About this release

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<td>Author:</td>
<td>Ryan Horne – Innovations and Research Manager</td>
</tr>
<tr>
<td>Authorised by:</td>
<td>Chris Harrison – Director Engineering Services</td>
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References

The following documents are referenced by this Technical Guide such that some or all of their content may be requirements or recommendations of this document:

- Guidelines for Road Safety Audit Practices – NSW Centre for Road Safety;
- Safe System approach – NSW Centre for Road Safety;
- Factors influencing single-bicycle crashes at skewed railroad grade crossings, Knoxville (USA);
- Bicycle Interaction and Street Cars – Alta Planning & Design, Portland (USA);
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1 Introduction

1.1 Background

Light rail has provided a new mode of transport for people in NSW cities, however the introduction of this infrastructure has resulted in a new safety risk to cyclists navigating across the tracks.

In Australia, incidents have been reported where cyclists have fallen from their bicycles when crossing rail infrastructure at skewed angles, resulting in one or more of their wheels riding into the groove in the track. International studies show that cycling across light rail tracks at angles between 60° and 90° significantly reduces the risk of riding into the tracks. Further information is available at https://www.sciencedirect.com/science/article/pii/S2214140516303450.

The principles in this Technical Guide have been developed based on investigations in urban locations where potential unsafe interactions between cyclists and light rail tracks may occur. Future investigations may result in the identification of improved safety treatments, which may be incorporated into this document.

1.2 Purpose

This Technical Guide aims to assist with the safe design and development of cycle facilities at light rail intersections and serves as a tool for designers and subject matter experts when considering safety at these locations. Additionally it provides the following:

- General principles for consideration as part of a more thorough investigation in order to achieve safer outcomes for cyclists at light rail intersections.
- Guidance during investigation and design stages for new light rail projects.
- Considerations for upgrading infrastructure at existing light rail intersections.

This Technical Guide does not provide any requirements that are prescriptive in nature.

1.3 Exclusions

This guide does not consider or apply to:

- Rail profiles or rail systems other than groove profiled tracks used in NSW Light Rail infrastructure
- Infill treatments. At the time of publication, infill treatments are being developed as part of a separate program and tender process by Transport for NSW (Transport).
- The use of unapproved coloured pavement treatments for delineating bicycle movements. At the time of publication, further investigations are being undertaken by Transport into the feasibility of such treatments, along with any potential for future trials.
2 Principles of a safe solution

2.1 Safe System approach to design

As part of a Safe System approach to the design of new infrastructure, consideration should be given to the use of the infrastructure by all road users and their individual responsibilities to creating a safer road environment. Humans make mistakes when using our roads, however these errors should never result in serious injury or death. A Safe System approach places the responsibility of safety on the following four pillars (see Figure 2-1):

- Safe Roads;
- Safe Speeds;
- Safe Vehicles; and
- Safe People.

Each pillar working together aims to reduce the likelihood of a crash, however if one of the pillars fails, the remaining pillars seek to reduce the severity of the outcome. Speed limits and travel speeds can have a significant impact on severity, with research indicating that pedestrians and cyclists have an 85% to 90% chance of sustaining fatal injuries when struck at 50 km/h by a car compared with only a 10% chance of suffering fatal injuries when struck at 30 km/h. The chance of sustaining fatal injuries at those speeds if the collision involves a tram may be much greater.

When considering a design a treatment for bicycles and light rail interaction based on a safe system approach, consideration should not only be given to the proposed treatment, but the whole road environment. This includes looking at how road users will respond and consideration of localised speeds around the crossing. Provision should also be made for appropriate guidance and education where possible to ensure the four pillars of a Safe System approach function together and treatments focus on reducing one or more factors of likelihood, exposure or severity to deliver a safe system aligned outcome.

2.2 Unsafe crossing angles

Light rail tracks often follow road corridors shared by other modes of transport including cyclists. Whilst most other modes have wider wheels, allowing them to drive or ride over the channels in the road pavement, bicycle wheels are often narrow enough to fall into the tracks. This can result in serious injury or death if the cyclist loses control of the bicycle.

