Urban Truck Crashes—What Really Happens

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ABSTRACT

This paper reviews the driver, road, vehicle and environmental factors involved in urban heavy vehicle crashes of various levels of severity. Consideration is given to factors contributing to such crashes, factors affecting their severity and potential countermeasures to such crashes. Results are presented from a recent major study of urban truck crashes in Australia, concentrating on the outcome of post-crash analyses carried out for all fatal urban truck crashes in Sydney and Melbourne for the year 1992. These results include the incidence of a wide range of contributory factors and the potential effectiveness of a range of countermeasures in either avoiding the crash or reducing its severity. The methodology of the study, which has been used previously in a study of long-haul truck crashes, is described and the role of trucks in urban crashes is discussed.

INTRODUCTION

In many countries considerable research into heavy vehicle safety has been carried out since the mid 1980s. In Australia, this research has tended to focus on long-haul and rural operations with relatively little attention paid to the circumstances and causes of urban crashes involving heavy vehicles. However, urban crashes represent a significant component of heavy vehicle crashes. In Australian urban areas, crashes involving trucks represented approximately thirteen percent of fatal crashes [1]. Fifty to seventy-five percent of all serious rigid truck crashes and twenty-five to fifty percent of serious articulated vehicle crashes occur in urban areas [2].

The Federal Office of Road Safety (FORS) is undertaking research into the types, severity and causes of crashes involving heavy vehicles in urban areas in order that countermeasures may be developed to reduce the incidence of such crashes and/or reduce their severity.

A consortium from Roaduser Research, Monash University Accident Research Centre (MUARC) and Monash University Civil Engineering was contracted to provide an integrated investigation of the urban heavy vehicle crash issue, how it differs from current knowledge of heavy vehicle safety and potential ways of reducing serious urban crashes involving heavy vehicles. The project included five components:

(1) a review of the literature concerning heavy vehicle safety in urban areas

(2) analyses of available mass data (involving trucks over 3.5t GVW and buses over 5t GVW), covering fatal and injury crashes in urban areas of NSW, Victoria and Queensland and including (i) trends over the period 1984-1993 and (ii) characteristics of crashes occurring during the period 1989-1993

(3) detailed post-crash analysis of all fatal heavy vehicle crashes occurring in Sydney and Melbourne in the year 1992 (a total of 59 crashes were investigated)

(4) further analysis of existing MUARC in-depth data, where occupant protection issues had been investigated in detail; 29 Victorian crashes, including 14 fatal crashes, were re-investigated

(5) investigation of heavy vehicle black spot intersections in Sydney and Melbourne for the period 1987-1993; the fifteen intersections showing the highest frequencies of heavy vehicle casualty crashes in each city were investigated.

This paper describes the methodology and some of the results of the detailed post-crash analysis (component 3 of the study).

STUDY RATIONALE

The Federal Office of Road Safety (FORS) objectives for this study included (i) the examination of the circumstances and causal factors of a representative sample of urban heavy vehicle crashes and (ii) the identification of countermeasures likely to be cost effective in improving the safety of heavy vehicle operations in urban areas.

In order to address these objectives, it was necessary to select a sample of crashes with the following characteristics:

- maximum availability of information relating to crash circumstances
- containing information on factors relating to crash consequences as well as crash risks
- reasonably uniform availability of information across the sample

- high intrinsic significance of the group of crashes from which the sample was selected, generally interpreted as crashes of high severity.

In consultation with FORS, it was decided to investigate all fatal heavy vehicle crashes which occurred in Sydney and Melbourne within a period of one year. On the basis of analyzing the most recent data possible, as well as having access to all Coroners' reports, the year 1992 was selected for analysis. The investigation covered 29 Sydney crashes and 30 Melbourne crashes.

The investigation considered all available data concerning drivers (and all involved road users), vehicles, road, traffic, traffic control, environmental conditions and heavy vehicle operations. Information sources included crash site visits and reports by Police, Accident Investigation Squad and Coroners. Data on crash circumstances and contributory factors was incorporated in a database, in order to permit multi-factor analysis.

