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INITIAL RESULTS OF THE B-TRIPLE TRIAL IN QUEENSLAND

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ABSTRACT

Recent advances in heavy vehicle design and technology enable superior performance standards to be met in areas of reduced rollover risk, improved braking and reduced road wear. This results in improving productivity through increased utilisation of freight vehicles on the existing road system in a manner which does not place undue pressure on roads and bridges while reducing the safety risk associated with large vehicles in the traffic stream.

Freight efficient and innovative vehicle configurations such as B-Triples, AB-Triples and 2B3s play an important role in the economic development of Queensland and would provide significant productivity and safety benefits to the industry and the community.

Queensland Transport is conducting a B-Triple trial to promote the use of a more productive and safer vehicle combination and to encourage operators to switch to newer and safer vehicles than existing road trains, a move that would reduce the number of road trains in certain areas. Four operators have been selected for the B-Triple trial which runs for 15 months in Queensland. The suitability of B-Triples is assessed through computer simulation and analysis. Infield testing of the B-Triples is also carried out to evaluate the performance requirements set up for these combinations.

This paper addresses the issues involved with undertaking a trial of B-Triples, describes the performance characteristics of B-Triples, considers the appropriate operational requirements for the use of B-Triples and evaluates the initial findings of the trial. The experience with the operation of B-Triples will also be discussed.

Additionally the analysis highlights a range of issues that need to be clarified prior to allowing access beyond that already enjoyed by 36.5m long combinations and reinforces the need to conduct field testing to validate the computer predictions, and to translate the computer modelling into actual on-road performance.

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1. INTRODUCTION

Road transport is one of the fastest growing segment of the Australian economy, growing an average 6 percent per year in recent years. It has enormous economic and social impact, generates substantial employment and contributes significantly to National Gross Domestic Product. Road transport in Australia is a more important sector of the economy than in other countries because of the greater amount of transport per capita needed to link various economic regions of the country.

There is now a pressing need to improve the performance of vehicles within existing dimension constraints. There are obviously limits beyond which the general public would consider that undue risk is being undertaken. The application of new technology to allow vehicle regulation to be set by dynamic performance rather than just dimensions is a substantially promising development occurring over the last couple of years. The scope for change in this area will only be limited by the willingness of all participants, be they industry, government, or the general community, to allow these better performing vehicles to be developed and operate.

Freight efficient and innovative vehicle configurations such as B-Triples, AB-Triples and 2B3s play an important role in the economic development of Queensland and would provide significant productivity and safety benefits to the industry and the community.

To encourage the transport industry towards using safer, high productivity vehicles Queensland Transport launched a B-Triple trial. The B-Triple which is a prime mover towing three trailers, is a logical extension to the highly successful B-Doubles that have been safely operating throughout Australia since 1988. A typical B-Triple combination is shown in **Fig 1**.

Queensland Transport is conducting this trial to promote the use of a more productive and safer vehicle combination and to encourage operators to switch to newer and safer vehicles than existing road trains, a move that would reduce the use of road trains in certain areas. Four operators have been selected for the B-Triple trial which runs for 15 months in Queensland. The trial is to conclude in March 1998. The suitability of B-Triples has been assessed through computer simulation and analysis. Initial field testing of the B-Triples has been carried out to evaluate the performance requirements set up for these combinations.

This paper addresses the issues involved with undertaking a trial of B-Triples, describes the performance characteristics of B-Triples, considers the appropriate operational requirements for the use of B-Triples and evaluates the initial findings of the trial.

2. HEAVY VEHICLE OPERATIONS IN QUEENSLAND

Queensland, with a population of three and a half million people (1) and an area of 1.7 million square kilometres, has a low population density. Nearly half of the population is resident in the Brisbane - Gold Coast corridor of the South East corner. Queensland has 174,000 kilometres of public roads consisting of State and local government controlled roads. In Queensland, transport, storage and communication represented 9.3% (2) of the Gross State Product in 1991, and estimated to be on a similar or higher level in 1996. Transport is vital to commerce and the quality of life for residents in remote areas.

2.1 Heavy Vehicle Types

Large heavy vehicles can be either single rigid trucks (fitted with single axles or axle groups), articulated vehicles, truck-trailers or multicombination vehicles such as B-Doubles, B-Triples and Road Trains. Vehicles commonly used by the road transport industry, the maximum length limits and permitted Gross Combination Mass (GCM) are shown in Table 1.

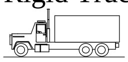
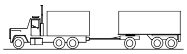
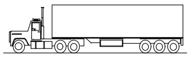
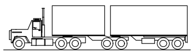
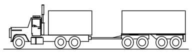
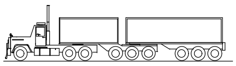
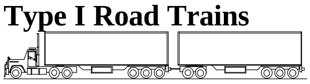
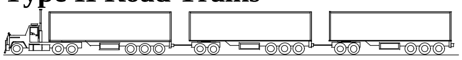
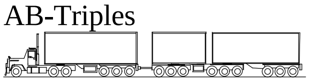
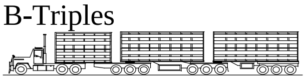
VEHICLE TYPE	MAXIMUM LENGTH (m)	MAXIMUM GCM (Tonnes)
General Access Vehicles		
Rigid Trucks 	12.5 m	22.5 t
Truck-trailers 	19 m	42.5 t
Prime-mover semi-trailers 	19 m	42.5 t
19m B-Doubles 	19 m	50.0 t
Truck and 4 axle dog 	19 m	50.0 t
B-Doubles 	25 m	62.5 t
Type I Road Trains 	36.5 m	79 t
Type II Road Trains 	53.5 m	115.5 t
Innovative configurations		
AB-Triples 	36.5 m	102.5 t
B-Triples 	36.5 m	82.5 t

Table 1. Typical Heavy Vehicle Configurations in Queensland

2.2 Registered Heavy Vehicles In Queensland

In line with the increasing freight task and increasing population, the number of registered vehicles in Queensland continues to increase steadily. Multicombination vehicles (Road Trains, B-Doubles, and B-Triples), grew out of economic necessity and have provided significant economic benefits to various industry groups.

