PERFORMANCE STANDARDS FOR HEAVY VEHICLES - OPPORTUNITIES FOR LARGER VEHICLES

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Presented to the

Institute of Road Transport Engineers of New Zealand

FIFTH INTERNATIONAL HEAVY VEHICLE CONFERENCE

AUCKLAND

19-22 APRIL 1994

1. INTRODUCTION

Gains in road freight productivity are available through the use of vehicles designed to carry increased payload, or volume of freight. Opportunities to operate such vehicles are limited by size and weight regulations and by some difficulties in designing larger and heavier vehicles which perform adequately in the traffic stream. However, significant economic benefits are available from the use of larger vehicles and experience shows that such cost savings tend to be passed on to consumers and provide significant benefits to the community.

While size and weight limits are reviewed periodically, it is likely that significant future gains will come about only through strategic increases in limits designed to eliminate any adverse effects on road and bridge infrastructure, safety or road space and traffic impacts.

Such strategies may be guided by a better understanding of heavy vehicle dynamic performance and the ability to assess standards of heavy vehicle performance in key areas.

This paper considers the potential role of performance-based standards and provides examples of innovative larger vehicles being evaluated in Australia.

2. WHAT ARE PERFORMANCE-BASED STANDARDS?

Performance-based standards are intended to focus heavy vehicle regulations on desired outcomes (ie. safety and the interaction with other traffic and the road system) and provide a rationale for assessing the implications of design modifications and vehicle innovations.

Performance standards, when combined with quality assurance mechanisms and industry self-regulation, offer the prospect of significant gains in the productivity of the road freight industry because vehicle design could directly address the needs of a particular transport task, instead of being constrained by generalised configurations and limits.

On the other hand, there are difficulties with performance-based standards in that they may be complex, highly-technical and difficult to enforce.

If used to replace conventional size-and-weight regulations, performance standards would result in increased diversity of truck configurations and perhaps greater possibilities for any exploitation of loopholes in the rules. There would also be a need for industry to be able to assess vehicle performance and show compliance with the rules.

The potential role of vehicle performance standards in Australia is a matter for debate and a recent National Road Transport commission (NRTC) study (1) has provided a starting point for discussion of how far we should go with performance-based standards. The immediate role for performance-based standards is probably to support the development and periodic review of size and weight limits and configuration rules. There is little doubt that the use of performance standards will assist the evaluation of the productivity and safety implications of such regulations and are essential to the assessment of vehicles and proposals which do not fit the general mould.

Most of the potential productivity opportunities with performance standards lie in:

- payload increases from strategic axle weight increases for certain vehicle configurations (within general road wear and bridge constraints)
- trailer and/or overall length increases leading to increased "cube" (within the general constraints of the road and traffic system)
- increased opportunities for the use of Medium Combination and Long Combination Vehicles.

3. AUSTRALIAN REGULATORY REGIMES

All states operate a variety of regulatory regimes: General Access Vehicles (GAV), Medium Combination Vehicles (MCVs) (predominantly B-doubles) and Long Combination Vehicles (LCVs) (both Type I, or double road train, and Type II, or triple road train).

3.1 Methods of Regulation

Regulations affecting the configuration of road freight vehicles are currently implemented in the following ways:

- Australian Design Rules (ADRs) control all individual new vehicle units and cover trailer length, width, overall length, tyres, suspensions, couplings, braking performance, turning circle, maximum operating speed, crash protection (General Access vehicles only) and gradeability (road trains only)

- State legislation covers tyre, axle group and gross weight limits and the issuing of permits for the operation of B- doubles and road trains, including route restrictions, speed limits and other exclusions; other issues usually considered in the issue of permits are vehicle dynamic stability, traffic impacts (especially overtaking and tracking) and the capacity of the route (especially lane widths, terrain, roughness and traffic volumes). State in-service rules cover matters such as load security and spray suppression

Under the National Road Transport Commission Act (1992), the National Road Transport Commission (NRTC) has responsibility for developing "technical and operating standards, rules and relevant procedures for the regulation of vehicles and their drivers".

AUSTROADS provides advice to the NRTC on technical matters related to heavy vehicle regulations, including the following areas:

- vehicle dimension limits
- axle spacing/mass schedule
- speed limiting requirements
- national registration scheme.

