Suggested Heavy Vehicle Air Suspension Contributions to Fatal Accident Statistics and Signatures

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SYNOPSIS

This investigation reports the categorisation of 'lead in' path characteristics to a finite yet representative 'random' accident population set. The accident set examined included articulated single vehicle loss of control on curves, on straights and articulated vehicle initiated head ons. Due to time and resource limitations the population set was restricted to fatal accidents for other than head on accidents. The particular fatal accident records examined where those available 'on line' from VicRoads Crash Stats Victoria Australia for the period 2003 – 2007, extended by use of 'Google Map' and where appropriate 'Google Street View'. The 'lead in' path characteristics strongly evidenced included negotiating relatively narrow windy roads, negotiating long sweeping curves, negotiating alternate lock curve sequences and negotiating a curve whilst applying and post high torque application.

The existence of these high risk accident signatures correlates well with expected drive (and undriven) axle group air suspension characteristics.

The research findings have significant heavy vehicle driver and general road safety implications including improved accident reporting, heavy vehicle driver education; road design, construction and maintenance; improved suspension parameters and performance requirements for advanced vehicle handling and braking technologies.

LITERATURE SURVEY

The Australian Federal Government Department of Infrastructure, Transport, Regional Development and Local Government regularly release National and State fatal heavy vehicle crash statistics. These statistics, in turn, are presented for crashes involving articulated trucks, heavy rigid trucks and buses. The most recent statistics declare 150 deaths from 130 crashes involving articulated trucks occurred in the 12 months ending December 2008 (ATSB July 2009). Of these fatalities over 70% resulted from accidents involving another vehicle, 12% involved pedestrian fatalities and over 16% resulted from single vehicle accidents. In 2008 at least 25 articulated truck driver fatalities occurred with Victoria contributing at least 3 of these single articulated vehicle fatal accident statistics. Of equal concern is that for each truck driver fatality approximately 8.3 drivers incur injuries in articulated vehicle crashes (ATA 2005) . According to the latter report of the 127 2002 driver fatalities 18.1%, 15%, 10%, 7.9%, 7.9%, 4.7% and 3.1% were attributed to running off the road, loss of control on a bend, speed, fatigue, rollover, alcohol and blowouts, respectively. Furthermore at specific high risk journey distances 33% of the accidents involved articulated trucks running off the road with general carriers representing some fifty-eight per cent of the crashes (Curnow 2002). Curnow also goes on to report some 65% of the articulated truck drivers killed in single vehicles crashes were not wearing a seat belt.

Another 2002 investigation reported in Australian truck crashes the proportion of persons killed that are truck occupants is 19% with approximately 70% occurring in single vehicle crashes (NRTC 2002). Furthermore the truck occupant rate per 10^8 kilometres travelled in Australia is only exceeded in New Zealand. This same report declared Australia has the highest proportion of single heavy vehicle accidents of the jurisdictions compared. Identified factors for the high incidence of single vehicle accidents included poorer road geometries, lower traffic volume, more night time driving, fatigue and higher speeds. Reasons stated for the tendency for the single vehicle accidents to be fatal included more dangerous roadside hazards, higher speeds, less protective cabin structures and lower use of seat belts. The latter three reasons were also repeated for the possible cause for crashes involving two or more trucks to be fatal. Poorer road quality was also given for non interstate roads incurring over 65% of (1994) fatal truck accidents in the USA (Clarke 1998). Characteristics of poorer quality road attracting higher heavy vehicle accident risk namely cross sectional geometry and lane width was aptly quantified by Milliken (2004) and McLean (1997), respectively.

Based on analysis of 325 crash incidents that occurred in 2007 Driscoll (2009) declared that some 27% of the reported incidents could be attributed to inappropriate speed particularly when altering direction. Furthermore he reconfirmed the driver behaviourial factors of fatigue and inappropriate speed as the major two accident contributory causes. These adverse driver behaviourial factors accounted for over 47% of the incidents. Also reported was that semi trailers were disproportionately over represented in the incident statistics relative to those involving B doubles. Surprisingly, somewhat contrary to the ATSB fatal accident statistics, discussed above, over 75.4% of the serious truck crashes were single vehicle accidents. Equally alarming is that in the remaining 24.6% serious truck crashes, which involved multiple vehicle accidents, the truck driver was totally responsible in 46.3% of the incidents.

Unfortunately the foregoing statistics provide scant attention to and mask possible contributory vehicle performance and stability factors in heavy vehicle, particularly articulated, accidents. Yet it is generally well known in the industry road haulage of a payload exhibiting a high centre of gravity will attract a higher risk of loss of control and rollover as validated by Mueller (1999) and as highlighted in the most appropriate industry guide published by the NZ Land Transport Safety Authority (undated). It is also noted Australian overall fatal single vehicle accident statistics typically fail to readily distinguish between rollovers to those involving loss of control.