Figure 2 illustrates the increase in numbers of 6-axle articulated vehicles, B-Doubles, Road Trains and the total number of prime-movers registered in Queensland over the last 5 years. It shows, that since 1992 the number of B-Doubles registered increased by more than 200 per cent from 234 to 725 vehicles. Over the same period the total number of Road Trains increased by 58 per cent from 1057 to 1665 combinations.

The data also shows that with the introduction of "As of Right" operating systems in Queensland for Road Trains and B-Doubles in 1994, where Road Trains and B-Doubles that meet performance guidelines no longer require permits to operate on Queensland's approved route system, the role of these vehicle combinations is rapidly increasing.

Between 1992 and 1997 the road freight task grew by around 25 per cent, but during the same period, the total number of heavy prime movers increased by only 16 per cent. Based on the experience with the larger heavy vehicle combinations, it has been recognised that the use of medium and large truck combinations can enhance the efficiency of freight haulage, the efficiency and safety of the road system, and reduce negative environmental effects.

3. BALANCING SAFETY, INFRASTRUCTURE AND PRODUCTIVITY

To analyse the level and conditions of access for a new combination vehicle the correct balance between safety, infrastructure protection and productivity must be achieved. The following criteria are issues for consideration:

3.1 Safety

The safety of the operation of the combination will depend on the performance of the vehicle and the operational environment:

- dynamic performance characteristics of the combination,
- road characteristics where the combination will operate,
- impact on other traffic (traffic factors), and
- environmental impact (mainly on adjacent land use and pollution).

3.2 Infrastructure Protection

The impact of the combination on road wear and bridge loadings and how to reduce these impacts per tonne of freight carried, is the main consideration.

3.3 Productivity

Many elements affect the cost per tonne of freight carried such as:

- increased payload/deck space,
- increased fleet flexibility,
- decreased maintenance costs,
- lower running cost per tonne of freight.

The ideal is to have improvements in safety with new combinations through improved dynamic performance with the target values based on the mid point the performance range of the combinations currently used on that part of the network. However, this is not always practicable and construction of the vehicle and the type of goods carried need to be taken into account. For example, a livestock B-Triple may not reach the mid point for existing Type 1 Road Trains, but it has superior dynamic performance compared with existing Type 1 livestock Road Trains. The introduction of B-Triples carrying livestock will have a net safety benefit.

4. THE B-TRIPLE TRIAL

4.1 Background

The B-Triple is a prime mover hauling three semi-trailers. In the simplest terms this combination is similar to the common B-Double with an additional lead trailer in the combination. The B-Triple can be up to 36.5 m overall length and up to 82.5 tonnes GCM.

While the introduction of the AB-Triple (an AB-Triple combination consists of a 6-axle prime-mover-semi-trailer towing an 8 or 9-axle B-double as shown in Table 1.) developed from an industry proposal the introduction of the **B-Triple** via the B-Triple trial was a Queensland Transport initiative. The transport industry continually seeks increased productivity through increased load carrying space, increased mass or increased access. The B-Triple was seen as a viable alternative to existing Type 1 Road Trains due to improvements in safety, productivity and infrastructure protection.

4.2 B-Triple Combinations

Initially there were 4 operators selected for participation in the trial; Wagners Transport of Toowoomba, NQX, Oakey Haulage and Porters of Kingaroy. In addition to the initial four combination, there are other B-Triple combinations approved to participate in the trial extending the scope of the trial. Table 2 summarises the overall lengths, Gross Combination Masses (GCM) and the type of operation of the approved B-Triples.

COMPANY	LENGTH (m)	GCM (t)	TYPE OF OPERATION
Wagners Transport	32.1	82.5	Tipping
NQX	36.02	82.5	General Freight
Oakey Haulage	35.51	82.5 (*90t)	Livestock
Porters	33.8	82.5 (*90t)	Livestock
McIver Transport	28.8	86.0	Tipping
Frasers Livestock	35.6	82.5 (*90t)	Livestock

(* Operated under the Livestock Loading Scheme)

Table 2. B-Triple Combinations running in Queensland

4.3 Operating Areas

The B-Triples currently running under the trial are allowed access to all road train routes in Queensland, with some extensions, as shown in **Fig 4.** There were numerous applications for participation in the B-Triple trial and these were evaluated, along with requested routes, by Queensland Transport in consultation with Main Roads and Queensland Police. Many of the proposals could not proceed as operators wished to operate a B-Triple outside road train areas.

The B-Triple also has superior dynamic performance compared to an AB-Triple, which relates to improved safety performance, but has a lower payload. One of the main aims of the B-Triple trial was to establish some definitive criteria and procedures for consideration of high productivity vehicles. Other expected project outcomes include:

- introduction of a new vehicle combination that is safer than many current large combination vehicles;
- produce a combination that is productive;
- expand the operating range or area of longer vehicle combinations, if appropriate;
- investigate actual vehicle on-road performance data to validate computer predictions of that performance;
- gather data on vehicle dynamic performance that will assist development of future directions of road transport in the national arena;
- develop comprehensive route assessment guidelines which will provide a basis for route assessment of high productivity vehicles and may result in increased access to the existing road network by balancing increased productivity with safety and infrastructure protection.

The entire trial was intended to be as transparent as possible with wide involvement of industry, local community and Main Roads through establishment of a Monitoring Group. Accordingly a number of stages were identified to be undertaken:

- develop a trial brief which clearly defines the project outcomes and responsibilities of all stakeholders;
- extend an expression of interest to industry for participation in the trial;
- evaluate the proposals and select the trial participants;
- conduct extensive consultation with all interested parties, including Department of Main Roads, local government, motoring public, Police and industry;
- get the combinations on the roads and operating;
- develop and conduct a testing and evaluation program that will meet the requirements of all interested parties (details of the test and evaluation program requirements come from both the initial trial brief and from the consultation process);
- produce a recommendation for continued operation of B-Triples.

