PERFORMANCE STANDARDS FOR HEAVY VEHICLES IN AUSTRALIA

John Edgar – Director Operations

National Road Transport Commission, Australia

Fiona Calvert – Manager Corporate Strategy

National Road Transport Commission, Australia

Dr Hans Prem

Head of RTDynamics

September 2001

PERFORMANCE STANDARDS FOR HEAVY VEHICLES IN AUSTRALIA

1 Summary

In 1999 the National Road Transport Commission (NRTC) and Austroads initiated a major joint project to develop Performance-Based Standards (PBS) for heavy vehicle regulation in Australia and New Zealand.

This paper discusses the principles that will form the foundations of PBS and spells out the likely process that will be followed in determining what and how vehicles can operate under the system. The report also identifies the benefits of moving to Performance Standards and the key issues in implementing a PBS approach.

This paper identifies 25 proposed performance standards against which the Australian heavy vehicle fleet is being tested. Concerns about the accuracy of available computer models have been addressed by a comparison of three simulation packages using a standard set of input data.

The paper reviews some parts of a large body of work being undertaken over a three-year period. Readers are referred to a number of substantive reports published by the NRTC for in-depth technical background on specific issues discussed here; policy principles, selecting and setting performance standards, and assessing computer simulation models. These papers maybe accessed through the NRTC Website (www.nrtc.gov.au), where information on the wider project may also be obtained.

2 Background

The use of heavy vehicles in Australia and New Zealand is regulated predominantly by prescriptive standards that evolved over a long period and often differed between States and Territories. Through the reforms progressed by the NRTC in conjunction with all jurisdictions, many inconsistencies have been removed. Nevertheless, some remain, particularly in relation to innovative approaches to solving transport needs. Modernising regulations by moving to a nationally consistent performance-based approach to regulation of heavy vehicle operations is now being considered as an optional alternative to the existing prescriptive regulations. Under a performance-based approach to regulation, standards would specify the performance required from vehicle operations rather than mandating how this level of performance is to be achieved (often indirectly). This approach to regulation has been adopted in other sectors, such as occupational health and safety and food standards, and is now well established as the approach preferred by regulatory review agencies.

Under the existing prescriptive regulations, general access requirements set out fixed controls that allow the vehicles that meet them (generally) unrestricted access to the entire road network. Systems of exemptions and permits allow these prescriptive standards to be varied for individual vehicles or classes of vehicles using specified routes or networks of roads, in recognition that different requirements are appropriate for different traffic and road conditions. For example, B-doubles are allowed to operate under general permit (gazettal) arrangements on restricted routes.

Under PBS, the interactions of vehicles with the roads they use are taken into account more explicitly. In determining whether a specific vehicle can operate on a particular road, the vehicle's capabilities and the relevant road standards and traffic conditions can be examined jointly to decide whether the operation meets the Performance Standards.

The PBS project being progressed by the National Road Transport Commission and Austroads is examining the potential to augment current prescriptive limits on vehicle mass, dimensions and configurations with appropriate Performance Standards and may have implications across a range of national road transport legislation.

2.1 The Need for Regulation

Road use is regulated because individuals and corporations do not always make the best road use decisions for the entire community. Typically, in other sectors of the economy, normal market mechanisms ensure that the choices of individuals are consistent with the best interests of the broader community.

Regulation is necessary to ensure that:

- roads are used safely;
- road congestion is minimised;
- the amount of road wear is minimised and the costs of repairing roads are recovered from users;
- road use does not result in excessive noise; and
- air pollution is minimised.

Regulation to meet these objectives will protect community interests to ensure that the total costs of road use are minimised.

This is achieved by minimising the total of:

(a) costs faced by road users in operating their vehicles, travel time etc;

(b) the whole-of-life costs of providing, maintaining and managing the road network, including costs associated with road alignment and geometry, pavement condition and bridge condition; and

(c) costs imposed on the broader community by road use, such as the costs of accidents and environmental impacts.

The direct costs faced by road users (vehicle operating costs and costs of travel time) are 10 to 15 times the costs of providing, maintaining and managing road networks. Regulation is necessary to minimise total costs because there are no in-built mechanisms to ensure road users take account of the impact of using their vehicles on the costs of road networks and the broader community.

