other users, including not complying with red signals.

Lower speeds require a shorter distance of observation for decisions. This makes judgment easier and safer. A clearly visible curved path will encourage choice of a suitable slow speed, as at a roundabout, or other speed reduction elements may be used on the approach.

Points of conflict should be designed to occur where vehicle speeds are lowest. Observation of other users is critical to safe encounters, and to efficiency of the intersection.

The geometry can aid this by presenting a user with only a limited range of observation to be able to decide to proceed safely. Turning to look in several directions, and looking for an opportunity to go, while also needing to look for people on foot or by bike, pose a complex task that may lead to mistakes. Separating out these decisions in time into a sequence can reduce the risk of a mistake. Roundabouts are well suited to allowing this kind of decision sequencing.

## Separation or integration

There are two alternative design approaches for intersections:

- Separating cycle and motor traffic streams - generally appropriate at intersections along main roads when protected bike lanes or shared paths are provided on the approaches.
- Integrating cycle and motor traffic streams – generally appropriate where motor traffic speeds and flows are low enough for people on bikes to share the roadway.

Where cycle lanes are used on the approaches to intersections, designers will need to consider carefully which design approach is appropriate.

A combination of design approaches may be used at a single intersection. For example, cycling in mixed traffic may be appropriate on a very lightly trafficked arm of a signal-controlled intersection which operates in its own stage.

Separating walk/cycle and motor traffic streams will increase the number of potential conflict points to be considered and managed, which may increase the overall time delay at an intersection (Figure 7.). Integrating traffic streams reduces the number of conflicts but mixes cycle and motor traffic. This is less likely to be appropriate at busier locations or where speeds are higher.

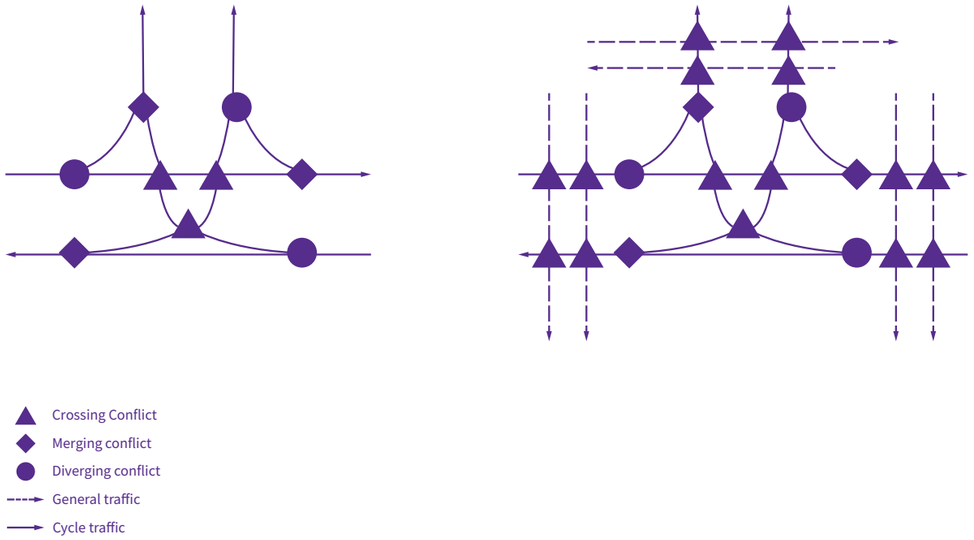



**Figure 7.** **Illustration of conflict points at a T-junction without separation and with separation (Source: DfT, 2020)**

## Adapted directly from:

Auckland Transport (2020), *Urban Street and Road Design Guide* (Auckland)

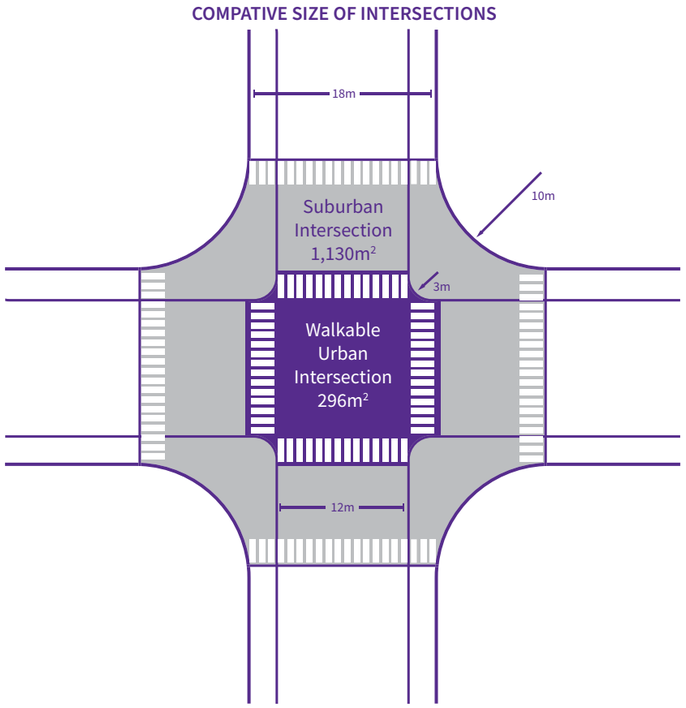
Department for Transport (2020). *Cycle Infrastructure Design*. Local Transport Note 1/20. July 2020 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/951074/cycle-infrastructure-design-ltn-1-20.pdf



# 7. Intersection geometry

The geometry of an intersection can be enhanced by considering a number of design treatments. The most important techniques are discussed below.

## 7.1. Kerb radii



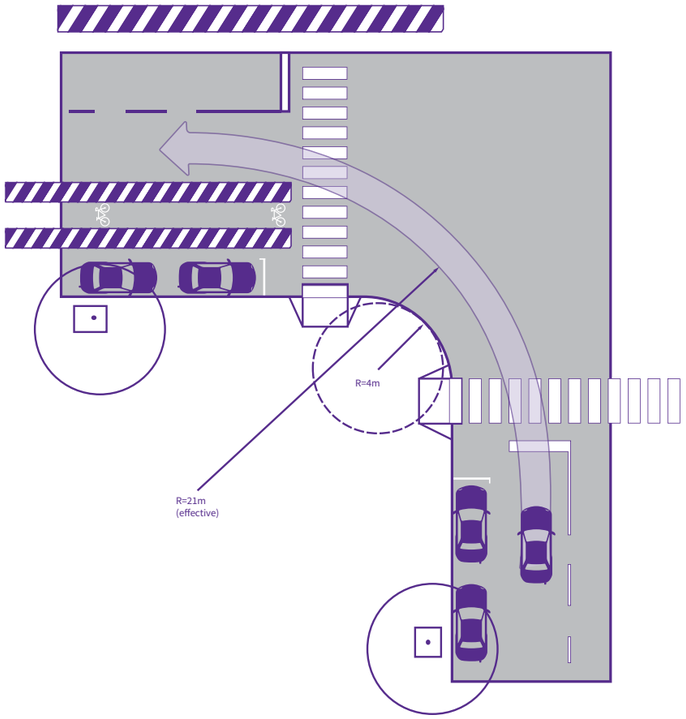

The geometry of a kerb radius (or corner radius) significantly affects the overall operation and safety of an intersection. The shape and dimensions of kerb radii vary based on street type and transport context. Kerb radii should be designed to **maximise pedestrian space and shorten pedestrian crossing distance**. The smallest possible kerb radius should be used, while providing for the appropriate design vehicle.

Minimising kerb radii has multiple benefits for both people walking and cycling. It reduces the crossing distance (thereby decreasing exposure to conflicts), enhances the visibility of the person on foot, slows turning vehicles down significantly, and brings pedestrian crossings closer to the intersection.

Because traffic is slowed by tighter kerb radii, it becomes easier for people using the intersection to see one another and adequately respond to each other's movements and actions. Tighter kerb radii also benefit people riding bikes, as speeds of turning vehicles are reduced, thus reducing the risk of a turning driver turning left across the path of a person cycling going straight across the intersection.

An appropriate kerb radii should be designed for every corner of an intersection, based on the range of vehicles that are expected to use the intersection. It is difficult to design for each and every type of vehicle that is expected to use the intersection, and the occasional difficult turning movement is acceptable. For instance, kerb radii at local neighbourhood streets can accommodate infrequent users like large removalist trucks, but not prioritise their movements. Appropriate design vehicles must be chosen.

## 7.2. Effective turning radius




When designing intersections, it is critical to consider the elements that create the effective turning radius. The effective radius is the curve that vehicles follow when turning. The effective radius is influenced by kerb extensions, parking, cycle lanes, medians and receiving lanes.

Many drivers will turn into the centre-most lane to minimise centrifugal force. In order to create the desired conditions of a street type, e.g. slow turning speeds, the effective turning radius must be considered when establishing the actual kerb radius.

The effective turning radius is also a key tool for designing for streets with regular large vehicle movements. The receiving and the kerbside elements (parking, cycle lanes) defines the effective turning radius that needs to be balanced with the desire to keep the actual kerb radius and intersection as small as possible. Where the effective turning radius for cars exceeds the preferred maximum radius, over-run paved areas can be used for large vehicles turning to manage speed and user conflicts.

Rare large-vehicle movements on neighbourhood and narrow streets can be accommodated by using the entire roadway, including adjacent and oncoming lanes.

## 7.3. Lane matching

Lane matching ensures that lanes are allocated in a manner intuitive for users and that supports the priorities of the street type. The number of entering lanes entering an intersection should align with the number of receiving lanes.

The introduction of additional, short vehicle lanes (e.g. auxiliary lanes) at intersection approaches introduces turbulence (unconfined, unpredictable vehicle movements), rewards aggressive drivers and compromises the objectives of designing a compact, multi-modal intersection.

Exclusive right turn lanes generally should be introduced to the right of the centremost through-moving vehicle lane. Through-moving lanes that become right turning lanes introduce unnecessary complexity and traffic turbulence and force people driving to make abrupt, unpredictable lane changes. The right turn lane should be as short as possible to accommodate the typical queue.

### Adapted directly from:

Auckland Transport (2020), *Urban Street and Road Design Guide* (Auckland)

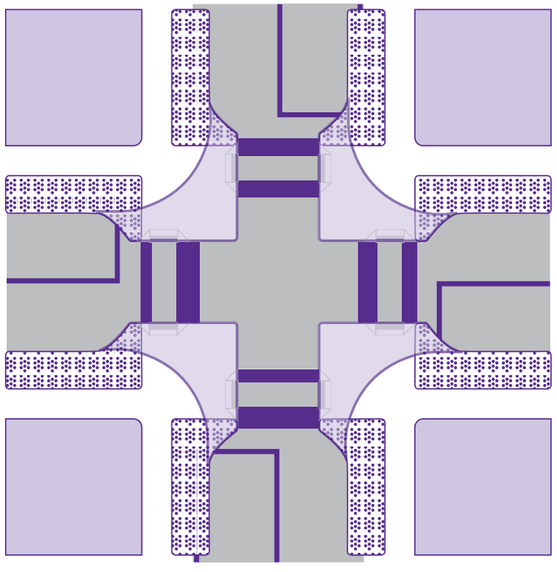


# 8. Intersection elements

A combination of hard elements can be used to shape the behaviours of drivers and to make intersections work better for path users. The desired function and the context of the intersection will determine the selection of elements.