Currently the B-Triple trial has progressed to the on-road testing program with all the preceding steps in the list above having been completed. Some of these obviously will continue throughout the entire trial, for example, consultation will continually be conducted throughout all aspects of the trial and feedback received will directly impact on the trial procedures.

Prior to any final recommendation coming out of the trial all interested parties will again have the opportunity for input through the consultation process.

5. THE B-TRIPLE TESTING PROGRAM

There are a number of tests that are to be conducted to meet the aim of the B-Triple trial, i.e., encouraging industry to consider improving efficiency through using safer vehicle combinations. Additionally, some of the expected outcomes include gathering data on heavy vehicle performance and progressing towards route assessment guidelines.

To determine the priority for conducting the tests certain selection criteria were developed and the proposed tests were then evaluated against these criteria:

Value: What will be the value of the test in meeting the aim of the B-Triple trial? The value addresses the important issues relevant to safety and community perceptions and takes into account the reaction from local government, police and communities during the consultation phase of the trial. This will be assessed from 1 - high to 5 - low.

Difficulty: How difficult will it be to conduct this test taking into account the level of expertise required, availability of equipment and test site necessary ? This will be assessed from 1 - easy to 5 - hard.

Cost: The additional cost and resources required to Queensland Transport to conduct the test. This does not include downtime for operators or the costs of existing Queensland Transport staff or equipment. This will be assessed from 1 - low to 5 - high.

Each selection criteria was given equal weighting.

TEST	VALUE	DIFFICULTY	COST	TOTAL	PRIORITY
Steady State Rollover	3	3	4	10	7
Braking	1	2	2	5	3
Lane Change (Rearward Amp.)	3	4	4	11	8
High Speed Dynamic Offtracking	4	4	4	12	9
Acceleration/ Gradability	2	1	1	4	2
Overtaking	1	1	1	3	1
High-speed Offtracking	3	2	3	8	5
Fuel Consumption/ Emission	3	2	3	8	4
Noise	5	1	1	7	6
Trailing Fidelity	3	5	5	13	10

Table 3. Performance Tests for B-Triples

Analysis of the table gives an order of priority for conducting the on-road testing program of the B-Triple trial of :

1. Overtaking
2. Acceleration/Gradability/Speed
3. Brake tests
4. Fuel Consumption
5. High Speed Offtraking
6. Noise
7. Steady State Rollover
8. Lane Change (Rearward Amplification)
9. High Speed Dynamic Offtraking
10. Trailing Fidelity

This paper reports the initial results from the test programs on braking, acceleration, overtaking, intersection clearance times and rearward amplification.

6. B-TRIPLE OVERTAKING TESTS

The introduction of B-Triple vehicle combinations has caused concerns from other road users about passing and overtaking distances and times. Additionally there have been some misleading statements made about the difficulty of overtaking the B-triple combination. Initially, the prediction of the overtaking distances and times for B-Triple combinations was conducted using data from the Bosch Automotive Handbook, 2nd Edition. An on-road test procedure has been used to validate the results of the calculation, to determine the difficulty of overtaking the B-triple combination and to assess how the variables of traffic affect the acceleration capacity of passenger vehicles whilst completing an overtaking manoeuvre.

6.1 Method

The time and distance required to overtake a B-Triple travelling on dual and single-lane carriageways was recorded and the acceleration capacity of various passenger vehicles was measured during overtaking manoeuvres. The acceleration performance of the overtaking car, was recorded by the G-Analyst, in terms of acceleration due to gravity (g=9.81 m/s).

The B-Triple speeds for the overtaking manoeuvres were set for 80, 90 and 100 km/h and the overtaking vehicle reached maximum speeds of 10, 20 and 30 km/h above the B-Triple's speed. The distance between the rear of the B-Triple and the test vehicle at the start of the overtaking manoeuvres was kept within the range of 25-40m.

The variables considered in the test procedure were the length of the B-Triple, the type of the overtaking vehicle with respect to engine characteristics, the initial and final speeds of the overtaking manoeuvre, the experience of the driver, the overtaking path, the test surface gradient, environmental and traffic conditions. The route for the overtaking manoeuvres was restricted to current road train routes where the terrain was relatively flat and traffic density was low. In addition to the B-Triple tests a 6-axle prime-mover-semitrailer combination was also used to perform similar overtaking manoeuvres and the same data was recorded.

6.2 Results

Table 4 and Table 5 outline the results of the overtaking manoeuvres recorded during the tests. The measured acceleration value of the overtaking vehicles was consistently in the range of 0.1 - 0.18g (0.98 - 1.77m/s^2) for most of the overtaking manoeuvres with a maximum acceleration of 0.19g (1.86 m/s^2) produced by a 4.0 litre Ford Falcon Station Wagon.

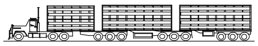
Initial Speed (km/h) 	Maximum Speed of the overtaking vehicle (km/h)	Distance (metres)
100	130	490
100	130	440
100	130	500
100	120	560
100	120	520
100	120	600
100	120	490
100	110	840
100	110	850
100	110	590
90	120	470
90	120	490
90	105	590
90	120	380
80	125	400
80	120	410
80	110	480
80	110	480
70	105	390

Table 4. B-Triple Overtaking Tests

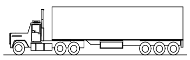
Initial Speed (km/h) 	Maximum Speed of the overtaking vehicle (km/h)	Distance (metres)
100	130	400
100	120	430
100	110	520
90	110	360
90	120	340
80	120	360
80	110	320

Table 5. Overtaking Tests with a 6-axle combination

6.3 Comments

These practical tests have proven that the major factor in the distance required for overtaking a B-Triple is the speed difference between the vehicles and not the length of the B-Triple. The distance required for overtaking is significantly reduced for the more powerful vehicle and for a bigger speed difference between the vehicles. Different drivers in the same vehicle may result in either longer or shorter overtaking distances but is a very important variable in the determination of safe overtaking distances for B-Triples.