Another overlooked and unreported vehicle performance factor is whether or not the involved heavy vehicle/s utilised air suspension either or both on the prime mover and trailer/s. Such omission in accident reporting is made despite the fact air suspensions display vastly different roll and handling characteristics relative to those displayed by mechanical or metal spring suspensions. This difference was highlighted in the investigation, which involved 27 formal complainant prime overs incurring handling difficulties. Of these prime movers 24 units were fitted with air suspension. Sweatman (2000). In addition, in or about 1999, in excess of 50 additional air suspended prime movers with similar (or more adverse) handling problems were known to the author. Sadly, this latter population was reinforced by involvement in numerous accident investigations involving air suspended prime movers. At the time, the percentage of air suspended prime movers in the national vehicle fleet was relatively low. This percentage has gradually increased particularly in response to air suspended axle groups gaining misnomer road friendly status and higher mass limit approval (subject to satisfaction of extremely crude minimum requirements). In addition the average engine power supplied into the fleet has likewise gradually increased (Sweatman 2000 Appendix Q).

Noting the accident reporting deficiency, in specific regard air suspension utilisation, this investigation aimed to identify if the air suspension handling problems, formally reported in 1999, resulted in any articulated heavy vehicle accident signatures. It was postulated these signatures, in turn, could be identified by effecting characterisation of the assumed ‘macro lead in’ path associated with each examined accident. Categorisation of the assumed ‘lead in’ path characteristics was, in turn, possible by examining a finite and representative number of paths associated with individual ‘random’ accidents. With the latter ‘random’ accidents selected as a particular population sub set of a readily available, web accessible, heavy vehicle accident bulk data record. The apparent existence of accident signatures, confirmed by expected air suspension behaviour, prompts possible actions and techniques to effect road safety improvements.

It should be noted this investigation was conducted and reported remote from investigations and categorisations involving local articulated heavy vehicle accidents. These local accidents involved all level of seriousness including submissions to and review of Coronial findings.

The alarming ongoing heavy vehicle accident statistics, as experienced in Australia, and New Zealand (Mueller (1999) and elsewhere (NTC 2002) prompts this current investigation. This work is a complement to the ongoing research by numerous heavy vehicle researchers seeking to ebb heavy vehicle fatality statistics. More importantly the same seeks to make road transport safer in general and to reduce the horrid human trauma and economic loss associated with road accidents.

INTRODUCTION

Utilising VicRoads Crash Stats (VicRoads on line) the articulated fatal single heavy vehicle accidents, attracting the accident describer classifications (DCA) listed in the following table, were examined. Notwithstanding the data records provide accident data for the period 1994 to 2007 particular attention was devoted to the most recent five year period, namely 2003 to 2007, inclusive.

DCA Group / Category	**D**efinitions for **C**lassifying **A**ccidents
120	Head on – not overtaking
170	Off carriageway to left
171	Left off carriageway into object / parked vehicle
172	Off carriageway to right
173	Right off carriageway into object / parked vehicle
174	Out of control on carriageway (on straight)
180	Off carriageway on right bend
181	Off right bend into object / parked vehicle
182	Off carriageway on left bend
183	Off left bend into object / parked vehicle
184	Out of control on carriageway (on bend)

Crash Stats Recorded Information

The recorded data bank for each accident records a host of information even at public access level. For this study the following details were paramount : accident number, date of accident, accident severity, number of persons deceased, number of persons injured, total number of involved persons, involved vehicles (A, B, C … etc.) accident location (route road, nearest cross street/s), chainage location, **A**ustralian **M**ap **G**rid (AMG) coordinates, initial direction of travel, final heading.

For vehicle A (make), **d**ate of **b**uilt (DB), (description (prime mover 6 x 4 etc), number of cylinders, horsepower, articulated or rigid) are also recorded. In some cases the trailer body type was recorded (eg tipper, pantechnicon, stock float, timber jinker, etc.).

Other accident or environs conditions recorded include: time of day, weather conditions, light conditions, road conditions, pavement condition, driver age, prevailing speed limit, traffic control, locality, intersection details (and/or number) if relevant). The latter additional contributing factors were subsequently ignored in this investigation.

