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Canada

Occurrence of Light-Duty Vehicle Rollovers in TRAID (1993 to 1997)

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1. INTRODUCTION

On 9 January 2001, the US Transportation Secretary Rodney E. Slater announced the first rollover ratings for passenger vehicles. This rating, which can vary from a low of one star to a high of five stars, is intended to provide consumers with information on the rollover propensity of a vehicle. A 5-star rating (best rating) indicates that the vehicle has a rollover risk less than 10% while the 1-star rating is given when the vehicle has a rollover risk greater than 40%. The US announcement created considerable interest in Canada in rollover crashes in general and rating schemes and technical countermeasures in particular.

The US National Highway Transportation Safety Administration (NHTSA) rollover resistance rating is based on the Static Stability Factor (SSF) and on the number of rollovers experienced in the United States by vehicles of various SSF. The concept of SSF was proposed by the Motor Vehicle Manufacturers' Association (MVMA) and the General Motors Corporation in the early 70's as an alternative to dynamic testing to characterize the rollover propensity of a vehicle. The SSF is computed by dividing one-half of the wheel track width by the height of the center of gravity of the vehicle. The track width is the lateral distance between the centerlines of the tires. The center of gravity is the point at which all the weight of the vehicle can be considered to be concentrated. The higher the SSF of a vehicle is, the less likely it is to roll over.

NHTSA used the 1994 to 1997 crash data for six States (Florida, Maryland, Missouri, North Carolina, Pennsylvania and Utah) to link the SSF to the probability that a vehicle will roll over in a single-vehicle crash. These six States were selected because their collision files contained all the data required for analysis, including the Vehicle Identification Number (VIN).

In Canada, data on motor vehicle collisions are contained in the TRaffic Accident Information Database (TRAID). This database is a census of all collisions reported in Canada. The data are collected by the various police forces on their respective accident report forms. The forms are then submitted to the appropriate Provincial/Territorial Government (Jurisdictions) where the data are ultimately entered into a database; each of these Jurisdictions has its own database system. Once the data for a given calendar year are finalised, they are provided to Transport Canada for collating and generation of national statistics on motor vehicle collisions. Transport Canada has no authority over the type of data being collected nor does it provide funding to the various Jurisdictions for activities related to data collection and quality control.

Since the vehicle make and model and the VIN are not available in TRAID, the rollover analyses performed by NHTSA cannot be replicated with Canadian data. Also, pickup trucks, sport-utility vehicles (SUVs), cargo vans and minivans are all grouped into one vehicle category called Light Truck and Van (LTV); this grouping further reduces the level of detail at which the analyses can be performed. While this Technical Memorandum was being finalised, VIN data became available for some of the vehicles involved in collisions in Ontario from 1997 to 1999 and in Quebec from 1996 to 1998; analyses that will be performed using VIN data will be discussed in a separate Technical Memorandum.

The purpose of this Technical Memorandum is to document the analyses that were performed with TRAID data supplemented with available vehicle registration data; analyses spanned the 5-year period of 1993 to 1997. In particular, it was desirable to determine the number of collisions involving rollover and the associated number of casualties, as well as determine whether LTVs were more prone than an automobile to be involved in a rollover and the factors contributing to this type of crash.

2. LIGHT-DUTY VEHICLE FLEET

The Census of Vehicles in Operation Canada (CVIOC) is the Directorate's source of information for light-duty vehicle (LDV) registration in Canada; this database is purchased annually and maintained by the Evaluation and Data Systems Division. Data are available for years 1989 to 1997; the "census day" is 1 July of each year. CVIOC does not contain information on motorcycles nor on mopeds.

CVIOC contains vehicle data obtained from Provincial registry information[1]. In addition to vehicle make, model and model year, CVIOC also contains such data as the class of vehicle (such as "subcompact" or "Full Size Sport Utility"). The vehicle class data were used to derive Table 1.

As shown in Table 1, the number of automobiles registered in Canada has been slowly decreasing while the number of LTVs has been steadily increasing; although there are still twice as many automobiles on the road as there are LTVs, automobiles are being replaced with LTVs in general, and minivans in particular. The number of SUVs has been increasing at a rate of 40,000 to 50,000 per year with the exception of 1997 where their number increased by almost 100,000. The number of pickup trucks stayed relatively stable from 1993 to 1995 before increasing sharply by 120,000 to 130,000 in both 1996 and 1997. Over the 5-year period, the increase in the number of pickup trucks was about the same as that for the SUVs.

Table 2 provides data on the distribution of the LDV fleet by age groups. We note that the total number of newer vehicles (aged 0 to 4 years) is decreasing while that of older vehicles (aged either 10 to 14 years or 15 years and older) is increasing. We also note that, in the case of the newer vehicles, the number of automobiles is decreasing while that of SUVs and Minivans is increasing. The number of newer pickup trucks went down in 1994 and 1995 before starting to increase in 1996 and coming back to their 1993 level in 1997.

Table 1. Census of Vehicles in Operation Canada

		Census Year					5-year
		1993	1994	1995	1996	1997	change
Automobiles		11,113,452	11,015,248	10,918,792	10,733,067	10,725,100	-388,352
LTVs	Pickup Trucks	2,142,673	2,139,096	2,136,614	2,253,651	2,386,261	243,588
	SUVs *	613,605	657,897	703,382	755,610	854,045	240,440
	Minivans	844,124	997,883	1,116,557	1,309,627	1,467,202	623,078
	Full Size Van	447,842	410,215	384,181	384,132	378,121	-69,721
	Unknown /Other	347,557	471,029	465,112	386,917	266,572	-80,985
Light Truck & Vans		4,395,801	4,676,120	4,805,846	5,089,937	5,352,201	956,400
Light-Duty Vehicles		15,509,253	15,691,368	15,724,638	15,823,004	16,077,301	568,048

* Sport Utility Vehicles

[1] The vehicles from Yukon are grouped with those in BC and the vehicles from the NWT are grouped with those in Alberta. The database manager advises that the files probably do not contain the full registry for both of these Territories.