## 8.1. Raised platforms

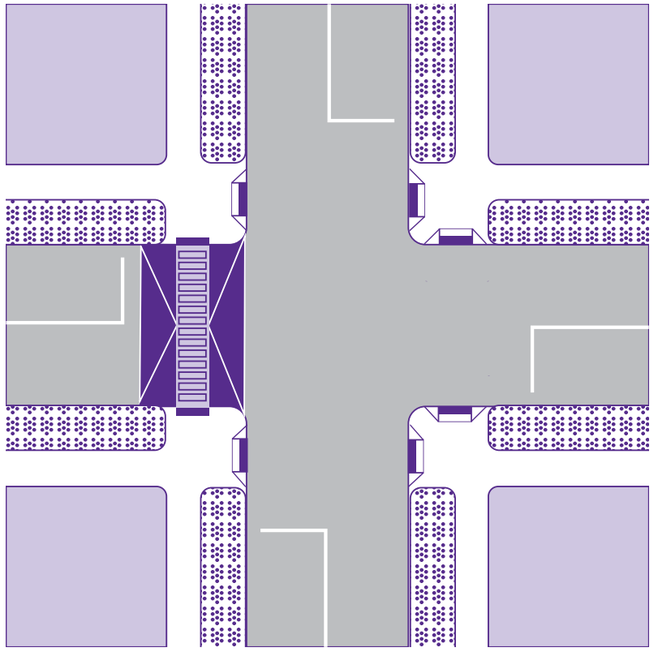
Raised platforms are effectively speed humps for intersections. They reduce speeds on all intersection approaches and through the intersection. They were first introduced in Australia's early traffic calming schemes in the early 1980's. They are most effective when combined with kerb extensions.



## 8.2. Kerb extensions

Kerb extensions physically and visually narrow down the roadway, increase general driver awareness, and are useful in reducing vehicle speeds. They are a commonly used tool to enhance pedestrian crossings, as they shorten the crossing distance and make people waiting to cross more visible, and allow path users to see oncoming traffic. When applied at both ends of a street, they act as effective traffic calming devices. Kerb extensions are generally most appropriate for streets with on-street parking.

## 8.3. Pedestrian crossings

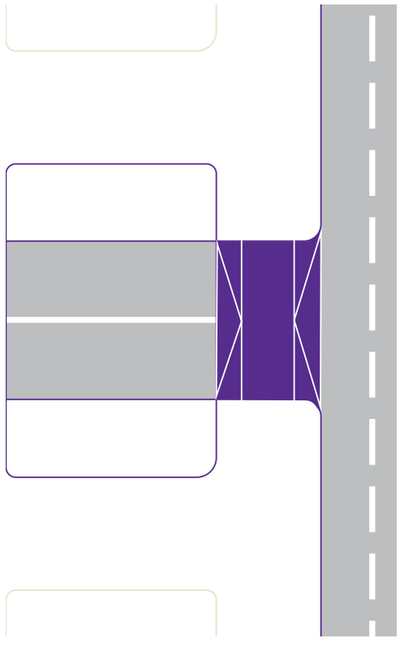


Pedestrian crossings (zebras) are a common crossing facility in the ACT. The pedestrian crossing consists of striped roadway markings running from kerb to kerb. Drivers are required to give way to path users on both sides of all zebra crossings, unless the crossing is divided by a raised traffic island.

Pedestrian crossings are not recommended on streets with traffic speed over 50 km/h or where there is more than one lane in any direction, as the path user may not be able to determine the appropriate time to cross due to the higher speed and/or traffic volume of the road. Traffic signals should be used in these locations. Raised tables should be used to ensure survivable speed at the crossing.

Consider pedestrian crossings at intersections or across side roads to increase accessibility and safety.

## 8.4. Continuous footpaths

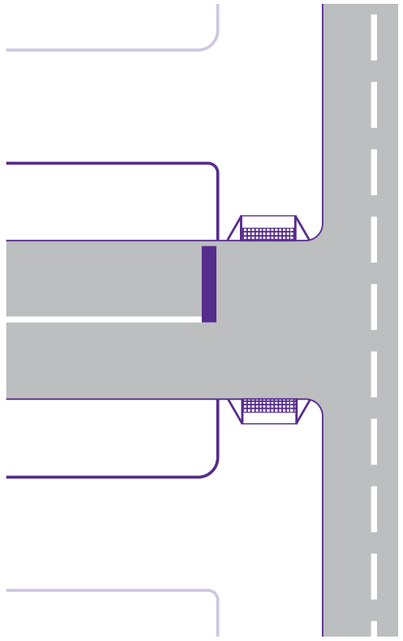


A continuous footpath extends the footpath across the intersections and creates a ramp to slow down crossing vehicles. This design solution makes it easier for path users to cross and slows vehicle movements. Importantly, as the title infers, it changes the priority in favour of all path users over road users (which could include people on bikes travelling in the roadway).

Continuous footpaths are appropriate in town centre contexts with high pedestrian volumes and at local or collector street intersections. They can be used at a speed zone threshold. They can also be marked with a zebra crossing or used with signal-controlled crossings.

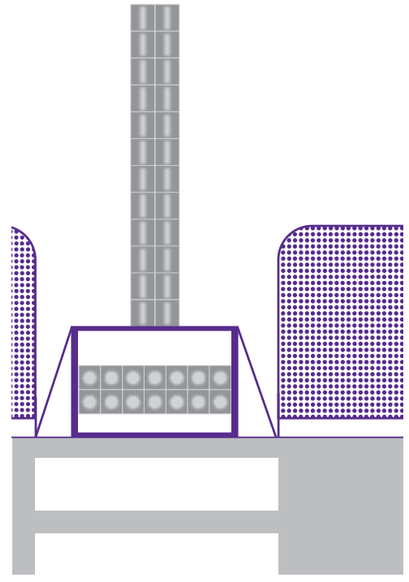


## 8.5. Recessed holding lines



To ensure priority for people walking and cycling across side roads, there is an opportunity to provide a simple, low-cost solution for these crossings, across most T-intersections. However this would require a change to the road rules. In combination with kerb extensions and smaller corner geometry to slow left turning vehicles, the holding line can be recessed before the pedestrian crossing point, creating a de facto pedestrian crossing at every intersection. This can be further supplemented by materials or colour to enhance the pedestrian crossing zone. This design has the added benefit of accommodating rare large vehicle movements, while maintaining a short crossing distance for path users. Visibility from the holding line must be considered, and how vehicles may move forward from it and possibly stop again before entering the main road.

## 8.6. Kerb ramps



Kerb ramps are gently sloping ramps that mediate the transition from the footpath to the roadway at pedestrian crossings. They are especially critical for people in wheelchairs and people pushing prams or shopping carts. At midblock locations, they should be placed at a 90-degree angle to the direction of the crossing. At intersections, they should be placed at an angle parallel to the road they are following.

## 8.7. Guidance for vision impairment

Placed along footpaths, at kerb ramps and platform edges at public transport stations, tactile paving strips guide people with visual impairments along pedestrian connections and other urban environments. They have a different texture from the surrounding paving, and have highly visible colouring. The requirements are determined by the *Disability Standards for Accessible Public Transport 2002.*

### Adapted directly from:

Auckland Transport (2020), *Urban Street and Road Design Guide* (Auckland)

### More information:

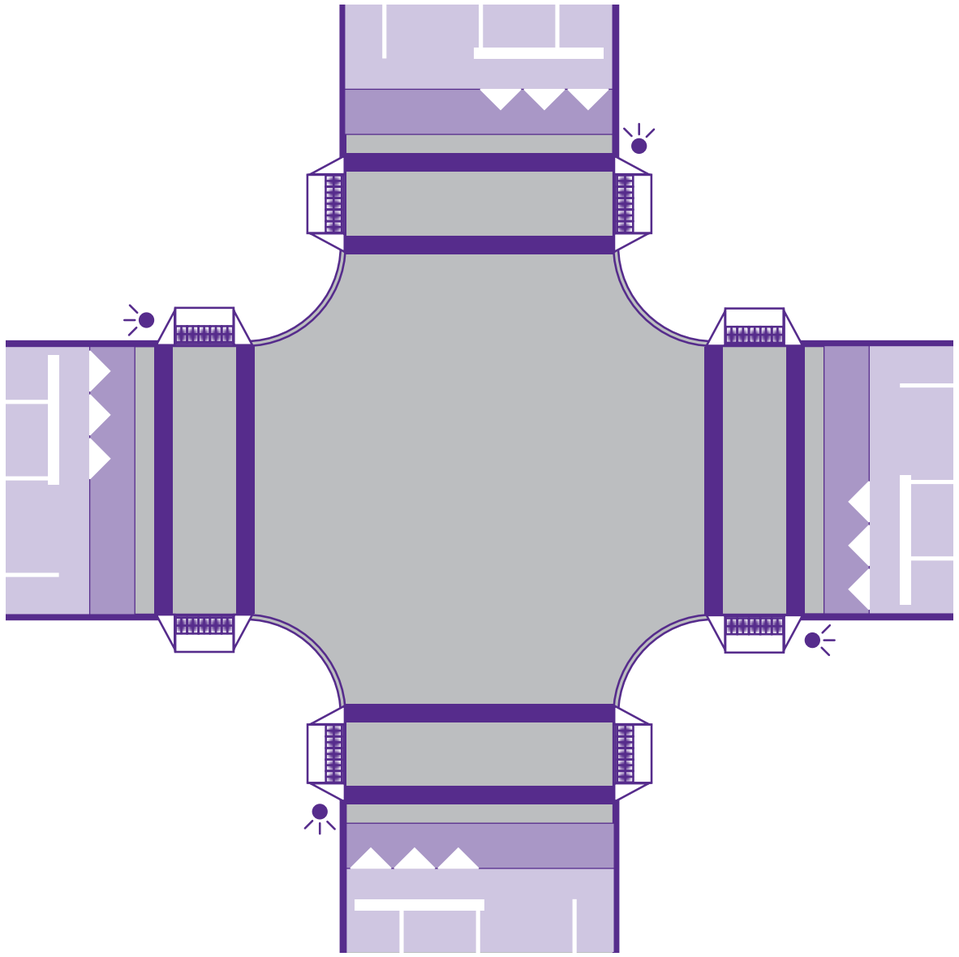
The *Disability Standards for Accessible Public Transport 2002* have specific requirements for tactile treatments on paths that may also apply to intersections. These requirements are covered in the ACT Municipal Infrastructure Standards and relevant Australian Standards.

The Centre for Universal Design has collated resources to assist in planning for accessibility in the built environment. https://universaldesignaustralia.net.au/category/practice-guidelines-for-built-environment/

# 9. Signalisation

An intersection's look and feel often mirrors that of the intersecting streets. When two busy urban arterials meet, the intersection will experience high volumes of traffic, and will often need signalisation to guide traffic through and avoid collisions. As a general rule, the more traffic an intersection sees, the more regulation is warranted to guide users of various modes through the intersection in a safe way.

## 9.1. Pedestrian crossings



Pedestrian crossings should be designed to offer as much comfort and protection as possible. Current practice utilises designs with broken lines of 100 mm wide, making the pedestrian crossing among the narrowest line marking on the street.

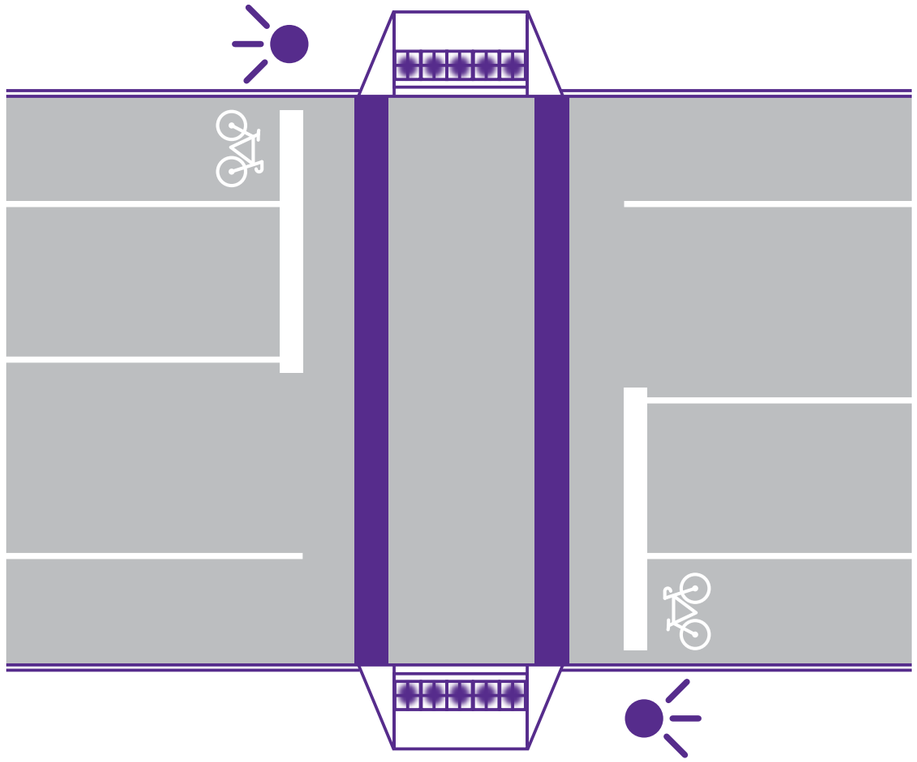
International best practice uses a more prominent road marking for pedestrian crossings that take the form of a zebra, ladder, or continental crossing. These are more visible to people who are driving a motor vehicle. Australian pedestrian crossing designs should evolve to become more in line with international best practice. An interim solution may be to make the typical pedestrian crossing stripe much wider, as was past practice in some Australian jurisdictions.