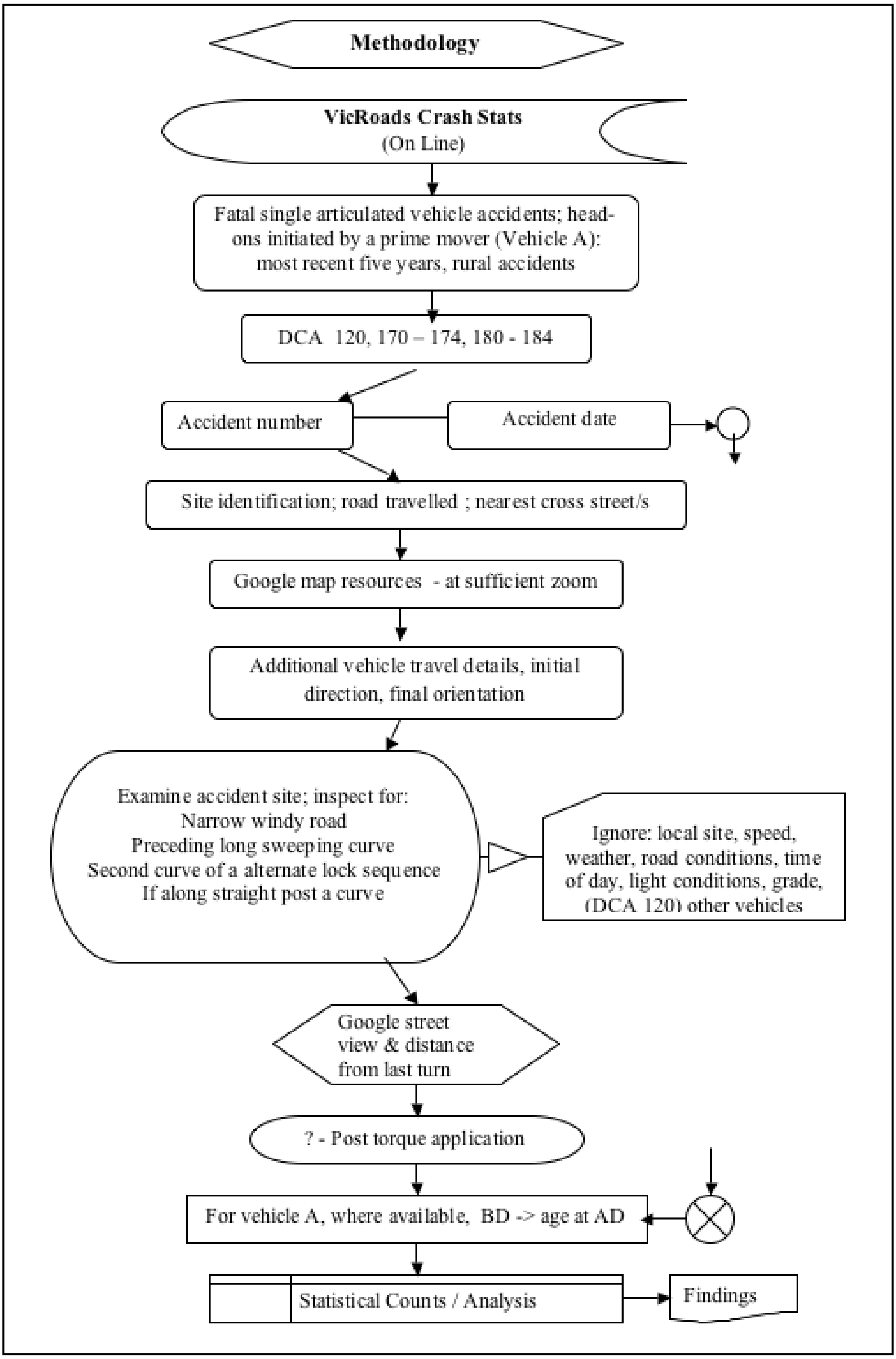
Only selected accidents in all Victoria excluding Melbourne metropolitan region were considered in this investigation.

METHODOLOGY

The methodology used in the statistical examination of the VicRoads Crash Stats is summarised in the following schematic.

Due to time resource limitations this investigations is restricted to generally single heavy vehicle fatal accidents. In the case of DCA 120 the other involved vehicle/s may or may not have involved another heavy vehicle. Due to articulated heavy vehicle initiated head on accidents typically resulting in a fatality the DCA 120 population was extended to all levels of seriousness (S1, S2 & S3).

For each listed incident the specific accident site was located using a Google map search via knowledge of the nearest cross street/s. On noting the initial direction of travel of vehicle A an assessment of the assumed ‘macro lead in’ path was first effected. Each individual accident ‘lead in’ path was then characterized. With the finite population size the characterized ‘lead in’ paths were then conservatively categorized. Based on a frequency count of the categorized ‘lead in’ paths, for each examined DCA population, accident signatures were identified. For additional supporting analysis statistics of the vehicle age at the accident date was also conducted. Here it is assumed that relatively new prime movers, at the accident date, would attract higher probability they were air suspended.


Methodology
VicRoads Crash Stats
(On Line)
Fatal single articulated vehicle accidents; head-ons initiated by a prime mover (Vehicle A): most recent five years, rural accidents
DCA 120, 170 – 174, 180 - 184
Accident number
Accident date
Site identification; road travelled ; nearest cross street/s
Google map resources - at sufficient zoom
Additional vehicle travel details, initial direction, final orientation
Examine accident site; inspect for:
Narrow windy road
Preceding long sweeping curve
Second curve of a alternate lock sequence
If along straight post a curve
Ignore: local site, speed, weather, road conditions, time of day, light conditions, grade, (DCA 120) other vehicles
Google street view & distance from last turn
? - Post torque application
For vehicle A, where available, BD -> age at AD
Statistical Counts / Analysis
Findings

FINDINGS

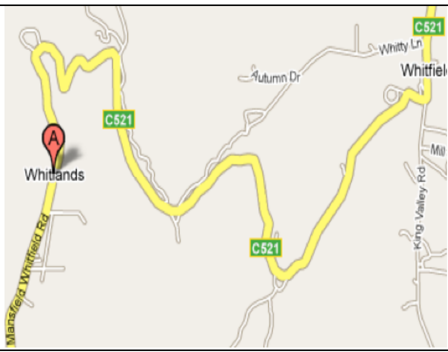
The significant overriding findings from the overall VicRoads Crash Stats data records (notably from an additional investigation for all levels of accident seriousness (ie S1, S2 & S3)) are:

- Movement of an out of control articulated vehicle into a near carriageway parked vehicle or object greatly exacerbates the risk the accident will be fatal.
- Movement of an out of control articulated vehicle deviating to the offside associates with a higher risk of a more serious accident.
- An expected large number of accidents involving minor injury (S3) and vehicle / property damage only are not reported.

