

A study of the practicality of allowing 33 metre road trains into a metropolitan environment

R. A. PEARSON, Director, Technical Standards, National Road Transport Commission, K.
W. OGDEN, Professorial Fellow, Department of Civil Engineering, Monash University,
and P. F. SWEATMAN, Director, Road User Research

This paper summarises the methodology and results of a major study, the objective of which study was to determine the practicality of allowing 33 metre road trains to operate to specific major transport depots within a city with a population of about 1 million. The range of issues considered included the operational characteristics of road trains, the existing road system, the future plans for the road system, the impact of foreseeable urban development, present and future traffic levels, intersection and traffic signal design, costs and benefits to the community and costs and benefits to the transport industry.

1 INTRODUCTION

Double bottom road trains to a length of 33 metres carrying freight and livestock between Perth and the northern areas of Western Australia presently assemble and dis-assemble at a road train area 26 kilometres north east of Perth. Following the improvement of sections of the urban road network in Perth, the possibility of access to road transport depots within the metropolitan area of Perth was raised by the transport industry associations.

A consortium of consultants undertook a study of the practicality of metropolitan operations of 33 metre double bottom road trains in Perth. The objective of the study was to determine the practicality of allowing double bottom road trains to operate to specific major transport depots within Perth, a city of approximately 1 million people.

The range of issues considered included:

- . the operational characteristics of road trains
- . the existing road system which included any relatively minor modifications required (eg widening, intersection improvement etc)
- . the future plans for the road system
- . the impact of foreseeable urban development
- . present and future traffic levels including heavy vehicle and road train traffic
- . intersection and traffic signal design
- . costs and benefits to the community
- . costs and benefits to the transport industry

2 BACKGROUND TO THE STUDY

2.1 Present Arrangements

A double bottom road train comprises a prime mover and the lead semi trailer (together forming an articulated vehicle) and a dolly and a second semi trailer (together forming a dog trailer). Road trains operate under permits specifying allowable routes and other conditions.

A road train is permitted a maximum length of 33 metres and a gross mass of up to 79 tonnes, but separate parts of the road train must comply with the mass and dimension limits of Western Australian legislation.

The individual parts of the road train are shuffled between depots and the road train assembly area by three methods:

Method 1 Tow the second trailer by means of a 'block truck', which is a hauling unit fitted with a tow hitch to which the dolly is attached. The block truck and dog trailer operate under specific permit. This is the most common method and is illustrated in Figure 1.

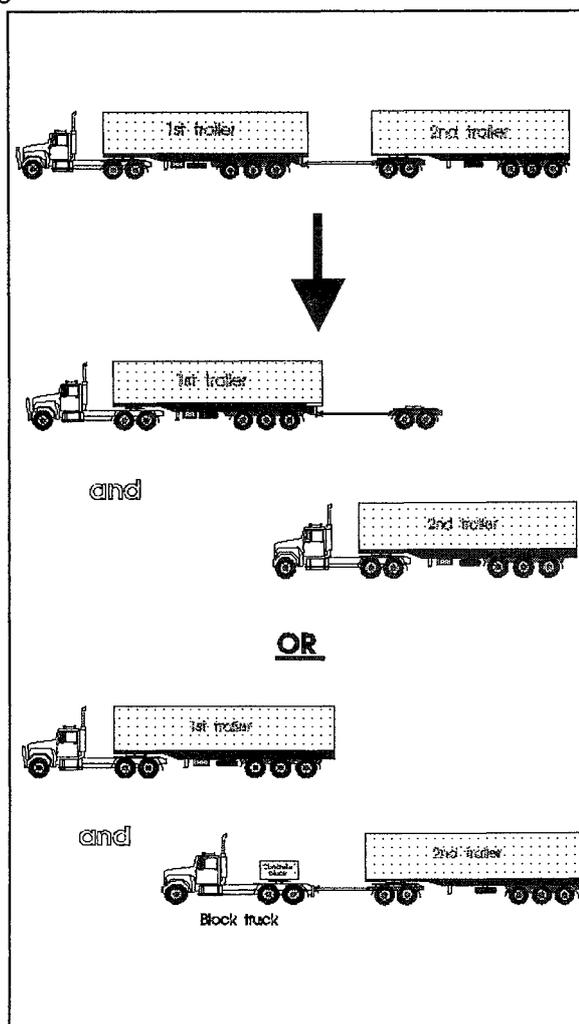


Figure 1: Road Train Shuttle Arrangements.

