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EXEMPTION GUIDE-LINES FOR NON-STANDARD VEHICLES

Rod George, Matt Elischer and Hans Prem
ARRB Transport Research Ltd

ABSTRACT

In Australia Regulations have been introduced that prescribe mass and dimensions limits for vehicles and vehicle combinations, while another set of Regulations provide for exemptions to be granted under a specified framework. The exemptions provide the opportunity to improve road safety and transport efficiency through the introduction of new and sometimes innovative vehicles. To grant exemptions, guidelines will need to turn to performance measures since prescriptive control is very difficult in this area which is likely to be one of considerable innovation.

Road Authorities are receiving applications for vehicles to operate outside the Regulations under the exemptions process, and in the absence of agreed standards, are make decisions on an ad-hoc case-by-case basis. The development of guidelines to assess candidate vehicles against agreed target values for performance measures is highly desirable as these performance measures will provide:

1. A consistent and meaningful method of assessment in an area where prescriptive control is difficult and can be misleading.
2. Improved transport efficiencies while maintaining, or enhancing safety levels.

Using the process of combining Regulations and exemptions through agreed guide-lines, a balance of 'standard' vehicle configurations and innovative/purpose-built vehicles can operate through an overall 'safety net' of the regulations. Improved transport efficiencies can be gained through appropriate exemptions with performance-based-measures to ensure safety is not compromised.

A program was conducted to develop National guide-lines to be used by regulators when assessing non-standard vehicles to use the road network. As road safety and transport efficiencies are best expressed through adequate vehicle safety and appropriate road geometry performance measures. A study was undertaken using computer modelling and simulations to obtain the performance of a range of 'standard' vehicles using a number of safety and road geometry based performance-based measures. From these simulations minimum levels or target values were recommend to be used when assessing the suitability of non-standard vehicles to access various parts of the road network.

These guide-lines specify target values for vehicle classes based on overall vehicle length.

Information from this study provided a suite of performance-based measures and target values that have been proposed for National endorsement to be used when assessing candidate vehicle for access to the road network.

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INTRODUCTION

The National Road Transport Commission (NRTC), with agreement from the States, has introduced Vehicle Standard Regulations (VSR) and Mass and Loading Regulations for heavy vehicles that prescribe mass and dimensions limits for vehicles and vehicle combinations. The majority of current vehicles are covered by these Regulations and are referred as ‘standard’ vehicles throughout this report. A further set of draft regulations, the Restricted Access Vehicle (RAV) Regulations provide for exemptions to be granted from these former Regulations under a specified framework and guidelines. The exemptions provide the opportunity to improve road safety and transport efficiency for innovative vehicles.

In general, any exemptions granted under the RAV Regulations must not exceed 10% of the Mass and Loading Regulations, but other provisions allow for innovative vehicles to support specially constructed facilities like mines and ports. The NRTC suggests that the criteria against which granting exemptions should include:

- Improved Road Safety
- Improved Transport Efficiency
- Reduction of Administration costs for road transport in the Inter-government Agreements.

To grant exemptions, guidelines will need to turn to performance measures since prescriptive control is very difficult in this area which is likely to be one of considerable innovation.

Road Authorities are receiving applications for vehicles to operate outside the regulations under the exemptions process, and in the absence of agreed standards, are being forced to make decisions on a largely ad-hoc case-by-case basis. These applications for exemptions take several forms:

- Vehicles longer than 53.5m;
- Different configuration of existing vehicle types, eg. shorter B-doubles, B-triples;
- A mixture of “A”[1] and “B” connected units;
- Vehicles that are within the current regulation dimensions but are seeking approval to operate with higher axle loads.

The development of guidelines to assess candidate vehicles against agreed target values for performance measures is highly desirable as these performance measures will provide:

1. A consistent and meaningful method of assessment in an area where prescriptive control is difficult and can be misleading.
2. Improved transport efficiencies while maintaining, or enhancing safety levels.

Using this process of combining regulations and exemptions, a balance of "standard" vehicle configurations and innovative/purpose-built vehicles can operate through an overall "safety net" of the regulations. Improved transport efficiencies can be gained through appropriate exemptions with performance-based-measures to ensure safety of transport operation.

Project Aim

The aim of this project is to recommend performance measures and target values that can be used as guidelines to assess candidate non-standard vehicles to use the road network. These performance standards can be used to quantify the performance of combination vehicles in safety related manoeuvres by comparison with standard vehicle types.

PROCEDURE

Road safety and transport efficiencies are best expressed through adequate vehicle safety and appropriate road geometry performance measures. A number of performance measures have been developed throughout the world that cover both safety and road geometry issues.

Analytical procedures have been developed for evaluating vehicle performance in safety related manoeuvres. Fancher and Mathew (1990) described the context in which these manoeuvres provide the basis to assess vehicle performance with the following goals:

- The rear end of the vehicle should follow the front of the vehicle with adequate fidelity;
- The vehicle should safely attain a desirable level of deceleration during braking;
- The vehicle should remain upright (not rollover);
- The vehicle should be controllable and stable while following a prescribed path.

