SIGNALS NZ USER GROUP

Stops and goes of traffic signals

Perspectives from signal practitioners

Report prepared for

Signals NZ User Group

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Prepared by

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VIASTRADA

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1 Introduction

In the early 2000s, the Signals New Zealand User Group (SNUG)[1] identified a need to achieve better consistency with the design and operation of traffic signals throughout the country. Land Transport NZ (LTNZ, now NZTA) funded the development of an audit methodology that examined safety and efficiency of signalised intersections. Ian Appelton was the LTNZ project manager. Nine territorial local authorities (TLAs) each had a representative number of signal installations audited, including some administered by TLAs on behalf of Transit NZ (now also part of NZTA). In total, 123 signalised intersections were audited.

Axel Wilke of ViaStrada (at the time known as Traffix) reviewed the audit reports from the nine TLAs, and summarised the key results summarised in the original 2005 *Stops and goes* booklet. A revised version, with minor updates to the original, was released in 2006.

Now, about 20 years later, SNUG has identified a need to update the *Stops and goes* to reflect recent advances at signalised intersections, particularly in terms of providing for pedestrians, cyclists, and buses. Whereas the first edition was produced based on a meta-analysis of a series of intersection audits conducted following a common methodology, the recent updates have been based on professional experience – that of the key authors, the SNUG committee, and survey responses from the wider industry. ViaStrada has been commissioned to undertake these updates.

The purpose of this booklet is to draw attention to those elements of traffic signals that the authors have frequently found to compromise safety and/or efficiency, and to present ways in which these deficiencies could be addressed. While some of the issues from the original Stops and goes edition have largely been eradicated from practice over the past two decades, most are still presented in this latest version to ensure this industry knowledge is retained and safe-guard against these issues resurfacing.

Appropriate standards and guidelines are in place, with the Austroads Guide to Road Design suite, the NZTA Traffic Control Devices Manual, and the Traffic Signals: Intelligent Transport Systems (ITS) design standard (NZTA,2025b; draft, awaiting final version) as the main reference documents.

The target audience for this booklet is engineers who design, construct, install, manage and maintain traffic signals. Therefore, the audit document will contain traffic signal terminology, which will not be explained in this booklet, but may be found in the glossary of terms in the ITS design standard (NZTA,2025b; draft, awaiting final version).

The aim of this booklet is to contribute to safer and more efficient installations and operations of traffic signals in New Zealand.

[1] A technical sub-group of the Institute of Professional Engineers NZ (Engineering New Zealand) Transportation Group.

2 Specialised tasks

2.1 Traffic signal peer reviews

All new signalised intersection designs and installations must undergo Safe System audits. The Safe System audit guidelines (NZTA, 2022) note "*specialist safety auditors may need to be co-opted onto the safety audit team for specific areas of expertise, for example traffic signals, lighting, cycle facilities, public transport and temporary traffic management*." The guide's primary focus is on safety, and it explicitly states "traffic capacity issues should not be discussed unless they have a bearing on safety outcomes"; where traffic signals are concerned, efficiency does have considerable implications on safety. Therefore, it is critical that a traffic signal audit covers both safety and efficiency, and should be undertaken by a competent signals engineer who understands these implications.

In addition, all signal designs must undergo a specialist peer review, to confirm the software has been appropriately programmed.

While the audit process reviews the existing installations, it does not cover any new installations or major upgrades of existing sites. Therefore, SNUG recommends a parallel process of traffic signal peer reviews to ensure best engineering practice is used at every new installation or major intersection upgrade. This recommendation recognises that traffic signal design is a highly specialised discipline of traffic engineering, and that there are few engineers in New Zealand with the appropriate in-depth knowledge and experience.

2.2 Intersection control

The set-up of the SCATS software used for operating traffic signals is a specialised discipline. It is recommended that suitably qualified engineers should be engaged periodically to review the set-up of SCATS networked traffic signals.

Another specialised field is the programming of the traffic signal controllers. RCAs should ensure that a suitably qualified and experienced engineer is employed for this task, and, as mentioned above, this must then be tested and peer-reviewed by another sufficiently qualified and experienced signals engineer.

2.3 Contact details

Please contact any SNUG committee member for a list of suitably qualified and experienced engineers. Contact details for SNUG committee members are available on the SNUG website:
https://snug.org.nz/committee/.

3 Crashes at traffic signals

The original version of the Stops and goes included a crash analysis undertaken by Tim Hughes of Land Transport NZ that identified the main safety issues at traffic signals. While the proportions have changed slightly, the main crash type and contributing factor remain the same, as shown in Table 3-1:

Table 3-1: common issues in injury crashes at traffic signals

Issue	Description	Proportion of injury crashes affected*	
		2021–2025	Early 2000s study
Most common crash type	Right turn against crashes	28%	*(32%)*
Most common crash factor	Did not stop at full red traffic signal	31%	*(30%)*
Vulnerable users	Pedestrians	11%	*(14%)*
	Cyclists	7%	*(8%)*

Points to note:

- Changes in the proportions shown in Table 3-1 could be due to changes in the transport system, e.g. publication of the original Stops and goes plus other efforts to improve industry practice could have resulted in the decrease in right turn against crashes. However, there have also been changes to the reporting system and methodology which could influence the comparison.
- The most common factor recorded for crashes is technically code 102: “alcohol test below limit” (recorded for 76% of injury crashes. However, this is simply used as a record that Police undertook a routine alcohol test after a crash – alternative codes such as code 101: “alcohol suspected” would have been used if the Police had considered alcohol to be a factor regardless of a negative test result (this did account for 11% of injury crashes).
- Pedestrians and cyclists are not the most common users in crashes (100% of injury crashes in the dataset involved drivers of motor vehicles). However, when exposure is accounted for, pedestrians and cyclists are over-represented in crash statistics compared with motor vehicle occupants (Koorey et al, 2024) due to their vulnerability (e.g. lack of physical protection compared with motor vehicle occupants).
- The exact analysis period for the original crash study undertaken sometime in the early 2000s is unknown.

Further detail on the common crash movement types and contributing factors to crashes at traffic signals are given in Figure 3-1 and Figure 3-2:

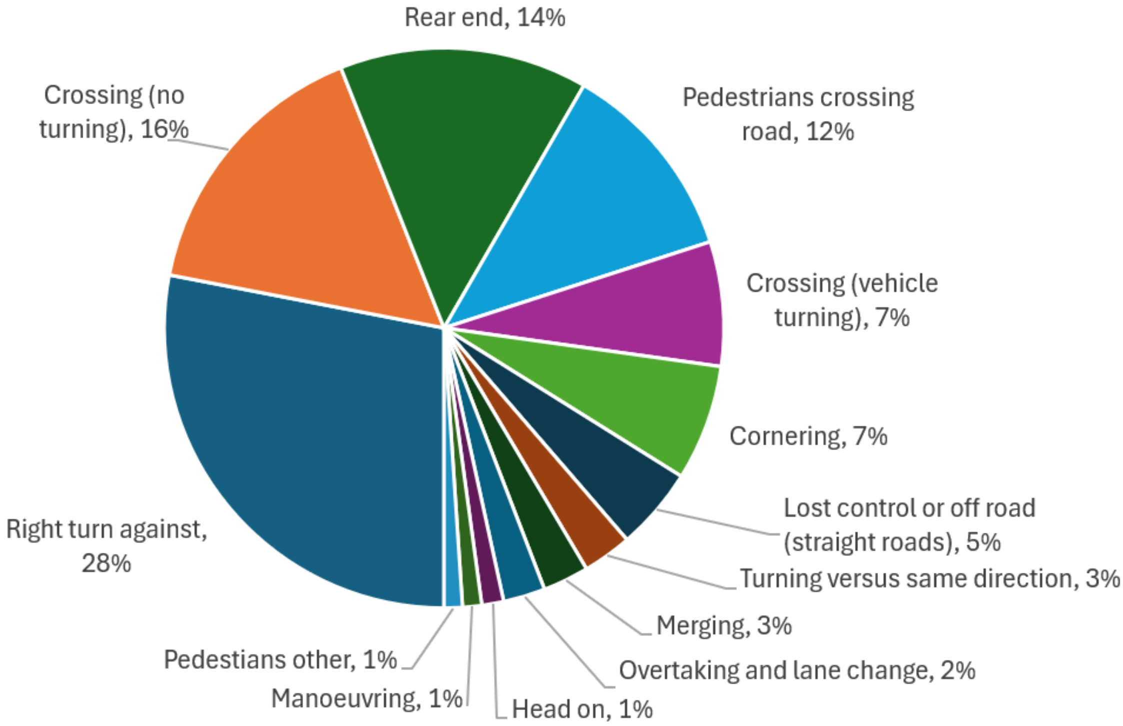


Figure 3-1: Crash movement types for injury crashes at traffic signals (2021–25)

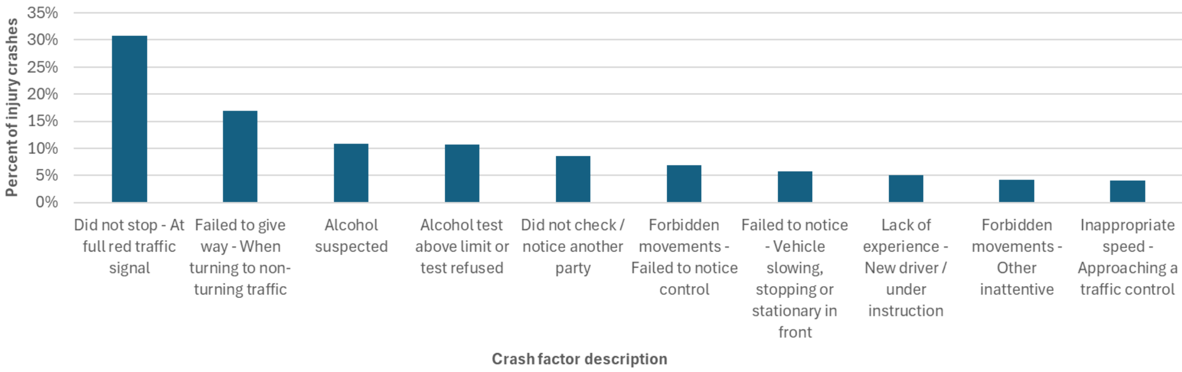


Figure 3-2: Top ten factors contributing to injury crashes at traffic signals

Approximately 200 other factors have been identified for injury crashes at traffic signals in the 2021–25 dataset, each contributing to up to 4% of crashes.

Subsequent sections of this booklet will give some guidance on how the safety performance of signals can be improved.

4 Intersection and lane layout

4.1 Opposed right-turn lanes

Exclusive right-turn lanes should be provided whenever possible. Opposed right-turn lanes should line up, and not be offset, allowing right turners waiting for a filter turn as much forward visibility past queued opposing right turners as possible.

Many 14-m-carriageways in the original round of audits had their two-lane shared approaches reconfigured to include an exclusive right-turn lane, without relocating the centre line. This resulted in the opposed right-turn lanes being offset.

Figure 4-1: Offset right-turn bays with visibility issues (further restricted by vertical geometry)

Safety and efficiency issues

Poorly aligned right-turn lanes can lead to:

- poor intervisibility between right turners and opposing through traffic, resulting in a higher right-turn-against crash rate
- drivers concentrating too much on opposing through traffic, overlooking pedestrians or cyclists to whom they must also give way
- some drivers being hesitant, reducing intersection capacity
- increased inter-green time due to the longer tracking paths.

Recommended treatments

- Ensure right-turn bays line up (i. e., 'back-to-back' design).
- Reducing the right-turn lane width minimises the offset between opposed right turners, further increasing forward visibility.
- Where filter right turns operate but opposed right-turn lanes are not possible (e.g., due to the inability to ban kerbside parking or tracking paths of vehicles), consider a different phasing operation (e.g., split approaches) or a right-turn ban for one direction.

Figure 4-2: Right-turn bays incorporated into solid median achieving excellent forward visibility

4.2 Captive turn lanes

Captive turn lanes are created when a mid-block through lane leads directly into a turn lane at an intersection. It is important that advanced warning is given to motorists that they may only turn from these lanes.

Ideally, drivers should be channelled into through lanes at intersections (or shared through and turn lanes) and should not be confronted with captive turn lanes.

Captive turn lanes with insufficient warning were found quite frequently during the signal audits and appear to result from the engineering plans not showing how to tie the intersection lane layout into the existing mid-block markings.

Safety and efficiency issues

Captive turn lanes can lead to:

- erratic and undesirable driver behaviour, including sudden lane changes or through movements when only turning movements are allowed, potentially resulting in a higher crash rate
- drivers unnecessarily slowing or stopping close to the intersection for a desired lane change,
- impacting on the intersection capacity.

Figure 4-3: Historic example: captive left-turn lane with insufficient warning to motorists

Recommended treatments

- Channel drivers into through lanes whenever possible (ensure that engineering plans show the tie- in into the mid-block layout).
- Where captive lanes cannot be avoided (e.g., where two approach lanes in the mid-block lead into the stem of a T intersection with exclusive turning lanes), ensure that drivers have sufficient pre-warning by lane arrows and possibly signs.

Figure 4-4: Lane markings advising motorists of captive turn lanes

4.3 Slip lanes

Slip lanes help to make intersections more compact and enable traffic signal poles and lanterns to be placed closer to drivers' line of sight; this generally simplifies motorists' decision-making processes and contributes to a safer intersection layout. While there has been some industry debate regarding the suitability of slip lanes for pedestrians, recent research shows that well-designed slip lanes (in particular those incorporating a high entry angle, raised safety platform crossing, and signalisation where appropriate – see O'Brien, 2019) can improve pedestrian safety (by separating conflict points) and reduce pedestrian delay (by providing a priority crossing across the slip lane and reducing the overall intersection cycle time).

