# Providing for bike riders at traffic signals

## DESCRIPTION OF SOME USEFUL TECHNIQUES

- V3.2
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# 1. Introduction

In recent years engineers have implemented a number of changes to traffic signals especially to assist bike riders. Many of these changes are not widely known because they are not prominent nor have they been publicised. Practising traffic engineers, traffic signal engineers, cycling advocates, local government staff and local government councillors often need to know how to improve conditions for bike riders at traffic signals. This report describes a number of techniques to help bike riders at traffic signals, which we hope will assist in informing each of these professionals and communication between the various agencies. Good communication means staff responsible for upgrading signals or installing new signals will be alert to the opportunities available to improve signals for bike riders at particular locations. Changes at traffic signals to assist bike riders often indirectly affect other road users such as pedestrians as well as priority measures for trams and buses, which are also discussed in this report.

## 1.1. Bike riders are different

The consideration of bike riders as a legitimate part of the traffic stream is now widely accepted. The design of traffic signals has subsequently responded to some of their particular characteristics. Bike riders generally;

- are more difficult to automatically detect than cars;
- are vulnerable to oncoming vehicles turning right across them and vehicles turning left from behind (or beside) them;
- are vulnerable to cars when making direct right turns at signalised intersections
- are vulnerable to being squeezed when merging on the far-side of intersections when the available road space narrows;
- usually clear wide intersections much faster than pedestrians but much slower than cars; and
- usually have difficulty crossing busy roads at unsignalised locations.

## 1.2. Scope

The report deals with material directly related to traffic signals. Moreover it concentrates on techniques that have already been implemented in Australia and New Zealand rather than on techniques in development or applied in other countries but not directly applicable to Australia. Examples given are from Melbourne, Victoria unless otherwise stated. It does not concern itself with measures to create road space at signals for bike riders except where they are essential to make the signal technique work. These measures include bicycle lanes, bike boxes (advanced stop lines) and physical separation for other types of traffic. Signal techniques such as ‘cyclist early start’ require bike riders to reach the stop line before the start of green and so sufficient road space has to be provided.

## 1.3. Traffic Signals are complex

Complex logic lies behind most sets of traffic signals. Many signals have hardware and software limitations that may prevent these techniques from being used at particular locations without major works and expense; particularly traffic signals that were installed many years ago. This complex logic and the nature of limitations at particular sites are only available to traffic engineers specialised in the operation of traffic signals. In some cases the details of the hardware, ducting and software can only be obtained by physically visiting the site. For example the possibility of adding bicycle lanterns and phases to a set of signals may be dependent on the controller limitations. Therefore additional bike rider signals that piggyback on existing pedestrian/bus/tram phases (and hardware) are the simplest to install i.e. bicycle lanterns that turn on and off at the same times as existing pedestrian/bus/tram displays.

The costs to implement the treatments cannot be easily generalised as cost depends on how much work would be required to make changes to existing signals and whether or not the controllers need to be upgraded.

## 1.4. Acknowledgements

We would like to acknowledge the contributions of a wide range of people in preparing this document. These include Harry Barber (Bicycle Victoria), Jason den Hollander (Bicycle Victoria), Bart Sbeghen (Bicycle Victoria), Jim Hondrakis (City of Boroondara), Kate Simnett (City of Yarra), Raoul Wainwright (City of Port Phillip), Richard Smithers (City of Melbourne), Alistair Cumming (VicRoads), Tony Fitts (VicRoads) and Martin Chelini (VicRoads).

We would also like to acknowledge the contribution of ViaStrada Ltd, who provided a peer review of the draft report and added examples of New Zealand practice.

This document was prepared following telephone interviews with many of the people named above and a workshop involving VicRoads signalling professionals in December 2009 to discuss a draft of this report.

However we take full responsibility for any errors or omissions. The views expressed do not necessarily coincide with those named above or with Bicycle Victoria.

## 1.5. Legal situation

Bike riders in Victoria are only allowed to cycle on the road or designated bike rider paths (often shared with pedestrians). At conventional pedestrian operated signals bike riders have to dismount before crossing. At increasing numbers of locations, signals that show the bicycle logo are being installed. The Victorian Road Rules have recently been updated to permit bike riders to cross where a green bicycle light is shown, even if facing a red traffic light (as in the case of early starts).

In effect this enables pedestrian crossings displaying a bike logo to operate in a way similar to the UK 'Toucan' crossings where '*two* (modes) *can*' cross.

Other legal matters that relate to bike riders using the road reserve in Victoria include:

- Bike riders under 12 years and any accompanying adults are permitted to ride on the footpath. Vehicles emerging from driveways must give way to these bike riders in the same way as they must give way to pedestrians.
- We understand that bike riders travelling on a path parallel to a road but not in the road itself must give way to vehicles turning at side streets. For example, at the off-road path that runs parallel to Harbour Esplanade in the Docklands and crosses Bourke Street just to the west of the signalised intersection. Advice is that bike riders here must give way to turning cars. Although red arrows displayed to turning cars would overcome this problem red arrow displays can lead to gross inefficiencies.

# 2. Summary of techniques

The following section summarises techniques used to assist bike riders at signalised intersections. We have concentrated on Victorian practice, although have also included some examples from around the world.

Current Australian guidance about providing for bike riders is provided by Austroads Guides to Road Design (2009), which replaces the Austroads Traffic Engineering Manual. The previous 'Austroads Traffic Engineering Manual: Part 14 – Bicycles' has been incorporated into new (various) manuals. None of the Austroads Guide to Road Design parts currently available discuss explicit provision for bicycles, so we have referred to Part 14 – Bicycles from the previous design manual in some parts of this document.

US guidance, FHWA (1998) suggests the following considerations when designing for bike riders at signals:

1) Bike rider detection
2) Clearance
3) Visibility of signals from bike rider position (compared to driver position). This point is not as relevant in Victoria as the location of vehicle signals are almost always such that they are visible to on-road bike riders.
4) Green wave (the synchronisation of successive signals for bike riders instead of motor vehicles).

This document considers these and other points.

■ DETECTION

# Push button detection of bike riders

## Description

Conventional push buttons, like those used at pedestrian crossings in Melbourne, can also be used to detect bike riders. Sometimes it is important to detect pedestrians, bike riders and motorised traffic separately.

According to Austroads (1999a) "it may be desirable to install a special push button to enable bike riders to place a call and/or ensure that the green time is long enough to allow them to pass through the intersection on a green signal. The button must be placed so that bike riders can conveniently reach it without having to dismount."