For a speed difference of 30 km/h the required overtaking range was 400 - 500 m. The required distance for a speed difference of 20 km/h was 500 - 600m. And the required distance for a speed difference of 10 km/h was around 7-800m. The overtaking manoeuvres were completed under 15 seconds which included pulling out of the lane, overtaking the B-Triple and returning to the left lane.

In comparison to those values calculated from the data in the Bosch Handbook it can be seen that the overtaking manoeuvres completed in the above test are shorter than that calculated. Conclusions which may be drawn from this result is that the calculations made previous to the test were for lower acceleration values than that achievable for the modern motor vehicle and those obtained in the test.

The average distance for overtaking a B-Triple which is travelling at 100km/h on a two lane road was around 470 metres and is only 70 metres more than the distance needed to overtake a semi-trailer in the same situation.

7. ASSESSMENT OF BRAKING PERFORMANCE OF B-TRIPLES

Another commonly expressed concern is the stopping distance of larger heavy vehicles. Heavy vehicle braking performance has a major influence on both the risk of truck crashes and the consequences of such crashes for both truck drivers and other road users. Australian studies have revealed heavy vehicle braking problems (skidding, jackknifing) as a directly contributing factor in 4 per cent of crashes and it has been suggested that improved heavy vehicle brakes could have prevented crashes or reduced severity in 13% of crashes. In New Zealand inadequate brake performance appears to be the dominant factor in six percent, possibly as high as 11 percent of crashes (3).

The minimum stopping distance in emergency braking is generally interpreted as the minimum stopping distance or maximum deceleration that can be achieved without wheel lock. The braking performance affects stability of the vehicle during braking, as lock-up of all wheels on an axle or axle group can lead to instabilities such as jackknifing or trailer swing. It also affects driver feel and confidence in carrying out certain types of braking manoeuvres.

The brakes of all new combinations, including B-Triples, must meet all regulatory standards including Australian Design Rules and stopping distance and response / recovery times for road trains as outlined in the Road Transport Reform (Heavy Vehicle Standards) Regulations.

As use of a new combinations on the road must not expose other road users to unacceptable risk, a test program has been developed by Queensland Transport for the assessment of the braking performance of the B-Triple combinations. The program included testing routines and the braking characteristics of a wide range of combination vehicles was investigated. The program was designed to assist both industry and government objectives by:

- gathering information on real-life brake performance of B-Triples,
- improving heavy vehicle safety on the road,
- supporting vehicle innovation and new technological changes to enhance safety and productivity.

The brake test program included:

- on-road brake tests,
- brake tests on a roller brake tester,
- measuring brake response times and
- a computer simulation of the braking performance.

7.1 On-Road Brake Tests

A series of brake tests was conducted using various heavy vehicle combinations including a B-Triple, a B-Double, a Type 1 Road Train and an AB-Triple.

In order to determine the relationship between the effects of increased number of trailers and Gross Combination Mass (GCM) on stopping distance and deceleration rate, on-road braking tests were carried out from different speeds and under various loading conditions utilising the maximum braking forces available on the vehicle.

Braking performance for all tests was surveyed using Datron VI Vector Sensor and an AEP-5 Data logger. Stopping distance, velocity and deceleration was measured as a function of time. The brake tests have been carried out with laden and unladen combinations. A temperature of the brake drums for friction differences from wheel to wheel was measured and the tyre pressures and the mechanical condition of the combinations have also been recorded. In addition, brake testing was carried out using a roller brake tester providing accurate measurement of the braking force at each wheel over a full range of braking effort.

7.2 Results

The braking performance of a B-Tiple was assessed against the requirements of the Road Transport Reform (Heavy Vehicle Standards). These standards specify that the braking system of a motor vehicle or combination must produce a minimum deceleration rate of 2.8m/sec/sec from any speed at which the vehicle or combination can travel.

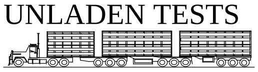
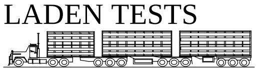
TEST	1	2	3	4	5	6	7	8	9
UNLADEN TESTS 									
Maximum Speed (km/h)	58.9	58.6	59.8	77.7	78.3	79.4	100	97.4	98.6
Stopping Distance (m)	51.3	45.8	46.4	75.8	67	60.7	116.7	123.1	102.4
Total Time (sec)	6.5	5.18	5.3	6.25	6.03	5.17	8.71	8.99	8.5
Average Deceleration (m/sec/sec)	-2.5	-3.14	-3.1	-3.45	-3.61	-4.27	-3.2	-3.01	-3.1
LADEN TESTS 									
Maximum Speed (km/h)	59.6	58.7	63.1	79.4	80.3	79.8	97.5	98.3	100.4
Stopping Distance (m)	42.9	45.8	47.7	67.52	77.7	79.2	115.9	116.4	117.8
Total Time (sec)	4.63	5.18	5.16	6.12	6.97	7.15	8.5	8.5	8.4
Average Acceleration (m/sec/sec)	-3.58	-3.14	-3.4	-3.6	-3.2	-3.1	-3.1	-3.2	-3.3

Table 6. Performance Tests for B-Triples

The test results for the B-Triple laden and unladen combination are summarised in Table 6. Apart from the first run, the measured deceleration values met the national requirements. Following the on-road brake tests the maximum braking force produced was measured on a roller brake tester machine.

However the braking system of the B-Triple produced 4.46 kN/tonne brake force, one axle group in the combination was not adjusted properly which affected the braking performance of the combination. This effect was more obvious, when the same trailer was used in a B-Double combination resulting in only 3.27 kN/tonne braking force during the test. **Figure 5** illustrates the measured stopping distances during the brake tests for a B-Triple (84 tonnes GCM), Type I Road Train (76 tonnes), AB-Triple (97 tonnes) and a B-Double (62 tonnes) and shows that the B-Triple combination produced good braking performance through a wide range of operational speeds (60-100 km/h).