Mark the pedestrian crossing to be at least as wide as the footpath it extends to. The crossing path should be aligned as closely to the pedestrian desire line as possible.

Pedestrian crossings with kerb ramps should preferably be located at every leg of the intersection to provide safe and direct crossing opportunities.

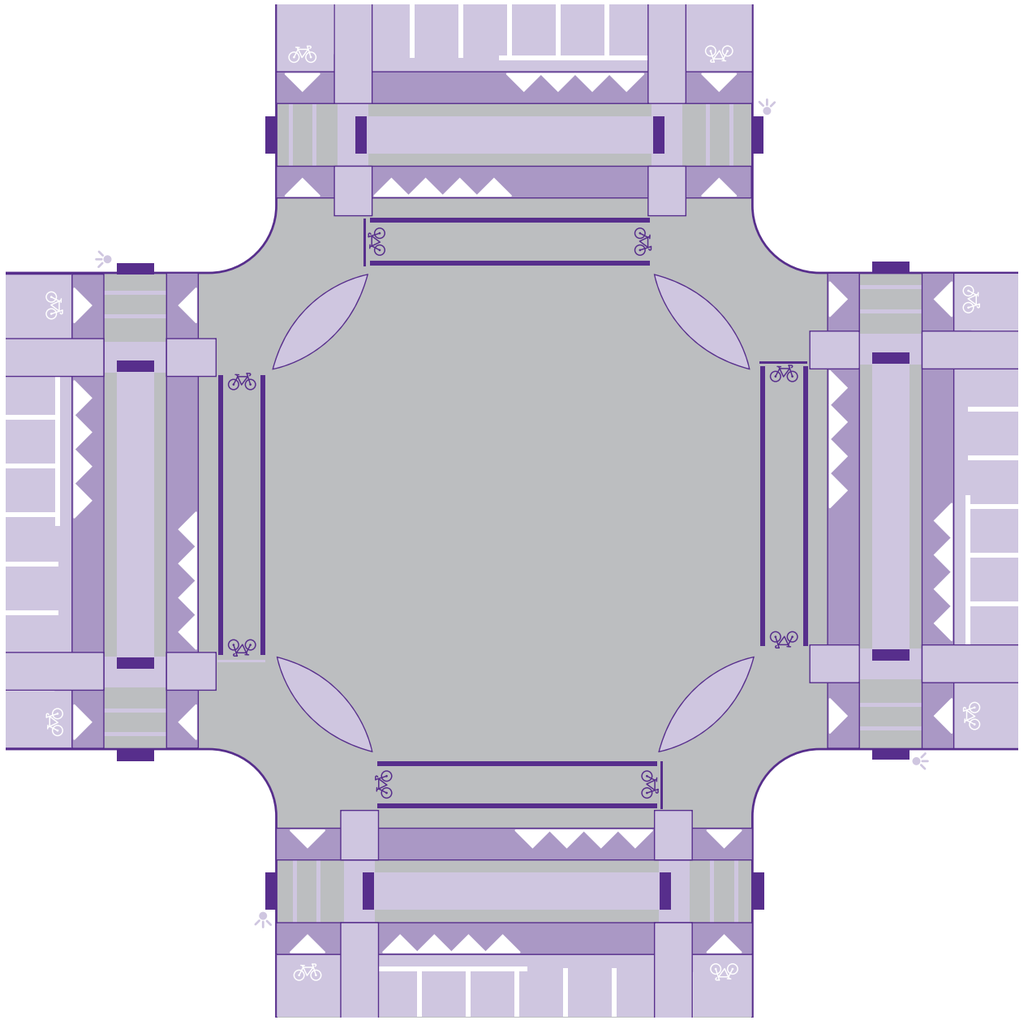
An advance vehicle holding line should be placed at least 2.4 m in advance of the pedestrian crossing. If the street has a cycleway or high levels of bike traffic, the holding line should be recessed even further (7.0 m before the pedestrian crossing).

## 9.2. Mid-block crossings



Mid-block pedestrian signals are installations that stop traffic so path users can cross safely and unimpeded. The signals are activated by path users. Mid-block signals are important features on busy urban arterials with higher speeds. They improve safety, accessibility and permeability of the walking network in town centres.

## 9.3. Raised intersection entries



Operation of traffic signals does not entirely prevent mistakes that lead to conflicts within the controlled intersection. It may be possible to reduce vehicle operating speed on all approaches to a signalised intersection, but often this is not feasible. It is then necessary to ensure that vehicles enter the intersection at a speed that is survivable in the event of a collision. One method is to provide a raised intersection table, or provide raised crossings on the approach arms. These should be designed to achieve a safe speed through to the last conflict point on the vehicle's path, which may be a pedestrian crossing on the exit side. Where there are pedestrian or cycle crossings, the safe speed is 30 km/h or less. For conflicts with other vehicles, the angle of incidence determines the acceptable collision speed.

The choice of raised platform intersection, raised crossing tables or approach-only (Swedish) ramps depends on local factors, including drainage. Additional measures on approaches may be needed to ensure that vehicles do not approach a raised intersection entry at an unsafe speed for the ramp height and gradient.

The design should aim to encourage a steady speed through the intersection on a green light phase, not high acceleration or deceleration, for both safety and efficiency. Any design should be evaluated with the Safe System Assessment Framework. Alternative treatments may be closing intersection arms, grade separation, roundabout or fully managed low-speed approaches.



## 9.4. Countdown pedestrian displays


Countdown pedestrian displays inform path users of the amount of time in seconds that is available to safely cross. Pedestrian countdown timers should be used in town centres, group centres and the city centre, and in other places with high pedestrian volumes.

Countdown timers are also useful to indicate when the green phase is next expected.

## 9.5. Signal timing

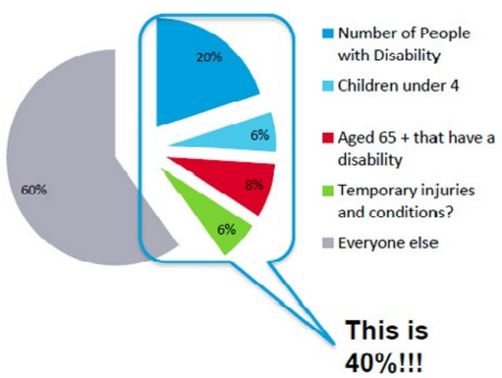
Signal timing for path users is provided through the use of pedestrian signal lanterns. Pedestrian signal lanterns should be provided on all approaches at all signalised intersections.

In the absence of pedestrian lanterns, the ACT road rules already require turning vehicles to give way to people walking and riding. However, these rules are poorly understood, often leading to conflicts.

The total time for the flashing red phase is equivalent to the pedestrian clearance time, or the time it takes for a pedestrian to clear the intersection if they leave at the onset of the flashing DON'T CROSS indication.

The pedestrian clearance time is typically calculated using a pedestrian walking speed of 1 metre per second. Recent Austroads research, however, indicates this speed is too fast for many user groups such as the young, the aged and people with disabilities. Pedestrian signals should allocate enough time for people of all abilities to safely cross the roadway.

Recent research by Transport for NSW indicates this may be as high as 40%.




### Design Goals to Improve Pedestrian Safety and Comfort

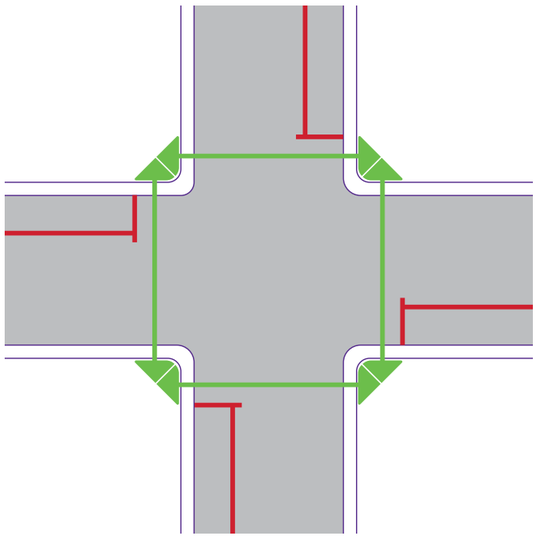
- Reduce vehicle speeds
- Minimise crossing distance
- Minimise wait for WALK indication
- Minimise conflicts with turning vehicles
- Provide sufficient signal time to cross the street.

### Lead-Pedestrian Interval

Where concurrent pedestrian phases are allowed, left turns should be held by a red arrow aspect rather than relying on 'Give way to pedestrians crossing' signs. This reduces pedestrian-vehicle conflicts that otherwise might arise when vehicles start to infringe on the pedestrian crossing when pedestrians are crossing.

## 9.6. Exclusive vs concurrent

### Exclusive



Exclusive pedestrian phasing is when path users are able to cross when there are no conflicting movements. Exclusive phasing is generally considered safer, since it theoretically removes conflicts. However, evidence presents a mixed story of the overall safety record of exclusive phasing schemes. This is largely related to the occurrence of path user non-compliance (i.e. crossing against the don't enter indicator).

Exclusive signals make signal cycles complex and long for all intersection users.

The green pedestrian walk indication is typically short, usually requiring a path user to be waiting at the corner and have activated the pedestrian call button in order to cross. It is common for path users to be required to wait for as much as 90 seconds to cross the street. The long wait time is potentially unsafe, as it leads to people crossing against the signals, or mid-block before the intersection. Long wait times are a significant barrier to walking, in particular when the destination is the diagonal corner.

Best practice guidance suggests that pedestrian wait times in urban centres should be no longer 30 seconds. However, because of road user rules and prevailing engineering practice, it is difficult to provide comprehensive signal phasing and timing guidance.

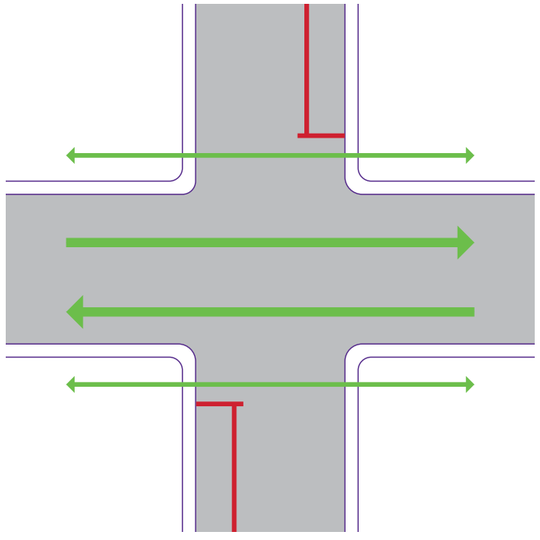
In addition to the design goals outlined above, the following general strategies should be considered to improve walking conditions.

- Provide crossings on all intersection legs wherever possible.
- Vehicular movements should be analysed at every intersection in order to utilise non-conflicting phases to implement walk intervals.

For example:

6. Where one-way streets approach intersections, path users can always cross while traffic is stopped.
7. Introduce concurrent pedestrian phases within signal cycles that also include an all-pedestrian phase.
8. Introduce concurrent pedestrian phases at intersections with slip lanes and an all-pedestrian phase.
9. Use double-phase Barnes Dance (two pedestrian phases each cycle) where long cycles cause excessive delays for pedestrians

### Concurrent



A concurrent pedestrian phase is when path users are able to cross while parallel and non-conflicting vehicular traffic is also moving. Concurrent phasing is often accompanied by signage, such as turning vehicles give way to path users.