*Bike rider push button at Napier St/Johnston St in Fitzroy*

## Potential Application

- There is a need to detect bike riders and/or pedestrians.
- Bike riders can be provided with separate push buttons from pedestrians so that the signals can detect which users are present and run appropriate cycle lengths.

*Harper Street crossing in NZ with separate push button detection for bike riders and pedestrians*

- Alternatively, bike riders and pedestrians can use the same push button. This reduces the amount of information the signal controller has to process.
- Push buttons are often used where shared paths cross roads.
- Buttons should be located on the left side of paths to avoid the need for bike riders and pedestrians to cross to the opposite side of the path, which can create conflict during crossing. This may require a separate pedestal (usually waist high) to be installed.

### Further information

- Austroads (1999a)
- Government of South Australia (2010)

### Benefits

- Assured detection for all types of bicycles.
- Possible to provide a separate cycle phase if bike riders can be detected separately from pedestrians and vehicles.
- May be able to use existing pedestrian infrastructure.
- Likely to improve bike rider compliance and therefore safety.

### Disadvantages

- Requires bike riders to slow and stop before being detected, increasing wait time.
- If additional infrastructure is required, it could become costly.

### Where can this be seen?

- Footscray Rd/Dudley St, Docklands - bicycle loops AND cyclist push buttons
- Napier St/Johnston St, Fitzroy
- Canning St/Princes St, Carlton
- Many shared path signalised crossings where bike riders and pedestrians use the same push button
- Bike rider push buttons are more prevalent in South Australia than Victoria.

■ DETECTION

# Inductive loop detection of bike riders (also called detector loops)

## Description

Inductive loops are loops of metal placed under the road or path surface. They can detect when metal passes over them (i.e. a bicycle or car), placing a request for a green signal.

Most inductive loops now used by VicRoads can normally detect bike riders, however they cannot distinguish the difference between a bike rider and a car. Further information on the sensitivity of different types of loops can be found in Austroads (1999a) and Leschinski, R (1994).

*Loop detectors in the road at Victoria St, Richmond*

An inductive loop in a bicycle lane is unlikely to detect vehicles in the adjacent traffic lane, provided the edge of the loop is at least 700mm from the general traffic lane.

## Potential Application

- At most intersections, existing loops for traffic can be:
  - used to detect both vehicles and bicycles
  - extended into the bicycle lane
- It is important to note the location of inductive loops when the road is re-linemarked. For example, if a bicycle lane is added, one loop may end up straddling two lanes. This reduces the usefulness of the data in determining which lane a vehicle is in (for example to trigger a turning arrow). Bike riders may also not be detected in the bicycle lane. Consideration should be given to re-cutting the loops.
- Loops have two functions – they can either call a phase, or they can extend a phase. Where loops don't call a phase (e.g. the through movements of major roads, as the signals will default to this movement), then bike riders don't need to be specifically detected. Where loops call phases (e.g. side streets, or right turn movements), then bike riders (and vehicles) do need to be detected.
- Where bike riders need to be detected separately from vehicles, separate loops in the bicycle lane can be used. This requires a *cyclist only* space (i.e. bike lane) or the signals won't be able to differentiate between bicycles and vehicles.
- Inductive loops can be used both at the stop line and before the stop line (providing enough time for the light to turn green by the time the bike rider arrives). Advanced loops should only be used where bike riders won't turn off prior to the signals (i.e. along a path on approach to a road crossing).

### Benefits

- At most intersections existing loops in the general traffic lane can also detect bike riders.
- Does not require the bike rider to stop to push a button.
- Can also be used to give an indication of bike rider volumes.

### Disadvantages

- May not be effective at detecting bike riders, depending on location, loop type and bicycle material. However no complaints from bike riders have been received by VicRoads to this effect.
- On roads, inductive loops cannot distinguish a bike rider from a vehicle unless there is a bicycle lane with a separate loop.

■ DETECTION

# Inductive loop detection of bike riders (cont.)

## Description

There are some inductive loops that have been specially designed for counting bike riders. These could be used in detecting bike riders at signals, but as yet have not been tested in this application.

In some locations, special markings are used to indicate to bike riders where the most sensitive position to ride is. These are currently not used in Victoria.

*Markings identifying the most sensitive part of an inductive loop in Portland, Oregon (USA)*

## Potential Application

- If two inductive loops are placed close together on a two way bike path the direction of the bike rider can also be determined.

*Two sets of inductive loops are used to detect bike riders approaching the signals on the Railway Cycleway in New Zealand.*

- See Case Study below and on p. 8.

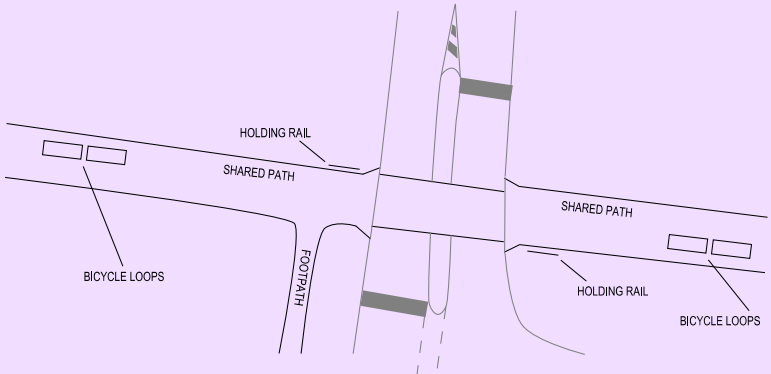
## Where can this be seen?

- Footscray Rd/Dudley St, Docklands - bicycle loops AND cyclist push buttons
- Christchurch, NZ
- Railway Cycleway, NZ
- Advanced detection loops are planned for installation on the Gardiners Creek trail on its approach to Winton Rd in Malvern East by mid 2010.

## Further information

- CAN (2005)
- Austroads (1999a)
- Leschinski, R (1994)
- FHWA and Mn/DOT (2003)
- http://viastrada.co.nz/project/2008/nzta-continuous-cycle-counting-research

## Case Study – Automatic bike rider detection on the Gardiners Creek Path




*Proposed advanced detection of bike riders on the Gardiners Creek trail*

City of Boroondara is planning to install a bike rider and pedestrian signalised crossing on the Gardiners Creek Shared Path at the point where it crosses Winton Road in Ashburton. There will be two inductive loops on each approach to the crossing to detect approaching bike riders and place a call before they reach the crossing. Having two loops means the signals can discern bike riders moving towards the crossing from those moving away (and so not requiring a green light). The loops will be placed far enough back from the crossing so that the bike rider lantern turns green just before a bike rider arrives at the crossing.