Consequently, regulations are needed to control:

- bridge costs;
- pavement wear;
- traffic operations; and

- road safety.

Currently this is achieved by regulations for:

(a) vehicle configurations;

(b) vehicle mass, including gross mass limits, axle spacing mass schedules and axle group mass limits;

(c) dimensions, such as length, width, height and rear overhang;

(d) road rules; and

(e) heavy vehicle charges.

In contrast, under a performance-based approach to regulating road use, the relationships between vehicle and road performance must be specified. This means it is necessary to understand the relationship between vehicle use and infrastructure costs, and the relationship between vehicles and road safety for different circumstances applying in different parts of the road network.

In regulating road transport, governments must also take into account administrative, enforcement and compliance costs. This means that a lower cost approach to regulating road use must be found if the administrative costs of a particular approach are higher than the costs that the regulations are meant to control.

2.2 The Need for a Performance-Based Approach

The main reasons for investigating performance-based approaches to heavy vehicle regulation are that:

- road transport is a vital component of the Australian economy and consequently any improvements to regulation that PBS can provide are significant;
- there is continuing pressure to improve the safety and amenity of heavy vehicles;
- there is little room for further wholesale relaxation of prescriptive standards, as has occurred in the past.

The search for regulatory solutions that will support Australia's high and growing dependency on road freight is critical to improving Australians' standard of living and the nation's economic wellbeing. Large increases in the size of the road freight task are forecast (NRTC, 2001d), highlighting the importance of continued efforts to improve the overall safety, efficiency and fairness of the road transport system. It is unlikely that these trends can be maintained without the adoption of mechanisms that promote innovation and provide the flexibility for transport operators to improve productivity, where this has no detrimental impact on safety or road infrastructure. In the road transport sector this includes a more sophisticated approach to heavy vehicle regulation.

At the same time as providing for innovations in the road transport sector, governments must also meet the community's expectations for improved health, safety and quality of life (NRTC, 2001d).

The introduction of PBS is expected to:

- encourage innovation;
- provide a better match between vehicles and roads;

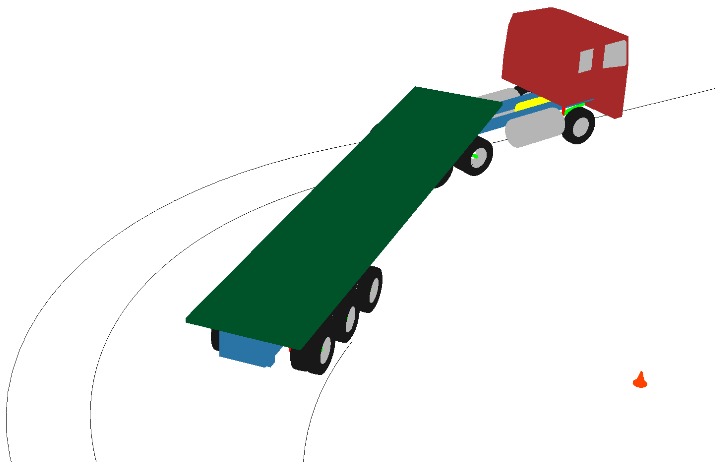
- increase regulatory transparency by providing a more consistent and more rational regulatory approach;
- improve performance (by providing better controls on safety and infrastructure wear); and
- improve compliance.

2.3 Terms and Concepts

Performance Standards specify the outcomes required of vehicle operations, but leave open the ways in which these outcomes are achieved. For example, *Performance Standards* might specify that a vehicle must be able to travel along the road and negotiate turns without tipping over or intruding on the road space of other road users. They might specify how well the vehicle should be able to stop and how much road wear it can cause.

Each *Performance Standard* assigns a numerical limit to a *Performance Measure*, defining a boundary between what is acceptable and unacceptable. A *Performance Measure* quantifies how a vehicle performs for a specific circumstance or manoeuvre. The manoeuvre and the method of measuring the vehicle's performance must be specified in detail, in order for the *Performance Measure* to be objective.

