Austroads Safety Barrier Assessment Panel – Technical Advice

Departure point of redirection

SBTA 21-001, February 2021
Review data, February 2023

Preamble

To perform satisfactorily, safety barriers must have sufficient length to enable vehicle redirection. In addition, barrier terminals require sufficient support to perform (e.g. absorb energy) as designed and tested.

This technical advice note provides guidance on the concept of the *downstream* point of redirection and its location. The methods to locate it are new to the *Austroads Guide to Road Design, Part 6* (Austroads 2020).

Audience

- Road Agencies
- Road Designers.

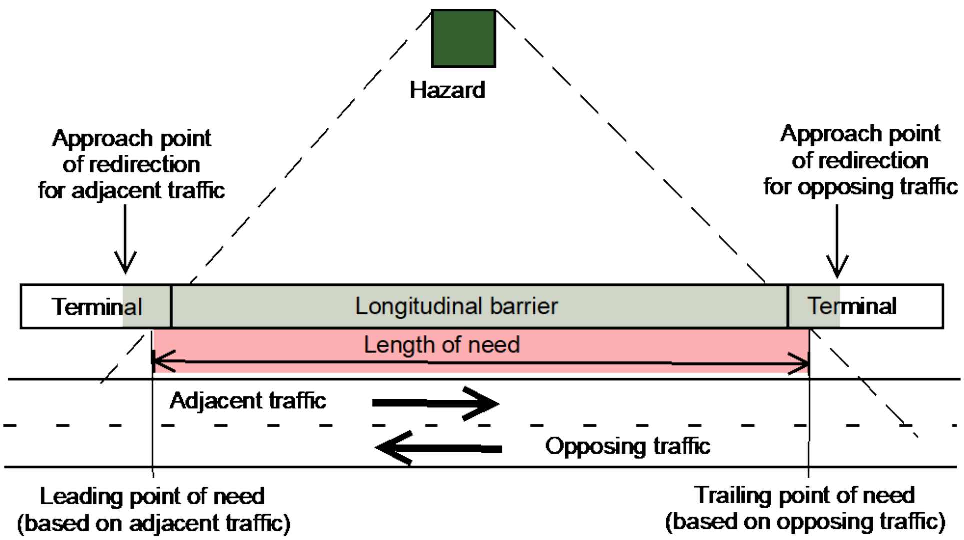
Point of redirection in *Austroads Guide to Road Design Part 6*

Austroads Guide to Road Design indicates that a barrier system has a point of redirection that may be at the terminal - barrier interface or it may be within the terminal depending on the design of the terminal. This point of redirection is observed and based on tests (35 and 36) on the terminal.

Figure 1 shows the typical configuration for a barrier on roads with traffic in both directions. The length of need (shown by the red shading) defines the barrier length required to shield a hazard, as described in *Austroads Guide to Road Design Part 6 (*using leading and trailing points of need shown in Figure 5.22 in Austroads (2020)).

The redirective section of the barrier system (shown with a green shading in Figure 1) must extend further than, or to the length of need required to shield the hazards (shown by the red shading in Figure 1). The redirective section is governed by the approach points of redirection for each direction of traffic.

Figure 1: Length of need and points of redirection for a barrier installation for a two-way road

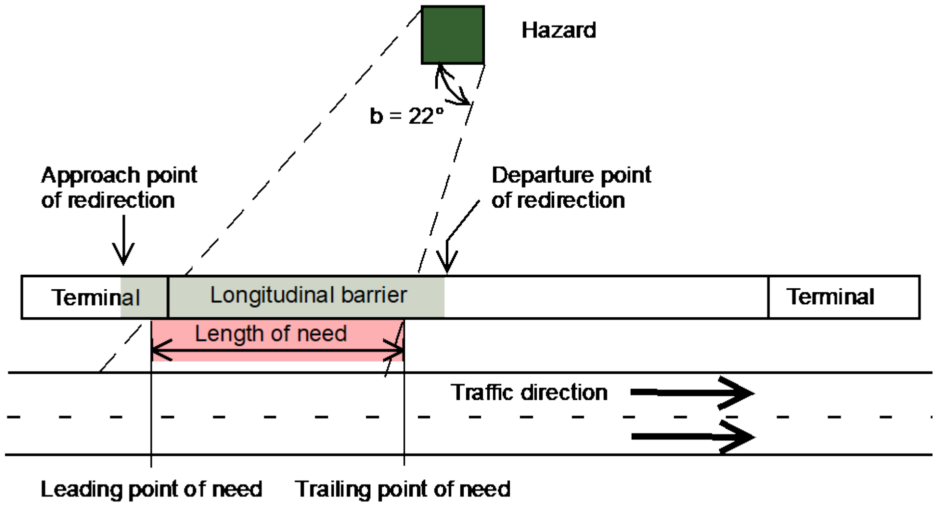


Note: Vehicles can impact the barrier in both directions. This figure is diagrammatic only and is not to scale.

