Submission by Dr Arnold McLean Principal Wheel Focus Engineering Technology and Certification (ETC)

Comments on NTC - Case for Change – C-RIS NTC (2023) Heavy Vehicle National Law Consultation Regulation Impact Statement

Excerpts NTC (2023) Heavy Vehicle National Law Consultation Regulation Impact Statement

'***Problem Statement 1****: There are several limitations to the HVNL that contribute to ineffective fatigue management.*
Problem Statement 2*: Limits to general access to the road network under the HVNL creates administrative burden and impacts on freight industry productivity.*
Problem Statement 3*: Confidence in the robustness of the current National Heavy Vehicle Accreditation Scheme (NHVAS) could be improved; there is a lack of consistency or recognition between accreditation schemes and a regulatory environment where operators are faced with multiple and duplicative assurance audits.*

To resolve these key problems, this C-RIS presents a series of policy proposals, the outcomes of which aim to improve the HVNL so that it better meets the object of the law.

Approach to Analysis

A combination of quantitative and qualitative analysis has been undertaken to assess proposed options:

The proposals subject to quantitative analysis are:
Expanding the scope of fatigue regulated heavy vehicles
Increase the HV general mass limits (GML)
Increase to prescribed heavy vehicle height limits
Increase to prescribed length limits for 19m vehicles.

Access
5% increase in general mass limits for all HVs. The new GML will effectively replace the current concession mass limits.
Options for increasing the prescribed height limit of vehicles from 4.3 to 4.6m
Options for increasing the prescribed length limit of vehicles currently limited to 19m to 20m. '

Comments on Problem Statement 1: There are several limitations to the HVNL that contribute to ineffective fatigue management.

It is most concerning current the NHVL in regards driver fatigue completely ignores:

- the extent of whole body vibrations, and,
- thermal loading

 experienced by drivers whilst operating along actual haulage routes both when laden and unladen in addition to their age and health condition.

In regard whole body vibration exposed onto drivers it is paramount the same be measured by in cabin monitoring of the driver's floor pad, driver's seat pad and steering column using readily available accelerometers interfaced to suitable data logging facilities. The data logged accelerometer outputs should be then interpreted in accord with ISO 2631-1: 1997 (E)[1].

Simultaneous the driver's floor pad, cab space atmosphere temperature and cab space atmosphere carbon monoxide concentration should be data logged.

The road haulage industry should be advised to avoid HVs which associate with axle spacings which are within 5% of integral multiples of any pair of axle spacings associated with the vehicle, especially that of prime movers and rigid trucks. Notably for 6 x 4 or 6 x 2 (2) single steer axle prime movers, it is typical for those displaying near integer axle spacing ratio F13 / F34 (where F13 represents the dimension between the steer axle (F1) and the lead drive axle (F3) and F34 the dimension between the two rear axles (F3 and F4, respectively) to exhibit higher cab floor and driver's seat pad vibration levels than seemingly identical prime movers displaying non integer ratio for the same axle spacing ratios (at near invariant extent of vertical motion damping to each of the respective axles).
Similarly for 8 x 4 and or 8 x 2 (2) twin steer axle (axles denoted F1 and F2) prime movers those identified to be more friendly to the drivers are those displaying non integer values for the following axle spacing ratios F23 / F12, F34 / F12, F23 / F34, F24 / F12 and F14 / F12 than seemingly identical prime movers displaying non integer ratio for the same axle spacing ratios (at near invariant extent of vertical motion damping to each of the respective axles).

In regard wheel base (WB) selection of 4 x 2 HVs it is paramount the wheel base not be an integer multiple of the road pavement long wave corrugation wavelength. This same recommendation also applies to each relevant axle spacing on HVs utilising 3 or more axles.

For improved ride it is paramount the capacity rating of all mechanical suspended axles / axle groups not exceed 115% of the allowable axle / axle group allowable load rating. Fortunately the 'softer' stiffness of air suspensions is inherently self regulating in direct accord with the actual load applied.

