TAC ATC

Boulevard Transportation Group

synectics
SAFETY SPECIALISTS

Transportation Association of Canada

Study on the Safe Accommodation of Vulnerable Road Users and Commercial Motor Vehicles in Urban Areas

June 12, 2009

File: 764

ACKNOWLEDGEMENTS

This report was made possible with funding provided by several agencies, namely:

City of Ottawa
Quebec Ministry of Transportation
City of Toronto
Translink
Transport Canada
City of Vancouver
City of Winnipeg

PROJECT STEERING COMMITTEE

This report was researched, written, and edited by representatives of Boulevard Transportation Group Ltd. and Synectics Inc. The work is a result of a collaborative effort of volunteers and professionals.

The authors would like to thank the TAC project steering committee members for providing guidance and suggestions in the development of this document.

Chair	Daniel Egan City of Toronto	Jerry Thomas City of Ottawa
	Leanna Belluz Transport Canada	David Tomlinson City of Toronto
	Gavin Davidson Translink	Joe Walls City of Vancouver
	Luis Escobar City of Winnipeg	
	Francois Janelle Quebec Ministry of Transportation	

Project Managers

Katarina Cvetkovic and Martin Rochon

Transportation Association of Canada

Project Consultants

Mike Skene

Boulevard Transportation Group

Mitchell Jacobson, M.Sc.,EIT

Boulevard Transportation Group

Greg Junnor

Synectics Inc

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Collisions between vulnerable road users (VRU's) and commercial motor vehicles (CMV's) in urban areas are a concern due to the potentially severe nature of these collisions, despite the low frequency of these incidences. There is, however, a deficiency in understanding the nature and characteristics of these collisions. This study was therefore conducted in order to: 1) identify factors that contribute to the occurrence and severity of collisions between CMVs and VRU's in urban areas; 2) identify practices that have been used to address factors that contribute to collisions involving CMV's and VRU's, and discuss their effectiveness, and 3) identify further studies that are needed to address problems that contribute to collisions involving CMV's and VRU's in urban areas.

A literature was conducted at the outset of the study, which yielded the following key findings. Collisions between VRU's and CMV's are most common at intersections, with right-turn collisions being most prevalent. For non-intersection collisions, CMV's pass closer to cyclists than do other motor vehicles. Important truck design factors that influence safety are CMV driver blind spots, adequate lighting, and front-and-side truck design. Countermeasures identified that may improve the safety between CMV's and VRU's are under-run protection devices, impact areas with lower stiffness, side-trailer lighting improvements, pedestrian detection systems, improvements to driver mirror design, improved CMV cab design, improved geometry at intersections, and education campaigns.

An agency survey was conducted regarding the safety between VRU's and CMV's. The survey confirmed that there are a low number of incidents between VRU's and CMV's in urban areas. Nonetheless, the issue of safety between VRU's and CMV's was generally viewed as important. Overall, agencies identified the ranking of safety issues between VRU's and CMV's in the following order of importance: 1) road geometry, 2) road operations, 3) CMV characteristics, 4) CMV driver actions, 5) VRU characteristics, 6) VRU actions. Most agencies indicated that they would like guidance on safety issues between VRU's and CMV's if available.

A collision analysis was conducted as part of the study, with data from the City of Toronto, City of Ottawa, and City of Vancouver, in order to represent a cross section of urban Canadian conditions. The analysis was undertaken in two parts: a high-level analysis that investigated and established general trends, and a detailed analysis of the most important trends as identified in the high-level analysis. Key collision analysis findings are as follows.

There are somewhat more pedestrian / CMV collisions than cyclist / CMV collisions (20 percent more). The vast majority (95 percent) of collisions between VRU's and CMV's are non-fatal in

nature, for both cyclists and pedestrians. Despite this, VRU fatalities resulting from collisions with CMV's are a particular concern, since in terms of total VRU fatalities (considering all vehicle types) CMV's are frequently involved. For midblock collisions between cyclists and CMV's, limited width was often an associated factor, indicating that bike lanes and/or restricted parking may be a potential mitigation. CMV driver behaviour for midblock collisions was generally either poor lane change or fail to yield right-of-way, indicating that visibility or driver awareness enhancements could be of potential benefit. At intersections, adverse driver and cyclist behaviour were both commonly cited, and therefore education for these road users may be beneficial. Illegal behaviour on the part of VRU's was often cited as a potential contributing collision factor, which can result in severe incidences given CMV characteristics. Education and injury reduction techniques may therefore be of benefit. There were data limitations which reduced the ability to investigate collision characteristics and trends in detail, due to the low frequency of incidents, the inability to receive data due logistical or data privacy concerns, and a lack of some potentially relevant collision information on collision report forms. Because of these issues it may be more feasible to conduct this type of collision analysis at the municipal level.

Based on the study findings, the following recommendations are made for further investigation and/or improvement of the safety between VRU's and CMV's in urban areas.

Need for Education - Education of VRU's and CMV operators regarding safety issues between each other, and education of roadway designers, so that they are aware of, and consider, safety issues between VRU's and CMV's

Enhanced Collision Data Collection – (1) Standardization of the collision report form across jurisdictions, which would allow for more uniform cross-country analysis, and (2) Either modification of the police collision reporting form or a new form used only for collisions involving CMV's, to allow for explicit assessment of unique CMV factors

Further VRU / CMV Collision Data Research Approach - Any further detailed research into collisions between VRU's and CMV's should be undertaken at the municipal level, and to be done in a targeted for a specific crash type.

CMV Design & Characteristics Research - Investigation of techniques for improving driver awareness and reducing collision severity (e.g. larger mirrors, proximity sensor alarm systems, cameras, side guards, etc), including benefits, drawbacks, barriers to implementation, etc.

Roadway Geometry and Operations Research - Investigation into the effect of installing bicycle lanes along high CMV and cyclist volume corridors, potentially through a comparative analysis within a jurisdiction; investigation into the effects of prohibiting parking on high CMV and cyclist volume corridors; investigation of the effect of right turn channelization on the frequency of CMV/VRU collisions; investigation of the effect of protected left turn phasing on reducing the frequency of CMV/pedestrian collisions; and the investigation of methods for separating right-turning CMV's from through-movement pedestrians at an intersection.

1 INTRODUCTION

1.1 Background and Objectives

Motor vehicle collisions are a major public health concern, both in North America and around the world. The collisions between vulnerable road users (VRU's) and commercial motor vehicles (CMV's) in urban areas are of particular concern, due to the potentially severe nature of these collisions. There is a deficiency in understanding the nature and characteristics of these collisions, however, as these types of collisions are infrequent as compared to the total number of vehicle collisions.

The objectives of the study are to:

- identify factors that contribute to the occurrence and severity of collisions between CMVs and VRU's in urban areas.
- identify practices that have been used to address factors that contribute to collisions involving CMV's and VRU's, and discuss their effectiveness.
- identify further studies that are needed to address problems that contribute to collisions involving CMV's and VRU's in urban areas

This study is Phase 1 of a potential two-phase project, whereby Phase 2 would address issues which contribute to collisions between VRU's and CMV's but for which no countermeasures have been identified and/or evaluated.

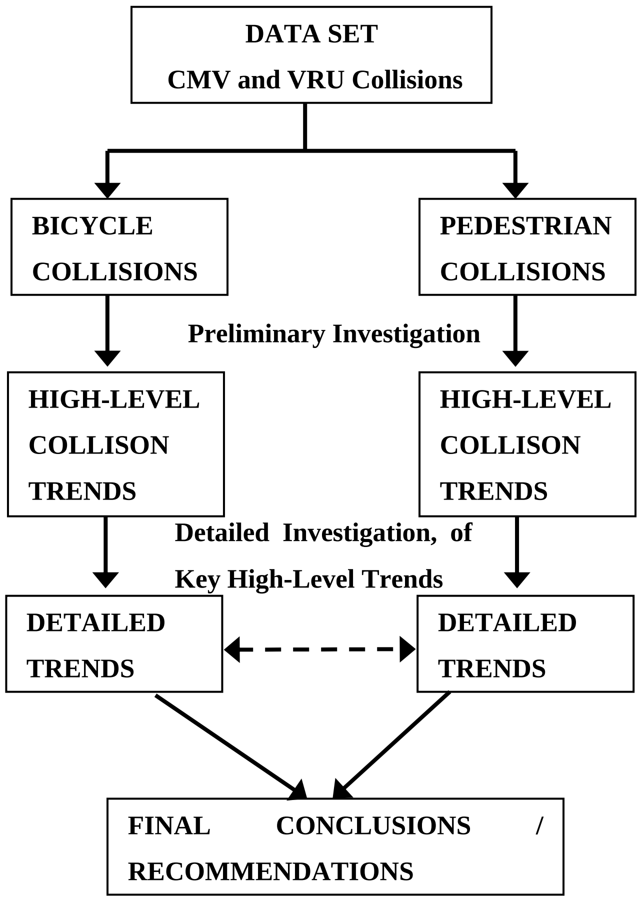
1.2 Report Content

The report consists of the following:

- A literature review of the nature of collisions between VRU's and CMV's, countermeasures and relevant legislation
- A survey of TAC agency members as well as other organisations for which these issues are relevant
- A high-level collision investigation, identifying general characteristics of CMV/VRU collisions
- A detailed collision investigation examining possible contributing factors for selected crash types, along with conclusions and potential mitigation recommendations
- Conclusions and recommendations

1.3 Collision Analysis Approach

The following flow chart illustrates the collision analysis approach taken for this study. At the outset, the collisions were separated into either CMV – bicycle collisions or CMV – pedestrian collisions, since the characteristics of these road users differ materially in terms of operational characteristics and locations found within the roadway cross section. These collisions were then investigated in terms of high level overview, to establish any key trends. Based on this preliminary review, detailed trends were investigated for selected crash types, from which final conclusions and recommendations were made.



2 LITERATURE REVIEW

This literature review was undertaken to gain an understanding of the nature of collisions between VRU's and CMV's in urban areas in terms of occurrence, severity, contributing factors, and recommended countermeasures. The review also investigates relevant legislation pertaining to CMV and VRU safety. In this report, vulnerable road users are taken as those road users which are exposed without a protective vehicle frame that travel at sub-motor vehicle speeds, such as pedestrians, cyclists, and wheelchair users. Commercial motor vehicles are defined as those vehicles larger than cars and pick-up trucks, such as single unit trucks, multi-trailer trucks, and buses.

2.1 Literature Sources

An extensive literature review was conducted on the subject, whereby a number of databases and sources were investigated for relevant literature. These sources include the following:

- TRIS Online
- CARSP-CMRSC Conference Proceedings
- Enhanced Safety of Automobiles Conference Proceedings
- ITE Journal
- Google Scholar Search

The literature search found a large number of resources on VRU safety issues and CMV safety issues individually, but only a limited number of resources considering the safety issues involving both.

2.2 CMV and VRU Collision Occurrence and Severity

A limited number of literature sources were found that contained statistics on the number of collisions between VRU's and CMV's in urban areas. Goodno (2004) found that for the period from 2000 to 2002, 2.1 percent of cyclist collisions in Washington D.C. involved large trucks, and 1.3 percent involved buses. In the state of Victoria, Australia, it was found that for the period from 1996 to 2000 that of the total number killed in large truck crashes, 9 percent were pedestrians and 4 percent were cyclists. This includes, however, both urban and rural statistics (Haworth & Symmons, 2003).

In terms of severity, it was found by Akiyama (2003) that for collisions involving large trucks in Japan, the majority of collisions were injury collisions for both pedestrian and cyclist collisions. The graphical nature of the presented data suggested that the total number of CMV collisions involving pedestrians and cyclists was similar, but that there were more fatal pedestrian collisions than cyclist collisions.

It was found that there are differences in VRU and CMV collisions for urban centres in different parts of the world. Yang & Otte (2007) found that in Changsha, China, 25 percent of pedestrian collisions involved trucks and buses, while in Hannover, Germany, less than 10 percent of pedestrian collisions involved trucks and buses.

The Organisation for Economic Co-Operation and Development (OECD, 1998) investigated the safety of vulnerable road users in OECD member countries. As part of the review, pedestrian and cyclist collisions were summarized by VRU injury severity (fatalities, serious injuries, slight injuries) as a percentage of motor vehicle type, for each of five countries (Denmark, Finland, Great Britain, Netherlands, and Sweden). Of note was that truck collisions were a higher percent of fatal collisions than for non-fatal collisions, for both cyclists and pedestrians, which may indicate that truck collisions can be particularly severe for vulnerable road users.

2.3 Collision Locations

The review found that in many cases the available literature was deficient in location-specific information. For example, Haworth and Symmons have totals for pedestrian-involved truck collisions by truck type (rigid, articulated, or truck) and by urban versus rural (2003). They do not, however, have any more specific statistics regarding more specific location descriptions.

2.3.1 Intersection Collisions

Nonetheless, it has been found that for fatal pedestrian collisions involving large trucks, they were more likely to occur, as compared to other vehicle collisions, at intersections than mid-block, at signalized intersections, occur during daylight hours, and to involve older pedestrians (Retting, 1993).

It was found by Akiyama (2003) that in Japan a majority of pedestrian fatalities and injuries from CMV collisions occurred at intersections, and that a majority of the fatal collisions occurred at night (although the majority of CMV and pedestrian collisions occurred in the day). Most of the daytime collisions were injury collisions. It was also found that most CMV collisions with cyclists occurred at intersections.

2.3.2 Right Turn Collisions at Intersections

Right turn collisions between large trucks and cyclists have been identified as a specific collision risk (in areas of right-side driving). This is where a truck is turning right, and either turns right into a cyclist, or is in the process of turning right and a cyclist collides with the CMV. These types of collisions were identified as particularly severe in the Netherlands, where an estimated 30 to 40 fatalities and 100 serious injuries happed per year, where right turning trucks collided with cyclists at intersections (Oxley et al, 2003)

Niewoehner and Berg (2005) reported that these collisions can in part occur because cyclists can approach alongside an CMV, whilst riding in the CMV driver's blind spot. Thus one of the causes of these collisions is limitations of CMV driver sightlines, in part from driver height in the CMV which results in both front and rear blind spots. Detailed geometric attributes of these types of conflicts were assessed by Niewoehner.

2.3.3 Non-Intersection Collisions

One type of non-intersection collision identified between VRU's and CMV's was collisions involving drivers overtaking cyclists. Walker (2007) found that buses and large trucks often pass nearer to cyclists than do other vehicle types, and that this can result in increased collision risk. It was surmised, however, that this was a result of the vehicle characteristics, whereby the weight of these vehicles results in slower acceleration and hence more difficulty in lane changing to provide extra separation from cyclists.

2.4 CMV Design and Safety

2.4.1 CMV Driver Blind Spots

Blind spots have been identified as a fundamental cause of conflicts between trucks and VRU's. This is a result of truck geometry which raises a driver's seat and eye level, as well as expanded blind spots due to the obstructions resulting from CMV trailers. Research conducted by Retting (2003) noted that, for fatal pedestrian collisions involving large trucks at intersections, truck cab design obstructed truck driver visibility, which appeared to be a major contributing factor for these collisions. CMV blind spots were also identified as the key factor for conflicts that arise between CMV's and cyclists (Niewoehner, 2005).

2.4.2 Lighting of CMV's

The lighting conditions at night were identified as an important consideration in CMV and pedestrian collision safety. A study by Olejnik (2007) found that semi-trailer side-lighting could improve the visibility of pedestrians, and thereby potentially improve safety for truck-turning manoeuvres.

2.4.3 CMV Impact Locations

There has been research into CMV design components as they relate to VRU injury severity. Under-run protection devices on trucks have been identified as a potential means of reducing the severity of CMV collisions with pedestrians. It was identified that reductions in fatalities and in injury severity can be reduced by improved frontal and side truck design (that reduces impact and or potential for under-run collisions) are estimated at 20 percent reduction in pedestrian fatalities and a greater than 25 percent reduction in injury severity for injury collisions (Haworth & Symmons, 2003).

Computer modelling of pedestrian collisions with trucks and buses was undertaken by Chawla et al (2000), for vehicle speeds between 15 km/h to 45 km/h, based on India design parameters. Their research found that front bumpers could be made less stiff, which would, at least theoretically, improve the safety for pedestrians for collisions at 35 km/h or less.

Computer modelling for throw distances between bikes and buses in front-bumper collisions was undertaken by Mukherjee et al (2006), which found that the flat front design of buses leads to shorter throw-distances as compared to cars or SUV's.

Walz et al (1990) investigated collisions between large trucks and unprotected road users, based on Swiss collision data from 1984 to 1986. Collisions were totalled by truck-location, based on the total number by VRU either the front, right, left, or rear of the truck, and by mean impact severity scale for each of the four truck locations. For pedestrian and truck collisions it was found that the majority of collisions were with the front of the truck, with a lesser number with the right and rear of the truck (and none on the left side of the truck). In terms of severity, the front and rear collisions had a high mean injury severity scale value (27 and 35 respectively), while the side collisions had a lower mean severity (severity of 8). It was also found that the most common location for cyclist collisions was the front of trucks, followed by right side collisions, then left and rear side collisions. In terms of severity, left-side collisions had the highest cyclist severity (15), with front, right, and rear having lower mean severities (7, 8, and 4 respectively).

The Walz study also categorized accident impact severity (AIS) for VRU's, by specific injury location, for both cyclists and pedestrians. This report recommended flat side guard panels for large trucks, to minimize the potential severity of side vehicle collisions with vulnerable road users.

Riley et al (1985) investigated designs for truck underrun guards and sideguards. Various device designs were physically tested, to assess the safety performance of different design characteristics. The sideguard devices were tested in collisions against a dummy and bicycle, where the run-over incidents and "probably fatal" incidents were catalogued for different ground clearance distances of the sideguard.

2.5 Countermeasures

A recommended area of emphasis in improving safety between pedestrians and trucks was for separating pedestrians and trucks at intersections and on designing truck cabs to improve driver visibility (Retting, 1993).

It has been suggested that CMV's should have large front and side mirrors to improve safety, that driver assistance technology could be used to ease the CMV driver task, that geometric design at intersections (specifically, advanced stop-bars for cyclists so as to not be placed in the CMV blind spot), and that education campaigns can help improve the safety between CMV's and cyclists (Niewoehner, 2005). CMV driver education was also identified as a means of reducing collisions for CMV's overtaking cyclists (Walker, 2007).

Akiyama (2003) suggests pedestrian detection systems and energy-absorbing body structures for trucks to help address safety concerns. For cyclist and CMV collisions, Akiyama suggests vision aides and rear alarms could be used, and that tire guards and possibly an automatic braking system could be used.

Also, as identified in Section 2.4, under-run protection devices have been identified as a possible vehicular countermeasure (and specifically to be designed with lower stiffness), as well as side-trailer lighting.

2.6 Legislative Issues

The review of legislative issues pertaining to issues involving CMV's and VRU's was undertaken as part of the literature search. The search, however, only found a few relevant documents regarding legislation involving both CMV's and VRU's, regarding CMV design.

The United Nations has adopted Regulation No. 73, "Uniform Provisions Concerning the Approval of Goods Vehicles, Trailers and Semi-Trailers with Regard to their Lateral Protection" (United Nations, 1988). This Regulation outlines construction or equipment requirements for these vehicle types such that they offer effective protection for unprotected road users (cyclists, pedestrians, or motor cyclists) against the risk of falling under the large vehicle and being caught under the wheels. The Regulation outlines technical specifications for design (including dimensions and smoothness). This Regulation has been ratified by a number of European countries. Similar lateral protection design legislation was not found for Canada or the United States.

In Canada, Transport Canada Technical Standards Document Number 131, "School Bus Pedestrian Safety Devices" provides a regulation for a stop arm signal for school buses (Transport Canada, 1999). The purpose is to reduce the number of injuries and deaths of pedestrians at school buses by minimizing the likelihood of vehicles passing a stopped school bus and striking a pedestrian. Strictly speaking, this safety measure is not primarily intended to minimize collisions between a stopped school bus and a vulnerable road user, but does address collisions that could potentially occur as a result of an CMV. This document provides technical requirements such as size and placement for the stop arm.

2.7 Literature Review Conclusions

The following conclusions are made based on this literature review. While there is much research into VRU and CMV safety issues individually, there were few resources found as part of this review that considered the safety between VRU's and CMV's. Estimates on the number of VRU fatalities as a total number of CMV-based fatalities are in the range of 9 percent of fatalities being pedestrians and 3 to 4 percent being cyclists (Australia and Japan), and as such there are more pedestrian fatalities involving CMV's than cyclist fatalities. However, the total number of pedestrian and cyclist collisions (i.e. fatal plus injury collisions) involving CMV's was found to be similar. There are, however, differences between cities in different parts of the world, with more CMV's involved with pedestrian collisions in Changsha China than in Hannover Germany.

For collision locations, VRU and CMV collisions tend to occur more frequently at intersection locations than non-intersection locations, and that right-turn collisions at intersections are of particular interest. For non-intersection collisions, large trucks and buses were found to pass closer to cyclists than other vehicle types during overtaking, which may increase the collision risk. In terms of truck design CMV driver blind spots, adequate lighting, and front-and-side truck design are all important factors influencing the safety of VRU's in collision scenarios.

Countermeasures identified that may improve the safety of CMV's and VRU's were under-run protection devices, impact areas with lower stiffness, side-trailer lighting improvements, pedestrian detection systems, improvements to driver mirror design, improved CMV cab design, improved geometry at intersections, and education campaigns. There is legislation in some European countries in regards to lateral protection devices, but no specific VRU protection device legislation was found for Canada or the United States.

3 SURVEY

3.1 Survey Overview

A web-based survey was undertaken to garner feeback regarding issues associated with safety between VRU's and CMV's in urban areas, with the survey being distributed to TAC agency members as well as other organisations for which these issues are relevant (such as trucking associations, safety researchers, and vulnerable road user groups). Nine questions were asked as part of the survey and was available in both English and French language versions.

The survey questions fell into five categories:

- General
- Safety Issues / Factors
- Design and Safety Strategies
- Collision Statistics / Research
- TAC Study Facilitation

In total, 58 English surveys and 3 French surveys were received. The survey can be found in Appendix A.

3.2 Survey Results

3.2.1 General

Respondents were asked to identify which type of agency they were representing; the summary is shown in Table 3.1. Types of Agencies listed in the "Other" category were trucking association, auto insurance company, safety departments, and planning organizations.

Table 3.1 Type of Agency:

Road Authority	63.8%
Safety or Research Organization	3.4%
Commercial Vehicle Operations	19.0%
Pedestrian / Cyclist Organization	0.0%
Other	13.8%

Respondents were asked to rate the importance of VRU and CMV safety issues to their agency. The results are shown in Table 3.2.

Table 3.2 Importance of VRU and CMV Safety Issues to your Agency:

Very Important	48.3%
Somewhat Important	43.1%
Somewhat Unimportant	6.9%
Not at All Important	0.0%
Not Applicable	1.7%

Those who responded that these issues were important were also asked to indicate how that importance was realized in the agency (i.e. policies, research, actions, improvements, design standards, etc). Forty (40) answers were given to that follow-up question, where some of the answers were:

- CMV driver training
- Speed limiters for CMV's
- Establishment of truck routes and/or truck-restricted areas
- Pedestrian & cyclist facility provision (e.g. sidewalks, paths, pedestrian count-down signals)
- Using TAC design guidelines
- Collision reduction strategies
- Collision reduction benchmarks
- Collision research studies
- Public education

3.2.2 Safety Issues / Factors

Respondents were asked to rank the issues of Road Geometry, Road Operations, CMV Characteristics, CMV Driver Actions, VRU Characteristics, and VRU Actions from 1 (most important) to 6 (least important) in terms of importance to the safety between CMV's and VRU's. Respondents were also asked to identify any other contributing safety issues that they felt were important. The results are shown in Table 3.3.