In addition, a conferencing session was held, where a range of expertise, including safety managers and representatives of the transport industry focused on the contributory factors and possible countermeasures applicable to crashes. This resulted in the establishment of a second database for the ranking of potential countermeasures

METHODOLOGY OF POST-CRASH ANALYSIS

DATA COLLECTION

Identification of 1992 Crashes The mass data was searched for fatal crashes involving a heavy vehicle within the Sydney and Melbourne statistical districts during 1992.

Police Accident Forms Police accident reporting forms were obtained for all crashes. These provide some information about the crash scenario and, importantly, a link to Coroners' court records.

Coroners' Court Records Records held in the Coroners' Courts were accessed and examined for each crash. These records included Coroners' reports and findings, photos of the crash scene, vehicles etc, Accident Investigation Squad reports, witnesses' statements and records of interview, where available.

Crash Site Inspections With the aid of the Police form and Coroners' Court information, the crash sites were inspected by the research team, and relevant data recorded. Information relating to contributory factors was recorded on a Truck Crash Factor Form.

TRUCK CRASH FACTOR FORM

A Truck Crash Factors coding form was devised in order to record the researchers' opinion of contributory factors. This form was based on the form used by the consortium in a previous rural truck crash study [3], but considerably expanded to take account of the much wider range of factors apparent in urban crashes.

Contributory factors (see Appendix) were recorded for their relevance to either the causation of the crash or the severity of its consequences, or both. The coding used was as follows:

- probably not a contributing factor
- unknown, but not ruled out
- probably was a contributing factor.

DATABASE OF CONTRIBUTORY FACTORS

This database included the following information:

- dominant factors causing the crash (without which it probably would not have occurred)
- contributory factors, sub-divided into appropriate categories.

Dominant Factors Data Block For each crash, no more than four dominant causal factors were identified. These dominant factors related to crash causation rather than severity of the crash consequences.

Contributory Factors Data Block A large number of factors relating to the vehicles, drivers, road and traffic conditions and the environment were considered for their potential contribution to each crash investigated. The categories and factors included in the database are summarized in the Appendix.

DATABASE OF COUNTERMEASURES

Countermeasure Form Based on the literature and on the experience of the consortium members, a list of potential countermeasures which may reduce the exposure, risk or consequences of urban heavy vehicle crashes was drawn up (see Appendix).

Conferencing Session A conferencing session, involving the full range of expertise available in the consortium, was held to discuss a representative group of the Sydney and Melbourne crashes, likely contributory factors and possible countermeasures. The main purpose of the conferencing session was to generate a detailed, practical and balanced approach to the identification of potential countermeasures for each crash. To avoid an over-optimistic or simplistic assessment of countermeasures, they were considered in isolation from crash contributory factors.

Database In the database, each countermeasure was coded in one of the following categories:

- probably would not have affected the causation or severity of the crash
- if present, there is a some chance that the crash may not have occurred, or that crash may have been less severe (termed minor countermeasure)
- if present, there is a good chance that the crash would not have occurred, or that the crash would have been less severe (termed major countermeasure).

CRASH CIRCUMSTANCES

The frequencies of a range of crash circumstances, for the combined Sydney and Melbourne data, showed that:

- 49% of crashes occurred away from intersections, and 44% occurred at intersections
- where intersections were involved, most were uncontrolled and only 15% occurred at intersections with traffic lights
- most of the intersection crashes involved the heavy vehicle turning or traveling across the path of the "other vehicle"
- most of the crashes occurred in residential or residential/commercial areas and occurred in daylight

- most of the crashes (56%) involved rigid trucks, and a smaller number (29%) involved tractor-semi-trailers
- a relatively small percentage of the crashes (24%) involved long-haul vehicles
- in most cases, the "other vehicle" was a car, although pedestrians were relatively frequently involved; in the majority of cases (64%) the "other vehicle" was solely responsible for the crash, and was solely or partially responsible in a total of 77% of cases; the heavy vehicle was solely responsible in 15% of cases and was solely or partially responsible in a total of 33% of cases; joint responsibility was assigned in 11% of cases
- a relatively large percentage of the fatalities involved persons aged over 60 years.

DOMINANT FACTORS CAUSING CRASHES

Certain factors were considered to be instrumental in the causation of each crash. In general, these factors tend to be reasonably variable. For the combined Sydney and Melbourne data, the most important factors were: inappropriate behaviour by pedestrian/cyclist, excess speed by car/motorcycle driver, inattention on the part of car/motorcycle (mainly car) drivers, disregard of traffic control by heavy vehicle driver, disregard of traffic control by car/motorcycle driver and alcohol or drug use by car drivers.