## 9.7. Signal coordination and other strategies

The practice of synchronising a series of signals that are situated in close proximity to each other, often referred to as creating a 'green wave' for road users, is called coordinated signal timing or signal coordination. Traffic signals are planned to allow vehicles, traveling steadily at the desired speed, to progress with little delay along a corridor by obtaining a sequence of green lights at signalised intersections. Traffic moves through signals with ease and delays are minimised, while mid-block speeding is discouraged simultaneously.

When used, signal coordination must be optimised to consider the needs of all road users. Delays for people who are walking and riding and for public transport vehicles need to be minimised. Furthermore, bicycle speeds should be considered when planning signal coordination along bicycle routes. Ideally, signal coordination would allow both bikes and motorised traffic to travel through a series of intersections without stopping.

Signal coordination can also be used as a tool to provide safe transitions between high-speed roads (and motorways) and urban streets. This is done by stopping all vehicles before they enter an urban area with red lights and platooning vehicles slowly as a group. A similar strategy can be utilised where the signals are held in a default red phase unless triggered by vehicles. This should be considered in very busy urban areas, in particular during late hours of the night, where vehicle speeds need to respond to the presence of vulnerable road users.

Slow signal progressions have multiple benefits, providing a green wave for bikes and buses, while slowing speeds for private vehicles.

Placement of bus stops needs to be considered along with phasing.

Low speed signal progressions create amenable environments for both bicycle green waves and bus or light rail priority streets (Figure 8).

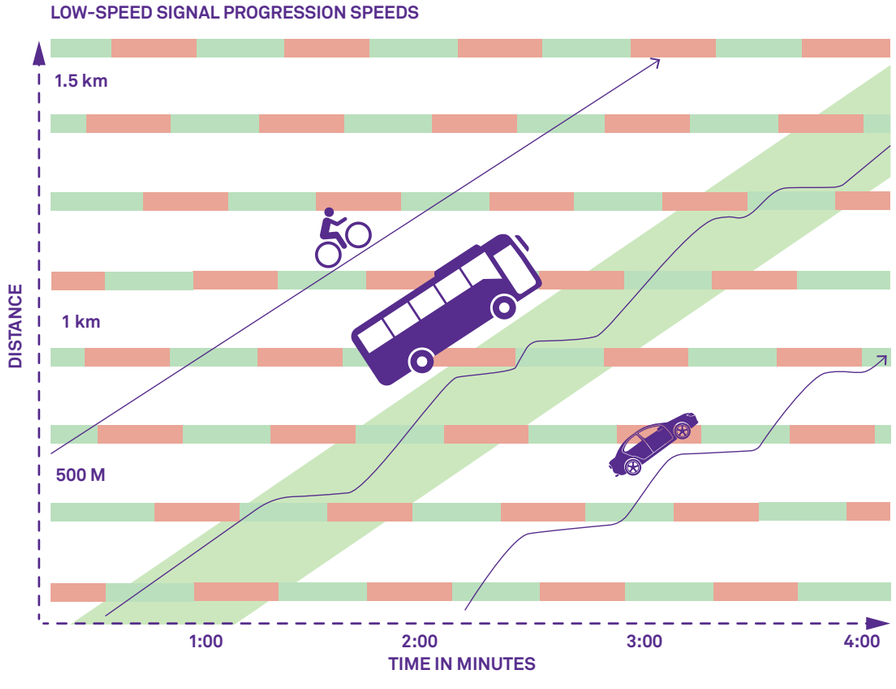



**Figure 8.** Low-speed signal progression speeds

## 9.8. Actuated -vs- automated signals

Pedestrian phases can be programmed to be automated at each cycle, or to be actuated by using push buttons. Generally, automated pedestrian phases are preferred, particularly in areas where higher volumes of path users create a need for a pedestrian phase during every cycle. Vehicles are detected automatically at signalised intersections; path users should be provided with the same service.

Push buttons are most fitting for intersections with infrequent pedestrian use and intersections designed to operate only with vehicle detection.

Where signal phases require a person to press the button, it is critical to consider how people on bikes will be affected when the pedestrian phase is not activated. Independent cycling detectors or cycling push buttons may be necessary to remove conflicts with left turning vehicles, for example.

Mobile phone technology to call the pedestrian phase for low-vision people is already in existence. Mobile phone Bluetooth technology can allow people to trigger the pedestrian phase without having to detour off a straight walking route to find the button. This allows a vision-impaired person to stay on the intended travel path up to the kerb crossing, and across the intersection without having to reassess the direction of travel after finding the button, so that crossing the intersection at the right place in the right direction is more likely. This is very useful where people cross concurrently with traffic, as it is easy to get a bit turned around and step towards the flow of traffic.

### Adapted directly from:

Auckland Transport (2020), *Urban Street and Road Design Guide* (Auckland)

# 10. Pedestrian provision at intersections

Pedestrian crossings, both formal and informal, are a key component of urban streets. Busier streets with high volumes or speeds over 30 km/h require multiple design treatments to provide safe and effective crossing facilities. Streets designed for lower vehicle speeds require less intervention and can support more opportunities for informal crossing.

Determining which type of crossing to use for a particular intersection or mid-block crossing depends on a variety of factors. These include traffic speed, average daily traffic (ADT), anticipated pedestrian volumes, and street geometry. Crossing locations should enable the desired land use activity of the street type and support wider transport access (e.g. bus stops) and walking and cycling networks. Frequent signalised or zebra crossings are vital to a safe and busy centre.

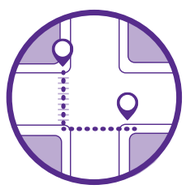

Vehicle speeds are slowed well in advance of the pedestrian crossings.

Crossing the street is made simple and convenient for path users in a clearly visible location.

Vehicle drivers are made aware of the presence of a crossing.


Vehicle drivers give way to legally crossing people who are walking and riding. It is legal to cross informally anywhere, as long as it is not within 20m of a crossing.

Concentrating people movements requires good attention to desire lines. Crossings can be wider than the minimum or be made into a shared zone if the concentration is not natural due to the place characteristics.



There are two types of formal controlled crossings: zebras, requiring vehicles to give way; and signals, requiring vehicles to stop. These should be used whenever safety of people crossing the street requires formal control.

**Adapted directly from:**

Auckland Transport (2020), *Urban Street and Road Design Guide* (Auckland)



# 11. Cycling provision at intersections

Intersections can be highly stressful for people riding bikes, forming one of the main barriers to cycling for the wider population. By far the most collisions in urban areas involving people riding bikes occur at intersections. ACT Police data shows that up to 53% of collisions occur within intersections (NRMA ACT Road Safety Trust, 2012). Getting the design of cycling facilities at intersections right, and creating a safe cycling environment, is therefore of critical importance to increasing cycling uptake.

Observing how people who are riding bikes use the street can provide useful cues to intersection design. Also consider the wider network in intersection design. Sometimes, solutions for the wider cycling network may be better achieved by relocating the crossing point to an adjacent intersection or at a nearby midblock location. In general, greater separation between people riding bikes and other modes reduces the risk of crashes and increases the cyclists' level of comfort.

Because of the importance of intersections in supporting cycling, there may be justification to provide intersection improvements for people riding bikes in advance of, or even independent of, wider corridor improvements. By reducing traffic routes for motor vehicles there can be a focus on improving a smaller number of intersections with only a few complex ones (Figure 9).

## Reducing the number of intersections to be managed

**Step 1.** Reduce the general traffic routes (and intersections)

**Step 2.** Identify walking and cycling routes through a precinct

**Step 3.** Develop excellent crossing facilities at a smaller number of intersections

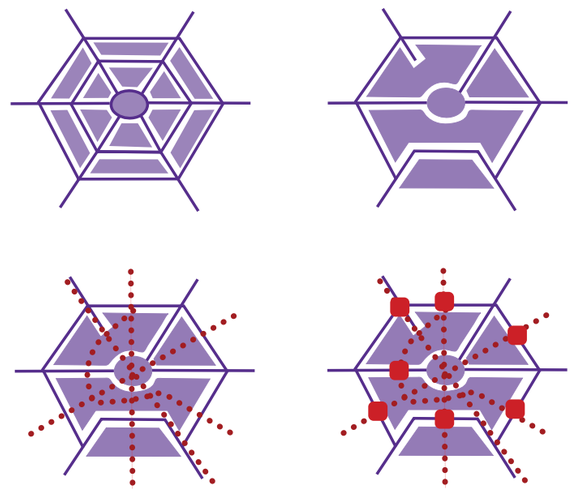
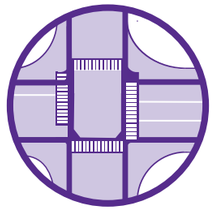


**Figure 9. Simplify traffic routes to focus on improving a small number of intersections (Source: submission to the Vulnerable Road User inquiry, ACT Legislative Assembly 2013)**

## 11.1. Principles of cycle provision at intersections



### Minimise exposure to conflicts

Intersections with bicycle facilities should be designed to minimise the area of potential conflict points between people riding bikes and other vulnerable users and vehicles. This can be achieved by separating cyclists and other vulnerable users from road users with higher speeds and higher mass, particularly at intersections with high traffic volumes. Intersection design should provide clearly marked places for people riding bikes to traverse the intersection. This both guides cyclists along the intersection and informs them where to ride, and at times, provides them with enhanced visibility.


### Communicate who has priority

Communicating clearly who needs to give way and who can take priority removes ambiguity and confusion that can lead to crashes even with clear sight lines. Designs should reinforce normal rules of the road where turning traffic from the main street has to give way because turning traffic gives way to through traffic. Markings (traffic control devices), warning signs, and physical features (e.g. raised crossings) should reinforce the desired user behaviour. These signs and markings may need special authorization.


### Reduce Speeds at Conflict Points

Lower speeds allow drivers to be more observant and aware of their immediate environment, and reduce the severity of crashes when they do occur. Tightening an intersection's geometry through the use of kerb build-outs, sharp kerb radii, narrow lanes, and limiting the number of lanes all contribute to lower speeds. Roundabouts reduce speeds and give time to observe each conflict in turn. Raised table crossings and raised intersections slow vehicles at pedestrian crossings. Design speeds may differ from regulated speeds.

### Raise Awareness

Visual cues such as a green surfaced lane across the intersection and additional signage can aid in managing drivers' awareness of where to expect people riding bikes.

### Maximise Safety & Comfort

Design measures include not only the array of safety-enhancing features, but also measures to increase cyclist comfort, such as handrails and automated detection of people on bikes at intersections. When cycling facilities are both safe and offer a degree of comfort, cycling becomes an attractive mode of transport.

### Provide Adequate Sight Distance

Providing an appropriate sight distance is fundamental in making intersections safe. At a minimum, oncoming road users must be able to see others who are approaching the intersection and who are already at the intersection.



## 11.2. Signalised intersections – protected

Both protected and unprotected cycleways at intersections must consider signal operations and phasing in order to avoid conflicts between turning vehicles and bikes. It is highly recommended that separate bicycle signal lanterns are installed at intersections with cycle facilities, especially at intersections with higher traffic volumes.

**Figure 10. Signalised intersection. The principles set out in this diagram have been generally adopted in ACT Standard Drawing ACTSD-0561 and are discussed further in Section 13 [adapted from the *Urban Street and Road Design Guide* (Auckland, 2022)].**

Protected intersections maintain the physical separation through the intersection, thereby eliminating the merging and weaving movements inherent in conventional bicycle path and shared path design.

The protected intersection design with corner safety islands emerged in The Netherlands and other northern European countries as an approach to define traffic movements at the intersection of streets with separated bicycle paths. The central design element is the **corner safety island**. They are used to tighten the turning radius for cars to decrease their speeds and slowly negotiate the turning movement. Additionally, they are required in order to design the bicycle path slightly set back from the intersection. Situating cycle tracks behind the corner safety island enables left-turning cyclists to turn without having to mix with traffic. The space behind the corner safety island allows people on bikes to wait to cross the intersection.