3.2 Vehicle Performance and Road Capacity

AUSTROADS is also interested in the use of performance-based standards for heavy vehicles, based on more explicit recognition of the capacity of the road system. Full performance-based regulation of heavy vehicles requires explicit identification of a comprehensive range of performance parameters. The key areas of vehicle performance to be considered include:

Asset Protection

• vehicle-pavement interface	the pavement stresses produced for a given tyre load
• suspension	springing medium, load-sharing and tyre "scrubbing"
• vehicle-bridge interface	the gross weight and the manner in which it is distributed across all axles of the vehicle

Safety

• braking	braking performance from the maximum speed of the vehicle
• stability	stability performance in key road and traffic situations
• speed limiting	requirements for fitment of speed limiters

Interaction with Road and Traffic System

• road space	swept path, width, length and height
• manoeuvrability	achievable wall-to-wall turning circle diameter

3.3 Accreditation and Quality Assurance

AUSTROADS and the NRTC have before them a proposal for the granting of concessions in mass limits in return for higher operational standards. It is likely that such operational standards would need to be related to Quality Assurance standards - covering vehicle performance and operational outcomes such as loading accuracy - being adhered to by relevant transport operators.

4. MORE PRODUCTIVE VEHICLES

4.1 General Trends

Some current trends in Australian road transport are conducive to improving productivity:

- a strong move towards improving national efficiency and competitiveness
- a change in emphasis to national vehicle regulations in Australia
- increased attention to truck safety issues
- rapidly increasing acceptance of B-doubles and positive operational and safety experience with these larger vehicles
- transport operators' Quality Assurance programs.

However, aside from the wider use of B-doubles and increases in the allowable length of semi-trailers, little has really changed in the make-up of the Australian heavy vehicle fleet which is controlled by prescriptive road regulations. There has, however, been an increasing number of proposals for unusual vehicle configurations, and increasing need for means of assessment of these proposals, based on vehicle performance.

Research has produced well-respected computer simulation models of truck dynamic performance, including roll stability, dynamic stability, offtracking (both high-speed and low-speed) and braking.

Many of these developments may be harnessed to point the way for the development, operation and regulation of more productive vehicle configurations in Australia and for more specific consideration of vehicle performance in regulatory decision-making.

4.2 Current Limits and Experience

The NRTC has recommended the following dimensional limits:

- 19m overall length for tractor-semi-trailers
- 13.7m semi-trailer length
- 23m overall length for B-doubles
- minimum axle spacings of 6m (tandem-tandem) and 7m (tandem-triaxle).

With regard to overall length of long combination vehicles, these limits equate to:

- 36.5m overall length for double road trains
- 53.2m overall length for triple road trains.

AUSTROADS has recently released three new axle mass schedules to apply in the GCM range 42.5-115t. This schedule has, inter alia, determined the viability of "tri-tri" B-doubles in relation to overall length and possible axle spacings. It is likely that overall length will need to increase to 24.5-25m to make the tri-tri concept viable under the AUSTROADS approach.

Following recent agreement between the NRTC and AUSTROADS, most states are now embarking on a 12-month trial period of 25m tri-tri B-doubles. This follows the trial operation of 23m tri-tri B-doubles, which commenced in 1993. In NSW, permits were issued for the trial operation of three 23m tri-tri B-doubles. RTA NSW carried out a bridge stress investigation and the following types of vehicle are currently operating:

- 62.5t GCM
- 23m overall length
- axle spacings: prime mover wheelbase 4.2m
bogie-tri spacing 7- 7.3m
tri-tri spacing 8.2-8.5m
- cab-over prime movers.

These are dedicated units, operated under a scheme of operator eligibility, assurance of loading accuracy and evidence of compliance.

In Queensland, there have been some applications for the use of road trains composed of multiples of B-double trailers. While the performance advantages of these combinations have been recognised, the use of these configurations have been resisted by regulatory authorities due to concerns about increased overall length. When considering possibilities for innovative road trains, authorities are principally concerned about:

- overall length
- swept width (the total amount of road width swept by the rear of the vehicle in straight travel) and dropping off road shoulders
- stability
- swept path (the amount of road space used in low-speed, low-radius turns).

In Western Australia, a few combinations based on multiple B-double units are in operation and the experience appears to be positive. Authorities have concerns about the overall length and swept width of such vehicle combinations.

4.3 Possible Initiatives

Measures which could be applied to increasing the productivity of combination vehicles include:

- general use of triaxle groups in place of tandem groups, to increase payload (this raises the issue of effects on bridge stresses and the required spacing between adjacent triaxle groups; adjacent triaxles have not previously been permitted)

- use of tri-tri B-doubles, together with increased allowable B-double length, to 25m

- basing Long Combination Vehicles on multiples of B-double units, rather than basic combinations of semi-trailers

- reviewing the current length limits on road trains (36.5m for Type I and 53.2m for Type II) with regard to the use of alternative configurations of Long Combination Vehicle

- reviewing the number of categories of road trains, to allow a more graduated relationship between vehicle performance and road capacity and to maximise the use of routes whose capacity varies along the route

- developing a performance-based approach to route selection, particularly with regard to the swept width performance of road trains.