CONTRIBUTORY FACTORS

The main contributory factors interpreted to have been involved in both Sydney and Melbourne crashes were:

- road geometric standard
- truck driver inattention
- car/motorcycle driver inattention
- pedestrian/cyclist inappropriate behaviour
- car/motorcycle driver attitude
- car/motorcycle driver excess speed
- roadside objects
- road alignment.

The most important contributions from each element of the heavy vehicle - traffic - road system are as follows:

ROAD/TRAFFIC	geometric standard roadside objects road alignment sight distance traffic control road shoulder
TRUCK DRIVERS	inattention slow speed disregard of traffic control attitude excess speed braking, no steering inexperience
CAR/MOTORCYCLE DRIVER	inattention attitude excess speed alcohol or drugs inexperience disregard of traffic control close following asleep
PEDESTRIAN/CYCLIST	inappropriate behaviour ill health age/mobility disregard of traffic control inexperience, youth
TRAFFIC INTERACTION	mis-anticipation impeded visibility traffic congestion
HEAVY VEHICLE	field of view side under-run and unguarded wheel areas vehicle size swept path rear structural stiffness vehicle age instability rear under-run turning circle
ENVIRONMENT	rain
CARS AND MOTORCYCLES	conspicuity

POTENTIAL COUNTERMEASURES

The analysis of major countermeasures shows that the following countermeasures are most frequently relevant to the crashes studied:

- more appropriate behaviour on the part of some road users involved - this includes car drivers, motorcycle riders, pedestrians, heavy vehicle drivers and bicyclists
- separation of carriageways to reduce the potential for traffic conflicts
- reduced frontal aggressivity of heavy vehicle - measures related to front bumpers and the frontal structure of the truck and designed to deflect, reduce the degree of under-ride and reduce the structural stiffness
- ITS technology - such measures cover a broad field and represent major steps in technical innovation; they include:
    - detectors of the presence of pedestrians at the front nearside of heavy vehicles
    - in-vehicle indicators of red signals, for both trucks and cars

    - in-vehicle stability warning for heavy vehicles
    - signals responsive to heavy vehicle speed and position
    - route guidance
    - emergency advice
- pedestrian capacity - measures to ameliorate the lack of mobility of older pedestrians
- enforcement of speed and alcohol laws - the use of devices such as speed cameras, alcohol ignition interlocks, etc to assist in automating the enforcement of laws relating to speed limits and BAC
- side under-run protection for heavy vehicles - means to prevent pedestrians, bicyclists and motorcyclists from becoming trapped under heavy vehicles and means to reduce the consequences of side under-run by cars
- car crashworthiness - improved car occupant protection in crashes involving under-ride and side impacts
- heavy vehicle field of view (nearside) - including improved lines of sight from the driver's position and improved mirrors, to assist in detecting the presence of pedestrians and cyclists on the nearside of the vehicle
- driving skills of heavy vehicle drivers - driving within the stability and braking limits of heavy vehicles, and exploiting the performance capabilities that are available in heavy vehicles, including the freedom to brake and steer at the same time
- road geometry (horizontal alignment) - curves, lack of overtaking opportunities, narrow lanes and bridges, or excessive width in residential streets (encouraging excessive speed)
- clear zones - the provision of non-hazardous avoidance space and turning space
- heavy vehicle field of view (forward)
- improved road shoulders - the provision of non-hazardous avoidance space
- driver fatigue control - means of preventing car drivers falling asleep
- intersection design - use of roundabouts
- occupant restraint usage - improved wearing of seat belts by heavy vehicle drivers, car drivers and passengers.

In implementing the results of the countermeasure analysis, it will be important to consider the potential cost effectiveness of each countermeasure. This is beyond the scope of the present paper.

INFLUENCE OF SIZE AND WEIGHT LIMITS

The effect on urban heavy vehicle safety of increasing truck size and weight limits is not clear cut. While this clearly would reduce the exposure of certain types of truck in the road system, many of the rigid trucks involved in urban crashes are below maximum weight limits in any case. In addition, there is clear evidence in the present study - especially in Melbourne - that heavy vehicle size (width and length), turning circle and swept path are factors in urban crashes. Thus the size and weight issue may need different treatment for the larger long-haul vehicles as distinct from the smaller delivery vehicles. Perhaps the larger vehicles need to become larger - or more productive - and the smaller vehicles need to become smaller.