Table 3.3 Importance of Specific Safety Issues / Factors (frequency of times cited)

Answer Options	Level of Importance					
	#1	#2	#3	#4	#5	#6
Road Geometry	32	7	8	7	5	3
Road Operations	12	22	11	6	4	6
CMV Characteristics	9	6	12	9	12	12
CMV Driver Actions	17	12	10	10	6	6
VRU Characteristics	9	10	5	9	17	10
VRU Actions	10	14	11	5	13	8

There was no overwhelming consensus in the results in terms of a "most important" and "least important" feature, as each category was identified more than once in each weighting range. Nonetheless, the following trends were found:

- Road geometry was identified most often as the most important safety consideration, with almost double the amount as the next closest factor (CMV driver action)
- The second most important factor was most frequently identified as road operations
- All of the factors were identified relatively equally in terms of being third or fourth most important.
- The least important characteristics were most frequently identified as CMV Characteristics, VRU Characteristics, and VRU actions

Other factors identified that may contribute to the safety issues between VRU's and CMV's in urban areas were identified by 19 respondents, with specific newly-raised issues consisting of land use, recognition of road right-of-way, environment / weather / road maintenance, lighting, and parking. Other specific items can be found in Appendix B.

3.2.3 Design and Safety Strategies

The question of whether VRU and CMV conflicts are a specific design consideration was asked and yielded the results, shown in Table 3.4.

Table 3.4 - Are VRU and CMV safety conflicts an explicit consideration in roadway designs for your agency?

Yes	33.9%
No	45.8%
Not Applicable	20.3%

Examples of specific design considerations were:

- Designated Truck Routes
- Corner radius considerations
- Right of Way acquisition (e.g. future bike lane or sidewalks)
- Sidewalk and curb ramps designed with consideration for VRU's.

When asked whether the agency would be interested in changing design parameters if VRU/CMV safety benefits become apparent through research, it was found that the majority of respondents would be willing to do so. The results are shown in Table 3.5

Table 3.5 - Would you be interested in changing design parameters if VRU/CMV safety benefits become apparent through research?

Yes	72.4%
No	6.9%
Not Applicable	20.7%

Some specific areas that were identified as being of potential greatest benefit were:

- How to provide for VRU's
- Urban areas with a high volume of pedestrians/cyclists
- Road design standards (e.g. Roads widths, turning radius, warrant for bike lane provision, signage & road markings)
- Methods of avoiding, reducing, and addressing potential conflicts and risk of injuries / fatalities for VRU's
- Standards for side-guards on City trucks.
- Establishing truck routes

Some caveats mentioned were:

- Would like to know the expected effectiveness of a treatment first (e.ge. if narrowing of roads are truly reduce number of injuries for VRU's)
- Assuming costs are not prohibitive.
- Depends on what changing design parameters looks like and the cost associated with changing design parameters. Will roads cost more to construct.
- Would like to know if those who can incorporate improved design parameters actually will.

3.2.4 Collision Statistics / Research

Three main questions were asked regarding collision statistics and research. The first question was in regards to whether the agency catalogued collisions between VRU's and CMV's. The following results were received, shown in Tables 3.6, 3.7, and 3.8.

Table 3.6 - Does your agency catalogue vulnerable road user collisions?

Yes	42.6%
No	48.1%
Not Applicable	9.3%

Table 3.7 - Does your agency catalogue commercial motor vehicle collisions?

Yes	53.7%
No	38.9%
Not Applicable	7.4%

Table 3.8 - Does your agency catalogue collisions between VRU's and CMV's in Urban areas?

Yes	37.5%
No	54.0%
Not Applicable	8.0%

For those that catalogued collisions between VRU's and CMV's, they were asked how readily available these collision statistics were (shown in Table 3.9).

Table 3.9 - How readily calculable is the data

Is regularly calculated for all VRU's	0.0%
Is regularly calculated by VRU type	0.0%
Is readily calculable	34.5%
Not readily calculable	65.5%

Four respondents provided the percent of annual collisions between VRU's and CMV's in their urban area, broken out by pedestrians and cyclists. Results are shown in Figure 10.

Table 3.10 - Percent of annual collisions between VRU's and CMV's in your urban area

Jurisdiction	CMV / VRU collisions (All VRU's):	% CMV / VRU collisions (Pedestrians):	% CMV / VRU collisions (Cyclists):
City of Toronto	0.07%	0.04%	0.03%
City of Waterloo	0.04%	0.01%	0.03%
BC MoT*	0.13%	0.07%	0.06%
Quebec Ministere des Transports	1.3%	0.9%	0.4%

*Note: the British Columbia Ministry of Transportation statistics are for large truck / VRU collisions on roads under their jurisdiction in urban areas.

As a portion of total intersection collisions, those between CMV's and VRU's form at most 1.3 percent to less than a tenth of a percent of total collisions. Of these, pedestrians and cyclists are relatively equally represented, although the frequency of pedestrian / CMV collisions is slightly higher in some jurisdictions.

For those jurisdictions which do not report CMV and VRU collisions, they were asked what the barriers to doing so were; the summary is shown in Table 3.11.

Table 3.11 - What factors preclude cataloguing collisions between VRU's and CMVs?

Data availability	36.4%
Not historically derived	21.2%
Low number of VRU and CMV incidents	24.2%
Viewed as not generally helpful	3.0%
Other (please specify)	39.4%

Outside of “Other”, data availability was the most cited factor, with not historically derived and low number of incidents also being mentioned. Only three percent of respondents identified the main factor being that the task would not generally be helpful. Some other factors identified were:

- The task is the mandate of other agency or jurisdiction (e.g. police)
- Manpower is a problem
- small community - numbers are small and known
- Difficult to extract CMV collisions from database.
- RCMP have stopped providing accident reports

Respondents were asked whether their agency has conducted any research into safety issues between VRU’s and CMV’s, and if so, what type of research. The following are the results, shown in Table 3.12.

Table 3.12 - Has the agency conducted research into safety issues between VRU’s and CMV’s?

Yes	11.1%
No	85.2%
Not Applicable	3.7%

Respondents were also asked to elaborate on the nature of their research; the results are shown in Table 3.13.

Table 3.13 - What type of research was conducted

collision statistics based research	50.0%
nature of collision impacts (e.g. trauma research, vehicle design vis a vis bodily harm, etc)	25.0%
human factors	12.5%
Other	12.5%

The final question was in regards to whether specific problem areas related to VRU and CMV safety have been identified in your urban area (shown in Table 3.14), and if so, whether any countermeasures have been put in place (and what type). Should any countermeasures have been put in place, respondents were asked if any follow up evaluation has been conducted and any successes realized.

Table 3.14 - Have any specific problems related to VRU and CMV safety been identified in your urban area?

Yes	18.5%
No	61.1%
Not Applicable	20.4%

For those identified areas, the following countermeasures were identified as being used:

- Truck turning prohibition
- Development of cycling trail
- Safety Improvement Program prioritization
- Enhanced enforcement of trucks (safety checks and overweight enforcement)
- Increased speed monitoring by police
- Cyclist user guide distributed to the VRU community
- VRU countermeasures installed (e.g. pedestrian signals, school area speed limits, traffic calming in neighbourhoods

In none of the cases of countermeasure implementation was follow-up monitoring conducted.

3.3 Survey Summary

The survey of TAC member agencies and other relevant organisations found the following results. Safety issues regarding the interaction of VRU's and CMV's was at least somewhat important to over 90 percent of respondents.

In terms of specific safety factors (for road geometry, road operations, CMV characteristics, CMV driver actions, VRU characteristics, and VRU actions), no clear consensus was found in terms of which items were most or least important, however road geometry was most often cited as being most important, road operations was most often cited as being second most important, and CMV characteristics, VRU characteristics, and VRU actions were most often cited as being the least important factors.

A majority of agencies do not explicitly consider conflicts between VRU's and CMV's as a specific design consideration, but most would be interested in changing design parameters to improve safety between VRU's and CMV's should benefits become apparent.

In terms of collision statistics and research, a majority of agencies catalogue CMV collision data, a minority of agencies catalogue VRU collision data, and fewer yet catalogue collisions between both CMV's and VRU's. Factors precluding the cataloguing of these collisions were most commonly cited as data availability, not historically derived, and low number of incidents between CMV's and VRU's.

For those agencies that do catalogue collisions between CMV's and VRU's, 35 percent are able to readily calculate collisions between VRU's and CMV's. As a percentage of total collisions, these collisions were found to range from 1.3 percent to 0.04 percent of all collisions, in various Canadian urban areas.

A few of the respondents (11 percent) have conducted research, most of which was collision statistics based, followed by nature of collision impacts and then human factors research.

A few jurisdictions indicated that specific CMV/VRU safety problems have been identified, and in some of those cases specific countermeasures had been employed (but no follow-up monitoring was conducted in any of the noted cases).

4 HIGH LEVEL COLLISION ANALYSIS

Collision data for collisions between CMV's and VRU's from Ottawa, Toronto, and Vancouver were used for this analysis. The Ottawa and Toronto data sets are comprised of police reports (with any confidential information blacked-out). The analysis approach was to first conduct a high-level analysis, from which any areas of interest and importance could be identified. For those characteristics of greatest interest, a detailed analysis was then conducted, to determine if any apparent causes or trends emerged which could expand upon the nature of collisions between CMV's and VRU's. To facilitate the detailed collision analysis, a collision typology was developed for this assignment.

The collision reports were effectively broken into one of two types: 1) cyclist collisions involving CMV's and 2) pedestrian collisions involving CMV's. Because the characteristics and operations of cyclists and pedestrians are in most instances quite different, they were, for a majority of the analysis, separately reviewed. Nonetheless, certain combined pedestrian / cyclist analysis was conducted at a high-level overview.

Note that the study was originally proposed to make use of collision data with collision diagrams from four urban area, however some jurisdictions were willing but unable to provide the required data due to limited data, logistical issues, or privacy issues. Transport Canada also provided a summary of Commercial Motor Vehicle collisions involving pedestrians and cyclists from the National Collision Database. This data was received too late to be incorporated into the high level analysis, however, it does provide a good snapshot of the national picture. For example, there are an average of 351 pedestrian-CMV collisions per year, including 27 collisions which result in pedestrian fatalities. There are half as many CMV collisions involving cyclists, an average of 166 cyclist-CMV collisions per year, including 8 cyclist fatalities. While the national collision pattern is generally consistent with pattern observed in the detailed analysis of the Toronto and Ottawa data there are some significant differences. For example, nationally there are twice as many pedestrian-CMV collisions as cyclist-CMV collisions; in Toronto and Ottawa there are only 20 percent fewer cyclist-CMV collisions in a similar time period. This may reflect a significantly higher cycling mode share in Canada's larger cities. The national data is summarized in Appendix D.

4.1 All VRU and CMV Collisions – High Level Analysis

4.1.1 VRU vs. CMV Collision Frequency by VRU Type

A comparison in the total frequency of collisions between CMV's and VRU's by VRU type (pedestrian or cyclist) was conducted, for collisions from the Ottawa and Toronto datasets. This was compared for the period from 2004 to 2006, which is the period for which these datasets overlap. For this three-year period, the number of cyclist-CMV collisions reported was 101, and the number of pedestrian-CMV collisions reported was 127. This gives a collision frequency of:

- Cyclist-CMV collisions (Toronto & Ottawa) – 33.7 collisions/yr
- Pedestrian-CMV collisions (Toronto & Ottawa) – 42.3 collisions/yr

Therefore, there are 20 percent fewer cyclist-CMV collisions than there are pedestrian-CMV collisions.

4.1.2 Intersection Collision Frequency

The collision datasets were reviewed in terms of intersection location to determine if any specific intersections experienced collisions between CMV's and VRU's on a frequent or recurring basis. A base threshold of three collisions was considered for establishing the list of most-frequent collision-prone intersections.

A review of the datasets found four intersections with three or more VRU / CMV collisions, all of which were in Ottawa. These were 1) Bank St. and Somerset St. (3 collisions; 1 bike, 2 pedestrian); Elgin St. and Slater St. (3 collisions; 2 bike, 1 pedestrian); Rideau St. and Cumberland St. (5 collisions; 2 bike, 3 pedestrian); and Rideau St. and King Edward Ave. (5 collisions; 1 bike, 4 pedestrian). Note that the Ottawa dataset covers a longer period of time than the Toronto dataset (2002 to 2007 vs. 2004 to 2006), and as such other intersections in other cities may emerge as meeting the three collision threshold if a longer timeframe is examined. In any case, the highest frequency locations (Rideau St. and King Edward Ave and Rideau St and Cumberland St.) had a frequency of 0.83 collisions/yr over six years. Some characteristics of note for these four intersections are shown in Table 4.1.

Of note:

- all intersections have approach legs with a posted speed limit of 50 km/h
- all of the roadways have at least one roadway with four lanes
- the intersection with the most collisions (Rideau St. and King Edward Ave.) has one roadway with six lanes, and the other with four lanes
- all of the roadways are designated truck routes except Bank St and the south leg of King Edward Ave

Table 4.1: Intersections with Three or More Collisions Between VRU's and CMV's, 2002-2007

Street 1	Street 2	Type of Collision	Street 1 Lanes	Street 1 Speed Limit	Street 2 Lanes	Street 2 Speed Limit
BANK ST	SOMERSET ST	BIKE	4	50	4	50
BANK ST	SOMERSET ST	PED				
BANK ST	SOMERSET ST	PED				
ELGIN ST	SLATER ST	BIKE	4	50	2	50
ELGIN ST	SLATER ST	BIKE				
ELGIN ST	SLATER ST	PED				
RIDEAU ST	CUMBERLAND ST	BIKE	4	50	2	50
RIDEAU ST	CUMBERLAND ST	BIKE				
RIDEAU ST	CUMBERLAND ST	PED				
RIDEAU ST	CUMBERLAND ST	PED				
RIDEAU ST	CUMBERLAND ST	PED				
RIDEAU ST	KING EDWARD AVE	BIKE	4	50	6	50
RIDEAU ST	KING EDWARD AVE	PED				
RIDEAU ST	KING EDWARD AVE	PED				
RIDEAU ST	KING EDWARD AVE	PED				
RIDEAU ST	KING EDWARD AVE	PED				

*All intersections are in Ottawa ON

4.2 Cyclist – CMV Collisions, High Level Analysis

The following is a summary of collisions between cyclists and CMV's for Ottawa and Toronto collisions. These datasets were merged as they are the same in format and available data fields. There was a total of 143 cyclist-CMV collisions in the combined dataset. Collision characteristics are investigated in terms of collision location, collision type, CMV vehicle characteristics, driver / cyclist characteristics, possible contributing factors, and incidence occurrence.

4.2.1 Collision Location – Cyclists and CMV's

The location of collisions between cyclists and CMV's was investigated, with the percent breakdown shown in the table below. Note that "intersection" collisions are differentiated into two categories: at-intersection (collisions directly at the intersection) and intersection-related (collisions directly upstream or downstream of an intersection that were judged to be a result of the intersection's presence).

Table 4.2: Collision Location, for CMV & Cyclist Collisions

Collision Location	Percent
Non Intersection	33.9%
Intersection Related	23.8%
At Intersection	31.5%
At/near private drive	9.5%
Other	1.2%

A majority of collisions were either at an intersection or were intersection related, with 56 percent of collisions. Of these, approximately half were at an intersection and half were intersection related. Non intersection collisions accounted for approximately one third of collisions, followed by driveway collisions at 10 percent. Therefore, collisions between cyclists and CMV's were most common at locations where two traffic streams intersect. A summary of the traffic control present for intersection collisions between cyclists and CMV's is shown below.

Table 4.3: Traffic Control Type at Intersections, for Collisions between CMV's and Cyclists

Traffic Control	Percent
Traffic Signal	66.3%
Stop sign	25.0%
Yield sign	1.1%
Pedestrian Crossover	1.1%
Traffic controller	1.1%
No Control	4.3%
Other	1.1%

For intersection collisions (either at the intersection or intersection related), a majority of almost two thirds occurred at a signalized intersection. Stop controlled intersections accounted for the next most common traffic control type with 25 percent of collisions, followed by all other traffic control types at 9 percent. Therefore signalized intersections are the most common location for intersection collisions between cyclists and CMV's. For the signalized intersection collisions, the controller was identified as "not functioning" or "missing/damaged" in three instances.

All of the recorded driveway collisions had no traffic control.

4.2.2 Collision Type – Cyclists & CMV's

A review of collisions by type was conducted, in consideration of impact type and of vehicle manoeuvres (for both CMV's and cyclists).

A summary of collisions between cyclists and CMV's by impact type is shown below, for all collisions in the Ottawa & Toronto dataset.

Table 4.4: Impact Type for Collisions between CMV's and Cyclists, for Collisions in All Locations

Impact Type – All Collisions	Percent
Approaching	3.0%
Angle	25.3%
Rear end	7.8%
Side swipe	29.5%
Turning movement	23.5%
Other	10.8%

Side swipe and angle collisions were the most common (30 and 25 percent respectively) followed by turning movement collisions (24 percent). Rear end accounted for 8 percent, and all others 14 percent.

In order to better understand where these impact types occur, the impact type was broken out by intersection / non-intersection locations. Non intersection collisions by impact type for cyclists and CMV's is shown below, followed by intersection collisions (broken out by intersection-related and at-intersection collisions).

Table 4.5: Impact Type for Collisions between CMV's and Cyclists, for Non-Intersection Collisions

Impact Type – Non Intersection Collisions	Percent
Approaching	3.6%
Angle	1.8%
Rear end	17.9%
Side swipe	46.4%
Turning movement	8.9%
Other	21.4%

For non-intersection collisions, sideswipe collisions are the most common with nearly 50 percent of the total. Rear end is the next most frequent at 18 percent, with turning movement, angle, approaching and others accounting for the remainder of collisions.

Table 4.6: Impact Type for Collisions between CMV's and Cyclists, for Intersection Collisions

Impact Type – Intersection Collisions	Intersection-Related, Percent	At Intersection, Percent	All Intersection Collisions, Percent
Approaching	5.0%	0%	2.2%
Angle	25.0%	52.8%	40.9%
Rear end	7.5%	0%	3.3%
Side swipe	25.0%	11.3%	17.2%
Turning movement	27.5%	34.0%	31.2%
Other	10.0%	1.9%	5.4%

For intersection collisions, there were some differences in the frequency of impact type for intersection-related and at-intersection collisions. For collisions at an intersection, a majority (53 percent) were angle impacts, followed by turning movement impacts (one third of the total) and side swipe impacts (11 percent). Intersection-related collisions, however, had approximately an equal number of angle, side-swipe, and turning movement impacts (approximately 25 percent in all cases). Intersection-related collisions also had other types of impacts recorded that were not in evidence for at-intersection collisions, namely rear end (8 percent), and approaching (5 percent) impacts.

Vehicle Manoeuvres

Vehicle manoeuvres associated with CMV's and cyclists in collisions involving both are shown below, for all collisions.

Table 4.7: Vehicle Manoeuvre for Collisions between CMV's and Cyclists, for All Collisions

Vehicle Manoeuvre (All Collisions)	CMV Manoeuvre - Percent	Cyclist Manoeuvre - Percent
Going Ahead	33.6%	68.5%
Slowing or stopping	1.4%	1.4%
Overtaking	5.0%	2.1%
Turning left	9.3%	5.6%
Turing right	23.6%	2.1%
Changing lanes	2.1%	0.7%
Stopped	10.0%	2.1%
Parked	1.4%	0%
Pulling away from shoulder or curb	0.7%	1.4%
Other / Unknown	12.9%	16.1%

It was found that a majority of cyclists were going straight ahead in collisions with CMV's, with 69 percent of all cyclists performing this manoeuvre. No other cyclist manoeuvre was recorded with a frequency exceeding 6 percent of the total (with the exception of other / unknown, with 16 percent of the total).

A greater range of manoeuvres was recorded for CMV's involved in collisions with cyclists; going ahead, turning right, stopped, and turning left were all represented by 34 percent, 24 percent, 10 percent and nine percent of incidences respectively. Therefore, it can be concluded that most cyclists involved in collisions with CMV's are going ahead, while CMV's are associated with a varied range of manoeuvres.

Vehicle Manoeuvres were also investigated for intersection collisions between CMV's and cyclists, with the results shown below.

Table 4.8: Vehicle Manoeuvre for Collisions between CMV's and Cyclists, for Intersection Collisions

Vehicle Manoeuvre (Intersection Collisions)	CMV Manoeuvre - Percent	Cyclist Manoeuvre - Percent
Going Ahead	26.9%	65.6%
Slowing or stopping	1.1%	2.2%
Overtaking	3.2%	3.2%
Turning left	9.7%	6.5%
Turing right	37.6%	3.2%
Changing lanes	1.1%	1.1%
Stopped	6.5%	3.2%
Parked	2.2%	
Pulling away from shoulder or curb	1.1%	1.1%
Other / Unknown	10.8%	14.0%

The results are similar to those for all collisions. For cyclists, a majority are going ahead (66 percent), followed distantly by left turns (7 percent) and all other manoeuvres, with less than 4 percent each. (Other / Unknown accounted for 14 percent of cyclist manoeuvres). For CMV's, going ahead, turning right, turning left and stopped remain the most frequent manoeuvres, however turning right was the most frequently recorded manoeuvre, at 38 percent of the total.

4.2.3 CMV Characteristics

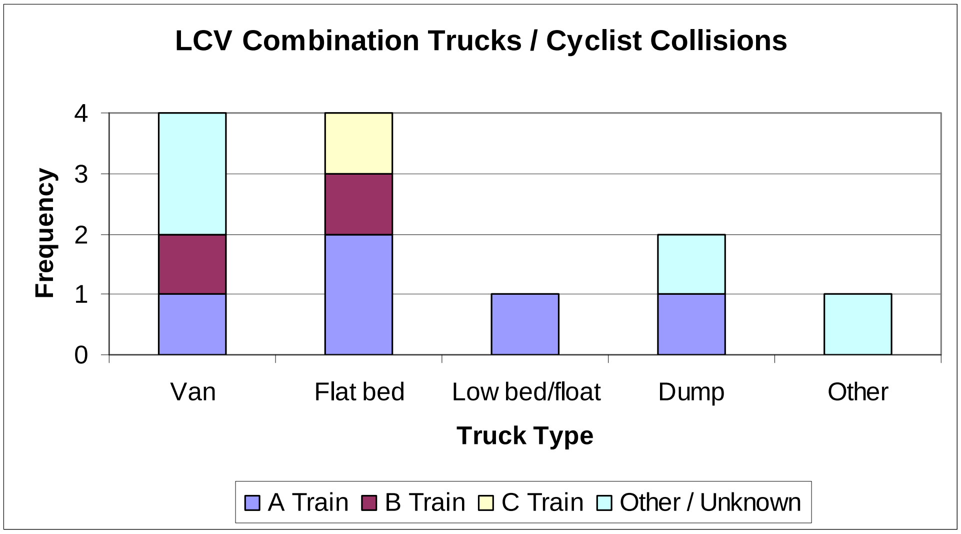
A summary of CMV characteristics for collisions between cyclists and CMV's is shown below, for all collisions in the Ottawa & Toronto dataset. Vehicle type (truck, bus, and other) is summarized, and more detailed truck details are investigated for truck/cyclist collisions.