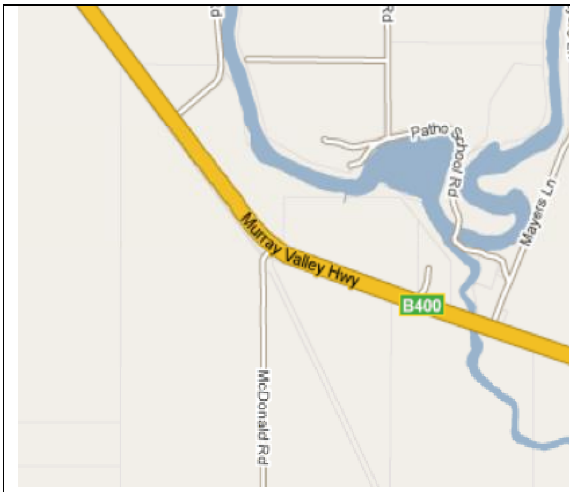
DCA 120 Head On Accident Statistics

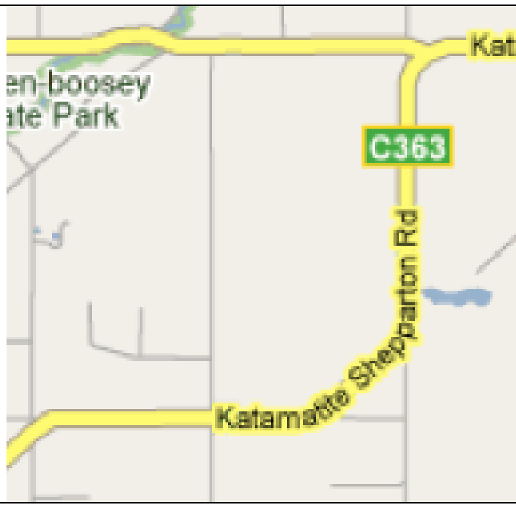
Total population -15 (Fatal sub group population 8)

Typical Examples: Narrow Windy Road



: Post a Standalone Long Sweeping Curve





: Alternate Lock Curves

Findings

a) Of the specific population of fifteen 40% were fatal (S1), 27% involved serious injury (S2) and 33% involved minor injury (S3). Hence it can be confidently stated a head on precipitated by a prime mover usually results in a fatal accident. Should the head on involve a light vehicles the occupant/s of the same is/are at highest risk of fatality.

b) Of the fifteen accidents 13.3% occurred on substantial straights, 73.4% were in close proximity to a curve and 13.3% were in close proximity to a curve and occurred on a narrow windy road.

c) Approximately 40% of the accidents occurred immediately post a long sweeping curve.

d) All known vehicle makes; prime mover less than 2 years old, 13.3%

e) All known vehicle makes; prime mover less than 5 years old 46.7 %.

f) In regard DCA 120 (head ons) a ‘memory’ steering deviation from a right hand lock curve is associated with greatest risk.

g) It is estimated 67% of the vehicles classified with this particular accident scenario had a left hand located **r**ide **h**eight **c**ontrol **v**alve (RHCV). A further vehicle possibly had a left hand RHCV consistent with the manufacturer fitting single left hand RHCV on their older model vehicles.

DCA 170 – 174 Fatal Accident Statistics

Total population 11

Typical Examples

(Note few if any DCA 170 – 174 accidents are reported on windy narrow roads)

: Post a Standalone Long Sweeping Curve

: Alternate Lock Curves

Findings

a) Of the 11 fatalities 36.4% involved the vehicle veering to the nearside (left) and 54.6% involved the vehicle veering to the offside (right). One fatality (9.1%) was due to loss of control on a straight carriageway (DCA 174).

b) A significant majority of fatal accidents reported to have occurred on a straight occur in very close proximity to at least one bend.

c) On a conservative basis approximately 27.3% of the fatal accidents occurred immediately post a long sweeping curve. At least two additional accident situations would satisfy this accident signature should the overall route details, of the subject articulated, vehicles be appropriate.

d) It follows that one in four DCA 170 – 174 accidents reported as occurring on a straight actually occur at the exit of a long sweeping curve.

e) 27.3% of the involved vehicles where less than 2 years old and 54.5% were less than five years old at the accident event. Here the make and build date were not known for 18.2% of the population.

