

**Road and traffic guidelines**

**RTS 18**

# New Zealand on-road tracking curves for heavy motor vehicles

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# A guideline for using New Zealand on-road tracking curves

This publication has been prepared for road controlling authorities and engineers involved in the geometric design of roads and intersections, and replaces a similar document published in October 1995.

The guideline has been prepared for Land Transport New Zealand by Traffic Engineering and Management Ltd with input from Transit New Zealand and the New Zealand Road Transport Forum.

In keeping with the earlier document, this publication is divided into two sections, with the first section providing a general guide for the types of vehicles that should be used, useful information on alternative vehicle configurations, and the design vehicles that should be used to accommodate these alternative configurations.

The second section of the publication includes a suite of tracking curves for the design vehicles executing a range of turns at different radii.

These tracking curves can be printed to obtain paper copies or downloaded to incorporate into design drawings from the electronic versions in PDF and JPEG format at the Land Transport NZ website at: [www.landtransport.govt.nz/roads/rts/index.html](http://www.landtransport.govt.nz/roads/rts/index.html).

A group of vehicles, representative of New Zealand's vehicle fleet, has been identified to produce these tracking curves for on-road design. This will allow designers to tailor the geometric characteristics of their design to the operational requirements of an appropriate vehicle.

Care should be exercised to ensure that this 2007 suite of design vehicles is not confused with the earlier suite of vehicles and associated tracking curves contained in the October 1995 publication. Whilst several vehicles have remained or may appear to have remained unchanged, others have updated internal dimensional characteristics or overall lengths to reflect changes that have been made to the regulations controlling these vehicles.

Examples of these differences include:

- the semi-trailer design vehicle is now 1 metre longer and has more demanding off-tracking<sup>1</sup> as a result of a recently approved axle set on the trailer
- the large rigid truck is now longer than the 1995 design vehicle of the same name.

Intersections, roundabouts and other on-road facilities should be designed using the 2007 suite of tracking curves. This is to ensure that vehicles that can operate legally on New Zealand's roads are able to turn safely without damaging other vehicles or road facilities.

It is therefore recommended that this new publication be used as the sole reference for on-road tracking curves and older out-of-date material be discarded. Potentially significant outcomes could arise if outdated tracking curves or curves sourced from overseas are used.

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<sup>1</sup> Off-tracking is a performance measure that defines the extent to which the rear of a vehicle tracks inside the path followed by the front of the vehicle as it executes a horizontal turn.

Using the current tracking curves will ensure the designs are suitable for New Zealand's roads and transport infrastructure and reflect:

- the controlling dimensional regulations for New Zealand vehicles (Land Transport Rule: Vehicle Dimensions and Mass 2002, Rule 41001)
- the size and weight configurations for different vehicles
- the axle spacing and locational requirements that have been formulated to protect New Zealand's roads and bridges
- the characteristics of the New Zealand heavy vehicle fleet.

In using these tracking curves it is important to remember that they **only** apply to the specified vehicle executing the specified turn. Should the details of the turn, the manner in which it is executed, and/or the dimensional characteristics of the vehicle be different, the tracking curve will also be different.

It is important to also note that these curves have assumed that the vehicle enters and leaves the turn in the manner shown. In the event that the design being considered requires a compound or complex manoeuvre (where the position and/or orientation of the vehicle through one turn has been influenced by its behaviour through a previous turn), the tracking curve through the entire manoeuvre will be different – with an accurate construction of the actual tracking curve using the curves contained in this document being exceptionally difficult to achieve.

In these situations, it is recommended that the designer seeks advice from a professional traffic engineer, as specialised computer models are available to simulate alternative vehicle dimensions and complex manoeuvres.