In a study undertaken at a rail crossing in Knoxville Tennessee, cyclists significantly reduced their risk of groove-related crashes when crossing at angles greater than 30°. In the data sample of over 2000 crossings recorded at a single location of a rail crossing less than 30°, a total of 32 crashes were recorded.

From this data, the study found that crossing angles were the most likely factor to contribute to the cause of single bicycle crashes at the skewed rail crossing, after considering a range of factors, including demographic, environmental and behavioural factors.

From video analysis of the crossing, which included cyclists crossing at various angles, most crashes occurred at crossing angles less than 30°. That number was significantly reduced at angles between 30° and 60°, with no crashes recorded at angles between 60° and 90° (see Figure 2-2).

These findings align with international benchmarks of the safest crossing angle being 90° and the risk of a cyclists’ wheel falling in the groove, increasing at angles below 60°.

Additionally, a further study undertaken in Portland, Oregon (USA) found that over 67% of respondents had experienced a crash at rail tracks, which represented a large number of unreported crashes.
3 Determining a safer solution

3.1 Process

When considering safer crossings for either new light rail projects, or improving cyclist interactions at existing light rail intersections, a structured process should be followed to determine the most appropriate treatment for the crossing. The process should incorporate the following:

1. **Investigation of the issue.** This includes collecting information about the site and the problem, and should include the following:
   - Crash data;
   - Vehicle and bicycle volumes;
   - Vehicle and bicycle movements and desire lines;
   - Alternate route options;
   - Feedback from community groups; and
   - Internal information such as feedback correspondence or complaints.

2. **Options design:** Includes the design of possible solutions to manage the risk.

3. **Options assessment:** After design options are identified, gathering input from subject matter experts is required to identify other alternatives and to select a preferred option.

4. **Stakeholder engagement:** This includes engaging the community and relevant stakeholders to identify and address any concerns in the final design.

5. **Endorsement and approval.** Including following all relevant design approval processes to obtain correct approvals for implementation/construction.

6. **Monitor and review.** Monitoring the completed treatment to ensure the safety deficiencies have been improved and to identify potential new risks or hazards.

3.2 Investigation

3.2.1 General

It is important to mitigate the risk of crashes involving cyclists at light rail tracks when designing an intersection for a new light rail project or if upgrading an existing light rail intersection. When investigating the needs of cyclists, there are a number of key considerations and design principles which should form the basis of the investigation. Data captured during the investigation should be used to assist in determining the safest and most suitable outcome for the safety of cyclists.

Section 3.1 Process contains the key considerations when investigating cyclist safety for their respective project types. While there are many similarities between the consideration points for each, refer to the appropriate section for your project type.

3.2.2 Investigations for new light rail intersections

New light rail projects present an opportunity to design an intersection inclusive of safety infrastructure or bicycle crossings that may not otherwise be possible post construction. When planning for new infrastructure, identifying safety improvements and making decisions early in the project lifecycle will benefit the safety of cyclists, and overall project outcomes. The ability to dedicate or reassign land for other facilities means that additional types of cycling facilities may be possible to incorporate into new designs, offering improved safety. This may include separated cycleways, or cycle facilities that are not feasible under existing conditions.
In order to provide safer means for cyclists to cross the tracks, Table 3-1 provides the factors that should be considered when designing new light rail intersections.