Table 4.9: Vehicle Type

Vehicle Type	Vtot	Percent	
Truck - open	14	8.4%	47.3%
Truck - closed	44	26.3%	
Truck - tanker	3	1.8%	
Truck-dump	12	7.2%	
Truck - tractor	6	3.6%	
Municipal transit bus	25	15.0%	29.3%
Intercity bus	7	4.2%	
Bus (other)	10	6.0%	
School bus	7	4.2%	
Motor home	1	0.6%	23.4%
Farm tractor	3	1.8%	
Other / Unknown	35	21.0%	

Most of the CMV's involved in collisions with cyclists were trucks, followed by buses and then other vehicle types.

A total of 12 combination vehicles (or 7 percent of the CMV's) were identified in the datasets in terms of combination type and trailer connection type (A train, B train, C-train, or Other/ Unknown), for collisions with cyclists. A summary graph of these collisions is shown below. No obvious trend is evident, which may be due to the small sample size.



4.2.4 Driver / Cyclist Characteristics

Specific CMV driver and pedestrian characteristic information of age and gender was available for some but not all of the collision reports investigated. Therefore these characteristics were not examined (but could be investigated in the future to some extent).

4.2.5 Possible Contributing Factors

The datasets contained some information regarding possible contributing factors to collisions between cyclists and CMV's. Driver action (both CMV driver and cyclist), driver condition, and environmental conditions were investigated. Below is a table summarizing the actions as recorded by CMV drivers and cyclists in the datasets, for all of the cyclist-CMV collisions.

Table 4.10: Driver and Cyclist Action

Driver Action	Apparent CMV Driver Action - Percent	Apparent Cyclist Action - Percent
Driving Properly	46.3%	47.5%
Following too close	0%	1.3%
Exceeding speed limit	0%	0%
Speed too fast for condition	0%	0%
Speed too slow	0.6%	0%
Improper turn	8.8%	1.9%
Disobeyed traffic control	1.3%	6.9%
Failed to yield right-of-way	18.1%	10.6%
Improper passing	6.9%	3.1%
Lost control	1.3%	8.1%
Wrong way on one-way road	0%	1.3%
Improper lane change	2.5%	2.5%
Other	14.4%	16.9%

Nearly half of all cyclists and of all CMV drivers were identified as having driven properly.

A number of the potential contributing actions were found to be infrequent for both CMV drivers and cyclists (3 percent of cases or less). These were: following too close, exceeding speed limit, speed too fast for condition, speed too slow, wrong way on a one-way road, and improper lane change.

Of the remaining identified contributing actions, failing to yield right-of-way, improper turn, and improper passing were found to be most common for CMV drivers (at 18 percent, 9 percent, and 7 percent respectively), followed by other (15 percent). For cyclists, failing to yield right of way, disobeyed traffic control, and loss of control were most common (at 11 percent, 7 percent, and 8 percent respectively), followed by other (17 percent). The only "at-fault" factor to be somewhat common (i.e. found in more than 3 percent of cases) to both CMV drivers and cyclists was failing to yield right-of-way.

Driver Condition

Table 4.11: Driver and Cyclist Cognitive Condition

Driver / Cyclist Condition	CMV Driver Condition	Cyclist Condition
Normal	77.2%	70.3%
Impaired (Alcohol, drugs)	0%	6.7%
Inattentive	8.2%	7.9%
Other / Unknown	14.6%	15.2%

In terms of driver condition, a majority of both CMV drivers and cyclists were identified as "normal". Seven percent of cyclists were identified as impaired, while no CMV drivers were so identified. CMV drivers and cyclists were found to be inattentive in 8 percent of cases for both.

Environment Factors

Environment characteristics that may be relevant were investigated, in terms of weather, road surface condition, and lighting conditions.

Table 4.12: Weather Condition

Weather Condition	Percent
Clear	94.6%
Rain	3.6%
Snow	0.6%
Freezing Rain	1.2%

In the vast majority of cases, the weather was clear (95 percent of incidents) during collisions between cyclists and CMV's.

Table 4.13: Road Surface Condition

Road Surface Condition	Percent
Dry	89.6%
Wet	7.3%
Loose Snow	1.2%
Slush	1.2%
Ice	0.6%

Similar to the weather conditions, the road surface conditions were dry for the majority of incidents (90 percent). The surface was wet in 7 percent of instances, and snow, slush, or icy for the remainder of cases.

Table 4.14: Lighting Condition

Lighting	Percent
Daylight	87.5%
Dawn / Dusk	0.6%
Dark	9.1%
Other / Unknown	4.9%

Most of the collisions between cyclists and CMV's occurred during daylight conditions (88 percent), with 9 percent in dark conditions, 1 percent at dusk, and 5 percent unknown.

It can be concluded that most collisions between CMV's and cyclists occur during good environmental conditions, and therefore adverse weather conditions are not the cause of most of these types of collisions. Wet and/or dark conditions may however be a mitigating factor in a limited number of instances.

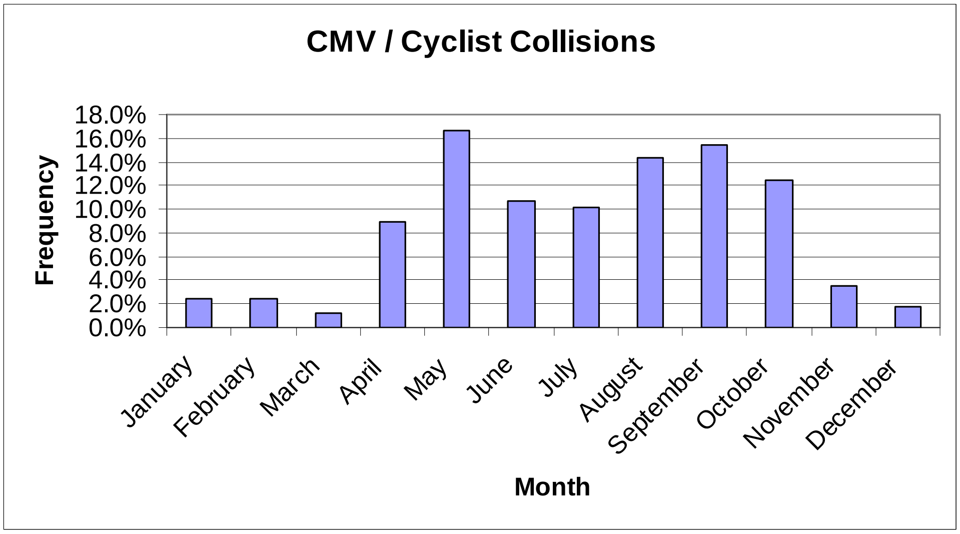
4.2.6 Incident Occurrence

Incident occurrence characteristics were investigated, in terms of collision classification and incident occurrence timeframe (month, day of week, time of day).

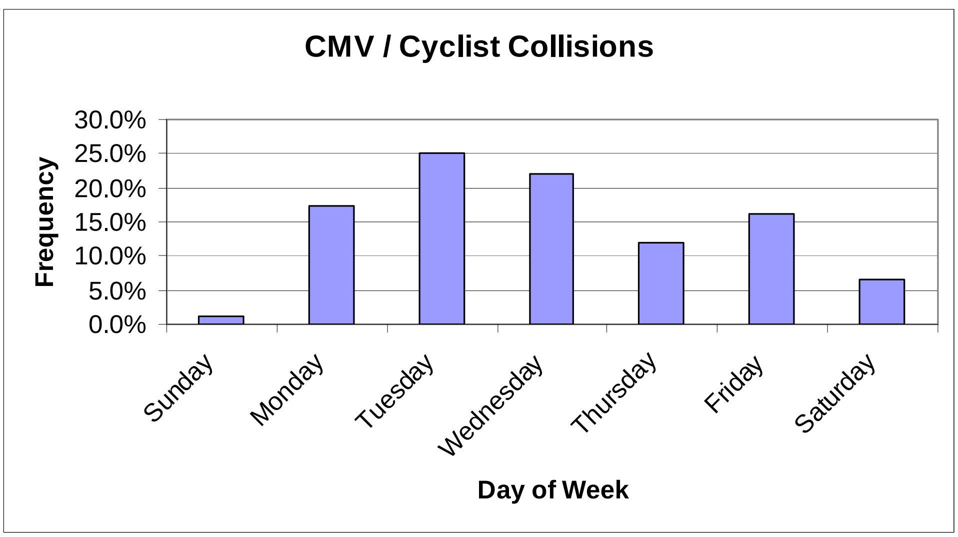
Table 4.15: Collision Classification

Collision Classification – CMV & Cyclist Collisions	Percent
Fatal Injury	4.9%
Non-fatal injury	76.9%
Property damage only	18.2%

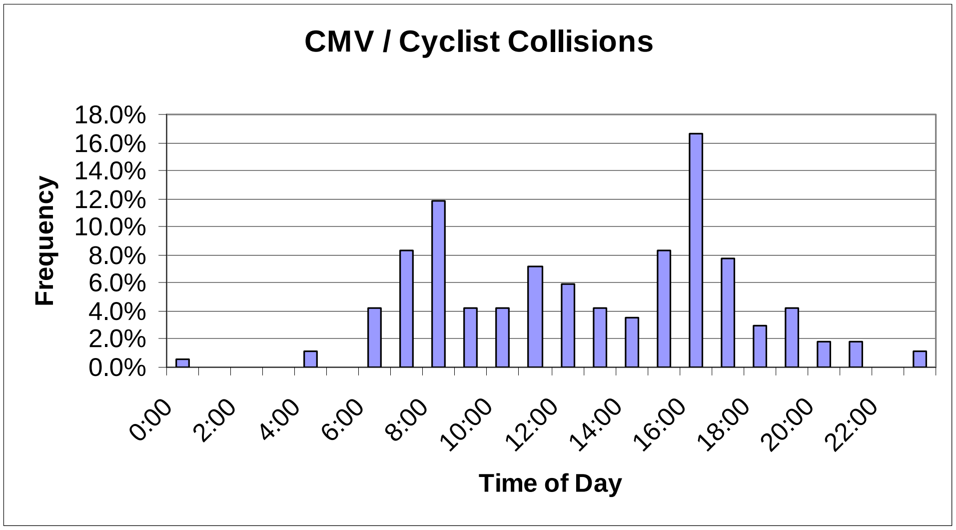
A majority of recorded collisions between cyclists and CMV's resulted in a non-fatal injury (77 percent), with 5 percent resulting in a fatal injury and 18 percent as property damage only. Therefore, most of these types of collisions result in injury to the cyclist, with a small percentage being fatal collisions.



Most collisions between cyclists and CMV's occur between April and October (in Toronto and Ottawa). This is perhaps to be expected, as there are more cyclists during those snow-free and warmer months.



In terms of day-of-week, most cyclist / CMV collisions occur on weekdays, with Monday, Tuesday, Wednesday, and Friday having the greatest frequency of collisions.



In terms of time of day, there is a frequency peak at 16:00 hrs, with most other daytime hours (6:00 hrs to 20:00 hrs) having between 3 percent and 10 percent of the total frequency. The late night and overnight hours have few collisions between CMV's and cyclists.

4.3 Pedestrian – CMV Collisions

The following is a summary of collisions between pedestrians and CMV's for Ottawa and Toronto collisions. These datasets were merged as they are the same in format and available data fields. There was a total of 196 cyclist-CMV collisions in the combined dataset, which cover from 2002 to 2007 (Ottawa) and 2004 to 2006 (Toronto). Collision characteristics are investigated in terms of collision location, collision type, CMV vehicle characteristics, driver / cyclist characteristics, possible contributing factors, and incidence occurrence.

4.3.1 Collision Location – Pedestrians and CMV's

The location of collisions between pedestrians and CMV's was investigated, with the percent breakdown shown in the table below.

Table 4.16: Collision Location, for CMV & Pedestrian Collisions

Collision Location	Percent
Non Intersection	27.9%
Intersection Related	17.5%
At Intersection	35.1%
At/near private drive	6.4%
Other	13.1%

A majority of collisions were either at an intersection or were intersection related, with 53 percent of collisions. Of these, approximately two-thirds were at an intersection and one-third intersection related. Non-intersection collisions accounted for approximately one third of collisions, followed by driveway collisions at 6 percent. Therefore, collisions between pedestrians and CMV's were most common at locations where two traffic streams intersect.

A summary of the traffic control present for intersection collisions between pedestrians and CMV's is shown below.

Table 4.17: Traffic Control Type at Intersections, for Collisions between CMV's and Pedestrians

Intersection Collision - Traffic Control	Percent
Traffic Signal	77.3%
Stop sign	15.9%
Pedestrian Crossover	0.8%
No Control	5.3%
Other	0.8%

For intersection collisions (either at the intersection or intersection related), a majority of three-quarters occurred at a signalized intersection. Stop controlled intersections accounted for the next most common traffic control type with 16 percent of collisions, followed by all other traffic control types at 7 percent. Therefore signalized intersections are the most common location for intersection collisions between pedestrians and CMV's. For the signalized intersection collisions, the controller was identified as "not functioning" in two instances.

Nine of the eleven recorded driveway collisions had no traffic control, with the other two having signalization.

4.3.2 Collision Type – Pedestrians & CMV's

A review of collisions by type was conducted, in consideration of impact type and of vehicle manoeuvres (for both CMV's and pedestrians).

A summary of collisions between pedestrians and CMV's by impact type is shown below, for all collisions in the Ottawa & Toronto dataset.

Table 4.18: Impact Type for Collisions between CMV's and Pedestrians, for Collisions in All Locations

Impact Type	Percent
Approaching	4.8%
Angle	6.0%
Rear end	3.6%
Side swipe	2.0%
Turning movement	9.6%
Single Moving Vehicle	62.2%
Other / Unknown	12.0%

A majority of collisions between pedestrians and CMV's were coded as a single moving vehicle collision. No other impact type had more than 10 percent of the total frequency. Therefore impact type is of limited descriptive benefit for pedestrian collisions.

Vehicle Manoeuvres

Vehicle manoeuvres associated with CMV's in collisions involving CMV's and pedestrians are shown below, for all collisions.

Table 4.19: Vehicle Manoeuvre for Collisions between CMV's and Pedestrians, for All Collisions

CMV Vehicle Manoeuvre (All Collisions)	Percent
Going Ahead	34.8%
Slowing or stopping	2.8%
Overtaking	0.4%
Turning left	21.1%
Turing right	17.8%
Changing lanes	0.8%
Reversing	12.1%
Stopped	0.8%
Pulling away from shoulder or curb	4.9%
Pulling onto shoulder or curb	0.4%
Other	4.0%

The most frequent CMV manoeuvre was going ahead, followed by turning left, turning right, and reversing. All other manoeuvres occurred in 5 percent or less of pedestrian/CMV collisions.

Vehicle manoeuvres were also investigated for intersection collisions between CMV's and pedestrians, with the results shown below.

Table 4.20: Vehicle Manoeuvre for Collisions between CMV's and Pedestrians, for Intersection Collisions

CMV Vehicle Manoeuvre (Intersection Collisions)	Percent
Going Ahead	26.5%
Slowing or stopping	2.2%
Overtaking	0.7%
Turning left	34.6%
Turing right	30.9%
Changing lanes	0.7%
Reversing	0.7%
Stopped	0%
Parked	0%
Pulling away from shoulder or curb	1.5%
Pulling onto shoulder or curb	0%
Other	2.2%

The results are similar to those for all collisions. Going ahead, turning left, and turning right remain the most frequent manoeuvres, however the reversing manoeuvre was not found to be a major factor at intersections (less than 1 percent). Also, turning left manoeuvres and turning right manoeuvres were more frequent than going ahead. Unlike cyclist/CMV collisions, more pedestrian/CMV collisions involved a left-turning CMV than a right-turning CMV.

4.3.3 CMV Characteristics

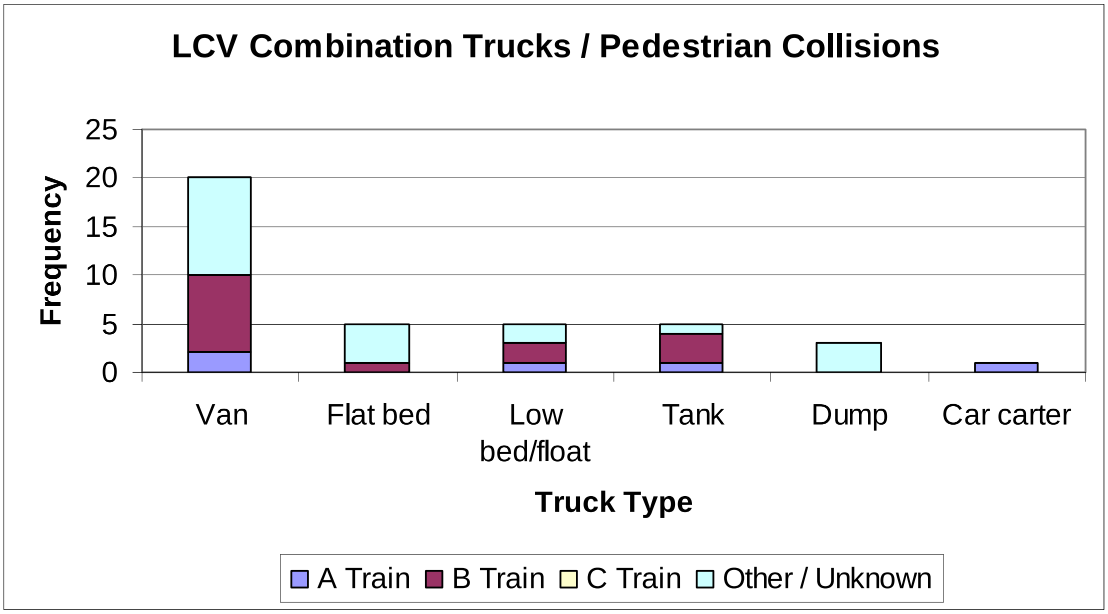
A summary of CMV characteristics for collisions between pedestrians and CMV's is shown below, for all collisions in the Ottawa & Toronto dataset. Vehicle type (truck, bus, and other) is summarized, and more detailed truck details are investigated for truck/pedestrian collisions.

Table 4.21: Vehicle Type

CMV Vehicle Type	Percent	
Truck - open	4.8%	58.1%
Truck - closed	31.9%	
Truck - tanker	1.7%	
Truck - dump	5.2%	
Truck - car carter	0.9%	
Truck - tractor	13.5%	
Municipal transit bus	21.8%	35.4%
Intercity bus	3.5%	
Bus (other)	5.2%	
School bus	4.8%	
Other	7.4%	7.4%

Most of the CMV's involved in collisions with pedestrians were trucks, followed by buses and then other vehicle types.

A total of 39 combination vehicles (or 14 percent of the CMV's) were identified in the datasets in terms of combination type and trailer connection type (A train, B train, C-train, or Other/ Unknown), for collisions with pedestrians. A summary graph of these collisions is shown below. Combination van trailer units are most frequently recorded in these collisions, with more instances than all other combination truck types combined.



4.3.4 Driver / Pedestrian Characteristics

Specific CMV driver and pedestrian characteristic information of age and gender was available for some but not all of the collision reports investigated. Therefore these characteristics were not examined (but could be investigated in the future to some extent).

4.3.5 Possible Contributing Factors

The datasets contained some information regarding possible contributing factors to collisions between pedestrians and CMV's. CMV driver action, driver condition, pedestrian action, pedestrian condition, and environmental conditions were investigated. Below is a table summarizing the actions as recorded by CMV drivers in the datasets, for all of the pedestrian-CMV collisions.

Driver Action

Table 4.22: Driver Action

Apparent CMV Driver Action	Percent
Driving Properly	55.9%
Following too close	0%
Exceeding speed limit	0.4%
Speed too fast for condition	0%
Speed too slow	0.4%
Improper turn	5.9%
Disobeyed traffic control	1.7%
Failed to yield right-of-way	22.0%
Improper passing	1.7%
Lost control	2.5%
Wrong way on one-way road	0%
Improper lane change	0.8%
Other	8.5%

A majority of CMV drivers were recorded as driving properly (56 percent) in collisions with pedestrians. The most common contributing or at-fault action was failing to yield right of way (22 percent), with all other actions occurring in five percent or less of incidents.

Pedestrian Action

Table 4.23: Pedestrian Action

Pedestrian Action	Percent
Crossing with right-of-way	28.9%
Crossing without right-of-way	13.2%
Crossing - no traffic control	7.0%
Crossing at pedestrian crossover	2.2%
Crossing at marked crosswalk without right-of-way	4.4%
Waiting on roadway with traffic	2.6%
Waiting on roadway against traffic	2.6%
On sidewalk or shoulder	10.1%
Playing or working on Highway	3.9%
Oncoming tram behind parked vehicles or object	1.8%
Running onto roadway	6.6%
Person getting on/off school bus	
Person getting on/off vehicle	2.2%
Working on vehicles	1.3%
Other	13.2%

More pedestrians were recorded as crossing with the right-of-way than any other action, but only in 29 percent of collisions. This is a lower percentage of having the right-of-way than CMV drivers had when involved with pedestrian collisions, and a lower a percentage than cyclists and CMV drivers involved in cyclist-CMV collisions (all of which are near or greater than 50 percent with the right-of-way). It should be noted, however, that other pedestrian actions listed are not necessarily "pedestrian at-fault", such as pedestrian on sidewalk. Therefore the number of collisions for which pedestrians are not at fault is likely greater than 29 percent. The most commonly recorded actions were crossing without right of way, pedestrian on sidewalk or shoulder, crossing where no traffic control was present, and running onto the roadway. All other actions were observed in less than 5 percent of incidents.

Driver and Pedestrian Condition

Table 4.24: Driver and Pedestrian Cognitive Condition

Driver / Pedestrian Condition	CMV Driver Condition - Percent	Pedestrian Condition - Percent
Normal	90.4%	67.2%
Impaired (Alcohol, drugs)	0.9%	9.3%
Fatigue	0.5%	0%
Inattentive	8.2%	19.6%
Other	0%	3.9%

In terms of driver / pedestrian condition, a majority of both CMV drivers and pedestrians were identified as "normal". Nine percent of pedestrians and one percent of CMV drivers were identified as impaired (alcohol or drugs). CMV drivers and pedestrians were found to be inattentive in 8 percent and 20 percent of cases respectively. While most drivers and pedestrians are in normal condition when a pedestrian/CMV collision occurs, a greater percentage of pedestrians are either impaired or inattentive.

Environment Factors

Environment characteristics that may be relevant were investigated, in terms of weather, road surface condition, and lighting conditions.

Table 4.25: Weather Condition

Weather Condition	Percent
Clear	80.1%
Rain	11.7%
Snow	5.5%
Freezing Rain	0.8%
Strong Wind	1.6%
Other	0.4%

As with cyclist-CMV collisions, a majority of pedestrian-CMV collisions occurred in clear weather. A greater percentage, however, occurred in rain, snow, and strong wind for pedestrians than cyclists, perhaps as these adverse conditions are more easily navigable by pedestrians.

Table 4.26: Road Surface Condition

Road Surface Condition	Percent
Dry	70.9%
Wet	21.9%
Loose Snow	2.4%
Slush	2.8%
Ice	1.2%
Other	0.8%

The road surface was found to be dry in a majority of incidents between CMV's and pedestrians (71 percent). Surface conditions were wet for 22 percent of incidents, and snow/ice/other for 7 percent of incidents. This is also similar to CMV-cyclist collisions, however as with weather conditions, there are more incidents with pedestrians where conditions are wet.