A number of these performance-measures, which are primarily safety related, have been selected to assess a range of vehicles for this study.

Fancher and Mathew (1990) suggested that to judge vehicle performance it is useful to arrive at performance targets representing desired level of performance. It would be ideal for these performance targets to be based on analyses of accident record which unfortunately are not generally available. They also suggested that one approach to establish performance target values is to use the performance of a baseline or reference vehicle. This approach was used by George et al (1996) to establish a roll-threshold target value for vehicles higher than 4.3m.

A range of "standard" vehicles were assessed against performance measures using computer simulations, and their performance characteristics were used as a basis to recommend minimum performance level or target values.

PERFORMANCE-BASED MEASURES

There are a number of performance-based measures that characterise the nature and level of performance of heavy vehicles. These measures have been studied by a number of research organisations throughout the world, one of the most comprehensive studied was conducted in Canada reported by Pearson (1986).

This pioneering Canadian study established an extensive set of performance measures and recommendations for heavy vehicle performance specifications. A full description of the performance measures and results are given in Ervin and Guy (1986). This work has provided a background and basis for most other work in this field. For example, in Australia NRTC (1993), New Zealand White (1989) and United States of America, Fancher and Mathew (1990). Further work was conducted in Canada by El-Gindy (1991), El-Gindy et al. (1992) and implementation issues have been address by Pearson (1995).

Vehicle performance measures can be classified into two general groups. The first group covers safety related and traffic mix issues and the other group considers the ability of a vehicle to operate within the capacity of the road network system. Vehicle performance measures can therefore be classified by the following:

- Low speed operation — Safety and Road geometry
- High speed operation — Safety and Road geometry
- Acceleration/deceleration — Safety and Road geometry
- Evasive manoeuvres — Safety
- Road space requirements — Safety

These vehicle performance measures can be further expanded into the groups shown in Table I.

Table I: Grouping of performance measures

General Safety	Low speed	High speed	Acceleration/ deceleration	Evasive manoeuvres
Load Retention	Stability	Pavement loading	Startability	Roll-Threshold
Conspicuity	Pavement loading	Suspension load sharing	Friction requirements	Dynamic Stability
Mechanical Couplings	Offtracking - inboard (swept path)	Ride comfort	Power/weight ratio	Load transfer ratio
Under-Run Protection	Out-swing - outboard (initial rear movement)	Dynamic offtracking	Gradeability	Rearward Amplification
Cab Strength	Friction requirements	Dynamic road space	Deceleration	
		Yaw damping	Acceleration	
		cruising speed capability	Stability under braking	
		Spray suppression		

A number of the measures listed in Table I are covered by Australian Design Rules, eg., braking (ADR 35/00 and 38/01), and Under-run protection (ADR 42/02), and some are covered by Australian Standards, eg., Mechanical coupling between prime movers and trailers AS 2174.2-1994, Kingpins AS 2175-1995 and Fifth wheel assemblies AS 1773-1996. Load retention is covered by guidelines issued by the Federal Office of Road Safety and the National Road Transport Commission (1994).

As the mechanical connections and braking systems are covered by the above mentioned standards, this project will therefore concentrate on measures that quantify vehicle performance that influence safety and road access issues.

Table II: General relationship between measures of intrinsic safety and vehicle characteristic (after Fancher Mathew (1990)

	Measures of Intrinsic Safety				
	Offtracking				
	Low-speed	High-speed	Braking efficiency	Roll-threshold	Rearward amplification
Increasing # of articulations	⇑	↓	?	-	⇓
Longer wheelbase	⇓	↑	↑	-	⇑
Longer overhang to rear hitches	↑	↓	-	-	⇓
Increasing # of axles	↑	↓	⇓	⇑	⇓
Increasing axle load	-	↓	?	⇓	⇓

⇑ Greatly improves the level of intrinsic safety

↑ Moderately improves the level of intrinsic safety

? May not be important

⇓ Greatly reduces the level of intrinsic safety

↓ Moderately reduces the level of intrinsic safety

- Not applicable or Small effect

There are some interactions between performance measures which impacts on combination vehicle safety. Fancher and Mathew (1990) showed that there are strong interactions between some performance measures (see Table II), which highlights the notion that any performance measures should be implemented together and not in isolation.

The concept of extending performance-based measures beyond the intrinsic properties of the vehicle to its interaction to the road system was explored by Billing (1992). Billing expressed concerns that an incomplete set of performance standards could result in incomplete control of traffic. Billing (1995) also suggested "It is important to dismiss the concept that vehicles should be configured based only on objective performance standards". He quotes experiences where innovative vehicles were configured in the pursuit of maximum gross weight or distribution of the gross weight that led to many classes of vehicles that cannot properly carry or distribute the gross weight they may theoretically accrue, and/or have significant other objective performance deficiencies.