For example, low-speed off-tracking (see Figure 1) is a performance measure for the tendency of the rear trailer or rear axle to track inside the path of the steering axle in low-speed turns. It is measured at a specific speed, angle of a turn and so on. Without this, comparisons between vehicles and tests would be meaningless. If low-speed off-tracking were measured at 10 km/h for one vehicle and 20 km/h for another, it would not be possible to say which vehicle had the better low-speed off-tracking performance.



Note: shows how each axle tracks inboard of the preceding axle – the fine line on the pavement is the path followed by the steering axle.

Figure 1: Illustration of Low-Speed Off-Tracking

A *Performance Standard* sets a numerical limit for a *Performance Measure*. It says that performance within the limit is acceptable, but if a vehicle's performance is not within that limit it is not acceptable (for example, because it will be unsafe or because it will have an unacceptable impact on other road users or the road infrastructure).

Performance-based standards may be either *Performance Standards* or prescriptive proxies for these standards that were developed from performance evaluations, and ensure that the same outcome is achieved. For example, a *Performance Standard* for turning might be to fit within a swept path envelope of specified dimensions, whereas a *Performance-Based Standard* might specify maximum overall and internal dimensions that ensure the same swept path envelope is not exceeded.

2.4 Objectives

In examining any regulatory system, it is important to establish that regulation of an activity is necessary, and that it has been cast in the best way to achieve the objectives of regulation. Clearly identifying the objectives of proposed regulations is an important step in this process, and helps ensure that regulations developed will provide the best outcome for the whole community.

Two objectives have been identified for the introduction of a PBS approach to regulating heavy vehicles. They are:

1. Development of more sustainable transport systems through improved road vehicle regulations controlling heavy vehicle safety and infrastructure impacts; and
2. More flexible road transport regulations that provide for increased innovation and more rapid adoption of new technologies, while providing seamless operations nationally.

3 PBS Principles

Five principles form the basis of the policy framework for this proposal. These principles, developed through a stakeholder consultation process, have been agreed by the Australian Transport Council (ATC). The ATC consists of the Australian Commonwealth, State and Territory Transport Ministers.

They are:

Principle One:

Performance-based standards will be a national system of regulating heavy vehicle safety and infrastructure impacts that operates as an alternative to existing prescriptive regulations.

a) *Some existing heavy vehicle regulations will continue to apply, but PBS will provide alternative controls in the main areas of mass, dimension and configuration controls.*

b) *If an operator chooses to operate outside PBS, the relevant prescriptive standards must be satisfied.*

Principle Two:

Performance standards should be matched to road and traffic conditions.

a) *Consequently, standards established for some performance measures will differ between a limited group of road classes, based on variations in road and traffic conditions that characterise each class of roads.*

b) *Road authorities will determine which classification applies to the roads they manage.*

Principle Three:

Compliance with performance-based standards will be ensured by nationally consistent and practical methods that are based on certifying that vehicle-related features meet the performance standards and identifying simple operating conditions.

a) *Where warranted, vehicle operators will be required to be accredited to demonstrate that they comply with these conditions.*

Principle Four:

All parties in the transport chain will be held responsible for factors in their control that ensure Performance Standards are achieved and maintained.

Principle Five:

An approval process will apply to each proposed PBS operation. Features of the approval process will be:

a) *Anyone should be able to apply for a vehicle, component or operation to be approved under the performance-based standards.*

b) *Lower cost ways of accessing the benefits of PBS must be available to smaller operators and those with fewer technical resources.*

c) *The approval process and compliance arrangements should provide vehicle operators with the flexibility to choose at different times whether to operate under the existing prescriptive regulations or the performance based standards.*

d) *Procedures should be incorporated to provide for mutual recognition of PBS approvals nationally.*

e) *All performance assessors will need to be accredited to ensure their assessments are consistent and of sufficient quality.*

The PBS system will apply to both general access and access to limited routes/regions. The approval process will involve:

- identifying which set of performance standards applies for the circumstances of the proposal, eg the roads to be accessed;
- assessing whether these standards are met by the proposal and identifying simple conditions to ensure they will be met on-road;
- certifying that the vehicle(s) to be used are consistent with the proposal assessed; and
- recording the approval and any operating conditions.