The industry should be aware rigid vehicles typically display lower driver seat pad vibration levels than do turntable articulated prime movers. Furthermore COE HVs typically display higher driver seat pad vibration levels relative to the driver seat pad vibration levels typical of long bonnetted normal control HVs with the driver seat pad vibrations levels typical of short bonnetted normal

1 International Standard Mechanical vibration and shock – evaluation of human exposure to whole-body vibration – Part 1: General requirements.

control HVs falling intermediate. Preferably for long distance operations the driver’s seat, within the cab, should be located longitudinally at least 1.5 steer tyre diameters aft of the lead steer axle.

Furthermore, in service, the extent of inherent damping to each axle vertical motion should be at least 18% of critical damping to each particular axle.

Furthermore the road haulage industry should be aware drivers of:

- right hand drive heavy vehicles are exposed to greater thermal loading than are drivers of left hand drive vehicles when powered by in line diesel engines with the engine exhaust manifold on the right hand side (as is typically the majority for most US and European sourced engines), and,
- cab over engine HVs are generally exposed to greater thermal loading than are drivers of otherwise similarly driveline and GVM/GCM specified short bonnetted normal control vehicles with drivers of the latter, in turn, generally exposed to greater thermal loading than are drivers of otherwise similarly driveline and GVM/GCM specified long bonnetted normal control vehicles.

Preferably cabin roofs of HVs should be painted white or be installed externally with air cell insulation (or similar).

HV manufacturers, vehicle specifier and dealerships should be included in the chain of responsibility to ensure HV drivers are exposed to minimal levels of:
seat pad, cab floor pan and steering wheel vibrations,
engine / exhaust noise, thermal loading, and,
carbon monoxide emissions whilst operating within the cabin space.

Furthermore every effort should be expended to minimise driver exposure to solar sourced thermal loading and sunlight glare when operating daylight hours summer time especially when operating in the more northern parts of mainland Australia. Equally paramount HV drivers should not be exposed to excessively cold in cabin conditions when operating in extreme winter conditions and sub frost ambient temperatures especially when operating in the S/E mainland alpine zone and elevated parts of Tasmania.

In regard driver age it is well known the local HV average driver age is significantly above the world average and is continuing to increase. Increased driver age typically implies need for more frequent and increased duration rest breaks.

In regard driver health this should be monitored simultaneous to vehicle health (road worthiness). Notably whenever a HV is subject to an on route road worthiness inspection the driver’s basic physic and paramount health details should be assessed. In regard to the driver’s physic height, weight, waist dimension and navel height should be measured and extent of ‘pear shaping’ ranked. Whereas, in regard driver’s health: age, alertness, mental status (stemming from say financial, family / household, vehicle behaviour / performance), eye pupil stability, presence of steering wheel contact calluses, back injury, diabetes symptoms or medication, presence of varicose veins, oedema, vertigo and gout should all be consistently crudely observed and recorded onto the driver’s medical status file. The observed road side health assessments and data records so established should be regularly correlated to HV driver worker compensation insurance claim data records.

Should the suggested correlations identify particular significant statistical population focal health issues the cause of each focal health issue should be thoroughly investigated. Such focal health issues along with the required abatement strategies should be regularly reported back to the road haulage industry.

Here opportunity is taken to suggest the incidence frequency of HV driver (especially long distance or interstate) incurring varicose veins, oedema and gout is expected to increase consistent with the increased utilisation of fully automatic transmissions in HV drive lines.

Opportunity here is taken also to highlight the undersigned observed first hand the adverse health status, gross accelerated ageing and driver fatigue implications of the majority of the (owner/) drivers of complainant vehicles reported to the FORS 2000 investigation[2] and at least some 150 additional complainant vehicles located in all parts of the continent. (Here it should be noted a complainant vehicle may have, in fact, represented a vehicle fleet with the fleet ranging in size from 5 off to over 50 off identical units!) Of recall only two drivers general health significantly differed from their reported end of haulage task acute fatigue syndrome. The deviation for one driver was possibly due to him being a very proficient, keen and regular scuba diver whereas the other was a very keen gardener caring for a large family garden when not behind the steering wheel. In a large number of other complainant vehicle situations the owner / driver parked their vehicle. Typically on subsequent recontact some three to 6 months post parking their vehicle the driver appeared to be some ten to fifteen younger than his assumed age when first contacted and his health and general well being including mental condition greatly improved. Equally concerning and sad was contact by numerous deceased driver next of kin reporting their husband or son mental status had deteriorated significantly and or reported the same were experiencing gross handling difficulties and cabin vibrations when operating the driven vehicle prior to their fatal accident.