# The design vehicles

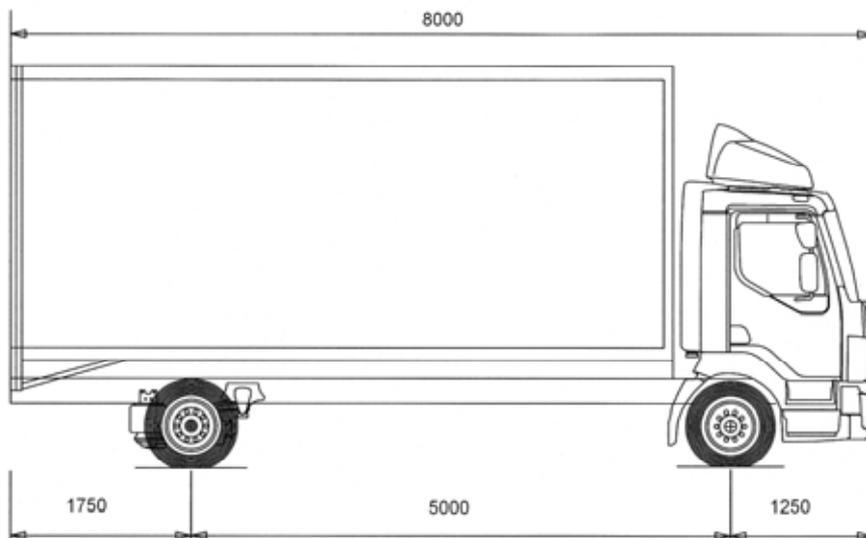
The following notes briefly describe each of the commercial vehicles that have been identified as design vehicles and gives an indication of their likely use. Pictures of the vehicles have been included to assist with the identification of the vehicles where there may be some uncertainty, and key dimensions have been provided. This will allow comparisons to be made with a specific vehicle the designer may be considering.

The following is a summary of each vehicle's characteristics.

## Medium rigid truck

The **medium rigid truck** is 8 metres in length, typically has two axles and is larger than the vans and small light trucks used by courier companies for urban deliveries.

Medium rigid trucks are used to transport small- to medium-sized consignments in local areas and are similar in length to a rubbish truck, moderate sized furniture moving truck, typical fire appliance and those trucks that generally service convenience stores.



All dimensions are in millimetres. Vehicle width is 2500 mm.

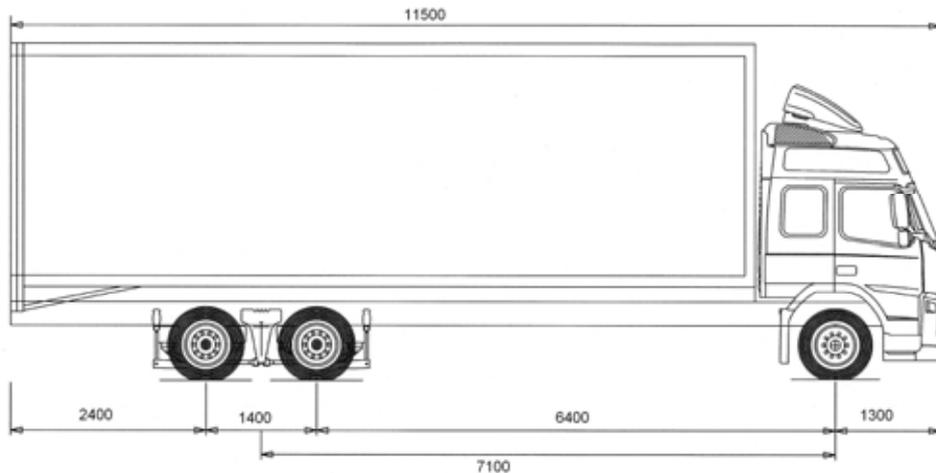


## Large rigid truck

The **large rigid truck** is 11.5 metres in length, typically has three or four axles, and is the largest rigid truck that can tow a trailer on New Zealand's roads. It also has the potential to carry larger and heavier loads than the medium rigid truck.

These trucks tend to service large commercial, industrial and retail operations.

Flat deck versions can usually accommodate a standard 20 foot International Standards Organisation (ISO) shipping container.