## Case Study – Automatic bike rider detection in Christchurch, New Zealand

In this example from Christchurch, bike riders are automatically detected by inductive loops in the ground on a *cyclist-only* approach to the intersection. There is a modified push button incorporating a bicycle symbol which lights up when a bike rider rides over the loops to reassure them that they have been detected.

The approach also includes a bike rider hold rail so that bike riders don't have to take their feet from the pedals while waiting for a green light.

*Loop detectors in the path with bike rider reassurance light in Christchurch, NZ (Image from Cycling Advocates' Network, New Zealand (2005))*

■ STARTING

# Early starts for bike riders

## (also called late starts for vehicles, cyclist head starts, leading intervals)

### Description

Bike riders receive a green signal (in the form of a green bicycle lantern) while the general traffic continues to face a red light. After a pre-determined length of time (usually a matter of seconds), the parallel vehicles are also given a green light. This can be done by either reducing the length of green time for parallel vehicles (most common) or increasing the overall cycle time.

*Bike rider early start at Napier St across Johnston St in Fitzroy*

Early starts can be used for several reasons. Historically in Melbourne the most common reason has been to reduce the green time available to vehicles (i.e. reduce rat running by restricting the number of vehicles during each green phase). Because pedestrians (and bike riders) take longer to cross the intersection than vehicles, pedestrians crossing the major road often 'force out' the time available for traffic on the side street.

More recently, early starts have been used to allow bike riders to 'claim' the road space before right and left turning vehicles cross the bike rider's path. The length of time given to bike riders as an early start depends on the reason for using this technique.

### Applicability

- Limited to sites where there are high bike rider volumes along one (generally minor) road. This technique is generally used where a local (minor) road crosses a major road.
- Signalised intersections where there is some 'spare capacity' i.e. all of the signal phase time is not needed to get vehicles through the intersection.
- Bike riders must be able to pass queued traffic and get to the head of the queue (i.e. preferably a bicycle lane on approach or wide kerbside lane).
- Usually used as part of a wider strategy, such as to reduce rat running. This can be done by limiting the green time available to vehicles on the side road but allowing bike riders the usual time.
- As part of the wider network, Network Operating Plans should be considered which provide a hierarchy of users at each location. Early starts for bike riders are a good fit where bike riders are a high priority and vehicles are not.
- Used where other space solutions don't work (i.e. advanced bike box can be as effective depending on the number of bike riders, far-side road layout and vehicle tracking positions).
- Can be used where there is a far-side merge to allow bike riders to safely position themselves in the lane before vehicles arrive.

### Benefits

- Gets bike riders out into the intersection where they are visible to turning car drivers (reducing conflicts).
- Where there is a far-side merge, can assist bike riders in claiming their space.
- Can be used as part of implementing Network Operating Plans.
- Can assist bike riders in moving from one position (i.e. the kerbside lane) to another (i.e. centre of the road path).
- Can be introduced with minimal effort in some locations.
- Provides visible bike rider priority to all road users.

■ STARTING

# Early starts for bike riders (cont.)

**Where can this be seen?**

- Napier St/Johnston St, Fitzroy
- Nicholson St/Scotchmer St, Carlton North
- Canning St/Elgin St, Carlton
- Swanston St/Latrobe St, Melbourne CBD
- Swanston St/Flinders St, Melbourne CBD
- Denmark St/Stevenson St, Kew
- Proposed for Brunswick St, Fitzroy

## Applicability

- Early starts can also be used where bike riders have to move to a different position to access bicycle facilities. For instance, at the south end of the St Georges Road path, bike riders have to cross from the kerbside to the central median of the road.
- In some instances, an early start for bike riders has been introduced with minimal effort and cost where there is already an existing pedestrian/bus/tram early start (depending on the set up). See Case Study below.

**Disadvantages**

- Parallel vehicular traffic often gets less green time (depending on set up), although this can be an advantage if restricting the number of vehicles.
- Right turning bike riders may not have enough time to get through the intersection during the cyclist early start. This means they have to either approach the intersection in the right traffic lane or wait in the intersection for oncoming vehicles to pass.
- Car drivers may be less aware of bike riders during the vehicle green (thinking they've all already moved through the intersection).
- Creates more information for the controller to process, which may be costly to implement.

**Case Study – Early start for bike riders at Nicholson St and Scotchmer St, Carlton North**

- There was previously an existing pedestrian early start across Nicholson St. This is to restrict the vehicle volume along Scotchmer St (Pigdon St on the other side of the intersection).
- Introduced a green bicycle lantern. This runs only when the pedestrian phase is called and lights up at the same time as the green man. Once vehicular traffic gets a green light, the bicycle lantern turns off and bike riders are governed by the traffic signals. If no pedestrians have pressed the button, the bike rider lantern does not light up and bike riders go with the general traffic.
- Linking a bike rider early start to an existing pedestrian early start is the most basic application of a bike rider early start. It requires minimum infrastructure and hardware (as the bike rider early start does not necessarily require its own phase or separate programming), but only operates when a pedestrian triggers the pedestrian phase.

*Bike riders start early with pedestrians at Nicholson St/Scotchmer St, Carlton North*

■ STARTING

# Early starts in conjunction with bus priority

## Description

Bike riders are often allowed to share bus priority lanes at intersections. In Victoria, bike riders are only permitted to use the bus lane if there are signs specifically allowing them, however this is the case in most instances. In some cases, buses may be given an early start ahead of general traffic in the adjacent lanes, similar to the early start for bike riders described in the previous section.

It is important that, in situations where buses and bike riders share the same lane and buses are given an early start, bike riders are also given an early start. This ensures that bike riders queuing in front of buses do not prevent buses from taking advantage of the early start and that bike riders queuing beside buses are not unsafely exposed to moving buses. It also enforces the message that, like buses, bike riders are of high priority at a particular intersection.

In terms of cycling, the benefits offered by this technique are similar to those outlined in the previous section on "early starts for bike riders".