Hence it can be most confidently stated total ignorance of whole body vibration, thermal loading exposure and driver age and health from HV driver fatigue considerations is nothing short of acute industrial manslaughter.

2 Sweatman, P. F. and McFarlane, S., (2000 April), Road User International Pty Ltd, Investigation into the Specification of Heavy Trucks and Consequent Effects on Truck Dynamics and Drivers: Final Report, Report prepared for FORS, Table 1 page 11.

Comments on Problem Statement 2:

Limits to general access to the road network under the HVNL creates administrative burden and impacts on freight industry productivity.

a) Increase the HV general mass limits (GML) -
5% increase in general mass limits for all HVs. The new GML will effectively replace the current concession mass limits.

For original equipment manufactured (oem) air suspended drive axle heavy vehicles a 5% increase in GML will associate with a 5% decrease in the driven axle steady state air spring air pressures. The same will, in turn, associate with a near proportional decrease in the drive axle group’s roll resistance. Subsequently the 5% increase in GML will associate with increased risk of loss of control and rollover of heavy vehicles installed with oem air suspended drive axle group. This risk of loss of control of oem air suspended vehicles is exacerbated locally by the lower quality road design and conditions, poorer pavement standards, greater extent of unsealed roads, higher grades, sharper curves, sharper turns and high frequency of close coupled alternate lock curves and relatively sharp curves close coupled to significant grades or duration of positive torque applications.

b) **Increase to prescribed heavy vehicle height limits - Options for increasing the prescribed height limit of vehicles from 4.3m to 4.6m.**

Accident Statistics

Unfortunately and most concerning the NTC (2023) Heavy Vehicle National Law Consultation Regulation Impact Statement does not specifically examine and report on the specific relative accident rates of the existing cohort of 4.6 m. 4.3 m and 3.7m high HVs. Of greatest interest would be the relative (to the total population of the particular vehicle cohort) roll over accident statistics of 4.6 m, 4.3 m and 3.7 m high vehicles.

Furthermore the reported cost of accidents appears to grossly ignore the traffic congestion costs and if applicable increased detour travel times and distances incurred by other road users.

Dependent on the air suspension source of manufacture they are either designed for operation on, relatively high quality road haulage superior US highways or European autobahns. It so happens US highways are void of intersections, traffic lights and round abouts. Furthermore US highways are designed for a maximum grade of 6%, curves are required to exhibit a considerably larger minimum radius and the pavement standard considerably higher relative to local roads, all overpasses are at a standard minimal clearance of 4.115 m (13’ 6”) and heavy vehicles (not carrying dangerous loads) are allowed to operate at 115 kph (70 mph) (whereas heavy vehicles carrying dangerous goods are restricted to 90 kph (55 mph)).

In comparison it is appropriate to list some typical local major highway situations which significantly deviate from US Interstate Highway standards. Namely, :
The Great Western Highway (Emu Plains to Lithgow); The New England Hwy (Scone to Toowoomba particularly the Coonabarabran Rise and Cunningham Gap Run (both rise and fall), The Kings Hwy (Bega to Cooma); M1 Princes Motorway (Bulli Tops to Mount Ousley); A1

Princes Hwy (Kiama bends, Batemans Bay bends (immediately post a significant grade), Tilba Tilba bends, Milton Ulladulla bends / urban area / tourist interaction and numerous other local high curvature sections); Cane River Hwy (B23); Memorial Drive to M1 Northbound (Gwynneville – light vehicle speed restricted - 25 kph curve involving rapid elevation and camber changes); M1 to Picton Rd turn westbound (post completing the major M1 Mt Ousley ascent); M31 Hume Highway (Yass – Bowning Climb, Conroys Gap, Tarcutta Cutting, Keajura, Kyemba, Jugiong, Mundarlo cuttings); Snowy Mountains Hwy B72 (Adelong to Tumut); etc, etc.
(In summary NTC must be joking!!!)

