SITE DESIGN FOR HEAVY VEHICLE FACILITIES

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AN IMPORTANT NOTE FOR THE READER

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EXECUTIVE SUMMARY

Transit New Zealand Research Report No. 32, *"Site design for heavy vehicle facilities"*, is to assist architects and site planners in the design of on-site facilities for trucks and buses. Its scope is confined to the on-site aspects of the overall design and spatial arrangements for manoeuvring and parking vehicles. The report is the compilation of a series of research projects conducted between 1985 and 1990, commissioned by the former National Roads Board (now Transit New Zealand). Information in this report is updated to 1993.

An Annex to this Report is Transit New Zealand Research Report No. 32A, *"Annex: Site design for heavy vehicle facilities"*. It summarises the seven individual research studies (unpublished) that were undertaken and from which this Report has been prepared.

The relevant district plan and the conditions and requirements of the road controlling authority of the area in which the facilities are to be located should be consulted to ensure compliance with local regulations and ordinances.

1. Introduction

The concepts for and the development of the site criteria for the design of heavy vehicle facilities are given.

2. Heavy Vehicle Characteristics

The physical aspects of the turning behaviour of a heavy vehicle, and a summary of the basic dimensions of heavy vehicles, and the limits imposed on heavy vehicles by current regulations in New Zealand are described.

3. Design Heavy Vehicles

The vehicles of New Zealand's large heavy vehicle fleet vary widely in dimensions and turning characteristics.

Therefore for design purposes, the large number of different vehicles has been reduced to a few "typical" vehicles that can be used as "design" vehicles on which the design of any on-site facilities can be based.

The "design" vehicles and their maximum lengths that have been selected comprise:

Truck fleet	**Bus fleet**
Medium rigid truck (8.0 m)	Midi-bus (9.3 m)
Large rigid truck (11.0 m)	City bus (11.3 m)
Semi-trailer (17.0 m)	Tour coach (12.6 m)
B-train (20.0 m)	

4. Site Design for Heavy Vehicle Facilities

Site design for heavy vehicle facilities for different situations and recommendations on a wide range of design aspects relating to on-site facilities are presented. The different aspects covered include:

Access from street:	crossing locations, widths, sight distances
Driveways:	widths, overhanging obstructions, speed humps
Manoeuvring areas:	spatial requirements, horizontal clearances, headrooms, visibility
Ramps and gradients:	gradients, widths, headrooms, surfaces
Loading:	platform heights, dockbay widths, canopy heights and headrooms in buildings for trucks, buses, rubbish trucks and forklifts, floor gradients, stairs and steps
Parking:	layouts, depths, widths.

Although "design" vehicles have been adopted to simplify the process of on-site design, it is still necessary to determine the most appropriate "design" vehicle to use for any given situation, to ensure that a balance is struck between "over-designing" for an inappropriately large vehicle and "under-designing" in which undesirable constraints are placed on the size and type of vehicle that can visit and use the site. The general principles of design are discussed, together with some guidance on which "design" vehicle may be appropriate in different situations.

5. Heavy Vehicle Tracking Curves

"Tracking curves" that are made by each of the "design" vehicles when they perform different turning manoeuvres are presented.

Manoeuvres include simple turns at 10.0 m, 12.5 m, 15.0 m, 25.0 m radii, and complex turns.

Note that, because of the small radius of turn and the rate of entry into the turn, THESE "TRACKING CURVES" ARE ONLY TO BE USED FOR SLOW-SPEED ON-SITE DESIGN AND ARE NOT NECESSARILY SUITABLE FOR ON-ROAD DESIGN PURPOSES.

ABSTRACT

Transit New Zealand Research Report No. 32, *"Site design for heavy vehicle facilities"*, is to assist architects and site planners in the design of on-site facilities for trucks and buses. Its scope is confined to the on-site aspects of the overall design and spatial arrangements for manoeuvring and parking vehicles. The report is the compilation of a series of research projects conducted between 1985 and 1990. Information in this report is updated to 1993. The district plan and road controlling authority of the area in which the facilities are to be located should be consulted to ensure compliance with local regulations and ordinances.

An Annex to this Report is Transit New Zealand Research Report No. 32A, *"Annex: Site design for heavy vehicle facilities"*. It summarises the seven individual research studies (unpublished) that were undertaken and from which this Report has been prepared.

1. INTRODUCTION

1.1 Background

This report providing site criteria for the design of facilities for heavy vehicles is a result of Transit New Zealand project GM/11 (which has in part been reported earlier in Beca Carter Hollings & Ferner Ltd 1987a,b, 1988a,b, Traffic Planning Consultants Ltd 1988, 1989a,b). The report is the compilation of this series of research projects conducted between 1985 and 1990, commissioned by the former National Roads Board (now Transit New Zealand), and updated to 1993. Other reports on which the information is based include one by Beca Carter Hollings & Ferner Ltd in 1985 and an unpublished report for on-street design for large heavy vehicles, "Geometric design of roads for trucks and buses", prepared for Transit New Zealand project GM/8 (Dickson 1987).

An Annex to this Report is Transit New Zealand Research Report No. 32A, *"Annex: Site design for heavy vehicle facilities"*. It summarises the seven individual research studies (unpublished) that were undertaken and from which this Report has been prepared.

This report is to assist architects and site planners in the design of on-site facilities for trucks and buses and its scope is limited to the on-site aspects of the overall design. The relevant district plan and the conditions and requirements of the road controlling authority of the area in which the facilities are to be located should be consulted to ensure compliance with local regulations and ordinances.

In the development of the project, reviews were undertaken of:

- both national and international current practices and facility design data available for truck and bus operations, and for on-site parking;
- existing data on New Zealand truck and bus fleets, to define appropriate "design" vehicles;
- international standards (in particular those of Australian and United Kingdom), for their appropriateness to New Zealand.

From these reviews, the need for developing designs for on-site facilities specific to New Zealand "design" heavy vehicles was determined.

1.2 Explanation of Text Arrangement

The report is presented in five sections as follows:

1. **Introduction**
   The concept for and background of the site criteria for the design of heavy vehicle facilities are given.

2. **Heavy Vehicle Characteristics**
   The physical aspects of the turning behaviour of a heavy vehicle, and a summary of the basic dimensions of heavy vehicles, and the limits to them imposed by current regulations in New Zealand are described.

3. **Design Heavy Vehicles**
   The "design" vehicles selected to represent the wide range of vehicles in the truck and bus fleets are defined and described.

4. **Site Design for Heavy Vehicle Facilities**
   Site design for heavy vehicle facilities for different situations and recommendations on a wide range of design aspects relating to on-site design are presented.

5. **Heavy Vehicle Tracking Curves**
   "Tracking curves" that are made by each of the "design" vehicles when they perform different turning manoeuvres are presented. Note that, because of the small radius of turn and the rate of entry into the turn, THESE CURVES ARE ONLY TO BE USED FOR SLOW-SPEED ON-SITE DESIGN AND ARE NOT NECESSARILY SUITABLE FOR ON-ROAD DESIGN PURPOSES. Copies of these tracking curves have been produced at 1:500 and are contained in Section 5.

The report includes a description of the basic characteristics of the New Zealand truck and bus fleets. These vehicles vary widely in terms of dimensions and turning characteristics, from small mini-buses to large B-trains. Therefore for design purposes, the large number of different vehicles has been reduced to a few "typical" vehicles that can be used as "design" vehicles for which the design of any on-site facilities can be based. The "design" vehicles that have been selected, based on the New Zealand truck and bus fleets, are defined and described in Section 3.

Although the "design" vehicles have been adopted to simplify the process of on-site design, it is still necessary to determine the most appropriate "design" vehicle to use for any given situation, to ensure that a balance is struck between "over-designing" for an inappropriately large vehicle and "under-designing" in which undesirable constraints are placed on the size and type of vehicle that can visit and use the site. The general principles of design are discussed, together with some guidance on which "design" vehicle may be appropriate in different situations.

While many of the design issues relating to the design of on-site facilities are relevant to all heavy vehicles (both trucks and buses), other details are clearly only appropriate to either trucks or buses. For example, requirements for loading/unloading platforms are entirely different for buses (because of the need for passengers to board and alight) and trucks (which need facilities for goods handling).

To avoid unnecessary repetition and to facilitate easy reference, the relevant pages in Sections 2, 3 and 4 of the report have been arranged in two separate halves. References that are relevant to trucks only are contained in the left hand column of the page, while those pertaining specifically to buses are contained in the right hand column. All general comments relating to both are across the entire page, viz:

General comments

Information on TRUCKS	Information on BUSES

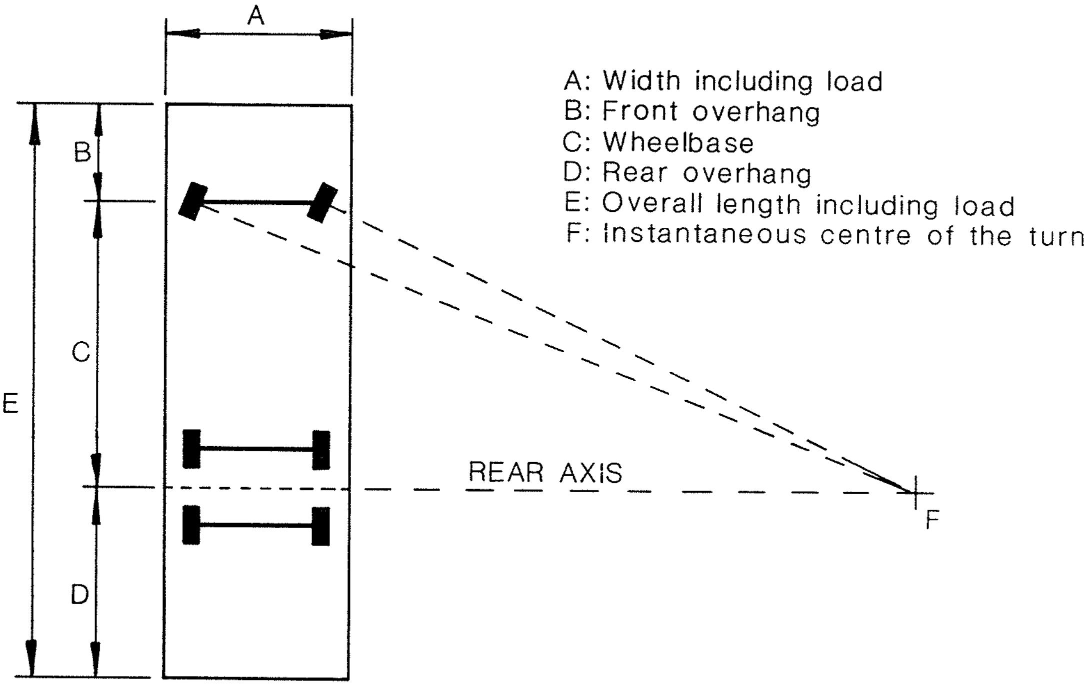
2. HEAVY VEHICLE CHARACTERISTICS

2.1 Turning Characteristics of a Heavy Vehicle

As a vehicle executes a turn at slow speed, the rear wheels of the vehicle do not follow the paths of the steering wheels. Instead the rear wheels follow paths which are closer to the centre of the turn than the steering wheels. This behaviour is called "off-tracking" and, in association with the path followed by the front corner of the vehicle (i.e. not the steering wheels), determines the spatial requirements to successfully achieve that turn (swept path). The extent of this "off-tracking" is a complex relationship between the dimensional and performance characteristics of the vehicle and the nature of the turn.

When a vehicle executes a turn, the steering wheels at any instant during the turn are at angles where lines drawn perpendicular to the line of travel of each steering wheel meet at a common point on the line of the vehicle's rear axle (if the vehicle has a single rear axle) or the rear axis (if the vehicle has multiple rear axles) (Figure 2.1.1).

Figure 2.1.1 Characteristics of a vehicle.



This common point represents the centre of the circular arc (F on Figure 2.1.1) being followed at that instant. As additional steering lock is applied, this common point moves towards the vehicle at a rate which is in part a function of the rate at which the steering lock is being applied.

As the vehicle's speed increases to that of highway speeds, additional factors such as tyre slip and lateral acceleration become significant and the "off-tracking" of the trailing units of the vehicle can determine the outer limit of the swept path rather than the inner limit at slow speeds. The effect of such high speed factors is insignificant in on-site situations where vehicle manoeuvres are carried out at slow speeds.

Occasionally vehicles must be modified to satisfy the legal requirements or, if they already fall within these legal requirements, they may be modified to suit the specific needs of the operator. If these modifications affect the wheelbase of the vehicle, and the steering mechanism is not adjusted to take into account these changes, the effective rear axis of the vehicle may not be in the middle of the axle group. Accordingly the actual turning characteristics may be different to those suggested by theory.

The state and position of a vehicle's load can also influence the position of the vehicle's effective rear axis. Research conducted in New Zealand (Traffic Planning Consultants Ltd 1989a) to establish the significance of these variations has found that positioning a significant load on a vehicle can influence the position of the vehicle's rear axis. Although these variations exist, they are generally not significant when their effect on the swept path of the vehicle is considered. One exception is the semi-trailer, discussed in Section 3.

2.2 New Zealand Fleet

2.2.1 Types

The New Zealand traffic regulations permit a wide range of heavy vehicle combinations and sizes to be used on the road. Thus the nation's truck fleet varies widely both geographically and in the types of vehicles in use.

Vehicle combinations approaching the legal maximum length are suited for the transportation of bulky materials and goods over long distances. Vehicles with dimensions less than the maximum are often more suited to the delivery of smaller consignments in urban areas.

In general, the nation's truck fleet can be grouped in the following categories:

- Rigid (single unit) trucks,
- Semi-trailers (articulated trucks),
- Truck-and-trailer combinations,
- B-trains (semi-trailer coupled to the rear of an articulated truck),
- A-trains (vehicle combination of draw-bar trailer coupled to the rear of an articulated truck).

Rigid trucks are often used for deliveries in urban areas, particularly where the delivery area is constrained. Their use for the transportation of goods over longer distances tends to be for small- to medium-sized consignments. To transport larger or heavier loads, multi-unit vehicles tend to be used.

In general no one type of vehicle combination is more suited to a particular transport need than another, although some vehicles tend to be used in certain situations more than others. For example, semi-trailers, B-trains, and truck-and-trailers tend to be used to transport containerised goods, and the semi-trailer

The specific demand for passenger transport dictates the type of bus used. For the transportation of small groups over relatively short distances the midi-bus is generally the most suitable, while the transportation of larger groups either on a chartered or on a timetabled route makes the city bus a desirable option.

Where large groups of people are to be transported over longer distances, the passenger comfort and ride quality become significantly more important. The tour coach is best suited to fill this role.

Although there are variations in the specifications of buses between manufacturers and assemblers, each bus can be classified as one of three broad groups (with typical seating capacities):

Midi-bus	25-30 seats
City bus	40-45 seats
Tour coach	45 seats

is the only vehicle type capable of carrying the large "40-foot" ISO shipping container. Stock trucks are usually truck-and-trailer combinations.

2.2.2 Lengths

Studies (Ministry of Transport 1984, Ministry of Works & Development 1985) of the variations in the overall lengths of vehicles in the five vehicle categories show a wide range of lengths, with the distribution biased towards the legal maximum.

2.2.3 Heights

The height of a vehicle is primarily determined by either its type of body (e.g. an enclosed refrigerated truck) or the physical size of its load. If the body is the determining factor, the only height variations that can be expected from the vehicle are those introduced by the reaction of its suspension to the load carried. If the load itself determines the overall height of the vehicle, a wide range of heights can result.

The height of the vehicle in off-road situations should include not only the height of the moving vehicle to allow for clearance on driveways and the like, but also the height required for loading and unloading. For example, semi-trailers capable of loading and unloading their containerised cargo using on-board swing-lifting equipment can require up to 5.7 m of vertical headroom from the pavement surface.

Table 2.2.1 sets out the 90th percentile heights of different truck types and configurations obtained from a detailed sample survey of the New Zealand truck fleet (Ministry of Transport 1984).

The heights for the three bus types are given in Table 2.3.1.

Table 2.3.1 Typical bus heights (metres)

Midi-bus	2.9 m
City bus	3.2 m
Tour coach	3.5 m

Table 2.2.1 Truck heights (metres) at 90th percentile.

Truck Type	SU	ST	T&T
Dump	3.33	4.15	3.44
Enclosed	3.53	4.13	3.53
Flat deck	3.25	4.20	3.93
High sides	3.99	3.15	4.01
Stock	3.90	3.97	4.22
Tanker	3.79	3.59	3.82

Key:
SU Single Unit
ST Semi-trailer
T&T Truck-&-Trailer

The heights of semi-trailers and truck-and-trailer combinations tend to be greater than those of rigid trucks. B-trains will have height distributions similar to those of the semi-trailer and truck-and-trailer combinations.

2.2.4 Widths

To maximise the freight-carrying potential of the vehicle, manufacturers and body builders usually build the vehicles close to the legal maximum width of 2.5 m. Some vehicles also have the capability of increasing their overall width to accommodate an over-sized load.

Other vehicles carry on-board loading and unloading equipment (e.g. trailers with side-lifting equipment for containers) which require additional width. Rubbish trucks, fire-fighting appliances and cranes also have the potential to increase their dimensional characteristics when stationary which affect the clearances required.

2.2.5 Waste Collection Vehicles

The wide range of wastes generated, and the requirements for their safe collection and disposal, result in the wide range of vehicle sizes, types and configurations used for waste collection.

For regular domestic street collection, some uniformity exists in vehicle size. Rigid trucks are often medium-sized vehicles with overall length of about 8.0 to 9.0 m. Semi-trailers are sometimes used in major metropolitan areas.

The use of vehicles for industrial waste collection is dependent on the nature of the industry and the type and quantity of its waste. If the waste is in a liquid form, generally a specialised tanker is required for collection and disposal. Solid wastes are collected using either a front-lift compaction truck, a roll-on bin truck, or a truck designed to carry a "jumbo bin". These vehicles are often based on a large single unit truck, with each variation having different working clearance requirements (particularly the overhead clearances of front-lift compaction trucks).

Designing facilities for the bulk transportation of refuse from say a processing plant to a landfill requires particular knowledge of the nature of the loading operations. Thus the assistance of persons with specialist expertise in this field should always be sought. Nevertheless the transportation of bulk refuse generally uses semi-trailers, the dimensions of which tend towards the legal maximum.

2.2.6 Fire Trucks

Fire-fighting vehicles used by the New Zealand Fire Service are all large rigid trucks. The typical fire tender has an overall length less than the legal maximum. However, some of the aerial scopes, snorkel and turntable appliances exceed the legal maximum as the extra length is in the larger than normal rear overhang.

2.3 Heavy Vehicle Size Limits

2.3.1 Introduction

In planning on-site facilities for heavy vehicles, it is important to have not only an appreciation of the type of vehicle that will most probably be using the facilities, but also the maximum possible size of vehicle that could visit the site.

The basic dimensional limitations on trucks and buses imposed by current regulations in New Zealand (Ministry of Transport 1976) are set out below. As site designers do not need to know all the dimensional regulations that are imposed on vehicle design, only the essential aspects are given.

In some instances these dimensions can be exceeded for specific purposes, but then special permits to operate the vehicle on public roads are required. Specialist advice will be needed when designing facilities for such over-sized vehicles to ensure that the facility can accommodate the vehicle and its load.

2.3.2 Maximum Width

- Maximum width of vehicle or load from each side of the vehicle's centreline is 1.25 m.

- Additional 0.025 m width is permitted on each side of the centreline for temporary load securing devices such as ropes and lashings.

- Collapsible mirrors may extend up to 0.24 m from each side of the vehicle, beyond the maximum vehicle width of 2.5 m.

2.3.3 Maximum Height

- Maximum height of vehicle or load, including load restraints/attachments, measured from the roadway, is 4.25 m.

2.3.4 Ground Clearance

- A minimum ground clearance of 0.1 m is required within 1.0 m of any axle of the vehicle (truck or bus) combination.

- The ground clearance at any point between axles shall be at least 10% of the distance of that point from the nearest axle on the truck.

- The ground clearance at any point in front of the first axle and behind the last axle shall be at least 10% of the distance of that point from the nearest axle on the truck.

- The ground clearance at any point between axles shall be at least 6% of the distance of that point from the nearest axle on the bus.

- The ground clearance at any point in front of the first axle and behind the last axle shall be at least 6% of the distance of that point from the nearest axle on the bus.

2.3.5 Turning Circle

- All vehicles and vehicle combinations must be capable of turning within a 25.0 m diameter circle.

2.3.6 Overall Length

- The overall length of vehicles and vehicle combinations shall not exceed the following:

Rigid truck	11.0 m
Full trailer	11.0 m
Semi-trailer	17.0 m
A-train	20.0 m
B-train	20.0 m
Truck-and-trailer	19.0 m(a)
Bus	12.6 m

(a) Truck-and-trailers can now be 20.0 m long on permit approval, available from Land Transport Safety Authority. To obtain a permit, some conditions must be met.

2.3.7 Projection of Loads

Loads are not permitted to project beyond the envelope defined by the legal maximum length, height and width. In situations where the vehicle is smaller than the legal limits, restrictions are imposed to limit the extent of any protrusion the load may have beyond the envelope of that vehicle.

3. DESIGN HEAVY VEHICLES

3.1 Introduction

Before recommendations can be made on specific aspects of on-site design, particularly the spatial requirements for manoeuvring, the dimensional characteristics of appropriate vehicles that are to be used in the design of a site need to be established.

The heavy vehicles of New Zealand's truck fleet vary widely in dimensions and turning characteristics. Therefore for design purposes, the large number of different vehicles have been reduced to a few "typical" vehicles that can be used as "design" vehicles on which the design of on-site facilities can be based.

The "design" vehicles that have been developed accommodate most of New Zealand's heavy vehicle fleet, and therefore ensure that in most cases facilities designed for any particular "design" vehicle are suitable for other vehicles with similar configurations.

Most of the "design" vehicles established for this report have overall lengths which are the maximum permitted under the transport regulations for that type of vehicle.

Those "design" vehicles which have dimensions less than the maximum lengths legally permitted are intended for use in specific design situations where the use of a "design" vehicle of maximum dimensions would be inappropriate. Such an example is design for vehicles servicing an office building in a central city location.

The "design" vehicles have been selected to represent those buses that are most widely used in New Zealand.

However, not all buses in use in New Zealand are represented by the "design" vehicles. For example, the high public transport demands in peak periods in metropolitan Auckland have led to the use of high-capacity articulated (bendy) buses on some routes. If the design of a facility is to accommodate such specialist vehicles, or others for which the "design" vehicles are not appropriate (e.g. trolley buses), some of the recommendations in this report may not be appropriate. It is recommended that the designer consult either the operator's technical staff or a professional traffic engineer for such cases.

With the exception of the Tour Coach, all "design" vehicles have overall lengths less than the permitted maximum.

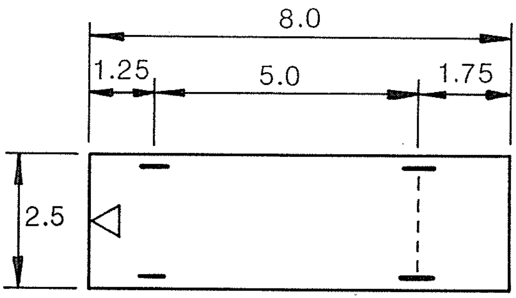
3.2 Design Vehicles

- **Medium rigid truck**

The medium rigid truck, with an overall length of 8.0 m, is larger than the vans and small light trucks used by couriers in metropolitan centres. Its use tends to be confined to local trips with small- to medium- sized consignments rather than to the long-haul transportation of bulk quantities.

The overall dimensions of the medium rigid truck "design" vehicle (Figure 3.1.1) are similar to those of the moderately large furniture moving trucks used in metropolitan areas, and is of a similar size to the larger rigid trucks that often service "corner store" type retail outlets with commodities such as soft drinks. Medium-sized concrete trucks and rubbish trucks also have overall lengths similar to the medium rigid truck "design" vehicle.

Figure 3.1.1 Medium rigid truck.

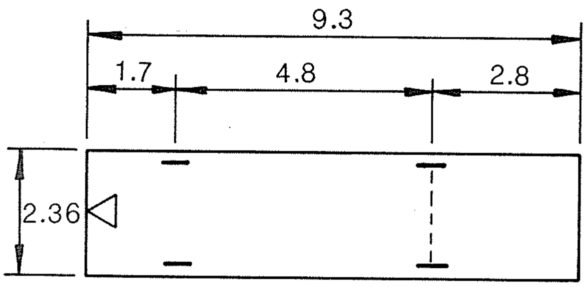


All dimensions in metres

- **Midi-bus**

The midi-bus (Figure 3.2.1) with an overall length of 9.3 m, represents the type of bus typically used for scenic tours of metropolitan areas for small parties of tourists.

Figure 3.2.1 Midi-bus.



All dimensions in metres

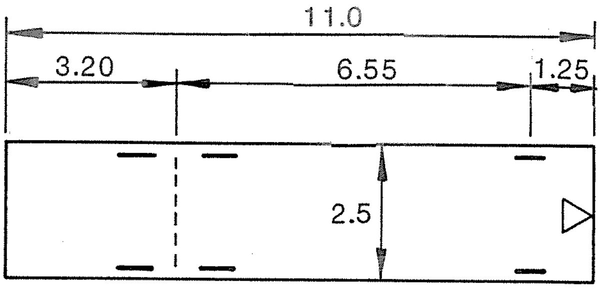
- **Large rigid truck**

The large rigid truck "design" vehicle (Figure 3.1.2) has the maximum overall length of 11.0 m permitted under current dimensional limits. The vehicle's wheelbase is however less than the maximum possible because of the requirement for correct weight distribution.

This vehicle is effectively the largest rigid truck that can operate on the roads in New Zealand and, because of its length and the greater number of axles (than the medium truck), it has the potential to carry larger and heavier loads. Accordingly the vehicle tends to be used to service industrial and large commercial or retail operations.

The large rigid truck with an open flat deck can accommodate a standard "20-foot" ISO container. The large rigid truck "design" vehicle is therefore appropriate to use for container transport.

Figure 3.1.2 Large rigid truck.

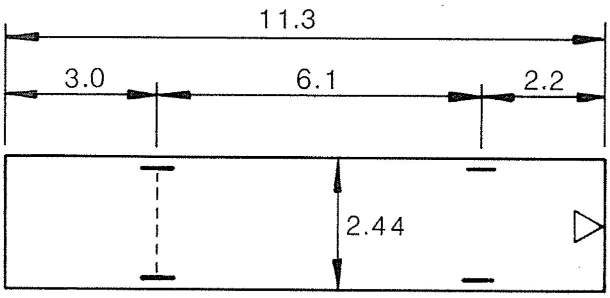


All dimensions in metres

- **Urban city bus**

The urban city bus (Figure 3.2.2) has an overall length of 11.3 m, which is approximately 1.0 m less than the dimensional maximum. It is typical of the two-axled omnibus frequently used on timetabled routes in provincial and metropolitan areas.

Figure 3.2.2 Urban city bus.



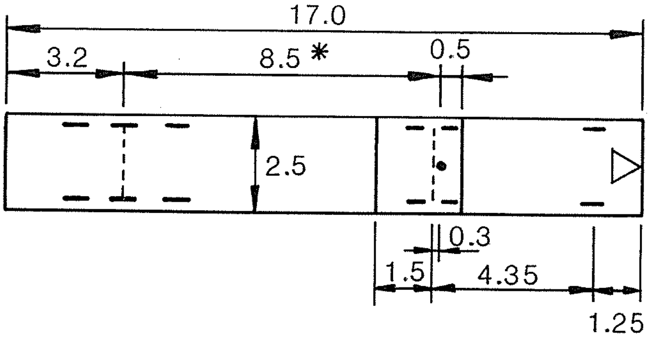
All dimensions in metres

- **Semi-trailer**

The semi-trailer "design" vehicle (Figure 3.1.3) has an overall length of 17.0 m which is the maximum permitted for this vehicle configuration. The distance between the coupling point and the rear axis, at 8.5 m, (✳) is also the maximum allowed and permits the transportation of large consignments, including containerised goods.

The tracking curves for this vehicle have, however, been prepared for a vehicle with a distance between the coupling point and the rear axis of 8.9 m, 0.4 m greater than the legal maximum.

Figure 3.1.3 Semi-trailer.