*Bike riders, buses and left turning vehicles get a green before general through traffic at the intersection of Colombo St / Moorhouse Ave in Christchurch, NZ*

## Potential Application

- For existing lanes that are shared by buses and bicycles, ideally both modes would be given an early start simultaneously.
- If the bus / bicycle lane is a kerbside lane shared by left turners, the left turn phase should also be operated at the same time as the early start to buses and bike riders to avoid the situation of left turning vehicles blocking the priority lane. Care should be taken where through bicycles may be waiting while left turning vehicles are given an arrow. Ideally the bike riders and buses would get a light at the same time as the left turners to reduce the conflict between turning vehicles and through bike riders.
- If the bus / bicycle lane is located between a left turn lane and through lane, whether or not the left turn is operated at the same time as the bus / bicycle early start depends on whether or not buses (and bike riders) can turn left from the shared lane. The speed of vehicles in the left turn lane and queue lengths may also need to be considered if there is the possibility drivers will endanger bike riders.
- Operating the adjacent general traffic lane(s) with some intended inefficiency will ensure a queue develops at peak times. This enforces the message of bus and bike rider priority to queuing motorists. It also ensures buses and bike riders experience less traffic downstream of the intersection.
- This technique has not yet been used in Victoria, but has been employed at several locations in Christchurch, NZ.

### Benefits

- Safer mixing for buses and bike riders at intersections.
- Enhances bus and cycle priority message to general motorists.
- Presence of buses makes motorists more aware of the lane (and less likely to ignore or overlook bike riders).
- See "early starts for bike riders" section.

### Disadvantages

- Introduces inefficiencies for general traffic lanes if the bus early start does not already exist.
- May become particularly inefficient if a high volume of left turning traffic exists.
- See disadvantages in "early starts for bike riders" section.

### Where can this be seen?

- Colombo St / Moorhouse Ave (Christchurch, NZ)
- Harman St / Lincoln Ave (Christchurch, NZ)
- Proposed for Mickleham Rd/Melrose Dr, Tullamarine in Feb 2010

■ DURING

# All red to vehicles (also called Barnes Dance, Scramble phase, Four way crossing)

## Description

An intersection with a phase where all vehicular traffic faces a red light while a *bike rider only* phase runs. This allows bike riders to cross the intersection in any direction, including diagonally.

The pedestrian version of this treatment is employed for pedestrians at select locations in Melbourne, such as outside Flinders Street train station at the Flinders St/Elizabeth St intersection. It is used in many other cities at locations near the centre of town.


*Diagonal bike rider crossing of Malvern Road into Winton Road, Malvern East. During the all red vehicle phase, both the cyclist & pedestrian signals turn green. Note this is likely to be a temporary measure at this location until the parallel bike path is upgraded.*

## Potential Application

- Limited applicability
- Most beneficial at intersections where there is a strong diagonal bike rider demand (i.e. right turn).
- Applications for this sort of treatment would require strong supporting evidence because it significantly reduces the amount of green time available to vehicles (at a standard four leg intersection). As for bike rider early starts, this treatment could be implemented as part of a package of measures to reduce rat running.
- Signal displays have to be realigned so that they are visible from all approaches for bike riders crossing in all directions. New road markings indicating the direction of travel for bike riders may also need to be installed. This is conventional in the pedestrian version of this treatment.
- In some instances, this treatment can be applied for one approach only, e.g. when there is only one diagonal movement that bike riders commonly undertake (such as at Palmerston North, NZ).

### Further information

- Eckerson Jr, C (2007) http://www.streetfilms.org/archives/portland-or-innovative-bicycle-signal/

### Benefits

- Bike riders can travel across the intersection in any direction (diagonally or parallel to the road).
- Slows vehicles approaching signals.
- 'Reclaiming' the space for people rather than vehicles.

### Disadvantages

- Less time available to vehicles.
- Only one phase per cycle, therefore may result in longer wait times for bike riders crossing only one leg
- Compared to pedestrians who can easily filter between one another, bike riders may need more defined paths.

### Where can this be seen?

- Malvern Rd/Winton Rd, Malvern East (temporary)
- Similar pedestrian treatments at Flinders St/Elizabeth St, Melbourne and at Droop St/Barkly St, Footscray at the Nicholson St Mall.
- Featherston St / Ruahine St, Palmerston North (NZ)
- Portland, Oregon (USA)

■ DURING

# Dwell on green for bike riders (& pedestrians) (also called dwell on red for vehicles, rest on red for vehicles)

## Description

The default signal is green to bike riders and pedestrians until a vehicle is detected, at which time the vehicle phase runs for a predetermined length of time. This is opposite to conventional practice where signals revert to show green to vehicles after pedestrians have crossed.

Traditionally dwell on red has referred to signals which dwell on red for *all* users (including pedestrians and bike riders) and has been considered to reduce vehicle speeds when approaching an intersection with a high pedestrian accident rate. The focus has usually been during high alcohol times (i.e. late on Friday and Saturday nights) where there can be high numbers of intoxicated pedestrians.

The signals look exactly the same as conventional signals.

*Dwell on red signal at the bus station in Robina, Queensland*

## Potential Application

- This treatment could be applicable where a busy cyclist path (generally a shared path) crosses a road at signals.
- A dwell on green signal could operate all day, or only at times of high pedestrian volume. The St Kilda dwell on green for bike riders and pedestrians defaults to 'normal' operation between 12 and 6am to give nearby residents a break from the otherwise constant audio clicking noise.
- Would be most beneficial at crossings with high bike rider and/or pedestrian volumes and low vehicle volumes.
- Can operate as red to users in all directions (including bike riders).
- See Case Study on p. 14.

### Where can this be seen?

- A dwell on green for bike riders and pedestrians is operational at the west end of Fitzroy St, St Kilda
- Bus station at Robina railway station on the Gold Coast- for crossings of an exclusive bus lane.
- A dwell on green for pedestrians is proposed within the bus interchange adjacent to Ringwood Railway Station.

### Benefits

- Reduced delay for bike riders.
- Bike riders more likely to arrive on green, reducing the time spent slowing, waiting and moving off.
- May reduce vehicle speeds in the vicinity, improving safety for all road users.
- Provides visible bike rider (and pedestrian) priority to all road users.

### Disadvantages

- Less time available to vehicles.
- Vehicles will almost certainly be delayed at the crossing.