Performance measures used in this study and initial target values

Based on previous studies in this area, and current Austroads work in progress at ARRB TR, nine performance measures were used in this study to assess vehicle performance. A description of these measures and methods of assessment are following. Definitions of these performance-based measures are given in **Appendix A**. These description include the proposed target value (if known) and information on a method to measure the characteristic. Computer simulation programs have been developed to predict vehicle performances using these measures.

Static roll stability

Static roll stability is one of the most fundamental and important properties for vehicle safety. There are several terms that are in common use that are loosely used to describe vehicle roll stability. These terms are defined as:

- **Roll-threshold** is the level of lateral acceleration required to lift *one complete* axle group. These measures are all expressed as a fraction of the acceleration due to gravity 'g';
- **Roll limit** is the maximum level of lateral acceleration that a vehicle can sustain *without* rolling over;
- **Roll-stability** the minimum lateral acceleration required to cause *rollover* of a vehicle or a unit of a combination vehicle.

Ranking the above definitions from smallest to largest lateral acceleration is as follows: **Roll-threshold** is less than **Roll limit** which is less than **Roll-stability.**

The roll threshold characteristic is relatively easy to measure using a tilt table and is generally used to quantify vehicle stability. The roll stability measure was established with computer simulations applying a ramp steer input to the vehicle at a constant speed and noting the lateral acceleration to cause each axle group to lift.

A target value 0.33g has been proposed for the static roll-threshold by George et al (1996).

Low-speed offtracking (Swept path)

This measure is of concern when negotiating intersections. It is generally referred to as in-board offtracking and is the distance between the path of the last axle on the vehicle and the steer axle in a low-speed 90° turn.

A performance-based swept path measure was developed in Australia (see Austroads, (1992). This measure defines the entry radii and the maximum exit width and gives 3 target values of maximum offtracking for vehicles to access 3 levels of the road network - local, arterial and roadtrain routes. This performance measure was designed to provide a set of target values for vehicle designers and operators to meet and to prevent "incremental creep" in vehicle dimensions.

The low speed offtracking characteristic is relatively easy to measure - by noting the lateral position of the front and rear axles of a vehicle as it negotiates a left 90° turn. The VPATH computer program was used to obtain estimates for the low speed offtracking for the vehicles in this study.

High-speed offtracking - Steady-state

This measure is the distance between the path of the last axle of the vehicle and the steer axle in a steady-state high speed turn. In contrast to the low-speed offtracking the last axle may track out-board of the steer axle.

This characteristic can be measured by tracking the position of the front and rear axles of the vehicle under standard test conditions typically, as it negotiates a circle path of 318m radius at 90 km/h. It may also be possible to measure the high-speed offtracking by recording the yaw rate at the front and rear axles and computing the difference in radius of travel.

A target value of less than 0.46m in a steady turning manoeuvre of 0.2g lateral acceleration has been proposed by White (1986) and Ervin and Guy (1986).

Rearward amplification ratio (RA)

Rearward amplification is the relationship between the maximum movements of the first and last units in a combination vehicle during a rapid avoidance manoeuvre. This measure expresses the increased risk of rollover and swing-out of the last unit. This measure is of primary concern for multi-trailer and non-roll coupled vehicle units, ie., vehicles connected with “A” couplings.

Rearward amplification is defined as the ratio of the peak lateral acceleration of the rear trailer to the peak lateral acceleration of the hauling unit in a prescribed lane-change type avoidance manoeuvre. This measure is steer-frequency and speed dependent and useful comparisons between vehicles can only be made when all vehicles are subjected to similar steer-frequencies, travel speed and lateral offsets during the test manoeuvre.

There has been several target values for the rearward amplification ratio measure proposed throughout the world, however, it is difficult to apply these to the Australian fleet without considering factors such as axle load, overall vehicle length and track width (some of the proposed target values were also based on wider vehicles).

Target values for rearward amplification recommendations will be based on the predicted performance of the vehicles in this study.

A standard procedure for rearward amplification tests has been proposed by the Society of Automotive Engineers (see SAE (1993). This procedure outlines a lane change course test with a lateral offset of 1.46m over a distance of 61m, and a manoeuvre speed of 88 km/h. This course is designed to induce a 0.15g lateral acceleration level at the steer axle of the hauling unit. This SAE test procedure was used in the computer simulations to predict the rearward amplification, load transfer ratio, high speed transient off-tracking and the yaw damping for the vehicle in this study.