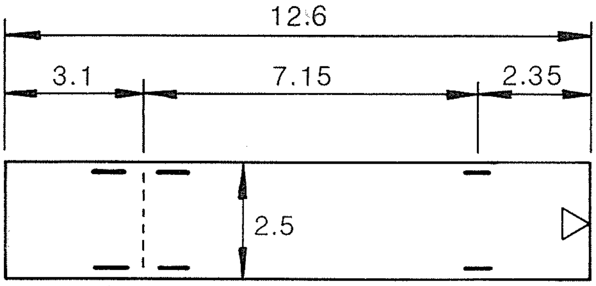
All dimensions in metres

✳ refer to text

- **Tour coach**

The tour coach "design" vehicle (Figure 3.2.3) has an overall length of 12.6 m which is the permitted maximum for this vehicle configuration. Most tour coaches are constructed towards this maximum dimension.

Figure 3.2.3 Tour coach.



All dimensions in metres

This increase makes allowance for the attitude of the unloaded semi-trailer when the rear axle in the trailer's axle group frequently carries more weight than the forward-most axle in this group.

Indeed, investigations and observations of this behaviour (Traffic Planning Consultants Ltd 1989a,b) have found that in some instances the tyres on the leading axle are effectively non-weight bearing and scuff to a marked extent when the vehicle turns. This behaviour causes the effective rear axis of the trailer to be behind the position of the theoretical rear axis.

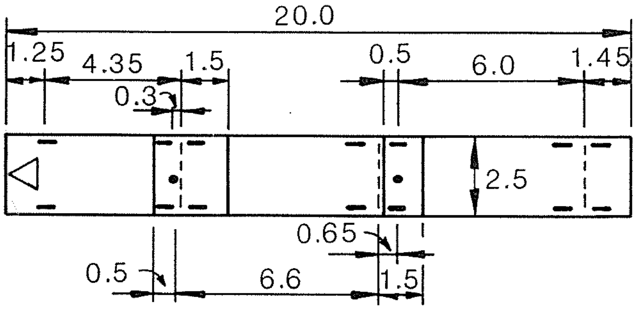
Most semi-trailers (or articulated trucks) are constructed with dimensions that approach the upper limits and therefore have dimensions similar to the "design" vehicle. This is the only vehicle that can accommodate a large "40-foot" ISO shipping container.

The use of semi-trailers with dimensions similar to those of the "design" vehicle tends to be confined to industrial and large retail activities, together with long haul inter-city operations.

- **B-train**

The B-train "design" vehicle (Figure 3.1.4) has an overall length of 20.0 m which is the upper limit permitted by regulations and tends to be used for similar kinds of freight. However, the B-train usually is not able to transport a "40-foot" ISO container but it can carry two "20-foot" containers, one on each trailer. It is recommended that B-trains are not expected to reverse in constrained locations.

Figure 3.1.4 B-train.



All dimensions in metres

- **Other vehicles**

Other vehicles such as A-trains and truck-and-trailer combinations have not been included as "design" vehicles. The planning and design of facilities for these vehicles can instead be successfully achieved using information relevant to the B-train.

However, the curves illustrating a reverse manoeuvre for the B-train are not shown as these vehicles should not require reversing as part of their expected manoeuvres. Stock truck-and-trailers do of course have to reverse up to stock yards as part of their normal operation.

4. SITE DESIGN FOR HEAVY VEHICLE FACILITIES

4.1 Introduction

The design recommendations for the different aspects of on-site design for facilities for large heavy vehicles are set out in the following order:

The layout required for any aspect of on-site design depends on the type and size of vehicle that is expected to use the facility. Guidance to selecting the appropriate "design" vehicle is included in Section 3 and 4.2.3. The layout of the text is explained in Section 1.2.

While many of the issues relating to the design of on-site facilities are relevant to all heavy vehicles (both trucks and buses), other details are clearly only appropriate to either trucks or buses. For example, requirements for loading-unloading platforms are entirely different for buses (the need for passengers to board and alight) and trucks (the need for goods handling).

4.2 General Principles

4.2.1 Need for Site Design

Achieving an appropriate design to accommodate commercial vehicles relies on a number of general design principles. While various recommendations for design are presented, it is not possible to cover every individual situation in terms of site operation and layout, and of vehicle type. Nevertheless, an understanding of the basic design principles will enable the designer to adapt the recommendations where necessary to suit a wider range of circumstances than can be covered in this document.

4.2.2 General Principles

The general principles of site design for heavy vehicle facilities should incorporate the following:

- The key to good site design is to achieve a balance between space allocated for the main activities on the site (industrial, warehousing, retail or office space) and space allocated for the vehicle servicing function. Too much space for vehicles is wasteful of valuable land, while too little space for vehicles can seriously affect the efficient operation of the site activities.

- Careful consideration must be given to the type and size of vehicle for which the site is to be designed. While, for a particular site activity, it may be possible to be quite specific about the type of vehicle that will visit the site, the type of activity and site operation may well change in the future, requiring a change in the type of vehicle that must be accommodated on the site. The designer can be faced therefore with a need to strike a balance between over-designing for the immediate use of the site and under-designing, thus introducing unnecessary constraints to the possible future utility and value of the site.

- Design layout should not be based on the best performances of vehicle and driver as these are rarely attained, especially in adverse weather conditions. Adequate clearances and allowances should therefore be included.

- Selection of the appropriate "design" vehicle, and application of the recommendations (which include the desirable clearances) should accommodate all vehicles that are normally expected to use the site. However, the use of the site by larger, extreme vehicles should also be contemplated, albeit accepting that the manoeuvres required for such extreme vehicles will be more difficult or complex, and will not conform to the normal safety margins and tolerances.

- In general, vehicles should be able to use a forward gear to enter the facility from the public street, and to exit onto the street on leaving the site. Access roads should be wide enough to allow vehicles to pass safely. The site should be designed to require only simple manoeuvres, without repeated shunting. Designs should include, where appropriate, items such as queueing spaces for waiting vehicles, parking for employees' cars, and areas for refuse skips and pallet stacks.

Failure to plan for such requirements can lead to serious disruption to site operation.

An appreciation of the relative differences between the swept paths of the various "design" vehicles can be of value in selecting the appropriate "design" vehicle for a given site. Figures 4.2.1 and 4.2.2 illustrate these basic differences. These curves assume that the vehicles execute a continuous circular turn at the stated radius.

Figure 4.2.1 Swept path widths for design trucks.

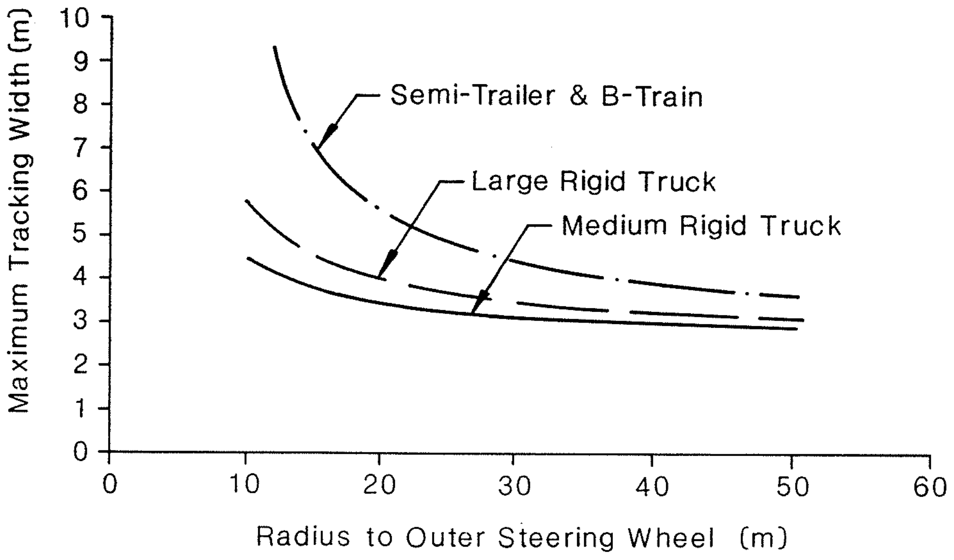
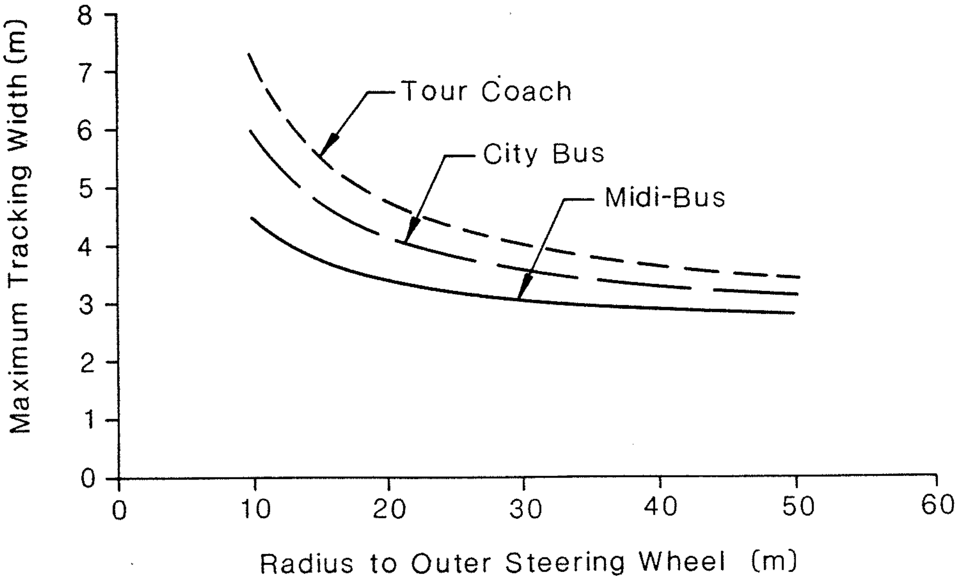


Figure 4.2.2 Swept path widths for design buses.



4.2.3 Heavy Vehicles for Different Land-use Categories

As a general guide, the following list of land-use categories includes the appropriate "design" vehicles. As it is only a guide, the general principles listed above must be borne in mind when designing for a particular site and use.

Freight Depots: Freight depots cater for all types of vehicles; line-haul operations tend to use semi-trailers, truck-and-trailers and B-trains; local distribution operations normally use large rigid trucks. The semi-trailer would normally be selected as the "design" vehicle.

Container Terminals/Wharves: A single "20-foot" ISO shipping container can be carried on the large rigid truck, or two can be carried on a B-train, semi-trailer or truck-and-trailer. The "40-foot" ISO container can only be carried on a semi-trailer. Container terminals and wharf areas should be designed to accommodate all heavy vehicles, using the semi-trailer or B-train as the "design" vehicles.

Warehouses/Industry/Manufacturing: Sites for these uses should be capable of accommodating both large rigid trucks and semi-trailers. The specific vehicle requirements of the type of activity should be checked to determine whether the site should be designed to accommodate B-trains (for which the additional length required and desirability of avoiding reversing manouevres need consideration).

Service Commercial and Retail Centres: Although many retail developments rely on rigid trucks for deliveries, supermarkets and other activities such as fast-food restaurants use semi-trailers for their major deliveries. The servicing areas of major retail centres should therefore be designed to accommodate the semi-trailer "design" vehicle.

Office Development: In general, office development is served by the medium rigid truck for most of its needs, including day-to-day deliveries, cash transfer, courier services, towel services, etc. Loading docks can therefore be designed to the medium rigid truck "design" vehicle.

Large rigid trucks may be used for special deliveries (such as office furniture) but, as these are relatively infrequent occasions, they can be accommodated either in the loading dock or on the street frontage or driveway.

Requirements for refuse vehicles serving the office development must be given special consideration. Although the large rigid truck "design" vehicle would cover the spatial requirements of refuse vehicles, the special requirements (e.g. height) for mechanical retrieval of waste containers must also be considered in the site design.

Hotels/Motels: The servicing area must be capable of accommodating a medium rigid truck "design" vehicle, although those of larger hotels may need to be designed for the semi-trailer "design" vehicle. Hotels may also provide for buses and coaches, for which the tour coach "design" vehicle should be used.

Service Stations: Bulk fuel deliveries to service stations are generally made using semi-trailers and occasionally truck-and-trailer units; where possible, the semi-trailer should be able to enter the site, gain access to the remote fill positions, and leave the site, all without reverse manoeuvres. Thus the "design" vehicle should be the semi-trailer.

Service stations generally do not cater for truck refuelling, but special consideration should be given to the need to accommodate trucks where diesel refuelling is provided.

Truck Stops: Truck stops are intended to serve all commercial vehicles, and therefore must be designed to accommodate the semi-trailer and B-train "design" vehicles. The design should ideally consist of a drive-through facility and particular consideration should be given to access from the roadway.

Residential Development: As for office development, most servicing of residential areas uses the medium rigid truck, although large rigid trucks will have to be accommodated on infrequent occasions (e.g. for furniture removal). Access of refuse disposal trucks and fire appliances must also be considered.

Emergency Services: All fire appliances are rigid trucks, and sites should be designed using the large rigid truck "design" vehicle.

4.3 Access from Street

4.3.1 Introduction

The design of on-site facilities off the public street is the primary concern in this report. The siting and design of vehicle crossings (i.e. the connection between the on-site driveway and the public street) must meet the requirements and standards of the particular road controlling authority, and its advice should be sought in this regard.

This section outlines the basic design principles that should be observed in locating and designing vehicle crossings on the street interface.

4.3.2 Vehicle Crossing Locations

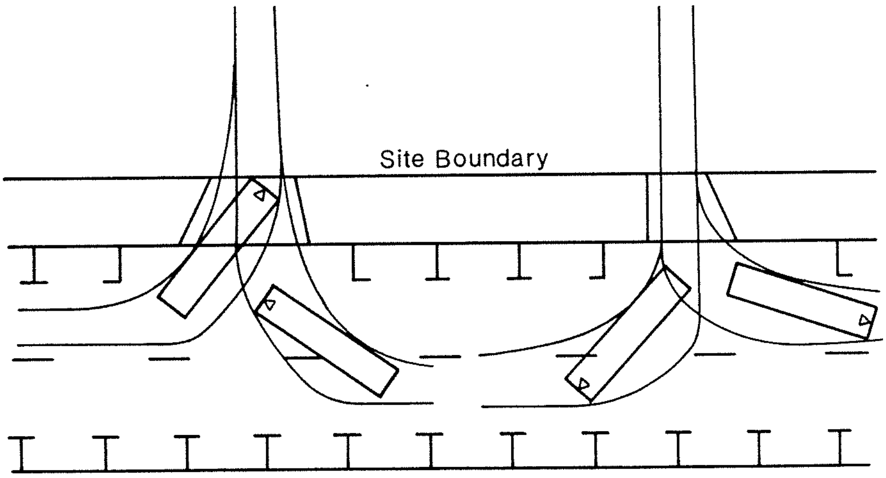
Vehicle crossings should be located clear of road intersections, to avoid the possibilities of confusion between turning movements. Minimum separation distances from adjacent intersections are normally required in local authority district plans, and the siting of vehicle crossings should meet these standards.

Left-turn movements to and from the crossing should be promoted wherever possible because right-turning vehicles, particularly large heavy vehicles, can have more disruptive effects on other traffic.

4.3.3 Accessway Widths

The accessway width is defined as the width of the vehicle crossing at the property boundary. Unless there are reasons that indicate that vehicles will arrive and depart in a specific direction, accessways between streets and sites should be designed for both left and right turns, in and out. Normally left turns will be to and from the nearest lane to the kerbline in front of the site and right turns will be to and from the lane on the opposite side of the carriageway nearest to the centreline (Figure 4.3.1). Encroachment into other lanes to make the turn should be avoided.

Figure 4.3.1 Typical accessway arrangements.



The accessway width actually required at the boundary is dependant on the distance from the traffic lane to the kerbline, the distance of the boundary back from the kerbline of the roadway (i.e. the width of the berm), the angle of turn required, and the type of vehicle for which the accessway is to be designed. These factors will affect both the width and the angles of the edge of the accessway between kerbline and site boundary.

The design width of an accessway should be determined using the appropriate "tracking curves" given in Section 5. After allowing for appropriate clearances, accessways should be kept to the minimum dimensions necessary for their function. Over-sized accessways are more hazardous and inconvenient for pedestrians, use up kerb space that would otherwise be available for parking, and lead to undisciplined turning movements which are potentially less safe.

Figures 4.3.2 to 4.3.4 illustrate examples of typical accessway widths for different berm widths required to accommodate a large rigid truck, a semi-trailer, and a B-train, all assumed to be turning left from a wide kerbside lane.

Figure 4.3.2 Accessway widths for large rigid truck.

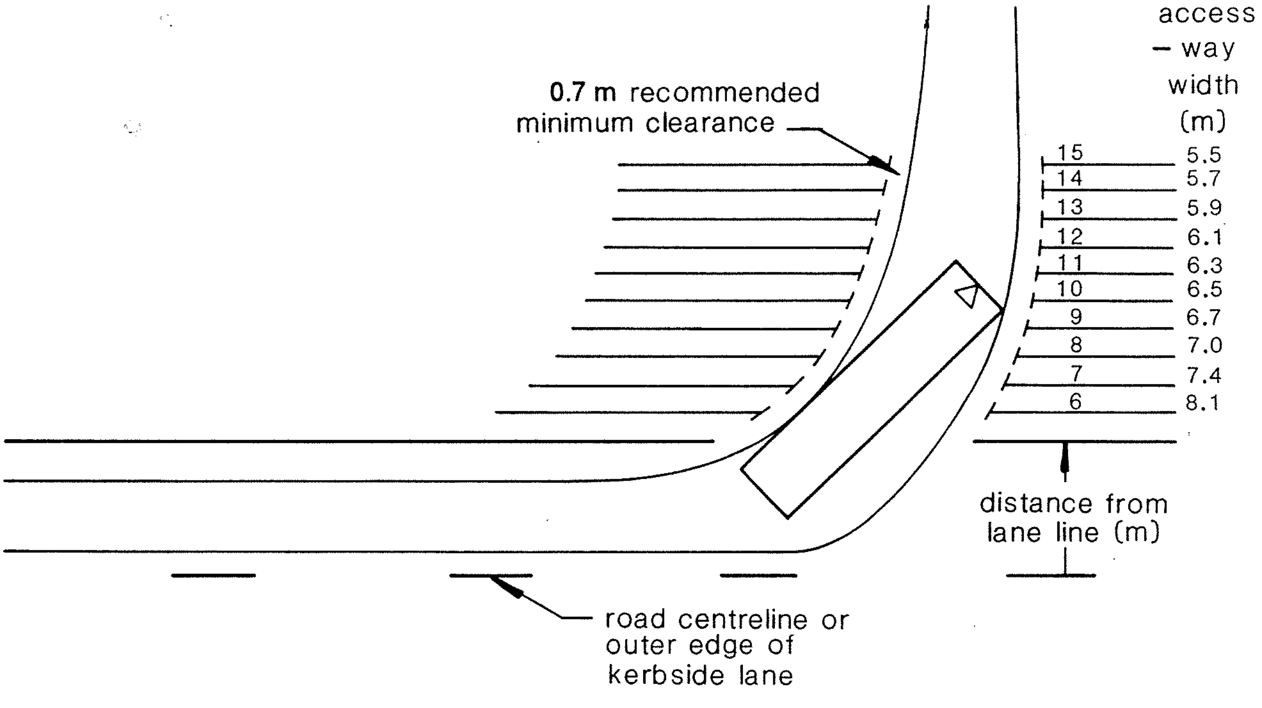


Figure 4.3.3 Accessway widths for semi-trailer.

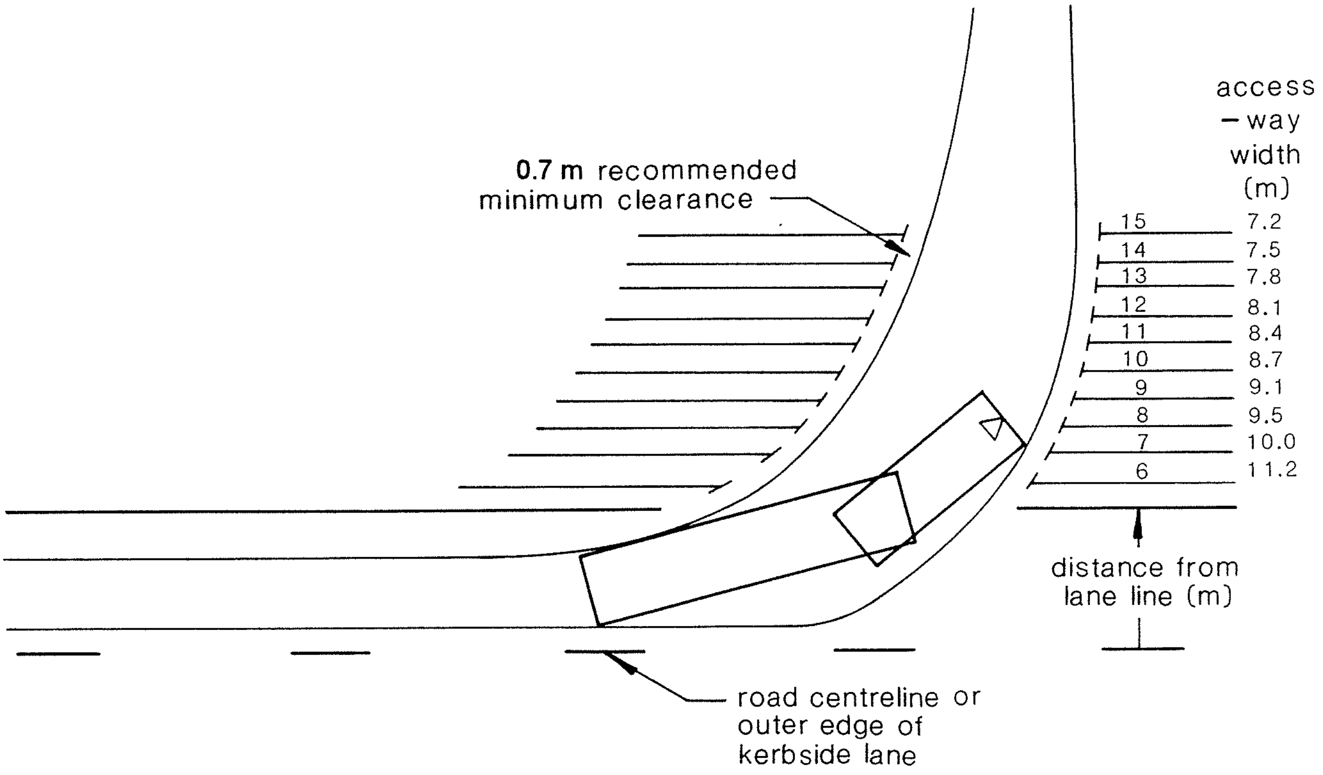
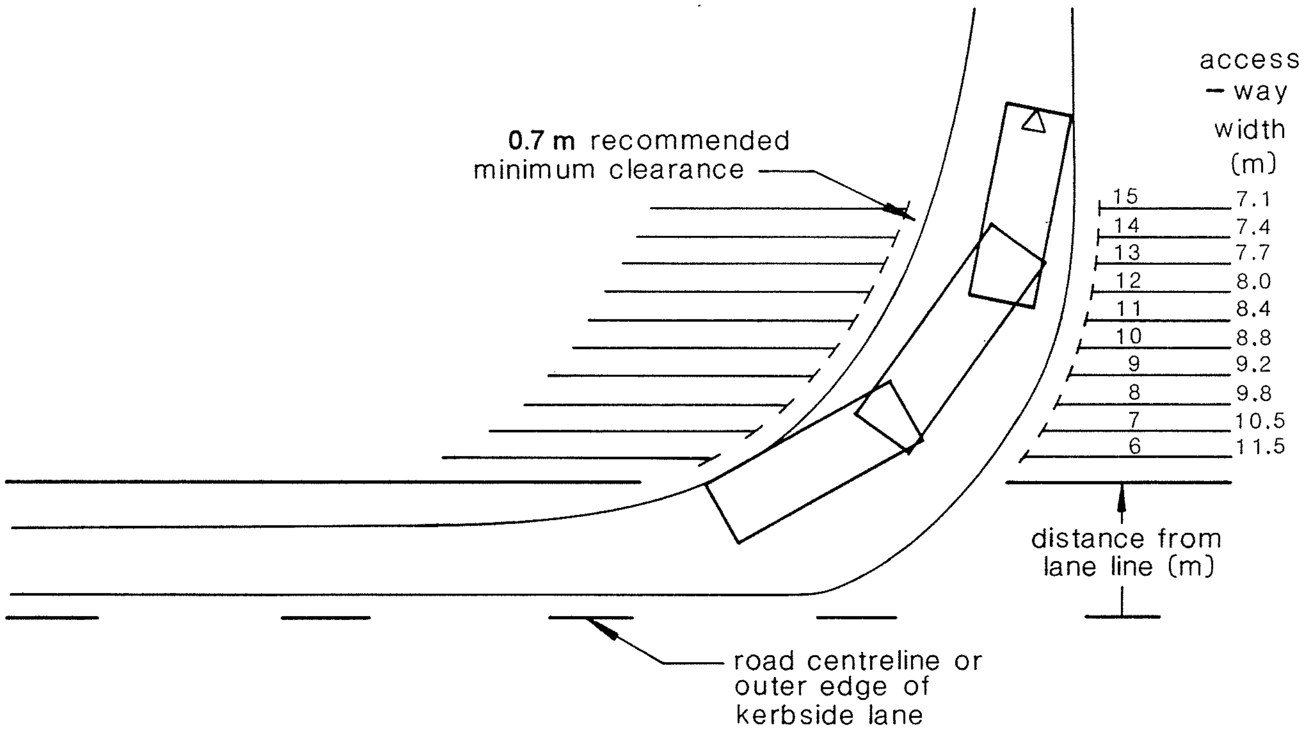


Figure 4.3.4 Accessway widths for B-train.

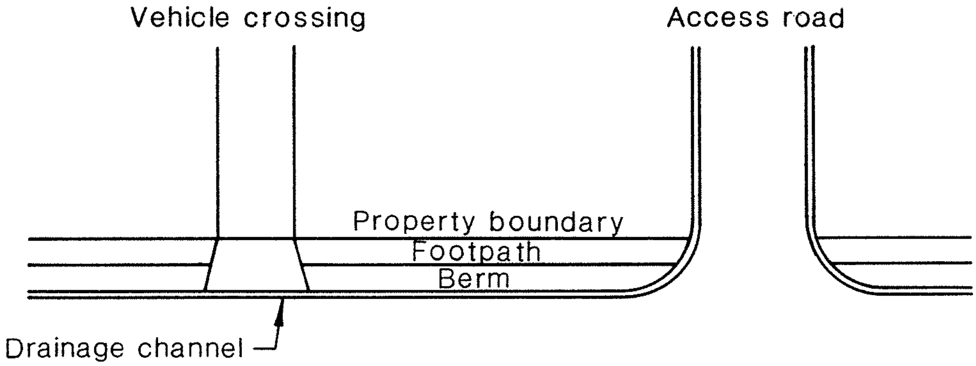


Where an accessway caters for both entering and exiting traffic, and where vehicle entry and exit movements may coincide, the accessway width should be increased to ensure that a vehicle waiting to exit onto the street does not block a vehicle wishing to turn into the accessway. The alternative of using separate entry and exit driveways should be considered, particularly where pedestrian movement requires accessway widths to be kept to a minimum. Queueing on-street should be avoided where possible, unless it can be specifically accommodated in the kerbside lane or in a special queueing lane.

The likely effect on pedestrian movement and safety is important when determining the width and design of an accessway. Where pedestrian volumes are significant, accessways should generally be reduced to the minimum required. The angle of the vehicle crossing over the footpath should also seek a balance between allowing easy access for vehicles (to avoid stopping in the traffic lane and making sharp turns) and reducing vehicle speed to enhance pedestrian safety.

The treatment of the vehicle crossing at the street frontage should be determined in consultation with the local authority, because relevant policies tend to vary from one authority to another. Typical treatments include those shown in Figure 4.3.5.

Figure 4.3.5 Typical vehicle crossing treatments.



4.3.4 Sight Distances

Vehicle crossings should be located where sight distances for approaching traffic along the road are adequate. Sight distances for large, slow moving vehicles should be in excess of those normally required for lighter vehicles because of their lower acceleration rates and longer lengths.

The appropriateness of available sight distances should be determined in consultation with the road controlling authority.

Adequate sight distances should be provided between entering/exiting vehicles and pedestrians crossing the accessway. The effects of fences and building walls located on or near the property boundary should be particularly noted. A driveway should not normally be closer than 2.0 m from a side boundary where a fence or wall obstructs visibility between vehicles and pedestrians.