Table 4.27: Lighting Condition

Lighting	Percent
Daylight	76.9%
Dawn / Dusk	3.2%
Dark	18.6%
Other / Unknown	1.2%

Most of the collisions between pedestrians and CMV's occurred during daylight conditions (77 percent), with 19 percent in dark conditions, 3 percent at dawn or dusk, and 1 percent other / unknown. These percentages match closely with those for collisions between cyclists and CMV's, however there is a greater percentage of incidents occurring during dark and dawn/dusk collisions for pedestrians than for cyclists.

It can be concluded that most collisions between CMV's and pedestrians occur during good environmental conditions (e.g. clear, dry surfaces, daylight), and therefore adverse weather conditions are not the cause of most of these types of collisions. Wet and/or dark conditions may however be a mitigating factor in some collision instances between pedestrians and CMV's.

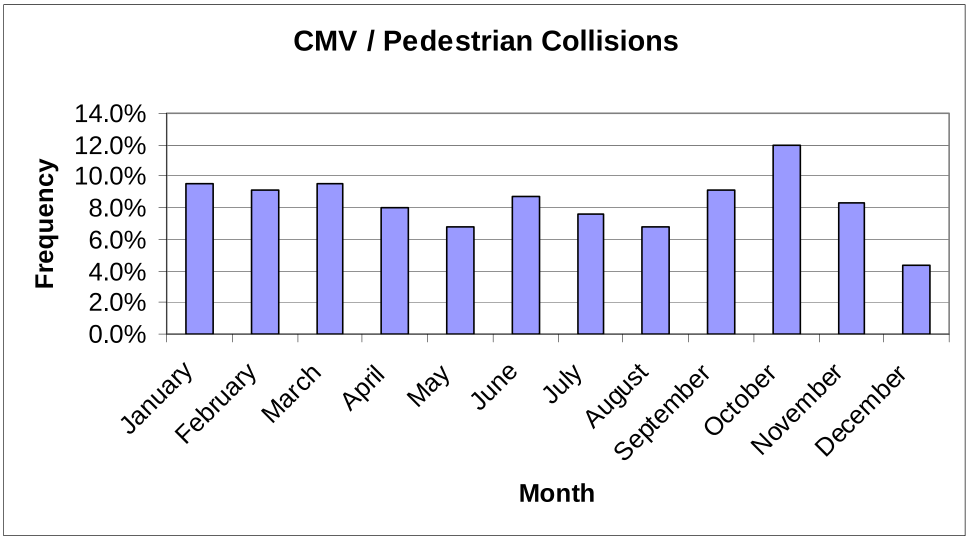
4.3.6 Incident Occurrence

Incident occurrence characteristics were investigated, in terms of collision classification and incident occurrence timeframe (month, day of week, time of day) for collisions between pedestrians and CMV's.

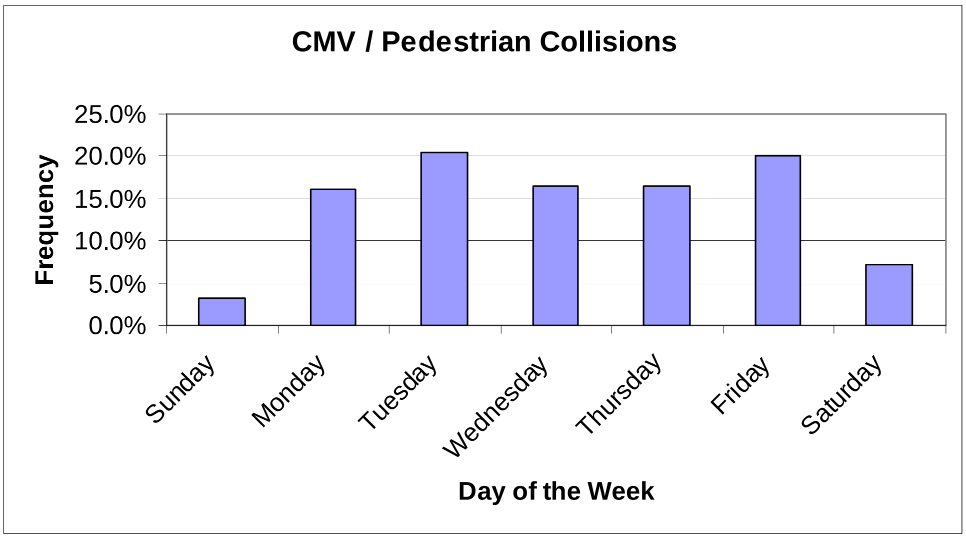
Table 4.28: Collision Classification

Collision Classification – CMV & Pedestrian Collisions	Percent
Fatal Injury	6.0%
Non-fatal injury	85.2%
P.D. only	4.4%
Non reportable / Other	4.4%

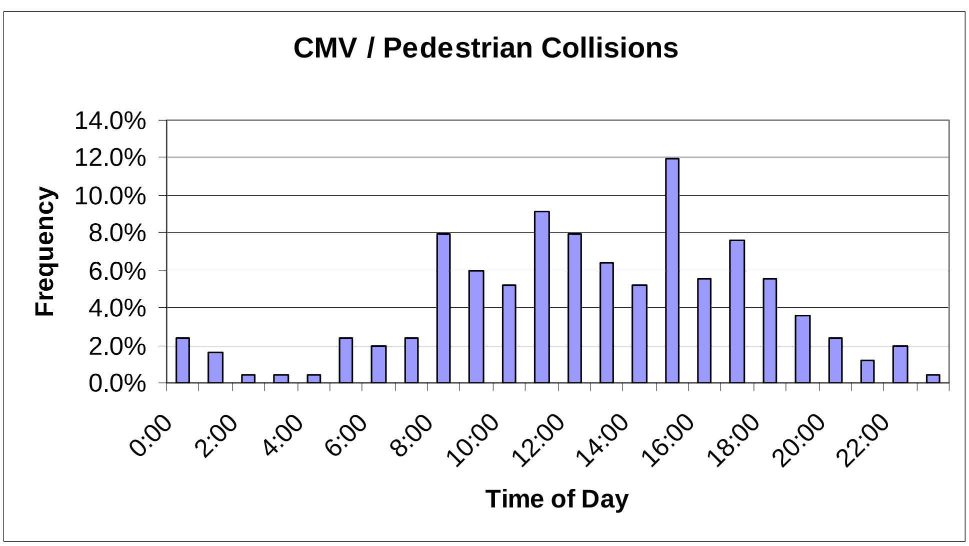
A majority of recorded collisions between cyclists and CMV's resulted in a non-fatal injury (86 percent), with 4 percent resulting in a fatal injury and 11 percent as property damage only or other. Therefore, most of these types of collisions result in injury to the pedestrian, with a small percentage being fatal collisions.



The frequency of collisions between pedestrians and CMV's is relatively consistent throughtout most months of the year (in Toronto and Ottawa), with December having a lower frequency of these incidents than other months. This pattern differs from that for collisions between cyclists and CMV's, where a drop in frequency over the five month period from November to March was observed. As noted in the section investigating environmental factors, this may be a result of walking being a more viable mode choice in inclement / winter weather than cycling.



In terms of day-of-week, most pedestrian / CMV collisions occur on weekdays.



In terms of time of day, there is a frequency peak at 15:00 hrs, with most other daytime hours (8:00 hrs to 19:00 hrs) having between 4 percent and 9 percent of the total frequency. The late night and overnight hours have few collisions between CMV's and pedestrians, however there are more overnight collisions between pedestrians and CMV's than cyclists and CMV's. It is also of note that the peak hour for pedestrian/CMV collisions is one hour earlier than that for cyclist/CMV collisions.

4.4 High Level Collision Analysis – Conclusions

In terms of overall collision frequency, there are more collisions between pedestrians and CMV's than cyclists and CMV's (20 percent fewer cyclist/CMV collisions). It was also found that these collisions rarely occur multiple times at a given location; therefore the nature of these collisions is not in general site specific but rather related to the urban transportation system at large.

A majority of collisions between cyclists and CMV's are at or near intersections (more than 50 percent). Non-intersection collisions account for 34 percent of collisions. There is a similar trend for pedestrian/CMV collisions, with more than 50 percent at intersections and approximately 28 percent being non-intersection related. These two locations are therefore of interest in the detailed analysis.

For collisions between cyclists and CMV's at intersections, a majority are signalized, with approximately 25 percent being stop controlled. An even larger majority of collisions between pedestrians and CMV's at intersections involve signalization.

In terms of impact type for collisions between cyclists and CMV's, the three most frequent types were angle, side-swipe, and turning movement; therefore these are of interest for detailed review. No obvious trend emerged for pedestrian/CMV collisions.

For vehicle manoeuvres in collisions between cyclists and CMV's, a majority of cyclists were going ahead, while a majority CMV's were either going ahead, turning right, or turning left (in relatively equal proportion). For collisions between pedestrians and CMV"s, the majority of CMV's were also either going ahead, turning right, or left in relatively equal proportion. Therefore, the three turning movements of CMV's are of interest for detailed review.

In terms of vehicle type, more of these collisions involved trucks than transit vehicles for both cyclist and pedestrian CMV collisions. Closed trucks and municipal transit buses were most commonly reported.

In terms of driver action, more than half of all cyclists and drivers were identified as driving correctly. No other behaviour was overwhelmingly reported. Pedestrians were reported as being with the right-of-way or in appropriate walking locations (i.e. correct behaviour) more frequently than other behaviours as well.

Travel conditions were reported as good for most of the collisions, for weather, road surface condition, and lighting (i.e. it was usually clear, dry, and light out) for both cyclist and pedestrian CMV collisions.

In terms of collision classification, most were non-fatal injury collisions, with less than 5 percent of all collisions being fatal, for both cyclist and pedestrian CMV collisions. While the overall percentage of collisions that are fatal for collisions between VRU's and CMV's is low, it must be noted that CMV's are over-represented in VRU collisions fatalities, particularly for cyclist fatalities. For example, in the City of Toronto, from 2003 to 2008, commercial motor vehicles were involved in 8% of all pedestrian traffic fatalities and two-thirds of all cyclist traffic fatalities. In 2007 almost 20% of all VRU fatalities involved a commercial motor vehicle. From 2005 to 2007, eight of nine fatal cycling collisions involved commercial motor vehicles.

In terms of time of year, a majority of collisions between cyclists and CMV's occur between April and October, during those months where more people are likely to ride bicycles. In contrast, collisions between pedestrians and CMV's occur relatively consistently throughout the year. Both cyclists and pedestrian CMV collisions occur most frequently on weekdays and during daylight hours.

5 DETAILED COLLISION ANALYSIS

5.1 Detailed Analysis Approach

The detailed analysis approach used was to investigate cyclist-CMV and pedestrian-CMV collisions in turn, to try to establish any potential trends in collision characteristics. From this, recommendations are made regarding potential future research areas. The approach was to first consider those collision types which were most common based on the high level collision analysis.

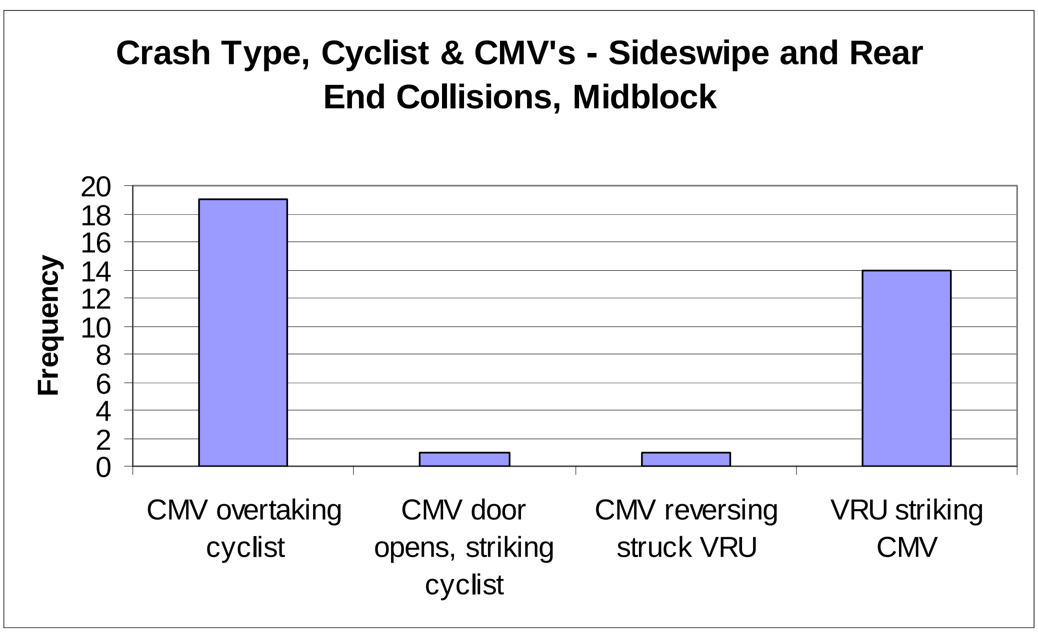
The detailed analysis was then conducted using a crash typology. This typology consisted of two main categories, namely crash type and possible contributing factors. The possible contributing factors was broken into four sub-categories, namely CMV design factors, road geometry and operational characteristics, behavioural factors, and environmental factors.

The complete crash typology can be found in Appendix C.

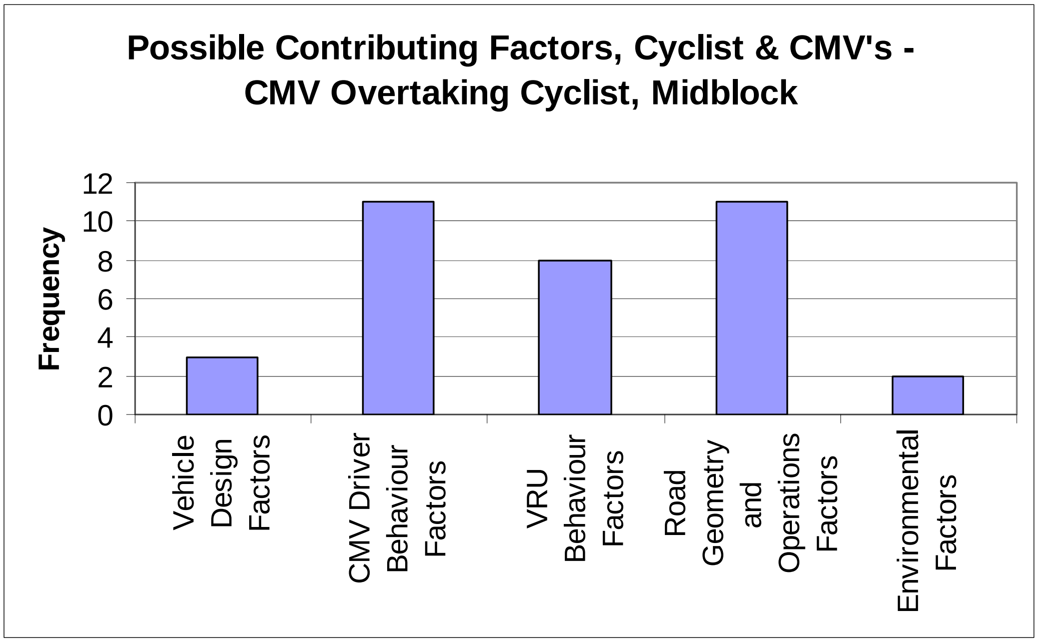
5.2 Collisions between Cyclists and CMV's

5.2.1 Non-Intersection Midblock Cyclist Collisions

For non-intersection midblock collisions, a majority (35 of 53) were found to be either sideswipe or rear-end in nature. Therefore these impact types were further investigated for possible trends or characteristics. The breakdown of these collisions by crash type is shown in the following figure:



It can be seen that most of these collisions either fall into the CMV overtaking cyclist category or VRU striking CMV category. These two collision types were looked at in more detail to investigate potential contributing factors. The following figure shows possible contributing factors by category, for 19 CMV overtaking cyclist collisions

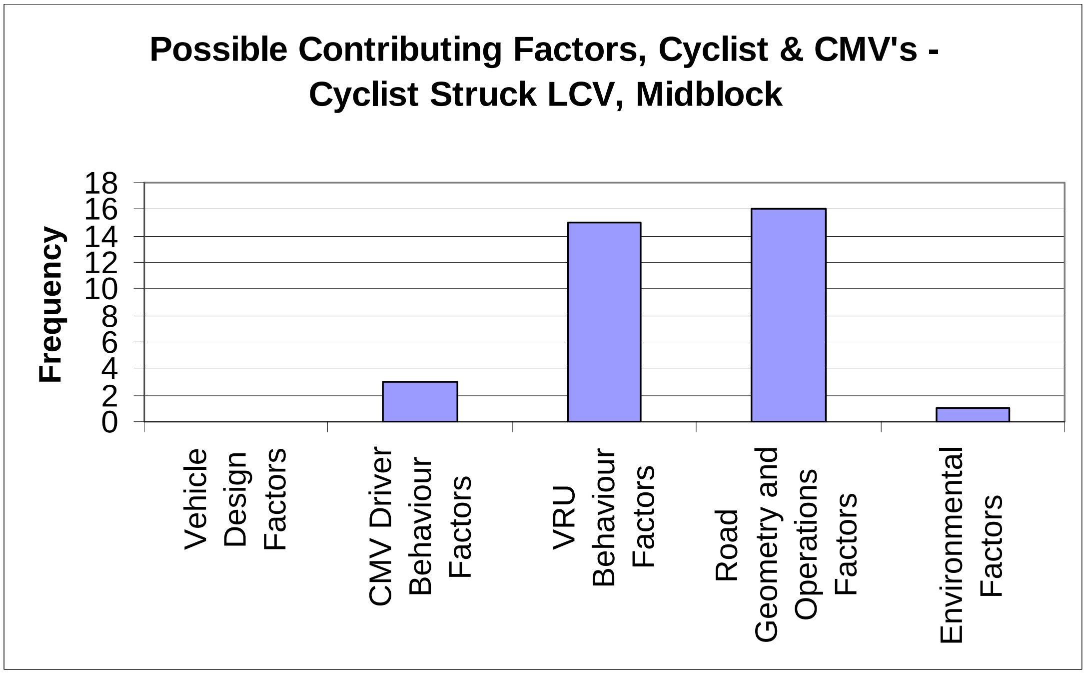


*Note: this is based on 19 total collisions over the data period

For the "CMV overtaking cyclist" collisions, CMV driver behaviour, VRU behaviour, and/or road geometry and operations were cited most frequently as possible contributing factors. Vehicle design and environmental factors were noted in a few instances only.

For CMV driver behaviour, all but one instance were unsafe passing / lane change, or failing to yield right of way related. VRU behaviour did not have more than three instances of any behaviour type; those noted with more than one instance were illegal VRU action (wrong-way cycling on road or cycling on the sidewalk), unsafe lane change, and intoxication. For road geometry and operations, possible roadway cross-section width was cited most (5 times), followed by parked or stopped vehicle (3 times), and roadway alignment (2 times). (Note that parked or stopped vehicles were associated with limiting the width between a CMV and a cyclist passing to the left of a parked or stopped car; effectively this is a road width lane factor.)

The following figure shows possible contributing factors by category, for 14 cyclist struck CMV collisions.



*Note: this is based on 14 total collisions over the data period

For the "Cyclist struck CMV" collisions, VRU behaviour, and/or road geometry and operations were cited most frequently as possible contributing factors, with all others accounting for only four noted factors.

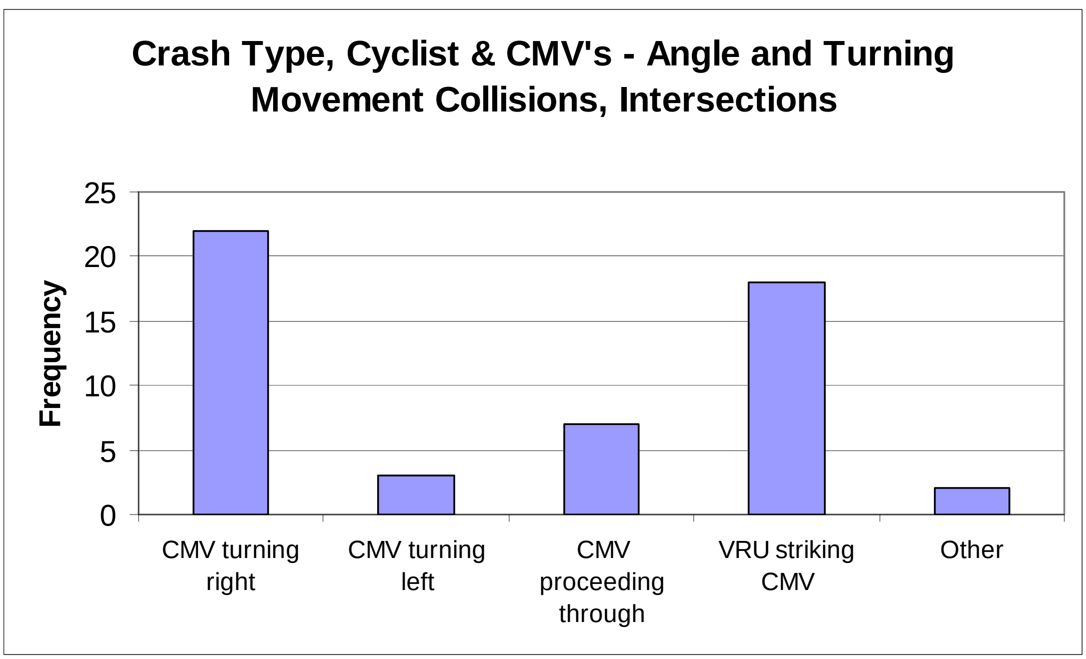
The breakdown of VRU behaviour in these collisions is as follows: loss of control (6 times), inattention (4 times), improper lane change / failure to yield right of way (3 times), others (2 times). For road geometry and operations factors, parked or stopped vehicles were associated with the collision 12 times, road cross section / narrow width identified 5 times (and always in conjunction with parking or a stopped vehicle). No other road geometry or operations characteristics were suspected of being a possible cause. Note that a bike lane was present in only one of the collisions. (Bike lanes were of no relevance in 3 of the collisions e.g. cyclist lane changing for left turn).

To conclude the non-intersection collision analysis of cyclist collisions, sideswipe or rear end collisions were found to be most common, with CMV overtaking cyclist or cyclist striking CMV to be the predominant collision types. While these collision types were found to be approximately equal in frequency of occurrence, the contributing factors differed. For CMV overtaking cyclists, CMV driver behaviour, VRU behaviour, and roadway geometry and operations were all noted with approximately equal frequency as potential causes. In contrast, for cyclists striking an CMV, CMV driver behaviour was rarely cited as a possible cause, and only VRU behaviour and roadway geometry / operations were cited with any frequency. Also of interest, a vast majority of the "cyclist striking CMV" collisions involved a parked or stopped vehicle, but only a few of the "CMV overtaking cyclist" collisions involved a parked or stopped vehicle. This may indicate that CMV's give cyclists enough room when a cyclist is ahead of them and there are parked or stopped vehicles to the right, but that cyclists are more likely to attempt to pass between stopped or parked vehicles that are in the right lane and a CMV to the left, even if there is not sufficient room.