5. SIZE AND WEIGHT R&D INITIATIVES - CURRENT SITUATION IN AUSTRALIA

5.1 Mass Limit Review

The NRTC is currently carrying out a Mass Limit Review, due to be completed at the end of 1994. The brief for the review includes the possibility of mass limit increases for "road-friendly" vehicles.

The review is being expedited because improved road freight productivity is seen as an important part of micro-economic reform and improvements in national competitiveness. The review is being carried out on the premise that the economic benefits of improved productivity will be passed on to consumers.

There are five modules of the review:

- definition of road-friendly vehicle
- effects of mass increases on pavements and bridges
- effects of mass increases on safety and the environment
- effects of strategic mass increases on transport operators
- any necessary increase in road user charges along with the granting of strategic mass increases.

5.2 Australian Institute of Petroleum (AIP) Productivity & Safety Initiative

A proposal has been developed specifically for the oil industry road transport operations - but applicable to any type of operation in principle - where higher mass limits are granted in return for higher operational standards. These standards are in the areas of: vehicle, loading (including loading accuracy) and driver (including training).

Proposed vehicle standards cover:

- rollover stability
- tanker barrel structural integrity
- braking
- under-run protection.

The proposal applies to the largest of current General Access vehicles - 42.5t six-axle tractor-semi-trailers. The scheme would be implemented under QA systems adopted by participating companies and would be subject to external audit to ensure that applicable standards are being complied with.

5.3 Medium Combination Vehicles

The use of MCVs on approved routes is expanding, and the favoured configuration is the B-double. MCVs are up to 25m in length and 62.5t in gross weight. "Super dogs" - comprising an 8x4 rigid truck hauling a 4-axle dog trailer are also increasing in use.

In order to obtain a permit to operate on the MCV network, vehicles must meet certain national standards, for example with regard to braking performance.

There has been some refinement of B-double configurations, and there is now a move towards 9-axle B-doubles, as mentioned above. Dynamic performance of MCVs is an important consideration and alternatives to the B-double are generally expected to have dynamic performance equivalent to a B-double.

6. KEY PERFORMANCE ATTRIBUTES

Four performance attributes having relevance to traffic safety and having the potential for practical implementation are being considered with regard to the use of larger vehicles in Australia.

6.1 Roll Stability

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

Criterion
Lateral acceleration (g) required to cause all wheels on one side of the vehicle to lift off (ie. zero wheel loads).

6.2 Rearward Amplification

Definition
The ratio of lateral acceleration at the centre-of-gravity (COG) of the rearmost unit to that at the hauling unit, at a defined speed and steering frequency.

Criterion
This ratio is evaluated at a speed of 90 km/h (in order to accommodate General Access, Medium Combination and Large Combination Vehicles) and at a steering frequency of 0.9 rad/s (representative of a realistic avoidance manoeuvre for Australian conditions) and 2.5 rad/s (2).

In addition to roll stability and rearward amplification, the Load Transfer Ratio (3) - which represents the instantaneous proximity to rollover in a transient manoeuvre - is being used. This performance attribute takes into account the beneficial effects of roll coupling between vehicle units and of increased overall length.

6.3 Low-Speed Offtracking

Definition
Level 1: The ability to track within the AUSTROADS Swept Path Specification (4).
Level 2: Offtracking of the rearmost axle with respect to the path of the steering axle.

Criterion
Level 1: Compliance of the vehicle with the appropriate level of the AUSTROADS specification.
Level 2: For GAVs, offtracking in a 90 deg turn of inner radius 13.9m; for MCVs, offtracking in a 90 deg turn of inner radius 14.5m; for LCVs, offtracking in a 90 deg turn of inner radius 28.5m.

6.4 High-Speed Offtracking

Definition
The degree to which the rear unit of a combination vehicle tracks outboard of the hauling unit in high-speed turns of moderate severity, or in straight travel under the influence of pavement crossfall.

Criterion
Offtracking of the rearmost axle with respect to the path of the steering axle in a curve of radius 319m at a speed of 90 km/h (equivalent to a lateral acceleration of 0.20g).

Computer simulation techniques developed by the University of Michigan Transportation Research Institute are being used to evaluate vehicles with regard to the above performance attributes. These include the Simplified Models, Yaw/Roll Model and AUTOSIM.

7. VEHICLE FACTORS

In assessing vehicle performance, a number of factors relating to, firstly, vehicle configuration and, secondly, vehicle specification and operation, need to be considered.