4.3.5 Other Considerations

Reversing manoeuvres from an accessway out onto the street are not recommended. Reversing manoeuvres from the street (e.g. into a loading bay) may be permitted in certain situations, depending on factors that include the frequency of occurrence; the function of the road in the roading hierarchy; the location in relation to adjacent intersections; traffic volumes, speeds and sight distances. Consultation with the road controlling authority at an early stage in planning is recommended.

The gradient of a driveway should not exceed a maximum of 5% (1-in-20) within 6.0 m of a site boundary or a pedestrian footpath.

Driveways should be clearly delineated with appropriate signing or other features that clearly identify their location, type and purpose. Measures that can further assist in such delineation include use of contrasting pavement materials, pavement markings, and landscaping.

4.4 Driveways

4.4.1 Introduction

The term "driveway", as used in this report, refers to any roadway, access lane or other link that provides vehicular movement (other than manoeuvring) within the site.

In most situations the "driveway" will link the public access road to defined manoeuvring and loading areas on the site. In some circumstances a "driveway" may combine this access function with all manoeuvring, loading and unloading taking place on the public access road itself.

4.4.2 Driveway Widths

A "driveway" must be wide enough to permit the safe and efficient passage of vehicles along it. The intended traffic movement pattern on the road, and of the activities that are expected to take place immediately adjacent to the road, influence the overall width of a "driveway".

Wherever possible, on-site circulation should be of a high standard by designing on-site driveways to accommodate the movement of traffic in one direction, rather than in two directions. Recommended minimum "driveway" widths are given in Table 4.4.1.

Table 4.4.1 Minimum "driveway" widths (metres).

One-way operation:	4.0 m(a)
Two-way operation:	7.0 - 7.5 m(a)
Additional width for each row of parallel parking of:	
Cars	2.5 m
Trucks or Buses	3.0 m

(a) Note: A little additional clearance should be provided for buses.

The width of a "driveway" on or in the immediate vicinity of a bend should be increased to accommodate the "tracking curve" and additional clearances of the most appropriate vehicle(s).

Narrow one-way driveways can be used for the movement of traffic in both directions where the development is particularly small and where truck servicing will be infrequent. In these situations, an area should be provided at both ends of the "driveway" to enable opposing vehicles to pass. The dimensions of these bays should accommodate the appropriate "design" vehicle and the anticipated number of vehicles that are expected to be delayed while servicing. If passing bays are not provided at regular intervals between the two ends of the "driveway", the overall length of the "driveway" should be as short as possible but no more than 50.0 m.

Loading and/or unloading should only be carried out on driveways if the volume of traffic using the "driveway" is low and the loading/unloading will not have a detrimental effect on other traffic. The design of the site should enable the vehicle to turn around to exit the site in a forward, rather than a reverse, manner.

4.4.3 Overhanging Obstructions

Overhanging obstructions should provide enough clear headroom to allow the free passage of the "design" vehicle. Tables 4.4.2 and 4.4.3 are guides to the minimum headroom to be allowed under overhead obstructions.

Table 4.4.2 Minimum headroom (metres) for trucks.

Medium rigid truck:	4.5 m
Large rigid truck/ Semi-trailer/B-train:	5.0 m

Table 4.4.3 Minimum headroom (metres) for buses.

Midi-bus:	4.0 m
Other buses:	4.5 m

Provision of a height clearance indicator in advance of any overhead obstruction is recommended. The indicator is usually an advisory board suspended overhead at a height similar to the height of the obstruction.

4.4.4 Speed Humps

The speed hump is an effective device to reduce the speed of traffic on roads. Because a speed hump can have a detrimental effect on a truck's load, its use on roads used by heavy vehicles should only be contemplated after alternative speed management measures have been fully considered.

Speed humps should be designed and constructed in accordance with the Ministry of Transport's guidelines (Ministry of Transport 1987).

In off-street situations also, where heavy vehicles such as trucks and buses are expected, speed humps should conform to the dimensions given in Table 4.4.4 and Figure 4.4.1.

Table 4.4.4 Speed hump dimensions (metres).

Maximum height	0.1 m
Length	5.0 m
Maximum distance between humps	80.0 m

Figure 4.4.1 _ Speed hump profile.

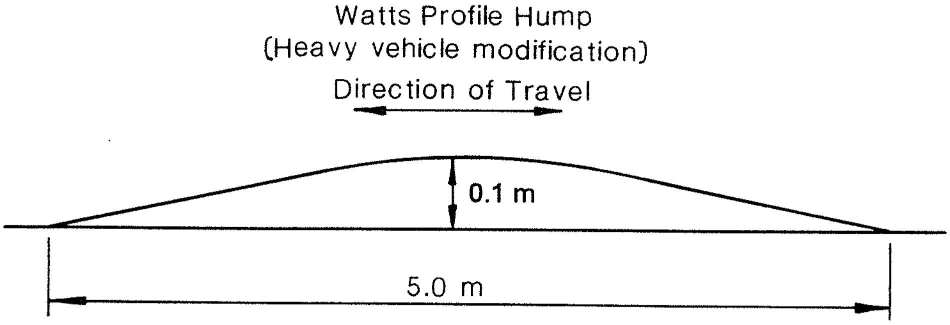
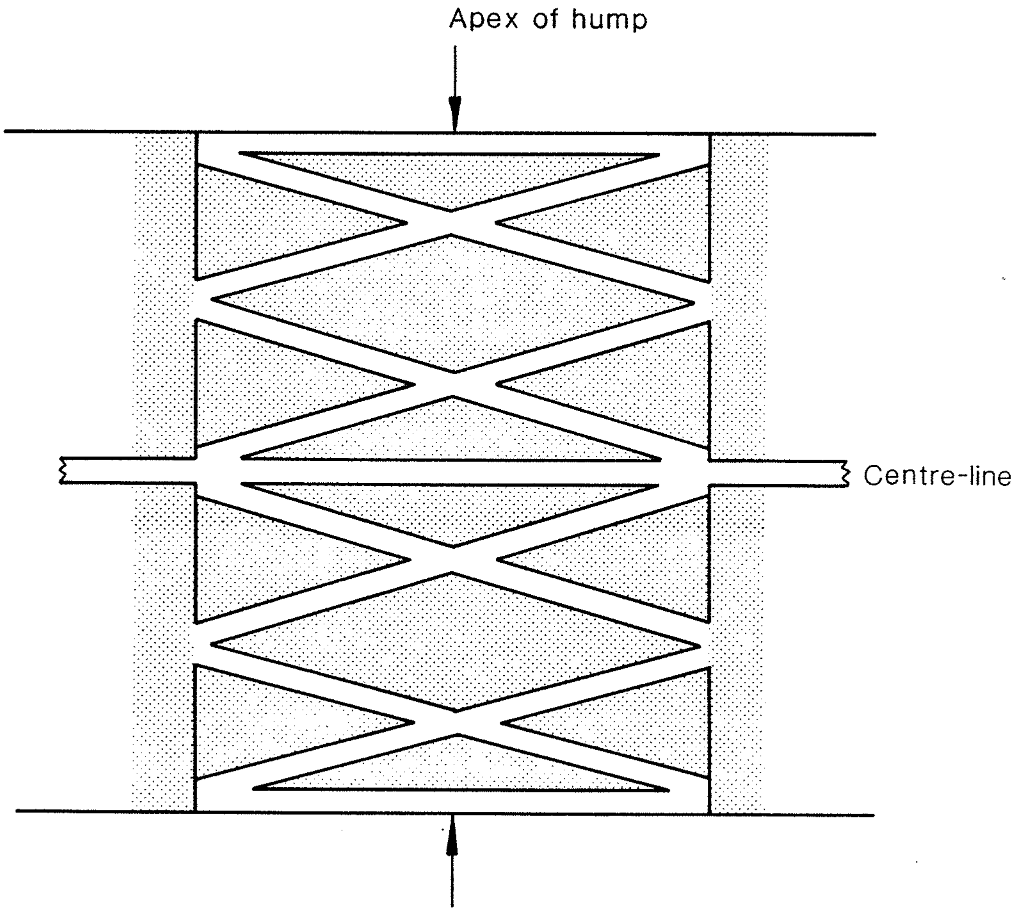


Figure 4.4.2 Speed hump markings[a].



Each speed hump should be marked (Figure 4.4.2) and supported by the appropriate signposting in accordance with Ministry of Transport guidelines (1987).

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[a] To ensure visibility, the humps should be marked as shown, with a minimum of four crosses, and the cross point on the apex of the hump. The pattern should be in white reflectorised road-marking paint, a minimum of 0.1 m width, with a centreline marked through the hump and extending 2.0 m either side of the hump (this centreline should be omitted when the hump is less than 5.0 m in width).

4.5 Manoeuvring Areas

4.5.1 General Considerations

The manoeuvring area of an on-site facility is that area between the access road and the parking/loading area, in which the vehicle must undertake the necessary manoeuvres to enter the parking or loading facility. Many of these manoeuvres will involve reversing the vehicle.

Adequate manoeuvring area is essential in the initial design of the overall site layout and in its subsequent operation. For example, encroachment of stored goods into an otherwise adequate manoeuvring area can severely disrupt site operation. The manoeuvring area must therefore be designed in conjunction with other areas of the site.

Manoeuvring areas should be as flat as possible, but with sufficient gradient to allow surface water to run off.

The design recommendations for manoeuvring areas assume that the site is essentially flat, that the pavement surface is in a well maintained condition, and that the manoeuvre is carried out at a slow speed where the dynamic properties of tyres (such as those causing scuff or slip) will not have significant effects on the behaviour of the vehicle. Where these conditions are not present, special attention must be paid to their likely effects on vehicle manoeuvring. For example, studies in the UK (Freight Transport Association 1983) have found that the spatial requirements of a turn can be increased as much as 10% for pavement gradients up to 5% (1-in-20).

As the number of articulation points of a vehicle is increased, the complexity of reversing the vehicle also increases. For this reason, vehicles with more than one articulation point should not be reversed. Accordingly, it is desirable that these vehicles should be able to conduct all manoeuvring in a forward gear. If some reversing must take place, sufficient space should be provided to enable the vehicle to be aligned so that reversing is in a straight line. This spatial requirement can be assessed using the simple turn tracking curves.

4.5.2 Spatial Requirements

The spatial requirements of particular types of turns ("tracking curves") have been prepared at 1:500 scale, and are reproduced in Section 5.

These "tracking curves" represent the actual space required for the vehicle to successfully execute the particular manoeuvre. **No allowance has been made for clearances between the vehicle and adjacent obstacles** such as kerbs or walls, and additional clearances should be added (Sections 4.5.3, 4.5.4).

THESE "TRACKING CURVES" ARE ONLY TO BE USED FOR SLOW-SPEED ON-SITE DESIGN AND ARE NOT NECESSARILY SUITABLE FOR ON-ROAD DESIGN PURPOSES

Note that, in general, the paths followed by the inner point of the vehicle at the rear axis and the front of the vehicle's body (not the steering wheels) define the vehicle's swept path.

If vehicles are required to execute a particularly tight turn at a slow speed, the rear of the vehicle may have a tailswing, thereby affecting the shape of the swept path envelope. This tailswing is of more significance to vehicles with a long rear overhang (that part of the vehicle behind the rear axis, Figure 2.1.1).

Tailswing can be important when considering the turning of city and tour buses. For example, the tailswing of tour coaches exiting from a parallel kerbside parking space can cause the rear of the vehicle to damage both street signs/furniture and the vehicle itself.

For manoeuvring without reversing, the "tracking curves" that make up a U-turn should be used. Note that, when vehicles with large rear overhangs execute tight turns, the tailswing of the vehicle may dictate the profile of part of the swept path.

Where reversing is envisaged, the curves for medium rigid truck (MRT), large rigid truck (LRT), semi-trailer (ST), midi-bus (MB), city bus (CB), tour coach (TC) in Section 5 could be used. An infinite number of manoeuvring scenarios exist for each vehicle, and those illustrated by these curves are but one example. Some of these curves require the application of a significant amount of steering lock.

The "tracking curves" of the semi-trailer "design vehicle" have been prepared on the basis that the effective forward distance of the trailer is 8.9 m, rather than 8.5 m (the legal maximum) given in the vehicle's descriptive statistics (Section 3.1).

Complex turns which involve reversing have not been prepared for the B-train "design" vehicle as these vehicles should not be reversed if possible. Where reversing cannot be avoided, the simple "tracking curve" should be used to ensure that the dimensions of the turning area allows the vehicle to be straightened before it is reversed.

When designing a facility for trolley buses or articulated (bendy) buses, specialist advice should be obtained. Note that articulated buses may only operate on permit approvals available from the statutory authority.

4.5.3 Horizontal Clearances

To accommodate the clearances needed between a vehicle and an adjacent obstacle, an additional clearance (Tables 4.5.1, 4.5.2) is to be applied to the "tracking curves" (Section 5). This clearance allows for variations in the skill of the driver, and the turning characteristics and capabilities of the vehicle.

Table 4.5.1 Horizontal clearances (metres) for trucks.

Minimum additional clearance each side of truck:	0.7 m

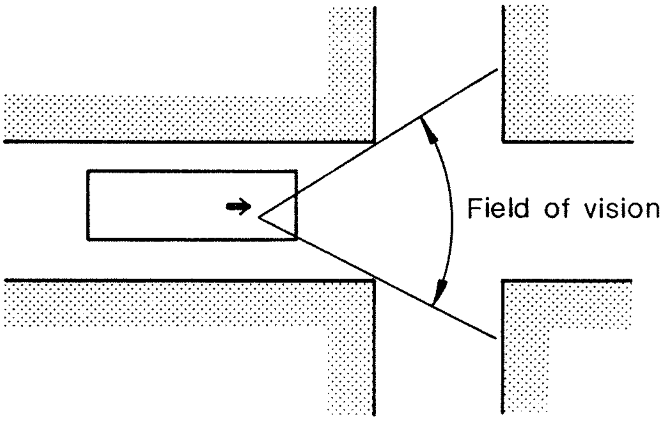
As bus drivers are generally more conscious of potential damage to the vehicle and therefore prefer a more generous space for manoeuvring (Traffic Planning Consultants Ltd 1988), additional horizontal clearances should be applied to the "tracking curves" of the design buses.

Table 4.5.2 Horizontal clearances (metres) for buses.

Minimum additional clearance each side of bus:	0.9 m

When the manoeuvring is in constrained locations, special consideration must be given to the adequacy of driver visibility from the vehicle (Figure 4.5.1) and adequate horizontal clearances to obstructions must be maintained, particularly when manoeuvring on access roads.

Figure 4.5.1 Driver visibility.



4.5.4 Headroom

Trucks within the legal maximum height of 4.25 m, that do not require an over-dimension permit to operate on public roads, require the headrooms in manoeuvring areas given in Table 4.5.3.

Table 4.5.3 Headroom (metres) for trucks.

Medium rigid truck	4.5 m
Larger trucks	5.0 m

The height of midi-buses, city buses and tour coaches can vary between that of an empty and of a fully laden condition. These heights can be further increased by opened roof-top ventilation hatches, or roof-mounted air-conditioning units. Buses seldom have heights in excess of 4.0 m. The headrooms recommended for buses are given in Table 4.5.4.

Table 4.5.4 Headroom (metres) for buses.

Midi-bus	4.0 m
Other buses	4.5 m

Where headrooms are limited, advanced height warning devices should be provided to alert the driver of the impending restriction. These devices are usually overhead swinging boards marked with the warning. If hit by a vehicle body or load, they swing to prevent serious damage to the vehicle.

Additional care is required when positioning overhead obstacles near areas with changing gradients. See Section 4.6 (Ramps and Gradients).

4.5.5 Visibility When Reversing

The driver's field of vision can be severely restricted when reversing. Drivers of large vehicles are often unable to view and assess the progress of their reversing through the rear of the vehicle and instead must rely either on the vision provided by the vehicle's wing mirrors, or by leaning out an opened window or door.

The availability of rear visibility is particularly important when semi-trailers are being reversed. In these instances the cab (or tractor) unit is often not in the same line as the trailer, further reducing the useful field of vision provided by the mirrors.

For sharp turns, the mirrors on the "outside" of the turn provide little or no useful coverage. Therefore where possible the reversing should be carried out anti-clockwise, with the driver's side of the vehicle on the "inside" of the turn. This arrangement allows drivers to use the mirrors on their side of the vehicle or alternatively drivers can view the progress of the manoeuvre through an opened door or window.

Most drivers are particularly skilled at assessing the available manoeuvring space and the type and extent of the manoeuvre required before its commencement. However it is desirable to keep the area where reverse manoeuvring is proposed free of obstructions and property furniture such as poles and posts.

4.6 Ramps and Gradients

4.6.1 Ramp Gradients

The ability of a vehicle to successfully climb a ramp is directly related to the weight of the load it is carrying. Most heavy commercial vehicles have the mechanical capability to climb relatively steep gradients when unloaded and moderate gradients when loaded. However, difficulties can arise when trucks have to stop and restart on a gradient, particularly when loaded, and therefore gradients should always be as flat as possible.

The maximum ramp gradients in Table 4.6.1 are recommended for situations where the vehicle is not required to stop on the ramp.

Table 4.6.1 Maximum ramp gradients.

Straight ramp	10% (1-in-10)
Curved ramp (measured along inner radius of curve)	10% (1-in-10)

Curved ramps have gradients that increase from the outside of the curve to the inside. Therefore defining an acceptable maximum along the centre of the ramp is more difficult than defining gradients of straight ramps. As the width of each lane of a ramp is related to the "off-tracking" behaviour of the "design" vehicle, the desirable maximum gradient at the centreline would have to be related to the number of lanes and to the particular type of vehicle. For this reason, the maximum gradient of a curved ramp is taken along the inner radius of the curve.

Curved ramps should only be used where absolutely necessary because of the spatial requirements of large trucks and buses when executing a tight turn.

Curved ramps often have super-elevation (crossfall gradient) to make the ramp more comfortable to travel on. This makes vehicles on the ramp tilt towards the centre of the circle which can be of particular significance to a tall vehicle (because the top of such a vehicle could collide with adjacent obstacles, such as columns). Accordingly the immediate vicinity of curved ramps should be cleared of the obstructions to prevent this happening.

Australian standards (Standards Association of Australia 1988) suggest that where a change in gradient at the top or bottom of a ramp is greater than 2%, transitions should be provided to reduce the severity of the change. Without transitions, additional strain is placed on the vehicle and its couplings by the redistribution of the vehicle's weight.

International guidelines suggest that this transition should be one of the following:

- a vertical curve of radius not less than 6.0 m (Freight Transport Association 1983), (a greater radius is preferred as it will minimise changes in the vehicle attitude at critical points),

- intermediate sections providing a gradual change in gradient, Australian standards (Standards Association of Australia 1988) recommend that the change of gradient on a ramp should not exceed the following:

  8% (1-in-12.5) over a minimum of 4.0 m for rigid vehicles, and
  6.25% (1-in-16) over a minimum of 10.0 m for articulated vehicles.

4.6.2 Ramp Widths

The physical width of a ramp is determined by the spatial requirements of the vehicle using it. For example a ramp which has vehicles turning onto it from an angle must have additional width at the appropriate points, and this widening must be determined using the "tracking curves" in Section 5, and the horizontal clearances recommended in Section 4.5.3.

Similarly, curved ramps should be designed with the aid of the appropriate "tracking curves" plus clearances. Subject to these recommendations, the basic minimum widths (between kerbs) for straight ramps are given in Tables 4.6.2 and 4.6.3.

Table 4.6.2 Minimum ramp widths (metres) on straight ramps for trucks.

One-way ramps	4.0 m
Two-way ramps	7.0 - 7.5 m

Table 4.6.3 Minimum ramp widths (metres) on straight ramps for buses.

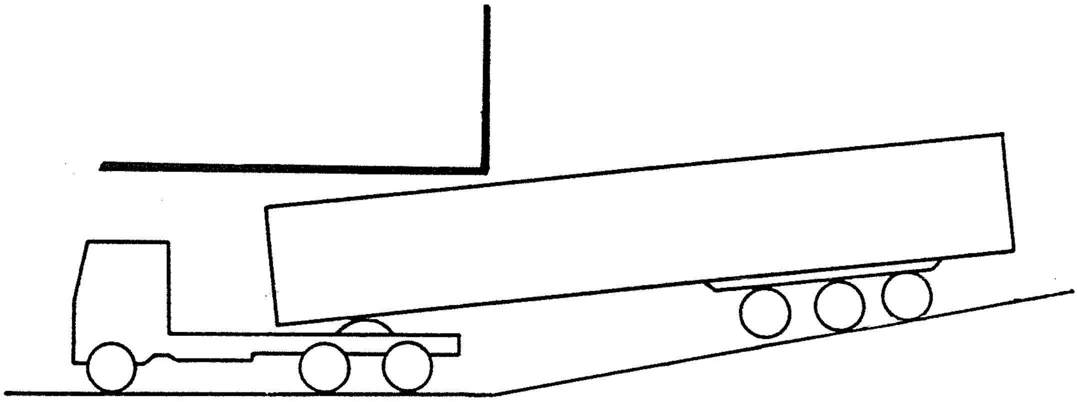
One-way ramps	4.3 m
Two-way ramps	7.8 m

The minimum distance between the face of the ramp kerb and any obstruction (e.g. wall or sign) should be 0.4 m.

4.6.3 Headroom on Ramps

Where a significant change of gradient occurs, special attention must be given to the available headroom. Problems commonly occur when a vehicle travelling down a ramp to a "basement level" passes under the end of the floor that forms the level above the basement. A similar situation occurs when a vehicle has to reverse down a ramp to a loading dock and pass beneath the top of an opened door or other overhead obstruction. Figure 4.6.1 illustrates this situation.

Figure 4.6.1 Headroom on ramps.



The available headroom is reduced when surface resealing involves pavement overlays. Attention should also be paid to the pavement strength on the ramp and its transitions to allow for the uneven load distributions that will occur.

The additional headroom required depends on the type of vehicle being manoeuvred and the position of the overhead obstruction in relation to the location of the change in gradient.

If an allowance of at least 0.1 m is added to the basic recommended overhead clearances for the different "design" vehicles, potential headroom problems associated with changes in gradient should be avoided.

4.6.4 Ramp Surface

The quality and finish of a ramp's pavement surface is an important aspect which, if overlooked, can create problems.

As a loaded vehicle climbs a ramp, its performance is not only determined by the mechanical capabilities of the vehicle itself but also by the coefficient of friction developed between the tyres on the driving axle(s) and the ramp surface. Wet and highly polished or loose surfaces should be avoided where possible.

4.6.5 Surface Gradients

Where the pavement surface is essentially flat, it is necessary to provide adequate crossfall to maintain surface water run-off. A gradient of 1-in-60 to 1-in-40 (1.7-2.5%) is therefore recommended.

4.7 Loading

4.7.1 Introduction

The design of loading arrangements for trucks requires an understanding of the type of commodity and handling methods that are to be employed. Most loading and unloading is carried out at designated loading docks although some is carried out in clear open spaces. Specific requirements, to accommodate vehicles with on-board tailgate loading equipment, must also be taken into account. Forklift details and their general operational requirements are supplied in Section 4.7.6.

If the facilities are being designed for a particular type of operation, consideration should be given to the suitability of the design for other potential uses of the building, should these change.

In general the only facilities needed for loading buses relate to the requirements of boarding and alighting passengers and, if appropriate, their luggage.

In some situations buses are used to transport goods which are not accompanied by passengers. This cargo is often loaded at a depot/despatching centre before boarding passengers at the beginning of the journey.

4.7.2 Platform Heights

The required height for a platform in a loading dock depends on the types of vehicles likely to use the facility. Trucks about the size of the medium rigid truck "design" vehicle often have deck heights lower that those on the larger rigid trucks, semi-trailers and B-trains. Platform heights that should be used are listed in Table 4.7.1.

Table 4.7.1 Platform heights (metres) above roadway for trucks.

Medium rigid truck	1.0 - 1.1 m
Larger trucks	1.2 - 1.4 m

To assess the height of a pedestrian platform, factors such as the step height between the platform and the first step of the bus, the height difference between successive steps, and if the bus will overhang the platform, should be considered. The pedestrian platform height, measured above the level of the roadway, that is recommended is given in Table 4.7.2.

Table 4.7.2 Platform heights (metres) above roadway for buses.

Buses	0.23 - 0.25 m

Ideally a dock that is used solely for unloading should have the surface of its platform marginally lower than the truck's deck; for loading only, the platform would ideally be higher. However the relative height of a truck's deck will change as it is loaded or unloaded because of the mechanics of the truck's tyres and suspension. A leveller could be used to aid loading and unloading. This behaviour can also affect the total height of the vehicle when considering overhead clearances.

4.7.3 Dock Bay Widths

The minimum width of a loading dock or bay depends on the type of vehicle for which it is designed, the area available for manoeuvring the vehicle into the dock, and the orientation of the bays in relation to the face of the loading area.

The most common dock arrangement is 90° (Figure 4.7.1), although other configurations are possible (Figure 4.7.2).

Figure 4.7.1 90° docks.

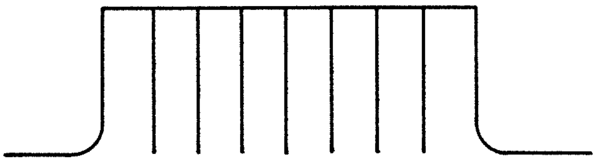
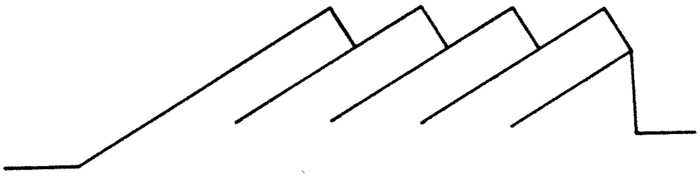


Figure 4.7.2 Angled docks.



Platforms less than the recommended height may make too great a height difference between the surface of the platform and the first step of the bus. Platforms greater than the recommended height may cause damage to the bus when it is manoeuvred close to the platform.

The minimum loading bay width should be 3.5 m when adjacent to a kerb or adjoining bay, and 4.0 m when adjacent to a wall. The 3.5 m width results in a 1.0 m inter-vehicle spacing. Additional clearance is provided when adjacent to a wall to allow for both driver error and pedestrian access.

Table 4.7.3 is a general guide to the manoeuvring area dimensions for different bay widths and angles for medium and large rigid trucks and semi-trailers (based on the complex "turning curves" given in Section 5). **They do not cover the spatial requirements of the vehicle leaving the loading dock, nor are they appropriate if the vehicle approaches the area from a different position.** To ensure that there is enough room for the vehicle to leave the dock, use the simple U-turn "tracking curve" for the "design" vehicle (Section 5). Figure 4.7.3 illustrates the terminology used with docking bays in Table 4.7.3.

Figure 4.7.3 Terminology used in Table 4.7.3 for dock bays used by medium rigid and large rigid trucks and semi-trailers.

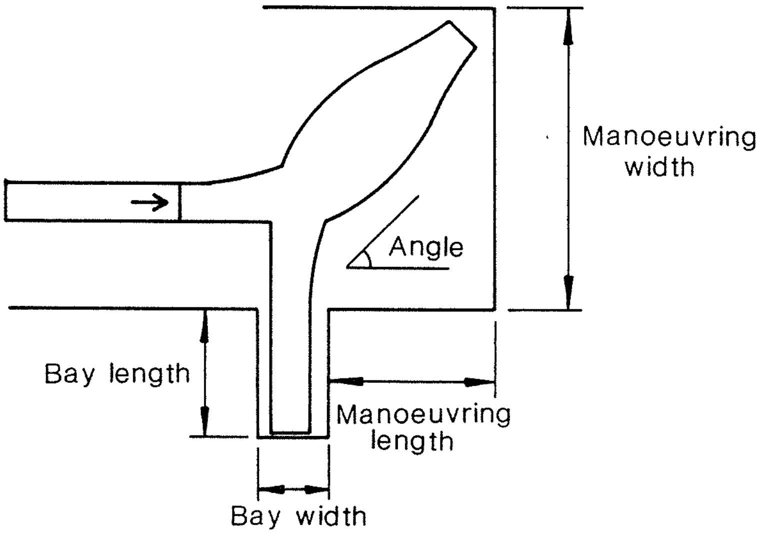


Table 4.7.3 Truck docking bays: manoeuvring areas for medium rigid and large rigid trucks, and semi-trailers (Figure 4.7.3 illustrates terms)(e).