The corner safety island also provides a queue space for a single vehicle to wait while giving way to crossing cycle traffic immediately after having made a turn. Vehicles will have significantly slowed down before they begin to cross the bicycle path. This facilitates vehicles coming to a standstill when they need to give way. It also places people who don't have the size or the protection of a motor vehicle, who are crossing the road, firmly within the driver's view.

A forward stop line is situated on the bicycle path right before the crossing, between the corner safety island and the pedestrian safety island (see diagram). The space at this line serves as a waiting area for people who are riding and waiting to cross. This allows left-turning bike traffic to proceed freely, unimpeded by other bikes that are waiting to cross the intersection.

Pedestrian crossings are situated behind the cycle crossing. path users crossing the intersection first cross the bicycle path, where people on bikes must give way to them. Pedestrian safety islands are provided between the bicycle path and the roadway, which are preferably accessed using zebra crossings.

To ensure that bicycle crossings at protected intersections work properly and remain safe, people crossing on bikes must be given priority by drivers. This can be achieved by signalising the intersection and allocating a dedicated signal phase to crossing cyclists.

Alternatively, on intersections with low traffic volumes, a policy of giving way to people crossing on bikes can be chosen. However, this only works where speeds are low (30 km/h) so that eye contact becomes possible. Traffic volumes must be low enough that an occupied queue area does not cause backed-up traffic.

The protected intersection provides opportunities to safely cross the intersection in any direction, facilitating left and right turns as well as through movements.

Where pedestrian volumes are high, pedestrian-cyclist conflicts should be considered.

## 11.3. Signalised intersections – unprotected

Unprotected intersections are intersections where people riding bikes are more exposed to traffic due to a lack of corner safety islands. People on bikes mix with vehicle traffic on the intersection and with people walking where they cross the pedestrian crossing.

Note that under the ACT Road Rules, this design detail creates a transition from a separated bicycle path to a bicycle lane. People riding bikes in a bicycle lane have statutory priority in favour of turning traffic.

While it is highly recommended to apply a design treatment that includes corner safety islands as described in Section 7.2, this may not always be feasible at signalised intersections, given financial and/or spatial constraints.

A number of alternative cycleway design treatments for intersections are provided below. These include recessed stop lines for vehicles, intersection crossing markings, no parking on intersection approaches, bicycle signal phasing, and two-stage turn queue boxes. At signalised intersections, it is recommended that the stop line for vehicles is further recessed by 3-5 m to increase the visibility of people riding bikes.

Pushing back the stop line for vehicles and allowing people on bikes to queue in the lane ahead of vehicles, provides those people with a head start and lets them clear the intersection more rapidly. This treatment might be supplemented by the addition of a bicycle box, to provide more queue space for people on bikes where volumes warrant it. Even though bicycle boxes use coloured surfaces to separate people on bikes from motor vehicles, bicycle boxes have the disadvantage that there is no physical barrier to prevent vehicles from occupying this space when cycling volumes are low. For this reason, bicycle boxes should be implemented with caution.

From the holding line, the person riding crosses the pedestrian crossing and is subsequently guided through the intersection by intersection crossing markings that indicate the intended path for cyclists. These can be short-dashed lines that are supplemented by coloured pavement markings and shared-use markings or bicycle stencils. Their purpose is to define a safe and direct path through intersections, and to define the boundaries between the path of people on bikes who are proceeding through, and vehicles in adjoining lanes that are turning or going through.

To enhance the visibility of people on bikes leading up to the intersection, remove a number of parking spots ahead of the intersection where on-street parking exists between the cycleway and the travel lanes.

While a bicycle exclusive signal phase may be used to segregate conflicting movements between people who are riding and driving, it might also be practical to investigate the use of a protected, yet concurrent signal phase. This phase might be adapted to allow people on bikes a green light a few seconds before vehicles, allowing them to largely clear the intersection before vehicles can proceed. See Section 10.5 for more information.

Two-stage turn queue boxes, also called hook-turn bays, may be included in the intersection design to allow people riding bikes to make a safe and comfortable right turn at multilane signalised intersections. They might be necessary where conventional cycleway design prevents people on bikes from merging into traffic to turn (which is generally best to avoid). By providing two-stage turns, this issue is addressed. The hook-turn bays are most appropriate for multi-lane roads at signalised intersections, as well as at roads with high traffic speeds and volumes, and where a high number of cyclists turn right.

Noted disadvantages of the hook-turn bay include an increase in delay, as people on bikes use two signal cycles to complete the turn (one for the through street and one for the cross street). Hook-turn bays must be located clear of moving vehicles and people riding bikes as well as people who are walking, and ideally physically protected by a kerb or other barrier.



## 11.4. Unsignalised intersections

Avoiding conflicts at unsignalised intersections depends on the geometric design of intersections to encourage safe interactions between people using different modes. The behaviour of street users can be guided by visual and tactile cues, including changes in level and road markings.

Raised cycleways are a preferred solution wherever cycleways cross minor side streets at T- and cross-intersections, as well as at driveways and entry lanes.

They can be used on approaches to roundabouts. They can be stand-alone raised cycleways, or form part of a raised table that accommodates both walking and cycling traffic across the side street, and act as a speed hump for cars turning into the side street. At the same time, raised tables function as a clearly defined entry point to a street type that is different than the intersecting street, thus acting as a spatial threshold that informs drivers that different speeds and behaviour are expected on the side street.

**Figure 11. Raised cycleway with clear priority for walking and riding**

While the ACT Road Rules are not explicit about give way requirements for vehicles turning into side streets, the design treatment of raised tables can be such that good give way practice is implied. Where it is necessary, the raised table can be slightly set back from the intersection, to allow vehicles to wait before crossing the raised table just outside the intersection, ahead of the raised table. While this causes modest deflection the desired line of travel of the person walking or riding, it provides an area where vehicles can queue and wait while giving way to people who are crossing, outside the heavy flow of traffic along some major and medium streets. It also improves visibility to see people on foot or bike as they approach. For compact intersections and mini roundabouts, the whole intersection can be raised, provided vehicles cannot gain too much speed once they have entered the intersection before reaching a cycleway crossing their exit lane.

### Street-level facilities

As street-level facilities provide a minimal level of protection (a horizontal buffer) at best, it is highly recommended that other types of cycling facilities are considered to offer a greater degree of separation.

Where they must be used, the treatment of protected and unprotected intersections is similar to some extent. Street level facilities might feature recessed stop lines for vehicles, combined with signage informing drivers to stop. Intersection crossing markings are used to guide people riding on safe and direct paths through intersections, defining the boundary between the path of the through rider and through and/or turning vehicle traffic.

Consider short, dashed lines filled in with (green-) coloured pavement and shared-use markings as a continuation of the bike lane across the intersection; in accordance with MIS-05 practice.

Suspend on street parking on the approaches to the intersection, in order to improve visibility. This is especially critical where the cycleway is buffered by a parking lane.

## 11.5. Signal design for bike traffic

Signal design plays an integral role in making intersections safe and convenient for people who are walking or riding. Signals are used to separate users by time, and help reduce or remove conflict from intersections for all modes. There are many opportunities to improve signal design in order to make it work better for people walking and cycling. These include phasing strategies, advance green lights, and minimising delays across corridors. Further advice is available from the former Australian Bicycle Council – *Traffic Signal Features for Bicycles* (2017).

### The Green Wave for people on bikes.

Applying advanced (leading) green lights for people walking and riding at most intersections along the key cycling routes is important, both in terms of ensuring safety, and in visibly promoting cycling as an efficient and fast mode of transport. The signals should be synchronised at average cycling speeds, about 20 km/h, assuring a consecutive string of green lights for people on bikes – a 'green wave'. This speed is also preferable for public transport operations and people walking.

**Figure 12.** A 'Green Wave' in the Netherlands using green lights to indicate syncronised signals [Source: CROW Fietsberaad (2016)].

### Cycling bypass

In some locations, it may be possible to design a short bypass or avoid a signalised intersection, providing people who are riding with a direct route that removes conflicts with traffic. Opportunities to provide a bypass may be found at T-intersections and where people on bikes turn left from a dedicated path.

### Remove the combination left turn arrow-green disc phase

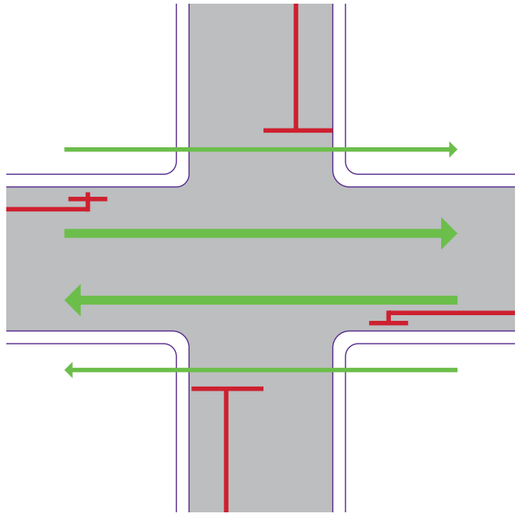
A combination left turn arrow – green disc (straight through) phase communicates to drivers an 'all clear' turning movement. This practice should be used with caution to ensure that turning vehicles take care and look for vulnerable road users, in particular where people on bikes may be expected to pass to the left of turning vehicles.

The ACT Road Rules require that on a green signal, turning vehicles must give way to people walking and riding to their left.

### All-way phase

People walking and cycling can take advantage of the pedestrian all-way phase (scramble crossing) as it creates a low stress crossing opportunity in particular for right turn and U-turn movements. This practice should be formalised with a caveat that there will be a point when the volumes of people walking and riding should be separated. The overall signal cycle times and the delay to both should also be considered.

### Protected, yet concurrent signal phase for bicycles



The conflict between left-turning vehicles and people on bikes is a critical design consideration at intersections. To resolve this conflict, consideration should be given to an all-pedestrian phase, or an exclusive bicycle phase. Using an all-pedestrian phase adds delays, as the overall green-to-green time increases substantially both for vehicles and pedestrians. This is because an additional signal phase is introduced. As vehicle phases have longer red times, queues grow longer and, in turn, need more time to clear. These long phases for general also increase waiting times for path users. Therefore, all-pedestrian phases or exclusive bicycle phases may limit an intersection's capacity.

Dangerous situations might also arise from path user non-compliance, with path users refusing to wait for their phase and crossing with parallel traffic, or mid-block, avoiding the intersection, leading to unanticipated conflicts. It is for these reasons that an all-pedestrian/all-bicycle phase is virtually non-existent in The Netherlands.


Consider using protected, yet concurrent phases instead. Protected phasing ensures conflicting walking-riding movements are not allowed to run concurrently. Left-turning vehicle traffic is allocated its own phase, usually in its own lane, directed by turn arrows. The cyclist (and pedestrian) crossing phase runs concurrently with parallel through traffic, and conflicts caused by left-turning vehicles is eliminated. The crossing phase might begin later or earlier, to allow additional time for the conflicting left turn phase. There is also an option to run an additional lagging phase to allow more people on bikes through an intersection. A protected, yet concurrent phasing uses both time and space efficiently. Protected, yet concurrent phasing requires fewer lanes to serve traffic. This contributes to keeping an intersection's geometry tight.

The protected, yet concurrent phases are what is normally used at signalised intersections with bicycle facilities in the ACT following common practice in The Netherlands and in North America.

One alternative is to permit conflicting vehicle turning movements, using permitted phasing. This should be considered acceptable for priority crossings only on two conditions; the geometry (turning radius) must force the turning movement to be made at a low speed, and the volume of turning vehicles must be low. One rule of thumb uses 250 turning vehicles per hour as the maximum for allowing permitted phasing. Because of the added traffic stress for people riding because of the lack of opportunity to respond, wherever conflicts with turning traffic exist, it is highly recommended that this conflict is removed to the greatest extent possible, and that the protected, yet concurrent configuration always be considered before any other treatments.

### Adapted directly from:

Auckland Transport (2020), *Urban Street and Road Design Guide* (Auckland)

# 12. Public transport provision

The main consideration when accommodating public transport vehicles at intersections is to enhance the reliability of the public transport service, and connecting path users to public transport. Most public transport stops are near intersections, and they are also where most delays are incurred. For instance, in major cities globally, over 10% of overall bus trip time and as much as 50% of bus delay is accounted for by waiting at traffic signals. It is likely to be similar in the ACT.