A number of studies have been conducted using a lane change manoeuvre to assess vehicle rearward amplification performance. It is difficult to compare results across all studies as some test manoeuvres were conducted using different steer frequencies and lateral displacements. **Figure 1** shows the effect of lane change lateral displacement on rearward amplification (RA) and lateral load transfer ratio (LTR) (see definition on the following page) on a truck/trailer combination. It can be seen that both the RA and LTR are nominally linearly related to the course lateral displacement. Changing the lateral displacement has a large effect on the LTR with the vehicle approaching 80% load transfer with a 2.25m displacement. Figure 1 highlights the importance of specifying the test conditions, for example it would be misleading to compare two identical vehicles with a 1 and 2m lateral displacements. The slight non-linearities in the RA plot could be attributed to the tyre characteristics. The results shown in Figure 1 are all based on a test steer frequency of 2.5 rad/s.

Figure 2 shows the effect of various lateral displacements on lateral acceleration at the steer axle during a lane change manoeuvre. This Figure shows clearly the strong linear relationship between lateral acceleration and the lateral displacement during the lane change test.

High-speed offtracking - Transient

The high-speed transient offtracking is the extent that the rear of a vehicle tracks outside the path of the steer axle in a rapid steering manoeuvre. Large values can lead to side-swipe accidents where the rear of the vehicle strikes a vehicle in an adjacent lane.

This property is difficult to measure as it requires the lateral position of both the steer and rear axles of the test vehicle to be measured as the vehicle negotiates a lane change manoeuvre. Instrumentation has been developed at ARRB TR to measure these parameters.

A target value of less than 0.8m has been proposed by White (1986) and Ervin and Guy (1986).

Lateral load transfer ratio (LTR)

The lateral load transfer ratio is the prime measure of vehicle stability during an evasive manoeuvre. The LTR describes load transfer from tyres on one side of a vehicle unit to those on the other side. The LTR is defined as the ratio of the absolute value of the difference between the left and right wheel loads to the sum of the left and right wheel loads. This measure will have a value of zero when the vehicle is at rest on a level surface, ie. when the difference between left and right axle loads is zero, and will rise to a value of one when a full transfer of load from one side to the other occurs, indicating lift-off of all tyres on one side. Front steering axles are excluded from the LTR calculations because of their low contribution to roll stability.

A target value of less than 0.6 has been proposed by Ervin and Guy (1986).

Yaw damping coefficient (YDC)

This measure is important because it characterises the lateral-directional damping of the rear most trailer of a combination vehicle. Vehicles with high yaw damping coefficients rapidly damp out swaying, conversely vehicles with low coefficients result in prolonged swaying and increased risk of rollover or impact with vehicles in adjacent lanes.

Yaw damping is quite difficult to measure as the vehicle is required to be subjected to a rapid reversal of steer input. During the lane change manoeuvre the lateral response of the rear unit can be used to estimate the damping coefficient using a logarithmic decrement procedure on successive peaks of the rear unit lateral acceleration response.

A target value for YDC of greater than 0.15 has been proposed by White (1996).

Road space requirements (RSR)

Road space requirements is a measure of the total lane width that a combination vehicle requires as it travels at highway speeds. Austroads project NRUM 9501 (George et al 1997) has shown that vehicle type, speed, road cross-slope and roughness influence road space requirements. This Austroads work has developed a test method of estimating road space requirements at highway speeds using a purpose developed water trace and video camera measuring system. Computer simulation software has also been developed to predict the road space requirements of vehicles. Table III lists the proposed a road space requirements, (George et al 1997) based on vehicle dynamic performance over measured road profiles and a vehicle width of 2.5 m.

Table III: Proposed road space requirements

Vehicle	Total space (m)
A123	2.71
A-double	2.96
A-triple	3.42
B-double	2.73
B-triple	2.72

Gradeability - Minimum speed on a grade

In order for combination vehicles to present minimum obstruction in traffic streams it is necessary for them to have the ability to maintain a reasonable speed. The minimum speed can be set by specifying a minimum power/weight ratio or alternatively a minimum speed performance requirement on a specified grade. Work conducted by Main Roads Western Australia, George (1997), proposed a minimum speed performance criteria for long combination vehicles to be 50 km/h on a 1% grade. This is recommended as a target value for the vehicle class < 53.5 and > 53.5 m for this study.

Gradeability is not difficult to measure directly if a suitable length of 1% grade can be found. Vehicle speed loss on grades can be predicted from first principles using parameters such as engine torque, transmission ratios and drive efficiencies.