### Further information

- Archer, J, Candappa, N and Corben, B (2008)
- Brzozowski, A (2007)

**Case Study – Dwell on green for bike riders and pedestrians at the west end of Fitzroy St, St Kilda**

*Bike riders and pedestrians have priority at this dwell on red crossing in Fitzroy St, St Kilda*

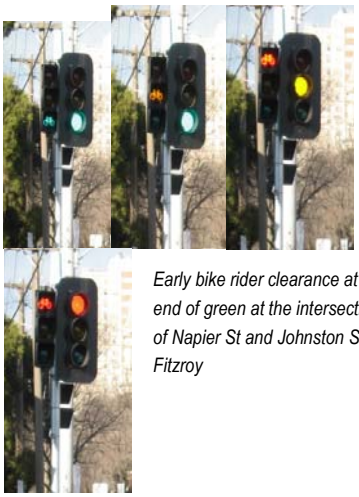
As part of the Fitzroy St redevelopment in St Kilda a dwell on green signal for bike riders and pedestrians has been installed at the west end of the street. The previous pedestrian crossing was replaced with a 15m wide shared crossing with pedestrian and bike rider lanterns. There is no detection for bike riders and pedestrians but the default signal display is green to pedestrians and bike riders. When a car is detected, the vehicle phase will run for a pre-determined length of time before returning to the pedestrian and bike rider phase. The speed limit has been reduced in the vicinity as part of this project and vehicle volumes reduced (with the closure of the Jacka Blvd road connection to Fitzroy St). The crossing always operates as dwell on green for bike riders and pedestrians, except between 12-6am when it reverts to normal operation to give nearby residents a break from the otherwise constant audio clicking noise.

■ CLEARANCE

# Clearance at the end of green

## Description

The clearance phase is probably most familiar as the yellow light for vehicles or the flashing red man for pedestrians. According to FHWA (1998), "Signal clearance intervals should be sufficient for the bike rider to react and stop safely, or pass through the intersection on the clearance interval".



*Early bike rider clearance at the end of green at the intersection of Napier St and Johnston St in Fitzroy*

Bike riders may require a different clearance time than other users because of the difference in speed. According to the Austroads Guides to Traffic Engineering Practice, the speed which should be used in designing for users is as follows:

- **Vehicles**: dependent on speed limit. In most instances this would be in excess of 40 km/h. (continued over the page).

## Potential Application

- By running the bike rider clearance phase with an existing pedestrian or vehicular clearance phase, there would be no impact on the operation of the intersection and minimal changes would normally be required within the controller.
- However if the bike rider clearance starts when the flashing red man commences, the bike rider clearance will begin earlier than necessary (refer back to user speeds). Bike riders arriving at the intersection may have to stop when in fact there was sufficient time for them to clear the intersection.
- If the bike rider clearance is run with the vehicle phase, there may not be sufficient time for a bike rider entering late in the green to clear the intersection, particularly at wide intersections.
- If the bike rider phase terminates early, then it is imperative that bike riders can stop safely on the approach, i.e. in their own bicycle lane.
- At signalised shared path crossings of roads, where the signals can detect the difference between a pedestrian and a bike rider, then it may well be possible for the bike rider phase to be run more often, as bike riders move faster than pedestrians and so the bike rider phase will be shorter. i.e. across Docklands Drive on the west side of Footscray Road opposite Dudley Street where there are few pedestrians therefore the time required for crossing is reduced.
- See Case Studies on p. 18 and p. 21.

### Benefits

- Providing signal phase clearance time suitable for bike riders reduces the chance that they will become trapped in the intersection, especially at wide crossings.

### Disadvantages

- Beginning the clearance phase for bike riders earlier than for motorists may frustrate bike riders who don't understand why it is programmed in such a way.
- A new phase means the controller has to process more information and may have to be upgraded as a result.

### Further information

- Austroads (1999a)
- Austroads (1999b)
- Wilke, A (1999)

■ CLEARANCE

# Clearance at the end of green (cont.)

## Description (cont)

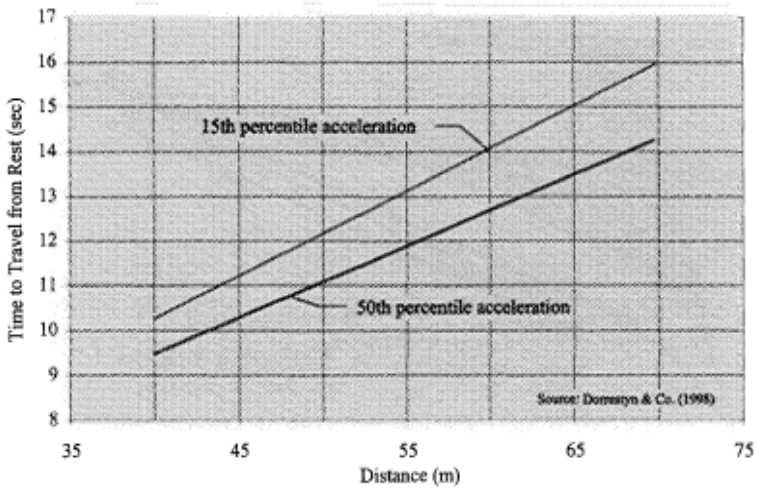
- **Bicycles**: 20 km/h. There is a large variation in cycling speeds but usually a 'conservative' value is used in design so that the majority of bike riders could clear the intersection. 20 km/h notionally represents the 15th percentile (i.e. the speed at which 85% of bike riders travel above). There is concern that this value is too high as the sample size was quite small. A more appropriate value may be 16 km/h.
- **Pedestrians**: 1.2 m/s (4.3 km/h).

Therefore at wide intersections it may be necessary to provide a separate clearance phase for bike riders to avoid them becoming stuck in the middle of the intersection when cross traffic accelerates off.

Another consideration is whether bike riders would be starting from a stationary or moving position. Starting from stationary requires more time to get through the intersection (illustrated at right) however bike riders entering the intersection during the clearance phase would be from a moving start.

## Potential application (cont)

- VicRoads Metro North West Region has received three complaints from bike riders who are unable to get across wide intersections within the allocated green time. Various treatments are available for bike riders at wide intersections.
  - A separate cycle light which begins clearance earlier than the motor vehicle light, as described here.
  - Extending every vehicle clearance phase (yellow light) to ensure a bike rider can get across the intersection if entering at the end of green. This will increase the signal cycle time even when no bike riders are present. The same could be done for the all red phase.
  - An all red time extension on demand could also be used (see next page).
  - Early cut off where the signals on the near side of the intersection go yellow before the far-side. This would only be used in unusual situations.
  - Installing a wide central median gives bike riders a safe place to stop within the intersection, although they will have to wait for another cycle to compete crossing.