Method 2 Tow the second semi trailer with another prime mover, while the dolly is towed behind the prime mover and lead semi trailer. A permit is required for the towing of the dolly as the combination is overlength, and is illustrated in Figure 1.

Method 3 As a variation to Method 2, operators leave the dolly at the assembly area, but this is more usual with livestock operators.

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2.2 Assessment

The practicality of double bottom road train use was assessed at two levels:

- . the impacts of the road train per se on the urban environment
- . the comparisons between existing conditions (separate towing of trailers) and possible new conditions (complete double bottom road trains)

3 DATA COLLECTION AND INSPECTIONS

A significant phase of the Study involved the collection and assimilation of a wide range of road network and vehicle information.

Information was supplied by the Main Roads Department for all roads and intersections to be evaluated for road train use.

The MRD also provided:

- . typical specification data on road train prime movers and trailers
- . acceleration tests carried out on road trains
- . conditions applying to road trains and block trucks

This information was used to develop standard vehicles for the purposes of the Study.

A survey was undertaken of the operators requesting to use road trains. The survey covered historical data on movements for the period July to December 1989 and a detailed survey of all movements related to road trains for the week commencing March 7, 1990.

The survey covered a total of about 9500 road train movements north and south over a six month period. Information extracted from the survey included method of transfer of trailers between depots and the assembly area, weekday distribution, time of day distribution and cost of operation.

4 THE CHARACTERISTICS OF ROAD TRAINS IN AN URBAN ENVIRONMENT

4.1 General

A major literature review of urban operations of larger combination vehicles was undertaken. Although road trains are widely used throughout Australia, their use is almost exclusively confined to roads which are lightly trafficked and to areas with very low population density.

There is no prior example of their use anywhere in the world in metropolitan areas of the size of Perth with a population of about 1 million people, and their use in urbanised areas is limited to rural towns with generally low populations and low traffic densities.

4.2 Standard Vehicles

Differences between various vehicles in the urban environment generally result from variations in their size and weight.

Use of standard vehicles is a well established technique to compare different configurations, and this technique was followed in the Study.

4.3 Acceleration and Deceleration

A computer simulation of the acceleration of a typical road train at maximum weight was obtained using the TNT Truck Performance and Fuel Model. These simulations were compared to actual road train acceleration tests provided by MRD, and the results indicated that the computer simulation was a good representation for the purposes of the Study, but was likely to overestimate the acceleration of some lesser powered road trains.

Normal stopping distances of a vehicle when the driver is confronted with a situation where it is known the vehicle must stop are given by Jarvis (1988). It was postulated that the decelerations measured by Jarvis (1.0 m/sec/sec) would also apply to road trains, and much of the stopping distance will be under engine retardation only.

These are the stopping distances chosen by the driver when it is known that the vehicle must stop. The other extreme is the 'spike' stop braking analysis, when a driver is faced with an emergency situation.

4.4 Low Speed Offtracking

Computer simulation of low speed off-tracking was used. A variety of plots were generated to simulate conditions at the 36 intersections and depot entrances in the Study, and any modifications necessary for the passage of road trains were determined.

4.5 Lateral Displacement at Travel Speeds

At normal traffic speeds, the rear wheels of a larger combination vehicle may not track behind the steer axles for reason of:

- . response to slight steering inputs
- . misalignment due to poor mechanical condition such as a binding coupling or poorly aligned axles
- . curves
- . crossfall or superelevation

The first three factors can cause lateral displacement either to the inside or the outside of the path of the steer axles, the last usually causes lateral displacement to the inside. On very tight radius curves, centrifugal forces can cause displacement on the outside of the curve.