All dimensions are in millimetres. Vehicle width is 2500 mm.



Rigid trucks up to 12.6 metres are also possible, however, with these not being able to tow a trailer, they tend to be designed for special purposes (eg furniture removal or as transporters for light contracting equipment such as rollers). Should a specific design anticipate the presence of these longer trucks, the four coach tracking curve should be used to represent the 12.6 metre long rigid truck.

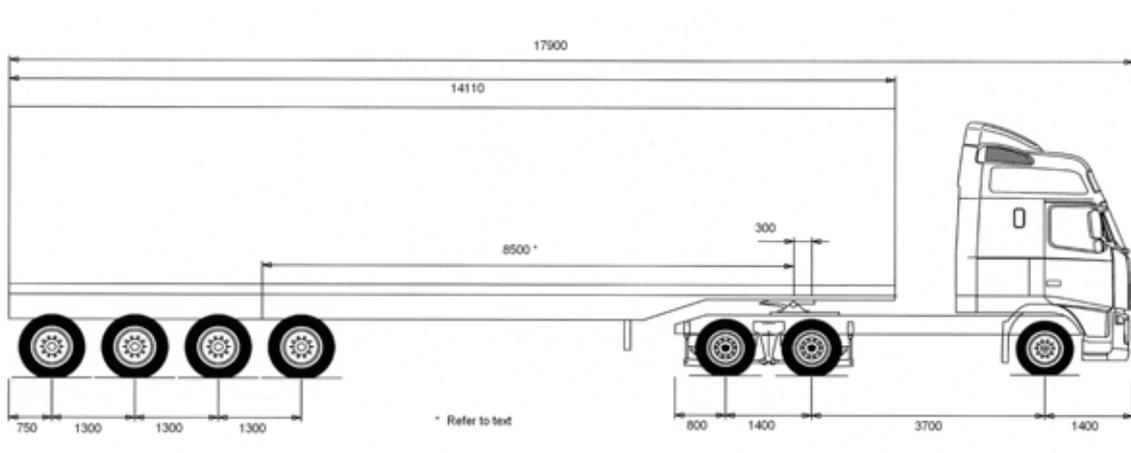
It should be noted that these large rigid trucks may have one or two steering axles at the front of the vehicle. For the radii being considered in this document, the presence of the second axle in a twin-steer axle group at the front of the vehicle will not significantly affect the off-tracking characteristics of the vehicle.

However, the designer should be aware that the presence of the second axle may affect the ability for these twin-steer vehicles to execute turns as tight as those possible by single-steer axle vehicles of a comparable size.

# Semi-trailer

The **semi-trailer** is 18 metres in length, the maximum permitted for this type of vehicle. This vehicle can also be referred to as an **articulated truck** and tends to be used to transport large consignments, including indivisible loads, over medium to long distances.

It is also the only vehicle combination that can carry a standard 40 or 45 foot shipping container. Shipping containers larger than these lengths can be transported by semi-trailers, but only under special conditions.



All dimensions are in millimetres. Vehicle width is 2500 mm.



It should be noted that:

- the 'tractor' (prime-mover) component of this combination may have one or two steering axles at the front, and generally has two axles at the rear (although single-axle or triple-axle combinations are also possible)
- the trailer has an axle set located towards the rear, which generally comprises three or four axles, although some trailers may only have one or two axles.

From an off-tracking point of view, the combination of axles on the tractor does not have a significant effect on the vehicle at the radii of the published curves.

However, at tighter radii, the axle combinations of some tractors may be more restrictive in their ability to turn than other combinations.

Trailers with a quad-axle set will generally have more demanding spatial needs than those combinations with fewer axles due to the dynamic behaviour of the quad-axle.

It is for this reason that the semi-trailer combination with a quad-axle set fitted to the trailer has now replaced other vehicles as the most critical long combination in terms of its swept path.