It is not possible to compute an exact average age of the vehicle fleet in Canada since the CVIOC database does not contain the model year for vehicles 15 years old or older (in 1997, those vehicles manufactured in 1982 or previously). In 1997, there were in excess of 1.2 million such vehicles registered in Canada or 7.6% of the fleet; the proportion of the fleet aged 15 years and older varied from a low of 6.8% in 1993 to a high of 8.5% in 1996.

Table 2. Light-Duty Vehicle Fleet Age

Vehicle Age	Vehicle Type		Census Year					5-year Change
			1993	1994	1995	1996	1997	
0 to 4	Automobiles		3,873,524	3,609,949	3,467,159	3,176,416	3,040,995	-832,529
	LTVs	Pickup Trucks	761,601	714,489	711,992	714,618	755,071	-6,530
		SUVs	310,486	306,431	318,104	322,849	365,808	55,322
		Compact Vans	555,940	616,690	631,424	726,131	766,743	210,803
		Full Size Vans	116,641	97,057	84,894	83,795	82,329	-34,312
		Unknown / Other	1,998	10,038	9,928	29	27	-1,971
	Light Trucks and Vans		1,746,666	1,744,705	1,756,342	1,847,422	1,969,978	223,312
0-4 years old			**5,620,190**	**5,354,654**	**5,223,501**	**5,023,838**	**5,010,973**	**-609,217**
5 to 9	Automobiles		4,629,164	4,594,970	4,471,834	4,253,090	4,173,564	-455,600
	LTVs	Pickup Trucks	890,146	924,196	913,544	883,872	864,367	-25,779
		SUVs	244,965	277,819	287,558	303,773	318,262	73,297
		Compact Vans	286,091	363,605	430,633	469,583	528,926	242,835
		Full Size Vans	196,638	195,669	184,786	165,406	142,363	-54,275
		Unknown / Other	3,446	8,279	2,461	239	523	-2,923
	Light Trucks and Vans		1,621,286	1,769,568	1,818,982	1,822,873	1,854,441	233,155
5-9 years old			6,250,450	6,364,538	6,290,816	6,075,963	6,028,005	-222,445
10 to 14	Automobiles		1,883,243	2,010,951	2,219,343	2,469,518	2,735,332	852,089
	LTVs	Pickup Trucks	490,926	500,363	511,057	564,017	628,871	137,945
		SUVs	58,154	73,647	97,718	121,255	157,822	99,668
		Compact Vans	2,093	17,588	54,499	113,482	170,595	168,502
		Full Size Vans	134,563	117,489	114,501	113,080	122,819	-11,744
		Unknown / Other	9,165	6,475	2,469	380	618	-8,547
	Light Trucks and Vans		694,901	715,562	780,244	912,214	1,080,725	385,824
10-14 years old			**2,578,144**	**2,726,513**	**2,999,587**	**3,381,732**	**3,816,057**	**1,237,913**
15 and older	Automobiles		727,521	799,378	760,456	834,043	775,209	47,688
	LTVs	Pickup Trucks	0	48	21	91,144	137,952	137,952
		SUVs	0	0	2	7,733	12,153	12,153
		Compact Vans	0	0	1	431	938	938
		Full Size Vans	0	0	0	21,851	30,610	30,610
		Unknown / Other	332,948	446,237	450,254	386,269	265,404	-67,544
	Light Trucks and Vans		332,948	446,285	450,278	507,428	447,057	114,109
15 years old and older			**1,060,469**	**1,245,663**	**1,210,734**	**1,341,471**	**1,222,266**	**161,797**
Total			15,509,253	15,691,368	15,724,638	15,823,004	16,077,301	568,048

3. LIGHT DUTY VEHICLE ROLLOVERS IN CANADA

The occurrence of rollover is determined through the "Vehicle Event" TRAID variable; up to three vehicle events can be recorded into TRAID. Most Jurisdictions report two or three vehicle events; however, Alberta and Quebec report none and Northwest Territories only report one.

Identifying all occurrences of light-duty vehicle rollovers in Canada is therefore not possible with TRAID since:

- Alberta does not report vehicle events (rollover is therefore not reported); and
- In Quebec, some of the vehicle rollovers can be identified through the Accident Type variable. Some rollovers may not be reported if fire, explosion or another major event is part of the collision. If a rollover is reported, TRAID will create a rollover vehicle event and will assign it to all vehicles involved in the collision since it is not possible to determine which vehicle rolled over. Therefore, if the collision involves at least two vehicles and if at least one of them rolled over, it is not possible to determine which vehicle rolled over nor the number and severity of the injuries received by the occupants of the vehicle(s) that rolled over.

Due to these data limitations, the TRAID data from Alberta and Quebec were excluded from the initial analysis.

Table 3 shows the number of reported collisions (all collision types and severities) in Canada, the number of collisions involving a light-duty vehicle (LDV) rollover, the total number of persons killed or injured in all collisions and the number of rolled-over LDV occupants killed or injured for the years 1993 to 1997.

Given the data limitations outlined above, it is quite challenging to provide national estimates of the number of vehicle that rolled over and the associated occupant casualties; as shown in Table 3, the excluded data represented, respectively, 42.1%, 40.0% and 32.4% of the total number of collisions, persons killed and persons injured in 1997.

To provide these national estimates, the TRAID data were compensated to account for the data excluded. For example, using the 1997 collision data, we found 14,558 collisions involving a light-duty vehicle rollover (Canada without Alberta and Quebec) in TRAID. Since the collisions reported by Alberta and Quebec in 1997 accounted for 42.1% of all collisions in TRAID, the number 14,558 was increased to 25,155 (14,558 / (1 - 42.1%)) to account for the excluded data. Similar manipulations were performed for the number of occupants killed or injured in rolled over vehicles. This correction implies that the ratio of the number of rollover collisions to that of all collisions in Alberta and Quebec is the same as it is, on average, in the remainder of the country. This may not be the case given that the vehicle fleet mix in these two Provinces differs from that observed in the remainder of Canada[2], and that there may be some differences in driver population, exposure, and driving environment (weather, road category, sizes of cities, etc.).