Travel speed displacement should not be confused with rearward amplification resulting from larger steering inputs.

To lessen the likelihood of sideswipes with either opposing, overtaking or parked vehicles, lane widths must cater for travel speed displacement, with some allowance for clearance. Research undertaken by ARRB (1991) with road trains in northern WA was adapted for calculation of lateral displacement in this Study.

5 THE PHYSICAL ABILITY OF ROAD TRAINS TO ACCESS DEPOTS

The capability of the existing road network to accommodate double bottom road trains was examined. Physical ability was defined as being able to travel within the roadway without mounting kerbs.

For a road train making a turn, it was assumed that the road train driver will position his vehicle to give him the greatest roadway space within the law. It was noted and taken account of that provision is made in law for road trains to turn from other than the kerb side lane in normal left turns.

6. VEHICLE PERFORMANCE

A key element of the viability of road train operations in urban areas is the dynamic performance of such vehicles compared to the performance of vehicles already operating on the same routes. Dynamic performance also impacts on the interaction of road trains and other traffic users.

The aspects of dynamic performance considered to be of significance were dynamic stability and braking.

The dynamic stability of road trains was compared with that of the alternative block truck plus road train dog trailer, and with that of a standard tractor semi trailer. The comparison covered operating situations likely to be encountered in urban operation of road trains.

- Two aspects of dynamic stability were considered:
- . the steady-state rollover threshold of each vehicle unit (not roll-coupled to another vehicle unit), and
 - . the rearward amplification (or crack-the-whip response) of the combination.

The University of Michigan Transportation Research Institute (UMTRI) steady state rollover program was used to determine the dynamic inputs for the Study.

7 THE INTERACTION OF ROAD TRAINS AND TRAFFIC ON THE ROAD NETWORK

Safety for users of a road network is the greatest community need. Therefore, if 33 metre road trains were to be permitted into depots, safety must not be degraded. In this context, the introduction of double bottom road trains must not lead to increased risk or likelihood of collision.

The assessment of the complex interaction between these elements took into account all factors, specifically:

- . horizontal and vertical geometry, number of lanes, lane width, surface condition, intersection geometry and treatments and road type together with the inter-action with and access to shopping centres, residential areas etc.

- . traffic variations with time, including speed and mix
- . intersection and traffic signal design

The critical safety issue was segmented into the analysis into safety at intersections, safety between intersections, operating conditions, mechanical conditions, and congestion impacts.

7.1 Safety at Intersections

The relevant aspects of safety at intersections that were considered are:

- . right turning movements
- . left turning movements
- . capability of reacting to traffic signal changes

7.1.1 Right Turning Movements

In the absence of a traffic signal phase for right turning traffic at through intersections or for entry to depots, such right turners need to choose a gap in opposing traffic which can be accepted without conflict with opposing vehicles. The size of the gap required depends on the time needed to complete the turn; the likelihood of a suitable gap appearing depends on the traffic volume.

Where right turns were to be made at intersections which are not presently signalised, the probability of delay was the main criterion used in the assessment.

7.1.2 Left Turning Vehicles

When a vehicle turns left at a signalised intersection, a conflict is created only when a slip lane is not subject to signal control and the right turner attempts to merge. In these circumstances, if a merge is not attempted, an acceptable gap will be available as soon as the red phase is activated.

7.1.3 Stopping at Signalised Intersections

When faced with an amber signal, a decision is made by a driver whether to stop or continue through the amber phase. The length of the amber and all-red phases are critical as it is unlikely that road trains will utilise emergency braking for traffic lights.

7.2 Safety Between Intersections

Safety between intersections was considered by a variety of means, including lateral displacement, overtaking, speed zoning and abutting lane use.

The analysis of speed zones was considered using the methodology outlined in ARRB Research Report ARR 155 (ARRB 1990). The basis of this approach is that critical elements of road safety, such as road type, number of lanes, level of traffic control, number of accesses, special roadside activities and pedestrian and cycle activities are used in the assessment of the desirable speed zone.

The assumption was that, if the traffic using each homogeneous road link is travelling at the speed assessed as appropriate, safety is unlikely to be compromised by the introduction of a limited number of larger vehicles operating under appropriate controls.