5.2.2 Intersection Cyclist Collisions

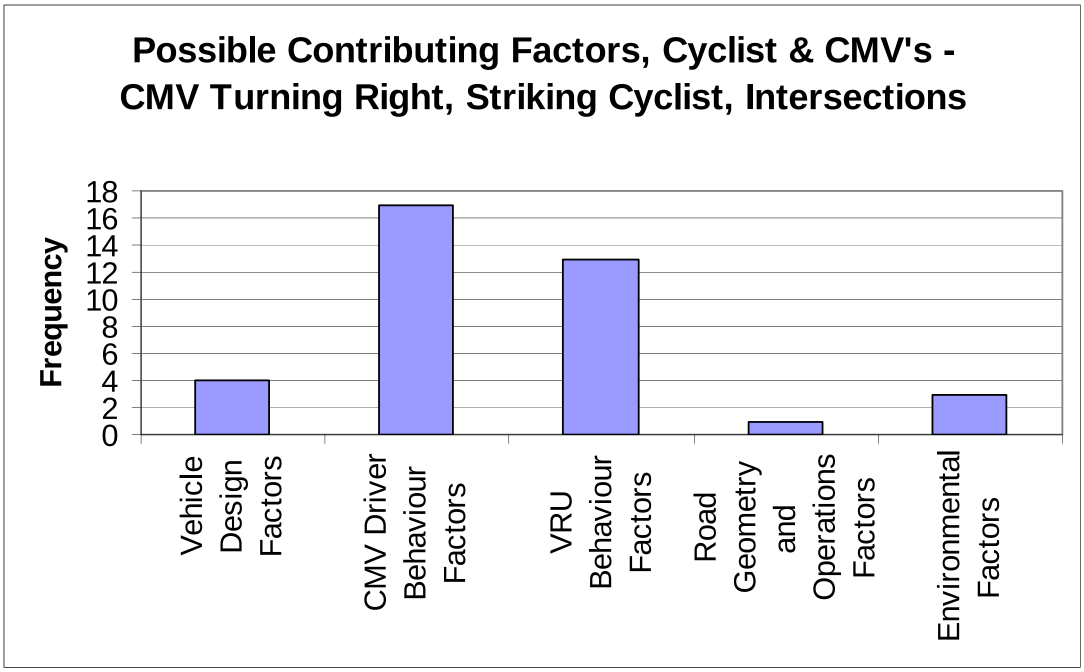
For intersection collisions, a majority were found to be either angle or turning movement in nature. Therefore these impact types were further investigated for possible trends or characteristics. Since most of these collisions occur at signalized or stop controlled intersections, only intersections with those traffic control types were investigated. This resulted in 52 collisions for analysis.

The breakdown of these collisions by crash type is shown in the following figure:



From this figure, it can be seen that a majority of the collisions are either the CMV hitting a cyclist on a right turn, or a cyclist hitting an CMV (any turning movement). These two collision types were therefore be investigated in terms of potential contributing factors. Since there are few incidences of any one right turn CMV typology category, they were all considered together.

The following figure shows a breakdown of possible contributing factors, for intersection collisions where an CMV turns right and strikes a cyclist.

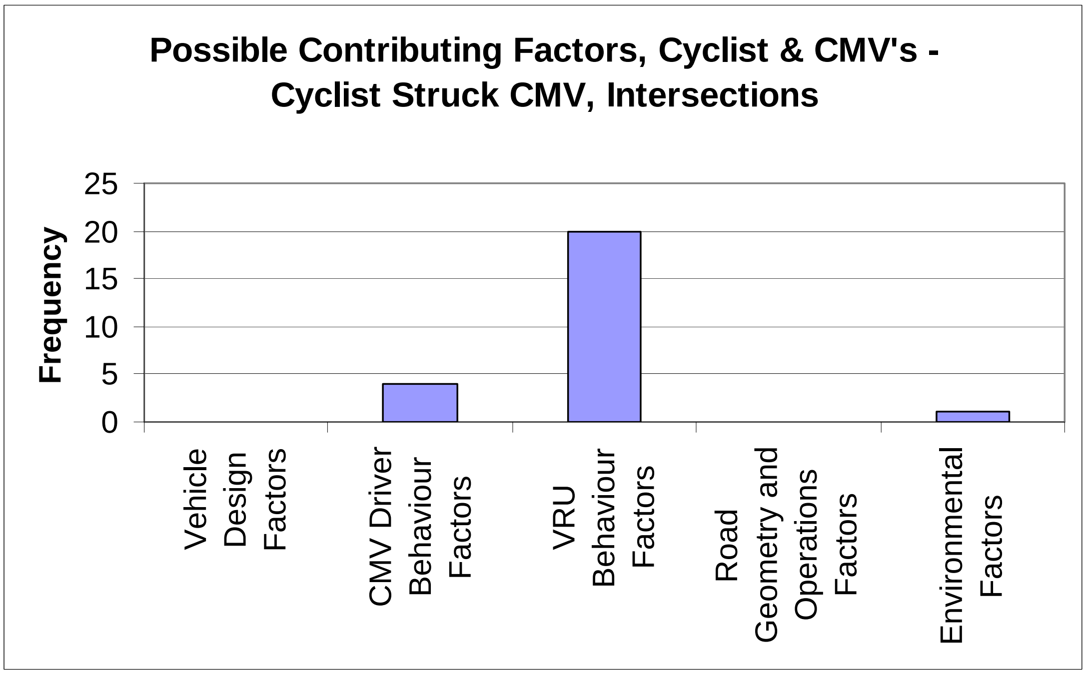


*Note: this is based on 21 total collisions over the data period

For these collisions, CMV driver behaviour was identified as a possible factor most often, followed by VRU behaviours. Vehicle design, road geometry, and environmental factors were cited as potential contributing factors infrequently. For the CMV driver behaviour, a majority of the instances were failure to yield right of way or unsafe passing, lane change, turn etc (13 instances) followed by inattention (3 instances). For VRU behaviour, a majority was illegal behaviour (8 instances), most of which were riding in the crosswalk, with all other factors having 2 or fewer instances.

It should be noted, however, that vehicle design and roadway geometry and operations may potentially have some contributing impact beyond what was reasonably extractable from the police collision records. (For example, in reviewing the reports, if an CMV driver struck a cyclist with the right of way, vehicle design (e.g. in terms of blind spots) was only considered as a factor if it was indicated that the driver did not see the cyclist. Many of the collisions indicated that a driver didn't give the right-of-way but no other information, where conceivably the driver may also not have seen the cyclist. Similarly, for roadway geometry, few of the diagrams had right turn dimensions or any indication that a right turn might be difficult for an CMV to navigate. None of the right turn collisions were identified as having occurred at a right-turn channelized island.)

The following figure shows a breakdown of possible contributing factors, for intersection collisions where a VRU strikes an CMV.



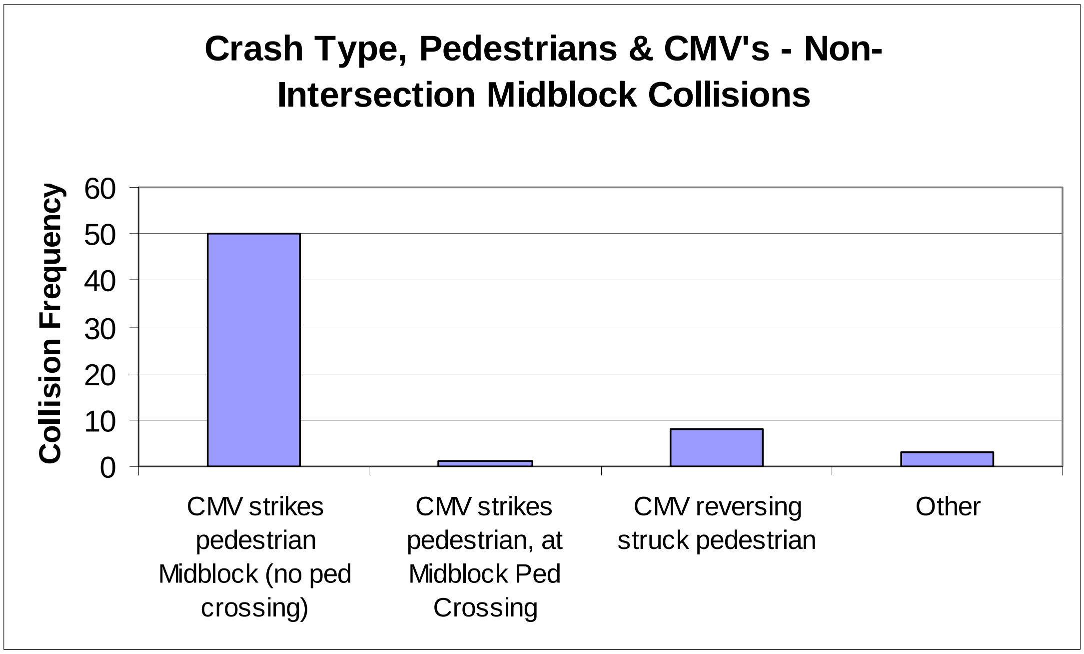
*Note: this is based on 18 total collisions over the data period

For these collisions, VRU behaviour was the predominant factor cited. All other factors were identified less than five times. For VRU behaviour, the most common factor cited was failure to yield right of way or unsafe passing, lane change, turn etc (8 instances), followed by illegal behaviour (6 instances), with all other factors having 2 or fewer instances. For the illegal cyclist behaviour collisions, the illegal behaviour was split between riding in the crosswalk, riding the wrong way on the street, or disobeying traffic control.

5.3 Collisions between Pedestrians and CMV's

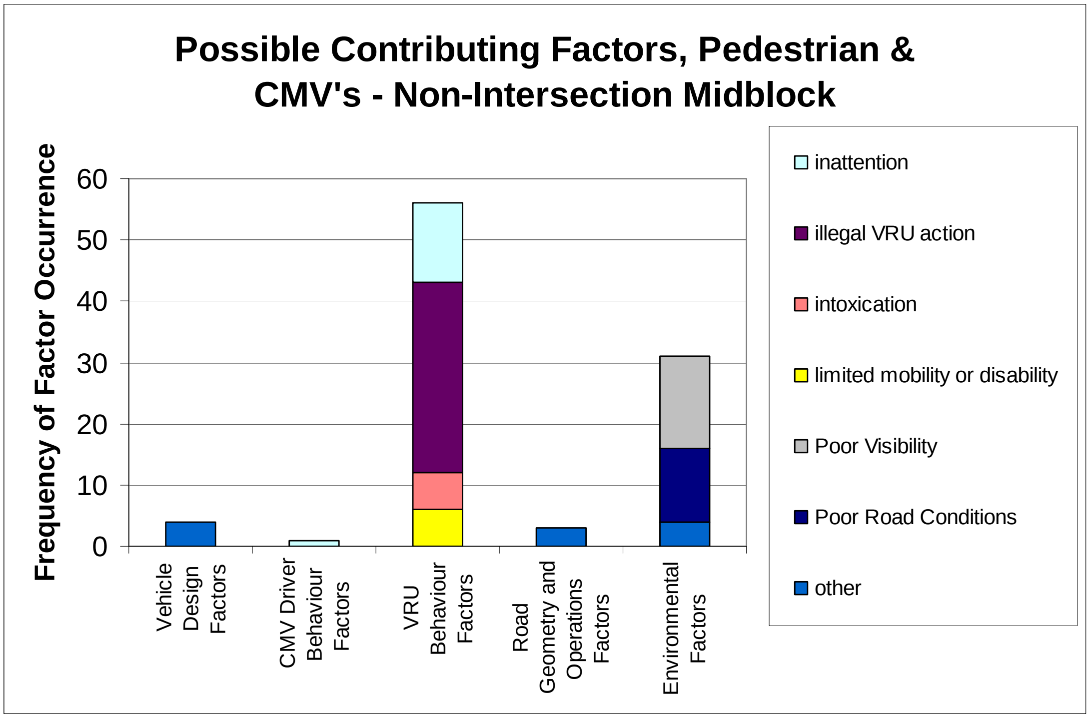
Collisions between pedestrians and CMV's were investigated in further detail. Based on the high level review, which found that these collision types occur most frequently at either intersections or midblock (non-intersection) locations, these were the collision locations considered for further investigation.

5.3.1 Non Intersection Pedestrian-CMV Collisions



For non-intersection midblock collisions, the majority are of the type where an CMV struck the pedestrian midblock where no pedestrian crossing was present. CMV's reversing and striking a pedestrian account for the next most common crash type. (There was one incidence reported of an CMV striking a pedestrian at a midblock crossing, and three others, which involved multiple vehicle collisions.)

The following chart shows the frequency of possible contributing factor occurrence for five main contributing factor headings, for collisions between CMV's and pedestrians at non-intersection locations. The frequency of key sub-factors for each main factor heading are also shown. Note that more than one factor may be noted per collision.



*Note: this is based on 62 total collisions over the data period

For collisions between CMV's and VRU's at non-intersection locations, VRU behaviour factors were the most commonly cited, followed by environmental factors. Factors associated with vehicle design, CMV driver behaviour, and road geometry and operations factors were infrequently noted for non-intersection collisions.

Vehicle design factors cited were of the type where driver blind spots shielded the view of the pedestrian. These potential blind spot factors were only noted for CMV reversing, CMV striking pedestrian at midblock crossing, and the "other" crash types.

Only one instance was noted where the CMV driver behaviour was a possible factor (inattention at a pedestrian midblock crossing.)

For VRU behaviour factors, illegal VRU action was most commonly cited, and the majority of these illegal actions were crossing midblock without the right of way. Inattention was the next-most cited VRU action (usually in conjunction with crossing midblock without the right of way), followed by limited mobility or disability (the very young, vision impaired, scooter riders, and wheelchair users were observed) and intoxication (which was generally associated with either crossing midblock without the right of way or slipping).

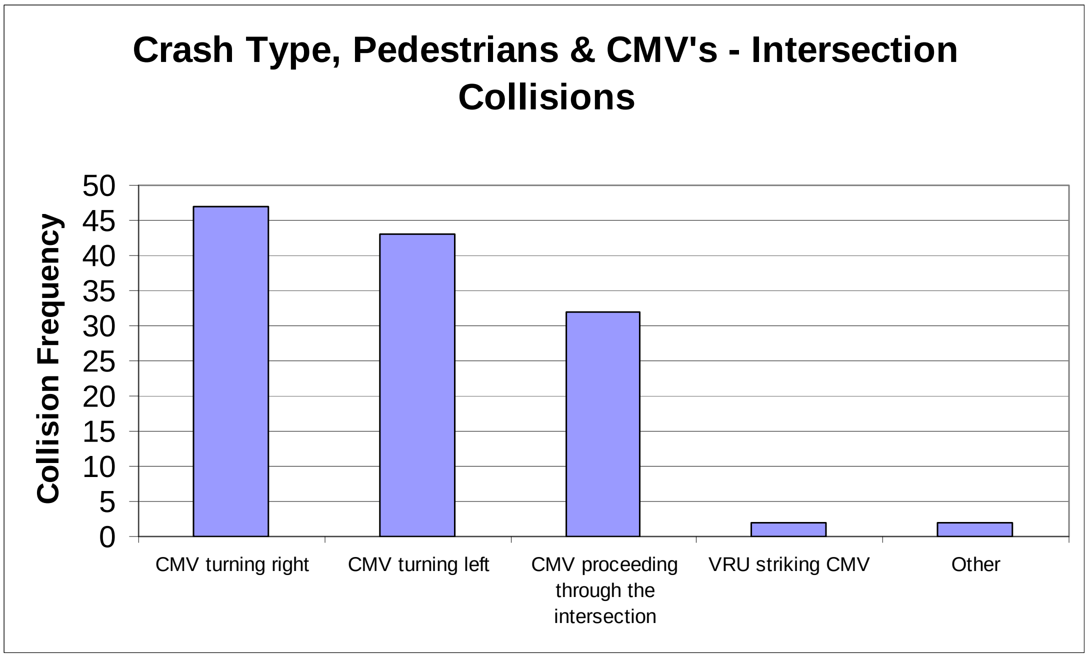
Road geometry was cited in a few cases only; in two instances no sidewalk was present, in one case horizontal curvature may have been a factor, and in one case sidewalk design was noted as a possible factor.

The environmental factors noted were generally poor visibility (darkness and/or precipitation) or poor road conditions (wet or snowy/icy conditions). Five collisions cited both poor visibility and road conditions. The other environmental factors noted were either road work related or obstructed pedestrian path, leading to a pedestrian entering the roadway in an unexpected location. In all but three collisions, the potential environmental factors were also associated with other factors (for those three, either roadwork or obstructed path was the environmental cause).

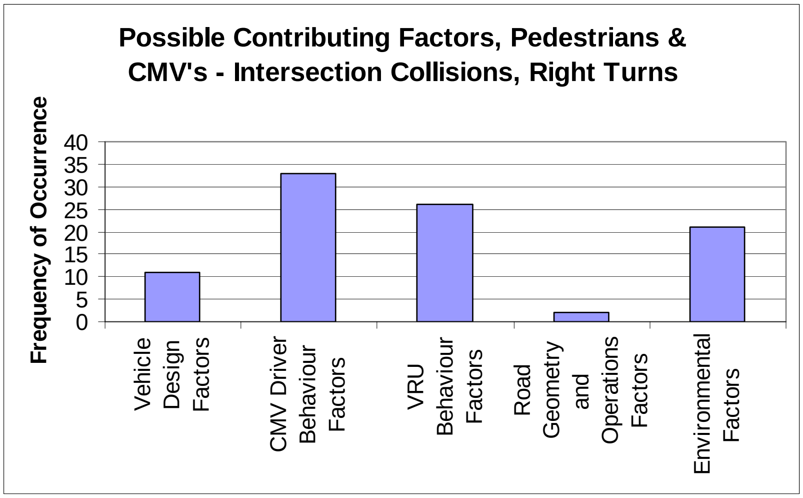
Note that there were also three collisions for which no potential factors were extractable at all from the collision data set.

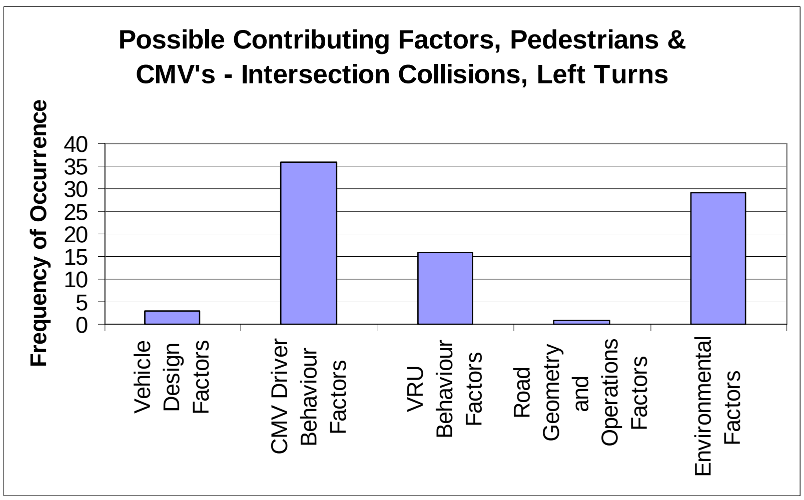
5.3.2 Intersection Pedestrian-CMV Collisions

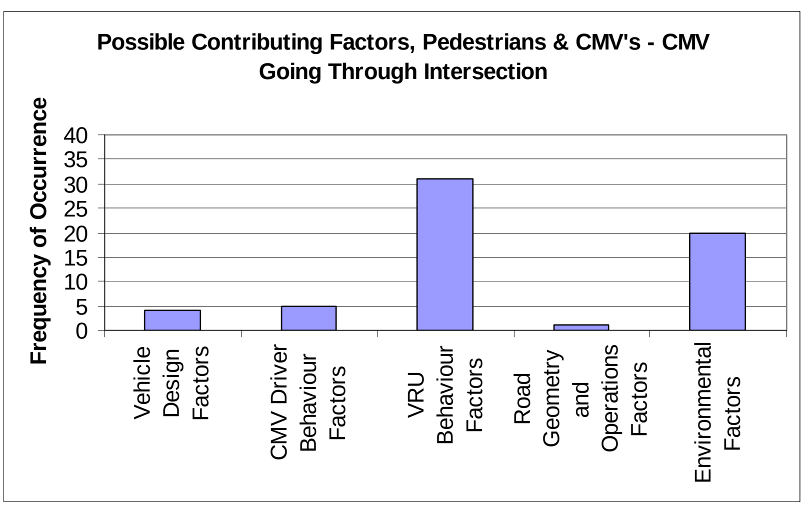
Collisions between pedestrians and CMV's were investigated by crash type in order to see which of these collision types are of most concern. The chart below shows the breakdown by crash type for collisions between pedestrians and CMV's at intersections.



The three most common collision types are CMV turning left, turning right at signalized intersection, and proceeding through the intersection. These collision types were therefore selected for further investigation. The following three figures show the possible contributing factors by category for CMV turning right, CMV turning left, and CMV proceeding straight through the intersection collisions.


Possible Contributing Factors, Pedestrians & CMV's - Intersection Collisions, Right Turns
Frequency of Occurrence
0
5
10
15
20
25
30
35
40
Vehicle Design Factors
CMV Driver Behaviour Factors
VRU Behaviour Factors
Road Geometry and Operations Factors
Environmental Factors

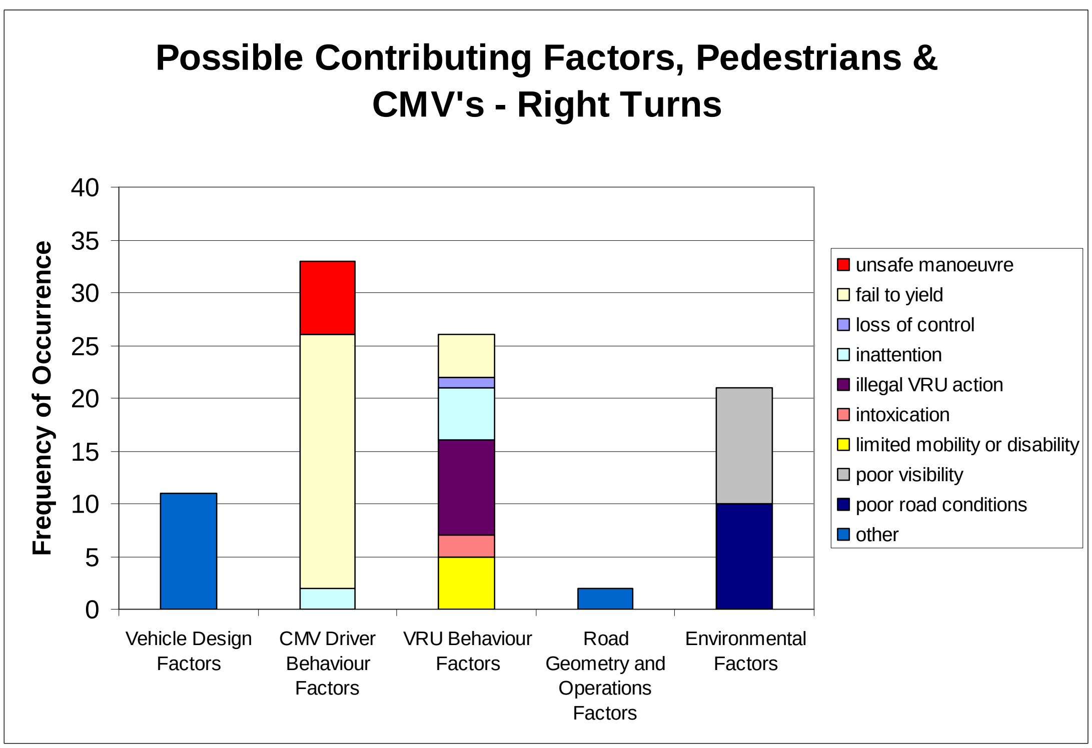

Possible Contributing Factors, Pedestrians & CMV's - Intersection Collisions, Left Turns
Frequency of Occurrence
0
5
10
15
20
25
30
35
40
Vehicle Design Factors
CMV Driver Behaviour Factors
VRU Behaviour Factors
Road Geometry and Operations Factors
Environmental Factors


Possible Contributing Factors, Pedestrians & CMV's - CMV Going Through Intersection
Frequency of Occurrence
0
5
10
15
20
25
30
35
40
Vehicle Design Factors
CMV Driver Behaviour Factors
VRU Behaviour Factors
Road Geometry and Operations Factors
Environmental Factors

In consideration of possible contributing factors, it was found that they somewhat varied between right turn collisions, left turn collisions, and through-movement collisions. Right turn collisions had the most variety in possible contributing factor types, with CMV driver behaviour factors being most observed, followed closely by pedestrian factors and environmental factors. Right turn collisions also had the highest frequency of possible vehicle design and roadway geometry and operations factors cited. For left turn collisions, however, CMV driver behaviour was most commonly cited followed closely by environmental factors, while pedestrian behaviour factors was less frequently noted (less than half as many pedestrian behaviour factors cited for these collisions as for CMV driver behaviour). For CMV going through the intersection collisions, in contrast, pedestrian behaviour was most commonly cited followed by environmental factors, while driver behaviour factors were rarely cited (where those factors were cited in comparable frequency as vehicle design and roadway geometry and operations factors). Overall, environmental factors were cited in approximately equal frequency for each of these three crash types.