COMPUTER SIMULATIONS

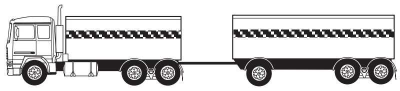
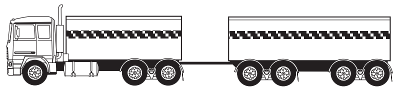
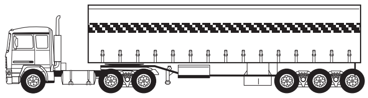
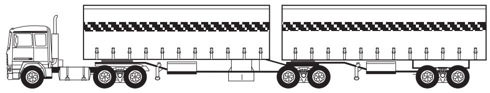
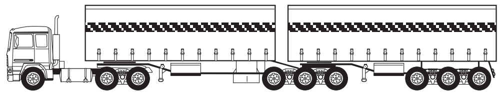
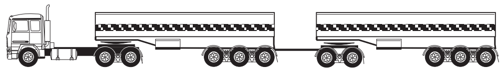
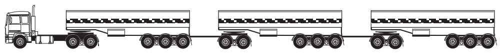
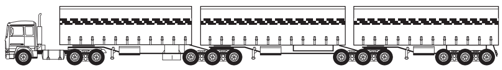
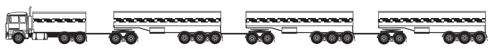
In order to confirm the proposed target values or establish target values for the performance measures listed above, a number of computer simulations were conducted on a range of “standard” vehicle types. The vehicles were modelled using dimensions for 85 percentile vehicles from Austroads (1995) with homogenous loads to achieve maximum cubic capacity and maximum current axle loads, vehicle types and coding are listed in Table IV. The vehicle loading conditions will provide load centre of gravity height at the load mid point and ‘worst case’ performance for each simulated vehicle. Simulations were conducted using ADAMS[2] multi-body dynamics modelling package after a validation program was conducted (Elischer and Prem 1997).

Results

It is proposed that the target values for vehicles to be assessed segmented into groups based on vehicle length and the performance of the standard vehicles in each group.

The results of the computer simulations are summarised in Table IV.

Table IV: Vehicle used to establish performance target values

Vehicle	Code	Pictorial
Truck/trailer	R12-T12	
Truck/trailer	R12-T22	
Single articulated	A123	
B-double	B122	
B-double	B1233	
A-double	A123-T23	
A-triple	A123-T23-T23	
B-triple	P12 (B3)3	
Rigid truck & three trailers	R12-T23-T23-T23	

Speeds on grades

Figure 3 shows the minimum speeds for vehicles with three engine powers and a range of GCM on a 1% grade. If the minimum speed criteria of 50 km/h is adopted, then for a 520 hp vehicle the maximum GCM would be approximately 130t, similarly a 400 hp vehicle could manage approximately 100t GCM.

Power/weight ratio

Another possible method of specifying minimum gradeability performance is by the power/weight ratio. This is a more general method as it does not consider engine performance issues such as the engine torque range, transmission ratios and drive efficiencies. It does however, provide a first order criteria to maintain a reasonable traffic flow. Table V lists the power/weight ratio for three current vehicle types.

Table V: Power/weight ratios for common vehicles

Vehicle	Engine power (hp)	GCM (t)	Power/weight (hp/t)
B-double	400	62.5	6.40
A-double	450	79.0	5.70
A-triple	450	115.5	3.90

Power/weight ratio for a vehicle powered by 520hp with a GCM of 130t, and a 400hp 100t GCM would both be 4 hp/t. For example, adopting a power/weight ratio of 4 hp/t in order to maintain a 50 km/h minimum speed on a 1% grade as a guideline for minimum performance on grades would seem acceptable.

Target values

Table VI lists the proposed performance measures and target values for each vehicle length class. These target are extracted from the vehicle attributes obtained by computer simulation given in **Appendix B**. It is proposed for any vehicles longer than the current maximum length of 53.5 m, that they meet the target values for the 53.5 m length class.

As shown in Appendix B the performance of the "A" coupled vehicles (A-double, A-triple and Rigid + 3), produce the worst performance. Given that the intention of using performance based measures to assess the suitability of new/innovative vehicles is to provide a safety neutral or improvement then using the worst performing vehicles in each length class to specify the target values will not produce the desired outcome. Therefore, some of the target values have been chosen after consideration to meet the safety objectives, ie. Not necessarily using the attributes of the worst performing vehicle in each length class. This approach seems reasonable as the introduction of new vehicle types should improve transport efficiency while maintaining or improving present safety levels.

It is proposed that all vehicles meet the criteria for axle spacing to meet the bridge formulae as set out in the Axle spacing schedule, Austroads (1992) or subsequent agreed national criteria.

Table VI: Proposed target values

	Vehicle length (m)			
	<19	<36	<53.5	>53.5
	Proposed target values			
Vehicle performance measures				
Load transfer ratio - less than	0.6	0.6	0.8	0.8
Yaw damping ratio - greater than	0.15	0.15	0.2	0.2
Static roll threshold (g) - greater than	0.35	0.35	0.35	0.35
Rearward amplification - less than	1.2	1.7	2.2	2.2
Low speed off-tracking (m) †	1	2	3	3
High speed transient off-tracking (m) - less than	0.2	1.4	1.8	1.8
High speed off-tracking (m) - less than	0.2	0.5	0.5	0.5
Minimum speed on a 1% grade (km/h)	70	65	50	50
Interaction with the infrastructure				
Road space requirements:				
Rough road @ 90 km/h (m) - less than	2.7	2.8	3.4	3.4

† Austroads swept path envelopes: 1 Level 1 - Local roads
2 Level 2 - Freight routes
3 Level 3 - Roadtrain routes

IMPLEMENTAION

The concept of determining the suitability of vehicle configurations using performance-based measures provides safety benefits, the development of innovative vehicles to improve transport efficiencies and provide design criteria for vehicle designers, manufactures and operators.