Slip lanes should comply in layout with guidance given in Austroads GRD part 4A (2023) and any local standards. The Pedestrian Network Guide (PNG) details the considerations for pedestrian crossings across slip lanes and the Cycling Network Guide (CNG) discusses how to provide for cyclists both travelling across the slip lane entry and across a slip lane crossing. For sign posting details and provisions for visually impaired pedestrians, refer to RTS 9 (1993) and RTS 14 (2025), respectively.

Safety and efficiency issues

Poorly designed slip lanes can lead to:

Figure 4-5: Pedestrian slip lane crossing point with poor visibility around the corner to approaching slip lane traffic

- poor intervisibility between pedestrians and left turners, if the crossing position is too far around the corner
- drivers having problems observing traffic to give way to if the slip lanes are not of the high-entry- angle type or if the kerb radii are too large (because some people have problems turning their heads and door pillars may obstruct visibility). Driver hesitance and increased crash rate are possible consequences
- increased turning speeds, resulting in loss of control or failure to give way
- not enough room for pedestrians (e.g., during the school peak) or street furniture, if islands are undersized.

Recommended treatments

- Slip lanes should be of a high-entry-angle type, with suitably tight corner radii.
- The location of the pedestrian crossing point should provide sufficient intervisibility.
- The slip lane island must have enough capacity to accommodate the number of cyclists and pedestrians expected to be waiting there between crossing stages.
- Pedestrians and cyclists should be given priority over drivers by using a signalised slip lane crossing or a priority (zebra / dual) crossing; both forms should preferably be on a raised platform.
- It should be considered whether through-cyclists are provided with the option to remain on-road (see Figure 8-9 in section 8.2), or whether all must travel via the slip lane crossing (see Figure 8-8). This decision depends on factors such as the cycling target audience, local conventions, and available intersection space. If all cyclists are diverted, the deviation should not be too great, otherwise some cyclists will choose to merge into the general traffic lane.
- It is critical that pedestrians and cyclists can tell the slip lane crossing and the main intersection crossing are two separate crossings, that may have different forms of control or phasing etc.

Figure 4-6: Slip lane with dual zebra / cycle crossing on raised platform for speed control

5 Signal pole and display location

5.1 Pole placement and signal conspicuity

One of the most common findings from the safety audits that informed the original *Stops and goes* was inadequate conspicuity of signals, which is a particular safety concern for signals that perform the warning and stopping functions. Austroads Guide to Traffic Management Part 10 (2020, section 10) details the requirements for locating signal faces to make them suitably conspicuous to road users.

Safety and efficiency issues

AGTM Part 10 notes several factors that can lead to poor signal conspicuity, such as:

- Poor signal placement (due to the positioning of signal poles or the signal faces)
- Inadequate number of signal faces (see section 5.2)
- Obstruction and visual distractions (e.g. from vegetation, utility poles, verandas, advertising signs or other illuminated backgrounds, sunstrike, etc)
- Road geometry and alignment

Poor pole placement and reduced signal conspicuity can lead to:

- an increase in inadvertent red light running
- an increase in rear-end crashes
- an increase in right-turn-against crashes
- reduced efficiency.

Figure 5-1: Historic example: no signals visible to approaching drivers (photo enhanced from original)

Recommended treatments

- RCAs should have an upgrading programme for conversion to tall poles or mast arms as appropriate.
- As per AGTM Part 10, kerbside poles should be located nominally 1 m (no less than 0.6 m) from the kerb face, and close to the tangent point; minimising corner radii can help achieve this.
- Kerb extensions should be used wherever possible to improve lantern visibility.
- Street furniture should not reduce signal conspicuity. Under-grounding aerial services, locating street lighting poles at the property boundary and using joint-use poles can all be considered. The size of trees must be taken into account both at the time of planting and at maturity, and ongoing maintenance (pruning, trimming) allowed for.

Figure 5-2: Good conspicuity of traffic signals

5.2 Sufficient stopping and manoeuvring displays

Motorists must receive the relevant information from signal displays, regardless of the lane they are travelling in. Some redundancy must be allowed for, as lamps can fail and the remaining signals must still provide a safe intersection. Legislated minimum requirements must also be met.

Safety and efficiency issues

An insufficient number of signal displays can lead to:

- compromised signal conspicuity (for motorists in some traffic lanes, for example, caused by large vehicles in adjacent lanes) and thus reduced safety
- motorists making wrong choices
- unsafe intersection operation in case of lamp failure (lack of redundancy)
- RCAs opening themselves to avoidable risks when legislated requirements are not met.

Figure 5-3 Historic example: non-complying two-aspect display (no green aspect)

Recommended treatments

Design as per AGTM Part 10 regarding signal face functions and site requirements, plus the following points:

- For each signal aspect (i.e. unique combination of type, colour, direction) used on an approach, at least one aspect must be provided in either the primary or dual primary position (including arrow displays).
- The minimum number of signal displays for major and minor movements is three and two, respectively. A major movement is one where the associated displays do not have an OFF state. Therefore, a right or left-turning movement that is allowed to filter is a minor movement, but a right-turning movement that is fully protected (at least during certain time periods) is classed as a major movement and must always have an aspect illuminated.
- Signal faces are not effective for drivers where two or more lanes separate their lane from the signal face; in such cases, mast arms or dual primary signals should be provided.
- As per the Traffic Control Devices Rule 6.4(4) at least one aspect must be illuminated in any one signal face at any one time; therefore, avoid signal faces with three arrow aspects only where filter turning occurs, as all aspects will be in the OFF state during filter turning.

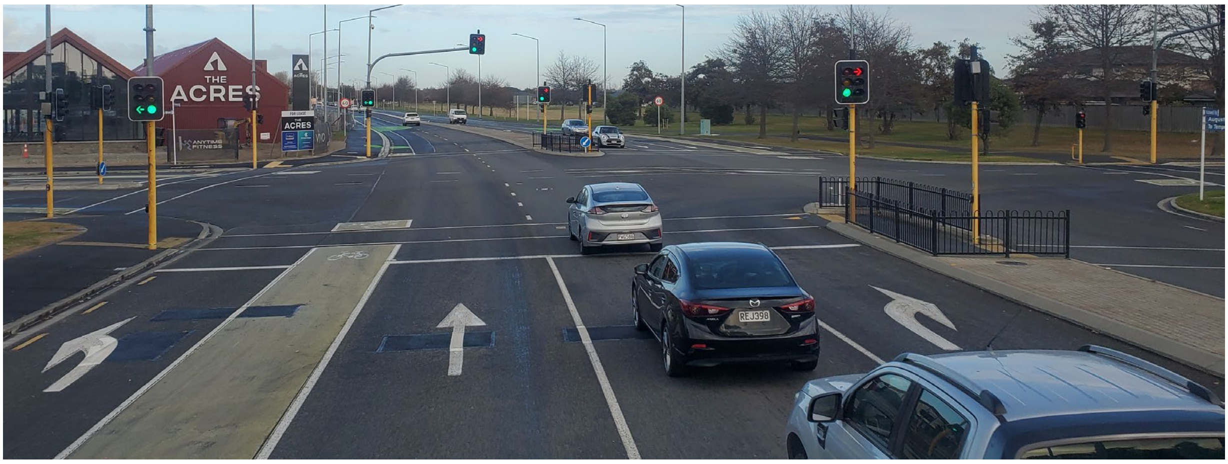


Figure 5-4: Fully protected right turn with the required three right-turn arrow displays

6 Phasing and operational issues

6.1 Right-turn and left-turn arrow operation

The objectives of signal phasing design are to provide safety and efficiency. As those objectives often conflict, compromises must be considered carefully.

Arrow signals can be used for:

- Partial or full control of a turn movement
- Allowing a movement to move when there is no conflict (e.g., operating a left turn from a side street during a diamond phase operation on the main road)
- Partial or full protection for a pedestrian crosswalk or cycle crossing (e.g., when a turning movement is held back for at least part of the time for parallel pedestrians crossing the road)
- Indicating to turning motorists that there is no conflict (e.g., pedestrian crosswalk / cycleway has a red signal, or does not exist on that leg).

Safety and efficiency issues

- The use of arrow displays needs to balance safety and efficiency.
- When consistency across the network is not met, motorists may be confused.
- Drivers may incorrectly anticipate a phasing change, or react to another signal changing to green when theirs is still red. Care should be taken to ensure movements prone to this will not result in false-starts that could result in conflict with other movements (e.g. a pedestrian crosswalk or cycle crossing close to that movement's limit line).
- Some sites with multiple departure lanes provide a green arrow for the left turn in and a green arrow for the opposing right turn in, based on the rule that drivers must turn into the nearest available lane. In practice though, this can result in conflict when a driver ignores this rule or attempts to make a quick lane change on the departure.
- Right turners 'cutting the corner' may drive over the right-hand approach lane of the side street, causing a false side street demand.

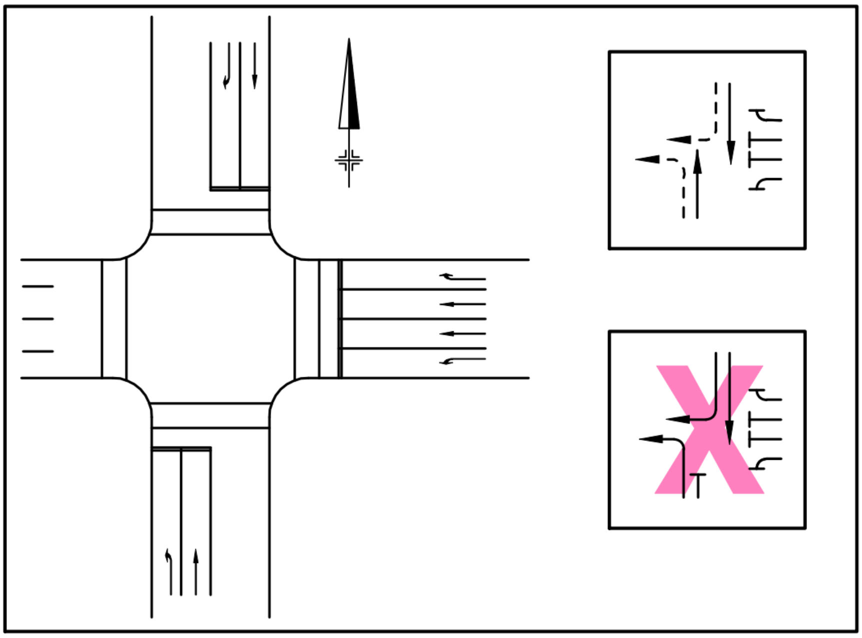


Figure 6-1: Bad practice of allowing protected turns into their own lanes simultaneously

Recommended treatments

- Where red arrow displays are present, they should always be used for full or partial pedestrian protection.
- Care should be taken to ensure that similar phasing philosophies are used at adjacent intersections and preferably throughout the network.
- The phasing design must match the lane arrangement. A protected right-turn phase requires an exclusive right-turn lane (except for split-approach phasing).
- If present, green left-turn arrows should be operated whenever that movement is unopposed.
- If the side street demand can be met by a left-turn green arrow, then this would be the most efficient way to operate the intersection.
- A protected turn phase can only be operated when there is no conflict. It is not considered good practice to have protected but opposing movements turn into their respective nearest lanes (i.e., a left-turn green arrow and an opposing right-turn green arrow should not be displayed together unless the departure lanes are physically separated by means of a solid island).
- Do not display a green left turn arrow for traffic in conjunction with a kerbside cycle facility, unless the cycle waiting areas are clear of vehicle tracking.
- Use a presence timer on the side street detector if it may be driven over by right-turning traffic from the main road, or offset the stop-lines on the departure approach further back so the right turner does not encroach over the centreline.
- When a left turn from a minor road is associated with a right-turn phase from a main road, it is good practice for the left-turn detector to also call the right-turn phase when there is no demand for the right turn from the side street (see Figure 6-2). This results in greater efficiency, as just one of the main road approaches needs to be stopped whenever there are only left-turn vehicles. Similarly, where the signal hardware is available, a green left-turn arrow should be displayed to the side street traffic when the main street operates a protected right turn.