The estimated number of collisions involving a rollover in Canada, as well as the casualties amongst the occupants of rolled-over vehicles, is shown in bold in Table 3 for emphasis.

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[2] In 1997, automobiles and LTVs represented 55.2% and 44.8% respectively of the Alberta LDV fleet while, in Quebec, the proportions were 74.1% and 25.9%. For the remainder of Canada, automobiles and LTVs represented 66.0% and 34.0% of the LDV fleet.

Table 3. Light-duty vehicle rollovers in Canada (1993 to 1997)

	1993	1994	1995	1996	1997
Number of collisions (all collision types):					
- in Canada	675,550	674,676	662,423	635,412	618,714
- in Alberta	84,588	84,640	85,220	93,832	92,365
- in Québec	169,563	169,078	167,756	160,514	168,280
- % (Alberta+Québec)/Canada	37.6%	37.6%	38.2%	40.0%	42.1%
Number of collisions with a LDV rollover:					
- Canada excluding Alberta and Québec	16,167	16,153	15,353	14,728	14,558
- Canada (estimated)	**25,918**	**25,889**	**24,839**	**24,558**	**25,155**
Number of Persons Killed (all collisions):					
- in Canada	3,615	3,263	3,351	3,091	3,063
- in Alberta	383	395	403	349	429
- in Québec	982	827	883	887	796
- % (Alberta+Québec)/Canada	37.8%	37.5%	38.4%	40.0%	40.0%
Number of Persons Injured (all collisions):					
- in Canada	247,588	245,110	241,935	230,890	221,352
- in Alberta	19,252	20,169	20,866	22,268	23,916
- in Québec	49,884	48,756	48,623	47,634	47,861
- % (Alberta+Québec)/Canada	27.9%	28.1%	28.7%	30.3%	32.4%
Casualties in Rolled Over LDVs:					
- Persons killed (Canada excl. Alberta and Québec)	364	320	321	263	318
- Persons killed (estimated Canada)	**585**	**512**	**521**	**438**	**530**
- Persons injured (Canada excl. Alberta and Québec)	12,697	12,198	11,828	10,559	10,460
- Persons injured (estimated Canada)	**17,616**	**16,970**	**16,594**	**15,144**	**15,479**

4. SINGLE LIGHT-DUTY VEHICLE COLLISIONS INVOLVING A ROLLOVER IN CANADA

4.1 Introduction

Collisions involving only one light-duty vehicle are of particular interest; these collisions may be inherently simpler to reconstruct and to analyse. An additional benefit for this analysis is that the Quebec data can be used (we know which vehicle rolled over since there is only one vehicle involved in the collision). The inclusion of the Quebec collisions reduces the uncertainty of the national estimates since the data from this Jurisdiction represent some 20% of all collisions reported in Canada for any given year. As was the case in Section 3, the data from Alberta was excluded from the analysis.

The analysis presented here is divided into two sections. Section 4.2 provides national estimates for the number of single LDV rollover collisions as well as the number of occupants killed or injured in vehicles that rolled over. Section 4.3 provides details on **fatal** single LDV rollover collisions.

4.2 Single Light-Duty Vehicle Rollover Collisions - An Overview

All single-vehicle collisions involving either an automobile or a LTV were extracted from TRAID for 1993 to 1997; a single-vehicle collision was defined as a collision involving either only one vehicle or involving two vehicles, one of which was parked. In collisions involving parked vehicles, only the colliding vehicle was considered when determining vehicle type, occurrence of rollover, the number of casualties and the severity of injuries[3]. Collisions involving other road users such as pedestrians and cyclists were excluded. This process resulted in a dataset containing 670,972 collisions as shown in Table 4.

National estimates of the number of collisions involving a rollover were computed, compensating for the excluded data in Alberta. Table 5 provides the distribution of the rollover collisions by collision severity, vehicle type and calendar year as well as the national estimates. Over the 5-year period, it is estimated that there were 103,234 single-vehicle rollover collisions.

Table 4. Single LDV Collisions (Canada excluding Alberta)

Vehicle Type	Collision Severity*	Calendar Year					Total
		1993	1994	1995	1996	1997	
Automobile	Fatal	619	550	574	529	478	2,750
	NF Injury	24,948	23,608	23,036	21,766	20,471	113,829
	PDO	80,587	77,193	77,674	73,043	69,323	377,820
Automobile Total		106,154	101,351	101,284	95,338	90,272	494,399
LTV	Fatal	242	193	218	203	226	1,082
	NF Injury	7,391	7,087	7,339	7,233	6,943	35,993
	PDO	27,401	28,199	29,171	27,433	27,294	139,498
LTV Total		35,034	35,479	36,728	34,869	34,463	176,573
LDV Total		141,188	136,830	138,012	130,207	124,735	670,972

* NF Injury: Non-Fatal Injury

[3] Fifteen (15) rollovers involving a collision between a light-duty vehicle and a parked vehicle in Quebec were not included, due to the data limitations described previously.

Table 5. Single LDV Rollover Collisions - Occurrence in TRAID and National Estimates

		1993	1994	1995	1996	1997	Total
TRAID Data (Canada excluding Alberta)							
Automobile	Fatal	217	191	207	170	159	944
	Non-Fatal Injury	6,076	5,907	5,601	5,112	4,954	27,650
	PDO	6,148	6,077	5,700	5,554	5,553	29,032
Automobile Total		12,441	12,175	11,508	10,836	10,666	57,626
LTV	Fatal	107	92	93	75	112	479
	Non-Fatal Injury	2,642	2,532	2,576	2,525	2,471	12,746
	PDO	3,553	3,624	3,620	3,760	3,888	18,445
LTV Total		6,302	6,248	6,289	6,360	6,471	31,670
Single LDV Rollovers (TRAID)		18,743	18,423	17,797	17,196	17,137	89,296
National Estimates							
% Collisions (Alberta/Canada)		12.5%	12.5%	12.9%	14.8%	14.9%	
Automobile	Fatal	248	218	238	199	187	1,090
	Non-Fatal Injury	6,946	6,754	6,428	5,998	5,823	31,949
	PDO	7,028	6,949	6,542	6,516	6,527	33,562
Estimated Automobile Total		14,222	13,921	13,208	12,713	12,537	66,601
LTV	Fatal	122	105	107	88	132	554
	Non-Fatal Injury	3,020	2,895	2,956	2,962	2,905	14,738
	PDO	4,062	4,144	4,154	4,411	4,570	21,341
Estimated LTV Total		7,204	7,144	7,217	7,461	7,607	36,633
Single LDV Rollover Collisions (National Estimate)		21,426	21,065	20,425	20,174	20,144	103,234