*Bike rider acceleration at traffic signals from Austroads*

■ CLEARANCE

# All red time extension on demand

## Description

At wide intersections, there is a particularly large difference between times taken by bike riders and motorists to clear the intersection. All red times (the short length of time when the signals are red for all directions of travel) are generally calculated according to motor vehicle travel speeds.

Thus when bike riders enter the intersection near the end of the green phase, they may not have enough time to clear the intersection. They may come into conflict with opposing filter right turners attempting to clear the intersection during the yellow phase and may even still be in the intersection after the all-red time ends and the side street traffic phase begins.

It may not be practical or safe to introduce longer all red times to every signal cycle, especially if the occurrence of bike riders starting to cross the intersection at the end of their green phase is relatively low. It is therefore preferable to only introduce longer all red times during cycles when bike riders need extra clearance time.

## Potential Application

- Inductive loops, similar to those used at intersections for advance or stop line detection can be effectively used to detect bike riders in wide intersections.
- Loops must be positioned in the path of bike rider travel at a location that can be reached by bike riders entering the intersection before the end of the normal all red time.
- The loops must also be placed out of the path of vehicle movements that occur in the same phase as the cycle movements in question. These may include vehicles travelling through in the same direction as the bike riders and opposing right turning vehicles. Otherwise, the loops would be triggered most signal cycles, even when bike riders were not present.
- Therefore, this application is best suited to roads with bike lanes on the approach and departure where there is a clearly defined path of bike rider travel.
- See Case Study on p. 18.

### Where can this be seen?

- Ferry Road / Fitzgerald Avenue (Christchurch, NZ)

### Benefits

- Improves safety for bike riders.
- Introduces extra time for bike riders when required.
- Does not decrease intersection efficiency when bike riders are not present.
- Cost-effective treatment using standard hardware.

### Disadvantages

- May be difficult to place loops for certain phasing / layout combinations.
- Loops are situated in centre of intersection and therefore have particular installation / maintenance implications.

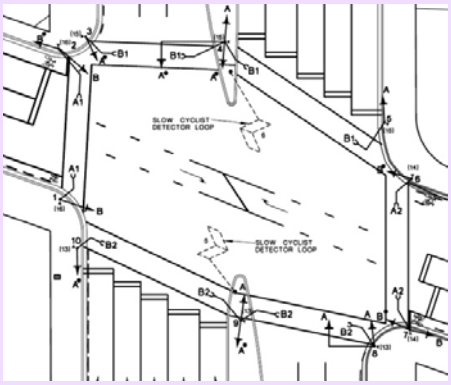
### Further information

- http://viastrada.co.nz/pub/single-loop

## Case Study – Wide intersection loops on Ferry Road at Fitzgerald Avenue intersection (Christchurch, NZ)

It was found that the all red time at the Ferry Road / Fitzgerald Avenue intersection was insufficient for bike riders on Ferry Road crossing Fitzgerald Ave, which has eight lanes and a wide median at the intersection. Bike riders who had begun to cross before the beginning of the clearance phase would often be exposed to cross traffic from filtering right turners and occasionally would still be clearing the intersection when the Fitzgerald Ave phase began. Introducing longer all red times to every cycle would create too much delay to traffic and could not be justified given the relatively low proportion of cycles in which bike riders were caught in this manner.

The Christchurch City Council investigated several technologies including video detection to determine when bike riders were still crossing the intersection and required an all red extension. It was decided that inductive loops were the best method available. The loops were positioned in the line of travel of bike riders on Ferry Road immediately after the Fitzgerald Ave central median. This location was chosen to ensure it would generally not be triggered by opposing right turners from Ferry Road. When bike riders ride over the loops near the end of the Ferry Road phase, the all red time is extended to ensure they have enough time to clear the intersection. This has been operating effectively since 2001.



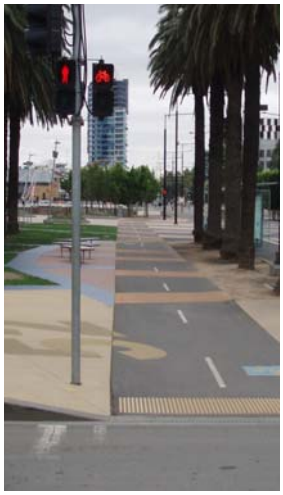

*Inductive loops in the centre of the intersection can extend the all red phase when a bike rider is detected.*

■ CLEARANCE

# Two aspect bicycle lanterns (normally only a red and green bicycle lantern)

## Description

Two aspect bicycle lanterns are used in Victoria and normally consist of only a red and green bicycle shaped light (no yellow as in standard traffic signals). They usually operate such that the red lantern flashes to signify the clearance phase, as for pedestrian lanterns.



*Two aspect cyclist signals run with the pedestrian signal along the shared path through the Docklands*

Note that two aspect bicycle lanterns are not legal in New Zealand.

**Further information**

- Victorian Government (2009)
- Austroads (1999a)
- Austroads (1999b)

## Potential Application

- A two aspect bicycle lantern can be run with the pedestrian lantern. However depending on the layout of the intersection or crossing, the bike rider phase may begin clearance earlier than needed, reducing the time available to bike riders. When bike rider lights are run with the pedestrian lights at an intersection (i.e. part of a traffic cycle) it is good practice to have the lights turn green automatically when the parallel vehicle phase is running. This reduces delay to both bike riders & pedestrians.
- The bike rider clearance phase should only begin at the same time as the pedestrian clearance if some benefit will be gained (for an innovative way of taking advantage of the pedestrian early start for bike riders without beginning the clearance unnecessarily early, see Case Study on p. 10). Otherwise the bike rider phase should be run with the vehicle signal or operate as a separate phase, which may require a three aspect lantern.
- As far as we are aware, a *flashing* red cycle symbol has no legal significance. More importantly however is that users understand the message that is trying to be conveyed. It is unknown how well a flashing red cycle symbol is understood, however evidence suggests that even the flashing red pedestrian symbol is not properly understood. A yellow bike rider lantern has the same requirements as yellow traffic signals do for drivers (stop if able, or complete crossing as soon as can do so safely).