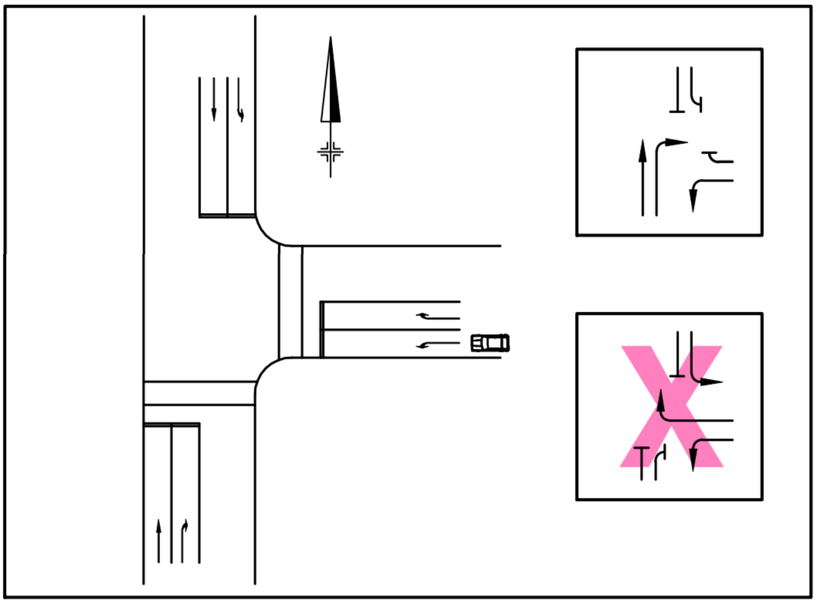
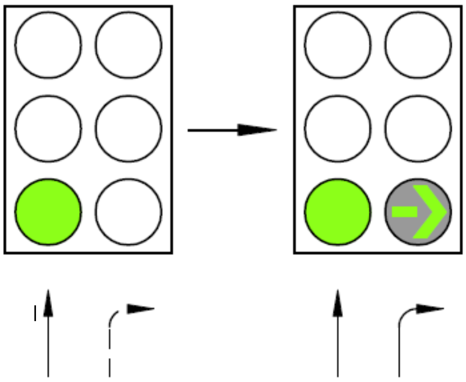


Figure 6-2: A left-turn demand on the side street should call the associated main road right-turn phase

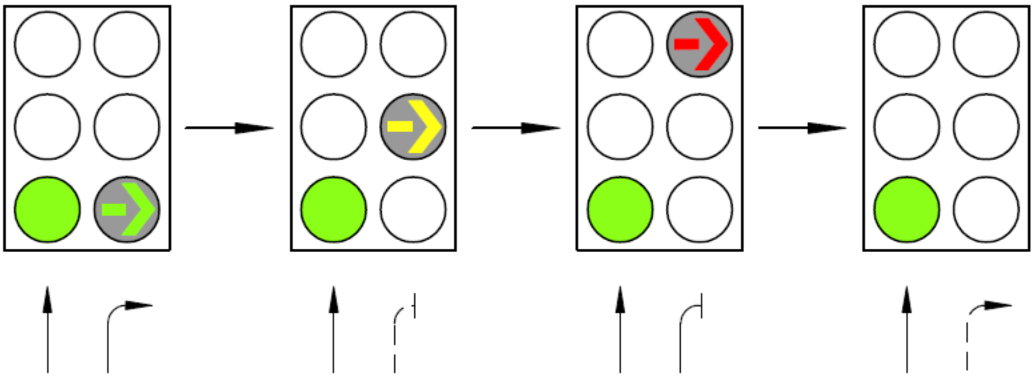
6.2 Filter turning operation

Compared to full filtering, the following crash rate reductions were identified in a British study (Hall, 1993); it is expected they remain relatively similar in NZ today:

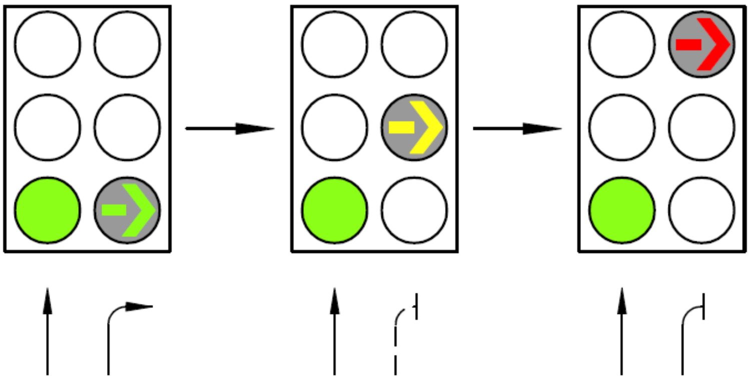
- 30 percent reduction for filter right turns, followed by a right-turn arrow (a lag right turn).



- 68 percent reduction for a right-turn arrow, followed by filtering (a lead right turn).



- 90 percent reduction for a lead right turn, followed by a red arrow (no filter).



There are a variety of reasons why, in some circumstances, a lag right turn at cross intersections is less safe than a lead right turn, and the default should be a lead right-turn arrangement. A lag right turn may be dictated by coordination requirements or when insufficient width does not allow opposing right-turning movements to occur simultaneously.

Particular care must be taken to avoid phasing an unintentional lag right turn when the opposing right-turn movement may filter-turn. This 'right-turn trap' happens when a filter right turner (or a u-turner at a T intersection) faces a yellow circle display but the opposing through movement overlaps to a lag right-turn phase. The right turner (or u-turner at a T intersection) has no indication whatsoever that the opposing through movement is not being terminated and may turn during the amber believing the opposing through movement is stopped. This situation can occur when intervening phases are skipped, e.g., during low-demand periods.

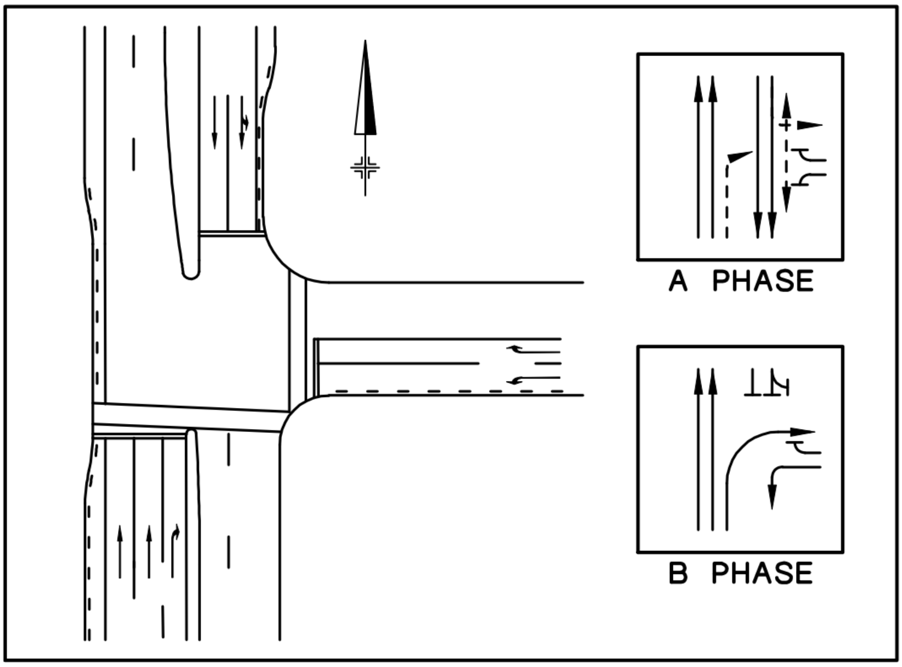


Figure 6-3: Avoid a 'right-turn trap' for u- turners from the north approach by either banning that U-turn or ensuring that A phase is never followed by B phase

Safety and efficiency issues

- Poor filter turning operation can lead to right-turn-against crashes, particularly where:
    - turning on yellow across multiple lanes of traffic when one opposing lane has stopped, but drivers in an adjacent lane proceed
    - opposing traffic speeds are high or unpredictable (particularly common on multi-lane roads),
    - visibility is limited (e.g. due to shielding by vehicles in other lanes on a multi-lane approach, or horizontal or vertical geometry.
    - phasing induces 'right-turn trap' scenarios (discussed above).
- Driver uncertainty and hesitation, especially where filtering operates intermittently or inconsistently across the network, reducing capacity and increasing rear-end crash risk.
- Conflicts with pedestrians and cyclists on parallel pedestrian or cycle movements (see also sections 7.1 and 8.2.
- Having to judge a gap in traffic and judge the intentions of other drivers (e.g. are they turning or proceeding straight ahead?) increases the cognitive load on drivers.
- Not providing filter turning and holding drivers at a red arrow when there would have been opportunity for them to turn safely can reduce level of service, increase driver frustration and ultimately result in drivers choosing to make non-complaint turns.

Recommended treatments

- Consult the local RCA signal engineer – different RCAs have different practices regarding provision and operation of filter turning – following local practice ensures consistency and avoids driver confusion.
- Avoid the 'right-turn trap' by using a suitable phasing sequence or, if necessary, banning the at-risk movement(s).
- Where filter turning operates, provide full or partial protection for pedestrians and cyclists using red arrows or late starts as appropriate to remove conflicts during at least part of the pedestrian or cycle movement.
- Where filter turning operates, ensure the layout supports this, including:
  - Exclusive right-turn lanes where filtering is expected to operate regularly
  - Adequate forward visibility between opposing traffic streams

6.3 Turn arrow logic

Only experienced signal designers and operators are likely to be aware of problems with turn arrow logic. Expert assistance is required in the design stage for both the physical intersection layout and phasing design. After installation, the on-street operation should be checked by a suitably experienced signal engineer. Only suitably knowledgeable and experienced engineers should be used for compiling the controller personality.

There are some standard operating procedures for turn arrow logic in Austroads GTM Part 10 (2020: section 10.3.3), including holding the right-turn red arrow for a suitable period before dropping it when changing from a protected turn to a filter turn.

Figure 6-4: Dangerous ambiguity: walk and green left-turn arrow displayed simultaneously (original photo enhanced to improve resolution)

Safety and efficiency issues

The following safety and efficiency issues can arise:

- Operating conflicting movements simultaneously will lead to crashes.
- Where intersections are linked, poor applications of signal logic and phasing will result in longer cycle times and poor efficiency.

Figure 6-5: Green arrows with no conflict, but "turning traffic give way to pedestrians" sign is misleading

Recommended treatments

- The correct sequence for a transition from a protected right turn to a filter turn involves holding the red arrow for five seconds before it is switched off.
- A left-turn loop should call an associated right-turn movement (but special provisions must be allowed for if force-skipping the right-turn phase via SCATS).
- Standard operating sequences should be adhered to.
- Carefully consider the impacts of signal logic phasing for linked intersections.
- Seek expert help and ensure designs are peer reviewed by independent and suitably experienced engineers.

Figure 6-6: Right turn arrow red between transitioning from protected to filter turn

7 Pedestrian issues

Guidance on planning and designing for pedestrians is available in the Pedestrian Network Guidance "PNG" (NZTA, 2026b) – see particularly sections on Pedestrian Design Principles, Crossings, and Intersections.

7.1 Pedestrian phase issues

Pedestrians are the most vulnerable road users and require special consideration during signal design. People who walk may be too young or too old to drive or cycle, or may have a vision impairment. Turning motorists may be allowed to filter through parallel pedestrian movements and, due to the complex demands at signalised intersections, pedestrians may be unintentionally overlooked.

Safety and efficiency issues

The following safety and efficiency issues can arise:

- Pedestrians need to be able to clear the length of the crosswalk during the clearance period to avoid conflict with crossing traffic.
- Wide intersections can intimidate pedestrians (i.e. their perception of safety, even if a sufficient clearance period has been allowed).
- Turning drivers may not give way to pedestrians, especially when:
    - There is no form of pedestrian protection through red arrows
    - The intersection is wide
    - Pedestrians seem to be crossing slowly
    - Pedestrians are coming from the opposite side of the intersection
    - The driver perceives pressure from traffic behind them – particularly in a shared turn / through lane
- Late introduction or reintroduction of a pedestrian phase can catch turning motorists by surprise.
- Right turning motorists at a 4-leg intersection may focus on filtering through opposing traffic and overlook pedestrians.
- Right turning motorists coming from the stem of a T have no opposing traffic to slow them down and reach higher speeds at the conflict zone.

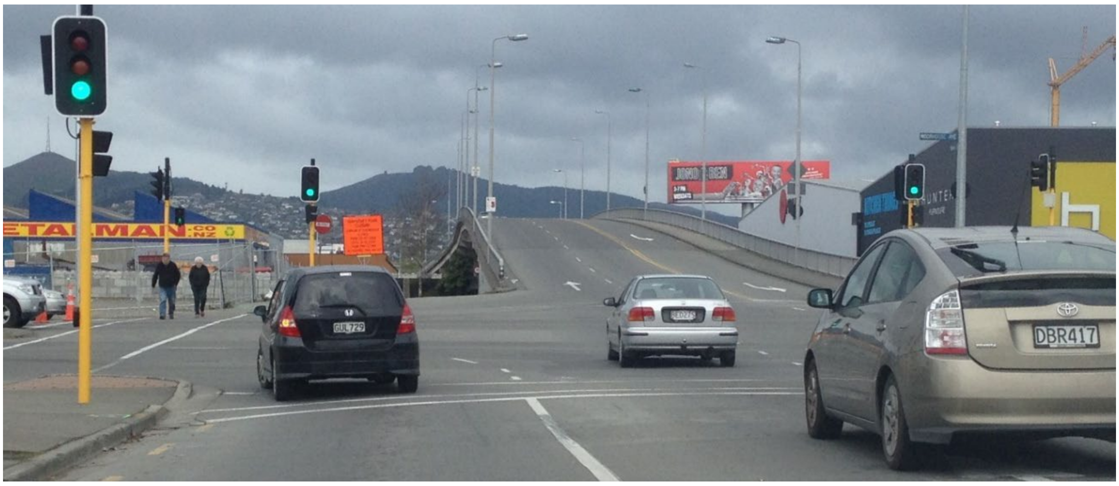


Figure 7-1: Bad practice – no pedestrian protection across busy, wide intersection with double left turn

Recommended treatments

What level pedestrian protection to provide:

- All pedestrian crosswalks should have some form of pedestrian protection from turning traffic, either:
    - Full protection – i.e. during the walk and clearance periods
    - Partial protection – i.e. terminating at some point before the end of the clearance period.
- It is strongly recommended that full protection be provided against right turning traffic, as these drivers start further away from the pedestrians, may be distracted by filtering through opposing traffic, and reach higher turning speeds at the point of conflict.
- Partial protection may be an option for left turning traffic, but full protection should be considered for site-specific factors that create higher left turn speeds, limit intervisibility between drivers and pedestrians, or in areas with high volumes of vulnerable pedestrians.
- For a crosswalk to the right of the stem of the T at a signalised T junction, full pedestrian protection should be used.