5.3.2.1 Intersection Pedestrian-CMV Collisions, Right Turns

The following chart looks in more detail at the possible contributing factors for pedestrian and CMV right turn collisions at intersections.



*Note: this is based on 54 total collisions over the data period

For vehicle design factors, several factors were represented, including large turning radius, mechanical defects, blind spots and side mirrors.

For CMV driver behaviour factors, failure to yield the right of way was the most commonly cited transgression, with other noted behaviours being unsafe manoeuvre (e.g. unsafe turn) or inattention. For those instances of CMV driver failure to yield, 6 of the 24 collisions also featured environmental conditions of visibility and/or road surface factors (25 percent of these collisions).

Pedestrian behaviour factors were varied among several different types, with illegal VRU action being the most frequently cited (which was generally the pedestrian crossing without right-of-way), followed by limited mobility / disability, inattention, and failure to yield, intoxication, and loss of control.

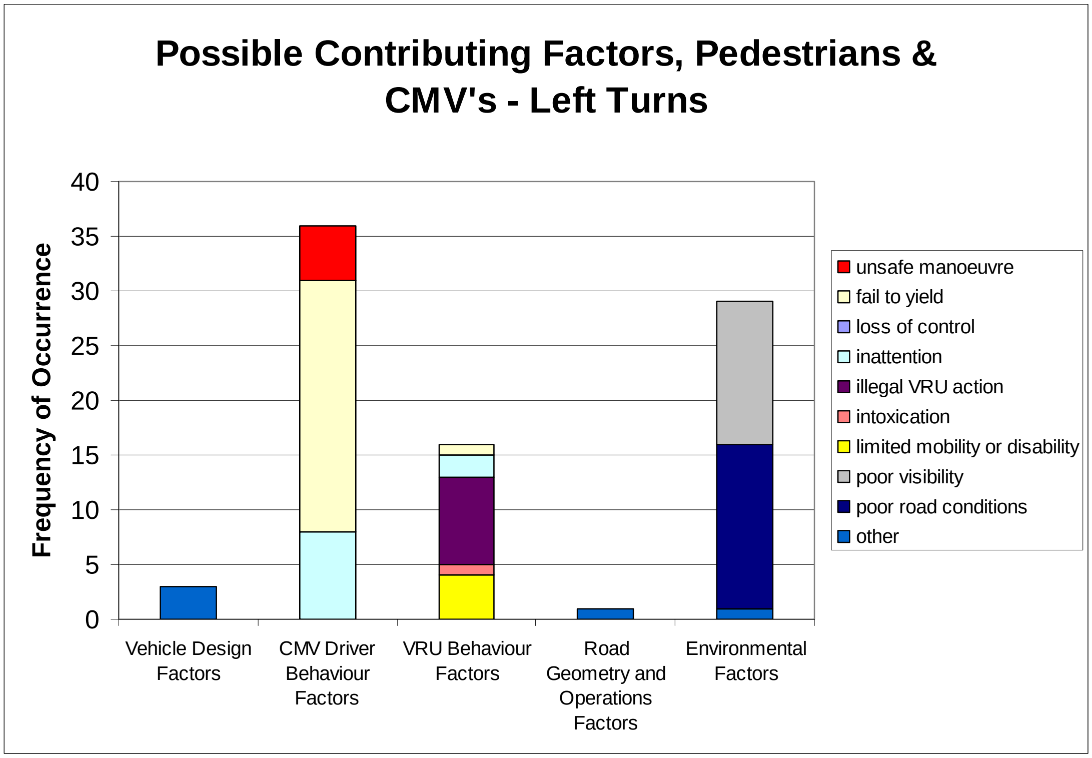
For the few instances where roadway geometry and operations were cited, it was due to inadequate turn geometry. Note that only one of the right turn collisions (out of 54) with a pedestrian occurred at a location with a right-turn channel noted in the collision data sheet.

For environmental factors, poor visibility and poor road surface conditions each accounted for half of the noted factors. For collisions where potential environmental factors were cited, there were also additional factors cited in all but one instance.

Note that for two collisions, no possible contributing factors were readily extractable from the collision dataset.

5.3.2.2 Intersection Pedestrian-CMV Collisions, Left Turns

The following chart looks in more detail at the possible contributing factors for pedestrian and CMV left turn collisions at intersections.



*Note: this is based on 43 total collisions over the data period

For the few vehicle design factors noted, side mirrors were noted twice and driver blind spot was noted once.

For CMV driver behaviour factors, failure to yield the right of way was the most commonly cited transgression, with other noted behaviours being unsafe manoeuvre (e.g. unsafe turn) or inattention. For those instances of CMV driver failure to yield, 10 of the 23 collisions also featured environmental conditions of visibility and/or road surface factors (43 percent of these collisions). Therefore, environmental factors may have a greater effect on driver behaviour for left turn crashes than for right turn crashes (or for through-movement crashes, which can be seen in Section 4.2.2.3). That is, in many of these cases environmental factors may have lessened driver reaction time and/or vehicle performance. It was not, however, clear as to whether drivers that failed to yield did so as a result of vehicle blind spots or operational conditions.

Pedestrian behaviour factors were varied among several different types, with illegal VRU action being the most frequently cited (which was generally the pedestrian crossing without right-of-way), followed by limited mobility / disability, inattention, failure to yield, and intoxication.

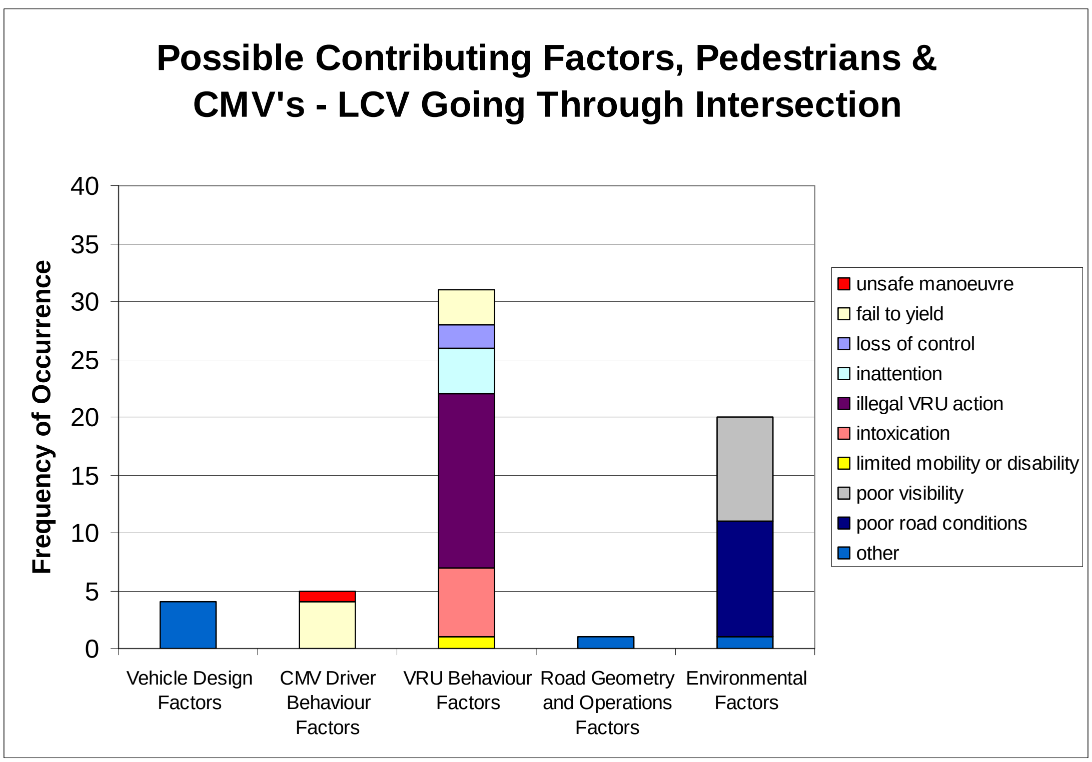
Only one instance was road geometry and operations factors cited as a potential factor (there was no sidewalk for that incident).

For environmental factors, poor visibility and poor road surface conditions each accounted for half of the noted factors. For collisions where potential environmental factors were cited, there were also additional factors cited in all but one instance.

Note that for two collisions, no possible contributing factors were readily extractable from the collision dataset.

5.3.2.3 Intersection Pedestrian-CMV Collisions, CMV Going Through Intersection

The following chart looks in more detail at the possible contributing factors for collisions between pedestrians and through-movement CMV's at intersections.



*Note: this is based on 32 total collisions over the data period

For vehicle design factors noted, mechanical defects and possible blind spots were noted twice.

For CMV driver behaviour factors, failure to yield the right of way was the most commonly cited transgression, with four instances, as well as one recorded occurrence of an unsafe manoeuvre. These occurred both at signalized and unsignalized intersections.

Pedestrian behaviour factors were varied among several different types, with illegal VRU action being the most frequently cited (which was generally the pedestrian crossing without right-of-way), followed by intoxication, inattention, failure to yield, loss of control and limited mobility / disability.

Only one instance was road geometry and operations factors cited as a potential factor (which was a narrow roadway, in conjunction with snowy conditions).

For environmental factors, poor visibility and poor road surface conditions each accounted for half of the noted factors. For collisions where potential environmental factors were cited, there were also additional factors cited in all cases for this crash type.

5.4 Detailed Collision Analysis – Conclusions

The following observations and conclusions are in regard to the detailed analysis, in consideration of both cyclist/CMV collisions and pedestrian/CMV collisions, and any collision trends observable between both collision types:

Collisions between Cyclists and CMV's

The following observations are made regarding collisions between cyclists and CMV's. At mid-block locations, roadway width limitations were often noted (generally lane width and/or parked car related). This suggests two possible mitigation measures: 1) bicycle lanes (or wide shared-use lanes), and 2) parking management (possible prohibition) along heavy truck and cycle use corridors. These measures could be considered for further research into cyclist/CMV safety. Driver behaviour cited for midblock collisions was generally poor lane change or fail to yield right of way, which may indicate possible vehicle blind spots or just inattentive behaviour. Facilitating improved driver awareness could potentially help address these collision causes (e.g. through bigger mirrors, proximity sensor alarm systems etc).

At intersections, collision factors were generally cited as either being driver behaviour or cyclist behaviour related. Unlike the non-intersection collisions, roadway geometry and operations factors were not readily attributable to these collisions as a potential cause.

Collisions between Pedestrians and CMV's

The following observations are made regarding collisions between pedestrians and CMV's. For midblock collisions, crossing midblock without the right-of-way was the most common factor cited (often along with environmental factors), but vehicle design, CMV driver behaviour, and road geometry and operations factors were infrequently noted. It is likely that a number of these collisions are not CMV specific (e.g. a pedestrian crossing midblock without the right-of-way may have just as likely been in a collision with a car), but in some cases it is possible that a properly driving CMV operator could not see or react to a pedestrian unexpectedly crossing without the right-of-way in a situation where a smaller vehicle perhaps may have. In any case, considerations for addressing pedestrians crossing midblock without the right-of-way are perhaps best considered in the larger roadway operations domain (not just from an CMV perspective).

For intersection collisions, CMV driver behaviour was frequently associated with turning movement collisions but not with through-movement collisions. The low prevalence of driver behaviour being cited for through-movement collisions may be due to the tendency for through vehicles to clearly know when they have the right-of-way combined with the fact that pedestrian movements generally should not conflict with a crossing vehicle that has the right of way. As such, a possible mitigation measure for turning movement collisions would be to either heighten a driver's awareness of a VRU or to separate vehicle movements (e.g. protected phasing, pedestrian scramble phase, etc).

For right turns at intersections, CMV driver behaviour factors was frequently cited as failure to yield the right of way, but infrequently was vehicle blind spot also cited. Nonetheless, vehicle blind spots may have played a role in some of these collisions; as such, technologies for improving driver awareness may be beneficial in this instance (e.g. proximity sensor alarm systems). For left turns at intersections, driver behaviour was often cited, and in half of these cases environmental factors were also associated. This may indicate either driving that is too aggressive for conditions or possible vehicle blind spots (such as limited or no visibility of a pedestrian before approaching an intersection). A possible measure at signalized intersections would be to employ protected left turn phasing, so that pedestrian and left-turning truck streams do not cross at the same time.

General Observations and Conclusions from the Detailed Analysis

CMV Design Factors

CMV design factors were, as a general rule, difficult to conclusively extract from the dataset. It is possible that the inherent geometric characteristics of an CMV actually had more of an impact than noted (e.g. blind spots, large turning radius etc). This may in part be due to the absence of a location or code on the collision form for easy entry of these factors.

CMV Driver Behaviour Factors

CMV driver behaviour was generally readily extractable from the datasets. However, the root cause of the behaviour was in many instances less apparent. In particular, failing to yield right-of-way was cited but the reason for the failing to yield was not readily extractable. Nonetheless, it is suspected from the collision analysis that in some instances, particularly for turning CMV's, that blind spots may have been an additional factor. Methods for potentially addressing blind spots include bigger mirrors and proximity sensor alarm systems. In some instances, however, side mirrors were associated with a collision. As such, any consideration of modifying mirror size must take into account the added risk of mirror collisions along with the benefit of reduced collisions resulting from better awareness.

VRU Behaviour Factors

For the collisions investigated in detail, there were some notable differences between cyclist factors and pedestrian factors, which is not surprising given the different roadway domains and characteristics of these user types. In many cases, however, the possible contributing factors came under the envelope of "illegal behaviour" for both cyclists and pedestrians; sidewalk cycling and travelling without right-of way for the former and crossing midblock without the right-of-way / entering the intersection without right of way for the latter.

VRU behaviour factors, along with driver behaviour factors, are also more readily obtained and extractable from the collision reports received than are other possible collision factor categories.

The VRU behaviour factors noted may, however, indicate an inherent collision risk for the vulnerable road user with all vehicles; that is to say, the VRU in question may just have likely been involved in a collision with a car as with an CMV. This is particularly true for certain illegal behaviour types such as pedestrian crossing midblock without the right-of-way or riding a bicycle in the crosswalk. As such, there is likely a limit to the ability to consider and address collisions between VRU's and CMV's.

Roadway Geometry and Operations

Roadway geometry and operations were not frequently discernible as a potential contributing factor for collisions between VRU's and CMV's. These factors were, however, commonly cited for midblock cyclist-CMV collisions, which are collisions that lend themselves to an assessment of geometric characteristics (in this case cross section / road width / presence or absence of bike lane etc). This suggests that perhaps roadway geometry and operations factors may play a role in other collisions, but because of the nature and location of those collisions, other factors overshadow the possible contribution of geometry and operation factors. For instance, a proper assessment of the potential impact of operations characteristics on a given collision may require a site visit and assessment by a road safety professional, as the "appropriateness" of a location's operations is generally beyond the scope of a typical police-recorded collision form. Similarly, geometry features may also be more completely captured in this manner.

In terms of roadway geometry, right-turn channelization was associated with only one collision. As such, it may be that right-turn channelization is beneficial for the safety between CMV's and VRU's. On the other hand, right turn channels are generally more frequently employed in suburban arterial circumstances with lower pedestrian and cyclist volumes, and therefore the lack of their noted presence in the collision dataset may instead be a result of limited exposure between VRU's and CMV's where right turn channels are employed (and not any inherent safety benefit). In any case, the effect of right turn channelization on the safety between VRU's and CMV's may be considered for future investigation.

Environmental Factors

Possible environmental factors were frequently cited in collisions between CMV's and pedestrians, but infrequently for collisions between CMV's and cyclists. This discrepancy may in large part be due to the tendency for a majority of cyclists to ride during good weather and daylight conditions in months outside of winter, while pedestrians travel at all times of the year and time of day.

Environmental factors are generally also cited in the presence of other collision factors, where in and of themselves they are not generally noted as the sole collision cause. Also, in many cases the potential environmental factors cited may have in fact had no effect; for example, a driver that loses control in when it is dark may just as well have lost control when it is daylight. Therefore, further examination of environmental factors as pertaining strictly to CMV – VRU collisions should be done with caution, and may in fact be better considered as part of the larger roadway operations / characteristics domain (as pertaining to all road users).

Environmental factors are, however, more strongly related with CMV driver behaviour in left-turn collisions with pedestrians than with CMV driver behaviour for other crash types investigated (for either pedestrians or cyclists); as noted above, these collisions may potentially be addressed through protected left turn phasing.

6 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are made regarding the study of the safe accommodation of vulnerable road users and commercial motor vehicles in urban areas.

Literature Review

The key findings from the literature review are as follows.

- Collisions between VRU's and CMV's are most common at intersections, with right-turn collisions being the most prevalent type.
- For non-intersection collisions, CMV's pass closer to cyclists than do other, smaller, motor vehicles.
- Important truck design factors that influence safety are CMV driver blind spots, adequate lighting, and front-and-side truck design (which influence injury severity).
- Countermeasures identified that may improve the safety of CMV's and VRU's are under-run protection devices (e.g. side guards, which may be of benefit for reducing severity of right-turn and overtaking collisions), impact areas with lower stiffness, side-trailer lighting improvements, pedestrian detection systems, improvements to driver mirror design, improved CMV cab design, improved geometry at intersections, and education campaigns.

Survey

The key findings from the agency survey are as follows:

- The survey results confirm a low number of incidents between VRU's and CMV's.
- Despite the low number of incidences, the issue of safety between VRU's and CMV's was generally viewed by respondents as important.
- Overall, agencies identified the ranking of safety issues between VRU's and CMV's in the following order: 1) road geometry, 2) road operations, 3) CMV characteristics, 4) CMV driver actions, 5) VRU characteristics, 6) VRU actions.
- Agencies would like guidance on safety issues between VRU's and CMV's if available; as such education on the subject would be beneficial.

Collision Analysis

The key findings from the collision analysis are as follows:

- There are somewhat more pedestrian / CMV collisions than cyclist / CMV collisions (20 percent more). The vast majority (95 percent) of collisions between VRU's and CMV's are non-fatal in nature, for both cyclists and pedestrians. Despite this, VRU fatalities resulting from collisions with CMV's are a particular concern, since in terms of total VRU fatalities (considering all vehicle types) CMV's are frequently involved (with 8 percent of pedestrian and two thirds of cyclist fatalities involving a CMV).

- For midblock collisions between cyclists and CMV's, limited width was often an associated factor. This indicates that bike lanes and/or restricted parking may be potential mitigation measures in order to provide a wider navigable roadway cross section.

- CMV driver behaviour for midblock collisions was, when cited, generally either poor lane change or fail to yield right-of-way. This indicates that visibility or driver awareness enhancements could be of potential benefit.

- At intersections, driver and cyclist behaviour was both commonly cited. Therefore increased education for these road users of the safety issues between one another may be of benefit.

- Illegal behaviour on the part of VRU's was often cited as a potential contributing collision factor; in combination with CMV characteristics the results can be lethal. Note, however, that in the agency survey VRU behaviour was cited as the least important contributing safety factor, indicating a disparity between perception and actuality. Therefore education (for both road users and designers) and injury reduction techniques (e.g. sideguards) may therefore be of benefit.

Collision Data and Analysis Considerations

There were data limitations which reduced the ability to investigate collision characteristics and trends. This was partly due to the small number of collision instances between VRU's and CMV's. In many cases jurisdictions were unable to provide the detailed collision report forms with collision diagrams, which further hindered the ability to perform more detailed analysis. This was either due to lack of data or privacy concerns. Even when collision report forms were provided, it was found that there was a lack of potentially relevant information, in particular as related to CMV design issues. Also, while CMV driver behaviour factors were often extractible, the root cause of the behaviour was not. (For example, "fail to yield" may be cited, but no reference to possible contributing blind spots was noted.) Because of these constraints, further statistical analysis would likely best be performed at the local or municipal level, where data is generally available and where site visits / local knowledge could enhance the analysis by incorporating more road geometry and operations characteristics.

6.1 Recommendations

Based on the findings from the literature review, survey, and collision analysis, the following recommendations are made for further investigating and/or improving the safety between VRU's and CMV's in urban areas.

Need for Education

- Education of VRU's and CMV operators regarding safety issues between each other

- Education of roadway designers, so that they are aware of, and consider, safety issues between VRU's and CMV's

Enhanced Collision Data Collection

- Standardization of the collision report form across jurisdictions, which would allow for more uniform cross-country analysis

- Either (1) modification of the police collision reporting form or (2) a new form used only for collisions involving CMV's, for enlisting police officers to explicitly assess unique CMV factors which may have contributed to a collision (in particular CMV design factors of large turning radius and blind spots).

Further VRU / CMV Collision Data Research Approach

- It is recommended that any further detailed research into collisions between VRU's and CMV's be undertaken at the municipal level, and to be done in a targeted approach for a specific crash type (e.g. right turns at intersections). This is because at the municipal / local level it is possible to investigate potential trends and factors in a way which is not readily practicable at the national level, where field visits and consideration of specific roadway operations are possible. It is also recommended that only those most frequently identified crash types in this report be considered for future analysis, to best have the potential for investigating trends and possible causal factors.

CMV Design & Characteristics Research

- Investigation of techniques for improving driver awareness and reducing collision severity (e.g. larger mirrors, proximity sensor alarm systems, cameras, side guards, etc), including benefits, drawbacks, barriers to implementation, etc.

Roadway Geometry and Operations Research

- Investigation into the effect of installing bicycle lanes along high CMV and cyclist volume corridors. This could potentially be done through a comparative analysis within a jurisdiction, comparing safety between a location with and without bike lanes.

- Investigation into the effects of prohibiting parking on high CMV and cyclist volume corridors.

- Investigation of the effect of right turn channelization on the frequency of CMV/VRU collisions, as a potential mitigation measure.

- Investigation of the effect of protected left turn phasing on reducing the frequency of CMV/pedestrian collisions.

- Investigation of methods for separating right-turning CMV's from through-movement pedestrians at an intersection.