4 The Proposed Performance Measures

As a first step in establishing an appropriate set of performance standards under a Performance Based Standards (PBS) approach to the regulation of heavy vehicles in Australia, the entire field of potential performance measures relevant for heavy vehicles were determined and documented (NRTC, 1999a; NRTC, 1999b). The next step in the process was to select an initial set of potential regulatory performance measures using the methodology described in (NTRC, 2000a). Several steps were used in the selection process, detailed in (NRTC, 2001a), to reduce the more than 100 potential performance measures to a set of 25 that cover safety and infrastructure related issues.

(NRTC, 2001c) provides definitions for the set of 25 potential regulatory performance measures that emerged from (NRTC, 2001a) reviewed by stakeholders (Appendix A). This report (NRTC, 2001c) also specifies an initial set of performance levels based on the review of the literature (available records) by the project team. The potential regulatory performance measures when combined with the associated performance levels lead to an initial set of potential regulatory performance standards.

The potential regulatory performance standards that are considered to have been developed to a useable level are to be tested against the Australian heavy vehicle fleet using the generic vehicle set described in (NRTC, 2001b). A set of eighty-four generic vehicle combinations which characterise the Australian Heavy vehicle fleet have been developed for this purpose. Fleet performance against the proposed standards will provide initial input to the regulatory impact statement that will quantify the potential benefits and costs of a PBS approach to the regulation of heavy vehicles in Australia.

It was also considered useful to provide stakeholders with a preliminary indication of what it may cost, and what resources (suitably qualified/certified providers) and input data would be required to evaluate a vehicle against each of the individual proposed potential performance standards. These data are presented under the headings of cost, resource availability and input data requirements. Cost has been specified in one of the following three categories:

- <u>Low</u> (up to $1,000);
- <u>Medium</u> (from $1,000 to $5,000); and
- <u>High</u> (more than $5,000).

Resource availability is also presented in three categories, viz:

- <u>High</u> (readily available);
- <u>Medium</u> (a moderate number of providers currently available); and

- <u>Low</u> (very few providers currently available).

Input data requirements are presented in the following four categories:

- <u>Low</u> (limited data required);
- <u>Moderate</u> (data available in the public domain; reports and/or product brochures);
- <u>Significant</u> (partial set of parameters required); and
- <u>Substantial</u> (full set of parameters and specialist input required).

The specific aim of this section of the report (NRTC, 2001c) is to compile and present the best available information on each of the proposed performance measures and thereby provide a starting point from which to move forward. Where the methods of evaluation for a particular performance measure are well established and developed, and the performance level(s) are widely accepted, there are reasonable grounds for acceptance of a particular performance standard.

The initial set of potential regulatory performance standards currently proposed are summarised in Appendix B, showing the test conditions/specification, proposed performance level (if known), the methods of evaluation, and resource requirements.

5 Comparison of Modelling Systems

As discussed above, the initial potential performance standards are being tested in the next stage of the project against the Australian heavy vehicle fleet. The performance of the heavy vehicle fleet will be primarily determined using computer-based modelling techniques.

Some stakeholders have expressed the concern that performance predictions from computer-based modelling packages may not be reliable and may substantially differ with software packages and with the Service Providers that use them. Given that PBS is intended to encourage and foster innovation in road transport, and that computer-based modelling is expected to play a central role in both the development and initial demonstration of innovative vehicles, the concerns that were expressed by stakeholders needed to be addressed promptly and as a priority.

A draft report "Comparison Of Modelling Systems for Performance-Based Assessments of Heavy Vehicles" addresses these concerns and, additionally, resolves calibration issues associated with computer-based modelling in a way that is transparent and open to scrutiny. This is an essential step in building stakeholder confidence in the use of computer-based modelling and in its application to the regulation of heavy vehicles in Australia using performance-based standards. The report (not published at the time of writing this paper), will be published and placed on the NRTC Website.