Departure point of redirection

Figure 2 shows a typical configuration for a barrier on a one-way road. The leading point of need is described in Figure 5.22(a) of Austroads (2020) using the run-out length method. The trailing point of need is described by Figure 5.20 (and in Figure G.1(b)) using the angle of departure method and with angle b equal to 22°.

Figure 2: Length of need and points of redirection for a barrier installation for a one-way road



Note: This figure is diagrammatic only and is not to scale.

The reader will note that the concept of the departure point of redirection is introduced in this figure. While the approach point of redirection is observed and based on the terminal tests (35 and 36), the downstream point of redirection is more difficult to obtain. This is discussed below.

Note that impacts upstream of the approach point of redirection and downstream of the departure point of redirection will result in the barrier gating and the vehicle proceeding past the barrier line.

Downstream point of redirection

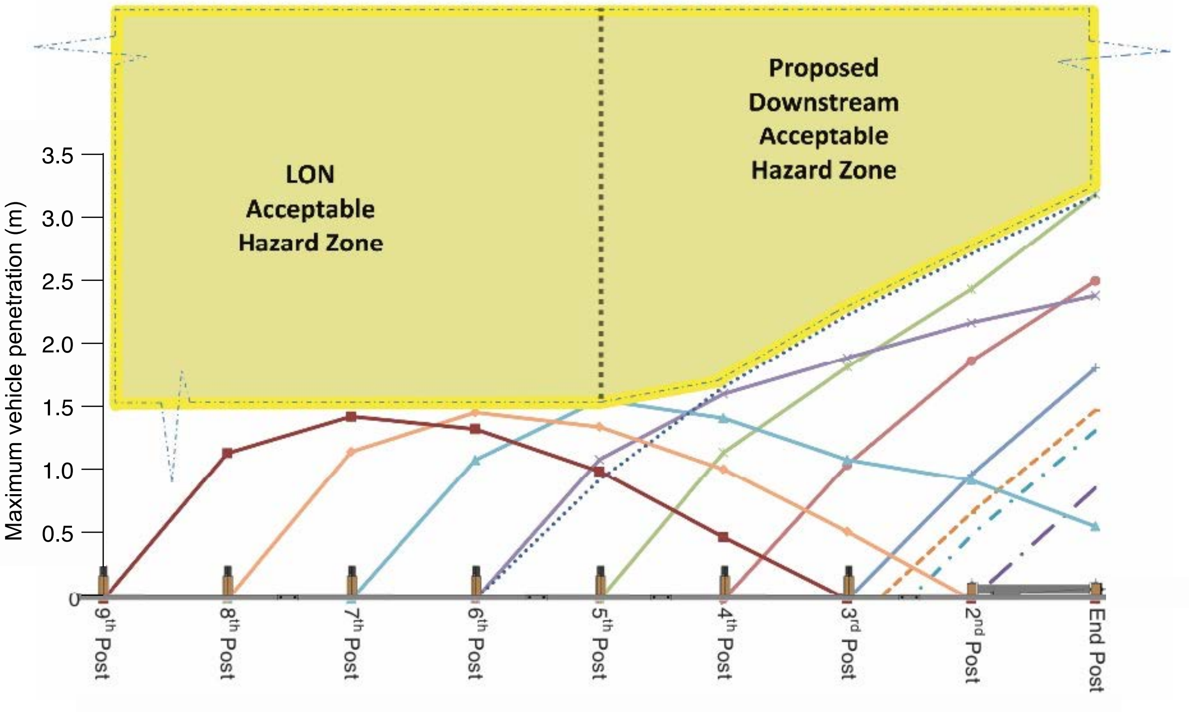
Attributes of the downstream point of departure

A barrier must provide sufficient force to the vehicle to enable it to be safely redirected. This force is required while the impacting vehicle is in contact with the barrier, but the magnitude of the force varies throughout the interaction.