**Benefits**

- Provides validation for bike riders using the intersection or crossing
- Can be used to provide priority
- Can be run with existing phases, minimising the complication and cost of installation
- Likely to improve bike rider compliance, therefore reducing conflict with others.

**Disadvantages**

- Flashing red cycle symbol may have no legal significance, and the intended meaning may not be properly understood.

**Where can this be seen?**

- Nepean Highway bicycle path. Two aspect lanterns run with the pedestrian signals across Cummins Road.
- Along the Docklands shared path.
- Many signals where shared paths cross roads.

■ CLEARANCE

# Three aspect bicycle lanterns

## Description

Three aspect bicycle lanterns consist of a red, *yellow* and green bicycle shaped light. They are very similar to standard traffic signals, with the same legal requirements for bike riders.

*Three aspect cyclist signals run with the vehicle signal at Nepean Hwy/Dendy St, Bentleigh. In this phase no pedestrians were detected and so the 'green man' was not displayed.*

## Potential Application

- Three aspect bicycle lanterns allow a greater degree of control of bike riders independently of other modes.
- Three aspect bicycle lanterns can be used for on-road bike riders to begin the bike rider clearance earlier than the motor vehicle clearance at wide intersections. This ensures bike riders have sufficient time to cross the intersection and don't get stuck in front of traffic coming from the side.
- Three aspect lanterns can be linked to vehicle signals to minimise the processing task and eliminate the need to upgrade the controller (which can be costly). This has the benefit that the bicycle signal comes up automatically every phase (without the need for detection). However this would not be necessary where bike riders are already on road as the vehicle signal provides the same priority. It could be used where a bike rider or shared path crosses an intersection next to the road (as in the photos at left).
- See Case Study on p. 21.

### Benefits

- As for two aspect bicycle lanterns
- Can be used to provide a phase better tailored to bike riders

### Disadvantages

- Usually need to be operated independently of existing phases, increasing the cost of installation

### Where can this be seen?

- Murrumbeena Rd crossing of Dandenong Rd, Murrumbeena
- Nepean Highway bicycle path. Three aspect lanterns run with the vehicle signals.

### Further information

- Victorian Government (2009)
- Austroads (1999a)
- Austroads (1999b)

## Case Study – Early bike rider clearance at Murrumbeena Rd/Princes Hwy, Murrumbeena

*The three aspect cyclist lanterns that have been added to the standard traffic signals for bike riders along Murrumbeena Road at Princes Highway.*

For bike riders travelling along Murrumbeena Rd (crossing Princes Hwy), the intersection is very wide and as such it takes bike riders longer to get across than motor vehicles. VicRoads have installed three aspect cyclist lanterns which turn yellow before the motor vehicle lantern to avoid bike riders becoming trapped in the intersection.

The cyclist phase runs every time the parallel Murrumbeena Road phase does, whether or not a bike rider is present at the start of green. Therefore there is no cyclist specific detection but a bike rider will trigger the phase by riding over the inductive loops in the traffic lane.

The introduction of this early cyclist clearance resulted in a longer side road phase than previously, as shown below, although this does not always have to be the case.

PREVIOUS SIGNAL TIMING

CURRENT SIGNAL TIMING

Vehicle signal

Bicycle signal

■ OTHER

# Other bike rider signal treatments

## Green wave

This involves synchronising successive signals for bike riders instead of timing them for the progression of motor vehicles. As bike riders take longer to accelerate from a stationary start and have a lower cruising speed, this provides a better flow for bike riders along a route. It reduces the number of times a bike rider has to stop, reducing travel time.

Previous studies have found that if a green wave is installed for bike riders, they learn to travel at a certain speed to 'catch' all the lights. This reduces the variation in bike rider speeds, including very fast bike riders.

This technique works best where there are several closely spaced signalised intersections along a major road and strong tidal flow. In Melbourne we tend not to have very closely spaced intersections, so this would not be widely applicable.

**Where can this be seen?**

- Nepean Hwy, Frankston
- Portland, Copenhagen and Amsterdam, and are under consideration in San Francisco.

**Further information**

- http://www.copenhagenize.com/2008/10/green-wave-spreads.html
- http://www.streetfilms.org/archives/accomodating-bike-speeds-by-re-timing-signals-on-valencia-street/

## Contra-flow bicycle lane at signals

At some signalised intersections there is a bicycle lane which operates in the opposite direction to vehicular traffic (therefore on one way roads). Depending on the signal setup and what vehicle movements are allowed, it may be necessary to provide a signal for bike riders.

*A contra-flow bicycle lane with standard signals at Lennox St and Highett St in Richmond*

**Where can this be seen?**

- The examples of contra-flow bicycle lanes that we are aware of around Melbourne are governed by standard traffic signals.
- Tuam Street between Oxford Terrace and Antigua Street in Christchurch, where there is a separate phase for contra-flow bike riders.

## Approach closed to traffic

In some instances one approach to an intersection is closed to vehicular traffic but remains permeable to bike riders. The most common is a four leg intersection where one leg is closed, to create a T intersection for motor vehicles but allowing bike riders to enter at the top of the T. In such cases good practice is to provide some sort of bike rider priority as well as signal lanterns showing bike symbols. A phase should be provided for bike riders, which in most cases would require all other approaches to face red.

See also Case Study p. 8.

*An intersection in Sydney where one approach was closed to traffic, but remains permeable to bike riders. Bike riders are given a green bicycle signal.*

**Where can this be seen?**

- Intersections in Sydney

■ OTHER

# Other bike rider signal treatments (cont.)

## Bike riders protected against a left turn merge

This involves showing a red signal to vehicular traffic merging from the left when bike riders are detected on the through movement. Through bike riders already have right of way over merging traffic if the bicycle lane markings continue across the merge. A common location that this occurs is when high volumes merge from the left into an 'added lane'.

There are no existing applications in Melbourne that we are aware of, but this technique has recently been considered for at least two locations where high volumes of relatively fast moving traffic merge into roads popular with bike riders.

A variation of this technique is to display a warning sign to motorists when bike riders are detected.

*Heidelberg Road bridge over Hoddle Street, where vehicles merging from the left have to cross the bicycle lane*

## Other forms of bike rider detection

Apart from the push button and inductive loop technology discussed earlier, there are various other forms of detection available. These include infrared, microwave and video detection.