Computer-based models of two vehicles were created in the course of this project by two Consultants using three separate computer-based modelling packages; ADAMS, UMTRI's constant velocity Yaw/Roll program and AUTOSIM. Comprehensive input datasets were developed for a non-descript B-double and a non-descript truck/trailer. The same datasets were supplied to each Consultant and identical simulations were performed using the same test manoeuvres comprising a pulse steer, step steer, standards SAE lane change and a low-speed 90° turn.

Time histories of a wide range of variables from the simulations were compared as well as numeric values from a selection of performance measures. For the more stable of the two vehicle models, the B-double, the time histories from the pulse steer and step steer simulations were almost indistinguishable showing excellent agreement between all three modelling packages. Agreement in the outputs from the simulations in all manoeuvres was generally better than 10% for the performance measures considered. These were marginally influenced by the characteristics of the steer controller in the lane change manoeuvre though agreement was still generally better than 10%.

The truck/trailer model, representing a less stable and dynamically more active vehicle compared to the B-double, produced larger but acceptable amounts of variation between simulations in the pulse and step steer simulations and low-speed 90° turn. However, in the SAE lane change the differences between the models were much too large as a result of the greater deviations in the path followed. To achieve acceptable agreement in the lane change manoeuvre between models a deviation from the desired path not greater than ±30mm is required and is recommended. This is significantly less than the current recommended tolerance of ±150mm specified by the Society of Automotive Engineers (SAE).

Simulations that provide a direct measure of only the vehicle responses to precisely defined steer inputs generally lead to more consistent results than simulations that require steer controllers and closed loop path following. When there is a choice, open loop manoeuvres should be selected in preference to closed loop manoeuvres that require the use of steer controllers.

6 Regulatory and Compliance Processes

A number of issues have bee identified as requiring further work to establish detailed regulatory and compliance process for PBS implementation. These include:

- Processes to ensure performance assessments are of a high quality and consistent;
- Arrangements to ensure that the physical attributes of vehicles match the PBS approval;
- Arrangements to ensure that appropriate operating conditions are applied to ensure the performance standards are met; and
- How theses factors will be controlled, such as:
  - What operating factors need to be checked and controlled in what circumstances of the performance standards are to be met; and
  - How these factors will be controlled (whether through use of technology to ensure absolute levels of compliance, auditable certification arrangements or road-side checks) depending on the risks of non-compliance.
- Processes of classifying the road network based on differences in road and traffic conditions to match variation in performance standards;
- Methods of protecting intellectual property associated with PBS proposals while providing for low-cost access to the PBS approach;
- Documentation and data storage requirements on both operators and road authorities including mechanisms to allow mutual recognition of approvals to occur between state authorities;

- Appeal and review procedures for PBS decisions;
- Incorporating chain of responsibility principles in PBS arrangements;
- Enforcement powers needed to ensure PBS operating conditions are met; and
- Identification of appropriate penalties to apply if PBS operating conditions are not met.

Work is under way on some of these issues and is intended to commence on others shortly. This will feed into a decision paper on regulatory and compliance process to be issued for discussion later this year.

7 References

(NRTC, 1999a). *Performance Based Standards for Heavy Vehicles in Australia: Field of Performance Measures*. Prepared by Roaduser International and ARRB Transport Research Ltd. National Road Transport Commission: Melbourne, Vic.

(NRTC, 1999b). *Performance Based Standards for Heavy Vehicles: Assembly of Case Studies*. Prepared by ARRB Transport Research. National Road Transport Commission: Melbourne, Vic.

(NRTC, 2000a). *Specification of Performance Standards and Performance of the Heavy Vehicle Fleet*. Discussion Paper prepared for the National Road Transport Commission by ARRB Transport Research Ltd., Pearsons Transport Resource Centre Pty Ltd., Phillips Fox, Economic Associates Pty Ltd, Woodrooffe & Associates Inc. and TERNZ Ltd. Melbourne, Vic. August 2000.