There are a number of implementation issues that need to be resolved, such as:

- How will permits be issued ?
  1. The outputs of computer simulations of vehicle dynamic ?
  2. Results of full-scale testing ?

3. Interim permit based on computer simulations and confirmation of performance by full-scale tests ?
4. In-service trial ?

- How will vehicles be checked ?

5. In-service inspections ?
6. Compliance assurance scheme ?

Computer simulation calibration

A means of verifying simulation techniques is required as it is expected that the majority of analysis for non-standard vehicles to be considered under these guidelines will be conducted by computer simulations. Given that different computer software packages use different levels of detail in both the modelling and simulation process and modellers use different parameter values, it is expected that different predicted performance attributed would be obtained from different software for the same vehicle. For regulators to achieve a high level of confidence in computer simulation outputs then a calibration or certification process would need to be conducted. A benchmarking process to evaluate computer simulation packages and vehicle parameters would need to be developed without impinge Intellectual Property.

Vehicle templates

Further analysis could be conducted to establish minimum specifications, (such as wheelbases), for vehicle units to comply with these target values. From this analysis design vehicle templates could be established to reduce costs of individual vehicle assessments. This could also provide a template for on-road compliance checking.

On-road compliance checking

One major operational restriction for the use of performance-based measures as a means of regulating heavy vehicles is the ability to readily validate compliance of the vehicle system, especially for fleet operators with different types and combinations of prime-movers and trailers.

Married vehicle combinations

The concept of "married vehicle combinations" was raised by El-Gindy (1992). The basis of this scheme is to ensure compatibility of use with intent of design of a prime-mover with trailers. To ensure this compatibility, a permanent identifier could be affixed on the prime-mover and all trailers it was designed to tow, in a way that was visible to operators and regulators. The prime-mover could have a plate or certificate indicating the compatible trailer type(s), while the trailers could have a plate showing the types or class of prime-mover which could tow them and comply with performance-based measures.

El-Gindy suggested that economic incentives might apply with respect to this married service. This concept could be applicable in this instance to allow longer vehicles that are inherently safer to operate with a form of marking to identify the vehicle units that can be combined.

Self regulation methods

Alternative compliance schemes are voluntary alternatives to conventional enforcement. The basis of alternative compliance is the desire of transport operators, regulatory authorities and enforcement agencies to work in a spirit of co-operation rather than potential conflict. Alternative compliance is intended to enable efficiency improvements in road transport by allowing a lesser degree of on-road enforcement for operators who can demonstrate a high degree of compliance by other means.

The trialing of alternative compliance schemes in the areas of: fatigue management, roadworthiness and mass management has enabled the effect of such schemes to be evaluated and impact on regulations (NRTC 1997).

The application of an alternative compliance scheme for vehicles that are granted exemption from the Vehicle Standard Regulations (VSR) and Mass and Loading Regulations should be considered as an efficient method of implementing the exemption process.

At the time of writing, a series of workshops was proposed to discuss the proposed scheme, implementation framework and related issues and seek views from both regulatory and key industry players to develop a nationally agreed performance measures and target values for the assessment of non-standard vehicles.

CONCLUDING DISCUSSION

Results from the computer simulations from this study have shown that it is possible to apply consistent assessment techniques to non-standard vehicles that are outside the Regulations. By setting the target values at the minimum acceptable performance level of the current standard vehicle a safety neutral or positive impact on road safety can be achieved with the introduction of good performing non-standard vehicles. These target values should reflect better vehicle performance than the current worst performing “standard” vehicles, eg. 4.6m high stock crates.

This immediate application of this work is concerned with vehicle that are outside the mass and dimension regulations, ie. ‘non-standard’. With the introduction of ‘new’ means of assessing/permitting heavy vehicles, there will be existing vehicle types with attributes that are outside these new assessment criteria and if these vehicle types are to continue? then the existing arrangements should apply.

Introduction Content

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APPENDIX A - DEFINITION OF TERMS

"A" coupling
Vehicle units that are connected with a converter dolly which is towed from a single hitch point on the centre line of the towing unit.

"B" coupling
Vehicle units that are connected via a fifth wheel permanently mounted towards the rear of a trailer.

High-speed offtracking
The extent of to which any trailing axles of the vehicle combination track outside (outboard) the steering axle, when subjected to 0.2g lateral acceleration in a steady turn.

Load Transfer Ratio
The ratio of the absolute difference between the sum of right wheel loads and the sum of the left wheel loads, to the sum of the total wheel loads - when the vehicle is an evasive manoeuvre.