Table 3-1 - Key considerations for new light rail projects

<table>
<thead>
<tr>
<th>Factor</th>
<th>Key considerations / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle routes/movements</td>
<td>Identify all cycle movements and desire lines within the intersection. Is it likely that any of these movements may involve crossing the tracks at less than 60°? Allow for cyclists who may not take the most direct line. There may be more than one potentially unsafe point of intersection if multiple rail lines intersect. Is it reasonable to assume that a cyclist may leave the traffic lane to improve their approach angle? In such cases, cyclists risk being overtaken/undertaken and may be forced to remerge with traffic travelling at a higher speed. The more predictable cyclist’s movement are, the less chance they are of being struck by a vehicle or tram. Will this intersection form part of a cycle route after construction? Are there alternate facilities for cyclists or will cyclists travelling through the area be required to ride on the road? Identify all routes through the intersection. Local Councils will have information on current cycle routes within their Local Government Area (LGA). Consider the demographics of the area. Will the intersection be mostly used by experienced or inexperienced cyclists? Also consider road bikes generally have narrower tyres than other bikes, exposing them to greater risk. Are projected cyclist volumes for the site available, or does traffic modelling suggest a particular level of use by cyclists? Does this differ from its current level of use? Is this part of a strategic cycle route? This should influence the type of facilities at the intersection as it will have much higher volumes of bicycle traffic. Consider dedicated cycle facilities. Are there nearby land use developments that may generate cycle movements, such as schools or parks? Are cycle facilities provided along the light rail network, such as bike parking at stops, that will encourage cycling to and from light rail stops?</td>
</tr>
<tr>
<td>Reported incidents or issues</td>
<td>Is there a history of crashes involving cyclists at this intersection which should be considered in the new designs? What is the likelihood of a crash occurring? What is the likely severity of the crash? Take into consideration volumes of cyclists, level of experience, demographic, road geometry etc.</td>
</tr>
<tr>
<td>Exploring solutions</td>
<td>Can alternate cycle facilities be constructed at the intersection to allow cyclists to cross at a safer location? Consider widening footpaths to accommodate cyclists at crossing points. Shared bicycle lanterns may be used at crossings where shared path facilities are present at both ends of the crossing. Shared paths should be designed in accordance with Austroads Guide to Road Design: Part 6A. Is there an engineering solution to reduce the likelihood of tyre entrapment in the track? This may include changing the angle of approach to guide cyclists across the tracks at a greater angle. Do the traffic volumes suggest that large numbers of cyclists are making particular movements? Could bike boxes be beneficial?</td>
</tr>
</tbody>
</table>
### Key considerations / questions

Has consideration been given to banning cyclists at dangerous locations? This will likely have the largest impact on cyclist amenity, and is recommended only when other treatments are not feasible. Adequate consultation should be undertaken as part of the project planning and alternative crossings along the existing route should be provided.

Will a bicycle ban affect other cycle routes passing through the intersection? Are cyclists likely to adhere to the ban? If a ban is to be implemented, will the message be clearly visible to cyclists before they get to the intersection. Consider clear guidance in advance.

### Investigations for existing light rail intersections

When improving safety at existing light rail intersections, there may be additional challenges or geometric constraints. Many of the principles in Section 3.1 Process are applicable, and consideration should still be given to alternatives to riding at unsafe angles across the tracks. Table 3-2 identifies the key considerations or questions that should be asked when investigating safer crossings for cyclists at existing intersections where cyclists cross light rail tracks at potentially unsafe angles.