Where an impact occurs near the trailing terminal, the barrier may not be able to provide sufficient redirective force. The vehicle will drive through the barrier or departure terminal. For instance, Mongiardini et al (2013) simulated a Midwest Guardrail System near the downstream terminal and found that impacts at the seventh post from the departure terminal and those closer to the trailing terminal resulted in the system "gating", although vehicles impacting at the seventh post were partially redirected with the trailing terminal gating. The posts were spaced at 1.905 m.

Figure 3 shows the results from Mongiadini et al (2013). A vehicle impacting at the eighth post is redirected with the vehicle in contact with the barrier up to the second post. The downstream point of redirection is at the eighth post. The angled section of the downstream acceptable hazard zone is approximately 15° to the line of the barrier.

Figure 3: Impact with a barrier close to the departure terminal



Source: After Mongiardini et al (2013)

Tests near the end of a W-beam barrier.

Mongiardini et al (2013) conducted a full-scale test with the barrier impacted at the sixth post from the downstream anchor. Figure 4 illustrates that the vehicle had minor damage. The occupant injury parameters were within the MASH limits. The vehicle's trajectory in this test is consistent with the simulation results in Figure 3.

Figure 4: Impact with a barrier close to the departure terminal

Source: Mongiardini et al (2013)

Determining the departure point of redirection

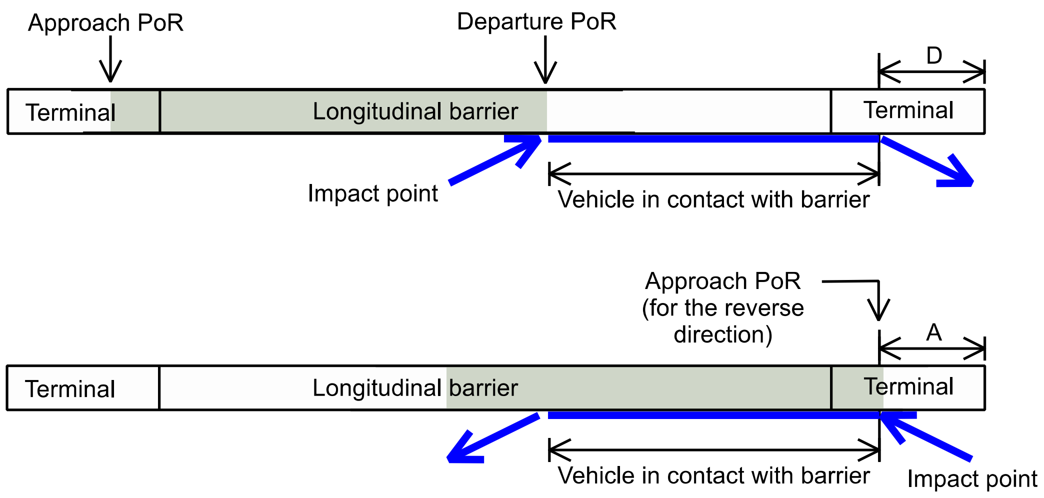
The downstream point of redirection is the point where a test vehicle impacts the barrier, remains in contact with the barrier without breaching it and with the trailing transition able to support the redirective loads as the vehicle exits the barrier. This is illustrated in the top view of Figure 5.

The lower diagram in Figure 5 shows an impact in the reverse direction at the point of direction, which was a distance A from the end of the terminal. The vehicle remains in contact with the barrier and exits the barrier as shown. The redirective forces are higher when the vehicle impacts the barrier than when the vehicle is exiting the barrier and dimension D is likely to be less than dimension A. Conservatively, dimension D can be assumed to be equal to dimension A.

Departure point of redirection

The location of the departure point of redirection from the end of the trailing terminal is approximately equal to the distance from the approach point of redirection from the approach end of the leading transition (dimension A) and the contact length of a MASH 3-11 test.

Figure 5: Determining the location of the departure point of redirection



Faller et al (2007) evaluated a standard Midwest Guardrail System (MGS) with a MASH 3-11 test and recorded a contact length of 10.5 m (or 5.5 post spacings). Using Figure 5 and the comments above, give a departure point of redirection at post 8, if the trailing terminal is redirective at the second post from its end. This concurs with the information in Figure 3. This approach can then be used to evaluate the departure point of redirection for other barrier systems which may have longer contact lengths and longer distances from the approach point of redirection to the end of the leading transition (dimension A).