8. ASSESSMENT OF THE OPERATING PERFORMANCE OF B-TRIPLES

According to the Australian Design Rules (ADR 44) the vehicle must have sufficient hauling capacity to safely draw the maximum load proposed. Larger and heavier vehicles can affect traffic operations in many ways including:

- requiring extra time to accelerate up to the posted speed limit;
- increasing sight distance requirements;
- increasing intersection clearance times (altering signal timing requirements).

In addition, as a vehicle's weight increases, its ability to climb hills at prevailing traffic speed and to accelerate quickly can be compromised if larger engines or different gearing arrangements are not used. Past experience with B-Doubles and Road Trains has shown that many of these traffic disruption effects can be minimised with the use of powertrains that ensure adequate acceleration performance.

8.1 Intersection Clearance Times

Long, heavy vehicles can be slow to accelerate and long vehicles must travel the full vehicle length to clear an intersection. In accordance with the national heavy vehicle standards, there are minimum saturability and gradeability requirements for B-Double and Road Train prime-movers.

The B-Triple combinations for each operator in the trial have been individually examined, as every combination had to comply with the conditions specified in the B-Triple Project Brief (4) before the permits were issued.

To demonstrate and assess this specific aspects of vehicle performance, on-road tests have been carried out to examine the acceleration performance of B-Triples compared with B-Doubles under normal traffic conditions. During these tests, the vehicles were instrumented, acceleration, vehicle speed and distance travelled have been recorded, and the turning manoeuvres have been recorded on video for any future analysis. The details of the tested vehicles are as follows:

> B-Triple: 84 tonnes GCM, 35.6 metres of overall length, fitted with a 525 HP engine and a 18-speed transmission;
>
> B-Double: 62.5 tonnes GCM, 24.4 metres of overall length, fitted with a 454 HP engine and an 18-speed transmission.

Fig 7 illustrates a typical turning manoeuvre during the tests. The intersection clearance time was measured while the test vehicle travelled from the starting position and the rear end of the last trailer cleared the kerb lane of the street (intersection is cleared). The results of these tests are summarised in Table 7.

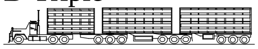
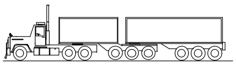
VEHICLE	Intersection 1 (25 metres)	Intersection 2 (35 metres)	Intersection 3 (29 metres)	Intersection 4 (23 metres)
B-Triple 	18.02 (sec)	21.7 (sec)	19 (sec)	17.4 (sec)
B-Double 	16.3 (sec)	18.2 (sec)	16.9 (sec)	15.9 (sec)

Table 7. Results of the tests

Although the test data shows that a B-Triple would take slightly longer to clear the same intersection than a general B-Double, this is a small difference (10-15 %) and would be within an acceptable tolerance level. This assessment has also indicated that the performance of the B-Triples is close or equivalent to the middle range of current heavy vehicle performance and the B-Triples would meet the B-Double standards.

8.2 Assessment of the Travelling Speed of the B-Triples

The Project Brief of the B-Triple Trial (4) has stated that additional to the dynamic performance of the combination the impact of a B-Triple on other road users will also be assessed. At the commencement of the B-Triple trial, there were some concerns raised that a vehicle of this length and mass may adversely affect the traffic flow on certain routes. Although performance standards were developed to ensure that the B-Triple is a better performing and safer combination than existing road trains, concerns have been expressed about how a fully loaded B-Triple could perform, especially on up-grades, when compared with an unloaded B-Triple and whether road users may need to queue behind the combination for unreasonable lengths of time. Due to this specialist type of specification of B-Triples it was anticipated that a B-Triple combination would have no or minimum impact on other road users.

On-road tests have been carried out with a B-Triple combination to record the speed of the B-Triple combination under various load and traffic conditions. The B-Triple was instrumented with a Datron V-1 optical sensor to measure speed, distance and body slip angle and magnitude. In addition a DAVIT PC-Based data acquisition system was used and the trips were recorded on video.

As a part of the evaluation process, two trips were conducted on the test route (Inglewood-Texas-Whyalla road) with a laden and unladen B-Triple combination. The Gross Combination Mass of the laden B-Triple was 84 tonnes and the tare weight was 38.8 tonnes. The test road represents a worse than average road train route in rural Queensland with a narrow 5.4 metre bitumen, grades between 1% and 4.16% and Annual Average Daily Traffic (AADT) of 215, 27% of the heavy vehicles.

Figure 8 shows the recorded speed of the test B-Triple for the two trips. It can be seen from the diagram, that the B-Triple was capable to maintain travelling speed for the entire trip. The average travelling speed for the laden run was 84.3 km/h and 87.5 km/h was for the unladen run representing a very small, 3.7%, difference only. These tests runs also demonstrated the excellent tracking capability of the B-Triple combination, as the driver of the combination was able to keep the outside wheels on the combination within an estimated 150-300 mm of the edge of the bitumen.

8.3 Comments on B-Triple Operation

During the period from November 1996 to November 1997 more than 100 trips were undertaken with various B-Triple combinations. Destination have included Toowoomba, Townsville, Warwick and a wide range of road train routes in South-East Queensland. Queensland Transport has collected information on loadings, maintenance cost, fuel efficiency and driver's comments on the B-Triple performance plus reports on other factors.

Queensland Transport have also undertaken extensive consultation with police, local government and interested road user groups about the B-Triple operations. To help the public identify this combination on the road, Queensland Transport requested that a special sign be attached to the rear trailer of the B-Triple picturing the outline of the B-Triple and the overall length of the combination. The sign also included a contact phone number for any comments.

Up to date Queensland Transport have received 8 phone calls commenting the B-Triple operations. 50 % of the complaints (4 calls) were anonymous, covered issues other than B-Triple operational problems (B-Double operations, overloading, environmental impacts and driver habits) or included technically incorrect information about the trial operation (length of a B-Triple). These claims can not be investigated. The remaining calls reported problems with overtaking on single lane carriageways and low speed on hilly, narrow road sections. These claims are being investigated, but it appears to be that there are some areas where the trial vehicles travelled more slowly than other vehicles would travel. Comparing the speed performance of a B-Triple with other heavy vehicle classes, especially with Type 1 Road Trains in those areas, it is apparent that there is no significant speed difference between the combinations that would affect other road users more adversely.