Due to the above mentioned US national interstate highway overpass clearances provision US heavy vehicles are restricted in height to 4.01 m height (13' 5"). This height corresponds to that of the semi trailer pantechnicons operated by the large super market chains to supply their retail outlets from distribution centres. Yesteryear all US trucks operated mechanical suspensions. Whereas, present day the majority are expected (other than the steer axle) to be air suspended. It so happens the majority of US designed and manufactured air suspensions installed on US HVs are void of anti sway bars. To the undersigned's knowledge the only US designed and manufactured air suspension incorporating anti sway bars are the PACCAR 4 air spring per drive axle Air Glide series. In comparison all European designed and manufactured 4 air spring per drive axle air suspensions utilise anti sway bars. Furthermore to the undersigned's knowledge no undriven air suspended axle / axle group incorporate anti sway bar/s. In comparison, again to the undersigned's knowledge, all passenger vehicles and most ADR light vehicle Category vehicles incorporate an anti sway bar to both the steer and rear axle. This general trend extends to most Japanese and Korean manufactured ADR Category NB2 vehicles.

Static Roll Threshold Considerations

The foregoing listed information suggests US HVs typically operate at a static roll threshold (SRT) (assuming zero suspension compliance) of some 0.35. In comparison local HVS operating at a height limit of 4.3 m operate at a SRT (again assuming zero suspension compliance) of some 0.34 some 3% lower than US counterparts. Should the allowable HV height be increased to 4.6 m the HV will operate at a SRT of some 0.33 (again assuming zero suspension compliance) some 6% lower than US counterparts or some 3% deficient to that applicable to current local 4.3 m HVs.

To date the static roll threshold of HVs is only tentatively correlated to static tilt table testing.

Dynamic In-service Dynamic Roll Threshold Considerations / In service dynamic roll resistance requirements

Exacting and thorough determination of the actual in service dynamic roll threshold and hence the minimal extent of in-service dynamic roll resistance requires full instrumented testing of the prime mover and attached trailer/s as per the instrumentation standard installed to the prime movers subject to instrumented testing in the FORS 2000 Investigation[3]. Subsequent analysis of the data collected provides proper confident prediction of the required minimal in-service roll stiffness or roll resistance[4] of each axle group to avoid prime mover steering and trailer tracking instabilities.

3 Sweatman, P. F. and McFarlane, S., (2000 April), Road User International Pty Ltd, Investigation into the Specification of Heavy Trucks and Consequent Effects on Truck Dynamics and Drivers: Final Report, Report prepared for FORS.

4 Ditto: Draft Final Report (December 1999), Appendix J: Guidelines for Drive Axle Suspension Performance Standards, Table J-1, Roll stiffness to maintain understeering behaviour – reference values. (Note this information was omitted from the FORS April 2000 Final Report.)

This extent of instrumented testing and subsequent analysis is vital to ensure maximum safety and health of local HV drivers, the National fleet and the safety of other road users and to minimise accident cost and traffic congestion to the community.

Comparison of Polar or Longitudinal Moment of Inertia of Increased Height HV Combinations

It is appropriate to compare here the relative magnitude changes of the polar or longitudinal moment of inertia about the vehicle’s longitudinal roll axis (in this case area assuming unit length and mass density with the vehicle’s roll axis at 750 mm elevation and side displaced 450 mm) of 3.7, 4.3 and 4.6 m high HVs. The calculated polar moments of inertia (or area) are 24.83, 41.43 and 52.02 m^4 for 3.7 m, 4.3 and 4.6 m high vehicles, respectively. Most concerning is the fact the polar moment of area is some 67% higher for a 4.3 m high vehicle relative to that of a 3.7m high vehicle and most alarming the polar moment of area for a 4.6 m high vehicle is some 110% (that is over double) that of a 3.7m vehicle. Furthermore, the polar moment of area of a 4.6 m vehicle is some 26% higher than that of a 4.3m high vehicle.
The latter increase suggests a HV combination operating at 4.6m high will require the vehicle axle group suspensions to exhibit an in-service roll resistance some 24% greater than that installed to an otherwise identical 4.3m high vehicle to maintain invariant operational safety.