Specifically, the distance between the trailer's rear axis and kingpin has been increased to 9.4 metres<sup>2</sup> for the preparation of the tracking curves, which is 0.9 metre longer than the maximum legal length. A corresponding reduction has been made in the vehicle's theoretical rear overhang.

Whilst technically illegal, the use of these dimensions in the preparation of the tracking curves allows the vehicle's actual performance to be better represented and, as discussed above, has resulted in this vehicle now being the most critical long combination in terms of its swept path.

It should be noted that the 9.4 metre distance is only appropriate when the vehicle is travelling in a forward direction.

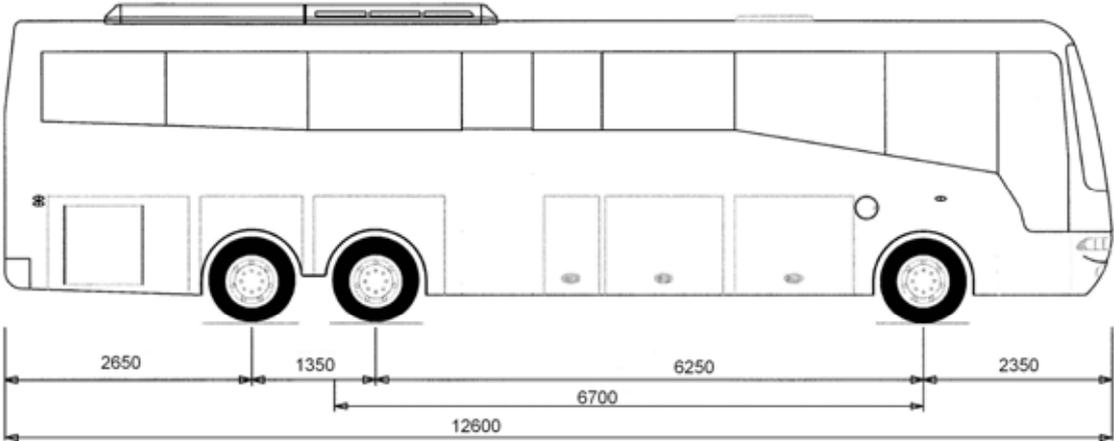
Should this vehicle be simulated executing a reverse manoeuvre, the 9.4 metre distance and associated rear overhang are inappropriate and must be amended to reflect the operational behaviour of the actual axle set during the reversing.

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<sup>2</sup> Land Transport NZ Rule 41001 specifies a distance of 8.5 metres as the legal design limit for the distance between the trailer's rear axis and kingpin.

# Tour coach

The **tour coach**<sup>3</sup> can have an overall length of 12.6 metres. This vehicle is regularly used for the transportation of tourists around the country and is more likely to be used at the luxury end of the market.



All dimensions are in millimetres. Vehicle width is 2500 mm.



Given the dimensional permutations possible for tour coaches longer than 12.6 metres, it is recommended that any geometric layouts that are expected to be used by these longer tour coaches are the subject of a specific design for the anticipated vehicle dimensions.

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<sup>3</sup> Land Transport NZ has allowed (by way of exemption from Rule 41001) some tour coaches to have an overall length of 13.5 metres, provided they have a rear steering axle. Roading engineers may need to allow for the additional 0.9 metre stall length when designing parking for these coaches. The extra length of this vehicle is likely to be found in the rear overhang of the vehicle (the distance between the rear axles and the rear of the vehicle), and therefore these vehicles may well have more tailswing than the tour coach design vehicle on entering a tight manoeuvre.

## Other vehicles

The **B-train** (a tractor unit towing two semi-trailers) has an overall length of 20 metres, the maximum length of any vehicle without a special permit. In most situations this vehicle will be used to transport general goods or bulk liquids (wine, chemicals etc) on long-haul routes. It therefore plays an integral role in the country's heavy vehicle fleet.

In the past, the B-train has generally been regarded as the design vehicle that should be used for the design of most roading projects.

However, with the introduction of four-axle semi-trailers, the tracking curve of the semi-trailer is now the reference vehicle for such designs.