In general, the motoring public has not noticed this new combination on the roads and it's unlikely that there could be any serious reservation about operating B-Triples in the areas tested.

9. REARWARD AMPLIFICATION TESTS

In 1996, computer simulation and analysis were carried out on the candidate B-Triples to assess the dynamic performance characteristics of the combinations and to ensure that they meet the performance requirements set out in the Trial Brief.

This assessment included the analysis of the Rearward Amplification performance of the B-Triples, as this performance attribute is a useful performance measure for quantifying obstacle avoidance capability. Rearward Amplification is defined as the ratio of the peak value of lateral acceleration achieved at the centre of gravity of the rearmost unit to that developed at the hauling unit. **Figure 9** illustrates the simulation results for a B-Triple during the standard lane-change manoeuvre (5). (This simulation was conducted using an AUTOSIM model provided by RoadUser Research.)

In addition to the simulation work, a Rearward Amplification test was carried out with a B-Triple combination. Although, the tests were conducted according to the recommendations of the Society of Automotive Engineers USA (SAE J2179) with respect to test course, basic instrumentation and speed, the data processing capabilities of the system did not fully meet the requirements of the draft standards and the high-speed dynamic off-tracking performance was not measured.

Consequently the data presented in this report has not been used to verify the predictions of the computer model but to ‘get a feel’ for the dynamic performance of a B-Triple combination.

The Rearward Amplification of the tested B-Triple was 1.7 that is comparable with the results of the computer simulation.

10. CONCLUSIONS

The tests and the computer simulations have shown that the B-Triple is clearly a much better performing and safer combination than existing Road Trains. This has been highlighted by the combinations involved in the B-Triple trial that have safely travelled approximately 250,000 km.

An economic analysis of the operations has shown that the cost per tonne of freight moved in a Type 1 Road Train configuration is generally lower than a B-Triple. An obvious alternative to encourage the use of B-triples is to allow B-Triples access to more highly populated areas. However, there are community perception issues that will need to be resolved before any additional access to B-Triples is granted.

Further testing and analysis of other performance aspects are expected to be undertaken before the conclusion of the trial.

Following the B-Triple trial in Queensland other states have investigated allowing B-Triples to operate within their state. Additionally a group of companies have joined together to fund a project, Freight Corridors 2000, with the long term aim of getting B-Triple access to major interstate freight corridors. The project has the support of a number of state road authorities and are building on the work started by Queensland Transport and described in this paper.

Introduction Content

11. REFERENCES

(1) Australian Census (1996) - ABS

(2) Government Statistican's Office (GSO) 1994, Estimates of Gross Regional Product Queensland, Queensland Government, Brisbane

(3) Inquiry Into Truck Crashes, 1996

(4) B-Triple Project Brief, Queensland Transport

(5) A Test For evaluating the Rearward Amplification of Multi-Articulated Vehicles (J2179, Draft)

Fig 1. A B-Triple Combination

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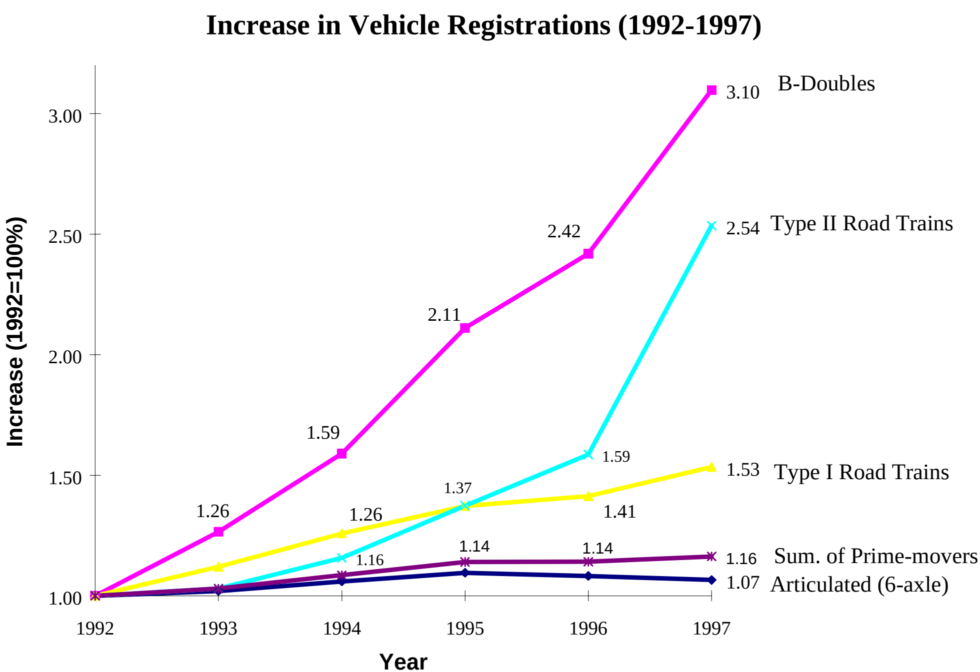

Fig 2. Heavy Vehicle Registrations by Vehicle Types in Queensland

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Fig 3. A Typical B-Triple Combination operated in Queensland