Low-speed Offtracking
The extent of inboard offtracking of the rearmost trailer from the prime-mover steer axle in a 90° left turn - in the absence of lateral acceleration.

Rearward amplification
The ratio of the peak value of lateral acceleration achieved at the mass centre of the rear most trailer to peak lateral acceleration developed at the mass centre of the prime-mover in a manoeuvre causing the vehicle to move laterally onto a path which is parallel to the initial path - at a defined steer input and speed.

Road Space requirements
The total envelope that a vehicle sweeps laterally as it travels at highway speed - it is the sum of the vehicle width at the rear plus the lateral deviation of the rear unit.

Roll-limit
The maximum level of lateral acceleration that a vehicle can sustain without roll-over.

Roll-stability
The steady state lateral acceleration required to cause rollover of a vehicle or a unit of a combination vehicle.

Roll-threshold
The minimum level of lateral acceleration required to lift one complete axle group.

Transient high-speed offtracking
The peak offset, in the direction normal to the direction of the travelled path, by the outside the outside front tyre of the tractor and the path of the most outboard trailing axle

Yaw damping coefficient
A measure that describes how rapidly oscillations of the rearmost trailer diminish after a rapid steer input. (eg. when a vehicle wanders off the road seal and swings laterally upon it transition over the pavement/gravel step).

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APPENDIX B - SIMULATED VEHICLE PERFORMANCE ATTRIBUTES - PRELIMINARY

	Vehicle type								
	A123	R12 T12	R12 T22	B-double	B-double	B-triple	A-double	A-triple	Rigid & 3
Overall length (m)	19	19	19	19	25	33	36	53.5	53.5
GCM (t)	42.5	45	49	50	62.5	82.5	79	115.5	132
Vehicle performance measures									
Load transfer ratio	-0.53	0.90	-0.88	-0.47	-0.47	-0.38	-0.78	1.00	-1.00
Yaw damping coefficient	0.34	0.19	0.19	0.39	0.39	0.48	0.27	0.28	0.23
Roll threshold (g)	0.36	0.42	0.45	0.31	0.31	0.26	0.38	0.25	0.35
Rearward amplification ratio	1.17	1.68	1.43	1.22	1.22	1.20	1.75	2.17	3.03
Low speed off-tracking (m)	7.73	5.82	5.87	9.33	9.33	11.67	10.57	13.64	13.77
High speed transient off-tracking (mm)	-202	-673	-580	-224	-224	-241	1463	-1824	-1727
High speed off-tracking (mm)	189	310	338	269	210	295	481	428	160
Minimum speed on a 1% grade (km/h)	70	70	70	70	70	60	60	50	50
Road space requirements: Rough road @ 90 km/h (m)	2.7	2.7	2.7	2.7	2.7	2.7	3.0	3.4	3.5

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AUTHOR BIOGRAPHIES

Rod George - Senior Research Scientist

Rod George joined ARRB Transport Research in 1977 after serving a traineeship at the Aeronautical Research Laboratories Melbourne. Rod is a member of the heavy research team at ARRB Transport Research and was appointed a Vehicle Design Associate of the International Journal of Vehicle Design. He is currently working on a Masters Degree in Engineering at Swinburne University of Technology. He has been involved in a number of heavy vehicle research programs including: stability, driver comfort, dynamic pavement loading of articulated vehicles, ride, stability and handling of ambulances and the evaluation of truck/trailer combination dynamics with increased mass ratios

Matt Elischer - Research Engineer

Matt joined ARRB TR in May 1996 after graduating from Royal Melbourne Institute of Technology (RMIT) with a Bachelor of Mechanical Engineering (Hons). He works in the Heavy Vehicles & Mining area, where he is heavily involved in computer modelling and simulation. Matt also investigates heavy vehicle dynamics and performance assessment, a component of this work is data interpretation and analysis.

Dr. Hans Prem - Principal Research Engineer

Hans Prem is a Mechanical Engineering graduate from the University of Melbourne and received his Bachelor's degree in 1979. Hans also has a Ph.D from the same University which he received in 1984 for his investigations into motorcycle dynamics and rider/motorcycle control strategies and behaviour. In 1984 Hans first joined ARRB, and was responsible for development of the prototype version of ARRB laser profilometer, used at that time primarily for improving NAASRA road roughness meter calibration, and to study road surface uneveness characteristics. He was also involved in truck research projects

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FOOTNOTES

1 Definition of terms is given in Appendix A

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2 ADAMS (Automatic Dynamic Analysis of Mechanical Systems) is a general purpose multi-body dynamics modelling package, developed at the University of Michigan in the late 1970's. It was enhanced and further developed into a commercial product by Mechanic Dynamics Inc., the first version was released in 1980.