Give careful attention to the design of cycling facilities and footpaths around public transport stops, as well as how they are integrated with public transport stops. Where space is available, each mode should be provided with its own space. Where this is not possible, street and intersection designs should seek to maximise safety by slowing traffic, providing good sight lines, and minimising conflicts. Wherever different users mix, they need time to see each other and follow predictable paths at safe, survivable speeds.

## 12.1. Public transport routes

Public transport routes include service routes as well as routes vehicles use to and from the depot. At intersections with very frequent bus turning movements (>12 buses/hour), streets should be designed for the 12.6m urban bus. The intersection principles established above are especially relevant to public transport routes, as they are likely to have high levels of people on foot, as well as multiple, competing interests in the road reserve. In order to maintain compact intersections along frequent bus routes (greater than 12 buses an hour), the techniques to accommodate large vehicle movements should be used. The following public transport strategies should also be considered to maintain compact intersections:

- Minimise bus route turning movements.
- Consolidate turning movements at one intersection (instead of at multiple adjacent intersections).
- Consider right turning patterns for bus routes (to minimise intersection geometry).

Other public transport design considerations:

- Consider the mutual benefits of public transport priority elements (bus lanes, queue jumps, signal advance, etc.) in intersection design.
- Consideration should also be given to private transport operators in areas where large tourist buses and vans are likely to conduct business on a regular basis.

## 12.2. Signal priority

Widely used at prioritised busways in many cities, public transport signal priority allows public transport vehicles to extend a green phase or shorten a red phase, without interfering with the phase sequencing or overall signal timing. The time difference is made up for in the subsequent cycle when the bus or light rail vehicle has passed. All other signal operations remain intact. Using an in-vehicle transponder, public transport vehicle drivers can trigger a signal change on their approach to an intersection, ensuring that they have a green light. This minimises waiting times at the intersection, or eliminates it altogether. This reduction of delays allows public transport to stay on schedule and it minimises bunching. Signal priority is currently applied to the light rail corridor in the ACT.

## 12.3. Dedicated bus lane, short approach lanes, queue jumps

Continuous bus lanes, short approach lanes and queue jump lanes provide a by-pass for public transport vehicles to reach the front of the intersections. These are used in conjunction with active signal priority (e.g. a white B-phase signal) to give buses and light rail vehicles a head-start into a receiving public transport lane or a general traffic lane (Figure 13).

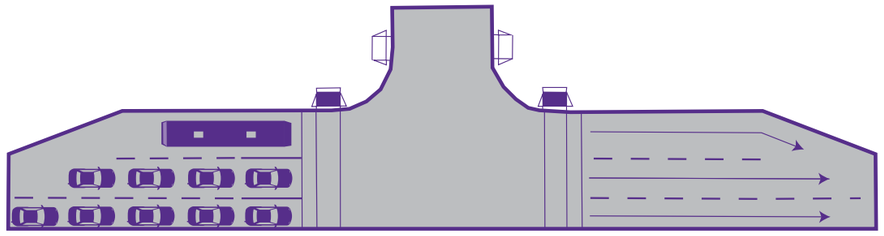


**Figure 13.** **Queue jump lane to allow busses to get to the front of the intersection.**

## 12.4. Public transport prioritisation/ signal timing

Public transport prioritisation at intersections can contribute to a more reliable, more efficient public transport service. It also makes it less polluting, as it leads to less queuing, stopping and starting.

Public transport prioritisation encompasses signal coordination, signal priority, dedicated public transport-only lanes, as well as queue jumps or bypass lanes.

Signal coordination and priority strategies are typically used in conjunction with dedicated public transport-only lanes and queue jumps. Where signal priority and queue jumps are provided, the impact on overall signal cycle lengths as well as the impacts to delay for other users should be considered.

Bus head-starts and bypasses can be an effective strategy to allocate road space across constrained corridors.

**Adapted directly from:**

Auckland Transport (2020), *Urban Street and Road Design Guide* (Auckland).


# 13. Intersection guidance

This section presents guidance on a variety of intersection types, applicable in both estate development and retrofit. The intersection guidance shows several examples for the following intersection types:

- arterial to arterial
- collector to collector
- collector to local street
- local to local street
- laneway/driveway
- local network intersection.

The existing conditions, design objectives and recommended treatments for each of these intersection types is discussed.

Guidance focuses on the desired outcome (Design Objectives) and provides a roadmap on how to get there, by providing Recommended Treatments for each intersection type. Beforehand, the existing conditions are to be analysed.

### NOTE 1

**The sketches in the following sections show 'one-way pairs' only. These are the generally preferred design strategy to reduce the number of conflict points as illustrated at the end of Section 6.**

**Two-way paths have similar design parameters but not all design options are suitable for all environments.**

### NOTE 2

**Not all combinations of major and minor roads at intersections are covered, but the design considerations will allow other combinations to be understood. Different land use contexts will require adaptation of the examples to other contexts.**

## 13.1. Intersection analysis

When considering a (re)design of any type of intersection, collect and consider the following features of the intersection.

### Vehicle volumes

Map and understand the turning movements required of the intersection. Overlaying vehicle volumes gives perspective on the relative importance of that link in the network. The NSW Walking Space Guide provides valuable procedures to balance pedestrian space against space required for the movement of general traffic.

### Pedestrian activity

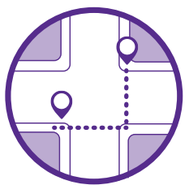
Note desire lines and where people linger. Where do informal crossings occur? Use land, use plans, census data and employment data to assess future demand, not just current use. Do older people, users of mobility aids and children use the intersection? If not, it may indicate poor accessibility.

### Safety analysis

Analyse crash history and assess safety of existing user conflict points. What may need to be improved for safe system design?

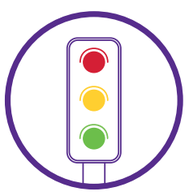
### Public transport and cycleway activity

Calculate the volume of people that may move through the intersection



### Context

Document gathering places, landmarks, bus and light rail stops and interchanges, and other relevant activity.



### Signalisation

Acquire signal plans (SCATS data) from Transport Canberra and City Services.



## 13.2. Intersection design

After acquiring and analysing the data above, begin to make informed decisions on what should be prioritised in the intersection. The following guidance provides illustrated intersection examples that show the principles and address the outlined features above. Not all features will be present at all intersections, especially where existing streets are being altered over time. Network planning will guide what features and considerations are currently required.

## 13.3. Treatments for NCA designated areas

- Minimise use of green paint.
- Add signal control for left turns to minimise potential for turning conflicts.
- Use bluestone for kerb faces.

More detail about these and other design treatments can be found on the NCA website: https://www.nca.gov.au/planning/plans-policies-and-guidelines

## 13.4. Laneway or driveway

Laneways and driveways intersection treatments can drastically improve amenity for people on city streets. Simple design measures can ensure that the pedestrian safety and priority is maintained with both laneways and driveways such as the laneways entering Bunda Street in the City Centre.

**Figure 14. Priority crossing over driveways [adapted from the *Urban Street and Road Design Guide* (Auckland, 2022)].**

### Recommended treatments

- Install steep ramp profiles that slow down vehicles.
- Use driveway-style transitions rather than kerb radii.
- Footpath material should reinforce the continuity of the path and be distinct from the roadway material. This helps to enforce proper yielding behaviour by people driving motor vehicles.
- Ensure that the footpath treatment is level and uninterrupted across the intersection.
- Add a holding line or speed hump at the exit of the laneway or driveway, before the footpath.
- Overall laneway width is minimised by allowing vehicles to share adjacent lanes, or (preferably) by limiting vehicles to one direction.
- Ensure that the driveway ramps are minimised and do not extend into the clear pedestrian travel zone.
- Overall design treatment should ensure that these intersections between main roads and laneways or driveways are clear entry points or transitions into a different type of environment.

## 13.5. Local network intersection – community path

**Figure 15.** Local path network intersection with a local street, prioritising walking and cycling movements .

### Design objectives

- Safety – slow speeds and ensure lines of sight for path and road users.
- Connectivity – provide dedicated crossing points for people walking and cycling at regular intervals and along desire lines.
- Environment – incorporate trees and landscaping and contribute to urban green spaces.

### Recommended treatments

- Main design principle: reduce speed of vehicles, and raise awareness of potential conflict points.
- Flat top speed humps (i.e., raised road platforms) with gentle ramp gradients that incorporate either a pedestrian crossing or kerb build-out.
- Narrow roadway designed to reduce speed of motorised traffic.
- Design features that provide visual cues to road users including changed surface pavement, clearly distinguishable by colour, texture and/or materials.



## 13.6. Local to local – mini roundabout

Local to local intersections make up the bulk of intersections in the ACT. They are the quiet intersections between the local streets that make up the fabric of the ACT's neighbourhoods. Whether they are situated in residential, commercial, industrial or mixed-use districts, local streets tend to be characterised by comparatively low volumes of vehicular traffic. They are the places where people live, work and socialise.

**Figure 16.** Local to local streets support local activities using short trips and therefore should prioritise active travel [adapted from the *Urban Street and Road Design Guide* (Auckland, 2022)].

### Design objectives

The primary functions of local streets are to support daily activities such as walking to school and nearby destinations, encouraging social interaction among neighbours and creating a pleasant living environment. In some cases, these intersections support important local services such as cafes and shops.

Where these intersections are retrofitted, they may be defined by using existing verge space for non-traffic purposes. as illustrated in Figure 16. In greenfield developments, the verge space near intersections may host more diverse functions to modify the intersection.

Creating a safer environment for all street users at local to local intersections is achieved by the following conditions:

- Slow down midblock traffic speeds (with a maximum of 30 km/h for local streets).
- Slow down turning vehicles (with a maximum turning speed 15 km/h).
- Enable eye contact between users where mixing occurs.
- Shorten pedestrian crossing distances. This might be achieved by scaling down the kerb radius and by implementing kerb build-outs, and by narrowing travel lanes.
- Accommodate pedestrian desire lines. This is particularly critical at pedestrian crossings. Detours should be avoided and pedestrian crossings should be kept as close to the intersection as possible.
- Re-allocate roadway space to public space or green infrastructure. Currently, the roadways on local streets tend to provide far more space than is required for regular vehicle operations. Excess roadway space can be repurposed as public space, or as green infrastructure such as rain gardens, bioswales, street trees, or berm gardening.
- Consider strategies across the wider network (traffic calming, local paths). Interventions across a network of streets might work together to bring speeds down across neighbourhoods, and to make communities more liveable.

- Manage traffic volume and speed so that people by bike can travel safely with other vehicles.

### Recommended treatments

- Square the intersection by removing oversized kerb radii.
- Remove pedestrian splitter islands where these exist, and instead shorten crossing distances by narrowing the street's geometry.
- Shorten pedestrian crossings with kerb build-outs.
- Remove road markings except holding lines at side streets. The removal of centre lines encourages drivers to reduce their speed.
- Placing the holding line at a slight distance from the pedestrian crossing is recommended to improve visibility of path users. Removing on-street parking along the roads leading up to the intersection is advised as well, as it frees up further space to keep crossing distances short.
- Introduce mini-roundabouts where appropriate (best introduced at regular intervals to help keep speeds low throughout the street network).
- Add missing footpaths where deficiencies exist in the footpath network. Where it is possible, footpaths must be provided on both sides of the street.
- Close redundant links.
- At T-intersections, align the side street and ongoing street to intersect at a 90-degree angle.
- Provide pedestrian facilities along desire lines. These can be distinguished using a different form of pavement material for the pedestrian crossing.
- Consider adding traffic calming elements that provide vertical deflection, in order to effectively slow traffic. These could be either raised tables that span the intersection, or individual speed bumps on each of the approaches to the intersection.
- Consider zebras where there are significant pedestrian movements,e.g. near schools and shops.
- Consider street trees and water-sensitive-urban-design where opportunities exist to provide shade and cooling. Street trees also provide vertical elements that create visual narrowing and speed reduction.