(NRTC, 2001a). *Report on Initial Selection of Potential Performance Measures*. Discussion Paper prepared for the National Road Transport Commission by RTDynamics, J.R. McLean, Pearsons Transport Resource Centre Pty Ltd., TERNZ Ltd., Woodrooffe & Associates Inc. and Economic Associates Pty Ltd. Melbourne, Vic. January 2001.

(NRTC,2001b). *Definition of Potential Performance Measures and Initial Standards.* Discussion Paper prepared for the National Road Transport Commission by RTDynamics, J.R.McLean, Pearsons Transport Resource Centre Pty Ltd., Woodrooffe & Associates Inc. and TERNZ Ltd., Melbourne, Vic. April 2001.

(NRTC, 2001c). *Dimension and Mass Characterisation of the Australian Heavy Vehicle Fleet*. Working Paper prepared for the National Road Transport Commission by RTDynamics and Pearsons Transport Resource Centre Pty Ltd., Melbourne, Vic. April 2001.

(NRTC, 2001d) *Performance-Based Standards Policy Framework for Heavy Vehicle Regulation*. Regulatory Impact Statement prepared by the National Road Transport Commission, Melbourne, Vic. May 2001.

Appendix A – Definition of Potential Performance Measures

#	POTENTIAL PERFORMANCE MEASURE	DEFINITION
1	Static roll stability	The steady-state level of lateral acceleration that a vehicle can sustain during turning without rolling over.
2	Rearward amplification	Degree to which the trailing unit(s) amplify or exaggerate lateral motions of the hauling unit.
3	Load transfer ratio	The proportion of vertical load imposed on the tyres on one side of a vehicle unit that is transferred to the other side of the vehicle unit during a standard lane change manoeuvre.
4	High-speed transient offtracking	The lateral distance that the last-axle on the rear trailer tracks outside the path of the steer axle in a sudden evasive manoeuvre.
5	High-speed steady-state offtracking	The lateral distance that the last-axle on the rear trailer tracks outside the path of the steer axle in a high-speed steady turn.
6	Yaw damping	The rate at which "sway" or yaw oscillations of the rearmost trailer decay after a short duration steer input at the hauling unit.
7	Tracking ability on a straight path	Amount of variation in the lateral position of the trailing unit (last trailer) measured relative to the path or track followed by the hauling unit (rigid truck or prime mover).
8	Braking stability (in a straight line)	The vehicle's ability to stay within a traffic lane under heavy braking on a straight path.
9	Braking stability (in a turn)	Amount of loss of control when braking in a turn.
10	Handling quality (understeer/oversteer)	No change
11	Low-speed offtracking	Maximum distance that the rear axle of a vehicle or combination tracks inside the path taken by the steering axle in a low speed turn.
12	Frontal swing	The maximum lateral displacement between the path of the front outside corner of the vehicle (or vehicle unit) and the outer edge of the front-outside steered wheel of the hauling unit during a small-radius turn manoeuvre at low speed.
13	Tail swing	The maximum lateral distance that the outer rearmost point on a vehicle moves outwards, perpendicular to its initial orientation, when the vehicle commences a small-radius turn at low speed.
14	Friction demand (steer tyres in corner)	The maximum friction level demanded of the steer tyres of the hauling unit in a tight-radius turn at low speed.
15	Ride quality	The level of vibration that a vehicle's driver is exposed to during a working shift that leads to reduced comfort and decreased proficiency, and contributes to fatigue.
16	Startability	The maximum uphill gradient, expressed as a percentage, on which the vehicle is capable of starting forward movement from rest.
17	Gradeability	The maximum uphill gradient, expressed as a percentage, on which the vehicle can climb at a specified constant speed.
18	Intersection clearance time	The time taken for the rear of the vehicle to clear a given intersection (either straight through or turning) with the vehicle starting from rest with its front immediately behind the intersection stop line.
19	Overtaking time	The time taken for another vehicle to safely overtake the vehicle.