#### Table 3-2 - Key considerations when improving existing light rail intersections

<table>
<thead>
<tr>
<th>Factor</th>
<th>Key considerations / questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General investigations</strong></td>
<td>Identify any points in the turn path which may have an approach angle less than 60°. There may be more than one location if multiple rail lines intersect. Ideal approach angles should be between 60° and 90°.</td>
</tr>
<tr>
<td></td>
<td>Where angles are less than 60°, is it possible that a cyclist may slip into the tracks? Can the angle be increased?</td>
</tr>
<tr>
<td></td>
<td>Is it reasonable to assume that a cyclist may leave the traffic lane to improve their approach angle? In such cases, cyclists risk being overtaken/undertaken and may be forced to remerge with traffic travelling at a higher speed. Has a safe transition been provided for cyclists leaving the traffic lane, and will it reduce amenity for other road users (e.g. if they are transitioned to a shared path is it wide enough to accommodate the demand)?</td>
</tr>
<tr>
<td><strong>Cycle routes /movements</strong></td>
<td>Is this intersection part of a bike route? Identify all routes through the intersection. Local Councils will have information on current cycle routes within their Local Government Area (LGA).</td>
</tr>
<tr>
<td></td>
<td>Identify all cycle movements and desire lines within the intersection. Is it likely that any of these movements may cross the tracks at less than 60°? Allow for cyclists who may cut corners and cross at shallower angles.</td>
</tr>
<tr>
<td></td>
<td>Consider the demographics of the area. Will the intersection be mostly used by experienced or inexperienced cyclists? Also consider road bikes generally have narrower tyres than other bikes, exposing them to greater risk.</td>
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<tr>
<td></td>
<td>Undertake a traffic survey. Collect data on volumes of cyclists and vehicles making the turn. Ensure the data surveyed is reliable from a typical day under typical weather conditions. The survey should not be undertaken during school holidays or during periods of reduced traffic volumes.</td>
</tr>
<tr>
<td>Factor</td>
<td>Key considerations / questions</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Reported incidents or issues</td>
<td>Have there been any reported crashes or incidents where cycle movements cross the tracks? Speak to local Bicycle User Groups.</td>
</tr>
<tr>
<td></td>
<td>Undertake a risk assessment of the design. What is the likelihood of a crash occurring? What is the likely severity of the crash? Take into consideration volumes of cyclists, level of experience, demographic, road geometry etc. Crash data suggests cyclists are vulnerable to injuries sustained when dislodged from their bike and also exposed to increased collision risk from vehicles following behind them.</td>
</tr>
<tr>
<td>Exploring solutions</td>
<td>Can cyclists be redirected out of the traffic lane and onto the footpath? What is required to achieve this? Consider shared paths, shared cycle/pedestrian crossings and investigate whether this may introduce an acceptable or unacceptable level of risk to pedestrians/cyclists as an alternative.</td>
</tr>
<tr>
<td></td>
<td>Do the traffic volumes suggest that large numbers of cyclists are making particular movements? Could bike boxes be beneficial? When considering bike boxes at traffic signals, large amounts of ‘green time’ allocated a particular movement may decrease their effectiveness.</td>
</tr>
<tr>
<td></td>
<td>Has consideration been given to banning cyclists at dangerous locations? This will likely have the largest impact on cyclist amenity, and is recommended only when other treatments are not feasible. Adequate consultation should be undertaken before implementation and alternative crossings along the existing route should be provided.</td>
</tr>
<tr>
<td></td>
<td>If suitable and direct alternatives are not provided, research indicates it is likely that cyclists will continue to travel through the intersection and will still be exposed to the risk.</td>
</tr>
<tr>
<td></td>
<td>Will a bicycle ban affect other cycle routes passing through the intersection? Are cyclists likely to adhere to the ban? If a ban is to be implemented, will the message be clearly visible to cyclists before they get to the intersection. Consider clear guidance in advance.</td>
</tr>
</tbody>
</table>

### 3.3 Option Design

#### 3.3.1 General

Option design and assessment should be completed using the outcomes of the investigation completed in Section 3.2 Investigation. The options designed should consist of a treatment which addresses each of the deficiencies and provides a clear safety improvement for cyclists while maintaining safety for all other road users.

There are many treatments available, some of which have been included in this Technical Guide, and all of which aim to either remove the cyclist from the hazard, reduce the difficulty of the crossing, or improve awareness.

The treatments within this Section are examples of ways which may improve safety for cyclists when interacting with light rail tracks, and should be considered as part of the overall investigation for both new light rail intersection designs and treating existing light rail intersections. More than one option provided in this Section may be applied. Additionally, this Section does not provide an exhaustive list of treatment options available and alternatives should be considered throughout the process.

Regardless of the treatments applied, road safety audits should always be carried out to assess the road safety risk. Along those light rail alignments that intersect with dedicated cycling routes a specialist cyclist advisor should be included in the audit team.
3.3.2 Redirecting cycle paths

If it is identified through the investigation that cyclists are taking potentially unsafe paths to cross light rail tracks, there may be opportunity to redirect cyclists to enable them to select a safer path for navigating the crossing. To do this a series of measures from this Section may be implemented including provision of signage to communicate the desired line and implementation of shared-use marked crossings.