CONCLUDING REMARKS

Urban truck crashes are relatively complex events and simple, cheap solutions are difficult to find. Investment in some of the more costly countermeasures may need to be considered, and research should be carried out to find more cost-effective countermeasures than are currently known. This research should include ITS technologies and means of improving and accommodating the capacities and behaviour of older - and younger - pedestrians and improving the design of crossings and signals to allow for these types of pedestrians.

ITS technologies have the potential to assist with some of the human issues and to augment possible driver education and training initiatives. In-vehicle indicators of red signals may reduce the current significant incidence of running the red light by both car and heavy vehicle drivers. In-vehicle pedestrian presence detectors would play a role in reducing pedestrian fatalities. Truck stability warnings, route guidance and emergency advice should all improve urban truck safety. Dynamically-interactive signals for heavy vehicles are a lesser-known quantity, but should be the subject of research which could have a substantial payoff in reducing urban heavy vehicle crashes.

Potential countermeasures also lie in improved performance of all the human players and in providing improved infrastructure to allow for transit of the larger classes of heavy vehicle and for access of the smaller classes of heavy vehicle. Education and training of road users should encompass car drivers and passengers, pedestrians, heavy vehicle drivers (including both trucks and buses), motorcyclists and bicyclists and should take into account the interactions which occur between all these participants in the urban road transport system and which influence the occurrence of serious urban heavy vehicle crashes.

The significant role of the design and maintenance of the heavy vehicle is reflected in the following contributions to the occurrence and severe consequences of crashes:

- poor field of view from the heavy vehicle
- lack of side under-run protection and unguarded wheel areas
- the sheer length and width of heavy vehicles
- the width of the swept path of heavy vehicles (the tendency of the rear wheels to track inboard of the front wheels in turns)
- high structural stiffness of the rear of heavy vehicles
- older vehicles, with a higher probability of maintenance-related defects
- instability
- lack of rear under-run protection

- the size of the minimum wall-to-wall turning circle which may be negotiated by heavy vehicles
- heavy vehicle braking performance
- high structural stiffness of the side of heavy vehicles
- high structural stiffness of the front of heavy vehicles and lack of front under-run protection.

In addition, the following heavy vehicle factors were involved in individual cases: conspicuity, lack of visibility of turning signals, lack of turning vehicle signs, bullbar aggressivity, tire failure, vehicle unroadworthiness and lack of load security.

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DISCLAIMER

This paper presents the views of the authors, and not necessarily those of the Federal Office of Road Safety.

APPENDIX

Summary of contributory factors considered in post-crash database

Ref #	Category	Factor
1	TRUCK DRIVER STATES	alcohol, drugs
2		ill health
3		inexperience
4		attitude - adversely affecting behaviour
5		running signals
9	TRUCK DRIVER BEHAVIOURS	excess speed - for the conditions
10		slow speed
11		aggressive behaviour
12		inappropriate evasive action
13		no avoidance
14		inattention
15		close following
16		disregard of traffic control
17		hit and run
18		asleep - probably due to fatigue
19		braking, no steering avoidance
22		insufficient gap
23		deviation from norm
25	CAR/MOTOR CYCLE DRIVER STATES	alcohol, drugs
26		ill health
27		inexperience
28		attitude - adversely affecting behaviour
29		running signals
32	CAR/MOTOR CYCLE DRIVER BEHAVIOURS	excessive speed
33		slow speed
34		aggressive behaviour
35		irresponsible behaviour
36		inappropriate behaviour
37		no avoidance
38		inattention
40		view obstruction - by heavy vehicle
41		close following
42		disregard of traffic control
43		hit and run
44		asleep - probably due to fatigue
45		insufficient gap
48	PEDESTRIAN/CYCLIST STATES	alcohol, drugs
49		ill health
50		inexperience
51		attitude - adversely affecting behaviour
52		conspicuity - lack of
53		suicide
54		age - lack of mobility
55		youth - affecting judgement
56	PEDESTRIAN/CYCLIST BEHAVIOUR	disregard of traffic control
57		inappropriate behaviour
58		insufficient gap
59		misread signal
62	TRAFFIC INTERACTION	impeded visibility
63		braking incompatibility - car/truck
64		mis-anticipation
65		signal clearance time
66		traffic congestion
71		intersection clearance time
84		swept path - offtracking at rear
85		structural stiffness - front
86		structural stiffness - side
87		structural stiffness - rear
88		visibility of turning signals
89		spray
90		vehicle age - affecting mechanical condition
91		truck-trailer gap
92		turning vehicle signs
95	CARS AND MOTORCYCLES	brakes
73	HEAVY VEHICLES	load security
74		brakes
75		instability
76		field of view - lack of
77		conspicuity - lack of
78		under-run into rear
79		under-run into side
80		under-run into front
81		unguarded wheel areas
82		vehicle size - length or width
83		turning circle - wall-to-wall
96		conspicuity
97		vehicle age - affecting mechanical condition
98		visibility of signals
101	ROAD/TRAFFIC	friction
102		roughness
103		roadside objects
104		delineation
105		traffic control
106		alignment
107		sight distance
108		geometric standard
109		channelisation
110		roadworks
111		shoulder
112		tram tracks
113		traffic diversion
114		no U-turn provision
124	ENVIRONMENT	rain
125		natural light
126		street lighting
127		object on road
128		glare