## 13.7. Collector to local – bent-out

The preferred treatment for an intersection where a facility interacts with a side street is a continuous cycleway with priority given to people cycling to provide high level of service and improved safety for riders. This is where there is strong separation of bicycle and pedestrian paths and where foot and bike traffic movements are clear. Any such facility needs to be checked against Austroads guidance and the ACT Road Rules to ensure compliance.

Where there is a greater mixing and complex movements between bike and foot traffic, shared zones are preferred to show pedestrian priority. Hybrid solutions may be required to reduce conflict, but these should be achieved on the path rather than adding greater complexity to the intersection within the roadway.

The interaction between people walking and cycling requires careful consideration. Any bend-outs should be as smooth as possible to allow for ease of manoeuvring and provide waiting space for vehicles a safe distance from the roadway. As much as possible, vehicle movements that cross the bicycle path (i.e. side streets, driveways, car parks, laneways) should be minimised. Where conflict zones are unavoidable, the infrastructure should be designed to reduce the speed of motorised traffic and adequate sight lines preserved where possible to allow for reciprocal visibility.

**Figure 17. Bent out path where a local road meets a collector road [adapted from Cycleway Design Toolbox. Designing for cycling and micromobility (Transport for NSW, 2020)].**

The main design principle is to provide a high level of service to people walking and cycling and reduce speed of intersecting traffic.

### Recommended treatments

- Raised intersection and clear road marking to indicate to all road users that path users have priority over turning vehicles.
- Smooth bend out to avoid uncomfortable manoeuvring for people cycling.
- Bent-out to store waiting vehicle outside roadway, and perpendicular crossing of bicycle path.
- No high objects (>1.0m) between the bicycle path and the road, to allow for reciprocal visibility.
- Prioritised pedestrian crossing and bicycle path where facilities are separated, or clear shared zone when they are not.
- Kerb build outs to narrow intersection to reduce vehicle turning speeds and increase reciprocal visibility.
- At smaller intersections, there may be insufficient space to incorporate bend-outs in the design of the bicycle path. Several alternative treatments may be appropriate. For example, the bicycle path could be kept close to the road, and turning vehicles required to wait on-road before turning.

## 13.8. Collector to local – raised, straight

Collector to local intersections are where traffic transitions from busier streets, often characterised by higher speeds, to the more quiet residential, commercial, industrial, or urban mixed-use streets; characterised by a limited amount of vehicle traffic.

There is a potential change between the continuing collector street and the local side street in terms of prevailing speeds, traffic volumes, land uses, public transport service and pedestrian amenity.

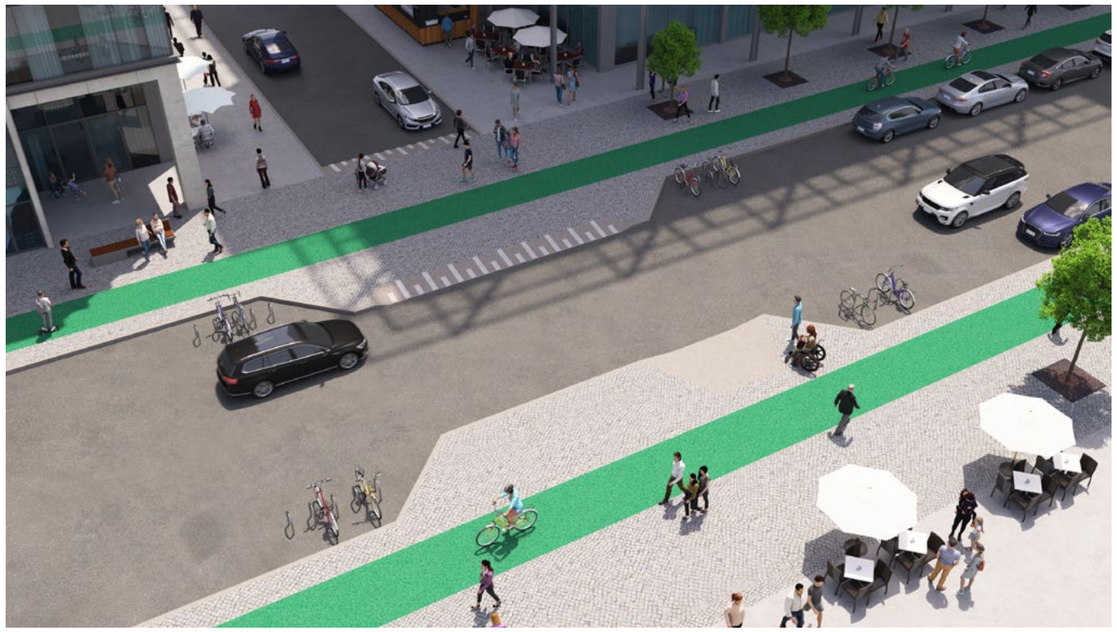


**Figure 18. Priority path over laneways and driveways [adapted from the *Urban Street and Road Design Guide* (Auckland, 2022)].**

### Design objectives

Turning speeds from the medium street to minor street should be slow. Tight kerb radii are advised to help achieve this.

These intersections should be designed to provide a safe and easy crossing for all users, including children, the elderly and people by bike. This includes crossings across the local street, and across the collector street. Creating a compact and safe intersection for all modes may be difficult to achieve simultaneously.

In these situations, the design should clearly reflect the appropriate user hierarchy for the street, and prioritise people walking and cycling.

In light of this, it is important to slow speeds on local streets to no more than 30 km/h (with 40 km/h being the advised top speed for the collector street).

The intersection must be designed for the design vehicle and not for the control vehicle.

A key set of outcomes that any collector to local intersection must seek to achieve:

- Minimised crossing distances.
- Safe (and where possible, level) pedestrian crossings.
- Defined entryways onto the side street (raised crossings or speed bumps may achieve this).
- Enforced slower speeds.

### Recommended treatments

- Provide path user priority through a combination of techniques, including a raised crossing in line with pedestrian desire lines. The raised platform reinforces path user priority and encourages slow speeds for turning vehicles. Platform ramp slope is designed to achieve the desired turning speed.
- Traffic lanes are reduced in size to reinforce slower traffic speed.
- On-street parking may be reclaimed for other uses, or reduced and balanced with other kerbside functions.
- Provide protected cycle lanes. The cycle lanes provide a buffer between the footpath (including outdoor seating areas) and the roadway and may help accommodate occasional larger vehicle turns made by the control vehicle, as they enlarge the effective turning radius.
- Provide a threshold to the different street type.
- Introduce kerb extensions in order to reduce pedestrian crossing distance.
- Remove splitter islands where these are present.
- Keep kerb radii small to slow down turning vehicles.

## 13.9. Local to local – shared street intersection

A shared street prioritises people by slowing vehicular speeds and including design features that communicate to drivers that they must give way to all other users. Shared streets allow people and motor vehicles to mix within the same space. This is accomplished by a design that encourages low motor vehicle volumes and speeds; does not have elements such as vertical kerbs, signs, and pavement markings that separate modes; uses material colour and texture changes to define clear zones for people walking; and establishes uncertainty of the movements of people walking and riding. This encourages caution by all users, slowing driver speeds, and indicates priority for people who are walking. The gateway or transition to a shared street should slow motor vehicle speeds and clearly communicate the entrance through changes in surface material colour or texture, raised pedestrian crossings, raised intersections, and vertical elements that aid in the visual narrowing of the street.

**Figure 19. Local shared street environment where all users can mix [Adapted from the World Resources Institute (2022)].**

### Design objectives

Shared streets may be appropriate in commercial areas with high pedestrian volumes, where pedestrians are likely to cross midblock, or on neighbourhood streets with low motor vehicle volumes to create more flexible space for children's play and other activities.

Designs may not look like traditional streets making cars the guest, rather than the priority user.

Shared streets are also common in old city streets that are too narrow for a travel lane and footpath.

### Recommended treatments

Shared street designs should do the following:

- Encourage very low motor vehicle speeds and volumes with a design and target speed of 10 km/h.
- Distinguish the shared street from conventional streets through changes in surface texture and colour.

- Avoid elements that suggest motor vehicle priority or segregation of modes, such as kerbs, pavement markings, etc.
- Include design elements that suggest priority for people and the function of the street as a place for social, economic, and cultural exchange, such as street furnishings, gathering areas, lighting, etc.
- Placing the holding line at a slight distance from the pedestrian crossing is recommended to improve visibility of path users. Removing on-street parking along the roads leading up to the intersection is advised as well, as it frees up further space to keep crossing distances short.
- Address and carefully consider the navigational needs of people with disabilities.
- Provide a way for people with mobility impairments to access buildings.
- Include appropriate drainage designs for shared streets that do not have kerbs to channel rainwater.

## 13.10. Local network intersection – cross intersection

Local network intersections are only available to people walking and cycling. They are integral to ensuring that low traffic speeds and volumes. Often, this will mean restricting access for motor vehicles. The above diagonal diverter is one example of many types of local network intersections.

**Figure 20. Treatment to reduce the number of intersections for cars and retain permeability for walking and cycling [adapted from the *Urban Street and Road Design Guide* (Auckland, 2022)].**

### Recommended treatments

- This treatment is recommended in areas with sufficient access options in the street network.
- No parking should be allowed around the central diverter.
- Use reflective pavement markings and signage to increase visibility at night.
- Gaps between bollards should be around 1.5 m to provide for bicycles, but not motorised vehicles.
- Sharrow markings may be used for wayfinding and warning purposes.
- Consider alternate emergency response routes.
- These intersections can provide an opportunity for landscaping; native and low-maintenance plants are recommended. Planting should not obstruct visibility and should be <1.0 m high.



## 13.11. Local network intersection – t-intersection

Local network intersections are often part of a series of streets and intersections that form a network of quiet streets with high-quality mixed traffic treatments. In the ACT, the term 'active travel street' is used. These are similar to 'bike boulevards' or 'quiet ways' used in other jurisdictions.

**Figure 21. Modified T-intersection to restrict motor vehicle traffic and allow walking and cycling to filter through [adapted from Cycleway Design Toolbox. Designing for cycling and micromobility (Transport for NSW, 2020)].**

### Design objectives

- Differing pavement texture and colour designed to increase awareness and adjust behaviour of all road users, with consideration given to green pavement to indicate priority to people cycling.
- Inclusion of a median strip, where appropriate, making it difficult for motor vehicles to overtake.
- Narrow traffic lanes designed to reduce speed and discourage overtaking.
- Modal filters to reduce volume of traffic while allowing people who are walking or cycling full access.

### Recommended treatments – raised intersection (right)

- Main design principle: reduce traffic speed, and raise awareness of potential conflict points.
- Flat top speed humps (i.e. raised road platforms) with gentle ramp gradients.
- Narrow roadway designed to reduce speed of motorised traffic.
- Design features that provide visual cues to road users including changed surface pavement, clearly distinguishable by colour, texture and/or materials.

### Recommended treatments – modal filter (left)

- Main design principles: reduce motorised traffic volumes, maintain connectivity for people walking and cycling, reducing travel time, create a more attractive environment for walking and cycling.
- Full road closure for motorised traffic.
- Turning loop.
- Connections for people walking and cycling.
- Landscaping elements.

## 13.12. Collector to collector – signalised, single bicycle route

Collector to collector intersections are common in the ACT and exist wherever the city's main streets, mixed-use and neighbourhood collectors intersect. Collector streets provide access to neighbourhoods and residential streets, and connect to the wider urban area. They are focal points of neighbourhood activity and retail. They are often the most intensively used by people on foot, both as places to pass through and destinations. As the backbone of the city's walking network, it is important to create adequate facilities for people and to provide pedestrian amenity in collector to collector intersections.

**Figure 22. This collector to collector design is applied in a higher density setting. As such detailed road markings would be used. In a lower density residential setting, minimal road markings would be applied. In this setting protected lanes are only facilitated on one of the streets [adapted from the *Urban Street and Road Design Guide* (Auckland, 2022)].**

### Design objectives

The primary function of collector to collector intersections is to support an exchange of traffic flows where two main streets intersect. Traffic flows include and should prioritise walking, cycling and public transport traffic. In most cases, these intersections support a wide variety of retail stores.