Existing puffin detectors use microwaves to detect users at pedestrian operated signals. They are able to detect the presence of bike riders, but not distinguish them from pedestrians. One microwave detector is able to cover two traffic lanes in general, so two dare used at standard pedestrian operated signals across four traffic lanes. Puffins may not be suitable for crossings of very wide roads.

Detection technologies are constantly evolving and new ones are being developed. One example is video technology, which provides the means for a single camera to detect a user as well as identify the type of user (i.e. pedestrian, bike rider) and adjust the signals accordingly.

## Bike button trigger at side street near pedestrian operated signals across main road

Where a pedestrian operated signal is installed near a side or cross road with high bike rider volumes, consideration should be given to installing a bike button at the side road to trigger the signals.

This would be most applicable when bike riders on the side road are trying to cross a main road, which is a common traffic situation in Melbourne. In some cases, pedestrian operated signals are installed to detect buses turning out of a side street. A bike rider button could be incorporated at these intersections in the same way.

This treatment would require minimal additional infrastructure. A pedestal with a bike rider push button is the only requirement; although a 'Keep Clear' zone may also be needed (depending if there is already one present or not). This option is much cheaper and simpler than signalising the intersection (as done at Napier St/Johnston St in Fitzroy). It doesn't give bike riders priority, but creates a gap in traffic (at least from one direction) in which they can cross.

There may be issues with multi lane roads (stationary traffic reduces sight distance and so bike riders don't see moving traffic) and vehicles may use the side road as a rat run.

## Automatic green

Along high volume cycle routes at peak periods, it may be desirable to provide an automatic green signal for bike riders at crossings and intersections. Where there is a parallel traffic signal, this would mean a green bicycle signal would be shown at the same time as the green traffic light.

This treatment means bike riders arriving during a phase can go immediately, rather than having to wait for the next cycle.

The applicability of this treatment will depend on site specific characteristics, such as the layout of the bike rider route and signalised intersection timings.

On a shared path, ideally the pedestrian signal would also be automatic. This will depend on crossing width (and so time); the number of pedestrians and intersection timing requirements.

**Where can this be seen?**

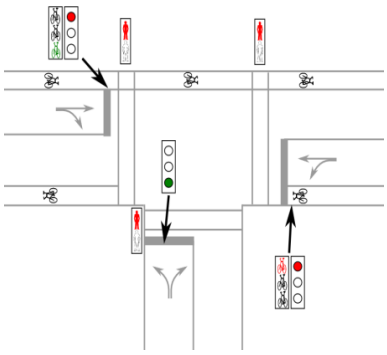
- Shared path in the median of St Georges Rd, Northcote and Thornbury

## Riding through the top of a T intersection

It may be desirable to allow bike riders to ride through the top of a T intersection when the vehicle light is red. As bike riders ride along the kerb, and provided right turning vehicles from the stem of the T track outside of the bicycle lane, there would be minimal conflict. Separate bicycle lights could be installed and the signals reprogrammed to allow bike riders to go when other traffic is held back. Alternatively, a parallel off-road path could be installed in the vicinity of the signals to allow bike riders to 'bypass' the signals.

In implementing this treatment, consideration should be given to possible conflict with pedestrians crossing the road and the tracking of turning vehicles. If there is a dedicated bicycle lane through the intersection, then turning vehicle conflict would be minimised. At some T intersections, this treatment would simply legalise behaviour that is already happening.

The only location we are aware of where this treatment has been applied is Buckleys Road / Russell Street, Christchurch. Similar off-road 'bypasses' have been applied past speed humps on bicycle routes in Melbourne.



## Two stage crossings of wide roads

Some pedestrian (and bike rider) crossings on roads with relatively wide medians operate as two separate crossings. In some instances the crossing of the second carriageway is timed to begin a certain period after the button was pressed. This works well for pedestrians, who don't have to press a second button in the median, but are given a green signal automatically and can continue across the second carriageway.

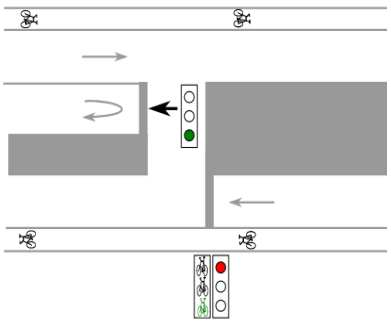
If such a crossing is also used by high volumes of bike riders, it may be reasonable to detect bike riders and pedestrians separately (using inductive loops or buttons). This way the second green signal can begin earlier for bike riders, reducing their delay in the median.

## Parallel to U turn

This technique allows bike riders who are going straight to go at the same time as a parallel U turn movement. This would only apply where through traffic is held back while the U-turning traffic goes (i.e. if the parallel traffic already has a green signal there is no need to install a bicycle signal). Signalised U-turns are rare in Victoria, so this technique has limited applicability.

As for 'Riding through the top of a T intersection', there may be no conflicting bicycle movements with the traffic movements. If the space provided for vehicles undertaking a U-turn is sufficient without intruding into the bicycle lane, then bicycle signals can be installed to allow bike riders to go at times when other traffic is held back.

On St Kilda Rd in Melbourne, vehicles perform a U-turn from the slip lane, requiring vehicles on the main carriageway to stop. Here bike rider lights have been installed and through bike riders in the slip (U turn) lane are given a green signal at the same time as the U-turn signal.



**Where can this be seen?**

- St Kilda Rd, Melbourne outside of the Arts Centre

## 'Vancouver' signals or 'hawk signals'

This treatment is so called because of its use in Vancouver, Canada. It is used at intersections where two roads meet, often a major and minor road. Signals are installed for drivers on the main road, and are triggered by a bike rider push button (and vehicle detection) on the minor road. This treatment is similar to installing pedestrian crossings across a major road on both sides of the intersection, which means traffic from the minor road does not face a signal.

The treatment has the advantage over a conventional intersection that if the major road is not busy, bike riders (and drivers) from the minor road do not have to wait for signals.

This treatment has not been used in Victoria because of concern about the ambiguity for users on side road who can't see a lantern that tells them whether they can go or not.

## Active Bicycle Warning Signs

Some states in the USA use active bicycle warning signs to alert drivers to the presence of bike riders. These are signs that read something similar to "Bicycles in tunnel when lights flashing – speed 30 mph" with flashing lights mounted around them. The lights are activated by the presence of a bike rider, often detected with a push button. They are most often used in tunnels and locations with poor sight distance.


*Source: Oregon Department of Transportation (2001)*

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