Cross Wind Loading Considerations

It should also be noted, should the side walls of the HV be impermeable, the additional 0.3 m of vehicle height will cause the HV to incur an additional overturning moment of some 2 kNm to a 20 m long HV operating subject to a very modest 40 kph cross wind. This increased overturning moment will inflict steering instabilities so increasing the risk of a vehicle loss of control or in fact a vehicle rollover. Unfortunately it is expected along with climate change the magnitude and localisation of cross winds will adversely exacerbate in the future.

The totally unpredictable action of wind suggests high sided HVs be installed with anti sway bars to each axle group to maintain instantaneous counter response to the occurrence of high velocity cross winds.

In Service Non Uniform Load Sharing in Axle Groups

Due to typical chassis frame slope and more so the successive in-service bump / road surface corrugation response of the individual axles, in typical static load sharing air suspensions, rearward air pumping action occurs in the longitudinal air lines (especially when of standard diameter) connecting the air springs along each side of each axle group both driven and non driven. Subsequently typically the rear most axle of each axle group supports the majority of the loading applied to the axle group. The same suggests in-service at highway speed the lead axles in the axle group are somewhat off loaded. As a result of the off loading of the axle group lead axles the in service roll resistance generated by the non dynamic load sharing axle group is deficient to that exhibited by the same axle group when static. The extent of this non dynamic load sharing is further complicated the axle group’s number, position, feedback variable and feedback gain of the ride height control valves.

The extent of this in service non dynamic load sharing of unpowered axle groups is blatantly evident by comparing the dynamic load coefficients of trailer air suspension groups T3 and T4 in the 1983 ARRB SR 27[5]report. Notably in this dual wheel hub force transducer instrumented testing investigation suspension T3 was an air suspended tandem axle trailer group, whereas, suspension T4 was an air suspended triaxle trailer group. In the case of test results for suspension T3 the force transducer instrumented wheel hub was placed on the lead axle off side dual tyre set of the tandem axle group, whereas, for suspension T4 the instrumented wheel hub was placed on the middle axle off side dual tyre set of the triaxle group.

The observed mean (μ) and standard deviation (σ) of the load sharing coefficient (LSC) for the tested air suspended trailer axle groups were reported to be 0.904; 0.014 and 0.924; 0.012 for suspensions T3 and T4[6], respectively. Here despite the observed mean LSC of suspension T4 recording higher than that for suspension T3 the standard deviation in the observed LSC was observed to be some 16.7% higher for the lead axle offside hub of the tandem suspension relative to the standard deviation observed for the mid offside hub of the triaxle suspension.

Furthermore, in terms of the paramount pavement dynamic wheel loads the reported dynamic load coefficients (DLC) were 0.158 and 0.135 for suspensions T3 and T4, respectively[7]. Notably the observed DLC was observed to be some 17.0% higher for the lead axle offside hub of the tandem air suspension relative to the standard deviation observed for the mid axle offside hub of the triaxle air suspension.

Most disappointing this 1983 testwork did not test and compare the observed DLC for the offside dual tyre hub dynamic loading both that on lead and rear axle on the tandem air suspension. Nor did the investigation test and compare the observed DLC for the offside dual tyre hub dynamic loading on the lead, middle and rear axle of the triaxle air suspended group. It is confident had this testwork being conducted the industry would have gained vastly superior understanding and insight into the grossly non dynamic load sharing characteristics of standard air suspensions in service.

Similar non uniformity in the in service wheel loading of air suspended tandem drive axle groups is indirectly revealed in Table 36 in the FORS 2000 Investigation Final Report[8]. Examination of this Table reveals each of the various tested complainant vehicle air suspended tandem drive axle groups displayed significantly different pneumatic manifold air pressures between the near side to the offside observation for both straight and winding road test sections. Furthermore for seven of the eight off test vehicles the standard deviation of the observed pneumatic manifold air pressures for the near side was significantly higher (2.94 – 5.7%) than that observed for the offside (2.98 – 5.46%) when operating on the straight road test section. For the eight test vehicle the standard deviation of the observed pneumatic manifold air pressures for the near side was only marginally lower (5.24%) than that observed for the offside (5.3%) when operating on the straight road test section.