Table 6 shows the proportion of single-vehicle collisions that involves a rollover of a given collision severity, for both automobiles and LTVs. The proportions were computed by dividing the number of single-vehicle rollover collisions in TRAID for a specific vehicle type and collision severity by the total number of single-vehicle collisions for that vehicle type. For example, Table 6 shows that 0.2% of automobile single-vehicle collisions in 1993 were fatal rollover collisions; this proportion was computed by dividing 217 (in Table 5) by 106,154 (in Table 4) and expressing the result as a percentage. Table 6 also compares the LTV proportions to the corresponding Automobile proportions; thus, we note that LTVs are 43%, 29% and 78% more likely to roll over than automobiles in fatal, non-fatal and PDO single-vehicle collisions. Overall, LTVs are 54% more likely to roll over than automobiles in single-vehicle collisions.

Table 6. Proportion of Reported Single Vehicle Collisions Involving a Rollover (Canada Excluding Alberta)

Vehicle Type	Collision Severity*	1993	1994	1995	1996	1997	Average
Automobile	Fatal	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
	NF Injury	5.7%	5.8%	5.5%	5.4%	5.5%	5.6%
	PDO	5.8%	6.0%	5.6%	5.8%	6.2%	5.9%
	All Severity	11.7%	12.0%	11.4%	11.4%	11.8%	11.7%
LTV	Fatal	0.3%	0.3%	0.3%	0.2%	0.3%	0.3%
	NF Injury	7.5%	7.1%	7.0%	7.2%	7.2%	7.2%
	PDO	10.1%	10.2%	9.9%	10.8%	11.3%	10.5%
	All Severity	18.0%	17.6%	17.1%	18.2%	18.8%	17.9%
LTV / Car Ratio	Fatal	1.49	1.38	1.24	1.21	1.85	1.43
	NF Injury	1.32	1.22	1.27	1.35	1.31	1.29
	PDO	1.75	1.70	1.75	1.85	1.83	1.78
	All Severity	1.53	1.47	1.51	1.60	1.59	1.54

Table 7 shows the number of single-vehicle rollover collisions as a ratio of the number of vehicles registered in Canada; the national estimates for the number of rollover collisions (Table 5) were used to compute these ratios. Table 7 also compares the LTV ratios to the corresponding automobile ratios. We observe that, on a per-registered vehicle basis, LTVs are involved in a rollover collision more often than automobiles for all injury severity collisions. We also observe that the ratios are decreasing with time and, with the possible exception of LTVs fatal rollovers in 1997, the fatal and non-fatal ratios for LTVs and automobiles are almost identical since 1995. The LTV fatal ratio was better than that of the automobile in 1996. We note finally that the non-fatal and PDO ratio for the automobile are of the same magnitude; this is not the case for LTVs where PDO ratios are roughly 50% higher than non-fatal ratios.

Table 7. Single LDV Rollover Collisions per Million Registered Vehicles (National Estimates)

Vehicle Type	Collision Severity*	1993	1994	1995	1996	1997	Average
Automobile	Fatal	22.3	19.8	21.8	18.5	17.4	20.0
	Non-Fatal	625	613	589	559	543	586
	PDO	632	631	599	607	609	616
	All Severity	1280	1260	1210	1180	1170	1220
LTV	Fatal	27.8	22.5	22.3	17.3	24.7	22.9
	Non-Fatal	687	619	615	582	543	609
	PDO	924	886	864	867	854	879
	All Severity	1640	1530	1500	1470	1420	1510
LTV / Car Ratio	Fatal	1.24	1.13	1.02	0.93	1.41	1.15
	Non-Fatal	1.10	1.01	1.04	1.04	1.00	1.04
	PDO	1.46	1.40	1.44	1.43	1.40	1.43
	All	1.28	1.21	1.24	1.25	1.21	1.24

Table 8. Casualties in Single LDV Collisions – TRAID Total for 1993 to 1997 (Canada excluding Alberta)

Vehicle Type	Injury Severity	Rollover		Total	Proportion of victims in rollover collisions
		No	Yes		
Automobile	Killed	2,011	1,050	3,061	34.3%
	Injured	115,020	42,098	157,118	26.8%
Automobile Total Victims		117,031	43,148	160,179	
LTV	Killed	652	520	1,172	44.4%
	Injured	31,074	19,914	50,988	39.1%
LTV Total Victims		31,726	20,434	52,160	
LDV	Killed	2,663	1,570	4,233	37.1%
	Injured	146,094	62,012	208,106	29.8%
LDV Total Victims		148,757	63,582	212,339	

We showed in Table 4 that LDVs were involved in 670,972 single-vehicle collisions over the 1993-1997 period; these collisions resulted in 4,233 occupants being killed and 208,106 others being injured as shown in Table 8. Table 8 also provides details of injury severity by the occurrence of rollover. Over the 5-year period, 34.3% of the occupants killed in automobile single-vehicle collisions were killed in rollover collisions; this proportion is 44.4% in the case of LTVs.

Table 9 shows the distribution of injuries in rollover collisions. From 1993 to 1997, 1570 occupants were killed and 62,012 others were injured in rollover collisions. Compensating for the excluded Alberta data, we estimate that the 103,234 single LDV rollover collisions resulted in 1,784 occupants being killed and 68,118 others being injured in that 5-year period. It is not possible to show the number of vehicle occupants that were not injured in these collisions, since these are not always reported, especially in PDO collisions.