What signals to use for pedestrian protection:

- Pedestrian protection should preferably be provided using red arrows.
- In some cases (e.g., shared lanes where turning traffic subject to a red arrow would block through traffic and cause the latter to make unsafe manoeuvres) it may be necessary to instead apply a late start to the whole parallel vehicle approach.

What signals to use for pedestrians

- The standard provision is two-aspect (green and red) pedestrian signals, mounted on the far-side of the crossing.
- Countdown timers can be applied where pedestrians have full protection (i.e. midblock or Barnes dance sites) to encourage pedesrians to cross swiftly by indicating the time left in the clearance period.
- Near-side (aka PUFFIN) signals can be applied at midblock crossings, to encourage pedestrians to look towards oncoming traffic.

Figure 7-2: near-side pedestrian signals at midblock crossing

Time settings for pedestrian movements

- The clearance-time settings need to be based on the actual crossing length and take into account special requirements (e.g., proximity to a rest home or hospital).
- It may be appropriate to run longer crossing times during busy pedestrian peaks such as school start/end times.

When to run pedestrian movements during the intersection phasing:

- Pedestrian movements may be introduced late in a phase to better suit pedestrian progression between adjacent intersections. Or, the pedestrian movement could be run twice within a phase. Late introduction or reintroduction of a parallel pedestrian crosswalk should only be used if the conflicting vehicle movements (left and right turns) have been terminated, separated (e.g., a left turn slip lane), or banned (e.g., crossing the upstream approach of a one-way street).
- For staged crossings – aim to help pedestrians cross the whole approach as quickly as possible, without having to wait in the central refuge for multiple phases.
- Avoid phasing that entices non-compliant crossing behaviour. E.g., if a pedestrian crosswalk only runs with a B signal, pedestrians heading to the bus may attempt to cross in other phases, so they can catch their bus before it leaves.

Calling and detecting pedestrian movements:

- Pedestrian movements can be called automatically, i.e. as a default movement, particularly in periods where there are high pedestrian volumes. This improves pedestrian level of service by increasing predictability, catering for those who arrive just too late to push the button in time to call their phase, and reducing the number of potential failure points. It also promotes walking by showing all users that walking is a default mode, not an exception.
- At one-way streets, the pedestrian crosswalk across the approach can be called whenever the intersecting street is given at least as much time as the pedestrian crosswalk requires.
- If a cycle movement is fully protected via a red left turn arrow, it makes sense to introduce the parallel pedestrian crosswalk at the same time (assuming the partial protection requirement for the crosswalk is not greater than the full protection requirement for the cycle movement).
- For long crossings, consider on-crossing pedestrian detection to provide dynamic clearance time, to extend and reduce clearance time (compared to default) to better cater for faster and slower pedestrians. This detection should be properly designed to avoid terminating the clearance while a pedestrian is still crossing, e.g., by having detectors on both side of the crossing and safe programming of the controller.
- Pedestrian inputs can be separately recorded by the controller, so when the “far side” button is pressed (i.e. pedestrians cross toward left turn traffic) the length of protection against left turners can be increased.

Figure 7-3: Partial pedestrian protection using a red left turn arrow

7.2 Pedestrian hardware positioning

The correct push button location is an important feature for pedestrians, especially for those with vision impairment (many of whom also have a hearing impairment). The correct placement is at the edge of the cutdown for the crosswalk, with an embossed arrow indicating the direction of travel through the intersection. The use of audio-tactile equipment requires that push buttons for different crossings are not located too close to one another. The placement of tactile ground surface indicators is critical for guiding vision impaired pedestrians to the crosswalk and the push button and warning them of the transition from the pedestrian space to the roadway. RTS 14 details all these requirements.

Safety and efficiency issues

The following safety and efficiency issues can arise from poor push button locations:

- Push buttons located away from the cutdown may result in pedestrians tripping at the kerb.
- Poorly orientated embossed arrows and tactile paving may lead vision-impaired pedestrians away from the crosswalk and they may cross in the wrong direction.
- Pedestrians may be less inclined to demand their phase if the push button is poorly located.
- Wheelchair users may not be able to reach poorly positioned push buttons.
- Audio-tactile equipment for adjacent crosswalks may confuse pedestrians if the poles are positioned too close to one another.

Figure 7-4: Poor provision – no pedestrian push button adjacent to crosswalk / cutdown

Recommended treatments

- Install push buttons at the cutdown. Make use of short stub pole if the signal pole is not in a suitable location and cannot or should not be shifted (e.g. Figure 7-5).
- In most cases, it is preferable to locate the pedestrian call buttons near the outer crosswalk line (relative to the intersection centre). This provides consistency for visually impaired pedestrians and often coincides with the primary signal pole for the approach leg and / or secondary or tertiary signals for the opposite leg.
- Avoid safety rails obstructing push buttons.
- Ensure audio-tactile equipment for adjacent crosswalks is at least 3 m apart.
- Ensure that the embossed arrow and any tactile paving are orientated correctly.
- Ensure the recommendations of RTS 14 are followed.

Figure 7-5: Use of stub pole for appropriate placement of pedestrian call box adjacent to the kerb crossing [2]

[2] Note, however, it would be preferable to locate both stub poles on the outer side of the crosswalks, as discussed above

8 Cyclist issues

Guidance on planning and designing for cycling is available in the Cycle Network Guidance "CNG" (NZTA, 2026a) – see particularly sections on Signalised Intersections and Signalised Crossings.

8.1 Legal definition of "roadway"

The guidance in this document reflects the current legal situation (as of June 2026) but is intended to be flexible in accommodating potential changes.

The Land Transport (Road User) Rule 2004 defines "roadway" as "the portion of the road reserve used or reasonably usable for vehicular traffic in general". Painted cycle lanes, therefore, are considered part of the roadway; however, separated cycleways and shared paths involve physical elements that prevent general traffic from entering the facility and are therefore not legally part of the roadway. This distinction is important, because common law requires anyone entering a roadway to give way to those already on the roadway.

At signalised intersections, cyclists coming from cycle facilities that are on the roadway are subject to the same legal rules as drivers of other vehicles, and therefore drivers turning across the path of cyclists must give way to cyclists travelling straight ahead. However, for cyclists arriving from facilities that are off the roadway, the give way requirements are at best ambiguous.

The Accessible Streets Package (NZTA, 2020) proposed regulatory changes to clarify these rules, specifically, to give cycles, transport devices, and buses priority over turning traffic when arriving at an intersection in a separated lane. However, while the Accessible Streets Package was issued for consultation in 2020, efforts to progress it appear to have stalled and, at the time of this publication, it has not yet been approved.

Therefore, in addition to the general aim to make intersection designs intuitive for users, the layout and signal operation must reflect the fact that turning motorists are not currently legally obliged to give way to cyclists arriving directly from a separated cycleway. The design options presented in subsequent sections do this by either fully separating the cycle and conflicting vehicle movements or transitioning the separated cycleway to an on-road provision.

8.2 Types of signals for cyclists

There are five types of signals that can be used for cyclists, as shown in Table 8-1.

The most critical principles for determining the cycle signals to use for a given facility are:

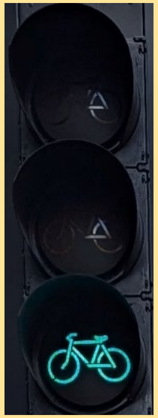
*On-road cycle lanes **may** have a single green aspect cycle signal,*

*whereas separated cycleways **must** have green, yellow, and red cycle aspects (except in the anticipated specific cases where two-aspect cycle signals might apply).*

There may be rare exceptions to these principles, where uncommon road layouts are involved.

The layouts and operations that employ the signals presented in Table 8-1 are presented further in sections 8.3 and 8.4.

Table 8-1: Traffic signals for cyclists

Signal type	Description	Applications & implications
General traffic signals 	Roundels (discs) and arrows See TCD Rule: 6.4	Apply to on-road cyclists (i.e. in a cycle lane or general traffic lane) wherever a specific cycle signal is not displayed. Turning motorists expected to give way to cyclists who are on the roadway and travelling straight through. Note, at the time of writing this guide, TCD 6.4(2A) stipulates if a red turn arrow is displayed, cyclists cannot turn in that direction, even if a green or yellow cycle signal is displayed. It is anticipated that this will be addressed in future, so that a red arrow would not override a green cycle aspect.
Standard cycle signals 	Signals with cycle maskings – could comprise: • a single green aspect, or • a three-aspect column (green, yellow, and red aspects) See TCD Rule: 6.4, S2-3, S4-10 and S4-11	Used when the cycle movement is operated differently to general traffic from the same approach, or where there is no adjacent traffic (e.g., midblock cycle crossing). Cycleways that are physically separated from the general traffic require three-aspect continuous displays (except in the anticipated case where a two-aspect cycle signal is applied). A single green cycle signal may only be applied to on-road cycle lanes (including short sections that have transitioned from a separated cycleway on the approach to an intersection, e.g. Figure 8-6). It is not permissible to allow filter turning across a cycle movement when a green cycle signal is displayed, since it is not included as an exception in TCD 6.4(6). Therefore, movements that conflict with the cycle trajectory must be held back when a green cycle signal is displayed. Note however, at the time of writing this guide, TCD 6.4(2A) stipulates if a red turn arrow is displayed, cyclists cannot turn in that direction, even if a green or yellow cycle signal is displayed. It is anticipated that this will be addressed in future, so that a red arrow would not override a green cycle aspect.

Signal type	Description	Applications & implications
Directional cycle signals 	Signals with cycle and arrow maskings within the same aspect See TCD Rule: 6.4 (especially subclause 12A(b)), S2-3B, S4-10 and S4-11	An option for cycleways that are physically separated from the general traffic. Can be applied in conjunction with a column of standard cycle signals, for operating different cycle movements coming from the same cycleway approach independently (e.g., Figure 8-1). Or as the only column of cycle signals, for indicating that the cycle trajectory follows an unusual direction (e.g., where the sole cycle route encounters a diagonal crossing). The rules applying to standard cycle signals also apply to directional cycle signals.
Bus signals 	Signals with "B" markings (note: a white B aspect is used where green would be used for other modes) See TCD Rule: 6.4, S2-1, and S4-10	If a B signal is displayed for a bus lane, it applies to cyclists lawfully riding in that bus lane (the default is that cyclists are included as users of a bus lane, but they may be specifically excluded). It is not permissible to allow filter turning across a bus lane movement when a white B signal is displayed, since it is not included as an exception in TCD 6.4(6). Therefore, movements that conflict with the cycle trajectory must be held back when a white B signal is displayed. Note however, TCD 6.4(2A) stipulates if a red turn arrow is displayed, bus lane users cannot turn in that direction, even if a white or yellow B signal is displayed.
Two-aspect cycle signals 	*Still in trial stage at time of writing – updates to the TCD Rule are pending* *Green and red aspects only – operate as per pedestrian signals* *Either as a shared cycle-pedestrian aspect, or cycle only* *See NZ Gazette notices 2018-au1574, 2020-au6, 2023-au1409 and 2025-au2116*	*Anticipated for use at locations where cyclists approach the intersection from an off-road facility shared with pedestrians, e.g., midblock crossings, parallel shared crosswalks at signalised intersections (*Figure 8-5*), and shared pedestrian-cycle Barnes dance intersections.* *It is anticipated that the TCD Rule updates will treat two-aspect cycle signals in the same manner as pedestrian signals are currently treated. Therefore, it will likely be an option to allow turning vehicles to filter across cyclists on a two-aspect cycle signal crossing. However, this guide recommends that full protection be provided wherever the cycleway involves two-way or contra-flow cycling, and at minimum, partial protection should be provided, as per the considerations outlined in section 7.1.*

Figure 8-1: Directional cycle signals to distinguish the through and diagonal cycle movements

8.3 Standard signalised intersection provision for cyclists

Very few audited intersections in the initial 2004 study had special provisions for cyclists; this has changed significantly in subsequent years including new midblock facility types such as separated cycleways, buffered cycle lanes and neighbourhood greenways, plus an increase in the use of cycle traffic signals including new variations such as directional cycle signals and two-aspect cycle signals (the latter still being in trial status).

Consider the following factors:

- How safe is the intersection for cyclists?
- What is the intended cycle target audience? For example, is the intersection expected to cater for “All Ages and Abilities”, or is the intention to only cater for “Enthused and Confident” cyclists? (See the CNG section on People who cycle).
- What is the projected cyclist demand ?
- Are there planned projects that could include the improvement of cyclist provisions as an incidental feature?

Safety and efficiency issues

The following safety and efficiency issues can arise from missing or deficient cycle facilities at signalised intersections:

- When cyclists are not guided through an intersection, their behaviour may be harder to predict for motorists.
- When cyclists experience stress, they may be more likely to make mistakes.
- In the absence of a cycle lane, most cyclists will occupy the left-turning lane, potentially resulting in conflict with motorists during a left-turn-only phase.
- Left turning drivers, especially truck drivers, may be unaware of, or even unable to see, cyclists to their left.
- When cyclists experience long delays, especially compared with drivers travelling in the same direction and where they can see there are few conflicting vehicles, they may start to run red lights, which can be hazardous if they haven’t accurately assessed the risk, or another active user follows them without properly checking for conflict.
- Addressing the conflict between left turning motorists and cyclists travelling straight ahead prior to the intersection can reduce the cognitive demand and number of conflict points at the intersection. However, less-experienced or less-confident cyclists may still prefer the perception of safety with layouts that manage the conflict through signalisation, at the intersection.