Furthermore the FORS 2000 Investigation also identified and reported vast differences in the dynamic roll gradient to lateral acceleration (measured in deg per g) of the tested vehicles and the correlation coefficient (R^2) for tandem drive air suspensions installed with anti sways (test vehicles

5 Sweatman, P.F. (1983), A Study of Dynamic Wheel Forces in Axle Group Suspensions of Heavy Vehicles, ARRB, Special Report SR No 27, ISBN 0 86910 141 2

6 Ditto, Table X page 18.

7 Ditto, Untitled Table top column 1 page 33.

8 Sweatman, P. F. and McFarlane, S., (2000 April), Road User International Pty Ltd, Investigation into the Specification of Heavy Trucks and Consequent Effects on Truck Dynamics and Drivers: Final Report, Report prepared for FORS, Table 36 Suspension air pressure by vehicle and road section, p82.

F1, F3, BM2 and BM3) was significantly higher than that for tandem drive air suspensions void of anti sways (test vehicles F4, F6, F26 and BM1)[9].

In driven axle groups the non dynamic load sharing characteristics of the air suspended axle group is further complicated by the torque extent delivered to the axle group and the relative power split between the driven axles in the axle group. Typically when subject to positive torque the air spring air pressures are suppressed relative to that acting when static and unpowered due to the fact air springs are intolerant to tension. Simultaneous to this air spring air pressure the suspension ride height increases hence this suspension response is referred to as ‘frame rise’. Subsequently, in response to the drive axle positive torque reaction frame rise the in-service air spring air pressures, are always suppressed relative to that exhibited when static. Hence the in-service roll resistance of powered axle group suspensions is always suppressed relative to the axle group’s static (and unpowered) roll resistance. The extent of the roll resistance deterioration of driven axle groups subject to positive torque is greatly further complicated the axle group’s suspension design (i.e. trailing arm or 4 bag) and (torque reaction and axle location) linkage arrangement in addition to the number, position, feedback variable and feedback gain of the axle group’s ride height control valves.

The extent of a driven axle group roll resistance suppression is minimised when the air suspension supporting the axle exhibits dynamic load sharing with the unitary ride height control valve receiving fractional gain of the axle group’s mean ride height. Preferably the dynamic load sharing suspension should incorporate inherent orifice damping to some 18%, when in service, of critical damping.

Recommendation

Due to the ubiquitous use of very strongly compliant air suspended axle groups, requirement for improved stability via enhanced in-service suspension roll resistance necessary for operating on generally more adverse road conditions especially during strong cross wind situations, the greatly increased longitudinal axis mass moment of inertia and the decreased SRT it is strongly recommended all HVs benefiting from 5% increased GML especially those hauling loads at height exceeding 4.3 m utilise dynamic load sharing inherently orifice damped air suspensions ride height controlled by a unitary ride height control valve responding to fractional feedback gain of the axle group’s mean ride height installed with anti sway bars on all axle groups on the HV combination.

Failure to abide with this recommendation will constitute nothing less than **gross industrial manslaughter**.

Arnold McLean
FIEAust MACRS
PhD (*UoW*) BE Hons I University Medal Shared (*UNSW*)
Proprietor Wheel Focus ETC
197 Gipps Rd Keiraville NSW 2500
E: wheelfocusetc@tpg.com.au
P: 0408 213053 (office – typically unattended)

9 Ditto, Table 34 Prime mover roll gradient (Nagambie (windy) section) by vehicle, p81.

Additional text provided to the NTC on 8 December 2023

In Service Heavy Vehicle Heights

The in service height of heavy vehicles installed with air suspended drive axle groups is highly variable. Of paramount concern is the fact the in service height is always higher, when subject to acceleration, than the vehicle's static height. Notably should a drive axle group under positive torque exhibit a 75mm frame rise the rearmost upper edge of a 4 x 2 rigid 4.3 m high pantechnicon will rise, due to geometric amplification, some 120mm, whereas, the lead upper edge of a 6 x 4 prime mover hauling a 4.3m high semi pantechnicon or stock grate will rise some 90mm.

It follows under braking or negative drive line torque conditions the in service height of heavy vehicles installed with air suspended drive axle groups is always lower than the vehicle's static height.