Design Vehicle	**Entry Angle (degree)**	**Bay Width (m)**	**Minimum Bay Length(m)(a)**	**Manoeuvring Area(b)**	
				Width(m)(c)	**Length(m)(c)**
Medium rigid truck	0	3.5	4.8	9.7	15.5
		4.0	5.4	9.2	15.3
		4.5	5.8	8.7	15.0
	15	3.5	4.6	10.6	12.8
		4.0	5.3	9.9	12.6
		4.5	5.8	9.4	12.3
	30	3.5	3.8	12.7	10.7
		4.0	5.0	11.5	10.5
		4.5	5.6	10.9	10.2
	45	3.5	2.8	15.1	9.0
		4.0	4.6	13.3	8.8
		4.5	5.2	12.7	8.5
	60	3.5	2.0	16.7	6.4
		4.0	4.3	14.4	6.2
		4.5	4.3	14.4	5.9
	75	3.5	1.0	19.4	4.4
		4.0	3.7	16.7	4.2
		4.5	3.7	16.7	3.9
	90	3.5	0	18.9	1.0
		4.0	0	18.9	0.8
		4.5	0	18.9	0.5

Design Vehicle	**Entry Angle (degree)**	**Bay Width (m)**	**Minimum Bay Length(m)(a)**	**Manoeuvring Area(b)**	
				Width(m)(c)	**Length(m)(c)**
Large rigid truck	0	3.5	4.0	13.9	19.4
		4.0	5.0	12.9	19.2
		4.5	5.7	12.2	18.9
	15	3.5	5.6	12.9	16.7
		4.0	6.0	12.5	16.5
		4.5	7.6	10.9	16.2
	30	3.5	5.0	15.2	13.2
		4.0	6.4	13.8	13.0
		4.5	6.6	13.6	12.7
	45	3.5	4.7	17.9	10.7
		4.0	5.8	16.8	10.5
		4.5	7.0	15.6	10.2
	60	3.5	4.5	18.2	8.2
		4.0	5.6	17.1	8.0
		4.5	6.7	16.0	7.7
	75	3.5	3.0	21.6	5.4
		4.0	4.0	21.4	4.7
		4.5	5.0	20.6	3.9
	90	3.5	0	22.3	2.7
		4.0	0	22.3	2.5
		4.5	0	22.3	2.2

Design Vehicle	Entry Angle (degree)	Bay Width (m)	Minimum Bay Length(m)(a) (d)	Manoeuvring Area(b)	
				Width(m)(c)	Length(m)(c)
Semi-trailer	0	3.5	5.8	19.2	32.8
		4.0	7.5	17.5	32.6
		4.5	9.5	15.5	32.3
	15	3.5	5.7	20.4	25.7
		4.0	7.1	19.0	25.5
		4.5	8.4	17.7	25.2
	30	3.5	5.7	25.3	23.2
		4.0	7.2	23.8	23.0
		4.5	8.0	23.0	22.7
	45	3.5	5.7	29.3	19.7
		4.0	7.3	27.7	19.5
		4.5	8.3	26.7	19.2
	60	3.5	5.5	29.3	12.8
		4.0	7.7	27.1	12.6
		4.5	8.7	26.1	12.3
	75	3.5	5.0	34.2	7.6
		4.0	7.5	31.7	7.4
		4.5	8.0	31.2	7.1
	90	3.5	0	36.8	2.6
		4.0	0	36.8	2.4
		4.5	0	36.8	2.1

(a) "Minimum bay length" - the length of the bay required for the rear of the vehicle to be parallel with the dock face. Where the minimum bay length is less than the overall length of the vehicle, the front of the vehicle will jut out (penetrate) into the manoeuvring area. The extent of this penetration will be the difference between the overall length of the vehicle and the minimum bay length. Ideally, the bay length should be 0.5 m longer than the overall length of the vehicle.

(b) These dimensions may be affected by the maoeuvring requirements of the vehicle as it leaves the bay. This will be site specific and must be checked to ensure that it is adequate.

(c) As the entry angle increases, the "off-tracking" of the vehicle also increases during the forward manoeuvre before reversing. Accordingly additional manoeuvring area is needed for this "off-tracking" on the "upstream" side of the bay. The extent of this "off-tracking" can be determined using the appropriate "tracking curve(s)" given in Section 5.

(d) If no bay length is available, i.e. it is an open area, the total minimum width required to back up to the face of a dock = manoeuvring width + minimum bay length.

(e) These dimensions assume that the vehicle, on reversing into a dock, is positioned in the centre of the bay, with equal clearances from either side of the vehicle to the edge of the bay.

4.7.4 Canopy Heights and/or Headrooms in Buildings

Canopies on the facility should neither restrict the movement of the vehicle into the dock nor its loading and unloading. Minimum headrooms below canopies, plumbing, ducting or service pipes in the immediate area should be as given in Table 4.7.4.

Table 4.7.4 Minimum headrooms (metres) for trucks.

Medium rigid trucks	4.5 m
Larger trucks	5.0 m

These standards are for "design" vehicle heights, which are 3.7 m for the medium rigid truck and 4.25 m for other "design" trucks. If vehicles with greater overall heights are to be accommodated, the above standards should be increased accordingly.

Where a vehicle's load may have to be secured or unsecured from the top of the vehicle, an additional clearance of 1.8 m should be added to the above standards.

Working clearances required by handling aids such as forklifts (Section 4.7.6) should, where appropriate, be considered.

In some instances open flat-deck vehicles can be loaded and unloaded using an overhead crane. If this method of goods handling is to be employed, the machine's overhead equipment should be positioned so that it does not prevent enclosed vehicles from using the dock.

To avoid conflict with the movement of a bus, and its loading and unloading, the headrooms that should be provided for all canopies, pedestrian shelters, plumbing, ducting or service pipes are those given in Table 4.7.5.

Table 4.7.5 Minimum headrooms (metres) for buses.

Midi-buses	4.0 m
Other buses	4.5 m

The standards in Table 4.7.5 are for the "design" vehicle heights which are of 3.2, 3.5 and 3.8 m for the midi-bus, city bus and tour coach respectively. To accomodate vehicles with greater overall height, the above standards should be increased accordingly.

Most loading and unloading of the unaccompanied cargo carried by buses is conducted manually with little use of handling aids. Working clearances for loading and unloading will therefore be determined by the volume and type of cargo, the nature of the loading/handling process and the surrounding physical constraints.

Where a vehicle has to go over a change in surface gradient, attention must be given to the effect the change in gradient has on the height requirements of the vehicle. This aspect is discussed in greater detail in Section 4.6 (Ramps and Gradients).

In some circumstances, additional headroom may be needed. A useful guide for this requirement are the safe loading heights for vehicles that have to cross North Island main trunk electrified railway line:

At public level crossings	5.24 m
In the Wellington area (low voltage)	4.50 m

The minimum overhead clearance required on motorways is 4.9 m. Otherwise the legal maximum vehicle height on public roads is 4.25 m (without special permission).

4.7.5 Waste Collection Vehicle Requirements

The use of vehicles for the collection of commercial and industrial waste is dependant on the nature of the industry and the type and quantity of waste. For example, if the waste is in a liquid form, a specialised tanker is used for its collection and disposal.

However, rubbish trucks that generally service industrial and medium to large commercial activities can be classified into one of the following three groups (Figures 4.7.4 to 4.7.6).

Figure 4.7.4 Jumbo bin truck.

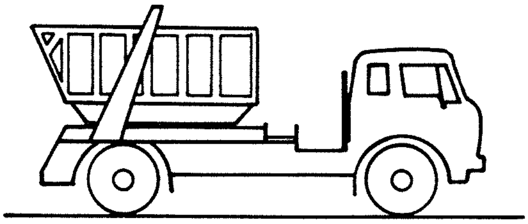


Figure 4.7.5 Roll-on bin truck.

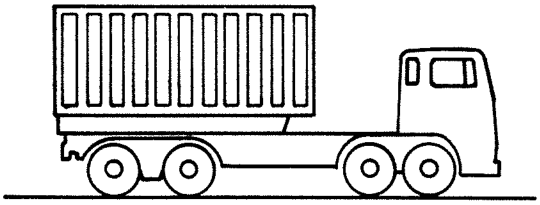
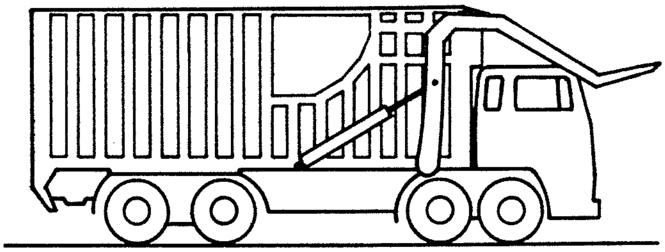


Figure 4.7.6 Front-lift compaction truck.



The spatial requirements for each of these three vehicles depends in part on the lifting equipment fitted to the vehicle. Consultation with appropriate truck operators is recommended to determine the requirements. However, typical minimum headroom requirements are given in Table 4.7.6.

Table 4.7.6 Headrooms (metres) for rubbish trucks.

Jumbo-bin truck	5.0 m
Roll-on bin truck	5.6 m
Front-lift compaction	5.7 m

4.7.6 Forklift Requirements

The range of forklifts available in New Zealand is diverse, with certain types being more suited to particular situations than others. In general, the most popular forklifts are those with a load capacity of 2 to 3 tonnes, that have either a 2- or a 3-stage lifting mast.

Such forklifts are often used to load and unload containers because of their ability to enter a container. Forklifts of this size tend also to be used to load and unload palletised goods from trucks, and to distribute this cargo within a warehouse or factory. Larger forklifts may be used in heavy industry though these are less common.

Where a loading area or dock is to accommodate forklifts, adequate headroom must be provided for their operation.

The most popular forklifts have the potential to lift their forks some 3.0 to 3.5 m above the ground, although this can be increased up to approximately 6.0 m with mast modifications. These heights exclude the height of the cargo above the level of the forks and the height of the load's backrest. Both of these should be considered in the assessment of available height.

The **minimum** working area of a forklift is often referred to as the area required for a "right angle stack". This is the minimum area for the forklift to pick up the goods, reverse back, manoeuvre through 90° to relocate the goods before reversing again to clear the goods of the forks. The minimum requirements are given in Table 4.7.7.

Table 4.7.7 Minimum work area requirements for 2.5-tonne forklifts.

Minimum working area	3.0 x 3.0 m
Additional working clearance	0.5 m
Maximum gradient	2.5% (1-in-40)

Additional allowance may have to be made for larger loads and forklifts with a higher lifting capacity. For example, palletised goods measuring 1.0 x 1.2 m would require a minimum clearance in excess of 4.0 x 4.0 m.

Most forklifts are fitted with very small wheels compared with those of trucks and so are more susceptible to irregularities or "pot holes" in the pavement surface. The working surface must therefore be relatively smooth with little or no deformation, and must be capable of carrying a loaded manoeuvring forklift.

In heavy industry or other working environments where heavy loads are moved (e.g. container terminals), the lifting capacity and operational requirements of the forklifts used may be significantly greater than those of the 2.5-tonne forklift discussed above. These operational requirements should be investigated and included in the design.

Where a vehicle is to be loaded or unloaded at a dock by a forklift, the transition(s) from the dock's platform to the deck of the vehicle must be considered.

4.7.7 Floor Gradients in Loading Areas

In loading areas, and areas where goods are to be stacked, the gradient of the floor or pavement surface should be as level as possible. This will facilitate safe forklift operation and handling of stacked goods. Sufficient gradient must however be provided for surface water run-off, and a gradient of 1-in-60 to 1-in-40 (1.7 - 2.5%) is recommended.

Where a vehicle is subjected to a change in surface gradient, the effect of the change in gradient on the height requirements of the vehicle must be considered. This aspect is discussed in detail in Section 4.6 (Ramps and Gradients).

4.7.8 Stairs and Steps

It is desirable to provide flights of stairs at the face of a dock to permit comfortable pedestrian movement between the ground and the platform.

The spacing of the flights depends on the nature of the operation, but should be provided at each end of small to medium sized docks. If a loading dock has a large number of bays, stairs should be located at reasonable intervals.

4.8 Parking

When a facility is to accommodate parked vehicles, the location and orientation of the parking is to be designed so that the general on-site traffic flows and site operations are not adversely affected by the parked vehicles or by the manoeuvring of the vehicles into and out of the designated parking spaces.

The layout of a parking area is dependent on the nature of the site operation, the type and location of adjacent constraints, and the types of vehicles expected to use the parking area.

Where possible the parking layout should be configured so that vehicles are able to enter and exit a parking space in a forward direction. This is particularly important where multi-unit vehicle combinations (semi-trailers, B-trains, A-trains and truck-and-trailers) are expected. Preferably this configuration would be complemented with a circulation system that has one-way aisles.

The dimensions of the parking space and aisle width/manoeuvring area are to be assessed using the appropriate "tracking curves" in Section 5, and the recommended clearances (Sections 4.5.3, 4.5.4). These clearances are to be applied as inter-vehicle clearances, not as vehicle-to-edge-of-parking-space clearances.

Where a vehicle does not have to turn to enter and leave a parking space, the width of the parking space is not to be less than 3.5 m.

Where the space is insufficient to provide a wide aisle/manoeuvring area, the width of the parking spaces is to be increased. The extent of this increase is to be determined using the appropriate "tracking curve" (Section 5) and clearance (Sections 4.5.3, 4.5.4).

The overall depth of the parking space is in part a function of the type of vehicle using the space and of the angle at which the parking is arranged relative to the aisle. Table 4.8.1 sets out the parking space depths related to parking space width and parking angle for each of the "design" vehicles. (For information regarding the minimum aisle width for these parking spaces, refer to Table 4.8.2 and Figure 4.8.2.) Figure 4.8.1 illustrates the terms used in Table 4.8.1. Using a sub-set of these data a worked example is as follows:

Assume:
- medium rigid truck
- 30° angle
- width of required parking space = 3.5 m

Therefore: depth of space (D) = 4.25 + (0.87 x 3.5)
= 7.295 m, (say 7.3 m)

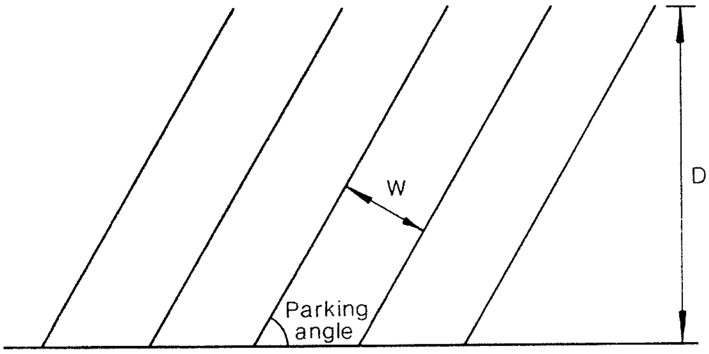
Table 4.8.1 sets out a mathematical equation to determine the parking space depth (D) from the parking space width (W) for each of the seven "design" vehicles at four parking angles. (Figure 4.8.1 illustrates the terms depth, width, and parking angle.)

It should be noted that the depth of a parking space at 90° is independent of the width and depends only on the length of the vehicle.

Table 4.8.1 Determination of minimum parking space depths (D in metres) for pre-determined parking widths (W in metres), at four parking angles. Figure 4.8.1 illustrates these terms.

Vehicle Type	**Parking Angle** **30°**	**45°**	**60°**	**90°**
Medium rigid truck	4.25+0.87W	6.16+0.71W	7.68+0.5W	9.0
Large rigid truck	5.75+0.87W	8.28+0.71W	10.28+0.5W	12.0
Semi-trailer	8.75+0.87W	12.52+0.71W	15.47+0.5W	18.0
B-train	10.25+0.87W	14.64+0.71W	18.07+0.5W	21.0
Midi-bus	4.92+0.87W	7.10+0.71W	8.84+0.5W	10.3
City bus	5.90+0.87W	8.49+0.71W	11.54+0.5W	12.3
Tour coach	6.55+0.87W	9.41+0.71W	11.66+0.5W	13.6

Figure 4.8.1 Explanation of dimensions depth (D) width (W) and parking angle used for parking bays in Table 4.8.1.



Where an alternative parking angle is to be used, the parking bay should be long enough so that the appropriate "design" vehicle can sit within the bay with a minimum of 0.5 m clearance from either end of the vehicle to the end of the bay.

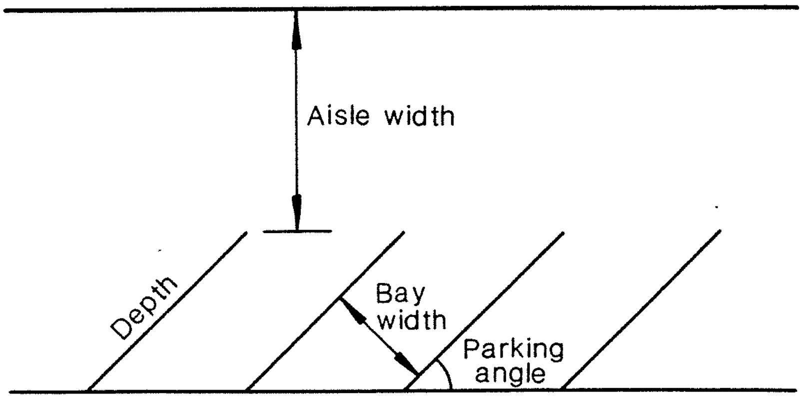
To obtain the maximum use of the available parking space, different parking angle configurations should be considered. The most efficient carpark layout often is that with 90° parking but at this angle trucks and buses will require particularly wide parking bays and aisle widths. Conversely a reduction in parking angle will reduce the aisle and parking bay widths but will result in an increase in the overall length of the bay. The smaller angles are generally preferred for large vehicles.

Table 4.8.2 sets out the minimum parking aisle widths required to enable the "design" vehicles to enter the recommended parking bay width of 3.5 m. Where the bay width is more than 3.5 m, a decrease in the aisle width may be possible. This should be determined using the appropriate "tracking curves" (Section 5).

Table 4.8.2 Minimum parking aisle widths (W in metres) for "design" vehicles using 3.5 m wide parking bays, at three parking angles. (Figure 4.8.2 illustrates terms.)

Vehicle Type	**Parking Angle** **30°**	 **60°**	 **90°**
Medium rigid truck	6.0	10.5	16.0
Large rigid truck	8.0	14.0	19.5
Semi-trailer	11.0	19.0	26.0
B-train	11.0	19.0	26.0
Midi-bus	6.0	10.5	16.0
City bus	8.0	14.0	19.5
Tour coach	10.0	18.0	24.0

Figure 4.8.2 Explanation of dimensions and parking angle used for parking aisle widths in Table 4.8.2.



5. HEAVY VEHICLE TRACKING CURVES

5.1 Introduction

"Tracking curves" provide specific details recommended for the design of facilities used by large heavy vehicles. The "tracking curves" are reproduced in this text at a scale of 1:500. The "tracking curves" have been grouped and numbered according to "design" vehicles.

Although every effort has been made to ensure that the scale of the copies is accurate, subtle distortions can be introduced during the reproduction of the originals. Care and judgement are therefore needed when using the "tracking curves". The linear scale provided on each figure is to be used to help detect such changes.

5.2 Tracking Curves for Trucks

5.3 Tracking Curves for Buses

5.4 Explanatory Notes to Tracking Curves

Each of the "simple" "tracking curves" is made up of a number of swept paths. In each case the paths followed by the outer part of the front of the vehicle's body, the outer steering wheel and the inside edge of the vehicle's body at the rear axis are shown. The centre of the turning circle is marked "+".

Notes [(a)] - [(f)] concerning some kinds of heavy vehicles are to be considered before using the specific "tracking curve" for design purposes.

[(a)] Large rigid trucks executing a turning radius of 10.0 m:
8x4 vehicles (twin steers) may not be able to execute this turn.

[(b)] Semi-trailers executing a turning radius of 10.0 m:
Significant tyre scuff can be expected from the trailer when the angle of turn is greater than 120°.

[(c)] B-trains executing a turning radius of 10.0 m:
Significant tyre scuff can be expected from the rearmost trailer when the angle of turn is greater than 120°.

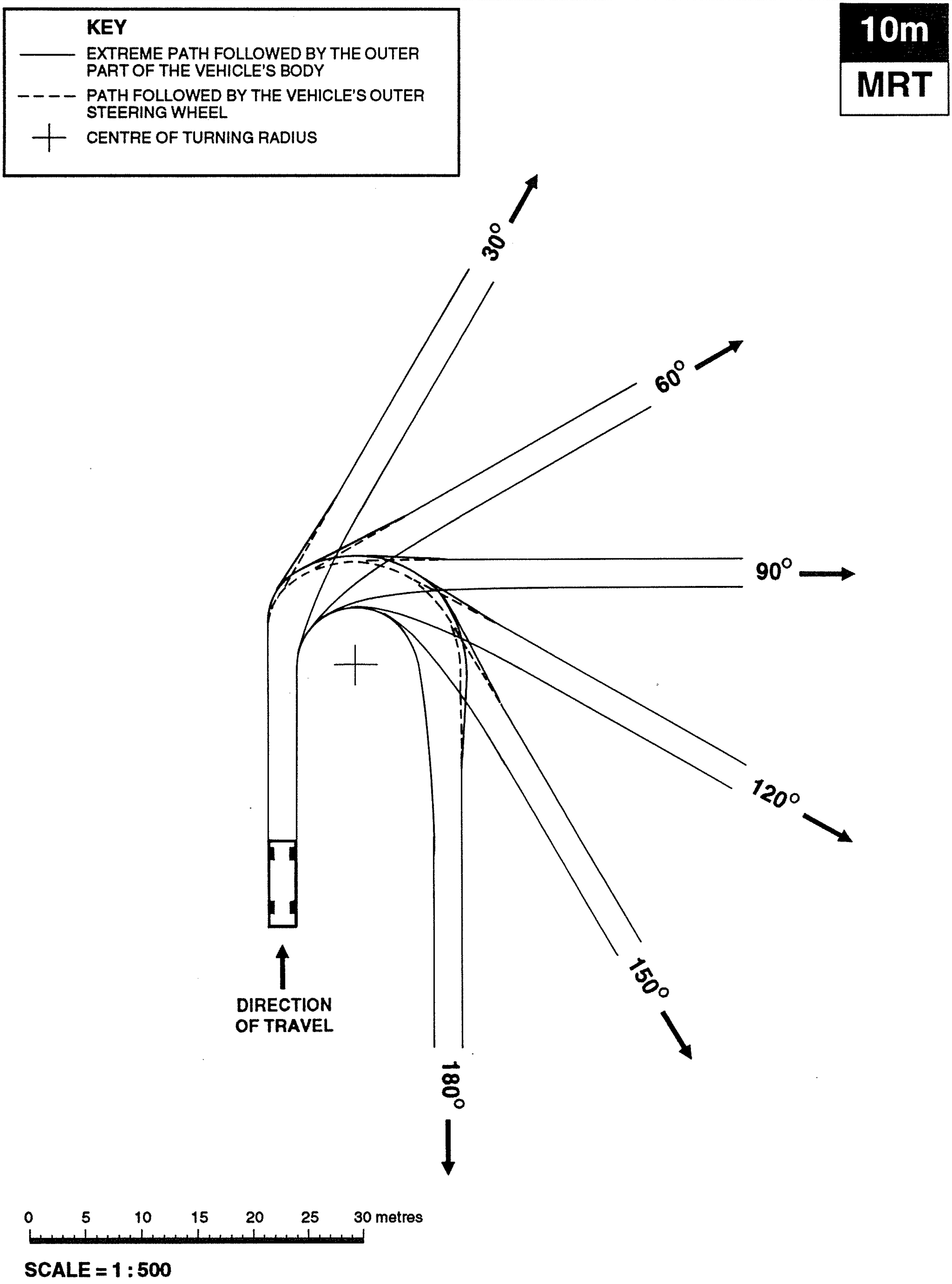
[(d)] Most city buses are unable to execute a 10.0 m radius turn.

[(e)] Tour coaches executing a turning radius of 12.5 m:
Most tour coaches are unable to execute turns much tighter than 12.5 m. Although all vehicles are required by law to satisfy this requirement, these vehicles will require the application of full lock to achieve this turn.

[(f)] Complex turns
The complex turns only cover vehicle manoeuvring to the standing point at the completion of reversing. The forward "tracking curves" should be used for the exit from this standing point.

An infinite number of manoeuvring scenarios exist for each vehicle and those illustrated in these "tracking curves" are but one example. Complex turns which involve reversing have not been prepared for the B-train "design" vehicle as these vehicles should not be reversed if possible. Where reversing cannot be avoided, the simple "tracking curve" should be used to ensure that the vehicle can be straightened before executing the reverse manoeuvre.

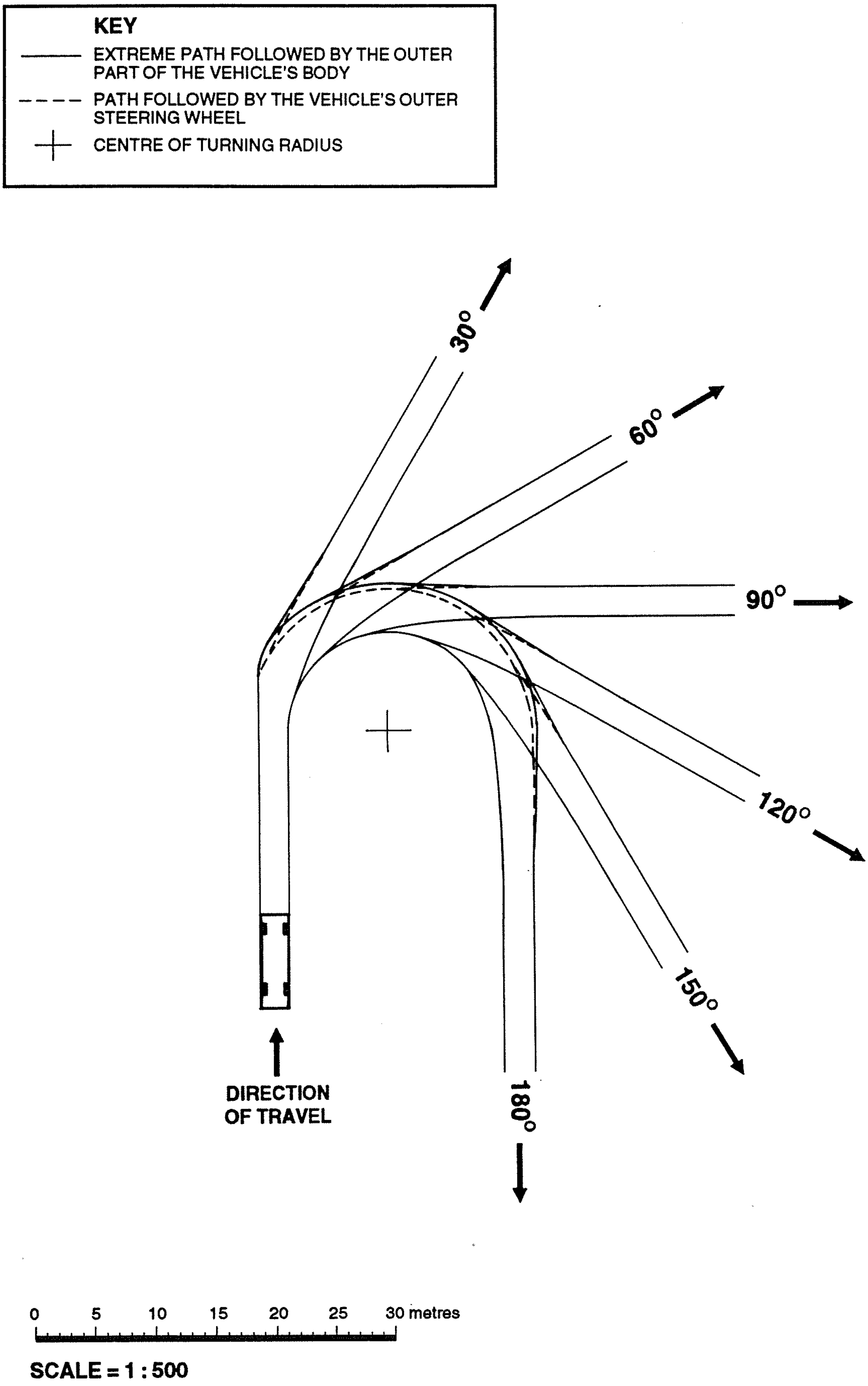
The "tracking curves" for complex turns show the swept path envelope defined by the front corners of the vehicle's body and the vehicle's rearmost rear axis.