#	POTENTIAL PERFORMANCE MEASURE	DEFINITION
20	Payload mass per ESA	*This measure replaced by:* Gross Mass per Standard Axle Repetition The Gross Mass (GM) of a heavy vehicle divided by the Standard Axle Repetitions (SARs) applied to the pavement by a single pass of the vehicle.
21	Horizontal tyre forces	Degree to which horizontal forces are applied to the pavement, primarily in a low-speed turn and at constant speed on uphill grades, by the tyres of multi-axle groups (drive-axle group tyres in particular) and the effect on remaining pavement life.
22	Tyre contact pressure distribution	The maximum local vertical stress under a tyre's contact patch for a given vertical tyre load and tyre inflation pressure.
23	Upper bound on axle/axle-group load	*These two performance measures have been replaced by the performance measure Gross Mass per Standard Axle Repetition (refer above under #20).*
24	Upper bound on GVM/GCM	
25a	Bridge Loads (Axle spacing mass schedule)	*These two measures have been combined into the following single performance measure:* Maximum Bridge Stress The maximum stress that a bridge can sustain under repeated loading without incurring damage.
25b	Critical design vehicle (bridges)	

Appendix B – Initial Performance Standards

PERFORMANCE MEASURE	TEST SPECIFICATION	PERFORMANCE LEVEL	TEST METHOD: Physical Testing	TEST METHOD: Calculation or Computer-Based Modelling
SAFETY RELATED				
Longitudinal Performance (Low Speed)				
Startability	Ability to commence forward motion on specified grade.	• Not less than 15% for unrestricted access to the entire network; • Not less than 10% for arterials and major freight routes; and • No less than 5% for remote areas.	✔	✔
Gradeability	Ability to maintain forward motion on specified grade.	1) Low-Speed Environment (maximum grade that the vehicle can climb at any speed) Unrestricted access to the entire network: 25% Urban roads of higher standard: 20% Urban roads in remote areas: 8% 2) High-Speed Environment (minimum speed on a 1% gradient) Unrestricted access to the entire network: 80km/h Remote areas: 50km/h	✔	✔
Intersection Clearance Time	Time required travelling a distance of 50m starting from rest to clear an intersection on a road with no grade. If location specific then suitable test conditions required.	No more than 12s for unrestricted access to the road network; No more than 15s for arterials and major freight routes; No more than 25s for routes designated for long combination vehicles. (May be location specific and require a separate performance level).	✔	✔
Longitudinal Performance (High Speed)				
Overtaking Time	Test specifications specific to road and traffic conditions.	Specific to delay caused to other road users, which in turn is dependent on route characteristics and traffic volumes. Table 2 in the body of the report provides a guide for various road classes.	✔	✔

PERFORMANCE MEASURE	TEST SPECIFICATION	PERFORMANCE LEVEL	TEST METHOD	
			Physical Testing	Calculation or Computer-Based Modelling
Tracking Ability on a Straight Path	Traverse 1000m road segment at two test speeds (60 and 90km/h), road roughness in each wheelpath 4.0m/km IRI (±0.4m/km) and average cross-slope 4% (±0.4%). Vehicle laden.	Specified in terms of required lane width. If route specific requirement do not exist then the following is proposed: In the range 3.1 to 3.5m for urban arterials; no greater than 3.5m on rural and regional roads; in the range 3.5 to 3.7m on national highways and freeways; no greater than 3.7m in remote areas.	✔	✔
Ride Quality	Traverse 1000m road segment at two test speeds (100 and 60km/h), road roughness in each wheelpath 4.0m/km IRI (±0.4m/km). Vehicle laden and unladen.	Performance level required. However, vehicles can be compared on a relative basis using the procedures outlined in British Standard BS 6841, or International Standard ISO 2631, to estimate the frequency weighted RMS vibration.	✔	✔
Braking Stability on a Straight Path	As required by and specified in ADR35/01.	The ability to stay within a 3.5m wide lane.	✔	✔
Directional Performance (Low Speed)				
Low-Speed Offtracking	Centre of steer axle to follow a path comprising a straight entry segment that is tangent to a 11.25m radius 90º circular arc followed by a straight exit segment. Vehicle speed is 10km/h.	Maximum width of the swept path: 5m for local roads, 7.4m for arterial roads, 10.1m for major freight routes, and 13.7m for road train areas.	✔	✔
Frontal Swing	Same as for low-speed offtracking	Not greater than 1.5m for unrestricted access to the entire road network.	✔	✔
Tail Swing	Same as for low-speed offtracking	Not greater than 0.5m.	✔	✔
Steer Tyre Friction Demand in a Low-Speed Turn	Same as for low-speed offtracking	No greater than 80% of the maximum available tyre/road friction. Table 4 in the body of the report provides friction values for a range of surfaces.	not yet demonstrated	✔