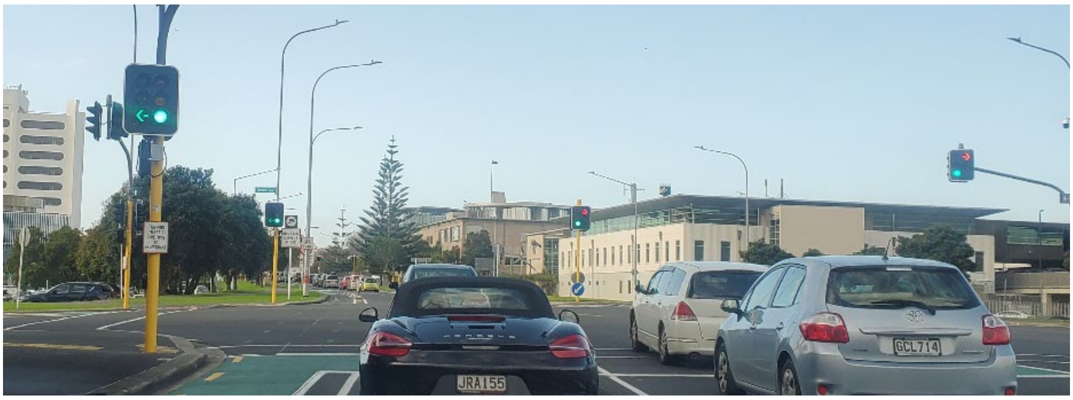


Figure 8-2: Signals and layout put left turners in conflict with through cyclists in kerbside cycle lane

Recommended treatments

The basic treatment principles are:

- Aim for a treatment that is as far as possible suitable for cyclists with basic competence.
- All normal manoeuvres should be possible (including the option of a hook turn[3] for turning right).
- Achieve an intuitive layout so that motorists and cyclists know where they are expected to be on the road. Colouring the cycle facilities approaching and departing the intersection will support this.
- Maximise level of service for cycling, so the phasing seems intuitive and fair, and cyclists are not tempted to make their own safety judgements and run red lights.
    - Use advance detection and automatic phase calling (a.k.a. "walk for green" in pedestrian-terms).
    - Make the cycle movement the main movement, with conflicting vehicle movements receiving the minimum green time necessary.
- Manage conflict between left-turning motorists and straight-through cyclists.
    - Avoid kerbside cycle *lanes* next to exclusive left turn lanes (although a similar layout with a kerbside separated cycleway operated with managed filter turning or full protection is appropriate – see Figure 8-6 and Figure 8-7 respectively).
    - Do not display a green left turn arrow when cyclists to the left of the left turners are allowed to proceed through the intersection (e.g. when a green cycle signal is displayed, or a green disc without a red cycle signal).
    - Do not display a green left turn arrow for traffic in a shared (or exclusive) lane if the left turn tracks over a cycle facility (advanced stop line, advanced stop box, hook turn box) at a time when cyclists are expected to be waiting there (e.g. when a red cycle is displayed or a red disc that applies to cyclists).

The standard treatment options for addressing conflict between left turning motorists and cyclists are outlined in Table 8-2 and illustrated in the subsequent figures. The appropriateness of each of these options depends on site-specific characteristics such as traffic movement volumes and spatial constraints. The cycling target audience identified for the location also plays a big role, as less-confident cyclists may *perceive* treatments that involve anything other than full protection as uncomfortably risky.

[3] See the CNG section on [Cyclist waiting facilities at signalised intersections](#).

Table 8-2: Standard treatments that address the conflict between left turning vehicles and through cyclists

Principle	Method and layout considerations	Signalisation considerations*
Crossing trajectories on the approach to the intersection	**Mixed approach lane** – Figure 8-3	General traffic signals apply to cyclists (OR: optional single green aspect cycle signal that runs with or gives a head start to the general disc signals). Must not provide a green left turn arrow while through traffic is held back. Through cyclists may be blocked behind waiting left turners during partial pedestrian protection.
	Lateral shift – Figure 8-4	General traffic signals apply to cyclists (OR: optional single green aspect cycle signal that runs with or gives a head start to the general disc signals).
Crossing trajectories through the intersection	**Filter turning on-road layout** – Figure 8-6 Includes a traversable separator or gap in the separator for the last few meters approaching the intersection to transition the cycleway to the "roadway". Ideally have separate lanes for left turning and through vehicles, or at least shared lanes wide enough to accommodate two streams of traffic (for when left turners have a red arrow when the cycleway operates). Suitable for up to about 150 turning vehicles per hour across the cycleway.	Should be preceded by a period of partial protection for cyclists (i.e. late start for turning motorists). The two signalisation options in Figure 8-11 have been developed in accordance with the TCD Rule particularly: 6.4(6) that prohibits filter turning during cycle green; 6.4(2A) prohibiting cyclists turning during red arrow; 6.4(3) re signal sequences; S4 showing single aspects must be attached to a continuous display; lack of provision for flashing yellow arrows as used in other countries; and NZTA interpretation that a 3-aspect cycle signal must be a continuous display. Option of adding advanced detection to extend period of cycle partial protection when cyclists are approaching the intersection during the cycle green. Right turn movements operated in different phases to cycleway movements.
	Off-road path crossing *– e.g. Figure 8-5 (reliant on anticipated two-aspect cycle signals)* *Same traffic lane considerations as per filter turning on-road layout*	*Anticipated future solution: two-aspect cycle signals (see section 8.2) with red left turn arrow operated for partial protection (i.e., arrow extinguished during clearance "flashing red bike" period).*

<table>
<tr><th>Principle</th><th>Method and layout considerations</th><th>Signalisation considerations*</th></tr>
<tr><td rowspan="2">Crossing trajectories on a slip lane</td><td>Slip lane crossing with no on-road cycle lane – Figure 8-8; all cyclists expected to use slip lane crossing and then cross via the main signalised crossing

Some cyclists may prefer to merge into the general traffic lane prior to the slip lane – this can be supported or discouraged through design.

Should involve vertical deflection for vehicles.

Slip lane crossing should be distinct from main crossing (by angle, offset, or distance) and should involve vertical deflection for vehicles.</td><td>Option to signalise the slip lane crossing.

After crossing the slip lane, cyclists cross the main intersection via the signalised crossing in the same phase as general through traffic. The cycle crossing should have three-aspect signals (or two-aspect, if approved).

Could be configured to accommodate two-way cycleway.</td></tr>
<tr><td>Slip lane crossing with on-road alternative– Figure 8-9; cyclists have a dedicated on-road option (generally a cycle lane)

The same considerations for deflection and distinction of the slip lane crossing as for the above option apply.

This slip lane option offers a more direct route for cyclists who don’t want to deviate via the shared path, but with the risk of a conflict point with vehicles entering the slip lane. Also, the provision of an on-road cycle lane likely reduces the available storage space within the slip lane island.

The decision between the two slip lane options needs to consider the needs of different cycling target audiences.</td><td>Option to signalise the slip lane crossing.

Cyclists in the cycle lane or the main signalised crossing proceed across the intersection with general through traffic. The cycle crossing should have three-aspect signals (or two-aspect, if approved).

While the slip lane crossing could be configured to accommodate two-way cycleway, the cycle lane must be one-way and obviously distinct.</td></tr>
</table>

Principle	Method and layout considerations	Signalisation considerations*
Separating movements through the intersection temporally	**Full protection on-road layout** – Figure 8-7 Ideally have separate lanes for left turning and through vehicles, or at least shared lanes wide enough to accommodate two streams of traffic (for when left turners have a red arrow when the cycleway operates).	Three aspect cycle signals in continuous display with red left turn arrow in conjunction with cycle green. This often results in the lowest green time for cyclists, which can lead to some cyclists choosing to run red lights when they consider it safe. Alternatively, the cycle movement could be prioritised, with the left turn allocated minimum green time or operated within a different phase e.g. a right turn overlap.
	Off-road path crossing – e.g. Figure 8-5 Same traffic lane considerations as per on-road full-protection layout.	Three-aspect cycle signals in continuous display with red left turn arrow in conjunction with cycle green. *OR (anticipated future option): two-aspect cycle signals with red left turn arrow operated for full protection (i.e., arrow only extinguished when cycle red has been steady for at least 2 seconds).* Same green time considerations as per on-road layout above.
Network modifications; remove one of the conflicting movements	**Ban the left turn movement** **Change the cycle route**	Simplifies the signal phasing by removing the conflict therefore providing a high proportion of green time to the remaining movement. But, the movement will need to be catered for somehow at another nearby intersection.

* see section 8.2 regarding the types of signals that can apply to cyclists.

Figure 8-3: Mixed approach lane

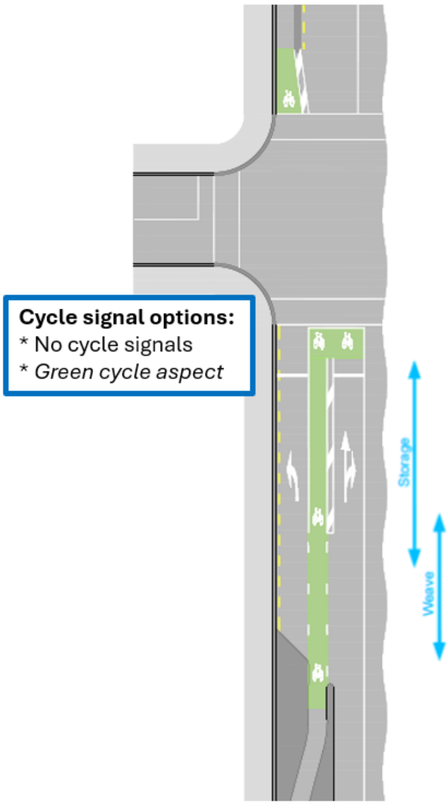


Figure 8-4: Lateral shift

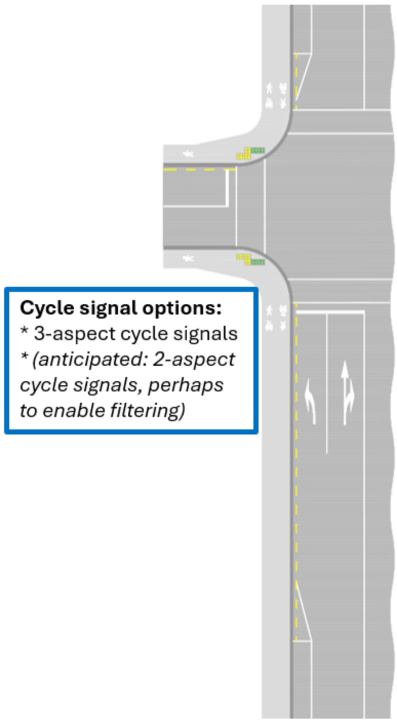


Figure 8-5: Shared path crossing (could be operated with full or partial protection)

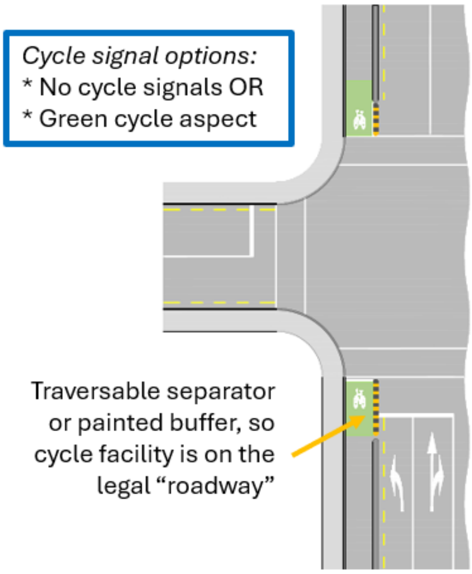


Figure 8-6: Separated cycleway layout to support filter turning

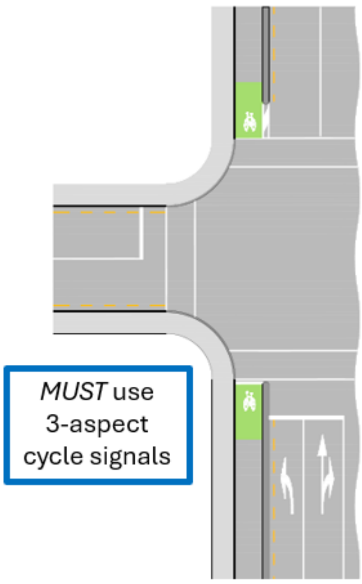


Figure 8-7: Separated cycleway layout to be operated with full protection

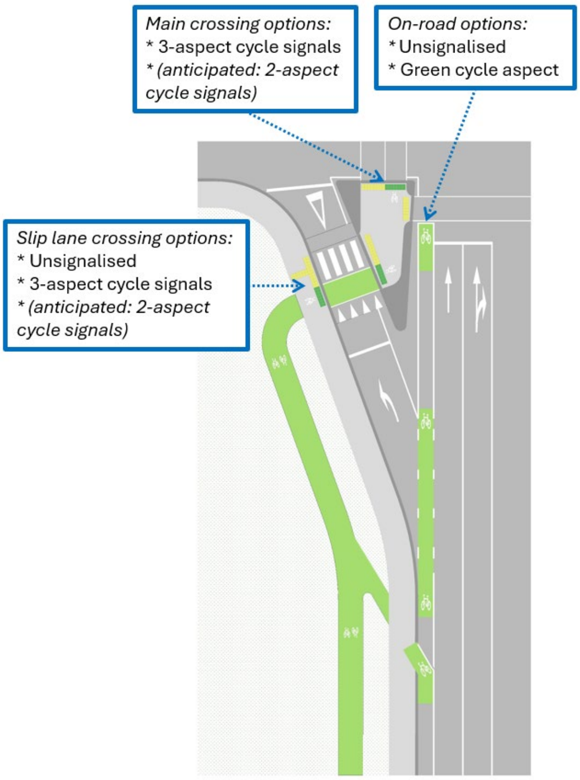


Figure 8-8: Slip lane crossing (no on-road cycle lane continuation)