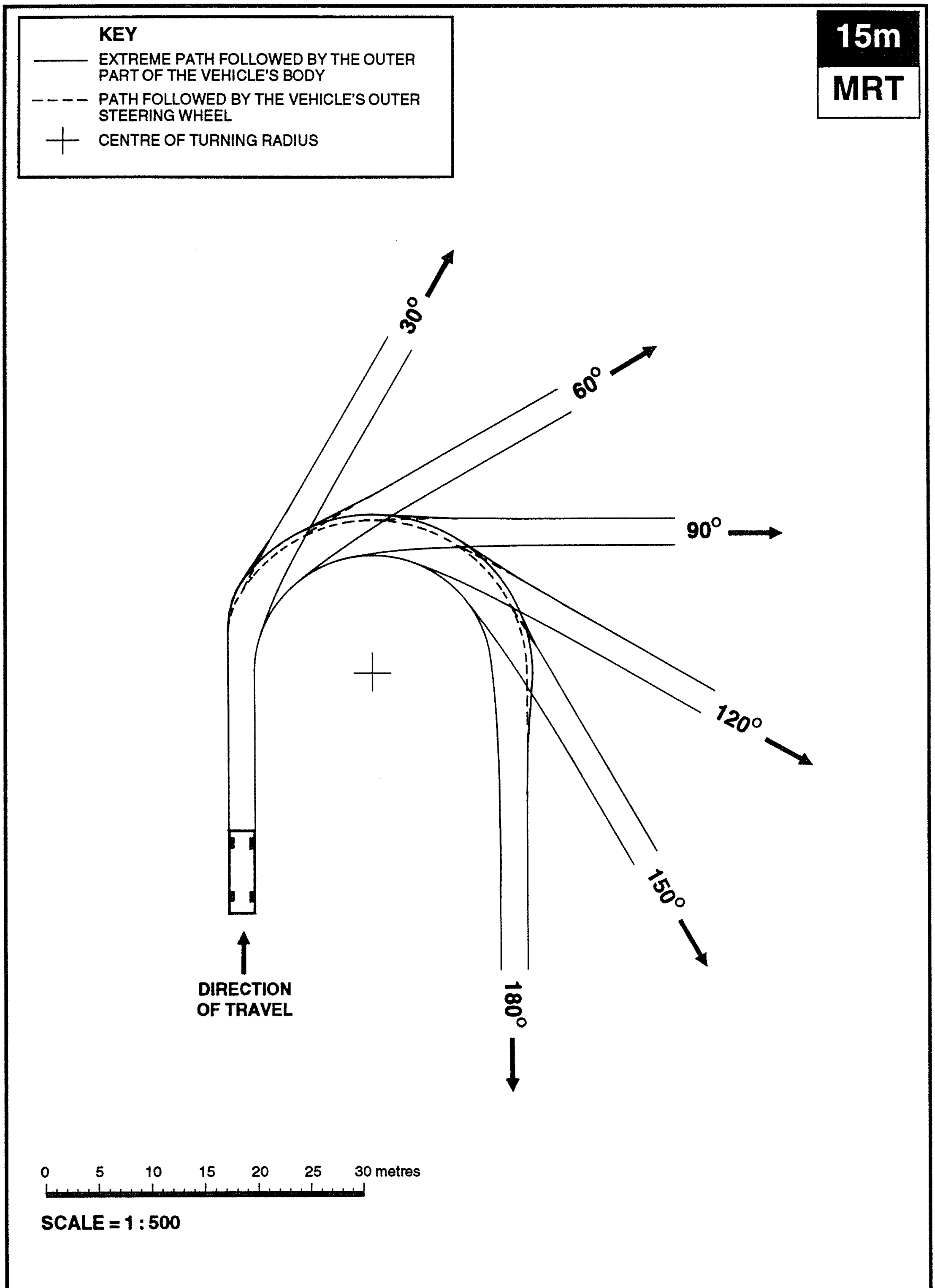
TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A MEDIUM RIGID TRUCK (MRT)

12.5m

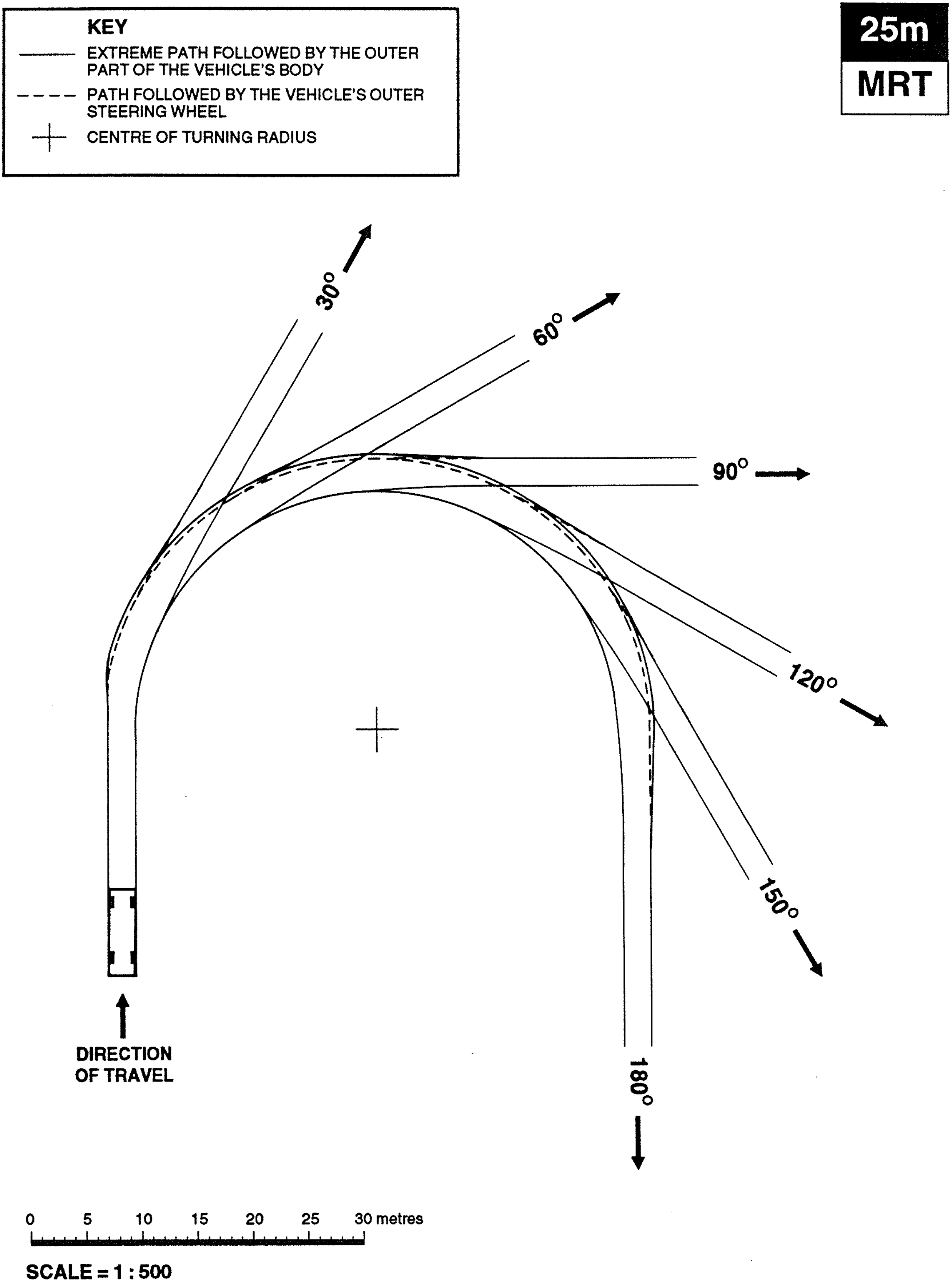
MRT



TRACKING CURVE WITH TURNING RADIUS OF 12.5 METRES FOR A MEDIUM RIGID TRUCK (MRT)



TRACKING CURVE WITH TURNING RADIUS OF 15 METRES FOR A MEDIUM RIGID TRUCK (MRT)

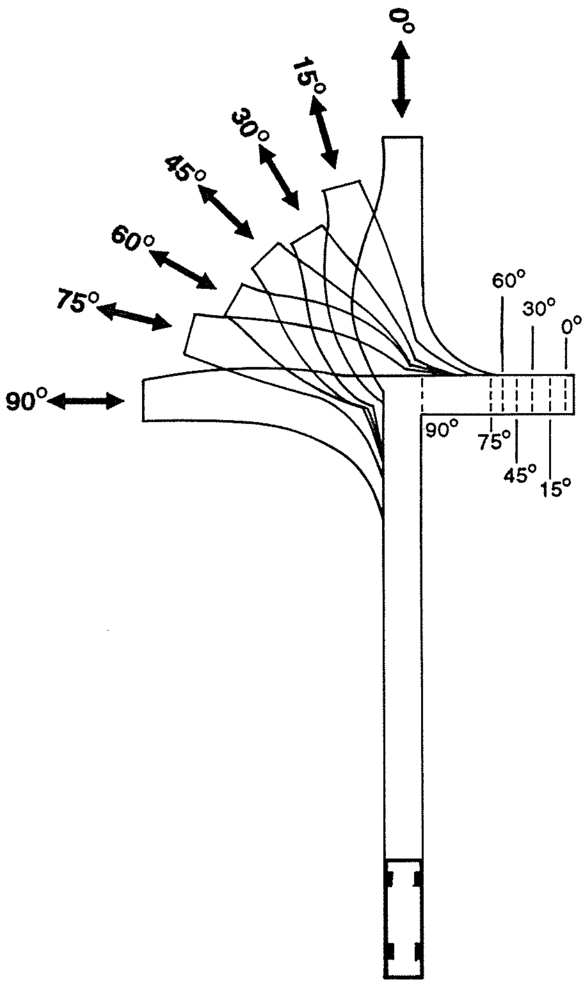


TRACKING CURVE WITH TURNING RADIUS OF 25 METRES FOR A MEDIUM RIGID TRUCK (MRT)

MRT

x° Closest position of a dock face to the manoeuvring area where rear of truck is flush with dock face, for x° angle of turn and for manoeuvre shown.

NOTE: These curves are to be used for the reversing manoeuvre. For the forward manoeuvre use basic tracking curves for MRT. Tailswing is not shown.

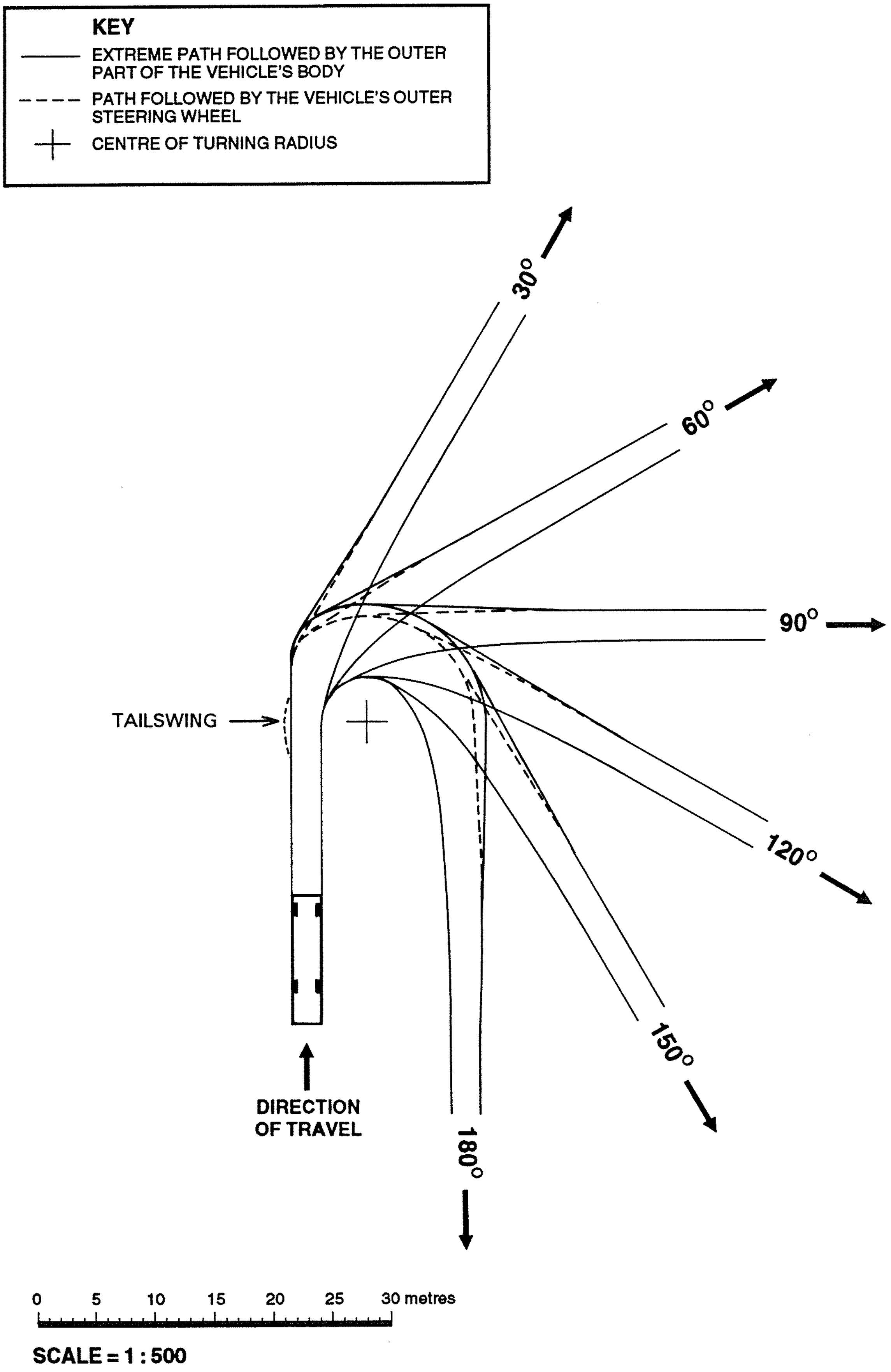


SCALE = 1 : 500

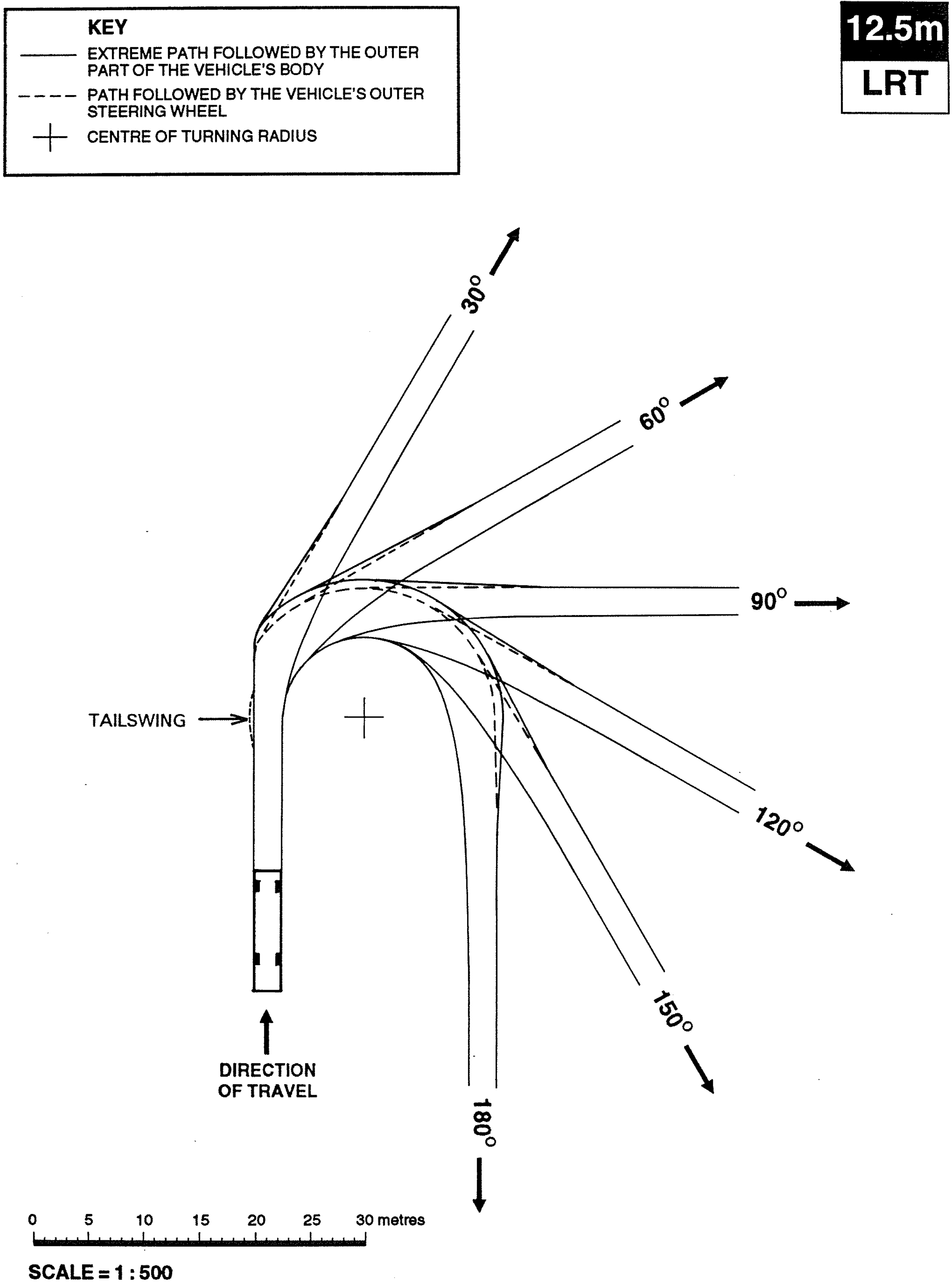
TRACKING CURVES SUITABLE FOR COMPLEX TURNS FOR A MEDIUM RIGID TRUCK (MRT)

10m

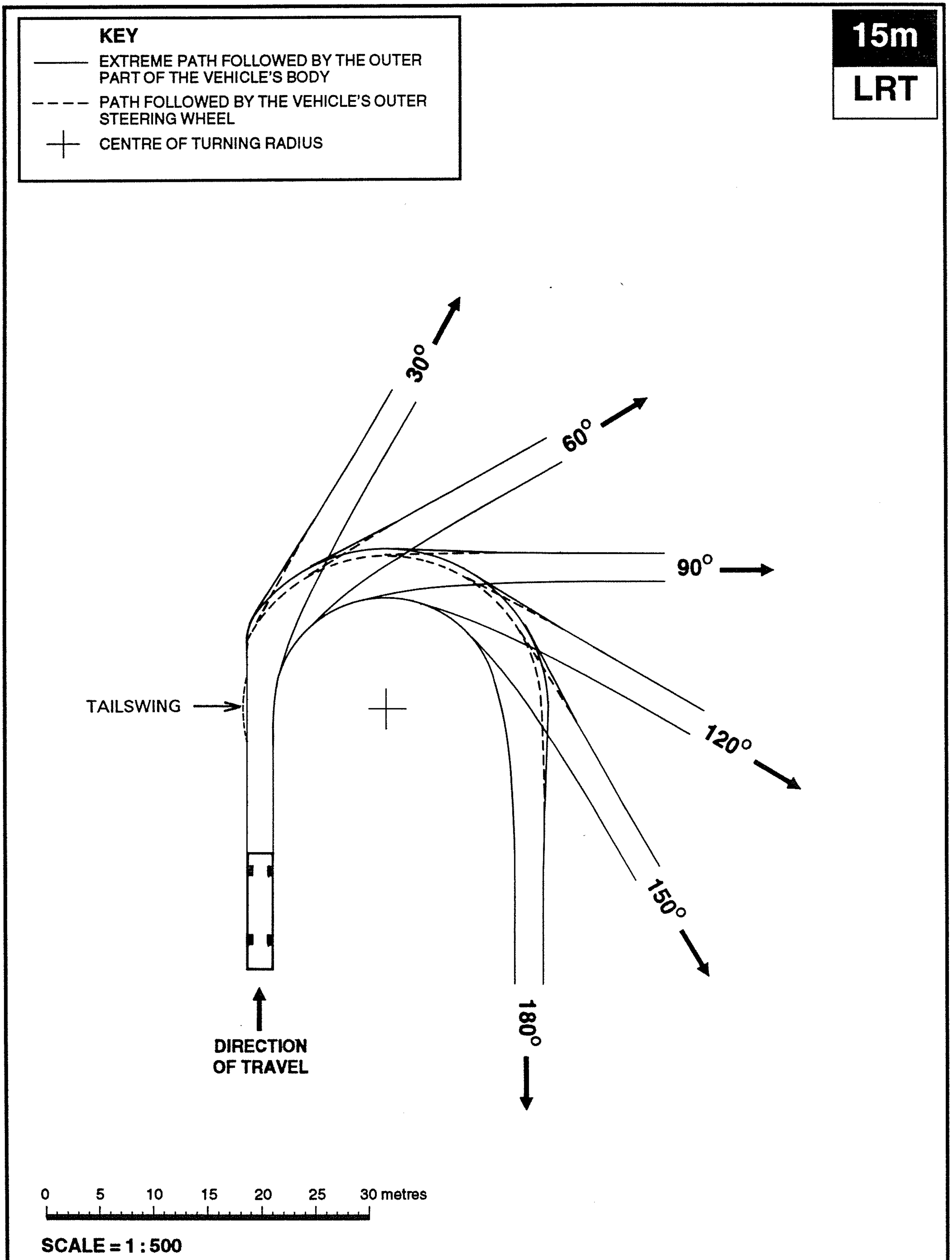
LRT



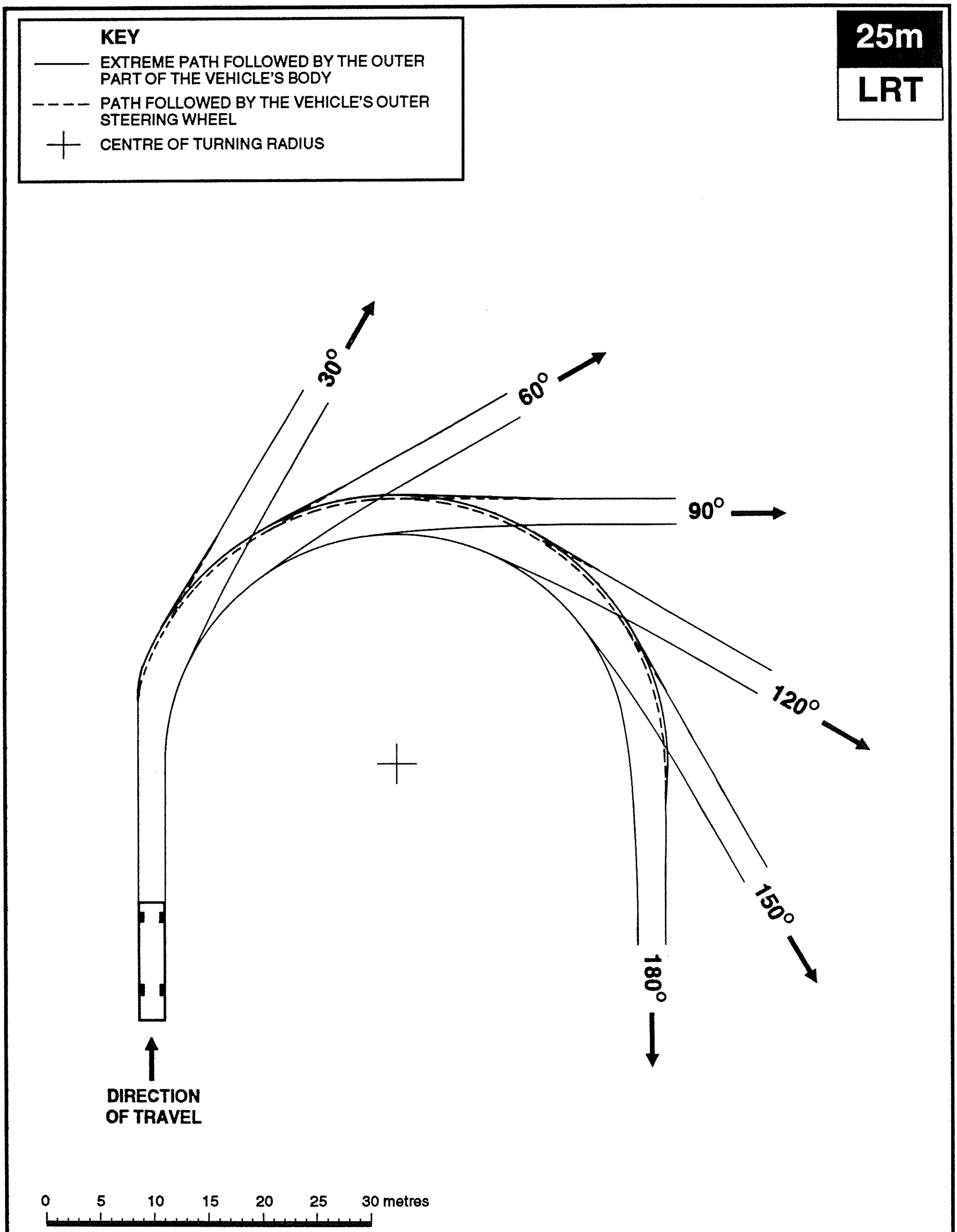
TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A LARGE RIGID TRUCK (LRT)



TRACKING CURVE WITH TURNING RADIUS OF
12.5 METRES FOR A LARGE RIGID TRUCK (LRT)



TRACKING CURVE WITH TURNING RADIUS OF 15 METRES FOR A LARGE RIGID TRUCK (LRT)

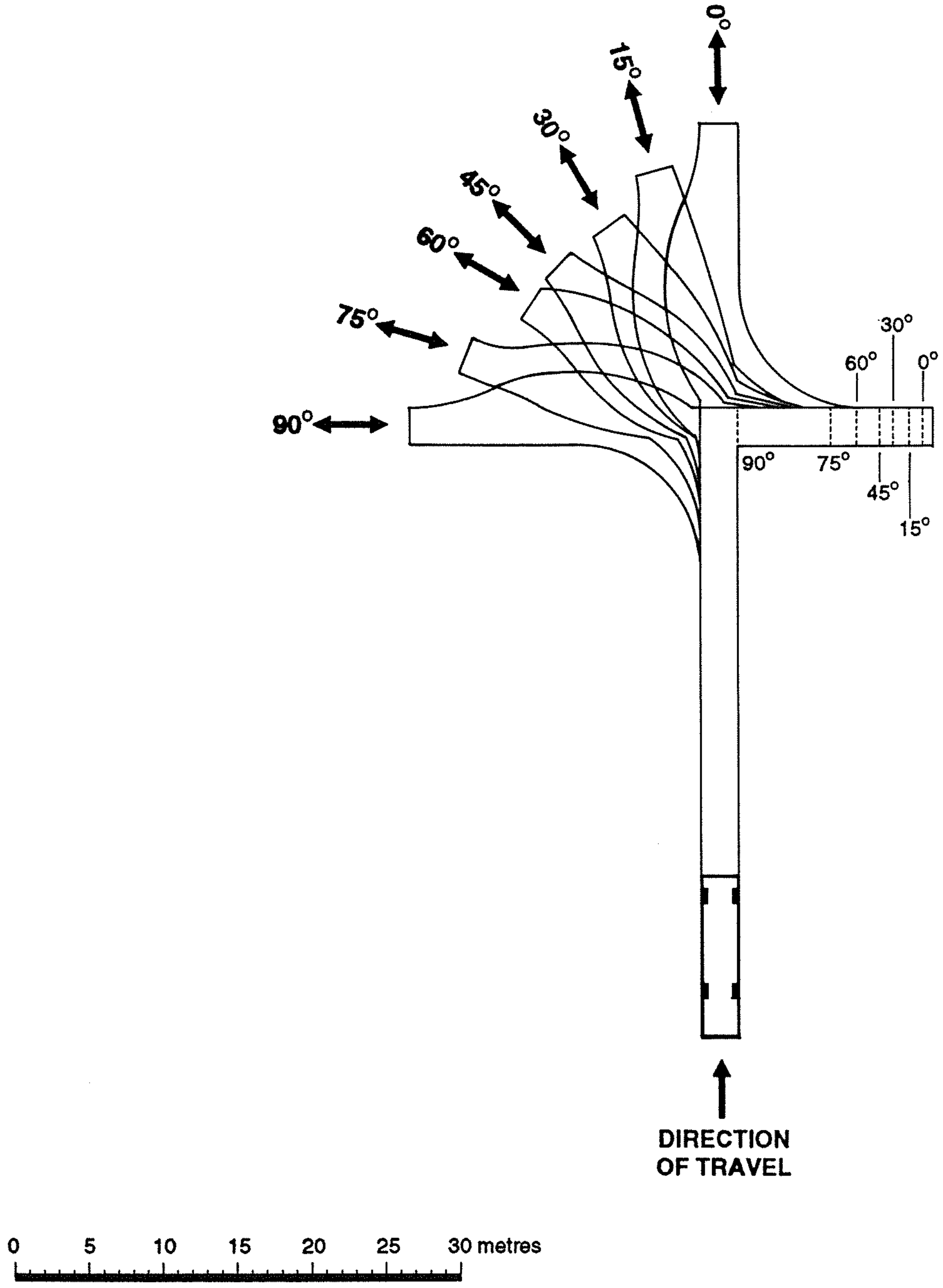


TRACKING CURVE WITH TURNING RADIUS OF 25 METRES FOR A LARGE RIGID TRUCK (LRT)