The following contact lengths from TL-3 tests have been recorded for different barrier types:

- 11 to 12 m for non-proprietary W-beam systems.
- 15 to 16 m for flexible W-beam systems,
- 22 to 25 m for wire rope barriers

For TL-2 tests, the impact severity is 49 percent of the similar value for TL-3 impacts. The contact lengths in TL-2 tests are less than those for TL-3 tests. Weiland et al (2015) simulated impacts into barriers at different speeds. They recorded 6 to 7 deflected posts [1] in TL-3 impacts and 5 in TL-2 impacts with the MGS; a non-proprietary W beam system. While this is not an accurate assessment of the contact length, it does indicate that the contact length for TL-2 impacts is likely to be 2 to 4 m less than for TL-3 systems. Also see Fang et al (2012).

Accepting that there needs to be three posts in the trailing terminal of a W-beam system to resist the loads, the location of the departure point of redirection from the end of the trailing terminal are:

- 16 m for non-proprietary TL-3 W-beam systems
- 20 m for flexible TL-3 W-beam systems,

For wire rope barriers the location of the departure point of redirection depends on the design of the longitudinal section and the terminal. It is expected to be in the range of 35 m to 39 m.

Similarly, for 70 km/h impacts into Tl-3 barriers, the departure point of redirection is considered to be 3 m less giving the location of the departure point of redirection from the end of the trailing terminal as:

[1] Posts that were deflected or rotated towards the impact were not considered.

Departure point of redirection

- 13 m for non-proprietary TL-3 W-beam systems
- 16 m for flexible TL-3 W-beam systems,

When should the departure point of redirection be used?

The departure point of redirection should be used when designing barrier installations on one-way roads, including divided carriageways.

Design guidance and recommendations

All safety barrier systems have a downstream point of redirection. Impacts downstream of this point are not redirected as the barrier gates. The location of the departure point of redirection from the end of the trailing terminal are:

- 16 m for non-proprietary W-beam systems
- 20 m for flexible W-beam systems,
- 35 m to 39 m for wire rope barriers depending on its design.

These values should be applied to installations where the likely impacts are consistent with TL-3 test conditions. If these barriers are installed on urban roads where the expected impact speeds are 70 km/h or less, then the location of the departure point of redirection from the end of the trailing terminal are:

- 13 m for non-proprietary W-beam systems
- 16 m for flexible W-beam systems.

The downstream point of redirection should be used to determine the required barrier length on one-way roads, using the concepts in *Austroads Guide to Road Design Part 6* (Austroads,2020) Section 5 and Appendix G. The same procedure should also be used to check the barrier length for impacts in both directions on two-way two-lane roads. It is recommended that angle b in Figure 5.20 (and in Figure G.1(b) of *Austroads Guide to Road Design Part 6* be 15°.

References

Austroads 2020, *Guide to road design part 6: roadside design, safety and barriers,* AGRD06-20, Austroads, Sydney, NSW.

AASHTO 2016, *Manual for assessing safety hardware,* 2nd edn, American Association of State Highway and Transportation Officials, Washington, DC, USA

Faller RK, Sicking DL, Bielenberg RW, Rohde JR, Polivka KA and Reid JD, 2007. *Performance of Steel-Post, W-Beam Guardrail Systems.* Transportation Research Record: Journal of the Transportation Research Board 2025, pp18-33. Transportation Research Board

Mongiardini M, Faller RK, Reid JD and Sicking DL, 2013. *Dynamic Evaluation and Implementation Guidelines for a Nonproprietary W-Beam Guardrail Trailing-End Terminal.* Transportation Research Record: Journal of the Transportation Research Board, No. 2377, Transportation Research Board of the National Academies, Washington, D.C., 2013, pp. 61–73.

Fang H, Gutowski M, Li N , DiSogra M, 2012. *Performance Evaluation of NCDOT W-beam Guardrails under MASH TL-2 Conditions* The University of North Carolina at Charlotte. Report to North Carolina Department of Transportation. Report number FHWA/NC/2012-11

Weiland, N.A., Stolle, C.S., Reid, J.D., Faller, R.K., Bielenberg, R.W., and Lechtenberg, K.A. 2015. MGS Dynamic Deflections and Working Widths at Lower Speeds Midwest Roadside Safety Facility (MwRSF) Report TRP-03-314-15. University of Nebraska-Lincoln