Abutting land use is a critical factor in safety, and is the major criterion in setting of speed limits, although the number of accesses is strictly the measure used for speed limit evaluation. Greater development along a road brings with it:

- more uncontrolled access points

- . greater activity in general, be it activity associated with trading, shopping or schools
- . with residential frontages, a greater number of children and domestic animals in the area

7.3 Congestion Impacts

Larger vehicles are generally slower to accelerate and turn, and opportunities to overtake on undivided roads are less. On the other hand, fewer trucks means less truck kilometres of travel.

7.4 Mechanical Condition

The simulations and considerations in the Study assumed any road train met the normal mechanical requirements in legislation. Of particular concern in this respect is the provision of brakes on dolly axles, adequate couplings and lighting provisions.

These aspects are critical because, if the requirements are not met, braking, tracking and visibility will be degraded and a safety neutral position will not be met.

8 THE INTERACTION OF ROAD TRAINS AND THE TRAFFIC ANTICIPATED ON THE ROAD NETWORK IN THE FUTURE

The two critical aspects of a consideration of future conditions are the changes to the network itself and the changes in type and volume of traffic. Each was considered in turn.

An increase in traffic per se does not necessarily affect safety since established traffic management techniques for addressing increased traffic may be applied to accommodate the traffic growth. These include:

- . speed zoning
- . local intersection improvements including provision for turning movement
- . traffic control devices
- . street lighting
- . provision for cyclists and pedestrians

The principal effect of increased traffic is on two lane undivided roads, where the product of the opposing traffic volumes is a factor in the likelihood of a collision.

9 THE DETERMINATION OF COSTS AND BENEFITS

The request by the transport industry for permission to operate road trains into depots arose from the claim that present arrangements are unnecessarily expensive. On the other hand, there are substantial costs involved in network modification to cater for urban operation of road trains. Other quantifiable costs and benefits include fuel usage, road wear savings and depot modifications. Non quantifiable costs and benefits were also considered. Extensive sensitivity analyses were undertaken.

10 RESULTS

This study established a framework for the assessment of the important factors which need to be examined in the consideration of the impact of larger vehicles in an major urban environment.

10.1 Operational Characteristics of Road Trains

The operational characteristics of road trains were compared to the alternative of separate shuttle using a block truck.

There is no difference between the steady state rollover characteristics of these vehicles as the dog trailer is the critical vehicle for both cases. The road train dog trailer behind an articulated vehicle or block truck is approximately 40% more likely to roll over in a crash than the equivalent articulated vehicle.

In emergency avoidance manoeuvres, the results indicate that the road train is significantly less stable than the block truck with dog trailer. Results for both vehicle types were highly speed dependant, and above 75 km/h there is a dramatic increase in rearward amplification for the road train and the difference between the road train and the block truck with dog trailer.

The risk of an emergency situation arising is less on the high standard divided highways with the higher speed zones. However, in normal urban traffic, it was concluded that speeds above 75 km/h should be avoided.

Differences between vehicle types in braking do not appear significant, assuming the vehicles are all in satisfactory mechanical condition.

10.2 Benefits and Costs

Benefits to the transport industry arise because of the elimination of shuttle arrangements, leading to a saving over 10 years of at least \$5 million after allowing for depot upgrade costs.

Road improvement costs exceed \$1 million and loss of fuel tax revenue was about \$800,000 over 10 years. On the other hand, the present assembly facility would not require upgrading, and the estimated cost of \$400,000 would not be incurred.

Thus the Net Present Value over a 10 year period was between \$3 million to \$6 million depending on the assumptions, with benefit cost ratios in the order of 3 or 4. Care must be taken with the use of benefit cost ratios, however, in this type of analysis and the economic worth varies significantly between depots.

Non quantifiable benefits and costs are a reduction in theft and vandalism, reduced employment for drivers of block trucks and likely public perceptions. Costs of compliance, enforcement and/or permit systems could be estimated but were classed as non-quantifiable for this Study.

REFERENCES

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