LRT

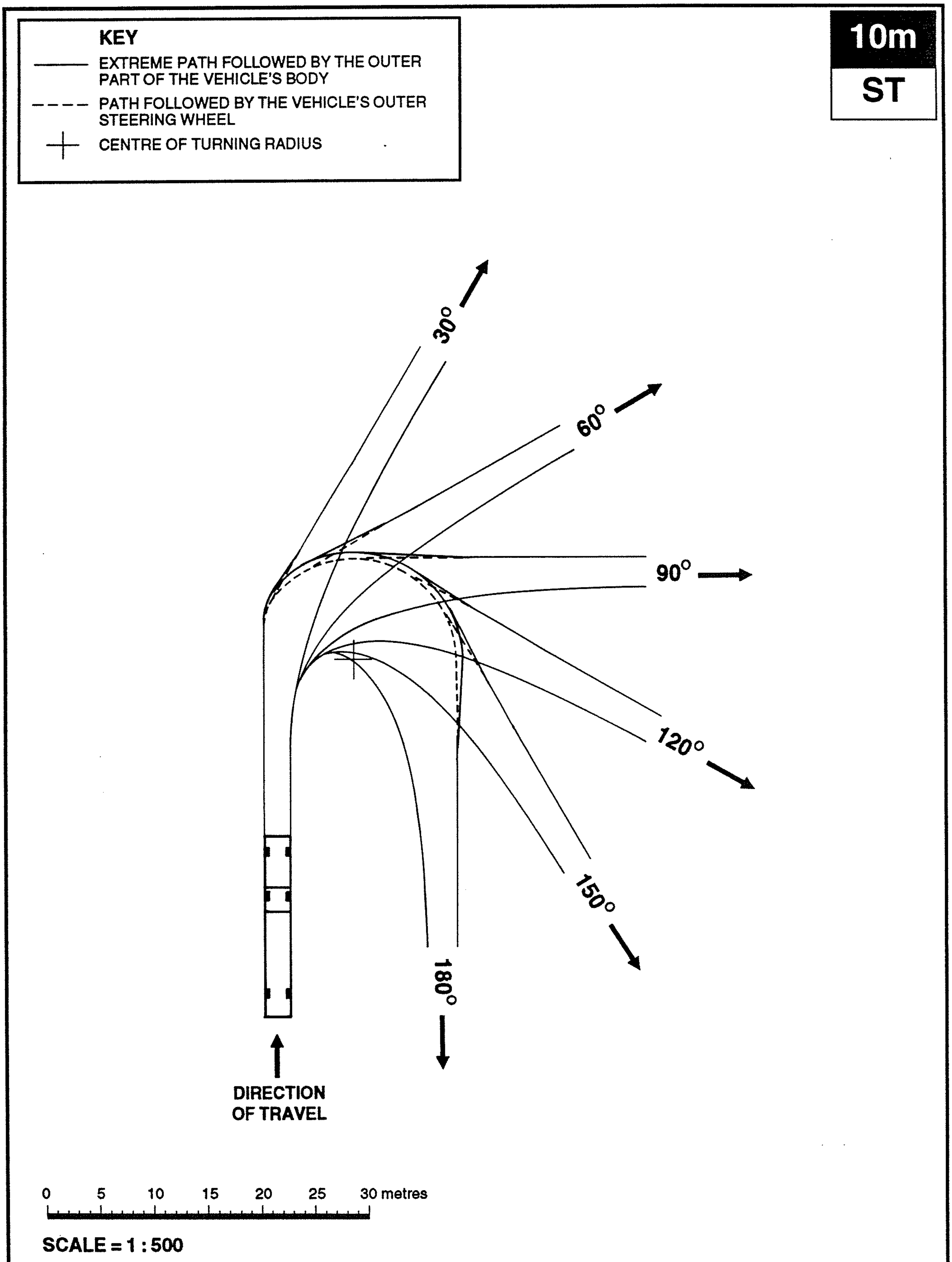
x° Closest position of a dock face to the manoeuvring area where rear of truck is flush with dock face, for x° angle of turn and for manoeuvre shown.

NOTE: These curves are to be used for the <u>reversing</u> manoeuvre. For the forward manoeuvre use basic tracking curves for LRT. Tailswing is not shown.



SCALE = 1 : 500

TRACKING CURVES SUITABLE FOR COMPLEX TURNS FOR A LARGE RIGID TRUCK (LRT)



TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A SEMI-TRAILER (ST)

12.5m

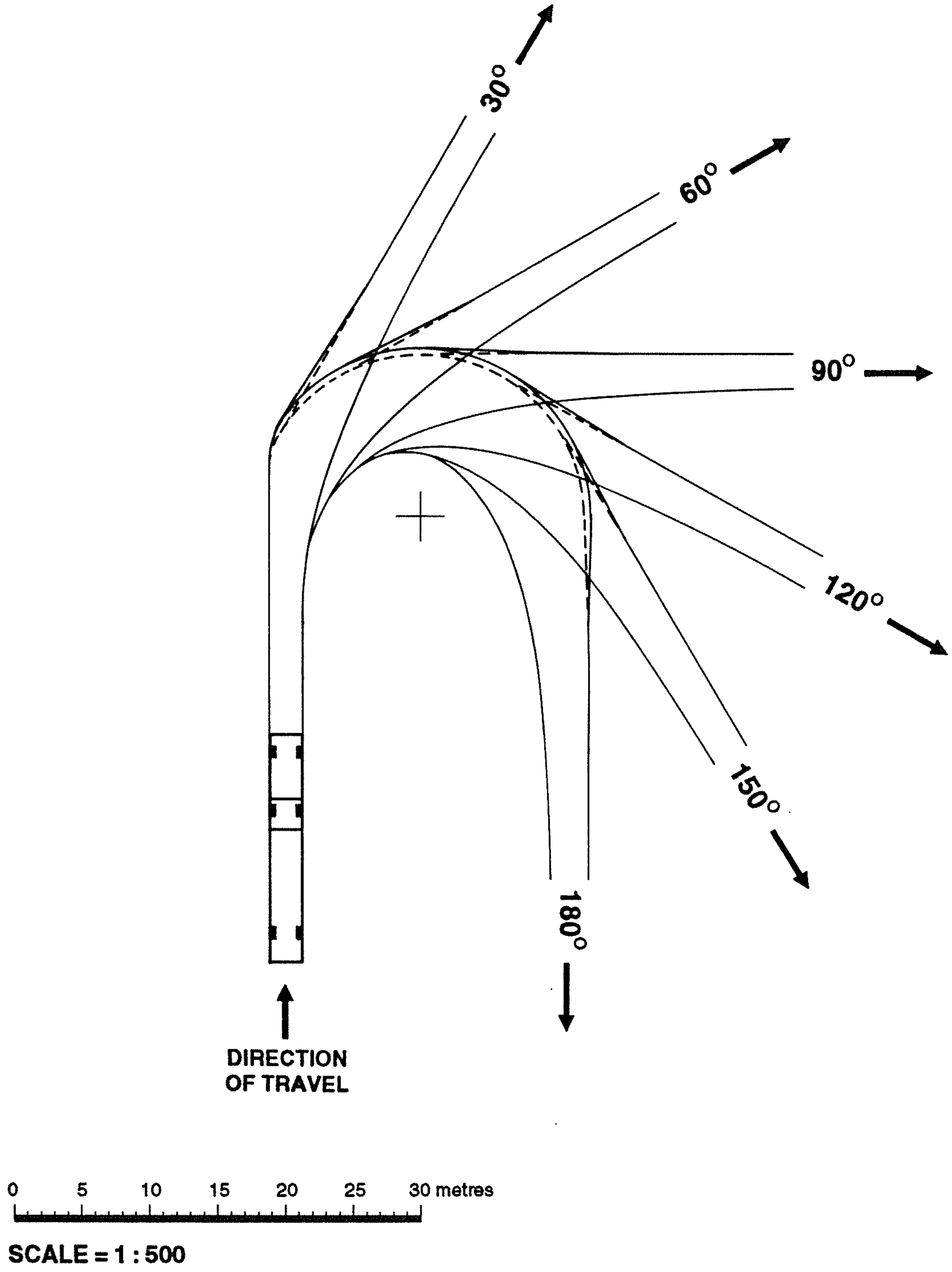
ST

KEY

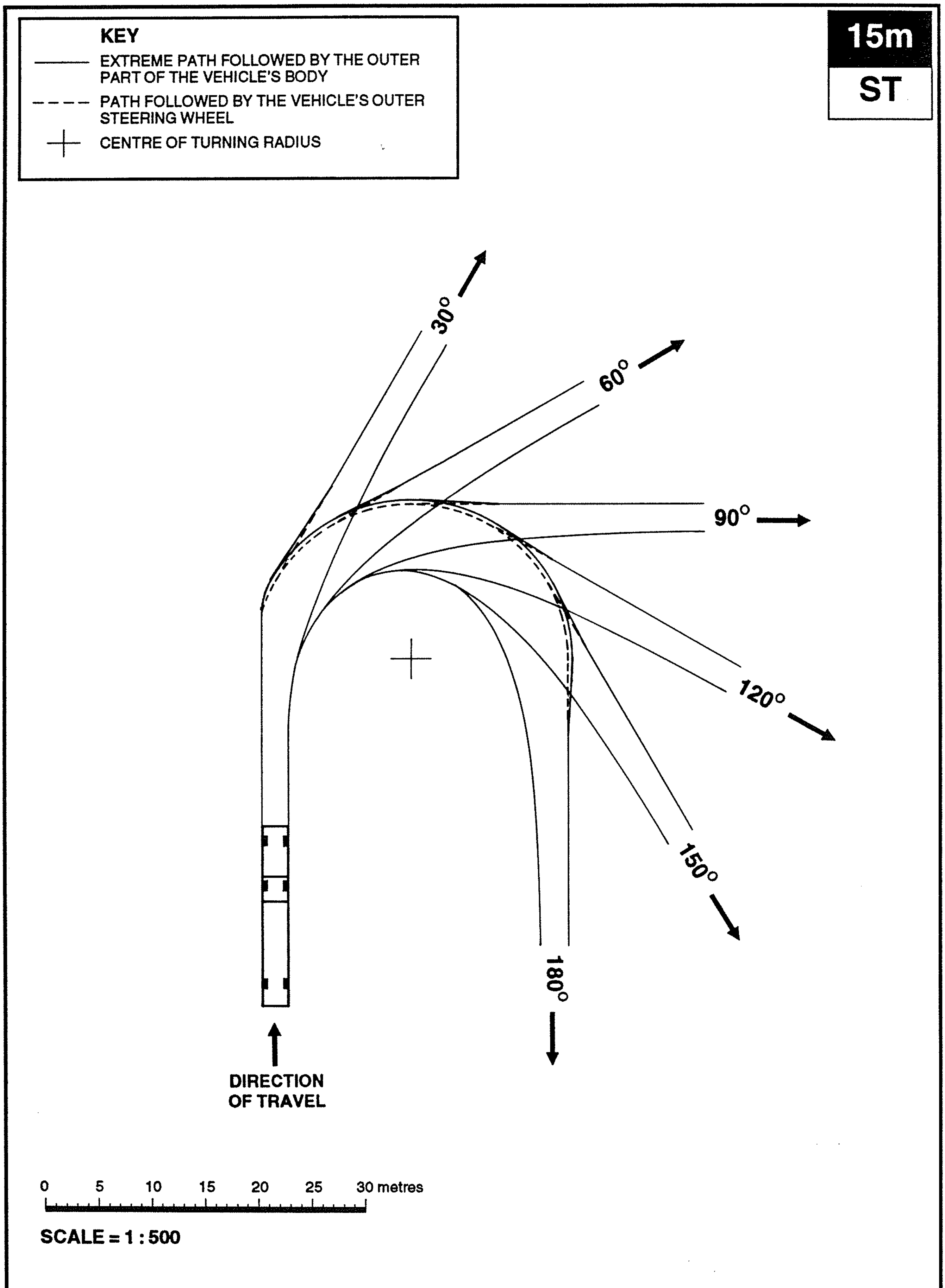
——— EXTREME PATH FOLLOWED BY THE OUTER PART OF THE VEHICLE'S BODY

– – – – PATH FOLLOWED BY THE VEHICLE'S OUTER STEERING WHEEL

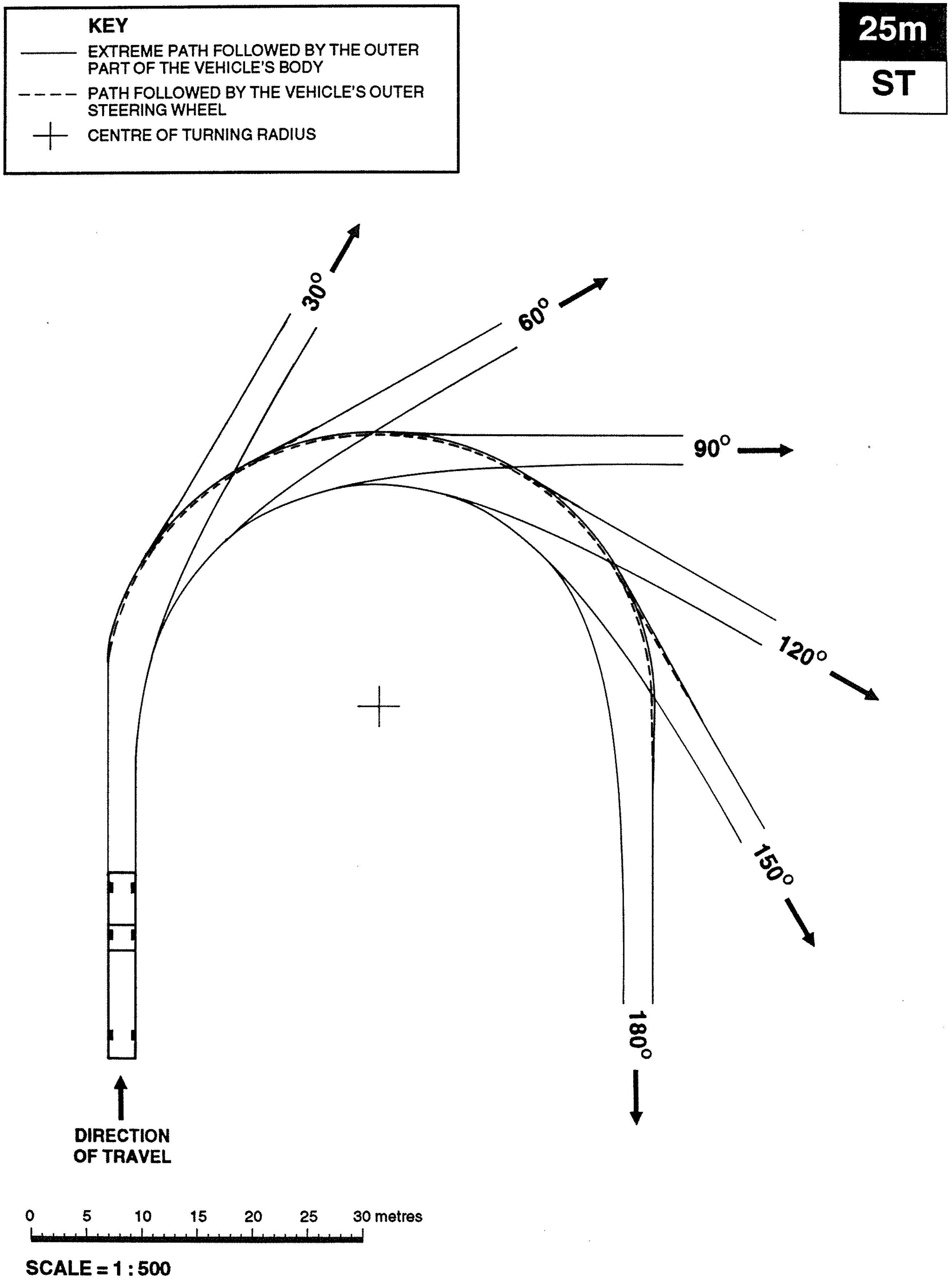
┼ CENTRE OF TURNING RADIUS



TRACKING CURVE WITH TURNING RADIUS OF 12.5 METRES FOR A SEMI-TRAILER (ST)



TRACKING CURVE WITH TURNING RADIUS OF 15 METRES FOR A SEMI-TRAILER (ST)

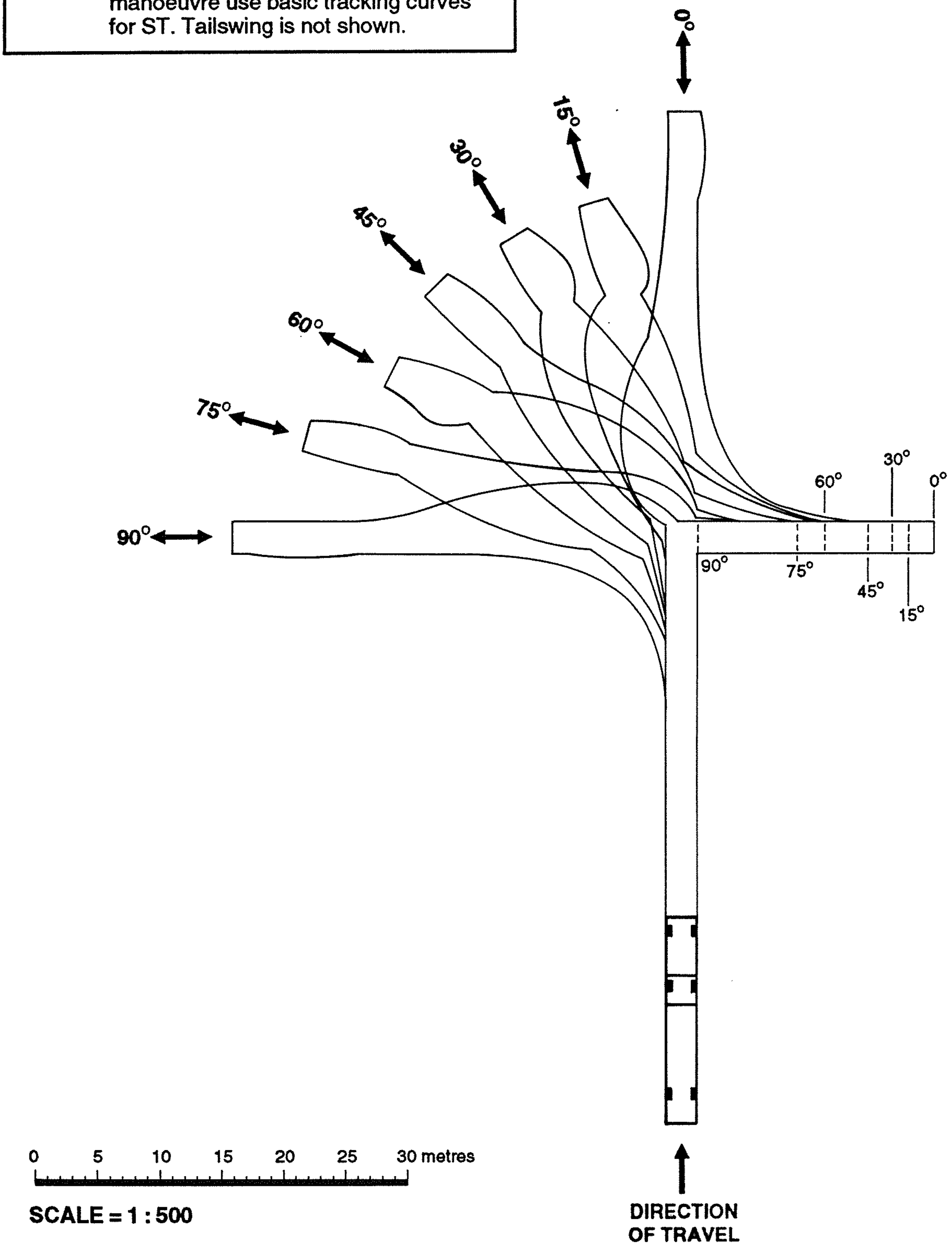


TRACKING CURVE WITH TURNING RADIUS OF 25 METRES FOR A SEMI-TRAILER (ST)

ST

x° Closest position of a dock face to the manoeuvring area where rear of truck is flush with dock face, for x° angle of turn and for manoeuvre shown.

NOTE: These curves are to be used for the reversing manoeuvre. For the forward manoeuvre use basic tracking curves for ST. Tailswing is not shown.



TRACKING CURVES SUITABLE FOR COMPLEX TURNS FOR A SEMI-TRAILER (ST)