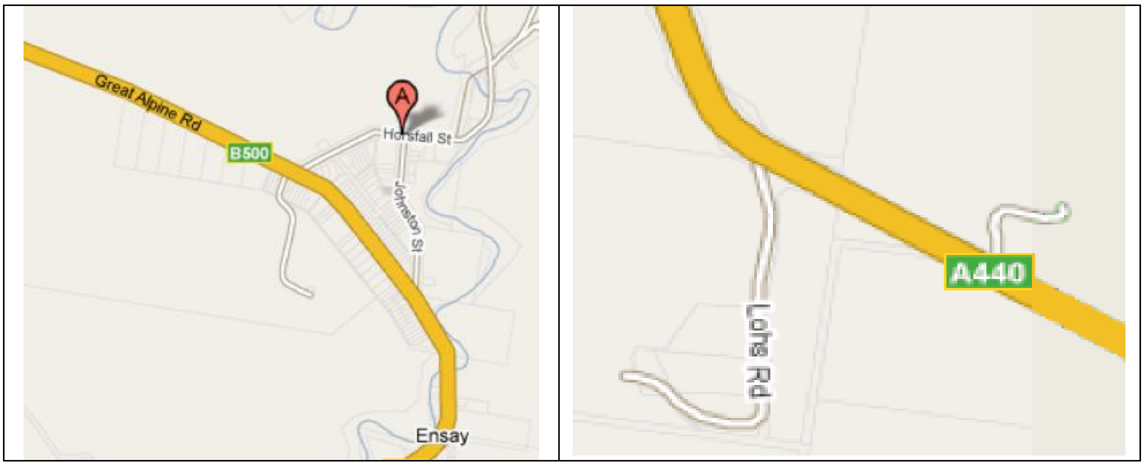
f) Of the fatal DCA 170 – 174 accidents identified to have occurred post a long sweeping curve, based on knowledge of make suspension details, at least 67% were fitted with twin ride height control valves (RHCVs).

DCA 180 – 184 Fatal Accident Statistics

Total population 12

Typical Examples : Narrow Windy Road

: Post a Standalone Long Sweeping Curve



: Alternate Lock Curves

Findings

a) Consistent with bend lock randomness 50% of the accidents involved a deviation from the road on a right bend, 41.7% on a left bend and 8.3% (a loss of control on a bend (DCA 184) (ie non specific hand lock)) .

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b) Movement of an out of control articulated vehicle into a near carriageway parked vehicle or object greatly exacerbates the risk the accident is fatal especially should the vehicle be deviating in a left bend.

c) Less recovery time and manoeuvring space is available for drivers incurring loss of control on right bends (DCA 180 – 181) relative to that available when experiencing loss of control on left bends (DCA 182 – 183). [Consequently a vastly greater number of reported accidents involving minor injury (S3), or worse occur, on right bends, (approximately twice more).]

d) Approximately 8.3% of fatal accidents described to have occurred on a bend occur on narrow windy roads. For these same accident situations identification of the actual accident site is relatively difficult due to the lack of close proximity cross streets (if any exist at all) (eg log truck haul routes).

e) Approximately 66.7% of fatal accidents described to have occurred on a bend occurred entering the second curve of an alternate lock sequence.

f) Approximately 25% of fatal accidents described to have occurred on a curve occurred entering or passing through a relatively ‘stand alone’ bend.

g) The statistics gleaned in (e) suggests that 2 in every 3 fatal accidents involving articulated heavy vehicles occur entering the second bend in an alternate lock curve sequence.

h) At the time of the accident 8.3% of the involved vehicles were less than 2 years old, 41.7% of the involved vehicles were less than 5 years old and 8.3% had no BD recorded.

i) 8.3% of the involved vehicles did not have a recorded make.

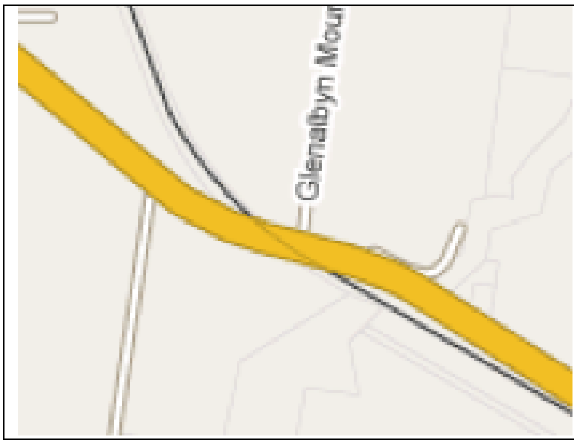
j) Of the involved vehicles less than 5 years old and whose make was declared, at least, 80% were probably fitted with a trailing arm suspension.

k) Post high torque application was a possible contributory cause in 16.7% of this population group. (In one case further details of the overall vehicle route details was appropriate to confirm categorization to this accident contribution factor.)

For the fatal DCA 180 – 189 accident situations involving curve sequences the curve sequence was consistent with the involved make being fitted with twin RHCVs (for known make, BD and vehicle age less than 5 years) in 15% of the cases.

High Torque Application Contribution

Examples



Approximately 6%, 18%, 15% of the examined DCA 120, 170 -179, 180 – 189 accidents were consistent with frame rise (due to high torque application) as a possible contributory factor.