Providing a safe environment for all street users at collector to collector intersections is achieved by the following conditions:

- Shortened pedestrian crossing distances.
- Accommodated desire lines.
- Footpath widths that are appropriate for retails centres.
- Safe facilities for people riding and public transport.
- Slow down traffic movements between intersections (target 30 km/h for local streets, 40 km/h for neighbourhood collectors).
- Slow down turning vehicles (design turning speed 15 km/h).
- Public space or green infrastructure.

### Recommended treatments

- By removing excessive markings on the roadway, centre lines in particular, drivers become more observant of their surroundings, and will begin to slow down, as their desired position on the roadway is less clear. Limit markings to the minimum required for safe intersection control.
- Tightening the kerb radii will enforce lower speeds as vehicles turn.
- Placing the stop line at a slight distance from the pedestrian crossing is recommended to improve the visibility of people crossing the street. Removing on-street parking along the roads leading up to the intersection is advised as well, as it frees up further space to keep crossing distances short.
- Where capacity allows, reducing the number of single-movement lanes (and having multi-purpose lanes instead) can support a narrower geometry. In addition, understanding the number of through and turning vehicles in each lane is important, to optimise allocation of lanes and avoid sudden lane change.
- Narrowing lanes is also highly recommended; many medium streets have excessively wide lanes and some of these are widened even further at intersections. Narrower lanes do not only save space, they also visually narrow the roadway, slowing traffic down.
- Provide protected, yet concurrent turn controls to allow cycle and pedestrian through movement priority (see Section 10.5).
- Ramps or raised tables on approaches slow down vehicles, allowing safe speeds if drivers fail to stop, and protecting people on crossings.
- Consider hook turn bays to facilitate right turns from the cycleways.

## 13.13. Collector to collector – signalised, dual bicycle routes

**Figure 23. Collector to collector intersection where bicycle routes are present in both directions, [adapted from Cycleway Design Toolbox. Designing for cycling and micromobility (Transport for NSW, 2020)].**

### Design Objectives

The main design principle is to provide safe and adequate crossing facilities for people walking and cycling.

### Recommended treatments

- Crossing facilities for people walking and cycling on all legs.
- Reduced waiting times for people walking and cycling through adjusted traffic signal controls.
- Barriers to protect riders from turning vehicles.
- Signal lead phase and dedicated green time for bicycle movements to remove signal conflicts.
- Automatic loop detectors for bicycles, reducing wait time.
- Buffer areas for right turning riders.

## 13.14. Collector to collector – roundabout

**Figure 24.** **Tightened kerb radii slows turning traffic and increases visibility between road and path users (adapted from Cycleway Design Toolbox. Designing for cycling and micromobility [Transport for NSW, 2020)].**

### Design objectives

The main design principle is to reduce the speed of intersecting traffic and people cycling, and provide high level of service to people walking and cycling.

### Recommended treatments

- Prioritised and continuous bicycle paths around the roundabout and pedestrian crossings on all legs.
- Raised crossing platforms and clear road marking.
- Narrow all approaches to the roundabout and apply deflection angle for motorised traffic to reduce speed.
- Raised island in the centre for use by wide-turning vehicles (e.g. trucks and buses).

### For discussion:

- What features should be included to balance the need to tighten kerb radii (to slow speeds), offset storage areas (cars) and provide logical connections to pedestrian crossings.



## 13.15. Arterial to arterial – signalised

Arterial to arterial intersections exist wherever arterials intersect. These roads provide access to the motorway network and to main street arterials and connect to the wider region. Their main purpose is servicing through movement. They are often the most intensively used by people in vehicles as places to pass through, though they are also destinations in their own right in some places, by virtue of the land uses adjacent to these roads.

As the backbone of the city's street network, it is important to create adequate facilities for people who are walking and riding. This is especially important given that large intersections can become barriers to these modes.

There is also a unique opportunity to redesign these arterial streets, which presently are mostly traffic-dominated places, back into the urban fabric by supporting the adjacent land uses and minimising the number of lanes, transforming them into better places.

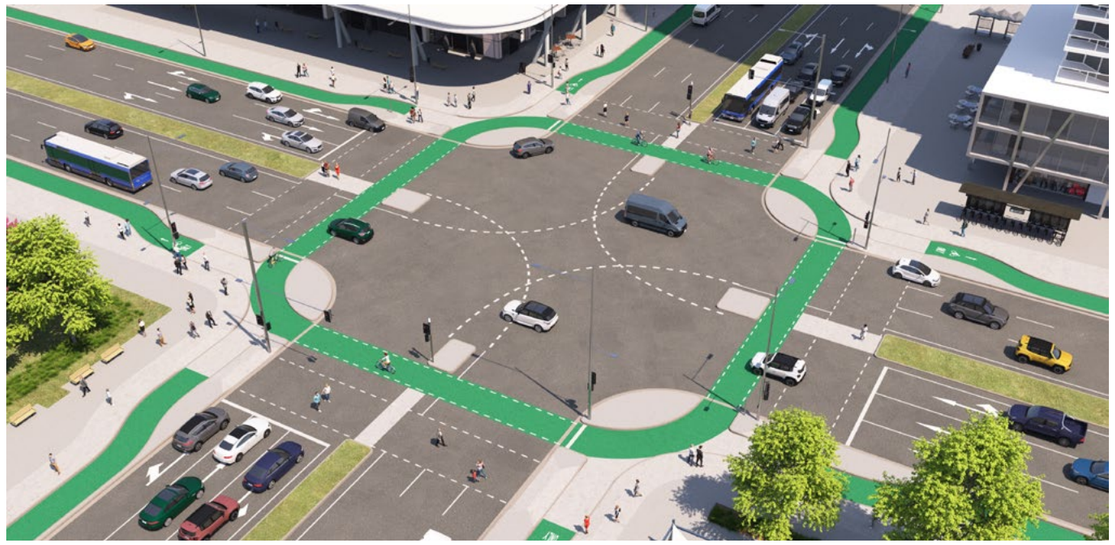


**Figure 25.** **Arterial to arterial intersection with priority to active users [adapted from the *Urban Street and Road Design Guide* (Auckland, 2022)].**

### Design objectives

The primary function of arterial to arterial intersections is to support an exchange of traffic flows where two arterial streets intersect. Traffic flows include and should prioritise walking, cycling and public transport vehicles, with a focus on accessibility if it is in a high use area.

These intersections tend to support retail activity, because of the great accessibility and visibility of the location.

Providing a safe environment for all street users at these intersections is achieved by the following conditions:

- Shortened pedestrian crossing distances.
- Accommodated desire lines.
- Footpath widths that are appropriate for retail centres.
- Safe and attractive facilities for cycling and public transport.
- Slow down traffic movements between intersections (40 km/h for urban areas).
- Slow down turning vehicles (target turning speed 15 km/h).
- Slow down vehicles through intersections to survivable speeds <30 km/h.
- Public space or green infrastructure.
- Line of sight on left turn (immediate crossing and the next one).

### Recommended treatments

It is best to apply design treatments that naturally slow down vehicles and provide safe methods for people to cross. This can be done in a number of ways:

- Tightening the kerb radii will enforces lower speeds as vehicles are making a turn and provide more walking space.

- Placing the stop line at a slight distance from the intersection is recommended to ensure that people crossing can be seen.
- Remove slip lanes and add signalised turn lanes for vehicles turning across oncoming traffic.
- Corner safety islands prevent cars from turning into the path of people riding and provide more visibility for people on foot.
- Reducing the number of single-purpose lanes (and having multi-purpose lanes instead) can support a narrower geometry.
- Narrower lanes can save space and visually narrow the roadway, slowing traffic down.
- Bicycle paths should lead up to the intersection from each direction.
- Pedestrian refuge to allow path users to focus on one direction of traffic at a time as they cross the street and to reduce crossing times.
- Direct and visible pedestrian and cyclist crossings that follow desire lines.
- Ramps or raised tables on approaches slow down vehicles, allowing safe speeds if drivers fail to stop, and protecting people on crossings.



# Bibliography

## Core documents


Auckland Transport (ca 2020). *Urban Street and Road Design Guide*.

Austroads (2020). *Integrating Safe System with Movement and Place for Vulnerable Road Users*. AP-R611-20. February 2020.

Department for Transport (2020) (UK). *Cycle Infrastructure Design.* Local Transport Note 1/20. July 2020.

Transport for NSW (2020). *Cycleway Design Toolbox. Designing for cycling and micromobility.* Version 1. December 2020.

Waka Kotahi New Zealand Transport Agency (2020). *Handbook for Tactical Urbanism in Aotearoa. A Guide for Project Teams.* Draft, revision A. August 2020.

World Resources Institute (2022). *Global Street Design Guide*. In collaboration with World Bank Global Road Safety Facility and Bloomberg Philanthropies.


## Supplementary documents


ACT Government (2020). *ACT Transport Strategy 2020*.

ACT Justice and Community Service (2020.1). *ACT Road Safety Strategy 2020-25. Road Safety. It's everyone's responsibility*. September 2020.

ACT Justice and Community Service (2020.2). *ACT Road Safety Action Plan 2020-2023. Road Safety. It's everyone's responsibility*. September 2020.

ACT Legislative Assembly (2013). *Inquiry into Vulnerable Road Users*. Submission by P Strang and D van den Dool, GTA Consultants. October 2013.

ACT Transport Canberra and City Services (2019.1). *Active Travel. Municipal Infrastructure Standard 05 and related Standard Drawings.* Version 1.0. January 2019.

ACT Transport Canberra and City Services (2019.2). *Planning for Active Travel in the ACT. Active Travel Infrastructure – Interim Panning Guideline*. Draft, version 1.0. January 2019.

ACT Transport Canberra and City Services (2021). *Movement and Place Framework*. Draft, version 0.1. May 2021.

AT Auckland Transport (2020). *Roads and Streets Framework*. Version 2. May 2020.

Australian Bicycle Council (2017). *Traffic Signal Features for Bicycles*. February 2017.

CROW Fietsberaad (2016). Nog meer rek in de regeling? In: fietsverkeer. Tijdschrift voor fietsbeleid en fietspraktijk. N° 39 jaargang 15 najaar 2016. [Ed – More Flexibility in Traffic Signal Timing?].

NACTO (2019). *Don't Give Up at the Intersection. Designing All Ages and Abilities Bicycle Crossings.* May 2019.

NACTO (ca 2020.1). *iRAP Star Ratings of NACTO-GDCI's Global Street Design Guide.* In collaboration with Global Designing Cities Initiative, World Bank Global Road Safety Facility, iRAP International Road Assessment Programme, FIA Foundation and Bloomberg Philanthropies.

NACTO (2020.2). *Streets for Pandemic Response & Recovery*. In collaboration with Global Designing Cities Initiative. June 2020.

National Capital Authority (ca 2005). *National Capital Plan*.

NRMA ACT Road Safety Trust (2012). *ACT Safer Cycling Strategy*. Prepared by GTA Consultants. June 2012.

NSW Government Architect (2020). *Movement and Place Evaluator's Guide. A guide to evaluating built environment projects and plans that balance movement and place in NSW.* In collaboration with Transport for NSW. Version 0.1. November 2020.

Third Global Ministerial Conference on Road Safety (2020). *Achieving Global Goals 2030*. Stockholm Declaration. Stockholm, 19–20 February 2020.

Transport for NSW (2020.1). *Practitioner's Guide to Movement and Place. Implementing Movement and Place in NSW*. Issue 0.1. March 2020.

Transport for NSW (2020.2). *Walking Space Guide. Towards Pedestrian Comfort and Safety*. July 2020.

Transport for NSW (2021). *Designing for Pedestrians and Bicycle Riders Training Course*. Session 1: why walking and cycling matter – government policies underpinning this course. May 2021.

UN United Nations (2020). *Improving global road safety. Resolution adopted by the General Assembly on 31 August 2020*. Seventy-fourth session, Agenda item 12.

World Resources Institute (2021). *Low-Speed Zone Guide. Empowering communities and decisionmakers to plan, design, and implement effective low-speed zones*. In collaboration with World Bank Global Road Safety Facility and Bloomberg Philanthropies.