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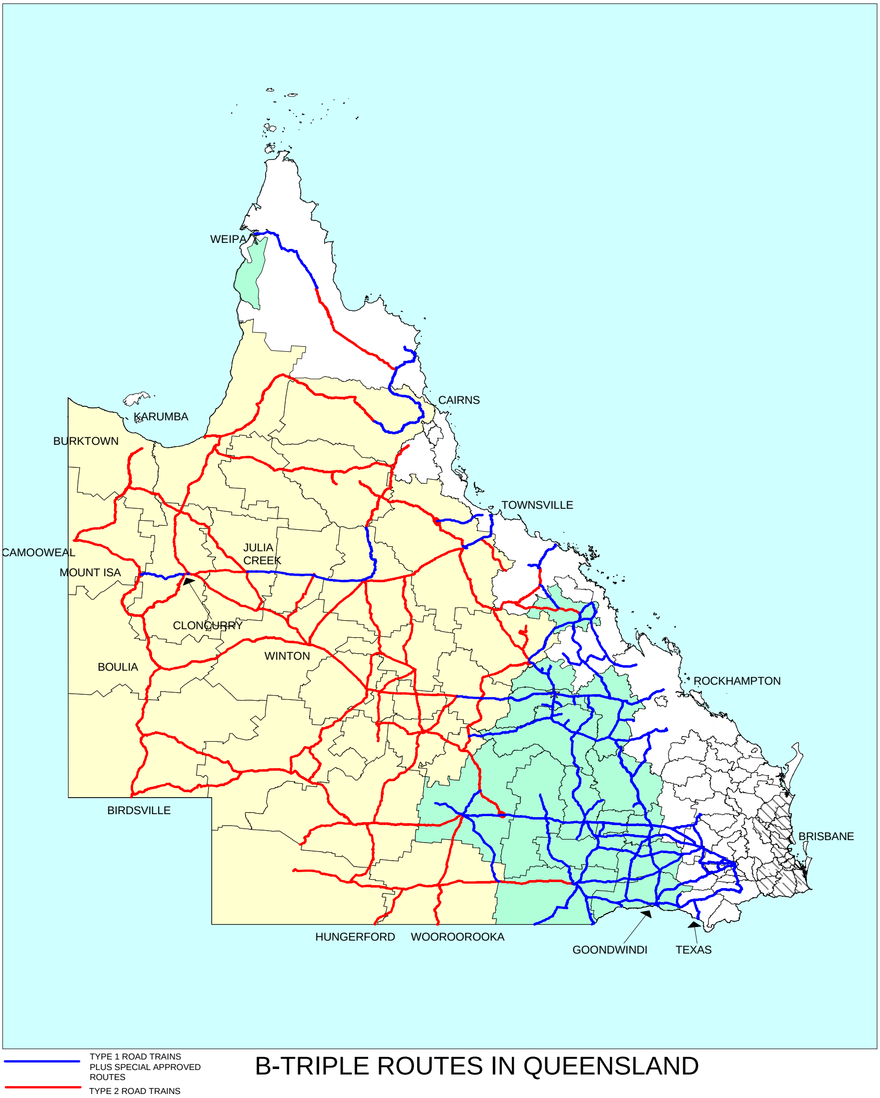

Fig 4. B-Triple Routes in Queensland

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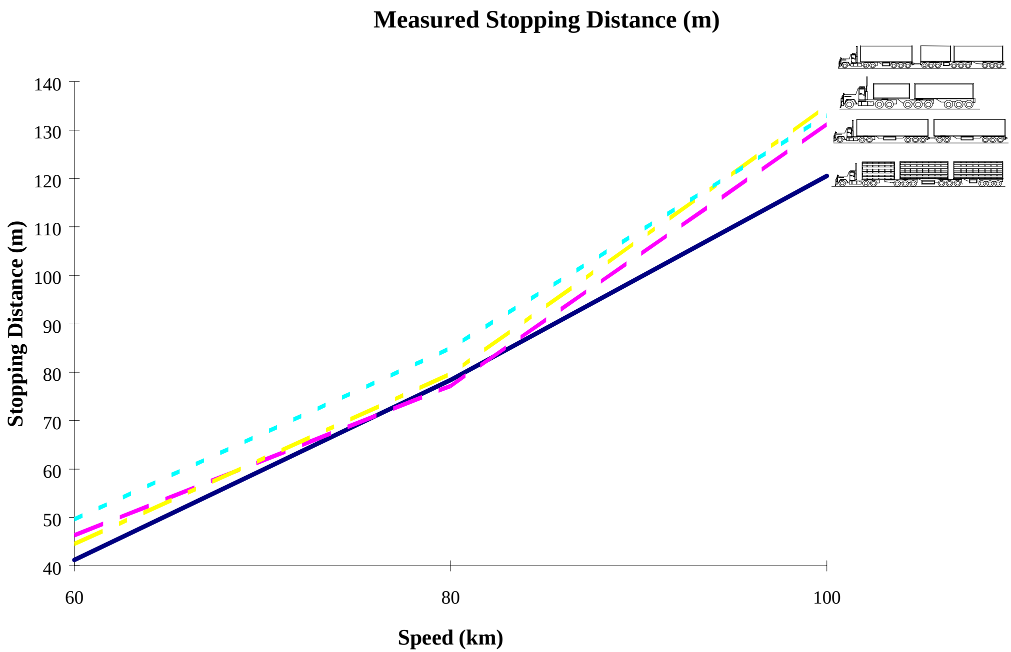

Figure 5. Measured Stopping Distance of Heavy Vehicle Combinations

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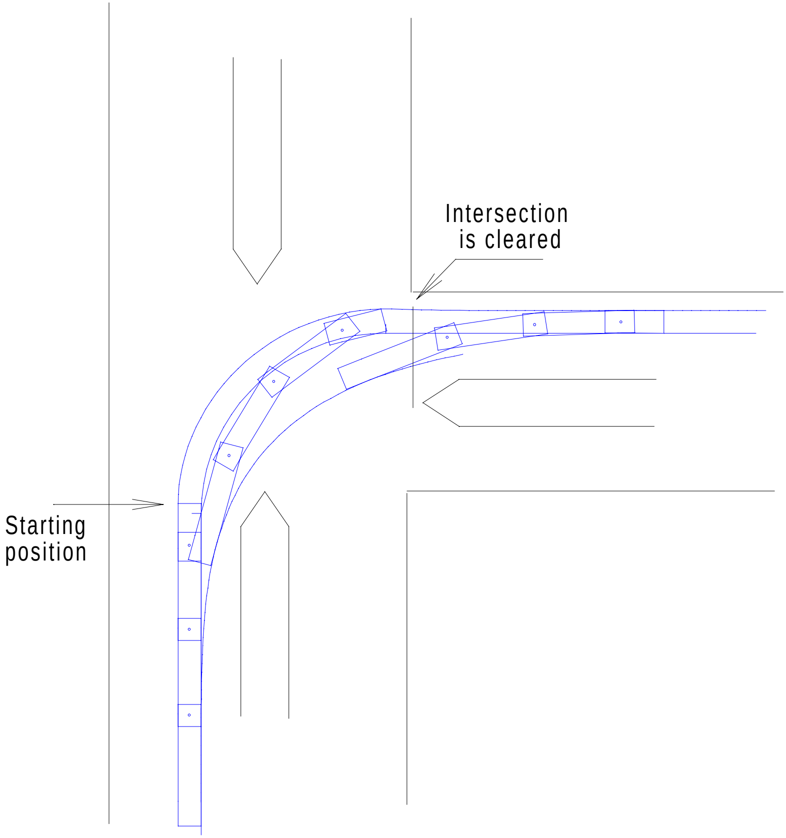