10m

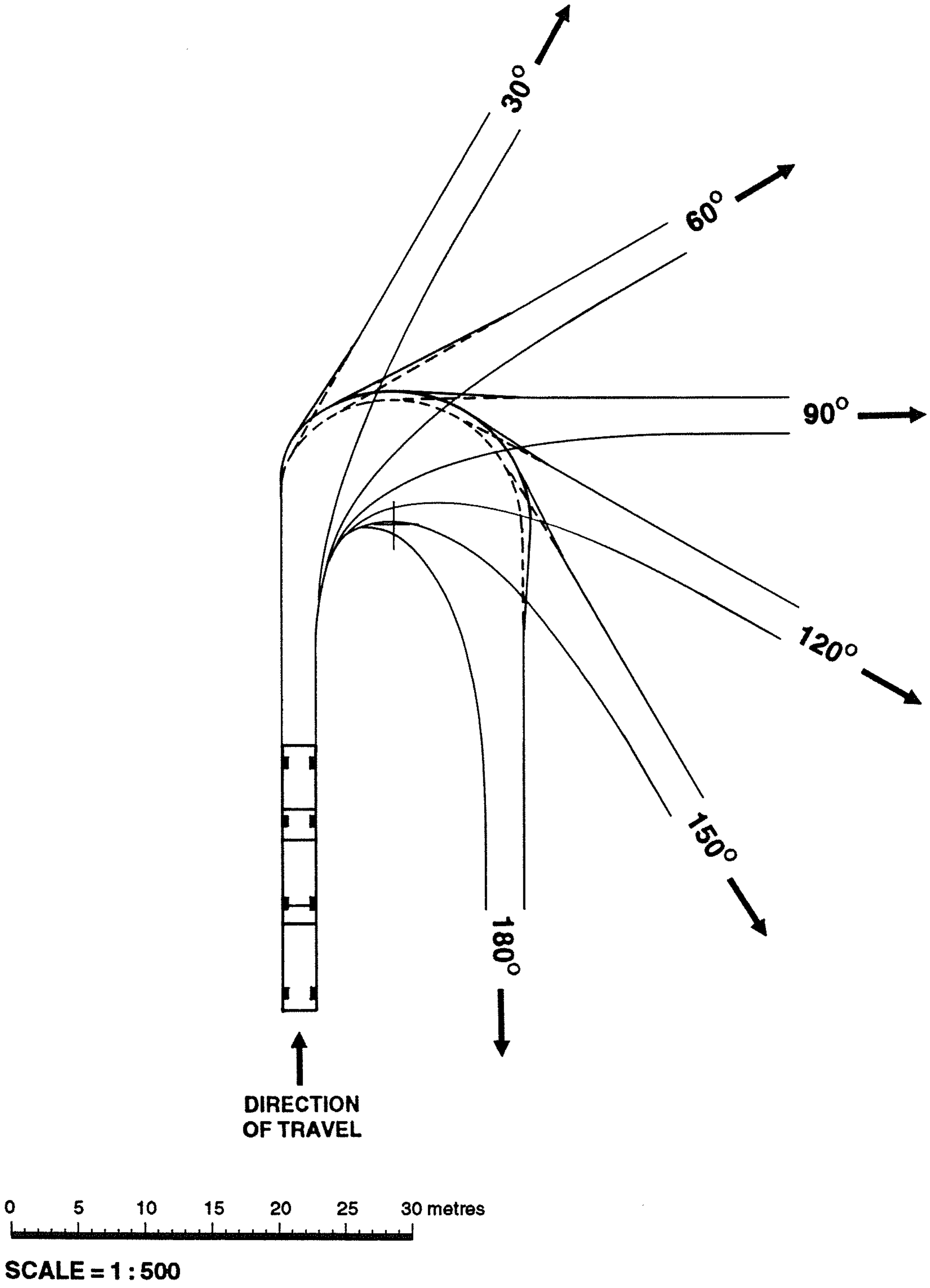
BT

KEY

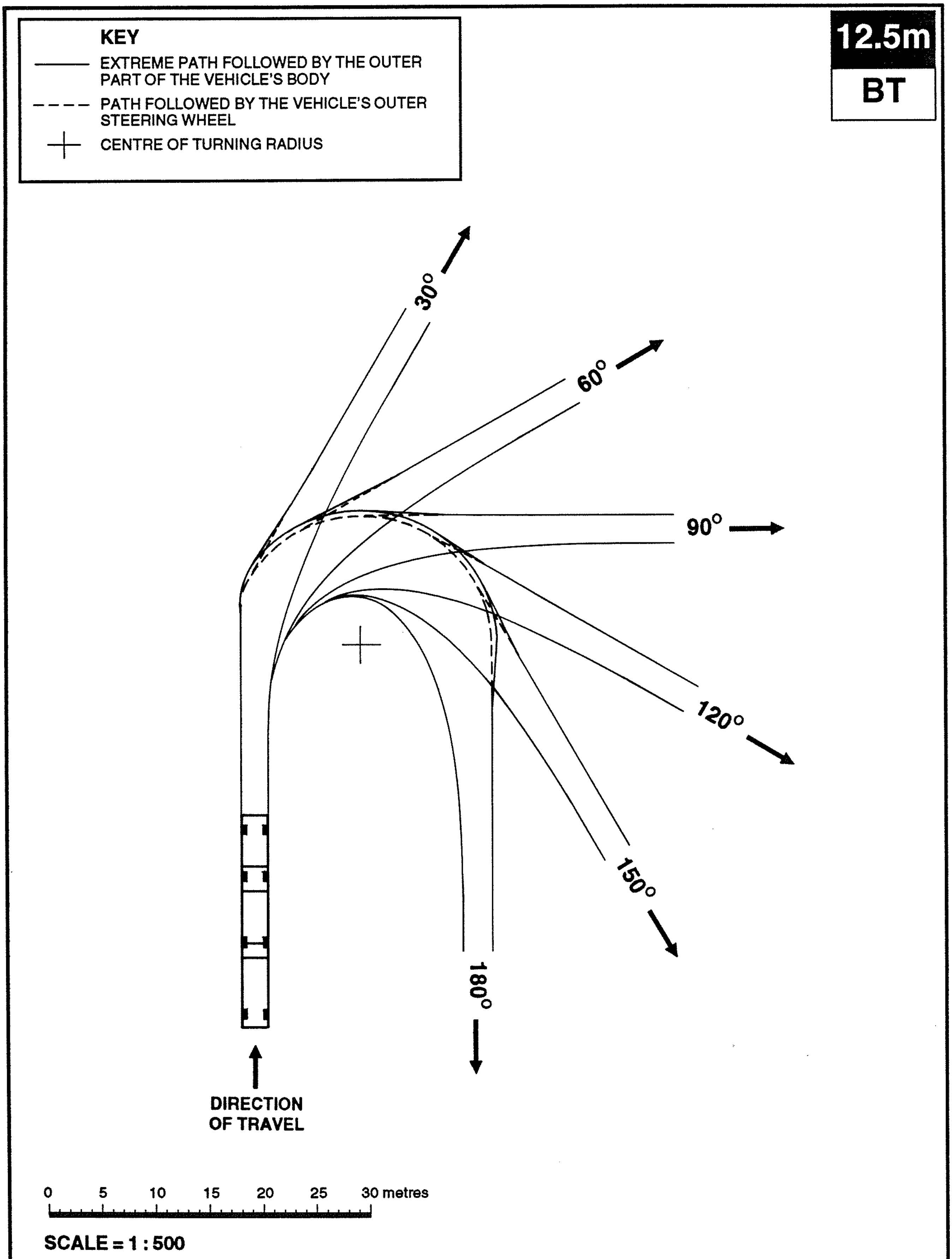
——— EXTREME PATH FOLLOWED BY THE OUTER PART OF THE VEHICLE'S BODY

- - - - PATH FOLLOWED BY THE VEHICLE'S OUTER STEERING WHEEL

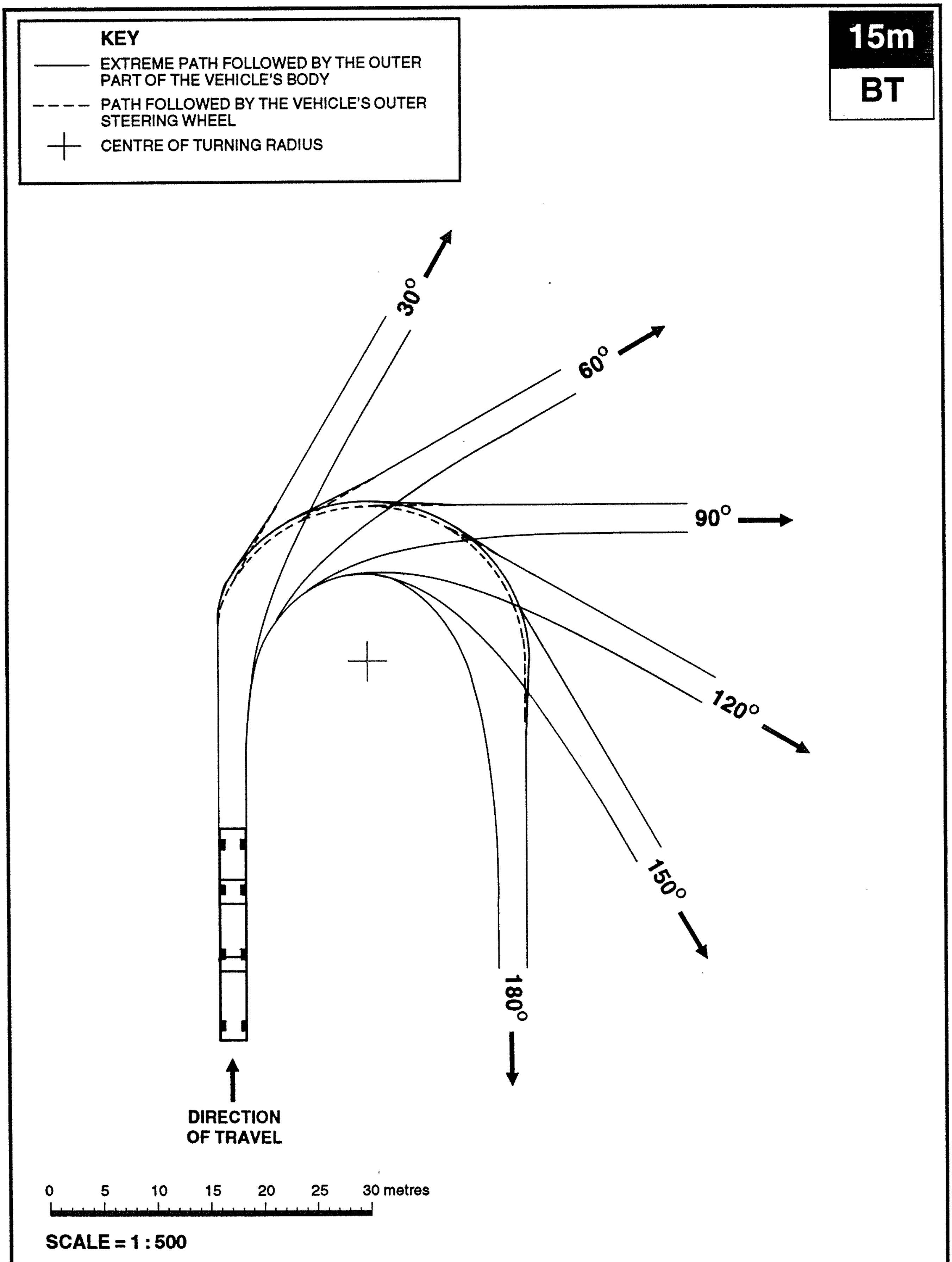
┼ CENTRE OF TURNING RADIUS



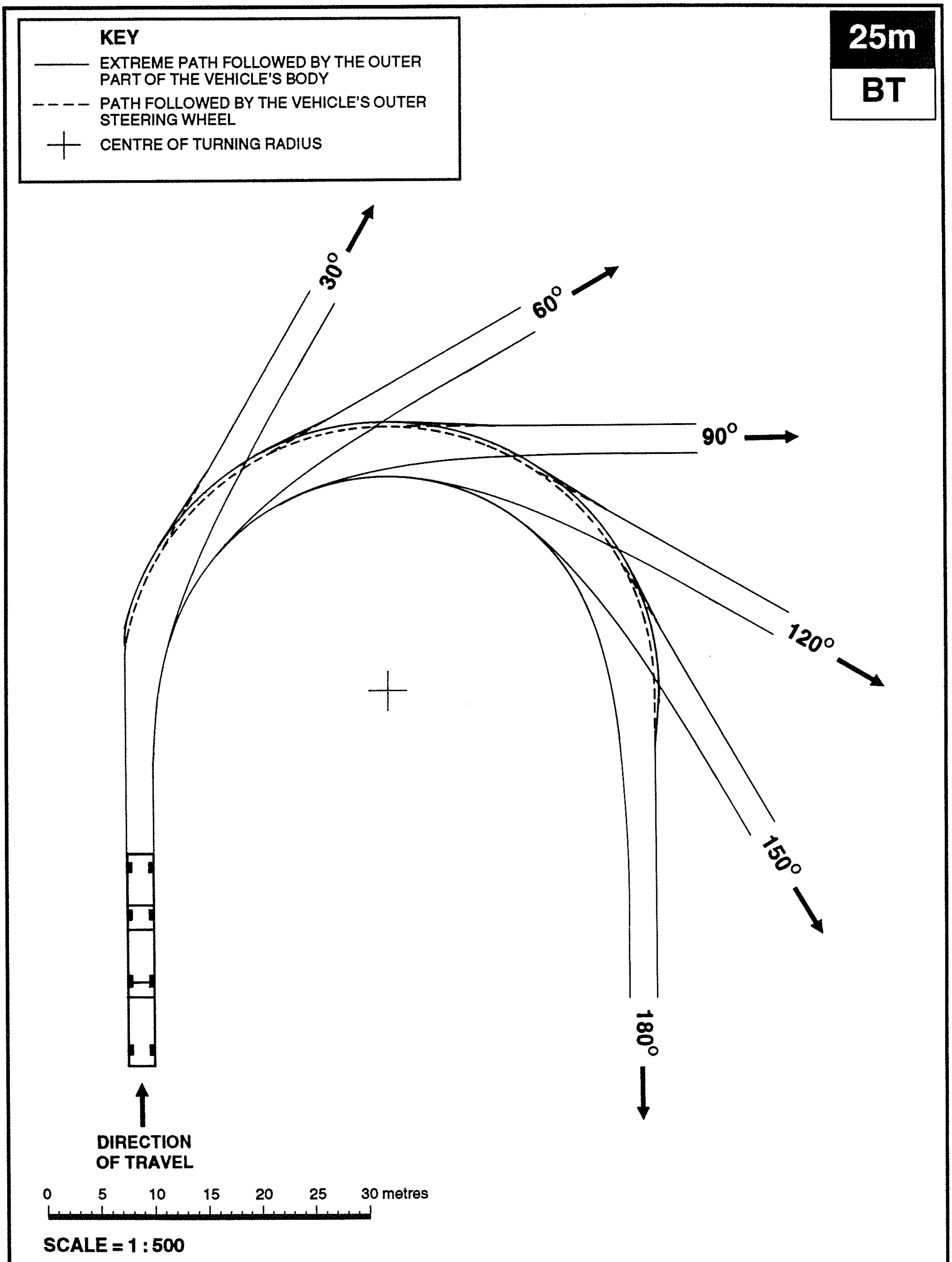
TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A B-TRAIN (BT)



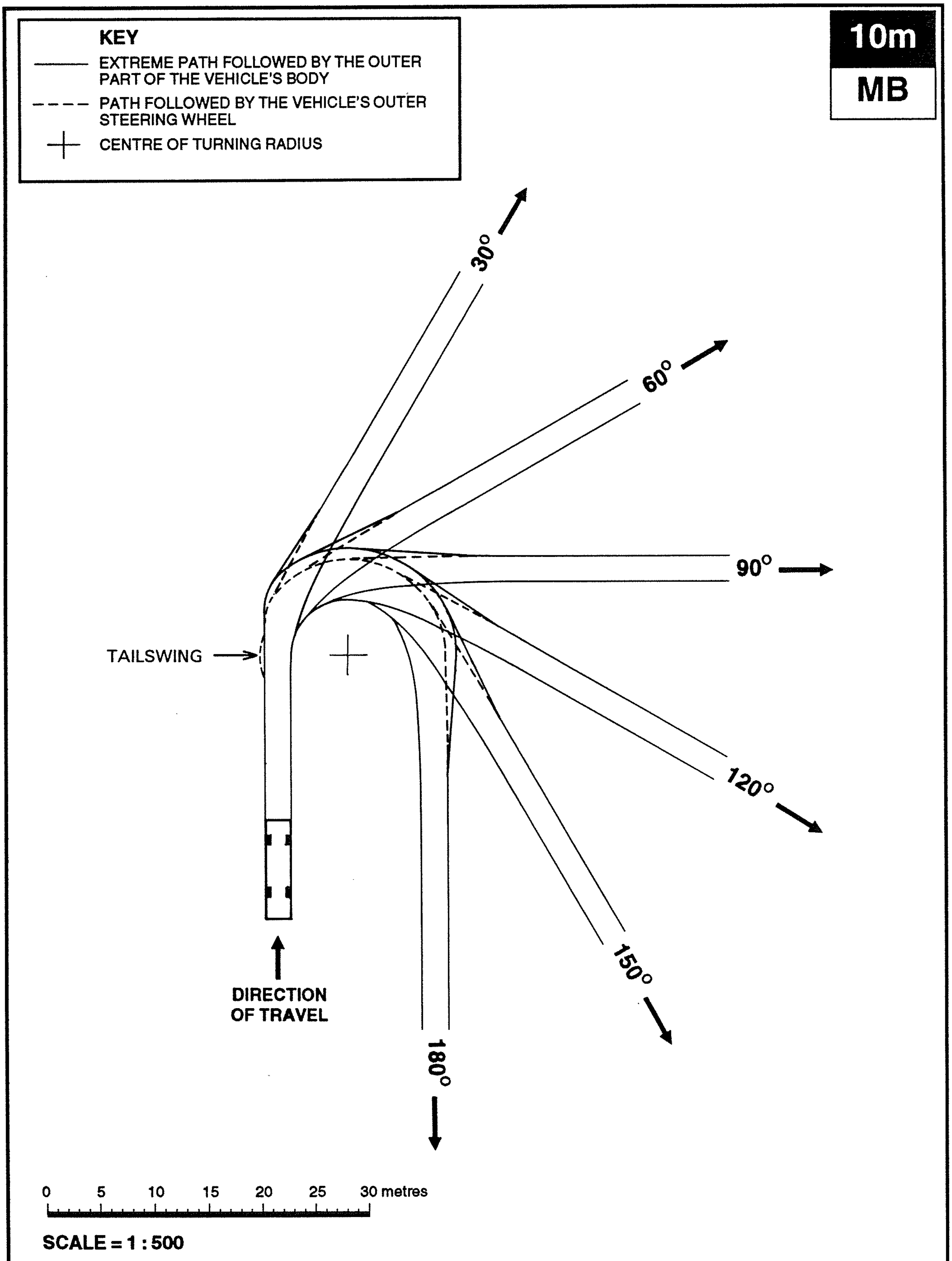
TRACKING CURVE WITH TURNING RADIUS OF 12.5 METRES FOR A B-TRAIN (BT)



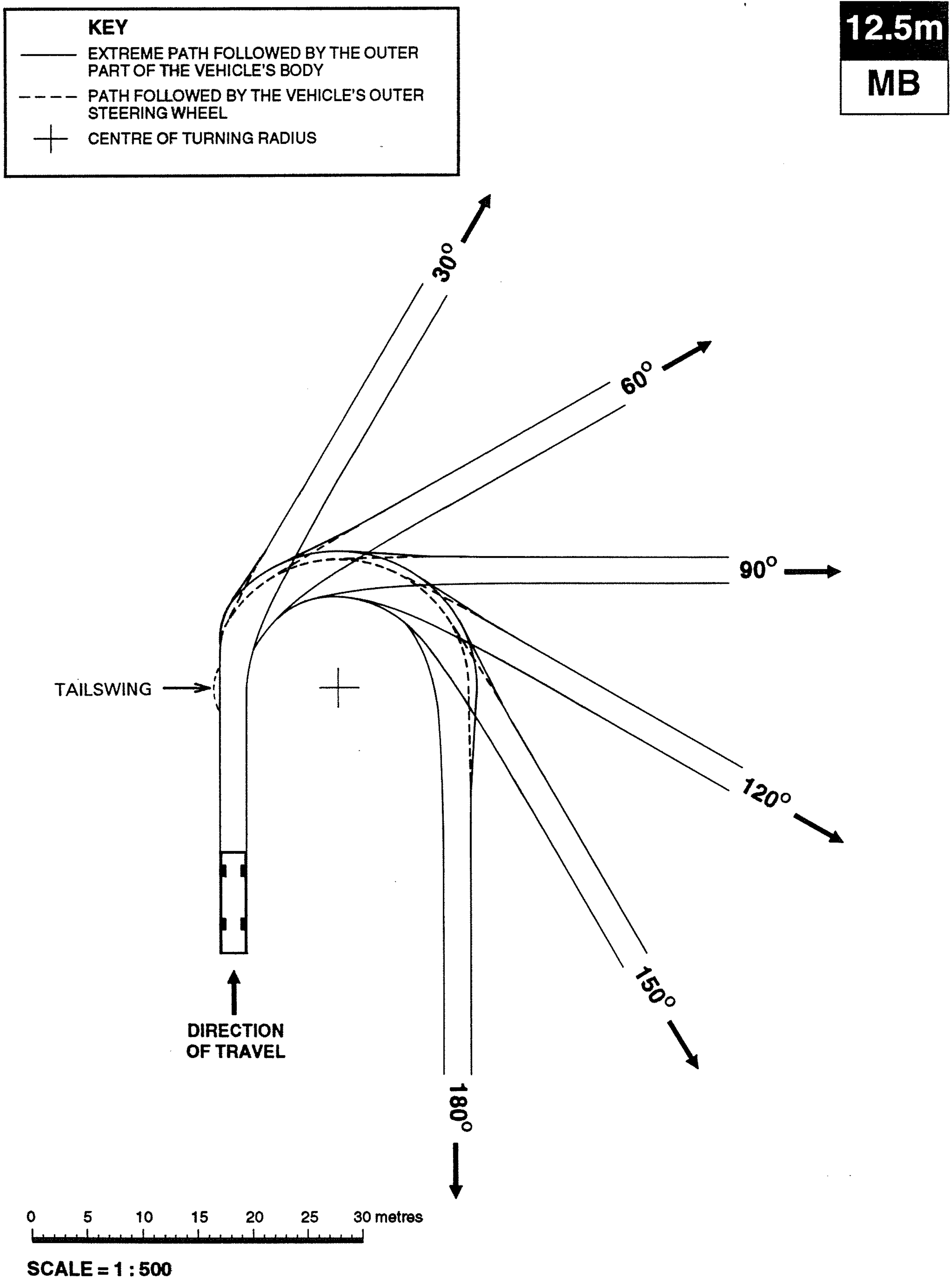
TRACKING CURVE WITH TURNING RADIUS OF 15 METRES FOR A B-TRAIN (BT)



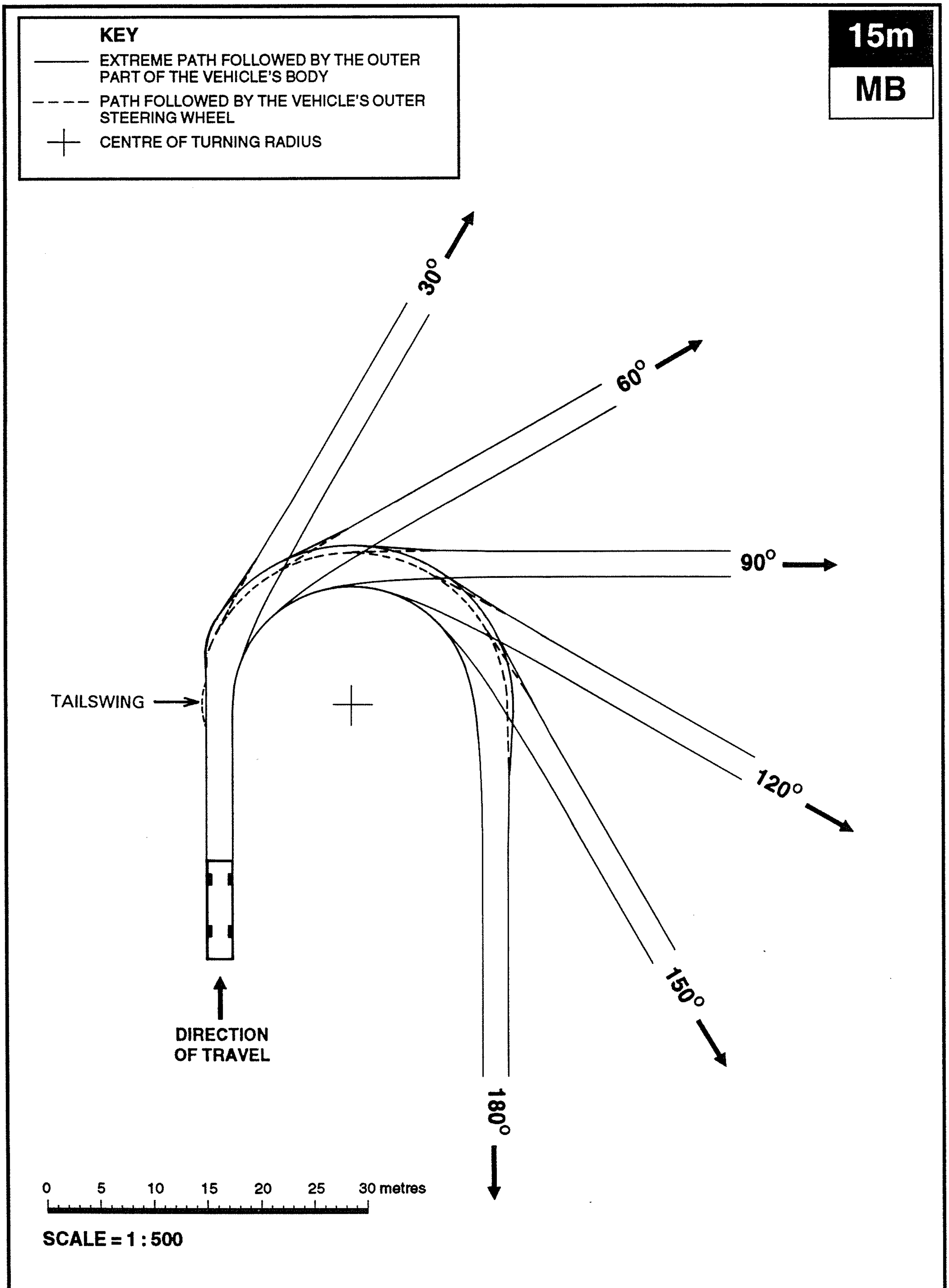
TRACKING CURVE WITH TURNING RADIUS OF 25 METRES FOR A B-TRAIN (BT)



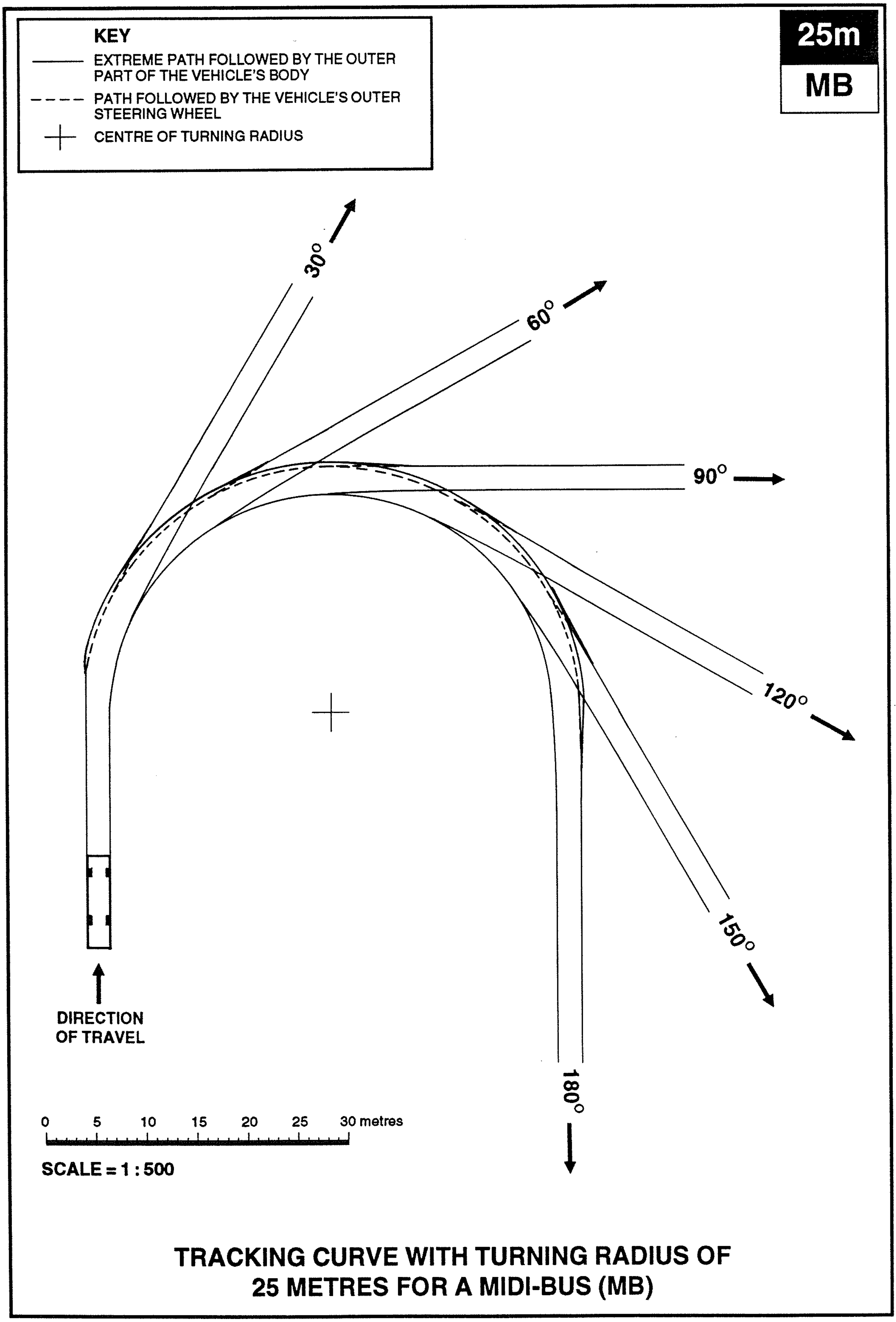
TRACKING CURVE WITH TURNING RADIUS OF 10 METRES FOR A MIDI-BUS (MB)



TRACKING CURVE WITH TURNING RADIUS OF 12.5 METRES FOR A MIDI-BUS (MB)



TRACKING CURVE WITH TURNING RADIUS OF 15 METRES FOR A MIDI-BUS (MB)

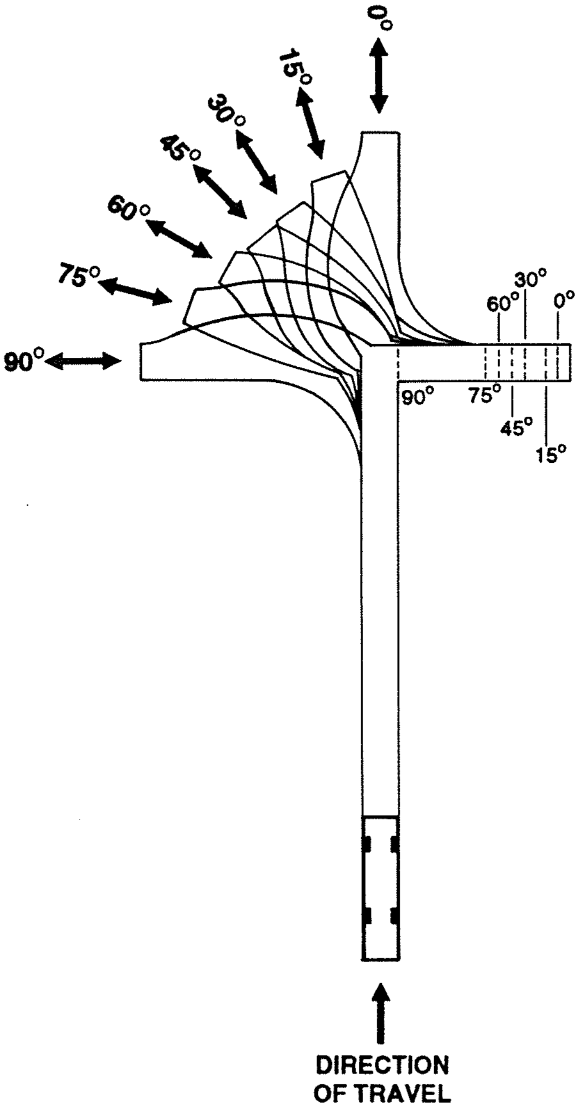


TRACKING CURVE WITH TURNING RADIUS OF 25 METRES FOR A MIDI-BUS (MB)

MB

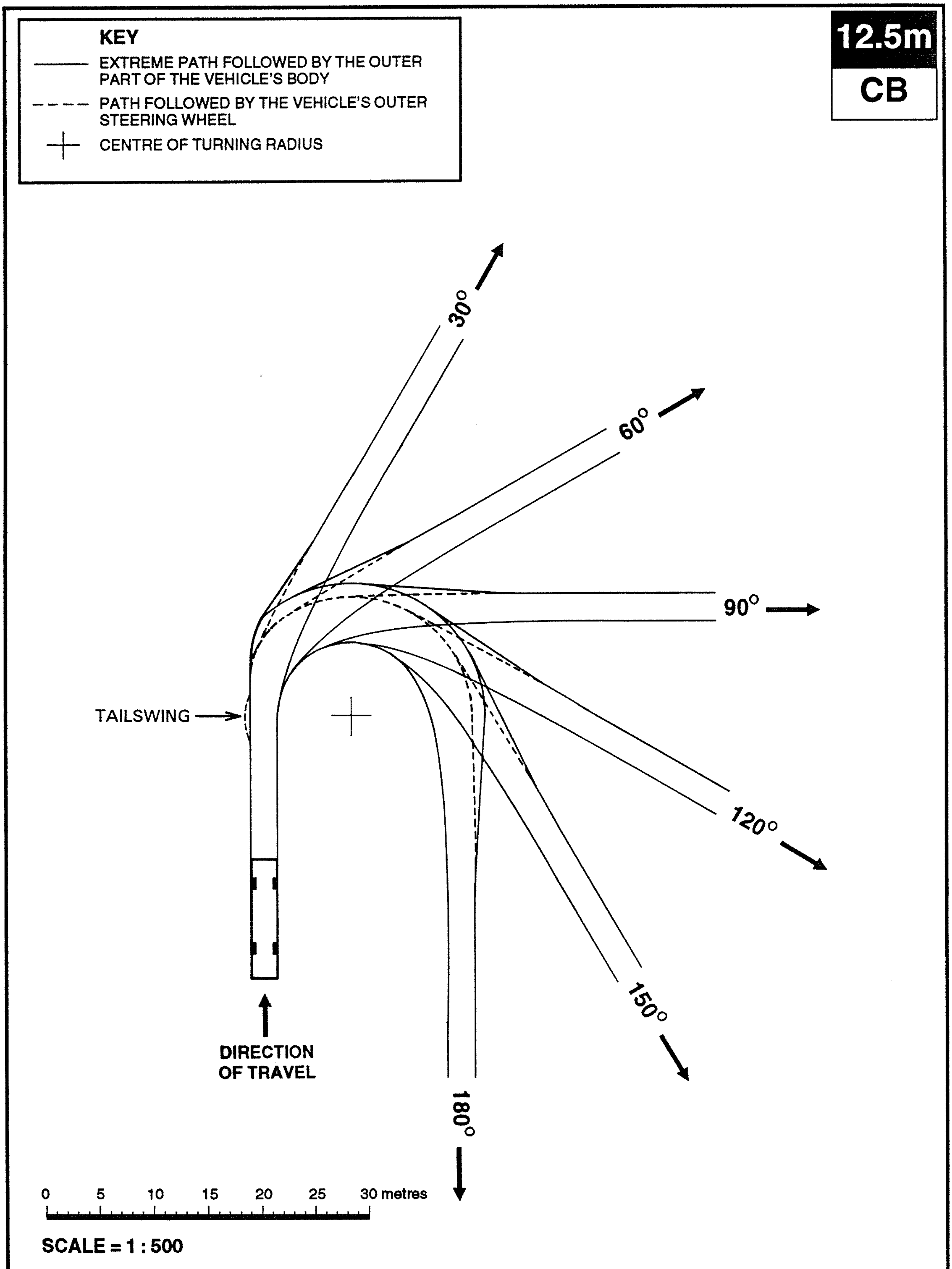
x° Closest position of a dock face to the manoeuvring area where rear of truck is flush with dock face, for x° angle of turn and for manoeuvre shown.