**Truck and drawbar trailer** combinations are typically in the order of 19 to 20 metres long and tend to be used for the transportation of bulk freight, stock, aggregate and products requiring refrigeration.

For the on-road situation, the truck and trailer combinations will track within the path of the 18 metre long four-axle semi-trailer, and a separate tracking curve has therefore not been provided for the truck and trailer combination.

The use of **A-train** combinations (a short semi-trailer towing a drawbar trailer) throughout New Zealand is not great due to the weight restrictions imposed on them and their potential instability, and tend to be confined to the dairy industry, where they are used extensively for the collection and transportation of bulk milk from farms to processing companies.

For the on-road situation, the A-train vehicle tracks within the path of the four-axle semi-trailer, and a separate tracking curve has therefore not been provided for the A-train.

The **urban city bus** is generally about 11.3 metres long and is typical of the two axle buses frequently used in urban areas on timetabled routes. Its dimensions are similar to those of the large rigid truck design vehicle. Due to this similarity, the tracking curves prepared for the large rigid truck should be used for the urban city bus.

# Tracking curve selection

This publication contains tracking curves for the following design vehicles:

- trucks:
  - medium rigid truck (8 metres in length)
  - large rigid truck (11.5 metres in length)
  - semi-trailer (18 metres in length)
- buses
  - tour coach.

Because a number of maximum-sized vehicle combinations have similar tracking curves through a simple turn, the following tracking curves should be used for the other vehicle combinations:

<b>For these vehicle combinations</b>	<b>Use this tracking curve</b>
Urban city bus	Large rigid truck
Truck and trailer	Semi-trailer
A-train	Semi-trailer
B-train	Semi-trailer
Rigid trucks longer than 11.5 metres	Tour coach

# Using the tracking curves

A total of 17 tracking curve diagrams have been prepared for the identified design vehicles, with these produced at a scale of 1:250 and covering a range of radii.

All of the curves have been prepared using the software programme AutoTrack, with the following assumptions:

- The off-tracking is not reduced by high speed effects. Therefore these curves are appropriate for slow-speed<sup>4</sup> situations.
- The forward-most part of the vehicle's body controls the direction of the vehicle throughout the turn, with the vehicle's steering wheels responding as required to achieve this performance.

These curves are available electronically from [www.landtransport.govt.nz/roads/rts/index.html](http://www.landtransport.govt.nz/roads/rts/index.html), in pdf and jpeg formats, to assist CAD-based designs, should vehicle simulation software not be available.

In using these curves, consideration should also be given to any additional design requirements that may be needed to accommodate overdimension or overweight loads. This is particularly important on, or close to, routes identified by Transit New Zealand or local road controlling authorities for these purposes, together with those close to major transportation hubs such as ports and wharves where special arrangements may be necessary.

In these situations, consultation with local heavy haulage operators or Land Transport NZ staff responsible for overdimension permits is strongly recommended. Additional useful information can be obtained from guidelines published by the New Zealand Heavy Haulage Association. This document is listed in the additional reading section of this publication.

This will enable the designer to gain an understanding of the type, size and operational requirements of these particular vehicles.

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<sup>4</sup> Low-speed situations are those where the lateral forces experienced by a vehicle as it executes a turn at a specific speed are very low and have no appreciable effect on neutralising the vehicle's low-speed off-tracking. The effects of these lateral forces are generally not significant at speeds less than 20 km/h.

# Clearances

The tracking curves show the paths followed by the outermost parts of the vehicle's body.

The curves therefore define the physical space necessary for the vehicle to execute the intended manoeuvre and do not include any clearances.

Additional clearances should therefore be added to each side of the tracking curve to allow for:

- variations introduced by driver unfamiliarity
- steering/judgement errors
- differences between the design vehicle and an actual vehicle
- any potential out-swing of the front or rear of a trailer as it enters or leaves a turn.

Additional clearances also help to act as a buffer to protect adjacent vehicles and pedestrians, street signs and other street furniture.