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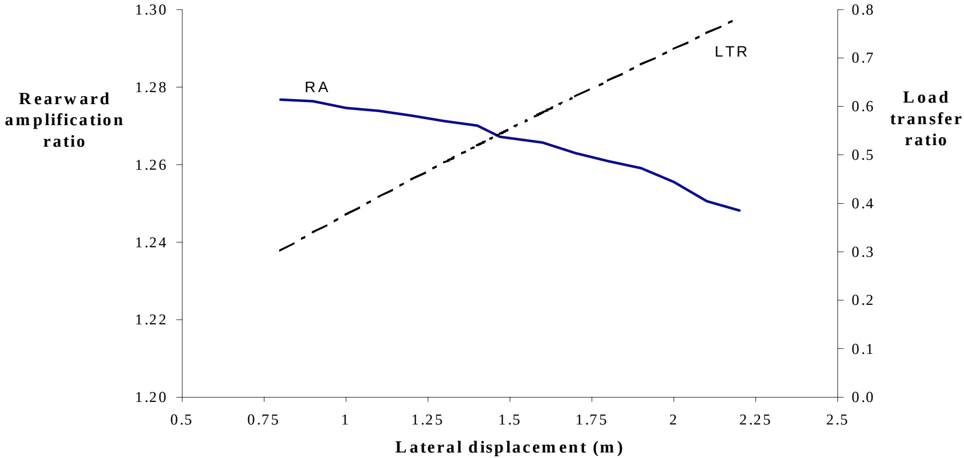

Fig. 1 - Sensitivity of measures to lane change lateral displacement

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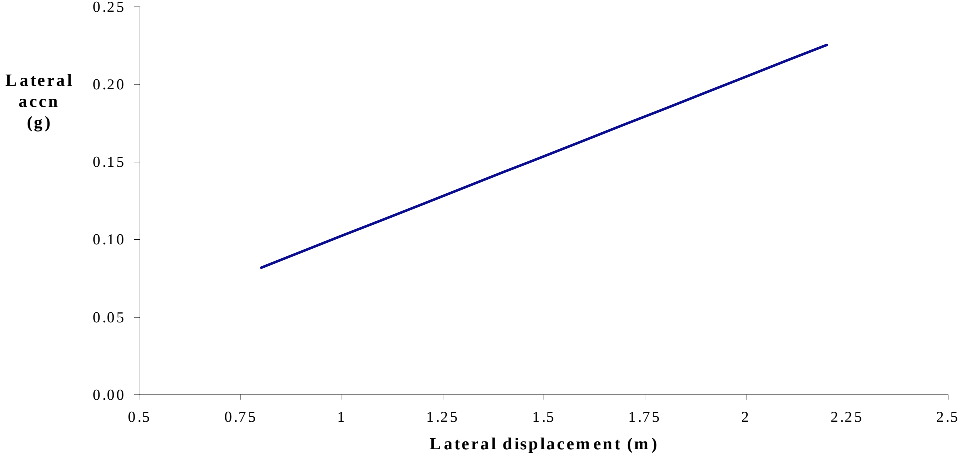

Fig. 2 - Lateral acceleration generated during lane change with various lateral displacements

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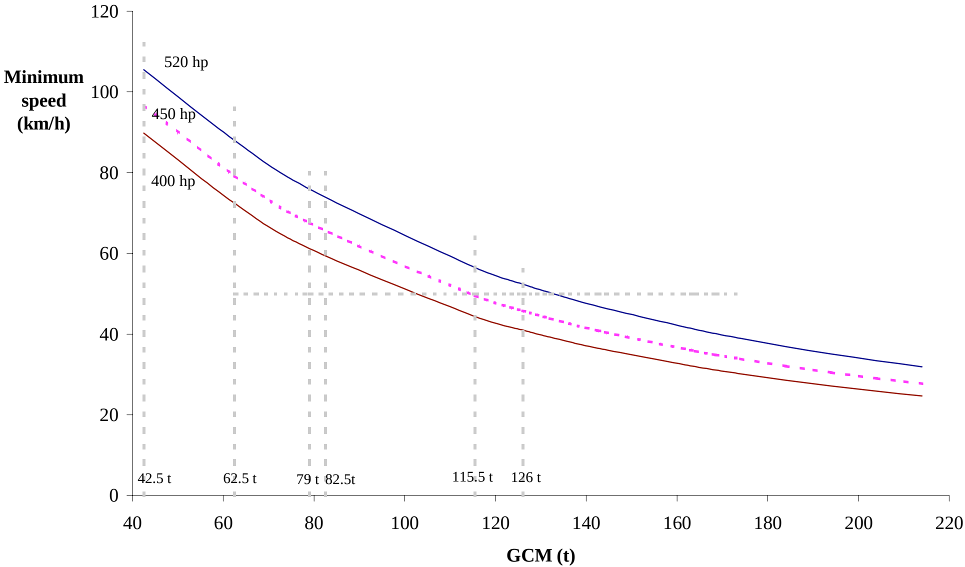

Fig. 3 - Performance curves for several engines on a 1% grade

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