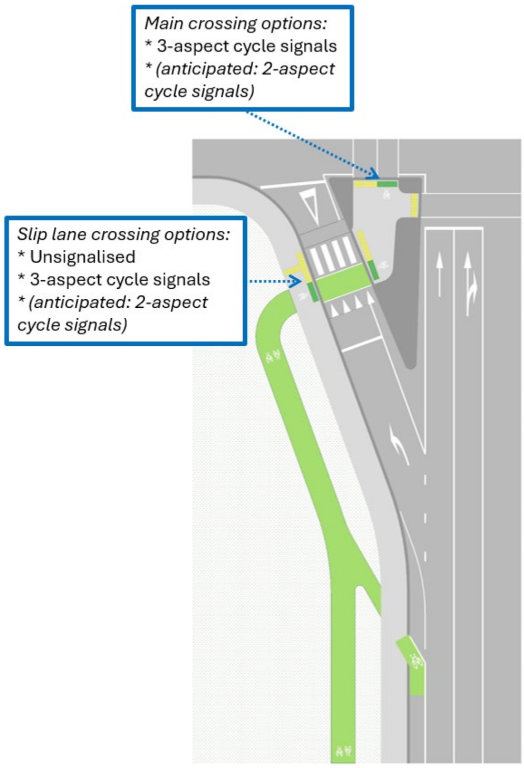


Figure 8-9: Slip lane crossing with alternative via on-road cycle lane continuation

Figure 8-10 shows a real-world example of how a physically separated cycleway can be transitioned to being on the roadway approaching the intersection, so that general traffic can be permitted to filter turn across the cycle trajectory (i.e. the concept illustrated in Figure 8-6). The signalisation options for this concept are presented in Figure 8-11

Figure 8-10: Cycleway separation terminates prior to intersection, to facilitate filter turning

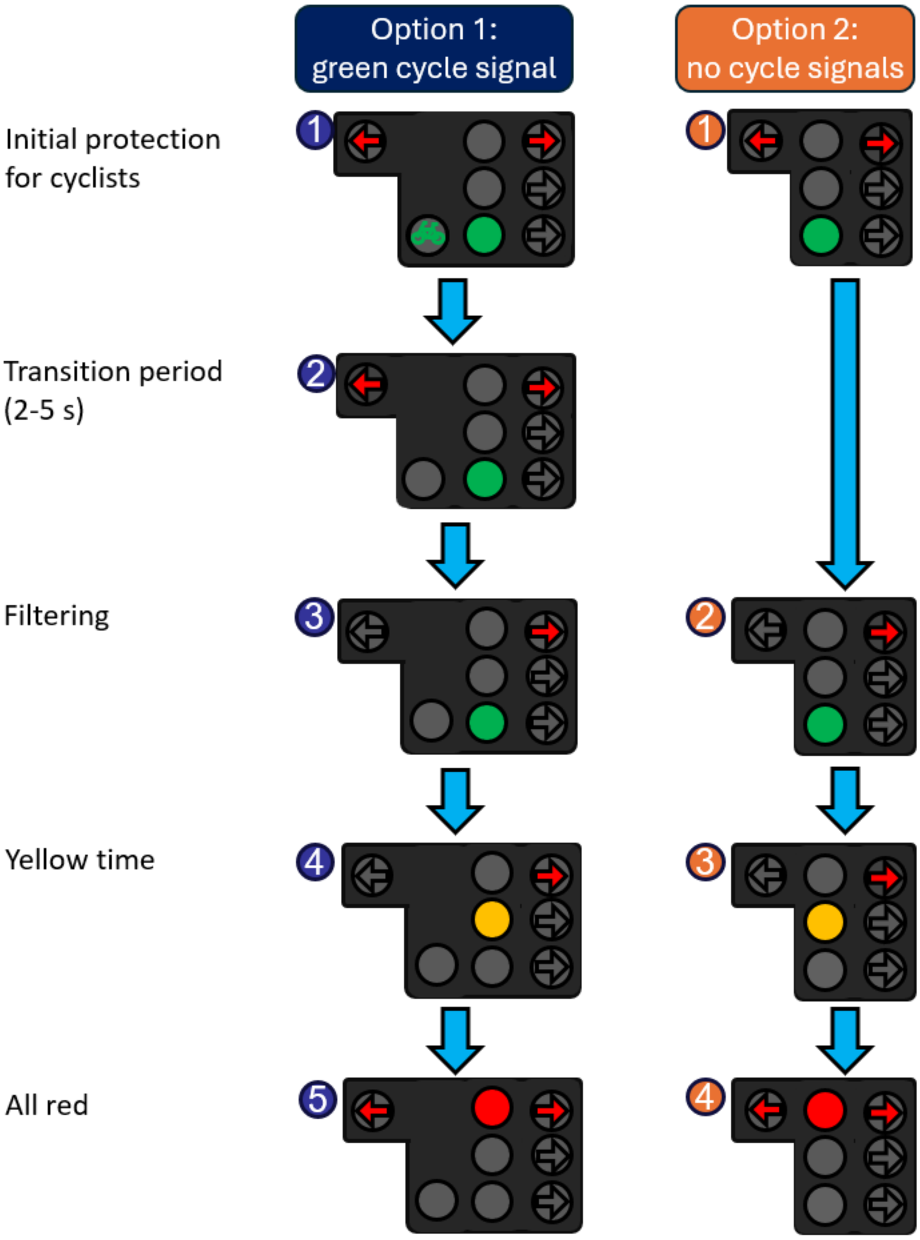


Figure 8-11: Signalisation options to support filter turning operation

8.4 Advanced signalised intersection layouts for cyclists

The following intersection treatments for providing for cycling are more complicated than those in section 8.2, and, while being used overseas, separated cycle intersections are very rare in New Zealand, and no CYCLOPS treatments have been implemented here.

8.4.1 Separated cycle intersection (aka "Dutch" or "protected" intersection)

This involves a package of signal phasing and layout features that seek to minimise delay to all users whilst also minimising potential for conflict.

Separated cycle intersections may be an appropriate intersection treatment for separated cycleways, especially where two such facilities intersect. They are not recommended for cycle lanes, due to the difficulties of channelling cyclists into the separated cycle intersection facilities.

The MassDOT (Massachusetts Department of Treatment) Separated Bike Lane Planning and Design Guide is a comprehensive source for designing protected intersections.

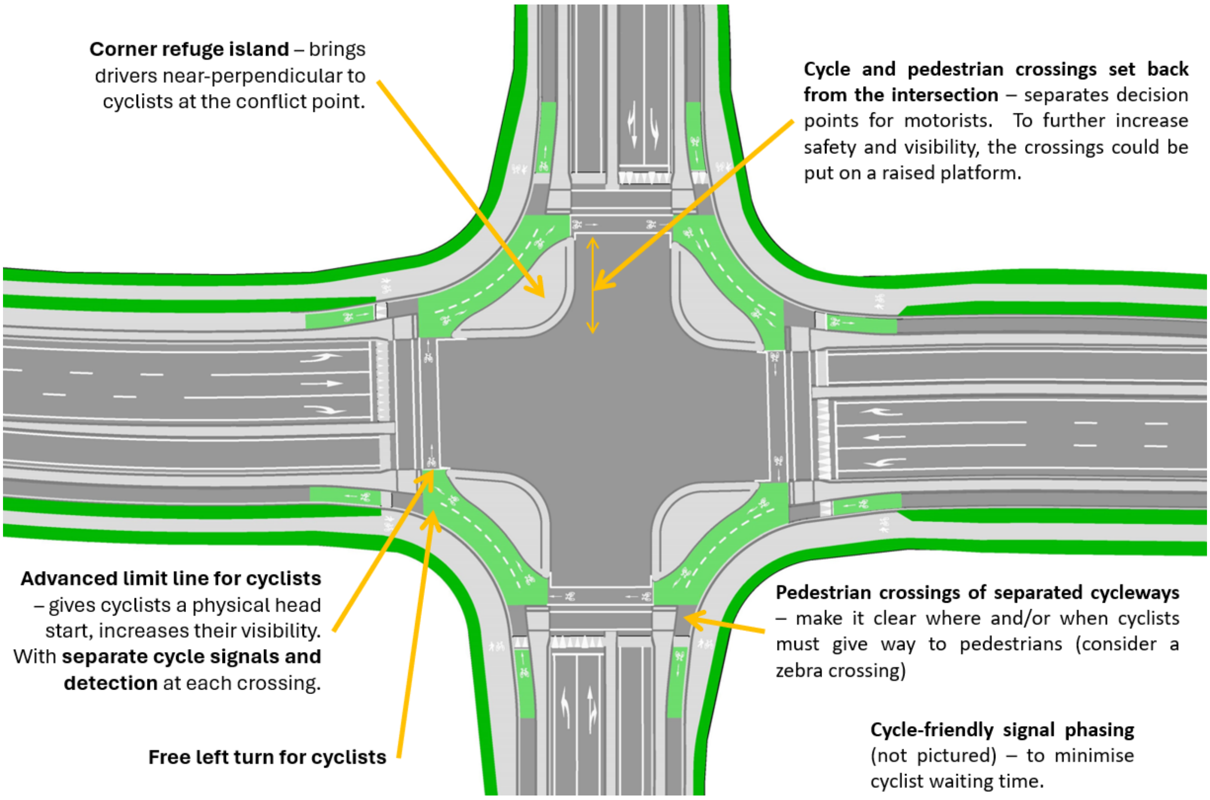


Figure 8-12: Separated cycle intersection with protected phasing and exclusive left turn lanes (designed for greenfield site) highlighting key design elements

8.4.2 CYCLOPS (CYCLe Optimised Protected Signals) intersection

The CYCLOPS design originates from the UK. It looks similar in layout to a separated cycle intersection, but with the pedestrian crosswalks closest to the centre of the intersection and pedestrian crossing refuges incorporated in the corner islands. However, the biggest difference is in the operation – whereas a separated cycle intersection involves some concurrent operation of cyclists and general traffic, the CYCLOPS does not operate cyclists and general traffic concurrently, rather it operates an exclusive cycle phase for all approaches, with sufficient time to make a full right turn. This makes a CYCLOPs more like a Barnes Dance operation for pedestrians, where cyclists must follow the circulating path and cannot cross through the centre of the intersection.

A substantial amount of space is necessary to achieve the elements of a CYCLOPS intersection – probably at least the same as a separated cycle intersection, but with larger corner splays to accommodate a footpath on the outside of the cycleway plus a pedestrian waiting area on the inside of the cycleway. There are also potential risks such as cyclists choosing to make non-compliant manoeuvres when parallel traffic runs, or travel in the contra-flow direction for more direct access.

Butler et al (2019) and Butler et al (2020) are useful starting points for designing a CYCLPOS intersection.

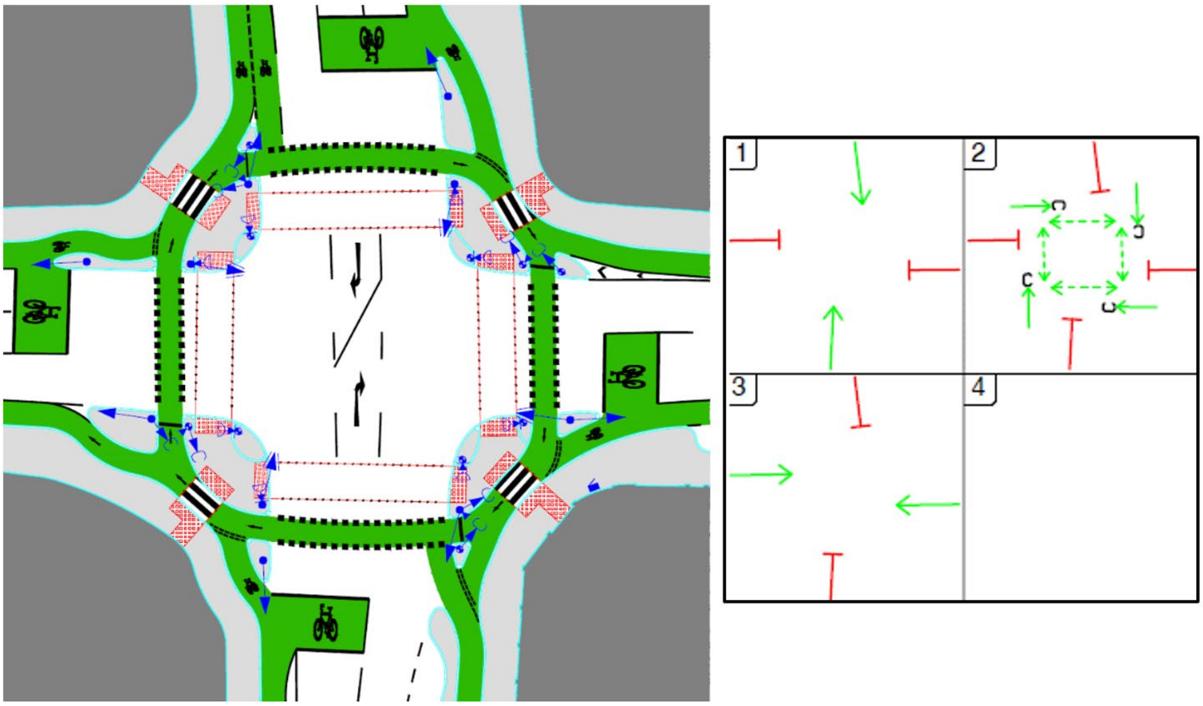


Figure 8-13: UK CYCLOPS layout and phasing (source: Butler et al, 2019)