NOTE: These curves are to be used for the <u>reversing</u> manoeuvre. For the forward manoeuvre use basic tracking curves for MB. Tailswing is not shown.

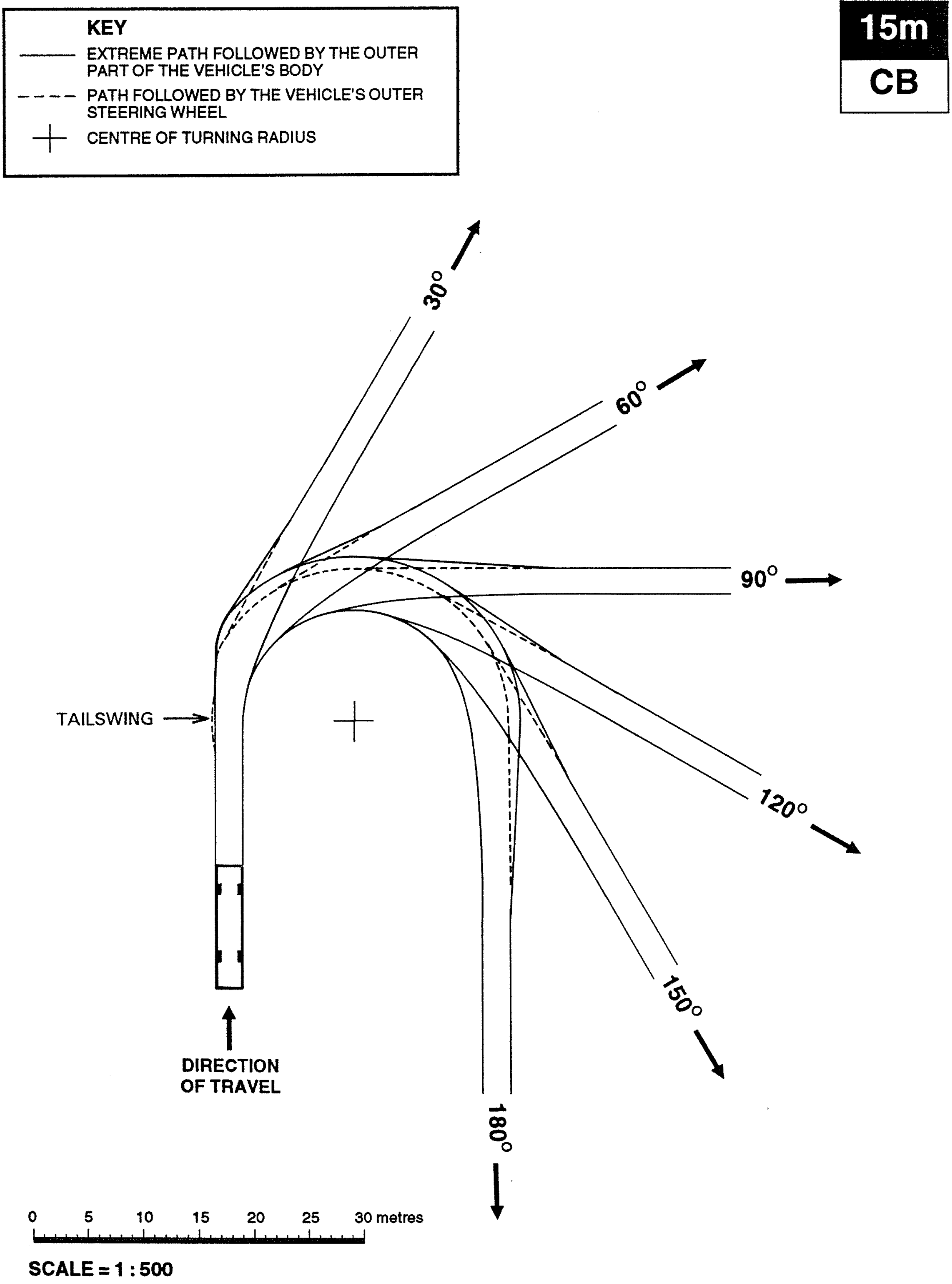


SCALE = 1 : 500

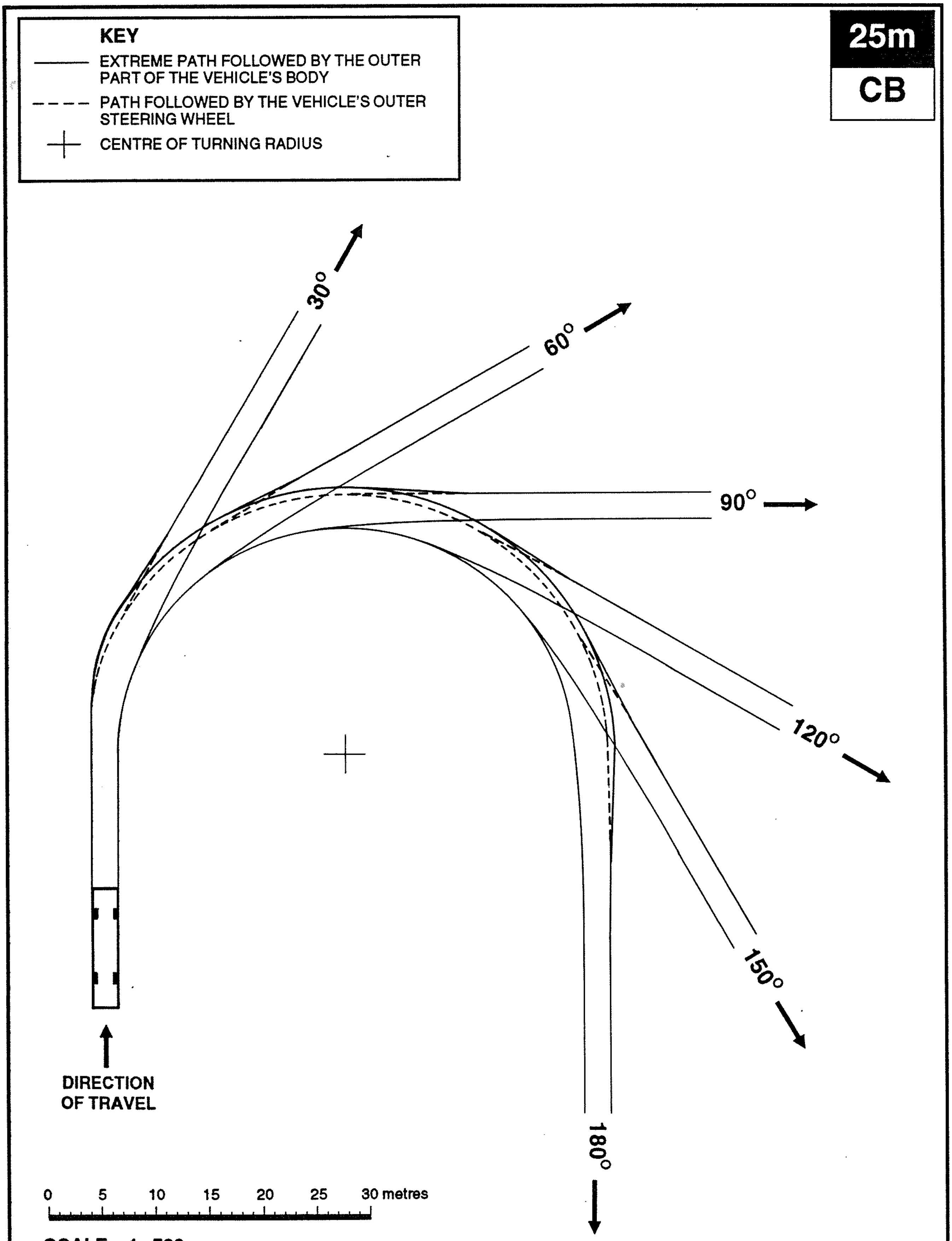
TRACKING CURVES SUITABLE FOR COMPLEX TURNS FOR A MIDI-BUS (MB)



TRACKING CURVE WITH TURNING RADIUS OF 12.5 METRES FOR A CITY BUS (CB)



TRACKING CURVE WITH TURNING RADIUS OF 15 METRES FOR A CITY BUS (CB)

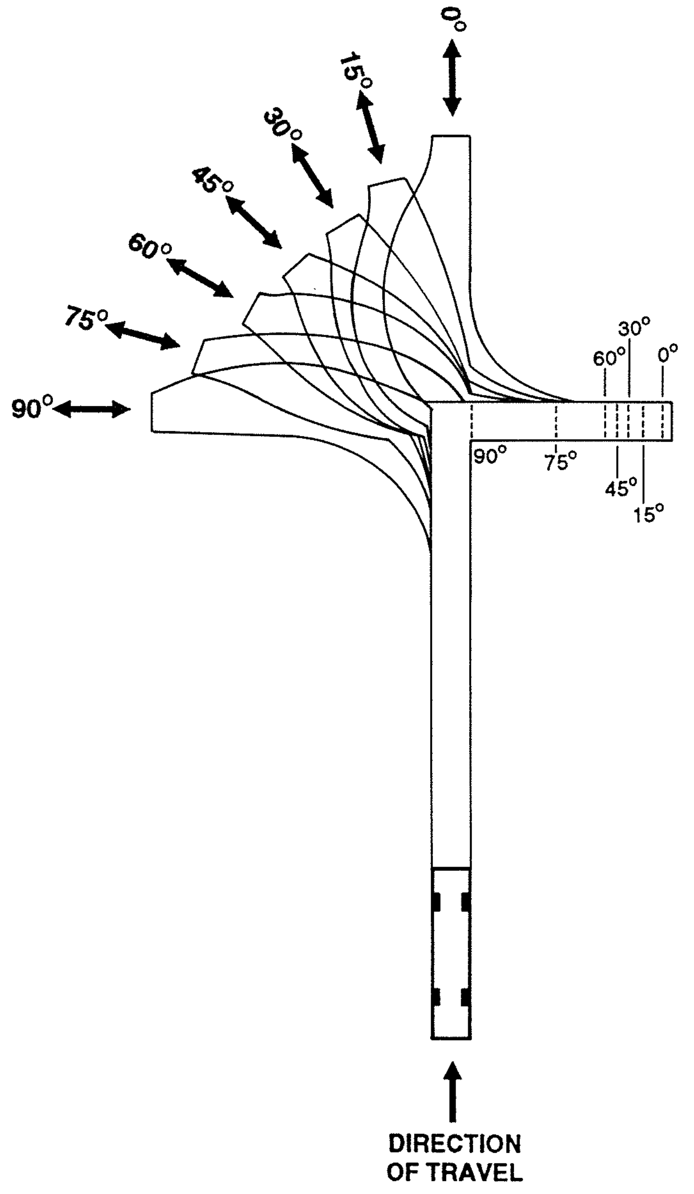


TRACKING CURVE WITH TURNING RADIUS OF 25 METRES FOR A CITY BUS (CB)

x° Closest position of a dock face to the manoeuvring area where rear of truck is flush with dock face, for x° angle of turn and for manoeuvre shown.

NOTE: These curves are to be used for the reversing manoeuvre. For the forward manoeuvre use basic tracking curves for CB. Tailswing is not shown.

CB



0 5 10 15 20 25 30 metres

SCALE = 1 : 500

TRACKING CURVES SUITABLE FOR COMPLEX TURNS FOR A CITY BUS (CB)

12.5m

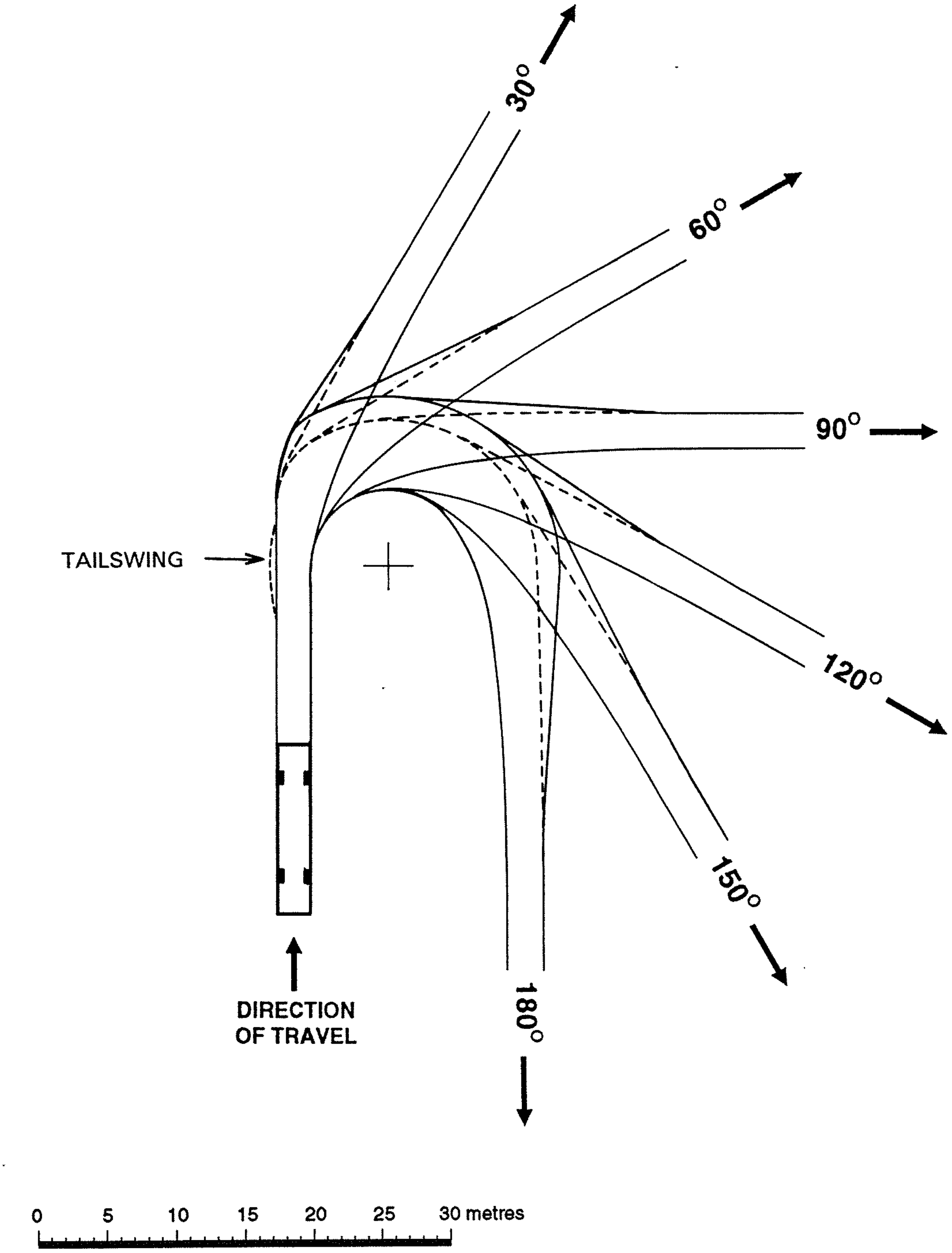
TC

KEY

———— EXTREME PATH FOLLOWED BY THE OUTER PART OF THE VEHICLE'S BODY

– – – – PATH FOLLOWED BY THE VEHICLE'S OUTER STEERING WHEEL

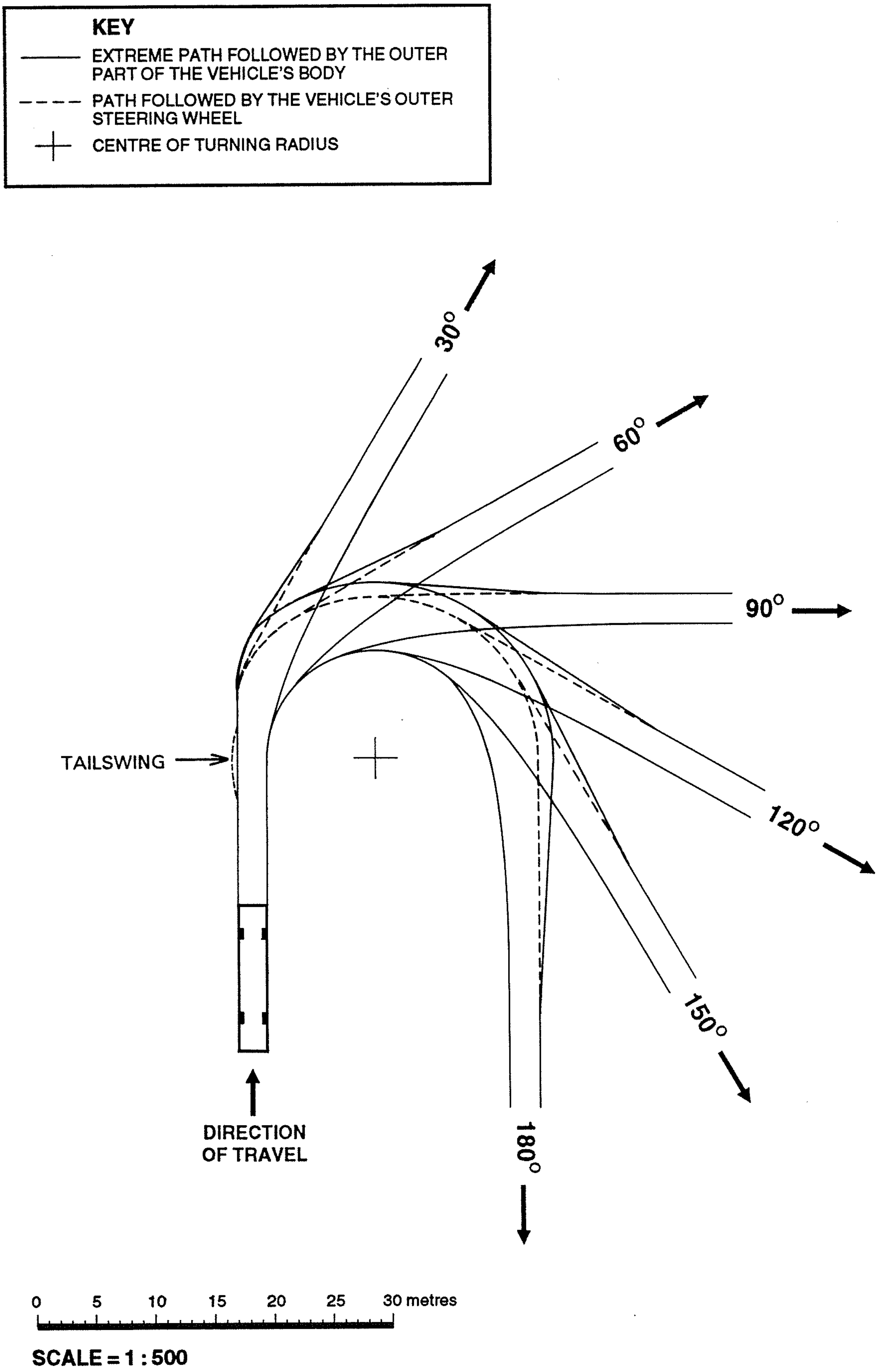
—+— CENTRE OF TURNING RADIUS



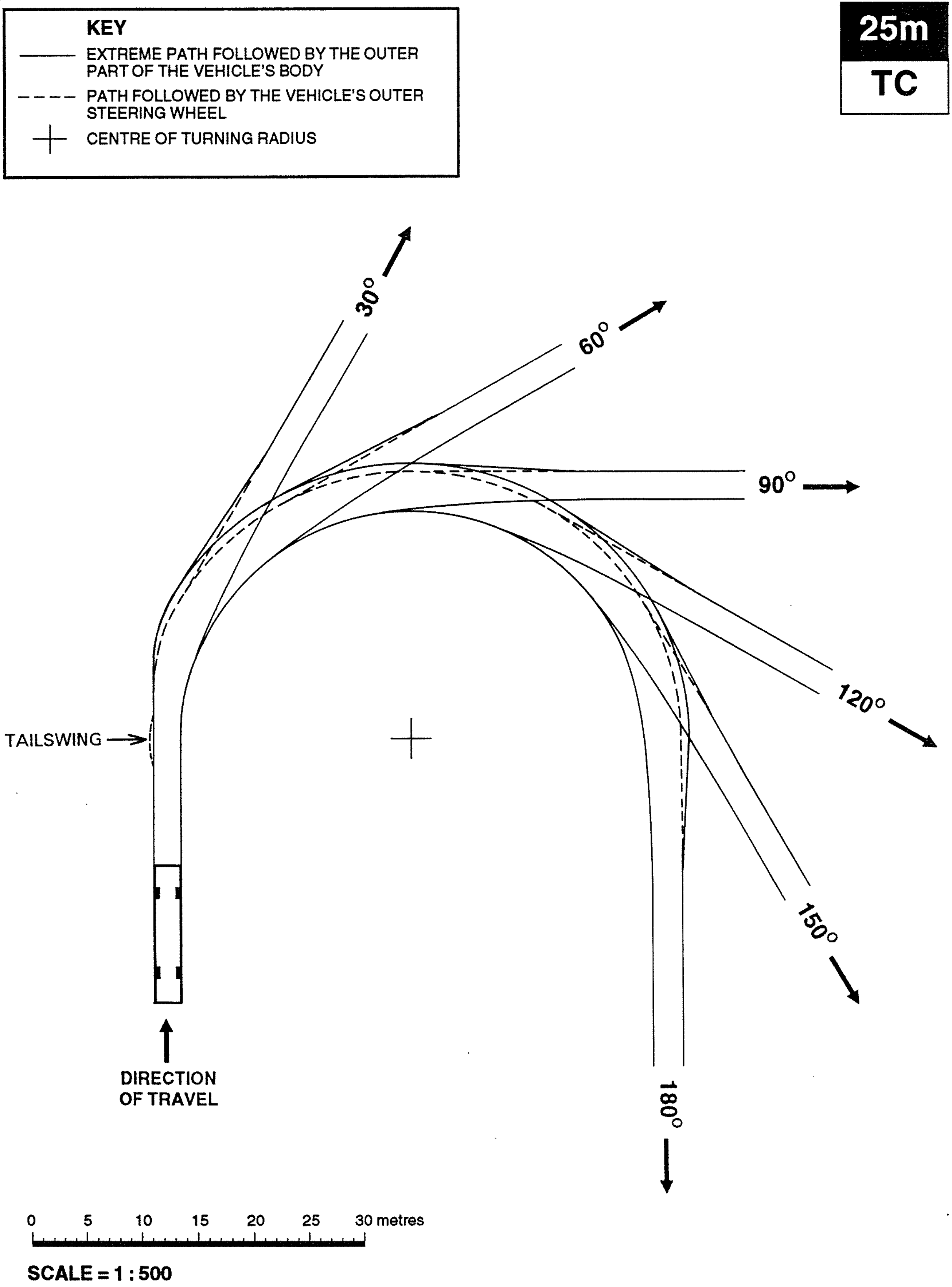
TRACKING CURVE WITH TURNING RADIUS OF 12.5 METRES FOR TOUR COACH (TC)

15m

TC



TRACKING CURVE WITH TURNING RADIUS OF 15 METRES FOR A TOUR COACH (TC)

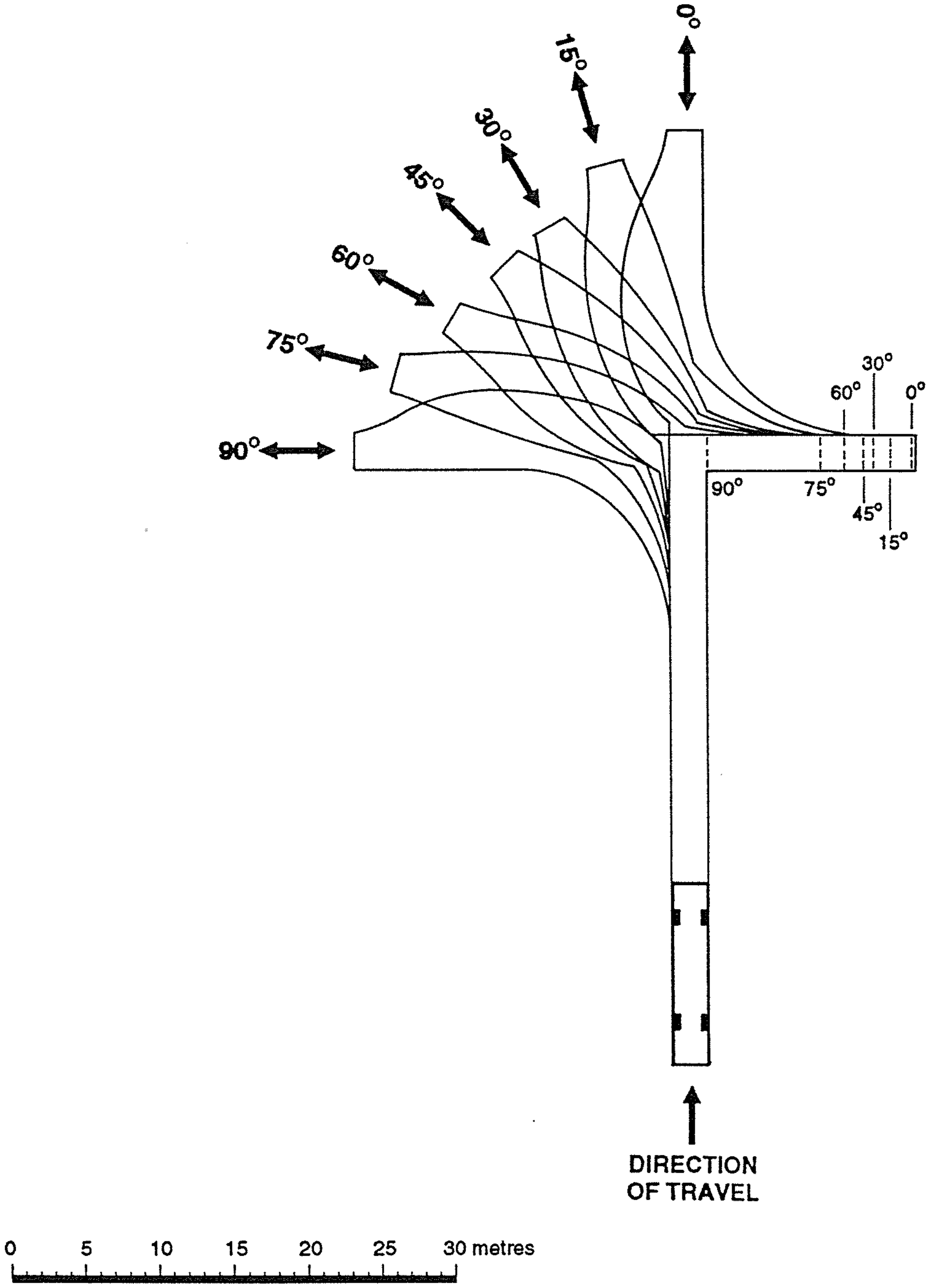


TRACKING CURVE WITH TURNING RADIUS OF 25 METRES FOR A TOUR COACH (TC)

x° Closest position of a dock face to the manoeuvring area where rear of truck is flush with dock face, for x° angle of turn and for manoeuvre shown.

NOTE: These curves are to be used for the reversing manoeuvre. For the forward manoeuvre use basic tracking curves for TC. Tailswing is not shown.

TC



SCALE = 1 : 500

TRACKING CURVES SUITABLE FOR COMPLEX TURNS FOR A TOUR COACH (TC)

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