The recommended minimum clearance to be added to **each side** of the tracking curve is 0.5 metre (500 mm), with greater clearances being desirable whenever possible.

# Radii

Table 1 provides a summary of the tracking curves, and their radii, that have been prepared for the design vehicles.

**Table 1:** Turn radii and tracking curve sheet numbers for the design vehicles at various radii.

Vehicle	Radius of turn				
	10 m	12.5 m	15 m	20 m	25 m
8 m rigid truck	1	2	3	4	5
11.5 m rigid truck		6	7	8	9
Semi-trailer*		10	11	12	13
Tour coach		14	15	16	17

\*As noted in the text above, the semi-trailer combination with a quad-axle set fitted to the trailer has now replaced other vehicles as the most critical long combination in terms of its swept path.

It should be noted that all vehicles have a legal requirement to be able to execute a 12.5 metre radius turn. However, some vehicles are able to turn in a radius less than this at slow speeds without affecting their dynamic stability.

Where this is possible and considered reasonable, tracking curves have been prepared for the appropriate radii. Care must be exercised when using these curves to ensure that the radius is appropriate for the anticipated traffic conditions, speed environment and classification of the road.

As mentioned above, consideration should also be given to any additional design requirements that may be needed to accommodate overdimension or overweight loads. This is particularly important on, or close to, routes identified by Transit New Zealand or local road controlling authorities for these purposes, together with those close to major transportation hubs such as ports and wharves where special arrangements may be necessary.

In these situations, consultation with the local heavy haulage operators or Land Transport NZ staff responsible for overdimension permits is strongly recommended. This will enable the designer to gain an understanding of the type, size and operational requirements of these particular vehicles.

# Scale

All of the tracking curves in this publication have been prepared at a scale of 1:250. Alternative scales can be easily obtained with the aid of the enlargement and reduction facilities of modern photocopiers.

If alternative scales are needed, it is strongly recommended that the radius (as drawn on the curve) and both the horizontal and vertical axes are checked for accuracy. If they do not scale correctly after the enlargement or reduction, distortions have been introduced during the copying process and the diagrams will no longer be accurate.

As a general guide, the theoretical scaling factors in table 2 should be used for single pass enlargements and reductions:

**Table 2:** Theoretical scale factors for single-pass enlargement and reductions.

Original scale	Desired scale	Scale factor	Enlargement (E) or reduction (R)
1:250	1:100	2.500	E
	1:200	1.250	E
	1:300	0.833	R
	1:400	0.625	R
	1:500	0.500	R

**Note:** Designs based on a scale smaller than 1:500 are not recommended.

As an alternative, specialist CAD-based programmes<sup>5</sup> are available that allow these vehicles to be simulated in CAD environments such as AutoCAD<sup>6</sup> and MicroStation<sup>7</sup>.

More details about these software packages can be obtained from CAD retailers or professional traffic engineers.

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<sup>5</sup> AutoTrack produced by Savoy Computing Services Ltd ([www.savoy.co.uk](http://www.savoy.co.uk)). AutoTurn produced by Transoft Solutions Inc ([www.transoftsolutions.com](http://www.transoftsolutions.com)). AutoTurn is a registered trademark of Transoft Solutions Inc.

<sup>6</sup> AutoCAD is a registered trademark of Autodesk Inc.

<sup>7</sup> MicroStation is a registered trademark of Bentley Systems Incorporated.

## Additional information

It is recommended that designers refer to the following documents when designing roads, intersections or other facilities for heavy vehicles.

Austrroads (2005). Traffic Engineering Practice Series, *Guide to traffic engineering practice, Part 5: Intersections at grade*. June 2005.

Land Transport New Zealand (2002). Land Transport Rule 41001, *Vehicle dimensions and mass*. May 2002.

Land Transport New Zealand (2005). Factsheets 13 series, *Vehicle dimensions and mass*. February to September 2005.

Land Transport New Zealand (2005). Factsheet 53, *Overdimension vehicles and loads*. July 2005.