3.3.3 Shared-use marked crossings

Under the NSW Road Rules, cyclists are required to dismount when crossing at a signalised marked crossing. The exception is at a shared use crossing, where a bicycle lantern is displayed. Installation of shared use marked crossings may be of benefit to cyclists at light rail intersections where crossing angles are less than 60°. Where possible, road users should always be separated from the hazard, particularly for larger more complex intersections.

If a safe passage across the tracks is not possible, the space available on the adjacent footpath should be considered. The NSW Road Rules do not permit cyclists over the age of 16 to ride on the footpath. As such, shared paths should be considered when trying to remove a hazard, in conjunction with combined pedestrian/bicycle lanterns (see Figure 3-1).

When considering this treatment, investigations should be made on the available footpath space to ensure there is enough room to safely mix both pedestrians and cyclists without adverse risk.

Consideration should also be given to upgrading the kerb ramps to allow additional space for cyclists and pedestrians to enter and exit the crossing.

3.3.4 Bike boxes

Bike boxes provide a safe refuge for cyclists at the front of a set of traffic lights. They improve safety by placing the cyclist at the front of stationary traffic, ensuring they are within the visible range of the motorists behind them. They also provide a small amount of extra time at the beginning of the phase to assist the cyclist completing their turn movement.

Bike boxes may be considered when designing for both new and existing light rail intersections. When investigating the installation of bike boxes, the following items should be considered:

- Bike boxes do not provide a safe path over the tracks, rather they improve safety by giving an advantage of additional time to determine the safest crossing over the tracks.

- Bike boxes are only effective if the cyclist has stopped within the box at the beginning of the green signal phase. If the cyclist approaches mid-phase, they are to proceed with the flow of traffic, removing any potential ‘head start’. Increased green time may improve overall intersection efficiency, but will result in less opportunities for cyclists to utilise the time advantage.

- Bike boxes improve safety by placing the cyclist in front of vehicles, making them more visible to motorists during the turn.
3.3.5 Improved guidance and delineation

Where changes are planned that may impact current cycle routes or movements, cyclists will be required to make decisions about the routes they take and their position on the road, including the lanes they choose. As such, any changes should be supported by appropriate signage at the intersection, and in advance of the intersection to ensure that cyclists have sufficient time to make decisions about alternative routes if required. This should include adequate wayfinding signage to support any alternate routes provided.

Consideration should also be given to the appropriate hazard warning signage if cyclists are required to cross the tracks. The Cyclist hazard symbolic (W6-10) sign should be used to warn cyclists of the approaching hazard ahead (see Figure 3-2). The following additional provisions apply when using the Cyclist hazard symbolic (W6-10) sign:

- The CROSS TRACKS AT 90 DEGREES (W8-250n) supplementary plate should be used where it is possible to cross at 90°; or
- The CAUTION CROSSING TRACKS (W8-251n) supplementary plate should be used where crossing the tracks at 90 degrees cannot be achieved.

3.3.6 Banning of bicycles within light rail intersections

Banning cyclist movements should be considered where all other options are not feasible. While this option may eliminate a hazard, it has the largest impact on cyclist amenity, and has the potential to relocate a problem. This option should not be considered without stakeholder engagement. If a ban is to be implemented, an alternative means of crossing should be provided along the direct route, to avoid detours which may not achieve high levels of compliance. If suitable and direct alternatives are not provided research indicates it is likely that cyclists will continue to travel through the intersection and will remain exposed to the risk.

Banning bicycles from a light rail intersection should be considered where crossing angles are less than 60°, and a risk assessment shows that there is a high likelihood of crash or injury.