Table 9. Severity of Injury to Occupants of Vehicles Involved in Single LDV Rollovers – TRAID Data and National Estimates

		1993	1994	1995	1996	1997	Total
TRAID Data (Canada excluding Alberta)							
Automobile	Killed	244	213	220	197	176	1,050
	Injured	9,238	8,924	8,628	7,809	7,499	42,098
LTV	Killed	115	99	102	78	126	520
	Injured	4,152	4,003	3,988	3,869	3,902	19,914
LDV	Killed	359	312	322	275	302	1,570
	Injured	13,390	12,927	12,616	11,678	11,401	62,012
National Estimates							
% Killed (Alberta/Canada)		10.6%	12.1%	12.0%	11.3%	14.0%	
% Injured (Alberta/Canada)		7.8%	8.2%	8.6%	9.6%	10.8%	
Automobile	Killed	273	242	250	222	205	1,192
	Injured	10,017	9,724	9,442	8,643	8,407	46,233
LTV	Killed	129	113	116	88	147	592
	Injured	4,502	4,362	4,364	4,282	4,375	21,885
LDV	Killed	402	355	366	310	351	1,784
	Injured	14,519	14,086	13,807	12,924	12,782	68,118

While TRAID is supposed to contain data on all vehicle occupants involved in reported collisions, there are reasons to believe that this may not be the case. Vehicle occupancy, the number of occupants in vehicles involved in collisions, was analysed as a function of collision severity for all collisions in TRAID for 1993 to 1997.

Table 10 shows the average vehicle occupancy and its standard deviation, for all LDVs involved in all crashes reported in TRAID; vehicles with no occupants were excluded from this analysis. We note that vehicle occupancy decreases from 1.75 to 1.1 occupants as the collision severity decreases from fatal to PDO. This would seem to imply that collisions are less severe when there is only a single occupant in the vehicle; another interpretation of the data is that non-injured occupants are not all reported when the collisions are not fatal. This second interpretation becomes particularly apparent when the data are analysed by Jurisdictions; in Saskatchewan, Manitoba, New Brunswick, and Newfoundland, all vehicles involved in PDO collisions only had one occupant (the driver). In addition, in Ontario and Quebec, the mean vehicle occupancy for PDO crashes is very close to one (less than 1.02 for Ontario and less than 1.001 for Quebec) for each year examined.

We also examined the transit bus collision data; they indicate that, out of the 8,250 transit buses involved in PDO collisions in the 1993-1997 period, 7,956 (96.4%) had only one occupant (the driver) on-board. Further, 40% of these 7,956 buses (3,221 transit buses) collided during rush hour (6:00 to 8:59 AM and 3:00 to 5:59 PM, Monday to Friday, local time); this appears to be inconsistent with expected transit bus occupancy during rush hour.

It therefore appears that many non-injured occupants are not included in TRAID, especially in PDO collisions; this limits the study of injury risk since the total number of vehicle occupants is unknown.

Table 10. Vehicle Occupancy for LDVs Involved in Collisions in Canada (1993 to 1997)

Calendar Year	Collision Severity	Number of Vehicles Involved	Mean Vehicle Occupancy	Standard Deviation
1993	Fatal	3,999	1.77	1.14
	Non-Fatal Injury	271,852	1.50	0.88
	Property Damage Only	792,398	1.08	0.39
1994	Fatal	3,686	1.79	1.19
	Non-Fatal Injury	270,350	1.50	0.88
	Property Damage Only	796,804	1.09	0.40
1995	Fatal	3,651	1.79	1.16
	Non-Fatal Injury	266,541	1.49	0.88
	Property Damage Only	775,396	1.08	0.39
1996	Fatal	3,457	1.74	1.15
	Non-Fatal Injury	254,158	1.48	0.87
	Property Damage Only	747,335	1.08	0.38
1997	Fatal	3,324	1.77	1.17
	Non-Fatal Injury	243,577	1.48	0.86
	Property Damage Only	735,990	1.06	0.35

Data on the total number of occupants in rolled-over vehicles are required in order to compute occupant injury risk. As discussed above, this is not available; some non-injured occupants of motor vehicle involved in collisions are not reported by police and therefore not included in TRAID. An alternative is to use indicators based on the number of casualties per collision. From the results of the various analyses reported in this section, three such indicators have been computed and are shown in Table 11 below.

The "Casualties per thousand reported single vehicle collisions without rollover" ratio is computed by dividing the number of casualties in single vehicle collisions without rollovers (the "No" column in Table 8) by the number of these collisions (obtained by subtracting the number of collisions in Table 5 from that in Table 4) for each vehicle type. Approximately 4½ occupants are killed per thousand single LDV collisions without rollover whether they are occupants of an automobile or a LTV. In addition, 263 automobile occupants and 214 LTV occupants are injured per thousand single automobile or LTV collisions without rollover.

The "Casualties per thousand reported single vehicle rollover collisions" ratio is computed by dividing the number of casualties in single vehicle rollover collisions (the "Yes" column in Table 8) by the number of these collisions (Table 5) for each vehicle type. We observed that approximately 3½ to 4 times more occupants are killed and almost three times more occupants are injured in rollover collisions than in non-rollover collisions. The rate at which occupants are killed or injured in the event of a rollover in LTVs is lower than that in automobiles; there are 16.4 occupants killed per thousand single LTV rollover collisions compared to 18.2 occupants for automobiles. Similarly, there are 629 occupants injured per thousand single LTV rollover collisions compared to 731 for automobiles. It is unknown whether this difference is attributable to superior occupant protection in LTVs or if it is mostly related to a difference in occupancy.