7.1 Vehicle Configuration

General Access Vehicles	-	rigid trucks, buses (route service plus coaches), truck-trailers, tractor-semi-trailers
Medium Combination Vehicles	-	B-doubles (including rear-tri and tri-tri configurations), truck-trailers
Long Combination Vehicles	-	double, triple, rigid-plus-two and rigid-plus-three road trains, plus AB-triples

7.2 Specification and Operation

The dynamic performance of these vehicle configurations may be influenced by:

mass limits - these are reasonably uniform throughout Australia, but some permitted variations occur; the NRTC is currently reviewing axle and gross weight limits and is considering the option of allowing load increases for vehicle types with "road-friendly" characteristics.

dimension limits - semi-trailer lengths have increased recently and height increases are allowed in some areas

body type - in addition to the conventional flat-tops, vans, tankers, tippers and stock crates, trailer manufacturers report a major swing to "curtainsiders"; here are also developments with drop-decks, second-decks, etc.

suspensions - within the existing fleet, there is continuing use of walking beam, single point and four-spring suspensions on tandem drive axles and of spring-and-rocker suspensions on semi-trailers; all manufacturers report a pronounced trend to high-performance air suspension, fitted with effective dampers and anti-roll devices *tyres* - wide single tyres, having apparently increased in use in the mid-eighties, are now believed to be declining somewhat in use, and there is a trend to the low-profile 275x70 or 275x80 dual tyres and to smaller-radius 19.5 inch and 17.5 inch dual tyres; 11R22.5 radial tyres still appear to be the predominant fitment

tare weight - certain sectors of the industry have pursued reductions in tare weight as a means of improving productivity; many manufacturers and operators report reductions in tare weight, although the trend is not as definite as it might be, due to counteracting tare weight increases such as air suspension

Vehicle stability is an important issue and greater use of air suspension incorporating roll stabilisation improves roll stability. Some trailer manufactures and operators report the use of wider-track axles for greater stability. Fifth wheel heights are also tending to be reduced in some types of operation, leading to improved stability.

Vehicle braking efficiency can be considered. There is a strong drive to improve compatibility between prime mover and semi-trailer brakes, plus increased interest in the use of retarders. It is known that concern about lack of compatibility between prime movers and trailers has led to some modifications of braking systems in-service, including changing actuator sizes and the use of limiting valves.

Newer technologies, such as steerable trailer axles, self-actuating lift axles, ABS brakes and load-proportioning brakes appear to be gaining only slow acceptance in the general fleet.

8. LIKELY EFFECT OF PERFORMANCE STANDARDS

If performance standards were implemented in the four areas discussed in Section 6, it is likely that:

- manufacturers of all vehicle types, with the exception of buses and coaches, would need to exploit all possible means to improve roll stability, including the use of high-performance air suspension

- rigid trucks would need to become longer, lower and lighter

- buses and coaches would meet all performance requirements

- GAV truck-trailers would become longer (with increased cube) but would require innovative means of improving roll stability and high-speed offtracking at the same time

- tractor-semi-trailers would become lower to improve roll stability

- innovative means of reducing low-speed offtracking of B-doubles may be introduced

- heavy truck-trailers would need to become lower to improve roll stability and would require innovative means of improving rearward amplification and high-speed offtracking at the same time

- road train configurations may tend towards increased use of those with lower rearward amplification and high-speed offtracking; more purpose-built road trains may be used.

Standards for the road-friendliness of vehicles will tend to increase the use of high-performance air suspension or equivalent and of tyres which are designed to operate at relatively low inflation pressures. Consideration of the road wear efficiency of vehicles will tend towards the use of triaxle groups in place of tandem groups. The inter-axle spacing within axle groups may also tend to increase with regard to minimising bridge stresses.

9. CONCLUDING REMARKS

Performance standards offer a rational approach to the development of road freight vehicles with increased productivity. While it is unlikely that such standards will replace conventional size and weight regulation in the short term, they already play an important supporting role in the assessment of new proposals for vehicle innovation.

Further development of assessment techniques, including computer simulation, vehicle testing and component testing is required in order to improve the range of application and reliability of heavy vehicle performance analyses. One important area requiring attention is the swept width, or trailing fidelity, of Long Combination Vehicles.

The use of performance standards also needs to be supported by improved means of ensuring compliance with performance requirements, including the use of industry quality assurance and auditing plus enforcement to ensure that non-accredited operators do not take advantage of performance-related productivity benefits.

10. REFERENCES

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11. ACKNOWLEDGMENTS

UMTRI has kindly given the world the simulation tools needed to get serious about heavy vehicle performance assessment.

Mr Bob Pearson, Director Technical Standards NRTC, is providing a firm hand in guiding consideration of the potential role of performance-based standards in Australia.