The Bicycles prohibited symbolic (R6-10-3) sign should be used where a ban on bicycles within an intersection is necessary (see Figure 3-3).
3.4 Options assessment

Throughout the option design process, a series of subject matter experts should be engaged to ensure options have been fully considered. Subject matter experts may include representatives from the following Transport branches/divisions:

- NSW Centre for Road Safety
- Network & Safety
- Traffic Engineering Services
- Road Design
- Asset owners

Options should be assessed with consideration given to the safety of cyclists, pedestrians and other road users. Where a ban on cyclists is the preferred option, the options assessment should document the reasons the other options were not feasible.

In consultation with subject matter experts, a risk assessment should be conducted to inform the final option selected to manage the risk so far as is reasonably practicable. Once assessed, a preferred design should be selected for stakeholder engagement.

3.5 Stakeholder engagement

Light rail infrastructure combines multiple modes of transport within the same road or road related area. As such, multiple stakeholders will have interest in or may influence the overall outcome of a project. The design process should include appropriate stakeholder engagement. Stakeholders for consultation on a light rail project should include, but not limited to the following:

- Local Councils
- Local/State Members
- Transport Service Providers
- Transport Operators
- Bicycle User Groups
- Local Traffic Committees
- NSW Police
- Bicycle NSW
- Affected local businesses

3.6 Road safety audit

A road safety audit is a formal examination of proposed or existing roads and road related areas from the perspective of all road users with the intention of identifying road safety deficiencies and areas of risk that could lead to road crashes. Road safety audits should be undertaken at various stages of a project, in accordance with the Guidelines for Road Safety Audit Practices.

The audit should consider cyclist safety, and be carried out by an independent professional team of auditors. The findings of the road safety audit should be addressed by the project manager after the audit has been undertaken, to ensure that any identified safety deficiencies in the report have been mitigated.

3.7 Endorsement and approvals

The principles in this document provide guidance in the design and selection of safer cycle facilities at light rail intersections, however all treatments and principles suggested are subject to the endorsement and
approval processes in accordance with current Transport delegations. Other treatments not included in this Technical Guide may still be effective, and should be considered as part of an investigation, including their required approval processes.

### 3.8 Monitor and Review

After a project has been completed and constructed, intersections should be monitored to ensure that new risks have not been introduced as a direct result of the treatment. If required, a post-construction road safety audit should be carried out, and if new risks are identified, they should be rectified and closed out by the project manager before handing over to traffic managers.
4 Supplementary considerations

The following supplementary considerations are in addition to the principles raised for investigating and designing a safer solution for cyclists at light rail intersections. They consider factors not directly related to the formal design process under the safe roads pillar of the Safe System Approach, but are part of other pillars necessary for the safe operation of new infrastructure.

4.1 Cyclist safety awareness programs

Cyclist Safety awareness programs are educational campaigns aimed at educating cyclists on how to correctly use new or unfamiliar infrastructure. While cyclist safety awareness programs do not directly form part of the design process for cyclists that interact with light rail, they play an important part in the education of cyclists and other road users.

Safety concerns requiring educational campaigns should be identified and implemented by safety practitioners during the project lifecycle to ensure the safe operation of a new piece of infrastructure.

Educational material should be targeted towards different groups or behaviours and be delivered in a range of formats, including but not limited to:

- Brochures/leaflets
- Educational workshops
- Promotional merchandise
- Advertising on TV, radio, newspaper or social media.

4.2 Wayfinding signage

Adequate wayfinding signage for cyclists should be installed where:

- Alternative routes have been provided; or
- Unusual manoeuvres are required in order to traverse the intersection, such as transition to a shared path.

Wayfinding signage assists cyclists in providing clear information on the safest path of travel, and helps to raise awareness of the hazard and ensure a safe passage through the intersection. Wayfinding signage should indicate the direction of travel, and also be linked to key destinations to which cyclists are likely to travel.
Contact Us:
If you have any questions or would like more information on this document please contact Transport for NSW:

roads-maritime.transport.nsw.gov.au

technfo@transport.nsw.gov.au

13 22 13

Customer feedback
Locked Bag 928,
North Sydney NSW 2059

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