The third ratio, "Rolled-over vehicle occupant casualties per thousand reported single vehicle collisions", combines the rate of casualty in a single vehicle rollover collision with the probability that the vehicle will roll over if involved in a single vehicle collision. The ratio is computed by dividing the number of casualties in single LDV rollover collisions (the "Yes" column in Table 8) by the number of single vehicle collisions for this vehicle type (Table 4). This ratio shows that 2.9 occupants are killed and 113 others are injured in a rollover per thousand single LTV collisions; the ratios for automobiles are 2.1 and 85, a reduction in the rate of fatal and non-fatal injuries of 28% and 24% respectively. This ratio indicates that, despite the LTV reduced rate of injury in rollover collisions, the fact that LTVs roll over more often than automobiles as a proportion of the number of single vehicle collisions results in higher casualty rates for LTVs.

Table 11. Occupant Casualty Rates in Single LDV Collisions

	Automobile		LTV	
	Killed	Injured	Killed	Injured
Casualties per thousand reported single vehicle collision without rollover	4.60	263	4.50	214
Casualties per thousand reported single vehicle rollover collision	18.2	731	16.4	629
Rolled-Over Vehicle Occupant Casualties per thousand reported single vehicle collision	2.12	85	2.94	113

4.3 Fatal Single LDV Rollover Collisions

This section of the analysis will focus specifically on fatal single LDV rollover collisions; relationships between some of the TRAID variables and the occurrence of rollover will be explored. The number of crashes and casualties reported in this section are not national estimates but reflect the data present in TRAID.

The initial dataset used for analysis contained the 1,423 single LDV fatal rollover collisions for the 1993 to 1997 period, as identified in Table 5.

4.3.1 Contributing Factors

Contributing factors are factors that, in the judgement of the investigating police officer, played a role in the occurrence of the collision. The TRAID contributing factors can be grouped loosely in four categories as follows: driver condition (such as impaired or inexperienced), driver action (such as exceeding the speed limit), vehicle condition (such as brake problems) and environmental conditions (such as slippery roads or animal actions). TRAID data from Quebec do not include contributing factors and collisions from this Jurisdiction were therefore excluded from this analysis, leaving 1,181 collisions (83% of fatal single-vehicle rollover collisions) to be analysed.

One should note also that contributing factors vary from one Jurisdiction to the next. For example, Saskatchewan accident report forms allow the coding of “exceeding the speed limit” and “driving too fast for road conditions”; in British Columbia, the factor “unsafe speed” is the only speed-related factor allowed on the accident report form. When the British Columbia data are consolidated into TRAID, the “unsafe speed” factor is converted into “driving too fast for road conditions”; there is effectively no collision in British Columbia where the contributing factor is “exceeding the speed limit”.

Figure 1 shows the frequency at which each category of contributing factors were recorded in single LDV fatal rollover collisions for the 5-year period.

Approximately 11% of the fatal single LDV rollover collisions have three or four contributing factors; this proportion drops to 5.6% for non-fatal collision and 3.6% for PDO Collisions. Approximately 47% of the fatal single LDV rollover collisions have two or more contributing factors; for non-fatal and PDO rollover collisions, the proportion is 28% and 20% respectively. There is therefore a concern that these factors may not be recorded as dutifully for non-fatal injury and PDO collisions.

Figure 1. Contributing Factors in Single LDV Fatal Rollover Collisions (1993 to 1997) – Canada excluding Alberta and Quebec

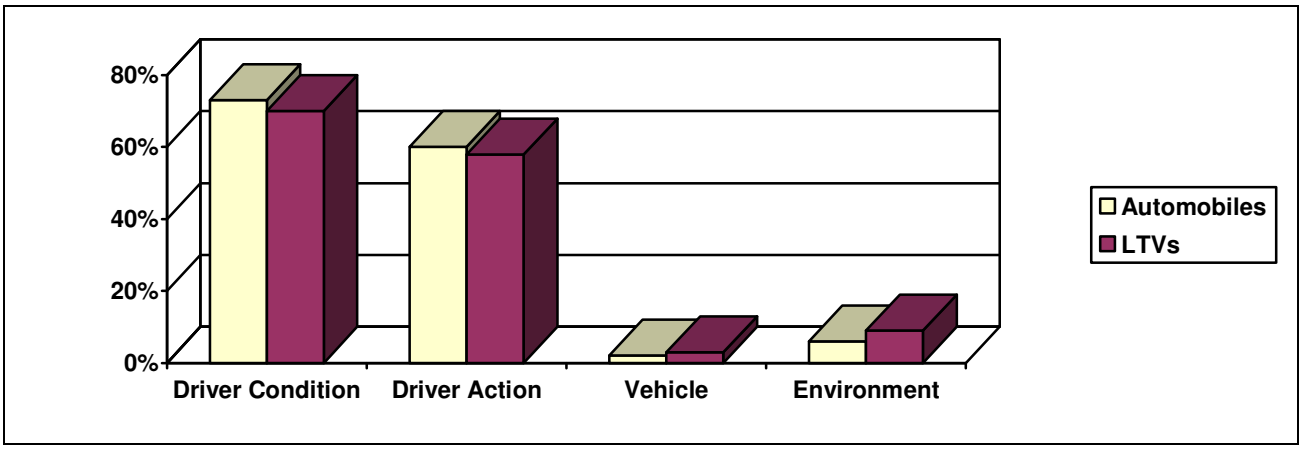

Table 12 shows the frequency with which some of the contributing factors were reported in the 1,181 collisions analyzed; the list of the eleven most frequent contributing factors has been sorted by descending frequency for single automobile rollover collisions. For comparison purposes, the same statistics are shown for the 1,663 fatal single-vehicle collisions that did not involve a rollover (Canada excluding Alberta and Quebec).

Alcohol impairment and exceeding the speed limit appear more often as contributing factors in collisions involving a rollover than in those not involving a rollover. In addition, and only for LTVs, the factor "Road Defects/Construction" is mentioned more often as a contributing factor in collisions with a rollover than in those without.