DRIVE AIR SUSPENSION RESPONSE NEGOTIATING A STAND ALONE LONG SWEEPING CURVE

The response of a drive (and towed axle group) air suspension, hence air suspended vehicle, when negotiating a standalone right lock long sweeping curve is depicted in the schematic sequence summarised in the following table. Here the vehicle is assumed to be hauling a load exhibiting a relatively high centre of gravity. This response is characterized by the suspension system variable transients. The paramount system variables are the pressure in (p) and ride height (h) across the left ($_L$) and right ($_R$) air springs. These variables are assessed relative to their, respective, set points (SP) which apply when travelling at steady state along a straight uncambered high quality pavement. For convenience the vehicle is viewed from the chassis rear moving into the page. In this discussion sufficient drive power and torque is applied to negotiate the constant radius curve at invariant speed. It is also assumed the vehicle is negotiating the curve at a speed far below that associated with the vehicles' static rollover threshold for the particular curve. Further it is assumed the vehicle is fitted with twin ride height control valves each with a supply and discharge time constant of T_S and T_D, in seconds, respectively. Typically, it is usual to observe $T_D < (<) T_S$. For simplicity this discussion ignores any secondary effect of transient tyre deformation due to differential lateral tyre load transfers during the manoeuvre. For convenience and brevity purposes this discussion also ignores both frame rise or torque application effects and the contribution of suspension auxiliary roll resistance. The effect of the latter is highly variable and time dependent especially when negotiating alternate lock curves and variable pavement conditions. In passing it is stated auxiliary roll resistance is favourable when negotiating stand alone curves on a high quality roads possessing high quality pavement. In comparison the effect of frame rise is dependent on whether positive (power), neutral (coasting) or negative (braking) torque is applied to the drive line. The frame rise (or droop) intensity is dependent, in turn, on the instantaneous applied torque level.

Cornering Phases

Approaching the RH curve the vehicle is travelling along a straight path void of cornering lateral forces as depicted in phase pre B in the following schematic. Here the vehicles' load centre of gravity (CoG) is directly above the vehicles' roll centre. Here, ignoring any road camber and drive line torque effect, the pressure in both the left and right air springs are more or less equal and at their set point. For this condition both the left and right ride heights are at their set points hence the ride height control valves (RHCVs) are in their dwell states.

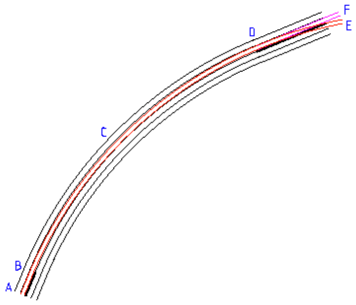
On lock application at point B the load leans outward as depicted in the schematic depicted for phase B to C . Here the cornering lateral load is transferred to the LHS air springs whereas the RHS air spring experiences reduced load. The LHS air spring compresses whereas the RHS air spring extends. The LHS air spring compression causes the LHS pressure to increase and the ride height to be deficient. Subsequently the LHS RHCV will open to supply the LHS air springs. On the other hand the RHS air spring extension causes the ride height to be excessive and the RHS pressure to decrease. Subsequently the RHS RHCV will open to exhaust the RHS air springs further reducing the air pressure in the same. This transient state will slowly dissipate over some 3 - 5 supply time constants. At which time both the LHS and RHS RHCV will reattain their dwell state,

Post the curve entrance RHCV transient actions post point C refer schematic for phase C to D, the RHCVs (mainly the LHS unit) will have had sufficient time to re-establish the payload to the upright state. In this state, up to the lock cancellation (point D), the LHS and RHS ride heights reattain and maintain their set point status. However, this geometric state demands the LHS air spring pressure exceed the RHS air spring pressure to maintain dynamic equilibrium subject to the lateral force action.

On right lock cancellation at point D, refer schematic for phase D to E or F, the load instantaneously leans towards the right (ie inwards relative to the curve just completed). This sudden to the right leaning is the system response to the now excessive pressures in the LHS air springs and the now deficient pressures in the RHS air springs noting now the cornering lateral force no longer acts. The chassis leaning and twisting, generated by the (drive) suspension air spring transients, transfers additional load to the diagonally opposite steer tyre (ie RHS) causing the vehicle to pull or dart to the right. This unstable state may be exacerbated by underdamped dynamic load second order system rocking response, pavement irregularities, suspension stiction and driver steering smoothness / skill. This transient state will dissipate exponentially over some 3 – 5 T_s. If uncorrected the vehicle will 'memory' steer along path D to E. Unyielding driver vigilance requires suitable corrective steering input to oppose the 'memory' steer effect and maintain the vehicle path along D to F.

The final steady state along straight, post the curve proper, is attained by the LHS RHCV venting and the RHS RHCV supplying to attain the suspension ride height set point status. Essentially, the same status as that applicable at the curve commencement, as depicted in the schematic for phase post F.

It should be noted the vehicle instantaneous lean may become 'locked' by the presence of stiction in the suspension system. Subsequent 'unlocking' or release may associate with sudden lean changes. Brevity requirements and presentation time limitations also omit opportunity to discuss the time lagged 'memory' steer effect disturbances generated by the vehicles towed axle groups. The latter disturbances are instantaneously transferred via the respective vehicle articulation points.

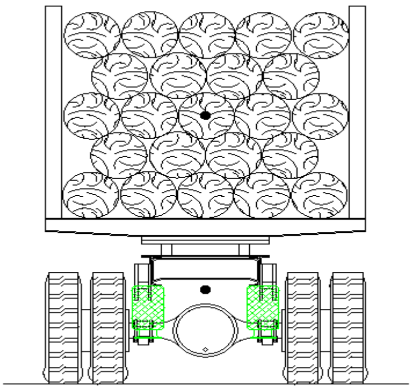


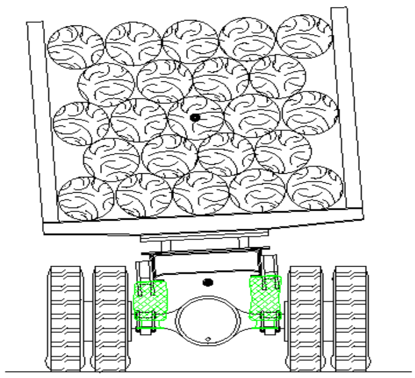
Suspension phases experienced negotiating curve:

< B lead in straight, lock application at B
A to B lead in straight
B to D constant radius long sweeping curve
B to C curve lead in transient phase
C to D curve steady state phase
D to E uncorrected ‘memory’ steering transient phase
D to F driver corrected ‘memory’ steering transient phase
F > > post curve steady state phase
D > post curve straight, lock cancellation at D
Legend Air Spring Conditions - (SP – Set Point)

Stand alone curve phases

Legend



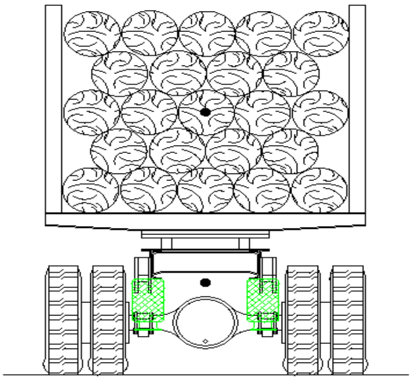


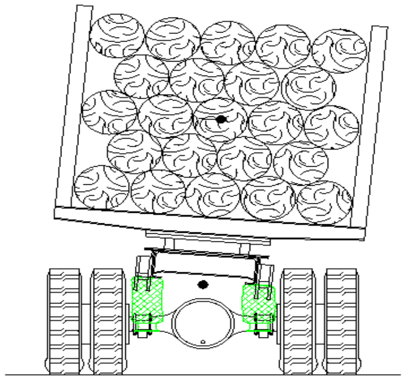
Phase pre B Air Spring Conditions

p_L	h_L	p_R	h_R
SP	SP	SP	SP

Phase B to C Air Spring Conditions

p_L	h_L	p_R	h_R
>	<	<	>



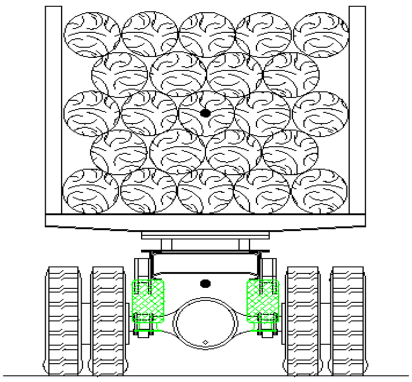


Phase C to D Air Spring Conditions

p_L	h_L	p_R	h_R
>	SP	<	SP

Phase D to E or F Air Spring Conditions

p_L	h_L	p_R	h_R
<	>	>	<



Phase post F Air Spring Conditions

p_L	h_L	p_R	h_R
SP	SP	SP	SP

Vehicle moving into page
Vehicle operating at a speed conservatively below that associated with the vehicles' static roll threshold
A high quality uncambered pavement assumed
Suspension auxiliary roll resistance effects neglected
Time lag effects of towed axle groups neglected
Sudden lock application and cancellation assumed
Suspension assumed to be in high state of repair
Suspension stiction effects neglected

Notes

In progress analytical and simulation research, supported by engineering tuition and driver feedback, indicates vehicles fitted with a single high gain right hand side RHCV will relatively strongly 'memory' steer post a left lock long sweeping curve, whereas vehicles fitted with a single high gain left hand side RHCV will relatively strongly 'memory' steer post a right lock long sweeping curve. (For right hand drive vehicles the former tendency results in a lower risk accident seriousness scenario (especially in high traffic density situations.) It therefore follows vehicles fitted with both left and right hand RHCVs (ie twin RHCVs) will display a tendency to strongly 'memory' steer exiting both left and right hand lock long sweeping curves.

The foregoing discussion also explains the higher risk of loss of control when entering a subsequent opposite lock curve and the particular previous 'memory' steer tendency (or driver over correction actions) related to the RHCV number and location. Due to time limitations this extended discussion is not presented here. [The same accident scenario also applies to the behaviour of air suspended heavy vehicle negotiating round abouts. This accident scenario is not discussed here because round abouts typically occur in metropolitan areas.]

IMPLICATIONS

Confluence

The identified accident signatures are supported by the expected behaviour of air suspended heavy vehicles in long sweeping curves, through alternate lock curve sequences and post high torque application situations. Conversely the predicted behaviour of air suspended heavy vehicles in the stated situations correlates well with the observed finite accident signature statistics.

Accident Details

Investigations of this enquiry would be greatly enhanced by full knowledge of the involved heavy vehicle (both prime mover and towed axle group/s) suspension details. Namely whether air suspended or not, the type or make of suspension, the number and location of the RHCVs. Furthermore the vehicle's payload centre of gravity, at the time of the accident, should be estimated and recorded.

Heavy vehicle characteristics

This investigation suggests newer heavy vehicles typically exhibit high risk of loss of control:

- Negotiating narrow windy roads (and lower quality roads)
- exiting long sweeping curves
- entering the second curve of an alternate lock sequence
- during and post high torque application.

The risk of loss of control is particularly acute should the lead curve be a long sweeping curve and the successive alternate lock curve be relatively sharp relative to the former.

Newer prime movers are most likely to be fitted with air suspensions.