GLOSSARY

Collision – generic term for an incident

Crash Type – a collision as defined in the crash typology

Crash Typology – a codified list of possible contributing factors and of crash types, used in the detailed collision analysis task.

Impact Type – a collision characteristic coded in police collision reports

Illegal Behaviour – an action by a pedestrian, cyclist, or motor vehicle in contravention of basic roadway operations and rules of the road in an atypical / unexpected fashion, such as disobeying traffic control (e.g. running a red light), cycling on the sidewalk or in a crosswalk, wrong way cycling, or a pedestrian crossing midblock without the right-of-way. While other actions are also technically "illegal", such as poor lane change or poor turn, they were not coded as "illegal" if the manoeuvre was deemed a typical roadway action (as would, for example, be the case for a poor lane change, which would instead be coded as unsafe behaviour).

Commercial Motor Vehicle (CMV) – a commercial motor vehicle is defined as a truck, tractor, trailer or combination thereof exceeding a registered gross vehicle weight of 4,500 kg, or a bus designed, constructed, and used for the transportation of passengers with a designated seating capacity of more than 10, including the driver, but excluding the operation for personal use.

Vulnerable Road User (VRU) – road users which are exposed without a protective vehicle frame e.g. pedestrians, cyclists, and wheelchair users (including young, elderly, and hearing or vision impaired persons).

REFERENCES

Akiyama, K. (2003). "Analysis of Large Truck Accidents in Japan", Proceedings from the 18th International Technical Conference on the Enhanced Safety of Vehicles, Nagoya, Japan. Available online, http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv18/cd/files/18ESV-000243.pdf

Chawla, A; Mohan, D; Sharma, V; Kajzer, J (2000). "Safer Truck Front Design for Pedestrian Impacts", Journal of Crash Prevention and Injury Control, Vol. 2, No. 1, pp 33-43.

Goodno, M. (2004). "Bicycle Collisions in the District of Columbia: 2000-2002", District Department of Transportation, Washington D.C.

Haworth, N. and Symmons, M. (2003). "Review of Truck Safety – Stage 2: Update of Crash Statistics", Monash University Accident Research Centre, Monash University, Victoria, Australia.

Mukherjee, S.; Chawla, A.; Mohan, D.; Singh, M.; and Dey, R (2006). "Effect of Vehicle Design on Head Injury Severity and Throw Distance Variations in Bicycle Crashes", Proceedings from the 20th International Technical Conference on the Enhanced Safety of Vehicles, Lyon, France. Available online, http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv20/07-0467-O.pdf

Niewoehner, W. and Berg, F.A. (2005). "Endangerment of Pedestrians and Bicyclists at Intersections by Right Turning Trucks", Proceedings from the 19th International Technical Conference on the Enhanced Safety of Vehicles, Washington D.C. Available online, http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv19/05-0344-O.pdf

Olejnik, K. (2007). "Evaluating the Need for Changing Current Requirements Towards Increasing the Amount of Lighting Devices Equipping Semi Trailers", Proceedings from the 20th International Technical Conference on the Enhanced Safety of Vehicles, Lyon, France. Available online, http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv20/07-0135-O.pdf

OECD (1998). "Safety of Vulnerable Road Users", Organisation for Economic Co-operation and Development, Paris, France.

Oxley, J.; Corben, B.; Fildes, B.; and O'Hare, M. (2003). "Older Vulnerable Road Users – Measures to Reduce Crash and Injury Risk", Monash University Accident Research Centre, Monash University, Victoria, Australia.

Riley B.S., Penoyre, S. and Bates, H.J. (1985) "Protecting Car Occupants, Pedestrians, and Cyclists in Accidents Involving Heavy Goods Vehicles by Using Front Underrun Bumpers and Sideguards", International Technical Conference ON,

Retting, R. (1993). "A Study of Fatal Crashes Involving Pedestrians and Trucks in Four Cities", Journal of Safety Research, Vol 24, no 4, pp 195-203.

Transport Canada (1999). "Technical Standards Document No. 131; School Bus Pedestrian Safety Devices", Motor Vehicle Standards and Research Branch, Road Safety and Motor Vehicle Regulation Directorate, Transport Canada, Ottawa, ON.

United Nations (1988), "Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, Addendum 72, Regulation No. 73, Uniform Provisions Concerning the Approval of Goods Vehicles, Trailers and Semi-Trailers with Regard to their Lateral Protection", United Nations.

Walker, I. (2007). "Drivers overtaking Bicyclists: Objective data on the effects of riding position, helmet use, vehicle type and apparent gender", Accident Analysis and Prevention, Vol 39, pp 417-425.

Walz, F.H.; Strub, C; Baumann, U; and Marty, W. (1990). "Collisions of Heavy Trucks against Cars, Two-Wheelers and Pedestrians", Proceedings from the 1990 International IRCOBI Conference on the Biomechanics of Impacts, pp 37-44, Bron-Lyon, France

Yang, J. and Otte, D. (2007) "A Comparison Study on Vehicle Traffic Accident and Injuries of Vulnerable Road Users in China and Germany", Proceedings from the 20th International Technical Conference on the Enhanced Safety of Vehicles, Lyon, France. Available online, http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv20/07-0417-O.pdf

APPENDIX A

Survey Questionnaire

TAC STUDY ON SAFE ACCOMMODATION OF VULNERABLE ROAD USERS AND LARGE COMMERCIAL VEHICLES IN URBAN AREAS

SURVEY

The following survey is in regards to the study currently commissioned by the Transportation Association of Canada (Road Safety Standing Committee) investigating the safe accommodation of vulnerable road users (VRU's) and large commercial vehicles (LCV's) in urban areas. This topic is an important issue because of the potentially severe nature of collisions between these road user groups. There is, however, only a relatively small number of studies that have investigated the issues pertaining specifically to collisions and/or conflicts between VRU's and LCV's. This study was commissioned with the goal of determining the characteristics of these collisions and to identify possible counter-measures for further research.

This survey is intended to garner information from the various perspectives for which this issue is of particular concern, from groups such as road authorities, safety researchers, commercial vehicle operators, and vulnerable road user groups. The results will assist in the understanding of the issues and will also help facilitate the next steps in the project, which is the undertaking of detailed VRU/LCV collision analysis.

Please fill in the questionnaire as much as possible, and where a section is not relevant to your field or agency please answer "Not Applicable".

Definitions:

- **Vulnerable Road User (VRU) – road users which are exposed without a protective vehicle frame e.g. pedestrians, cyclists, and wheelchair users (including young, elderly, and hearing or vision impaired persons).**
- **Large Commercial Vehicle (LCV) – vehicles larger than cars and pickup trucks e.g. single unit trucks, buses, dump trucks, tractor-semi trailers, tractor-double trailers, tractor triple trailer combinations, and bobtails.**

General

1.a) What is the name of your agency? ____

City / Jurisdiction: ____

City / Jurisdiction Population: ____

Contact Name / Phone Number: ____

1.b) What type of agency do you represent?

❍ **Road Authority**

❍ **Safety or research Organization**

❍ **Commercial Vehicle Operations**

❍ **Pedestrian / Cyclist Organization**

❍ **Other ____**

2) How important are VRU and LCV safety issues to your agency?

❍ **Very Important** ❍ **Somewhat Important** ❍ **Somewhat Unimportant** ❍ **Not at All Important**

❍ **Not Applicable**

If somewhat important or very important, how is this importance realized in your agency? (i.e. specific policy (please send), research, actions, commitments for improvements, design standards):

____

____

Safety Issues / Factors

3a) Please rank the following factors from 1 (most important) to 6 (least important) in the order that you feel they most contribute to safety concerns between VRU's and LCV's in urban areas:

- ❍ **Road Geometry (design speed, lane widths, boulevards, sidewalk widths, etc)**
- ❍ **Road Operations (speed limits, traffic control, volume, etc)**
- ❍ **LCV Characteristics (vehicle size, weight etc)**
- ❍ **LCV Driver Actions**
- ❍ **VRU Characteristics (age, ability etc)**
- ❍ **VRU Actions**

3b) If you feel there are other important factors that contribute to the safety issues between VRU's and LCV's in urban areas, please specify:

____

____

3c) If you have any further comments regarding safety factors please elaborate below:

____

____

Design and Safety Strategies

4) Is VRU and LCV safety conflicts an explicit consideration in roadway designs for your agency?

❍ **Yes** ❍ **No** ❍ **Not Applicable**

If yes, please describe:

____

5) Would you be interested in changing design parameters if VRU/LCV safety benefits become apparent through research?

❍ **Yes** ❍ **No**

If yes, please describe areas that would be of greatest benefit:

____

Collision Statistics / Research

6) Does your agency catalogue:

6a) vulnerable road user collisions?

❍ Yes ❍ No ❍ Not Applicable

6b) large commercial vehicle collisions?

❍ Yes ❍ No ❍ Not Applicable

6c) collisions between VRU's and LCV's in urban areas?

❍ Yes ❍ No ❍ Not Applicable

6d) If yes to c), how readily available is the data (please check all that apply):

❍ Is regularly calculated for all VRU's (please enter the percent of annual collisions between VRU's and LCV's in your urban area) ____________________

❍ Is regularly calculated by VRU type (please enter the percent of annual collisions between VRU's and LCV's in your urban area)

% LCV / VRU collisions (Pedestrians): ____________________

% LCV / VRU collisions (Cyclists): ____________________

❍ Is readily calculable (if possible, please enter the percent of annual collisions between VRU's and LCV's in your urban area)

% LCV / VRU collisions (All VRU's): ____________________

% LCV / VRU collisions (Pedestrians): ____________________

% LCV / VRU collisions (Cyclists): ____________________

❍ Not readily calculable

6e) If no to c), what factors preclude doing so? (check all that apply)

❍ data availability

❍ not historically derived

❍ low number of VRU and LCV incidents

❍ viewed as not generally helpful

❍ Other (please specify) ____

7a) Has your agency conducted research on safety issues between VRU's and LCV's?

❍ **Yes** ❍ **No** ❍ **Not Applicable**

7b) If yes, what type of research:

❍ **collision statistics based research**

❍ **nature of collision impacts (e.g. trauma research, vehicle design vis a vis bodily harm, etc)**

❍ **human factors**

❍ **Other** ____

7c) If yes to b) please elaborate on the nature of the research

____

____

8a) Have specific problem areas related to VRU's and LCV's been identified in your urban area?

❍ **Yes** ❍ **No** ❍ **Not Applicable**

8b) If so, have countermeasures been implemented on a site-specific basis? (please elaborate)

____

____

8c) Has follow-up evaluation been undertaken for implemented countermeasures? If so what has been the success of the measures? (please elaborate)

____

____

TAC Study Facilitation

9) Would your agency be willing to assist the collision analysis portion of this study through the provision of pertinent data sets, such as VRU/LCV collision data, roadway geometry / mapping, roadway operation features, traffic volumes, etc?

❍ **Yes** ❍ **No** ❍ **Not Applicable**

Please feel free to add any additional comments, concerns, or ideas.

____

____

____

____

____

____

____

ÉTUDE DE L'ATC SUR LES AMÉNAGEMENTS SÉCURITAIRES POUR LES USAGERS VULNÉRABLES DE LA ROUTE ET LES GROS VÉHICULES COMMERCIAUX EMPRUNTANT LES ZONES

Le questionnaire qui suit vous est envoyé dans le cadre de l'étude sur les «aménagements sécuritaires pour les usagers vulnérables de la route et les gros véhicules commerciaux empruntant les zones urbaines» commandée par le Comité permanent de la sécurité routière de l'Association des transports du Canada. Vu le caractère potentiellement grave des collisions entre ces groupes d'usagers de la route, l'importance du sujet ne fait aucun doute. Or, on ne dispose aujourd'hui que d'un nombre relativement restreint d'études consacrées aux questions qui se rapportent spécifiquement aux collisions et (ou) aux conflits entre les usagers vulnérables de la route et les gros véhicules commerciaux. La présente étude a été commandée dans le but de déterminer les caractéristiques des ces collisions et de dégager d'éventuelles contre-mesures à soumettre à des études ultérieures.

Le questionnaire est destiné à recueillir des informations auprès des groupes pour lesquels ce dossier représente une préoccupation majeure tels que les autorités routières, les chercheurs dans le domaine de la sécurité, les exploitants de véhicules commerciaux et les groupes d'usagers vulnérables de la route. Les réponses permettront de mieux comprendre les enjeux et faciliteront la réalisation des prochaines étapes du projet au cours desquelles on procédera à des analyses détaillées des collisions entre les usagers vulnérables de la route et les gros véhicules commerciaux.

Nous vous demandons de répondre au plus grand nombre de questions possible et de choisir «Ne s'applique pas» lorsqu'une partie du questionnaire ne concerne pas votre domaine d'intervention ou celui de votre organisme.

Définitions:

- Usagers vulnérables de la route – usagers de la route qui sont exposés en cas de collision en raison de l'absence d'un châssis de véhicule protecteur, notamment les piétons, les cyclistes et les usagers de chaises roulantes (parmi lesquelles on retrouve des jeunes, des personnes âgées et des personnes malentendantes et malvoyantes).
- Gros véhicules commerciaux – véhicules plus gros que les voitures et les camionnettes, p. ex., camions non articulés, autobus, camions à benne basculante, tracteurs semi-remorques, trains routiers doubles, trains routiers triples et tracteur circulant sans semi-remorque.

Généralités

1.a) Quel est le nom de votre organisme? ____

Ville / Province ou territoire: ____

Ville / Population de la province ou du territoire: ____

Nom et numéro de téléphone d'une personne-contact: ____

1.b) Quel type d'organisme représentez-vous?

❍ Autorité routière

❍ Organisme de recherche ou de prévention des accidents

❍ Exploitant de véhicules commerciaux

❍ Organisme de piétons ou de cyclistes

❍ Autre ____

2) Comment qualifieriez-vous l'importance pour votre organisme des problèmes de sécurité posés par les interactions entre les usagers vulnérables de la route et les gros véhicules commerciaux?

❍ Très importants ❍ Quelque peu importants ❍ Plutôt peu importants ❍ Pas du tout importants

❍ Ne s'applique pas

Si vous avez répondu «quelque peu importants» ou «très importants», comment cette importance se reflète-t-elle au sein de votre organisme? (p ex., politique précise en la matière (prière de nous la faire parvenir), recherche, interventions, engagements à apporter des améliorations, normes de conception):

____

____

Questions et facteurs relatifs à la sécurité

3a) Attribuez une cote sur une échelle de 1 (plus important) à 6 (moins important) aux facteurs suivants selon qu’ils contribuent plus ou moins aux problèmes de sécurité posés par les interactions entre les usagers vulnérables de la route et les gros véhicules commerciaux dans les zones urbaines:

❍ Géométrie routière (vitesse de base, largeurs des voies, boulevards et trottoirs, etc.)

❍ Exploitation routière (limites de vitesse, contrôles routiers, volumes, etc.)

❍ Caractéristiques des gros véhicules commerciaux (dimensions, poids, etc.)

❍ Comportement des conducteurs des gros véhicules commerciaux

❍ Caractéristiques des usagers vulnérables de la route (âge, habileté, etc.)

❍ Comportements des usagers vulnérables de la route

3b) Si vous pensez qu’il y a d’autres facteurs importants qui contribuent aux problèmes de sécurité posés par les interactions entre les usagers vulnérables de la route et les gros véhicules commerciaux dans les zones urbaines, précisez-les, s’il vous plaît:

____

____

3c) Si vous avez d’autres commentaires au sujet des facteurs qui influent sur la sécurité, formulez-les ici, s’il vous plaît:

____

____

Stratégies en matière de conception et de sécurité

4) Les conflits de sécurité entre les usagers vulnérables de la route et les gros véhicules commerciaux figurent-ils parmi les considérations explicites à intégrer à la conception des routes selon votre organisme?

❍ Oui ❍ Non ❍ Ne s'applique pas

Si vous avez répondu «oui», précisez, s'il vous plaît:

____

5) Seriez-vous disposé à modifier vos paramètres de conception si la recherche sur les usagers vulnérables de la route et les gros véhicules commerciaux sécurité faisait clairement ressortir des avantages sur le plan de la sécurité?

❍ Oui ❍ Non

Si vous avez répondu «oui», décrivez, s'il vous plaît, les aspects qui apporteraient les plus grands avantages:

____

Statistiques et études sur les collisions

6) Votre organisme recense-t-il:

6a) les collisions subies par les usagers vulnérables de la route?

❍ Oui ❍ Non ❍ Ne s'applique pas

6b) les collisions subies par les gros véhicules commerciaux?

❍ Oui ❍ Non ❍ Ne s'applique pas

6c) les collisions entre les usagers vulnérables de la route et les gros véhicules commerciaux dans les zones urbaines?

❍ Oui ❍ Non ❍ Ne s'applique pas

6d) Si vous avez répondez «oui» à c), dans quelle mesure est-il facile d'avoir accès aux données (prière de cocher toutes les réponses qui s'appliquent):

❍ Données régulièrement recueillies pour tous les usagers vulnérables de la route (indiquez, s.v.p., le pourcentage annuel des collisions entre les usagers vulnérables de la route et les gros véhicules commerciaux dans votre zone urbaine)

____

❍ Données régulièrement compilées par type d'usager vulnérable de la route type (indiquez, s.v.p., le pourcentage annuel des collisions entre les usagers vulnérables de la route et les gros véhicules commerciaux dans votre zone urbaine)

% des collisions entre les gros véhicules commerciaux et les usagers vulnérables de la route (piétons): ____________________

% des collisions entre les gros véhicules commerciaux et les usagers vulnérables de la route (cyclistes): ____________________

❍ Données faciles à compiler (dans la mesure du possible, indiquez le pourcentage annuel des collisions entre les usagers vulnérables de la route et les gros véhicules commerciaux dans votre zone urbaine)

% des collisions entre les gros véhicules commerciaux et les usagers vulnérables de la route (tous les usagers vulnérables de la route): ____________________

% des collisions entre les gros véhicules commerciaux et les usagers vulnérables de la route (piétons): ____________________

% des collisions entre les gros véhicules commerciaux et les usagers vulnérables de la route (cyclistes): ____________________

❍ Données difficiles à compiler

6e) Si vous avez répondu «non» à c), quels facteurs vous en empêchent? (Prière de cocher toutes les réponses qui s'appliquent)

❍ Données non disponibles

❍ Absence de dossiers historiques sur les données disponibles

❍ Faible nombre d'incidents entre les usagers vulnérables de la route et les gros véhicules commerciaux

❍ Exercice généralement perçu comme peu utile

❍ Autre (prière de préciser) ____

7a) Votre organisme a-t-il fait de la recherche sur les problèmes de sécurité posés par les interactions entre les usagers vulnérables de la route et les gros véhicules commerciaux?

❍ Oui ❍ Non ❍ Ne s'applique pas

7b) Si vous avez répondu «oui», quel type de recherche?

❍ Études des statistiques sur les collisions

❍ Études de la nature des impacts des collisions (p. ex., traumatismes, rapports entre les caractéristiques des véhicules et les blessures corporelles, etc.)

❍ Facteurs humains

❍ Autres ____

7c) Si vous avez répondu «oui» à b), décrivez la nature de la recherche de manière plus détaillé, s'il vous plaît.

____

____

8a) A-t-on constaté des problèmes particuliers relatifs aux usagers vulnérables de la route et aux gros véhicules commerciaux dans votre zone urbaine?

❍ Oui ❍ Non ❍ Ne s'applique pas

8b) Si vous avez répondu «oui», des contre-mesures ont-elles été mises en place à des endroits particuliers? (Prière de préciser)

____

____

8c) Les contre-mesures mises en place ont-elles fait l'objet d'un suivi? Dans l'affirmative, de quelle façon les mesures ont-elles réussi à remédier aux problèmes? (Prière de préciser)

____

____

Collaboration à l'étude de l'ATC

9) Votre organisme serait-il disposé à contribuer au volet «analyse des collisions» de la présente étude en fournissant des des données pertinentes telles que des données sur les collisions entre les usagers vulnérables de la route et les gros véhicules commerciaux, la géométrie et (ou) la cartographie routière, les caractéristiques d'exploitation de votre réseau routier, les volumes de circulation, etc?

❍ Oui ❍ Non ❍ Ne s'applique pas

N'hésitez pas à nous faire part de tout autre commentaire ou toute autre préoccupation ou suggestion qui vous semble à propos.

____

____

____

____

____

____

____

APPENDIX B

Survey – Feedback Details

Safety Issues / Factors – Additional Factors Noted by Survey Respondents

In addition to those items listed in the main document, there were some general suggestions and identification of specific items (that would fall in one of the categories) given:

- Lack of accommodation for vulnerable road users (mentioned twice)
- Driver training (mentioned four times)
- VRU defensive action training (mentioned twice
- Managing truck routes (mentioned twice)
- Should focus only on items for which practitioners can have control on
- Specific geometry concerns (twice)
- CMV's blocking sight lines (mentioned twice)
- Transportation demand management (e.g. reduce / manage truck deliveries, promote active travel modes)

Further comments identified were:

- Engine brake noise is an issue (can scare pedestrians)
- CMV underride protection can help improve safety
- Lack of enforcement of moving violations an issue
- Increasing numbers of CMV's on the road can frustrate others e.g. VRU's
- Age of VRU may result in unpredictable behaviour (both the young and elderly)
- Separate VRU's from CMVs as much as possible
- Need to view traffic safety from a systems thinking approach
- Crosswalk design (respondent stated that they use flourescent yellow green of the school zone signs or all vehicle/pedestrian related conflict signs to heighten driver awareness, & use of red/amber/green half signals rather than the TAC flashing amber pedestrian crossing signal to provide a more protected crossing)

APPENDIX C

Crash Typology

Crash Type

1 LCV turning left struck VRU proceeding with ROW
2 LCV turning left struck VRU proceeding without ROW
3 LCV turning right at signal on green, struck VRU
4 LCV turning right at signal on red, struck VRU
5 LCV turning right (unsignalized) struck VRU proceeding with ROW
6 LCV turning right (unsignalized) struck VRU proceeding without ROW
7 LCV proceeding straight though intersection struck VRU proceeding with ROW
8 LCV going straight though intersection struck VRU proceeding without ROW
9 VRU struck on road at mid-block location (not at Ped X-ing)
10 LCV exiting lane or private drive struck VRU on sidewalk
11 LCV Overtaking Cyclist (“rear-end” or “side-swipe” collision)
12 LCV door opens in cyclist's path, striking cyclist
13 LCV reversing struck VRU
14 Other
15 VRU striking LCV
16 LCV turning right at signal (signal phase unknown)

Possible Contributing Factors

LCV Design Factors

1 exposed wheels
2 large turning radius
3 mechanical defects
4 blind spots
5 side mirrors

Road Geometry & Operational Factors

11 obstructed sight-lines
12 roadway lanes/cross-section (insufficient lane width, number of lanes, presence/absence of bike lanes, presence/absence of curbs, sidewalks etc)
13 intersection turn geometry
14 road alignment (grades, vertical curvature, horizontal curvature)
15 short pedestrian crossing time
16 other signal phase issues
17 slippery road/pavement surface
18 faded and/or misunderstood markings/signage
19 parked / stopped vehicle
20 drainage issue

Behavioural Factors

21 unsafe passing, lane change, turns etc.
22 excessive speed
23 illegal VRU action (sidewalk cycling, jaywalking, illegal contraflow cycling, ignore traffic control)
24 fail to yield right-of-way
25 inattention
26 loss of control
27 intoxication
28 aggressive driving
29 limited VRU mobility (child, elderly, disabled)
30 medical or physical disability

Environmental Factors

31 poor visibility (rain, fog, glare, lighting issues)
32 poor road conditions (rain, ice, snow etc)
33 obstructed sight-lines
34 road work
35 VRU's path obstructed

APPENDIX D

Transport Canada - Summary of Commercial Motor Vehicle Collisions Involving Pedestrians and Cyclists

This Appendix contains one set for bicycle-CMV urban injury collisions (files prefixed with "BL") and one set for pedestrian-CMV urban injury collisions (files prefixed with "PL"). This data has been extracted from the National Collision Database (NCDB) and contains data for the years 2004 to 2006. Note that the analysis is limited to Fatal and Injury collisions only. Property Damage-Only collisions are excluded as they are under-reported and, when reported, the data is of poor quality. Furthermore, note that Manitoba is excluded from the analysis as they do not distinguish between urban and rural locations. Also, note that some tables have further data missing from certain jurisdictions. In these cases, the data elements are coded as 'Not Provided' and the documentation below states the jurisdiction missing from the data element.