A **driver condition** was recorded as a contributing factor in 73% of fatal single vehicle rollover collisions involving an automobile and in 70% of those involving a LTV over the period 1993 to 1997. Alcohol (including legal impairment) was the factor most frequently recorded; it was a factor in 52% and 56% of the automobile and LTV collisions respectively. The driver was reported as being legally impaired by alcohol in approximately 29% of fatal single LDV rollover collisions (British Columbia and Yukon do not report whether drivers were legally impaired). “Inattention”, “Fatigue” and “Inexperience” were also frequently reported.

A **driver action** was recorded as a contributing factor in 60% of fatal single vehicle rollover collisions involving an automobile and in 58% of those involving a LTV over the period 1993 to 1997. The factor most frequently reported was “Driving too fast for conditions” which was reported in 24% and 26% of the automobile and LTV fatal single vehicle rollover collisions respectively. The factors “Exceeding the speed limit”, and “Lost Control” were also frequently reported.

A **vehicle factor** was recorded as a contributing factor in 2% of fatal single vehicle rollover collisions involving an automobile and in 3% of those involving a LTV. The factor most frequently reported was "Tires", which was reported in 1% and 2% of collisions involving an automobile and a LTV respectively.

Table 12. Most Frequently Reported Contributing Factors for Fatal Rollover Collisions (1993 to 1997) – Canada excluding Alberta and Quebec

	With Rollover		Without Rollover	
Contributing Factors	Automobile	LTV	Automobile	LTV
Drinking (includes "Impaired by alcohol")	52%	56%	45%	50%
Impaired by alcohol	30%	29%	23%	24%
Driving too fast for conditions	24%	26%	25%	25%
Exceeding the speed limit	20%	17%	15%	10%
Inattention	18%	15%	16%	15%
Lost control	16%	16%	19%	15%
Fatigue (includes "Fell asleep")	9%	8%	8%	8%
Inexperience	6%	4%	4%	3%
Slippery road surface	3%	5%	1%	3%
Impaired by illegal drugs	2%	0%	1%	1%
Road defects / Construction	1%	3%	1%	0%

An **environmental factor** was recorded in 6% of the fatal single vehicle rollover collisions involving an automobile and in 9% of those involving a LTV. The most frequently reported factor was "Slippery Road Surface", which was reported in 3% and 5% of fatal single vehicle rollover collisions involving an automobile and a LTV respectively (this factor is not reported in British Columbia, Ontario, Newfoundland and Yukon).

4.3.2 Vehicle Speed

Speed (either "exceeding the speed limit" or "driving too fast for conditions") was a factor in over 40% of the fatal single vehicle rollover collisions; since the pre-crash vehicle speed is not available in TRAID, the posted speed limit at the collision site was used in the analysis. Table 13 shows the distribution of the 1,382 fatal single vehicle rollover collisions (97% of the single vehicle rollover collisions) where the posted speed limit was known, as well as the casualties resulting from these collisions.

The number of rollovers is highest on roads with a posted speed limit of 70 to 90 km/h (mostly undivided rural roads); this is the case for both the automobile and the LTV. Over the 5-year period, 666 automobile occupants and 336 LTV occupants were killed in rollovers on a road with a posted speed limit between 70 and 90 km/h. The distribution of injured occupants in these fatal single vehicle rollover collisions is roughly the same as that for killed occupants.

The distribution of 3,676 fatal single LDV collisions for which the speed limit is known is shown at the bottom of Table 13. The proportion of these collisions that resulted in a rollover, broken down by speed limit, is also provided. This proportion is higher for LTVs, regardless of the speed limit; LTVs are 20% to 70% more likely than an automobile to roll over in a fatal single vehicle collision. Finally, the ratio of fatal single vehicle collisions involving a rollover increases with the posted speed limit, for both LTVs and automobiles.

Table 13. Occurrence of and Casualties in Fatal Single Vehicle Rollover Collisions as a Function of Speed Limit and Vehicle Type (1993 to 1997) – Canada excluding Alberta

Vehicle Type		Speed Limit			Total
		10 to 60 km/h	70 to 90 km/h	100 to 110 km/h	
Automobile	Fatal Single Vehicle Rollover Collisions	135	605	173	913
	Occupants killed	150	666	195	1,011
	Occupants injured	151	533	163	847
LTV	Fatal Single Vehicle Rollover Collisions	77	310	82	469
	Occupants killed	80	336	93	509
	Occupants injured	81	301	146	528
Fatal Single Vehicle Collisions					
Automobile	Fatal Collisions	738	1,534	374	2,646
LTV	Fatal Collisions	241	643	146	1,030
Ratio of Fatal Single Vehicle Collisions that Resulted in a Rollover					
Automobile	Fatal Collisions	18%	39%	46%	35%
LTV	Fatal Collisions	32%	48%	56%	46%
LTV / Auto Ratio		1.7	1.2	1.2	

4.3.3 Road Category

Table 14 shows the distribution of and occupant casualties in the 974 fatal single vehicle rollover collisions (68% of fatal single vehicle rollover collisions) where road category is known; fatal single vehicle rollover collisions were more frequent on undivided roads. The "Interchange ramps" road category is only reported in British Columbia, Ontario, NWT and Yukon.

The distribution of the 2,361 fatal single vehicle collisions where road category is known is also shown in Table 14. The bottom section of this table contains the ratio of fatal single vehicle collisions that resulted in a rollover by road category. LTVs were 26% to 32% more likely than an automobile to roll over in a fatal single vehicle collision; the ratios for interchange ramps should be interpreted carefully, being based on a very small set of collisions.