8.5 Intersection waiting facilities for cyclists

The CNG section on [cyclists waiting facilities at intersections]() provides best practice guidance on the design and application of:

- advanced stop lines ("ASLs" – extension of a cycle lane beyond the adjacent general traffic lanes);
- advanced stop boxes ("ASBs" – queuing space for cyclists in front of the general traffic lanes); and
- hook turn boxes (safe waiting area within the intersection for cyclists in the middle of making a two-stage right turn)

Recommendations

Key points reiterated and / or extrapolated from the CNG are:

- ASBs are only useful if cyclists can access them during a red light. Extending ASBs across multiple lanes encourages cyclists to cross in front of traffic (e.g. to access an ASB in front of a right turn lane) and can result in cyclists getting caught out when the lights change to green. Therefore, as stated in the CNG and TCD Manual:
    - ASBs should not extend across more than two adjacent lanes in either direction from a cycle lane, or, if no approach cycle lane is provided, ASBs should not extend across more than two adjacent lanes.
- Hook turn boxes are not provided to tell cyclists that can make a hook turn at the intersection – they are allowed to do so at any intersection without a marked hook turn box, unless this is specifically prohibited; the purpose of providing a hook turn box is to show cyclists the best place to wait during stages.
- For a cycle target audience that includes less-confident and less-experienced riders, right-turn movements should primarily be provided via hook-turn boxes. An additional option may be enabled for more-confident cyclists by allowing space in front of the right-turn lane; however, this space should remain unmarked and uncoloured; this avoids it being mistaken for the default right-turn provision and helps ensure that cyclists who choose to use it do so by accessing it via the right-turn lane, rather than crossing in front of multiple approach lanes.
- Layout and phasing must be considered together. In particular, a cyclist waiting facility must not be within the tracking path of any movements that operate when cyclists will be waiting at a red signal. Common applications include:
    - ASBs expected to cater for through cyclists must not be placed in front of a left turn lane where a green left turn arrow is operated in conjunction with a red for general traffic, or a red cycle signal.
    - ASLs to the left of a left turn lane (e.g. for a separated cycleway) must be clear of the tracking path of left turning trucks wherever a green left turn arrow is operated in conjunction with a red for general traffic, or a red cycle signal.
    - Hook turn boxes must not be placed within the swept path of a left turning vehicle wherever a green left turn arrow is operated in conjunction with a red for general traffic, or a red cycle signal between the two hook turning stages (i.e. cyclists have arrived in the hook turn box, and the conflicting left turn runs before the phase that enables cyclists to leave the hook turn box).
    - Hook turn boxes must be clear of the cycle trajectory in the direction of the first stage of the hook turn (i.e. hook turning cyclists arriving at the hook turn box should be pulling over, clear of those cyclists coming from behind them and continuing straight ahead).

8.6 Managing cycle trajectories through intersections

It is important to consider how cyclists and vehicles move through an intersection, both where a marked cycle facility is present and where the cycle trajectory is unmarked. The aim is to ensure that cycle trajectories are clear, predictable, and free from avoidable conflict with vehicle movements.

Safety and efficiency issues

- Cycle facilities / trajectories on the inside of a curve are likely to be encroached on by vehicles (e.g. Figure 8-14).
- Marking a cycle facility (and, likewise, continuity lines for general traffic lanes) through an intersection (e.g. Figure 8-15) may reduce intersection conspicuity, leading road users to interpret the movement as continuous and increasing the risk of red light running and cross-traffic conflicts.

Figure 8-14: Car encroaching on cycle lane around bend through intersection

- Where the cycle trajectory is unmarked across the intersection and the cycle facility on the departure side is offset relative to that on the approach side, motorists may not anticipate the path of cyclists – particularly where the general traffic trajectory is also offset or unusual.
- Unclear or inconsistent trajectories increase cognitive load for all users and can lead to unpredictable behaviour.

Figure 8-15: Historic signalised intersection layout – cycle lanes and continuity lines marked through intersection, contributing to red light running and crashes with side road traffic

Recommendations

- Ensure the vehicle movements operating at the same time as cyclists can do so without conflicting with each other and without encroaching on the cycle facility. For example, Figure 8-16 shows a physical separator was subsequently added to the cycle lane shown in Figure 8-13, but this also required changes to the phasing because semi-trailers could no longer make the left turn without conflicting with opposing traffic.
- Provide physical separation where possible to prevent vehicles tracking across the a cycle facility within an intersection (e.g., a cycle lane on the inside of a curve).
- In some cases, physical separation can also be used to improve efficiency for cyclists – for example across the head of a T intersection so that the cycle movement can run in conjunction with the side street but free of conflict with right turners who might otherwise encroach on the cycle facility.
- Consider how to balance the often-competing aims of achieving intersection conspicuity and achieving cyclist conspicuity through an intersection – use continuity lines sparingly, to highlight where vehicles may turn across critical conflict zones, or complex trajectories.
- Use coloured surfacing on the cycle facility on the departure side, to indicate to cyclists and drivers where cyclists are heading.

Figure 8-16: Separator to address vehicles encroaching on cycle lane – resulted in phasing change due to vehicle swept paths

8.7 Cyclist phasing and detection at intersections

Delay, uncertainty, and lack of clear signal priority frequently contribute to cyclists choosing to run red lights at signalised intersections. Compared with drivers, cyclists are more sensitive to unnecessary delay and ambiguity, particularly where they can see that a conflict could be crossed safely. Effective cyclist phasing and detection therefore plays a critical role in both safety and efficiency, and should be considered early in the design process rather than treated as an afterthought.

8.7.1 Cycle movements that call phases

There are several scenarios for which cycle detection should be provided to call phases at a signalised intersection or crossing:

Table 8-3: Detection requirements depending on type and location of cycle movement

Scenario	When detection should be provided
Cycle movement operates as part of a main (a.k.a. default or stretch) phase (e.g., a through cycle lane on a major road)	Cycle detection is not normally required, as the movement will receive green time regardless of cycle demand. Except: if the phase includes the possibility of full or partial protection for the cycle movement.
Cycle movement is on the main road but is run as a sub-phase or separate phase to the main phase (with cycle signals)	Detection may be required to: a) determine whether the cycle movement runs; or b) choose the order between alternative sub-phases e.g., one that involves a green cycle signal in conjunction with partial or full protection against conflicting turn movements, versus allowing the turning movements to run first if no cyclists are present.
Cycle movement on the side road	Detection required to call the cycle phase, including in hook turn boxes in front of the side road
Cycle movement coming from off-road location	Detection required to call the cycle phase
Cycle movement through large intersection	Detection can be provided to extend the all-red time, to enable slower cyclists who entered the intersection during their relevant green signal to cross the intersection safely before conflicting traffic is introduced. See Wilke (2001) for more information.
Cyclists share general traffic lanes	The detection in the lane(s) used by cyclists should be located so that cyclists are most likely to travel along one of the lines of the loop oriented in the direction of travel. Similarly, radar / video detection zones should cover the part(s) of the lane where cyclists are most likely to be riding.

Note cycle detectors may be used for purposes other than calling phases – for example, activating a dynamic warning sign, or gathering data for a cycle counter.

8.7.2 Form and placement of cycle detection placement

Stop line cycle loops or radar / video detection zones in cycle facilities: provide a locking call (i.e. cyclists don't have to remain on them, as for a presence detector). They are typically placed several metres back from the cycle limit line, prior to where the cycle lane transitions into an advanced stop box (ASB) and generally in-line with vehicle loops. This placement ensures that cyclists ride directly over the loop in a location where cyclists are most likely to be in the cycle lane i.e., constrained between the kerb and / or vehicles in the adjacent traffic lane(s). When a cyclist gets close to their limit line, they tend to hug the kerb and will therefore not get detected by a loop located at the limit line. Placing loops within the ASB can be problematic, with either motorists driving over them, or cyclists not riding over them.

Approach cycle detection loops / zones should be applied in cycle facilities wherever cyclist demand is required to call the phase, so that the call can be placed prior to the cyclist stopping at the intersection. They should be located approximately 25 m from the cycle limit line, provided it is unlikely that cyclists will turn off prior to the intersection.

Figure 8-17: Cycle approach loops, marked with diamonds, approaching midblock crossing

Wherever cyclists share a general traffic lane or a bus lane, detection should be positioned so that cyclists are most likely to pass along one of the loop segments aligned with the direction of travel. Similarly, radar or video detection zones should be configured to cover the portions of the lane where cyclists are most likely to ride.

Cycle push buttons can be used for cycle facilities approaching from off-road facilities such as shared paths or cycle paths, or a "jug handle" turn where on-road cyclists move to the left of the road to make a right turn. Cycle push buttons should be set back from the intersection (approximately 1 m) so that riders of longer bikes can access them without their bike protruding past the kerb.

Figure 8-18: Midblock cycle crossing with call-accept lights (push buttons disabled)

The call accept light is an important component for push button units, especially for cycle signals that rest in red rather than blank (i.e., standard three-aspect cycle signals) because this confirms to a waiting cyclist that their demand has been registered. It is an option to only connect the call accept signal and not the push button, thus relying on loop or camera detection for cyclists or automatic phase calling; this configuration may be a preference of the RCA, or a site-specific consideration e.g., to avoid the case of pedestrians pushing the cycle button and crossing in a location where the timing is not sufficient for walking. If the push button is not connected, it must be replaced with a blank disc.

Figure 8-19 also shows a rare example of a cycle push button provided within the roadway to call a diagonal cycle crossing (note: directional cycle signals were not a permitted TCD at the time this was designed).

Figure 8-19: Cycle push button used to call exclusive diagonal cycle crossing

9 Bus priority

Bus priority measures are key in making public transport a viable and attractive mode choice. Priority can also be provided to other types of special vehicles – e.g., emergency services and rail – while these are not specifically discussed in this guide, some of the bus priority measures presented can also be adapted to suit other modes.

Further guidance on planning and designing for bus priority is available in the Public Transport Design Guidance "PTDG" (NZTA, 2026c) – see particularly the section on priority and optimisation.

9.1 Forms of bus priority

9.1.1 Head starts / queue jumps

Head starts, also known as queue jumps, are a short bus-only signal phase allowing permitted vehicles to enter the intersection ahead of general traffic at the start of an intersection phase. They are typically used in locations where public transport shares a general traffic lane and is delayed by congestion.

The minimum design elements are:

- A white B signal (noting any legal bus lane user can move on a white B signal: the rider of a cycle, moped, or motorcycle, or, where permitted, the driver of an electric vehicle).
- A bus lane on the approach long enough to bypass any queues
- Vehicle detection to trigger the bus phase

Optional design elements are:

- Yellow and red B signals, and
- Short bus lanes on the departure side of the intersection to allow rejoining with general traffic.

Head starts or queue jumps can be used at signalised intersections, in a mid-block location (sometimes combined with a bus stop – e.g. Figure 9-1 and / or a mid-block crossing), or on roundabout approaches. They support queue jumping or lane changes.

For further information, refer to the Public Transport Design Guidance (Priority and Optimisation), section 4.3.3, and the Land Transport (Road User) Rule 2004, section 3.6.

Figure 9-1: Bus head start enabling bus to rejoin traffic lane in peak period

9.1.2 Active signal priority

Active signal priority is a dynamic form of bus priority in which traffic signals adjust their timing to reduce waiting time for buses by extending, truncating, or reallocating green time. It can be used at intersections where public transport experiences delay from frequent or variable signal stops, and where real-time signal adjustment can meaningfully improve reliability. Priority may be applied to assist buses approaching or travelling through the intersection, or to assist buses at recessed stops immediately downstream of an intersection by providing an opportunity to re-enter the traffic stream.

The minimum design elements are:

- Detection capable of identifying an approaching bus (e.g., inductive loops in a bus lane, above-ground detectors, or transmitter/GPS-based systems)
- Signal controller capable of altering phase timings in real time
- Defined priority logic, such as green extension, early green (red truncation), or green reallocation

When a valid detection is received, the controller will modify timings within permitted limits. Green extensions help a bus clear the intersection when it is close to the end of a green phase, while early green (or red truncation) shortens conflicting movements to return the signal to the bus movement sooner. In locations with recessed far-side bus stops, priority may be requested once passenger service is complete, allowing the signal to recall or advance the relevant phase to assist the bus in re-entering the traffic stream.

Figure 9-2: Recessed bus stop with detection and programming to call the side-street phase and allow bus to enter traffic lane

Optional design elements are:

- Conditional priority (e.g., priority only for late-running buses or certain routes)
- Integration with SCATS/UTC strategies to optimise progression along a corridor
- High-resolution detection for improved accuracy (e.g., multiple detectors to confirm approach speed and position)
- Detection of other legal bus lane users (e.g. cyclists) so that they can still move when there is no bus queuing

Active signal priority can be used at most signalised intersections, including complex layouts, multi-lane approaches, and coordinated corridors. It supports improved bus travel time reliability and can be applied alongside other measures such as bus lanes or head starts.

For further information, refer to the Public Transport Design Guidance (Priority and Optimisation), section 4.3.2, as well as the legal requirements for bus signals in the Land Transport (Road User) Rule 2004, clause 3.6, and the technical requirements for traffic signal provision and operation in Land Transport Rule: Traffic Control Devices 2004, sections 6.1–6.4.