The bicycle-CMV analysis is performed on 499 collisions. For ease of analysis, these collisions contain exactly one bicycle and one CMV. 28 collisions also involving other vehicle types or pedestrians were deleted, three collisions involving multiple bicycles were deleted and two collisions involving multiple CMVs were deleted.

The pedestrian-CMV analysis is performed on 1055 collisions. For ease of analysis, these collisions contain exactly one pedestrian and one CMV. 161 collisions also involving other vehicle types were deleted and seven collisions involving multiple CMVs were deleted.

The contents of the files with the bicycle-CMV urban injury collision data are as follows:

BL1, Bicycle CMV Urban Collisions.htm

This file contains data at the collision level. There is one cross-tabulation for each of the 14 data elements below by C_SEV (collision severity):

C_YEAR (Year)
C_PROV (Province)
C_MNTH (Month)
C_WDAY (Day of Week)
C_HOUR (Hour)
C_CONF (Configuration)
C_RCFG (Roadway Configuration)
C_WTHR (Weather)
C_LITE (Light Condition)
C_RCL3 (Road Classification III)
C_RCON (Road Condition)
C_RALN (Road Alignment)
C_TRAF (Traffic Control)
C_SPED (Posted Speed Limit)

In addition to Manitoba being excluded from the entire analysis, note the following caveats:

- Nova Scotia and Quebec do not provide C_RCL3 (Road Classification III)
- British Columbia does not provide C_RCON (Road Condition)
- Alberta does not provide C_SPED (Posted Speed Limit)

In these situations, the data element is coded as 'Not Provided' for that jurisdiction.

BL2, CMV Vehicle Types.htm

This file has a cross-tabulation showing the distribution of CMV vehicle types by collision severity.

BL3, Bicycle Maneuver.htm

This file has a cross-tabulation showing the distribution of bicycle maneuver (the actual movement of the vehicle just prior to the collision) by collision severity. Note that Alberta does not provide this data element. Bicycles from Alberta are coded as 'Not Provided' in this table.

BL4, CMV Maneuver.htm

This file has a cross-tabulation showing the distribution of CMV maneuver (the actual movement of the vehicle just prior to the collision) by collision severity. Note that Alberta does not provide this data element. CMVs from Alberta are coded as 'Not Provided' in this table.

BL5, Bicyclist Condition and Action.htm

This file has two cross-tabulations showing the distribution of bicyclists by V_CF1 (Driver Condition) and collision severity and V_CF2 (Driver Action) by collision severity. Note that only Ontario, Alberta, Northwest Territories and Nunavut are included in the analysis. This is due to the nature of the way the four NCDB contributing factors are collected. These factors have 4 categories: driver/pedestrian condition, driver action, vehicular contributing factor and environmental. They are difficult to analyze as some jurisdictions (NF, PE, NS, NB, MB, SK, BC & YK) pick the four most important codes from a pool of codes from all categories (called "prioritized") and some jurisdictions (ON, AB, NT & NU) pick one code from each category (called "non-prioritized"). In this case, a distribution of driver condition codes only are required so therefore the analysis is limited to those jurisdictions that do not "prioritize".

BL6, CMV Driver Condition and Action.htm

Same as previous cross-tabulation except that it counts CMV drivers rather than bicyclists.

BL7, Bicyclists Speeding.htm

This file has a cross-tabulation that identifies whether a bicyclist was considered to be speeding prior to the collision or not. Speeding is determined by one of the four contributing factors being coded as "Driving too fast for conditions". Since Quebec does not collect any contributing factors, they are excluded from the analysis.

BL8, CMV Drivers Speeding.htm

Same as previous cross-tabulation except that it counts CMV drivers rather than bicyclists.

The contents of the files with the pedestrian-CMV urban injury collision data are as follows:

<u>PL1, Pedestrian CMV Urban Collisions.htm</u>

Same as <BL1, Bicycle CMV Urban Collisions.htm> above except with collisions involving pedestrians rather than bicyclists.

<u>PL2, CMV Vehicle Types.htm</u>

Same as < BL2, CMV Vehicle Types.htm> above except with collisions involving pedestrians rather than bicyclists.

<u>PL3, CMV Maneuver.htm</u>

Same as <BL4, CMV Maneuver.htm> above except with collisions involving pedestrians rather than bicyclists.

<u>PL4, Pedestrian Action 2.htm</u>

This cross-tabulation does not have an equivalent in the set of bicycle-CMV cross-tabs. It counts pedestrians and shows the distribution of pedestrian action (the action of the involved pedestrian just prior to the occurrence of the collision) by personal injury severity.

<u>PL5, CMV Driver Condition and Action.htm</u>

Same as <BL6, CMV Driver Condition and Action.htm> above except with collisions involving pedestrians rather than bicyclists.

<u>PL6, CMV Drivers Speeding.htm</u>

Same as <BL8, CMV Drivers Speeding.htm> above except with collisions involving pedestrians rather than bicyclists.

BICYCLE AND LCV URBAN INJURY COLLISIONS

Cyclist-CMV Collisions / Year			
C_YEAR(Year)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
2004	7	162	169
2005	7	153	160
2006	10	160	170
Total	24	475	499

Cyclist-CMV Collisions by Province			
C_PROV(Province)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
NF	0	1	1
NS	1	2	3
NB	0	3	3
QC	7	129	136
ON	11	181	192
SK	1	8	9
AB	1	66	67
BC	3	85	88
Total	24	475	499

Cyclist-CMV Collisions by Month			
C_MNTH(Month)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Jan	0	6	6
Feb	0	6	6
Mar	1	14	15
Apr	2	35	37
May	3	57	60
June	3	77	80
July	3	56	59
Aug	2	77	79
Sept	2	71	73
Oct	5	42	47
Nov	2	26	28
Dec	1	8	9
Total	24	475	499

Cyclist-CMV Collisions by Day of Week			
C_WDAY(Day of Week)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Mon	2	73	75
Tue	4	92	96
Wed	6	89	95
Thur	7	84	91
Fri	4	85	89
Sat	1	31	32
Sun	0	21	21
Total	24	475	499

Cyclist-CMV Collisions by Hour of Day			
C_HOUR(Hour)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Midnight to 00:59	0	2	2
01:00 to 01:59	0	2	2
02:00 to 02:59	0	1	1
05:00 to 05:59	0	4	4
06:00 to 06:59	1	12	13
07:00 to 07:59	0	28	28
08:00 to 08:59	3	40	43
09:00 to 09:59	0	31	31
10:00 to 10:59	1	25	26
11:00 to 11:59	1	25	26
12:00 to 12:59	4	28	32
13:00 to 13:59	3	20	23
14:00 to 14:59	1	34	35
15:00 to 15:59	3	53	56
16:00 to 16:59	1	56	57
17:00 to 17:59	0	44	44
18:00 to 18:59	3	19	22
19:00 to 19:59	1	21	22
20:00 to 20:59	1	11	12
21:00 to 21:59	0	9	9
22:00 to 22:59	1	3	4
23:00 to 23:59	0	3	3
Unknown	0	4	4
Total	24	475	499

Cyclist-CMV Collisions by Configuration			
C_CONF(Configuration)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
1V : Run Off - Right	0	1	1
1V : Other single veh	0	7	7
2V1D : Rear end	1	26	27
2V1D : Side-swipe	4	73	77
2V1D : Passing to Left	0	19	19
2V1D : Passing to Right	3	43	46
2V1D : Other 2-veh, same dir.	0	5	5
2V2D : Head-on	0	10	10
2V2D : Approaching Sideswipe	0	14	14
2V2D : Left Turn across Traffic	0	11	11
2V2D : Right Turn	1	3	4
2V2D : Right Angle	2	104	106
2V2D : Other 2-veh, diff. dir.	6	76	82
Other	2	24	26
Unknown	5	59	64
Total	24	475	499

Cyclist-CMV Collisions by Roadway Configuration			
C_RCFG(Roadway Configuration)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Non-intersection	8	137	145
Intersection with Public Road	14	260	274
Intersection with Private Road	1	23	24
Railroad crossing	0	1	1
Bridge	0	6	6
Underpass	0	1	1
Ramp	0	1	1
Other	0	6	6
Unknown	1	40	41
Total	24	475	499

Cyclist-CMV Collisions by Weather			
C_WTHR(Weather)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Clear	20	406	426
Cloudy	3	36	39
Rain	1	22	23
Snow	0	2	2
Sleet, Hail	0	2	2
Other	0	1	1
Unknown	0	6	6
Total	24	475	499

Cyclist-CMV Collisions by Light Condition			
C_LITE(Light Condition)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Daylight	20	423	443
Dawn	0	1	1
Dusk	0	6	6
Dawn or Dusk	0	4	4
Darkness	4	37	41
Unknown	0	4	4
Total	24	475	499

Cyclist-CMV Collisions by Road Classification			
C_RCL3(Road Classification III)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
1-way, 1-2 lanes	0	12	12
1-way, >2 lanes	0	3	3
Undivided, 2 way, 2 lanes	12	192	204
Undivided, 2 way, >2 lanes	2	17	19
Divided with barrier	0	9	9
Divided with no barrier	0	9	9
Divided (not specified)	1	38	39
Other	0	1	1
Unknown	1	63	64
Not Provided	8	131	139
Total	24	475	499

Cyclist-CMV Collisions by Road Condition			
C_RCON(Road Condition)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Good	21	369	390
Ruts, Potholes	0	2	2
Under Repair	0	5	5
Other	0	5	5
Unknown	0	9	9
Not Provided	3	85	88
Total	24	475	499

Cyclist-CMV Collisions by Road Alignment			
C_RALN(Road Alignment)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Straight, Level	14	351	365
Straight, Grade	7	49	56
Curved, Level	1	25	26
Curved, Grade	1	10	11
Unknown	1	40	41
Total	24	475	499

Cyclist-CMV Collisions by Traffic Control			
C_TRAF(Traffic Control)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Signals Working	7	147	154
Signals Flashing Mode	0	1	1
Stop Sign	5	70	75
Yield Sign	0	4	4
Pedestrian Crossing	0	5	5
Guard/Flagman	1	2	3
No Traffic Control	11	229	240
Other	0	9	9
Unknown	0	8	8
Total	24	475	499

Cyclist-CMV Collisions by Posted Speed Limit			
C_SPED(Posted Speed Limit)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
<40 km/h	0	8	8
40 km/h	3	21	24
50 km/h	14	302	316
60 km/h	3	41	44
70 km/h	0	6	6
80 km/h	0	4	4
90 km/h	1	1	2
Unknown	2	26	28
Not Provided	1	66	67
Total	24	475	499

Cyclist-CMV Collisions by CMV Vehicle Type			
V_TYPE(Vehicle Type)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Unit Truck >4536 kg	10	251	261
Truck Tractor	11	63	74
School Bus	0	44	44
Bus - Urban	2	97	99
Bus - Intercity	1	20	21
Total	24	475	499

Cyclist-CMV Collisions by Bicyclist Manoeuvre			
V_MNVR(Maneuver)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Straight Ahead	14	315	329
Left Turn	3	16	19
Right Turn	1	15	16
U-turn	1	0	1
Changing Lanes	0	6	6
Merge	0	2	2
Passing	0	10	10
Slowing/Stopping in Traf.	0	3	3
Start in Traffic	0	1	1
Leave Roadside	0	7	7
Stopped/Parked Legally	0	2	2
Unspec.	0	6	6
Other	4	13	17
Unknown	0	13	13
Not Provided	1	66	67
Total	24	475	499

Cyclist-CMV Collisions by CMV Manoeuvre			
V_MNVR(Maneuver)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Straight Ahead	9	192	201
Left Turn	2	41	43
Right Turn	9	110	119
Changing Lanes	1	6	7
Merge	0	3	3
Reverse	2	3	5
Passing	0	18	18
Slowing/Stopping in Traf.	0	14	14
Start in Traffic	0	2	2
Leave Roadside	0	6	6
Stopped/Parked Legally	0	5	5
Swerve	0	1	1
Unspec.	0	1	1
Other	0	7	7
Not Provided	1	66	67
Total	24	475	499

Cyclist-CMV Collisions by Cyclist Condition			
V_CF1(Driver Condition)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Alcohol	1	11	12
Drugs	0	1	1
Other Driver Condition	1	3	4
No CF	7	161	168
Unknown	3	71	74
Total	12	247	259

Cyclist-CMV Collisions by Cyclist Action			
V_CF2(Driver Action)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Too Close	0	5	5
Too Fast	0	2	2
Improper Passing	1	14	15
Fail to Yield	2	42	44
Disobey Traffic Cntrl	1	18	19
Wrong Side of Road	0	2	2
Wrong Direction	0	1	1
Lost Control	2	21	23
Other Driver Action	0	26	26
No CF	3	85	88
Unknown	3	31	34
Total	12	247	259

Cyclist-CMV Collisions by CMV Driver Condition			
V_CF1(Driver Condition)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Other Driver Condition	0	1	1
No CF	10	204	214
Unknown	2	42	44
Total	12	247	259

Cyclist-CMV Collisions by CMV Driver Action			
V_CF2(Driver Action)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Too Fast	0	1	1
Improper Passing	1	25	26
Fail to Yield	2	33	35
Disobey Traffic Cntrl	0	5	5
Wrong Side of Road	0	1	1
Reversing Unsafely	0	1	1
Lost Control	0	1	1
Other Driver Action	1	15	16
No CF	6	149	155
Unknown	2	16	18
Total	12	247	259

Cyclist-CMV Collisions by Bicyclist Speeding			
V_CF(Speeding)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Yes	0	3	3
No	17	343	360
Total	17	346	363

Cyclist-CMV Collisions by CMV Driver Speeding			
V_CF(Speeding)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Yes	0	2	2
No	17	344	361
Total	17	346	363

PEDESTRIAN AND LCV URBAN INJURY COLLISIONS

Pedestrian-CMV Collisions by Year			
C_YEAR(Year)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
2004	29	281	310
2005	26	387	413
2006	26	306	332
Total	81	974	1055

Pedestrian-CMV Collisions by Province			
C_PROV(Province)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
NF	0	4	4
NS	1	14	15
NB	1	2	3
QC	27	278	305
ON	21	369	390
SK	1	21	22
AB	7	135	142
BC	23	150	173
YK	0	1	1
Total	81	974	1055

Pedestrian-CMV Collisions by Month			
C_MNTH(Month)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Jan	8	102	110
Feb	7	82	89
Mar	4	87	91
Apr	5	76	81
May	8	69	77
June	5	79	84
July	4	50	54
Aug	4	74	78
Sept	3	73	76
Oct	12	96	108
Nov	12	93	105
Dec	9	93	102
Total	81	974	1055

Pedestrian-CMV Collisions by Day of Week			
C_WDAY(Day of Week)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Mon	15	170	185
Tue	13	170	183
Wed	16	176	192
Thur	16	183	199
Fri	13	163	176
Sat	3	69	72
Sun	5	43	48
Total	81	974	1055

Pedestrian-CMV Collisions by Time of Day			
C_HOUR(Hour)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Midnight to 00:59	3	5	8
01:00 to 01:59	1	14	15
02:00 to 02:59	1	3	4
03:00 to 03:59	0	5	5
04:00 to 04:59	0	3	3
05:00 to 05:59	1	4	5
06:00 to 06:59	0	25	25
07:00 to 07:59	3	47	50
08:00 to 08:59	2	93	95
09:00 to 09:59	3	56	59
10:00 to 10:59	5	63	68
11:00 to 11:59	7	64	71
12:00 to 12:59	6	55	61
13:00 to 13:59	5	62	67
14:00 to 14:59	8	59	67
15:00 to 15:59	6	101	107
16:00 to 16:59	2	84	86
17:00 to 17:59	9	68	77
18:00 to 18:59	7	42	49
19:00 to 19:59	3	37	40
20:00 to 20:59	4	20	24
21:00 to 21:59	1	21	22
22:00 to 22:59	1	15	16
23:00 to 23:59	1	10	11
Unknown	2	18	20
Total	81	974	1055

Pedestrian-CMV Collisions by Configuration			
C_CONF(Configuration)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
1V : Hit Moving Object	30	308	338
1V : Hit Stationary Object	0	5	5
1V : Run Off - Left	0	1	1
1V : Run Off - Right	0	2	2
1V : Other single veh	28	498	526
2V1D : Rear end	0	5	5
2V1D : Passing to Right	0	1	1
2V1D : Other 2-veh, same dir.	0	1	1
2V2D : Head-on	1	4	5
2V2D : Approaching Sideswipe	2	6	8
2V2D : Left Turn across Traffic	0	12	12
2V2D : Right Turn	0	4	4
2V2D : Right Angle	3	17	20
Other	15	87	102
Unknown	2	23	25
Total	81	974	1055

Pedestrian-CMV Collisions by Roadway Configuration			
C_RCFG(Roadway Configuration)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Non-intersection	24	278	302
Intersection with Public Road	36	477	513
Intersection with Private Road	5	42	47
Railroad crossing	0	3	3
Bridge	1	3	4
Ramp	0	2	2
Other	12	92	104
Unknown	3	77	80
Total	81	974	1055

Pedestrian-CMV Collisions by Weather			
C_WTHR(Weather)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Clear	56	722	778
Cloudy	8	103	111
Rain	13	94	107
Snow	3	36	39
Sleet, Hail	0	3	3
Bad Visibility	0	4	4
Wind	0	1	1
Other	0	5	5
Unknown	1	6	7
Total	81	974	1055

Pedestrian-CMV Collisions by Light Condition			
C_LITE(Light Condition)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Daylight	49	752	801
Dawn	0	10	10
Dusk	2	18	20
Dawn or Dusk	1	11	12
Darkness	29	177	206
Unknown	0	6	6
Total	81	974	1055

Pedestrian-CMV Collisions by Road Classification			
C_RCL3(Road Classification III)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
1-way, 1-2 lanes	1	29	30
1-way, >2 lanes	5	3	8
Undivided, 2 way, 2 lanes	24	373	397
Undivided, 2 way, >2 lanes	4	32	36
Divided with barrier	0	18	18
Divided with no barrier	2	33	35
Divided (not specified)	10	56	66
Other	1	7	8
Unknown	6	131	137
Not Provided	28	292	320
Total	81	974	1055

Pedestrian-CMV Collisions by Road Condition			
C_RCON(Road Condition)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Good	54	765	819
Ruts, Potholes	0	1	1
Under Repair	2	9	11
Other	1	10	11
Unknown	1	39	40
Not Provided	23	150	173
Total	81	974	1055

Pedestrian-CMV Collisions by Road Alignment			
C_RALN(Road Alignment)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Straight, Level	63	752	815
Straight, Grade	13	98	111
Curved, Level	0	29	29
Curved, Grade	3	9	12
Top of Hill	0	2	2
Unknown	2	84	86
Total	81	974	1055

Pedestrian-CMV Collisions by Traffic Control			
C_TRAF(Traffic Control)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Signals Working	28	363	391
Signals Flashing Mode	0	5	5
Stop Sign	6	74	80
Yield Sign	0	7	7
Pedestrian Crossing	1	22	23
Police Officer	0	4	4
Guard/Flagman	0	4	4
Reduced Speed Zone	0	1	1
School Bus, Lights Flashing	0	3	3
No Traffic Control	41	451	492
Other	0	10	10
Unknown	5	30	35
Total	81	974	1055

Pedestrian-CMV Collisions by Posted Speed Limit			
C_SPED(Posted Speed Limit)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
<40 km/h	2	39	41
40 km/h	4	41	45
50 km/h	47	539	586
60 km/h	5	98	103
70 km/h	2	2	4
80 km/h	1	4	5
90 km/h	0	4	4
100 km/h	0	2	2
Other	0	2	2
Unknown	13	108	121
Not Provided	7	135	142
Total	81	974	1055

Pedestrian-CMV Collisions by CMV Vehicle Type			
V_TYPE(Vehicle Type)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Unit Truck >4536 kg	36	429	465
Truck Tractor	30	111	141
School Bus	2	101	103
Bus - Urban	11	288	299
Bus - Intercity	2	45	47
Total	81	974	1055

Pedestrian-CMV Collisions by CMV Manoeuvre			
V_MNVR(Maneuver)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Straight Ahead	25	331	356
Left Turn	11	180	191
Right Turn	13	108	121
U-turn	0	1	1
Changing Lanes	0	6	6
Merge	1	5	6
Reverse	8	81	89
Passing	1	0	1
Slowing/Stopping in Traf.	4	49	53
Start in Traffic	5	13	18
Leave Roadside	4	28	32
Stopped/Parked Legally	0	2	2
Stopped/Parked Illegally	0	1	1
Swerve	0	1	1
Unspec.	0	1	1
Other	2	19	21
Unknown	0	13	13
Not Provided	7	135	142
Total	81	974	1055

Pedestrian-CMV Collisions by Pedestrian Action			
P_PACT(Pedestrian Action)	P_ISEV(Person Injury Severity)		Total
	Fatal	Injured	
X-ing Intersctn w/Traf Cntl, R-O-W	11	195	206
X-ing Intersctn w/Traf Cntl w/o R-O-W	6	63	69
X-ing Intersection, No Traf Cntl	8	70	78
Crosswalk	4	50	54
Crossing Between Intersections	2	14	16
On Roadside against Traffic	2	15	17
On Roadside with Traffic	4	41	45
On Sidewalk	2	73	75
On Road against Traffic	0	1	1
On Road with Traffic	0	3	3
Behind Parked Car	4	24	28
Run into Road	0	33	33
On/Off School Bus	2	6	8
On/Off Other Vehicle	1	32	33
Pushing Vehicle	1	8	9
Working on Vehicle	0	1	1
Playing on Road	1	7	8
Working on Road	2	23	25
Other	16	152	168
Unknown	15	158	173
Total	81	969	1050

Pedestrian-CMV Collisions by CMV Driver Condition			
V_CF1(Driver Condition)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Alcohol	1	2	3
Other Driver Condition	0	2	2
No CF	21	386	407
Unknown	6	114	120
Total	28	504	532

Pedestrian-CMV Collisions by CMV Driver Action			
V_CF2(Driver Action)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
Improper Passing	0	27	27
Fail to Yield	6	108	114
Disobey Traffic Cntrl	2	6	8
Reversing Unsafely	0	6	6
Lost Control	0	4	4
Other Driver Action	3	31	34
No CF	13	270	283
Unknown	4	52	56
Total	28	504	532

Pedestrian-CMV Collisions by CMV Driver Speeding			
V_CF(Speeding)	C_SEV(Collision Severity)		Total
	Fatal	Injury	
No	54	696	750
Total	54	696	750