PERFORMANCE MEASURE	TEST SPECIFICATION	PERFORMANCE LEVEL	TEST METHOD	
			Physical Testing	Calculation or Computer-Based Modelling
Directional Performance (High Speed)				
Static Rollover Threshold	Procedures defined in SAE J2180 (see Society of Automotive Engineers, 1993a). If by computer-based modelling then 100m radius circular path, centre of steer-axle follows path, test speed slowly increased from 60km/h until rollover occurs.	For road tankers and buses at least 0.40g, for all other heavy vehicles at least 0.35g.	✔	✔
Rearward Amplification	Procedures defined in SAE J2179. Lane change manoeuvre - test speed 88km/h, 1.46m lateral displacement, 61m manoeuvring length, 0.15g peak lateral acceleration (see Society of Automotive Engineers, 1993).	Not greater than 2.0	✔	✔
Load Transfer Ratio	Same as for rearward amplification.	Not greater than 0.6. Where maximum speed is less than 75km/h a load transfer ratio not greater than 0.75 may be considered acceptable on a provisional basis.	not yet demonstrated	✔
Yaw Damping	Application of a 3.2° (half sine) steer angle pulse at the road wheel over a 0.1s period, test speed 100km/h.	Not less than 0.15	✔	✔
High-Speed Transient Offtracking	Same as for rearward amplification	Not greater than 0.8m	✔	✔
High-Speed Steady-State Offtracking	393m radius circular path, test speed 100km/h, centre of steer-axle follows path.	No greater than 0.3m for unrestricted access to the entire network; no greater than 0.5m for arterials and major freight routes; and no greater than 0.7m for low-volume roads in remote areas.	✔	✔

PERFORMANCE MEASURE	TEST SPECIFICATION	PERFORMANCE LEVEL	TEST METHOD	
			Physical Testing	Calculation or Computer-Based Modelling
Handling Quality (Understeer/Oversteer)	As specified in El-Gindy, Woofrooffe and White (1991), or equivalent. Vehicle speed of 100km/h, the understeer coefficient, K_u, is evaluated over the range 0.15g to 0.3g.	Three-point measure. First point (evaluated at $a_y = 0.15$) $0.5 < K_u < 2.0$ deg/g; second point (transition from understeer to oversteer) $a_y > 0.2$g; third point (evaluated at $a_y = 0.3$) $K_u >$ critical understeer coefficient.	✔	✔
Braking Stability in a Turn	As specified in US FMVSS 121. The vehicle is stopped from an initial speed of 48.3km/h or 75 percent of the maximum drive through speed, whichever is less, on a 152.4m radius curve with a wet surface having a peak friction coefficient of 0.5. Both laden and unladen conditions considered.	The vehicle, when stopped four consecutive times, must stop at least three times within a 3.66m wide lane.	✔	✔
INFRASTRUCTURE RELATED				
Pavements				
Gross Mass per Standard Axle Repetition	Laden vehicle, pavement type and configuration specific.	For granular pavements with thin surfacings 8.3t/SAR for all heavy vehicles.	-	✔
Horizontal Tyre Forces	Same as for low-speed offtracking, and separately on uphill grades of 2% and 5%	Pavement wear for PBS vehicle for a particular freight task no greater than for the same task being performed by current common vehicles.	not yet demonstrated	✔
Tyre Contact Pressure Distribution	Laden vehicle, travel speed up to 100km/h.	Further research required to establish a performance level.	✔	not yet demonstrated
Bridges				
Maximum Bridge Stress	Representative loads imposed on the bridge by the proposed vehicle.	A load factor of at least 1.8 for general heavy vehicles. For vehicles carrying indivisible loads a suitable load factor remains to be determined.	✔	✔