Summary of countermeasures considered in post-crash database

Ref #	*Countermeasure Description*		
	Category	**Description**	
1	VEHICLES	reduced frontal aggressivity	-removal of bullbar
2		reduced frontal aggressivity	-improved front bumpers
3		reduced frontal aggressivity	-front underride protection
4		reduced side aggressivity	-side under-run protection
5		reduced rear aggressivity	-rear under-run protection
6		improved cabin crashworthiness	
7		improved truck braking	-brake maintenance
8		improved truck braking	-brake balance
9		improved truck braking	-ABS
10		improved truck stability	
11		reduced truck dimensions	
12		improved maneuverability	-improved turning circle
13		improved maneuverability	-reduced offtracking
14		heavy vehicle conspicuity	-daytime running lamps
15		spray suppression	
16		load security	
17		heavy vehicle inspection	
18		heavy vehicle field of view	-forward
19		heavy vehicle field of view	-nearside
20		heavy vehicle field of view	-offside
21		heavy vehicle field of view	-rear
22		vehicle recorders	
23		car crashworthiness	
24		car braking/stability	
25		motorcycle conspicuity	
26		motorcycle maintenance	
27		motorcycle braking	
28		motorcycle stability	
31	ROADS & TRAFFIC	divided road	
32		intersection design	-number of legs
33		intersection design	-angle
34		intersection design	-sight distance
35		intersection design	-channelisation
36		intersection design	-lane width
37		intersection design	-approach speed
38		road geometry	-horizontal alignment
39		road geometry	-vertical alignment
40		traffic engineering black spot treatment	
41		road engineer education	
42		improved delineation	
43		improved road shoulders	
44		rumble strips	
45	ROADS & TRAFFIC (CONT.)	improved sight distance	
46		clear zones	
47		roadside guard fences	
48		roadwork practices	
49		pavement skid resistance	
50		road culvert protection	
51		overtaking lanes	
52		rest areas	
53		pavement quality	
54		street lighting	
55		pedestrian crossing	
56		signal phases	-truck
57		signal phases	-pedestrian
58		controlled turn	-right
59		controlled turn	-left
60		stop line position	
61		truck routes	
62		ITS technology	
63		novel delineation devices	
66	ROAD USERS	education and training	
67		driver licensing, demerits	
68		fatigue control	
69		medical examination	
70		occupant restraint usage	
71		pedestrian conspicuity	
72		pedestrian mobility	
73		pedestrian incapacity	
76	HEAVY VEHICLE DRIVERS	seat belt wearing	
77		defensive driving training	
78		fatigue detection	
79		attitude improvement	
80		controlled driving hours	
81		driving skills	
82		driver record accessibility	
83		medical examination	
86	TRANSPORT POLICY	increased payload	
87		modal diversion (to rail)	
88		operator licensing	
89		crash research	
92	ENFORCEMENT	electronic enforcement of speed, alcohol	
93		enforcement at black spots	
94		speed limiters, tachographs	