9.1.3 Bus gates (modal filters)

Bus gates are short sections of roadway where access is restricted to buses and other permitted users, typically controlled by signs or signals that allow authorised vehicles to proceed while preventing entry by general traffic. They are used in locations where buses need a reliable, congestion-free path through constrained network points such as city centres, corridor pinch points, or bus-only links.

The minimum design elements are:

- A special vehicle lane or restricted entry point that clearly indicates only permitted users may proceed
- Traffic signals (e.g., B signals) and / or regulatory signs that control entry to the bus gate
- Detection or enforcement systems (e.g., transponders, loops, cameras) to trigger entry for legal users and / or prevent other users from entering (e.g., the location shown in Figure 9-3 includes two advance presence detectors spaced 10 m apart where the first detector retains detection up to and during the second detector being activated to call the B-phase in advance; there is however also a limit line detector that can be triggered by light vehicles, resulting in a few infringements per day).

Optional design elements are:

- Automated enforcement systems (e.g., cameras linked to infringement processing)
- Integration with corridor-wide signal timing or active priority logic
- Supplementary signs and markings to support legibility and compliance, especially where space is constrained

Bus gates can be installed at signalised intersections, mid-block, or at nodes where multiple movements converge. They support consistent travel times, reduce conflicts with general traffic, and can be combined with other priority measures such as head starts, bus lanes, or active signal priority.

For further information, refer to the Public Transport Design Guidance (Priority and Optimisation), section 5.1 and the Land Transport (Road User) Rule 2004, clause 3.6 for the legal meaning of bus (B) signals, as well as the Land Transport Rule: Traffic Control Devices 2004, sections 6.1–6.4 for requirements governing the design and operation of traffic signals and special vehicle facilities.

Figure 9-3: Left turn for buses only – with advanced detection for buses

9.2 Integrating provisions for buses and cyclists

Bus priority measures can introduce new interactions between buses and cyclists on the approach to, through, and immediately downstream of a signalised intersection. These interactions depend on whether cyclists share the bus lane, how much space is available, how priority phases operate, and whether buses perform turning movements across cyclist trajectories. Good design is required to ensure that bus priority does not compromise cyclist safety, and that cyclists do not undermine the efficiency of priority treatments.

Safety and efficiency issues

- **Lane widths and shared space**: as per the TCD manual, bus lanes should be wide enough to accommodate side-by-side use or narrow enough to ensure single-file use, without ambiguity. However, wide lanes can result in cyclists "floating" across the lane, making it harder for bus drivers to anticipate their position, or conversely could result in kerb-hugging cyclists getting trapped on the left side of left-turning buses. Conversely, cyclists may feel uncomfortable in narrow lanes with buses behind them.

Figure 9-4: Bus lane wide enough for side-by-side use with cyclists, approaching midblock signals

- **Turning conflicts**: buses turning left during or after a priority phase may conflict with cyclists travelling straight ahead, particularly where cyclists and buses share a wide lane, or where the cycle facility is to the left of the bus lane (see also section 8.2).
- **Far-side bus stops**: buses that stop immediately after a priority phase can block cyclists or force them to take unpredictable paths if no bypass is provided.
- **Signal interpretation**: if it is unclear whether cyclists should follow the B signal or the main signal, cyclists may make unsafe or unexpected movements.
- **Facility discontinuities**: sudden narrowing or disappearance of cycle facilities near the intersection can force sudden merges into bus lanes, increasing conflict potential.

Recommended treatments

- Select the appropriate facility type: allow cyclists to share the bus lane only where lane widths support predictable behaviour and where bus movements do not create unacceptable turning conflicts; otherwise provide a dedicated cycle facility.
- Use clear and consistent geometry: maintain continuous, legible cycle facilities to the intersection; avoid intermediate lane widths that create overtaking ambiguity; use deliberate narrow or wide configurations where sharing is intended.
- Address turning conflicts: where buses turn across cyclist trajectories, provide full protection for cycle movements or narrow lanes that ensure buses and cyclists are in single file.
- Use advanced stop lines or advanced stop boxes to ensure cyclists are visible to bus drivers at the start of a priority phase.
- Ensure legible signal indications: where cyclists are present in the bus lane and a B signal is employed, consider providing a cycle signal for clarity; where cyclists are excluded from a bus lane / B signal, reinforce this through markings and signage.
- Plan for far-side stops: provide cycle bypasses or alternative routes past far-side bus stops.

10 Checklist for traffic signal review

This checklist summarises the key elements discussed in this document to support the audits and peer reviews of signalised intersection designs. It is intended as a practical prompt to help practitioners identify common safety and operational issues, rather than a comprehensive statement of requirements. It should be used in conjunction with, and not as a substitute for, the relevant standards and guidance, including Austroads Guides, the Traffic Control Devices Manual, and other applicable national and local documents.

Table 10-1: Traffic signal review checklist regarding issues addressed in this document

Section / item	Y/N	Notes
Crashes and context (Section 3)		
Has the crash history been analysed to check for any trends in crash types or contributing factors?		
Intersection and lane layout (Section 4)		
Opposed right-turn lanes (Section 4.1)		
Are opposed right-turn lanes aligned and suitably narrow?		
Do right-turners have sufficient forward visibility?		
Where alignment cannot be achieved, is this mitigated by appropriate phasing?		
Captive turn lanes (Section 4.2)		
Are captive turn lanes avoided where possible?		
Is adequate advance warning provided (arrows, signage)?		
Slip lanes (Section 4.3)		
Do slip lanes have high entry angles and appropriately small radii?		
Is intervisibility between drivers and crossing users adequate?		
Is the island large enough for waiting users?		
Do pedestrians and cyclists crossing the slip lane have priority over drivers?		
Are slip lane crossings clearly distinct from main crossings?		
Is cyclist routing (on-road vs diverted) logical and acceptable?		

Section / item	Y/N	Notes
Signal pole and display location (Section 5)		
Pole placement and signal conspicuity (Section 5.1)		
Are signals clearly visible from all approach lanes?		
Are signals free from obstruction (vegetation, street furniture, glare)?		
Is pole placement consistent with AGTM guidance (distance from kerb, tangent point)?		
Are kerb extensions used where appropriate to improve signal visibility?		
Sufficient stopping and manoeuvring displays (Section 5.2)		
Is the minimum number of signal displays provided (major vs minor movements)?		
Is redundancy provided in case of lamp failure?		
Do all lanes have a signal face no more than one lane away (using mast arms or dual primary signals where necessary)?		
Does the phasing and hardware ensure at least one aspect on each signal face will be illuminated at any one time?		
Phasing and operational issues (Section 6)		
Right-turn and left-turn arrow operation (Section 6.1)		
Does the design employ protection for pedestrians and cyclists wherever possible?		
Are arrow provisions and operations consistent with network practice?		
Does the phasing match the lane configuration?		
Do protected movements operate without conflict?		
Does the phasing optimise efficient combinations of non-conflicting movements?		
Filter turning operation (Section 6.2)		
Is any use of filter turning appropriate for site conditions and in accordance with local practice?		
Is a suitable phasing sequence used to avoid “right-turn trap”?		
Is visibility between opposing streams adequate for filtering?		
Are pedestrian and cyclist conflicts addressed (partial/full protection)?		

Section / item	Y/N	Notes
Turn arrow logic (Section 6.3)		
Is turn arrow logic correctly sequenced (e.g. 5 second red arrow hold before filtering)?		
Are unopposed left turns given green arrows?		
Are standard operating sequences adhered to?		
Does signal logic integrate well with adjacent/linked intersections?		
Has the signal logic been appropriately checked/peer reviewed?		
Pedestrian issues (Section 7)		
Pedestrian phase issues (Section 7.1)		
Is full pedestrian protection provided where recommended (e.g. right turns, T-intersections)?		
Do all pedestrian crosswalks have at least some form of pedestrian protection from turn traffic?		
Are clearance times sufficient for crossing lengths and user needs, at all times of day?		
Is the phasing intuitive for pedestrians?		
Is the phasing convenient for pedestrians in a way that reduces delay and avoids enticing non-compliance?		
Are pedestrian crosswalks called whenever there is no conflict (e.g. one-way streets, in conjunction with protected cycle movements etc)?		
Are late-start or reintroduced pedestrian phases applied safely, when conflicting movements have been terminated?		
Have pedestrian detection options beyond push buttons been considered (e.g. automatic calling, on-crossing detection, separate programming for each crosswalk direction)?		
Pedestrian hardware positioning (Section 7.2)		
Are push buttons located at the cutdown, preferably on the outer side of the intersection, and accessible to wheelchair / mobility device users?		
Are tactile indicators correctly placed and oriented, according to RTS 14?		
Are audio-tactile devices for adjacent crosswalks at least 3 m apart?		

Section / item	Y/N	Notes
Cyclist issues (Section 8)		
Legal context and design implications (Section 8.1)		
Does the design appropriately reflect cyclist priority (on-road vs off-road facilities)?		
Are transitions between facility types clear and intuitive?		
Types of signals for cyclists (Section 8.2)		
Is the type of cycle signal applied to cyclists appropriate for the cycle facility type and operation?		
Are conflicting movements held back when cycle green signals are displayed?		
Standard intersection provision (Section 8.3)		
Is the layout intuitive so that cyclists and motorists know how they are expected to progress through the intersection?		
Do cyclists receive a suitable level of service, sufficient to discourage non-compliance?		
Are conflicts between cyclists and left-turning vehicles appropriately managed through the layout and / or phasing?		
Does the design avoid kerbside cycle *lanes* next to exclusive left turn lanes?		
Are any green left turn arrows only displayed when there is no conflict with cyclists either progressing through the intersection or waiting in their designated waiting areas?		
Is the treatment suitable for the target cycling audience?		
Are advance detection and automatic calling provided where appropriate?		
Advanced layouts (Section 8.4)		
If a separated cycle intersection or CYCLOPS treatment has been applied, have the design decisions been thoroughly documented to show a suitable rationale that accords with international best-practice examples?		
If a separated cycle intersection treatment has been applied, does it contain the key design elements indicated in Figure 8-12?		
If a CYCLOPS treatment has been applied, will it achieve a suitable level of service for cyclists, to avoid enticing them to make non-compliant manoeuvres?		

Section / item	Y/N	Notes
Waiting facilities (Section 8.5)		
Do advanced stop boxes (ASBs) extend across no more than two adjacent lanes (in either direction from a cycle lane, or overall where no cycle lane is provided)?		
Are cyclist waiting areas (advanced stop boxes, advanced stop lines, and hook turn boxes) appropriately sized?		
Are cyclist waiting areas clear of vehicle tracking when cyclists will be waiting at red signal?		
Are hook turn boxes clear of through cyclists originating from the same approach as the hook turning cyclists?		
Cycle facilities through intersection (Section 8.6)		
Is vehicle encroachment into cycle facilities or across unmarked cycle trajectories avoided via layout, physical separation, or phasing?		
Are continuity lines within the intersection used only where necessary and without creating the illusion of a midblock environment?		
Are cyclist trajectories predictable for drivers?		
Cyclist phasing and detection (Section 8.7)		
Is stop-line detection provided where needed (protected cycle movement, sub-phases, side roads, off-road approaches, relevant hook turn boxes)?		
Are approach cycle detectors provided?		
Are detection loops/zones correctly located where cyclists will ride over them?		
For large intersections, has all-red extension for slow cyclists been considered?		
Are push buttons used appropriately for off-road approaches?		
Bus priority (Section 9)		
Forms of bus priority (Section 9.1)		
Has an appropriate form of bus priority been applied?		
Is detection reliable and appropriately located?		
Does priority balance bus efficiency with overall network performance?		
Is access control clear and enforceable?		
Are compliance mechanisms effective?		

Section / item	Y/N	Notes
Integration with cyclists (Section 9.2)		
Are lane widths appropriate for either side-by-side or single-file use, without ambiguity?		
Are turning conflicts between buses and cyclists addressed?		
Are downstream conflicts (e.g. bus stops) mitigated?		
Is it clear whether the B signal applies to cyclists?		
Are facilities continuous and legible for both modes?		
General / system-level considerations		
Has a **specialist signal engineer** been involved in design/review? (Section 2)		
Has **peer review and controller programming verification** been undertaken? (Section 2)		
Is the **SCATS/network operation** appropriate and periodically reviewed? (Section 2)		
Does the design balance **safety and efficiency**, not just one objective? (Section 6)		
Is the design **consistent with network-wide practice** to reduce driver confusion? (Section 6)		
Overall assessment		
Does the intersection operate safely for **all movements and users**?		
Are **conflict points minimised** or clearly managed?		
Is the design **intuitive and legible** to users?		
Are any elements likely to encourage **non-compliance or unsafe behaviour**?		
Have **relevant standards (Austroads, TCD, PNG, CNG)** been applied appropriately?		

11 Conclusions

This booklet targets designers of traffic signals and RCA staff who control, operate and maintain signalised intersections. The aim is to raise awareness about commonly occurring safety and efficiency issues.

Designing signalised intersections is a highly specialised discipline. Safety and/or efficiency were compromised at many of the installations audited. Engineers should make use of all the available relevant guidelines and standards. If RCAs don't have their signals up to standard in all respects of their safety and efficiency, they will undoubtedly fall into disrepute with regular users.

The most important advice, however, is to engage a competent signal engineer for the peer review of new designs, in addition to the safety audit process.

It is also recommended that road controlling authorities engage suitably experienced specialists for auditing their SCATS set-ups. Contact SNUG committee members (https://snug.org.nz/) for a list of suitably qualified and experienced engineers.

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