An on road implication of the above variable in service air suspended heavy vehicle height is that should a dipped tunnel be signposted as 4.3m clearance a 4.3m high heavy vehicle can readily enter the down grade section of a road tunnel but as soon as the driver applies power or throttle to climb out of the dip the vehicle may contact the tunnel lights and / or ventilation ducting.

It is well known in the industry pivoted trailing arm two air spring per driven axle suspensions exhibit significantly greater in service ride height variation relative to the in service ride height variation exhibited by cradle type four bag per driven axle suspensions. Furthermore typically the frame rise extent of drive axles affixed to rigid trailing arm air suspensions is relatively greater than that exhibited by drive axles affixed to flexible trailing arm air suspensions other than when for floating type trailing arms. Unfortunately the industry has generally adopted two air spring per axle floating flexible arm arm suspensions. It so happens this suspension type (of particular well known International Brand), which exhibits very significant in service ride height variation, has been widely adopted for installation on both medium and heavy rigid pantechnicon units both 4 x 2 and 6 x 4 units.

Furthermore an exacerbating phenomena occurs for 6 x 4 air suspended vehicles. Notably, for standard air suspended tandem drive axle groups the majority of the drive line power is delivered to the lead drive axle. Subsequently the frame rise on the lead axle is relatively pronounced and hence significant. The same significant lead axle frame rise is geometrically amplified to the rear drive axle frame rise. (Consequently the rear axle air springs implode causing the rear drive axle to relatively unload. This rear axle unloading so promotes the extent of in service slippage or chipping to the rear drive axle tyres).

It also follows the same significant lead axle frame rise is directly geometrically amplified to the body of rigid vehicles (then, in turn, onto the upper rear edge at the vehicle's ROH) or to the lead trailer's articulation point at the prime mover's turntable table axis (then, in turn, via the trailer's geometric amplification factor to the connected trailer lead upper edge).

(This brief discussion, in turn, suggests the truck rear upper edge of truck and dog combinations exhibit lesser in service frame rise generated vehicle height variation than do other heavy vehicle combinations. This advantage results due to the typical lesser wheelbase and rear end overhang (ROH) of the truck and the strategic position of the truck's payload centre of gravity being forward of the drive axle group and the utilisation of pivoted draw bar trailer connections.)

This same discussion directly suggests the frame rise exhibited by dynamic load sharing air suspended tandem drive axle groups will be considerable less than that exhibited by an otherwise identical static load sharing air suspended tandem drive axle group similarly loaded and subject to identical drive line power delivery. This advantage results from the in service near equal share of power between the lead and rear drive axle in a dynamic load sharing tandem drive axle group.

Should the general height limit of heavy vehicles be increased to 4.6 m clearance and noting a large number of bridge clearances are sign posted 4.6 m safe passage under the bridge will depend on whether the vehicle is subject to braking, coasting or accelerating. However, this safe passage dependency is further complicated by the phenomena of frame rise lock in. Notably the vehicle's drive axle group frame rise extent is strongly history dependent. In fact locked in frame rise can only be cancelled by the driver applying shock loading to the drive line. The required shock loading is either sudden application of engine braking or dabbing the hauling vehicle's foot controlled brakes. Simply arranging a 4.6 m high vehicle to coast approaching and passing underneath a 4.6 m clearance signed over head bridge will not be sufficiently reliable driver strategy.

It follows should a 4.6m air suspended heavy vehicle enter a dipped road tunnel sign posted at 4.6 m the 4.6 m high new general access heavy vehicle will frequently contact the tunnel lights or ventilation system should the driver apply positive torque to the drive line.

Furthermore account should also be taken of the actual road local under bridge or in tunnel vertical plane curvature when assessing the required bridge and tunnel clearances for air suspended heavy vehicles. Especially should longer 4.6m high general access heavy vehicles be granted approval. Notably the required bridge or tunnel clearance should liberally exceed 4.6m to account for the geometric amplification of the frame rise and the road vertical plane curvature segment rise for the vehicle's most critical wheel base or prime mover axle group to trailer axle span forming the corresponding segment chord dimension.

The foregoing discussion heralds expected increased traffic congestion caused by increased frequency of 4.6m high generally longer air suspended heavy vehicles becoming jammed under bridges and in tunnels should the air suspended heavy vehicle be accelerating.