Land Transport New Zealand (2006). Road and Traffic Standards RTS16, *Guide to heavy vehicle management*. June 2006.

New Zealand Heavy Haulage Association (2006). *Road design specifications for overdimension loads*. (August 2006).

Transit New Zealand (1991). *State highway geometric design manual*. (Draft 2000). October 2003.

## Off-road tracking curves

The design of off-road facilities for vehicles should generally be done in accordance with the requirements of the relevant city or district council, particularly the district plan for the area and related relevant engineering design documents.

General guideline documents containing tracking curves are available for the design of facilities for both light and heavy vehicles in on-site situations where vehicle speeds are expected to be low and manoeuvring can be carried out with a tighter steering lock than at most road intersections. These documents should be referred to in conjunction with the city or district council requirements. Note that New Zealand design vehicles can be different from those used in Australia and so these documents should be used with care.

For light vehicle design (cars and vans etc) Standards New Zealand has available:

- AS/NZS 2890.1:2004 Parking facilities – Off-street car parking.

For heavy vehicle design, Standards Australia has available:

- AS 2890.2: 2002 Parking facilities – Off street commercial vehicle facilities.

Reference could also be made to Transit New Zealand Research Report no 32, *Site design for heavy vehicle facilities*, (1994) by Beca Carter Hollings & Ferner Ltd and Traffic Planning Consultants Ltd (but please note that some New Zealand design vehicles are now larger than those allowed in 1994).

Further information about these documents can be obtained from appropriate websites, regional Land Transport NZ offices or a professional traffic engineer.

# Acknowledgements

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Jamie Bell	Titan Plant Services Ltd
Lynn Sleath	Transit New Zealand
John de Pont	Transport Engineering Research New Zealand (TERNZ)
Derek Wilson	Analytico Pty Ltd (Australia)

# Tracking curve diagrams

The second section of this publication includes a set of 17 tracking curve diagrams. These vehicles, radii and their corresponding tracking curve sheet numbers are listed below.

<b>Vehicle</b>	<b>Radii</b>	<b>Sheet number</b>
<b>8 m rigid truck</b>	10 m radius	1
	12.5 m radius	2
	15 m radius	3
	20 m radius	4
	25 m radius	5
<b>11.5 m rigid truck</b>	12.5m radius	6
	15 m radius	7
	20 m radius	8
	25 m radius	9
<b>Semi-trailer</b>	12.5 m radius	10
	15 m radius	11
	20 m radius	12
	25 m radius	13
<b>Tour coach</b>	12.5 m radius	14
	15 m radius	15
	20 m radius	16
	25 m radius	17

# Road and traffic guideline publications

The following other Road and traffic guidelines are available:

*RTS 1 Guidelines for the implementation of traffic controls at crossroads (1990)*

*RTS 2 Guidelines for street name signs (1990)*

*RTS 3 Guidelines for establishing rural selling places (1992)*

*RTS 4 Guidelines for flush medians (1991)*

*RTS 5 Guidelines for rural road marking and delineation (1992)*

*RTS 6 Guidelines for visibility at driveways (1993)*

*RTS 7 Advertising signs and road safety: design and location guidelines (1993)*

*RTS 8 Guidelines for safe kerblines protection (1993)*

*RTS 9 Guidelines for the signing and layout of slip lanes (1993)*

*RTS 10 Road signs and markings for railway level crossings (2000)*

*RTS 11 Urban roadside barriers and alternative treatments (1995)*

*RTS 13 Guidelines for service stations (1995)*

*RTS 14 Guidelines for facilities for blind and vision-impaired pedestrians (2003)*

*RTS 15 Guidelines for urban-rural speed thresholds (2002)*

*RTS 16 Guide to heavy vehicle management (2006).*

Electronic copies of the Road and traffic guideline series can be downloaded from [www.landtransport.govt.nz/roads/rts/index.html](http://www.landtransport.govt.nz/roads/rts/index.html)

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