Figure 7. B-Triple Intersection Clearance Time Tests

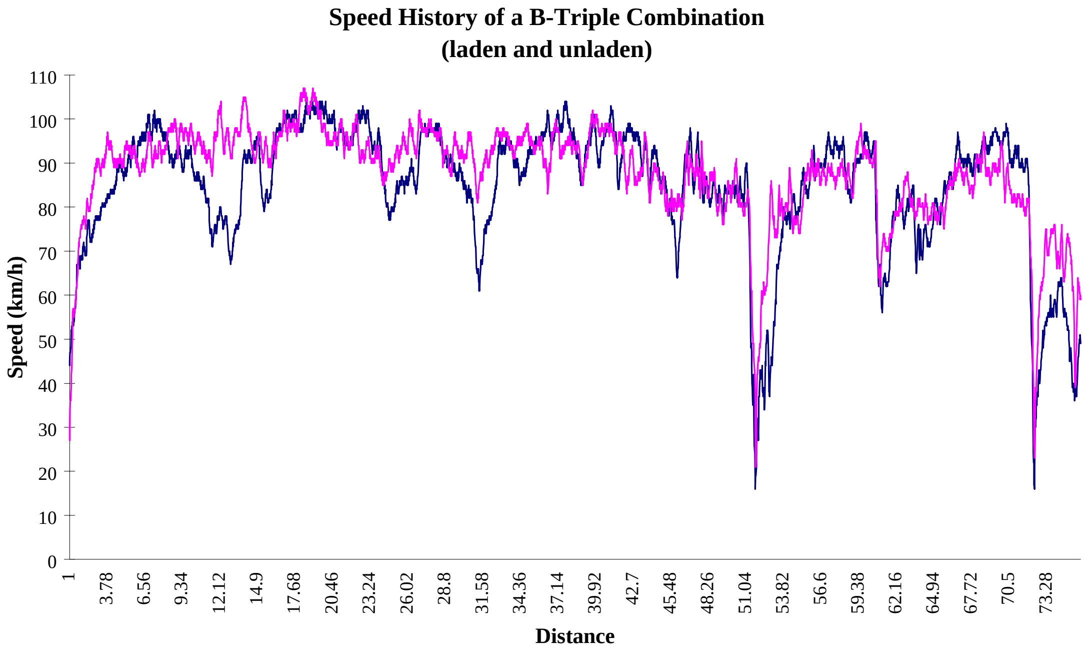

Figure 8. Speed History of B-Triples

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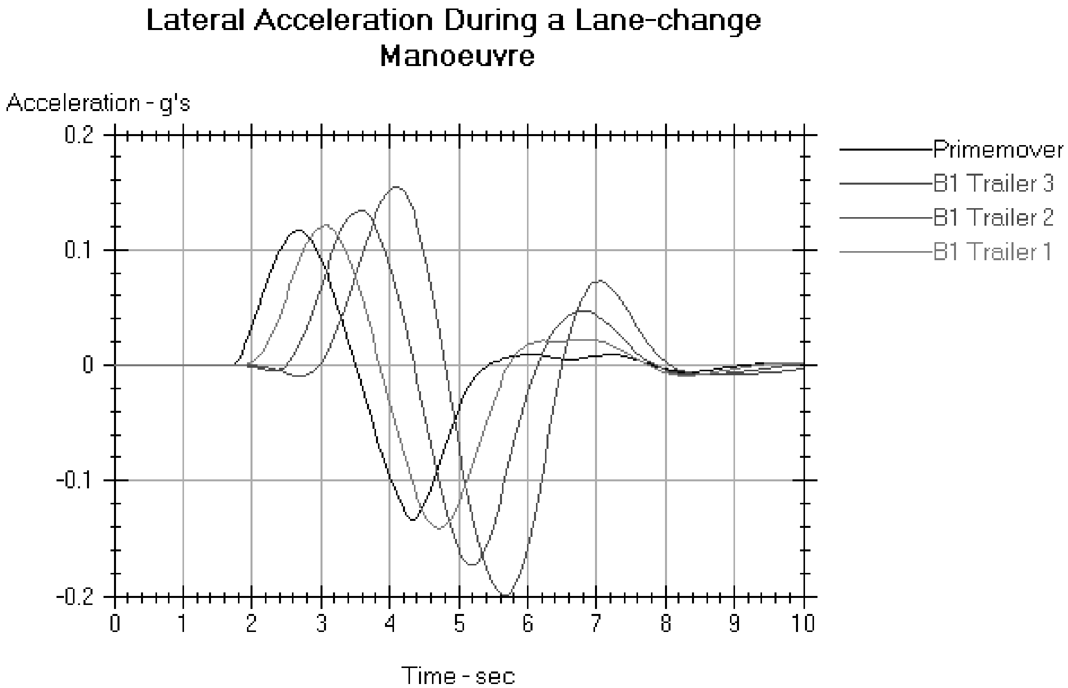

Figure 9. Simulation of a Lane-change test

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