Suspension parameters

The statistical findings are consistent with standard air suspended vehicles being fitted with:-

- twin RHCVs exhibiting a strong tendency to deviate to both the left and right.
- a single left RHCV exhibiting a strong tendency to deviate to the right post long sweeping right lock curves.
- a single right RHCV exhibiting a strong tendency to deviate to the left post long sweeping left lock curves.

Heavy Vehicle / Road Interaction

The statistical findings suggest standard air suspended vehicles are non optimal for 'typical' rural Australian roads. Notably approximately 1 in 10 fatal vehicle accidents described as occurring on bends occur on narrow windy roads (ie C grade and below).

This same suggest heavy vehicles operating in rural environs, based on Victorian conditions, do so on non optimal roads.

ROAD SAFETY BENEFITS

Accident Details

All jurisdictions should immediately introduce formal requirement to record heavy vehicle payload centre of gravity and suspension details in accident records. Furthermore the accident site should be specified by AMG or GPS coordinates. Alternatively individual accident details would be greatly enhanced by 'hyper linked' digital map access to the accident site. Such accident records should be public web accessible.

In terms of the VicRoads data base it would be appropriate to expand the DCA classifications to indicate whether or not the deviation involved a heavy vehicle roll over.

Accident Investigation Reports

In regard single heavy vehicle accident reports all should clearly declare the involved vehicle suspensions details. If air suspended the relative relevance of the following accident signatures, namely :

Narrow windy road,
Post long sweeping curve
Entering the second curve of an alternate lock curve sequence
During and post a high torque application
(Overcorrecting to one of the above scenarios.)

should be examined and declared.

Accident Record Statistical Investigations

All jurisdictions should conduct and report statistical examination of past accident records for at least the last five years. This examination should involve accidents at all level of seriousness including were possible property damage only. This statistical examination should identify whether the involved vehicle was air suspended or not. Most importantly such effort should identify the relative statistical relevance of the identified accident signatures. The information so gleaned should be used to advance long term road safety improvements.

Accident Investigator Expertise

Accident investigators should be made aware of a air suspended vehicles' response to the road curvature, terrain and topology for typically up to one kilometre prior to the actual accident site. These same investigators must be fully conversant with the behaviour of heavy vehicle air suspensions whilst cornering and accelerating. Likewise the vast response difference between air and mechanical suspended heavy vehicles must be fully appreciated.

Driver Education

The typical highway speed air suspended heavy vehicle steering behaviour in long sweeping curves, in close coupled alternate lock sequences particularly those possessing vastly different curvature and post torque application responses should be made known to drivers. Furthermore drivers should be informed of the high risk accident scenarios and techniques to allay this risk. Drivers should also be advised not to effect ‘short cuts’ utilising low quality roads but instead bias their routes to utilize higher quality pavements. This education will indirectly promote drivers to operate at more conservative speeds and the need to maintain unyielding vigilance. Appropriate aversive actions, in the case of a steering deviation, when in control of a air suspended heavy vehicle also should be disseminated throughout the industry.

Techniques to improve steering smoothness and effect optimal route selection, to minimise accident risk, should also attract high priority. Here chain of responsibility implications suggest drivers unfamiliar with particular routes should be informed of high risk curve and road situations prior to the journey commencement. The risk of same would be greatly allayed by enhanced ‘in cabin’ electronic navigation devices.

Improved Suspension Parameters

It is recommended highway speed right hand drive prime movers be fitted with no more than one low gain RHCV located biased towards the right hand side (RHS) and receive feedback of no more than 50% of a specific attached axle ride height. In the case of undriven axle groups the single RHCV, for the axle group, should be biased towards the left hand side.

Optimal air suspension performance demands maximization of each axle groups’ roll resistance.

The same findings suggest that all jurisdictions conduct audits of their vehicle fleets. Vehicles and haulage units identified with adverse air suspension details should be improved and /or retrofitted as soon as possible.

Payload parameters

Every effort should be made by transport engineers and operators to minimise the payload centre of gravity.

Road Design

Close coupled alternate lock curve sequences exhibiting vastly differing curvature should attract ‘black spot’ status and appropriate speed restriction signage, and particular situation signage (especially should the haul route be utilised by vehicles hauling payloads exhibiting high centre of gravity). Road design parameters should be selected remote from those attracting high accident risk. Road designers, installers and maintenance managers and personnel must pay particular attention to the exit zones of long sweeping curves over a distance covered by highway speed vehicles in up 5 T_s seconds.

Introduction of electronic stability and advanced braking technologies

Noting the majority of fatal heavy articulated vehicle accidents occurred subject to adverse low quality, ‘rural’, ‘near rural’ including unsealed road conditions it is doubtful electronic stability and advanced braking technologies will assist allay the accident frequency.

FUTURE RESEARCH

The finite accident population utilised in this examination should be extended to all articulated heavy vehicle accidents at all levels of seriousness occurring in the last five years. Resource limitations suggest this effort be devoted to VicRoads CrashStats data records DCA 170 – 179 and 180 – 189 accidents. In addition this future work should gain access to formal suspension details of the involved vehicles. This future phase should consolidate the correlation between the ride height control valve location and the specific accident scenarios. Due to the significance of the research findings substantial resources would be required. Such research resources would be minor relative to the expected road safety benefits from the findings.

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