Table 14. Occurrence of and Casualties in Fatal Single Vehicle Rollover Collisions as a Function of Road Category and Vehicle Type (1993 to 1997) – Canada excluding Alberta

Vehicle Type		Road Category			
		Undivided	Divided	Interchange Ramp	Total
Automobile	Fatal Single Vehicle Rollover Collisions	495	112	6	613
	Killed	551	123	6	680
	Injured	495	124	4	623
LTV	Fatal Single Vehicle Rollover Collisions	310	46	5	361
	Killed	334	52	6	392
	Injured	320	99	13	432
Fatal Single Vehicle Collisions					
Automobile	Fatal Collisions	1,327	269	13	1,609
LTV	Fatal Collisions	661	84	7	752
Ratio of Fatal Single Vehicle Collisions that Resulted in a Rollover					
Automobile	Fatal Collisions	37%	42%	46%	38%
LTV	Fatal Collisions	47%	55%	71%	48%
LTV/Auto Ratio		1.26	1.32	1.55	

4.3.4 Road Surface Material

Table 15 shows the distribution of and occupant casualties in the 1,240 fatal single vehicle rollover collisions (87% of fatal single vehicle rollover collisions) where road surface material is known. TRAID allows five possible values for this variable: “Asphalt”, “Concrete”, “Brick”, “Gravel” and “Earth or Dirt”. Collisions that occurred on either “Gravel” or on “Earth or Dirt” were grouped in the Deformable road surface material category while those that occurred on the three other surfaces were grouped in the Non-Deformable category. Most of the fatal single vehicle rollover collisions occurred on roads with non-deformable road surface material, probably because most traffic occurs on roads with a non-deformable surface.

Table 15 also shows the distribution of 3,552 fatal single vehicle collisions for which the road surface material was known, as well as the proportion of these collisions involving a rollover. Collisions occurring on deformable roads involve a rollover in a higher proportion than those occurring on non-deformable roads, for both automobiles and LTVs. In addition, the proportion of fatal single vehicle collisions involving a rollover is 23% to 26% higher for LTVs than it is for automobiles regardless of the road surface material.

Table 15. Occurrence of and Casualties in Fatal Single Vehicle Rollover Collisions as a Function of Road Surface Material and Vehicle Type (1993 to 1997) – Canada excluding Alberta

Vehicle Type		Road Surface Material		
		Non-Deformable	Deformable	Total
Automobile	Fatal Single Vehicle Rollover Collisions	759	88	847
	Killed	851	93	944
	Injured	675	121	796
LTV	Fatal Single Vehicle Rollover Collisions	305	88	393
	Killed	330	92	422
	Injured	350	101	451
Fatal Single Vehicle Collisions				
Automobile	Fatal Collisions	2,368	230	2,598
LTV	Fatal Collisions	772	182	954
Ratio of Fatal Single Vehicle Collisions that Resulted in a Rollover				
Automobile	Fatal Collisions	32%	38%	33%
LTV	Fatal Collisions	40%	48%	41%
LTV/Auto Ratio		1.23	1.26	

4.3.5 Road Alignment

Table 16 shows the distribution of and occupant casualties in the 1,369 fatal single vehicle rollover collisions (96% of the fatal single vehicle rollover collisions) where the road alignment is known. Collisions where the road alignment is either “Top of Hill” or “Bottom of Hill” were discarded; there were only 37 such collisions and these two categories provide no information as to the road alignment. Table 16 also shows the distribution of 3,727 fatal single vehicle collisions where the road alignment was either straight or curved.

We note that:

- Automobiles are more likely to roll over on a curved road than on a straight road whereas, for LTVs, the probability is the same;
- On straight roads, LTVs are 43% more likely to roll over than automobiles; on curved roads, LTVs are 16% more likely to roll over than automobiles.

Table 16. Occurrence of and Casualties in Fatal Single Vehicle Rollover Collisions as a Function of Road Alignment (1993 to 1997) – Canada excluding Alberta

Vehicle Type		Road Alignment		Total
		Straight	Curved	
Automobile	Fatal Single Vehicle Rollover Collisions	454	461	915
	Killed	494	523	1,017
	Injured	469	396	865
LTV	Fatal Single Vehicle Rollover Collisions	270	184	454
	Killed	292	200	492
	Injured	317	195	512
Fatal Single Vehicle Collisions				
Automobile	Fatal Collisions	1,476	1,216	2,692
LTV	Fatal Collisions	615	420	1,035
Ratio of Fatal Single Vehicle Collisions that Resulted in a Rollover				
Automobile	Fatal Collisions	31%	38%	34%
LTV	Fatal Collisions	44%	44%	44%
LTV/Auto Ratio		1.43	1.16	

4.3.6 Vehicle Age

Table 17 shows the distribution of and occupant casualties in the 1,372 fatal single vehicle rollover collisions (96% of fatal single vehicle rollover collisions) where vehicle model year is known; vehicle age was computed by subtracting vehicle model year from the calendar year. Table 17 also shows the distribution of 3,710 fatal single vehicle collisions where vehicle model year is known; the ratio of collisions involving a rollover is also shown.

This ratio is highest for the 0 to 4 years old group and lowest for the 10 years old and older group for both the automobiles and LTVs; the LTV ratio is 27% to 31% higher than the automobile ratio for all vehicle age groups.

Table 17. Occurrence of and Casualties in Fatal Single Vehicle Rollover Collisions as a Function of Vehicle Age and Type (1993 to 1997) – Canada excluding Alberta

Vehicle Type		Vehicle Age			Total
		0 to 4 years old	5 to 9 years old	10 years old and older	
Automobile	Fatal Single Vehicle Rollover Collisions	310	324	273	907
	Killed	356	354	300	1010
	Injured	267	315	272	854
LTV	Fatal Single Vehicle Rollover Collisions	164	149	152	465
	Killed	184	155	165	504
	Injured	196	166	160	522
Fatal Single Vehicle Collisions					
Automobile	Fatal Collisions	862	969	825	2,656
LTV	Fatal Collisions	352	339	363	1,054
Ratio of Fatal Single Vehicle Collisions that Resulted in a Rollover					
Automobile	Fatal Collisions	36%	33%	33%	34%
LTV	Fatal Collisions	47%	44%	42%	44%
LTV/Auto Ratio		1.30	1.31	1.27	

4.3.7 Driver Age

Table 18 shows the distribution of the 3,791 fatal single vehicle collisions where driver age and gender are known; 1,409 fatal single vehicle rollover collisions (99% of the fatal single vehicle rollover collisions) are tabulated. Occurrence of rollover is shown, as well as the ratio of rollover collisions to single-vehicle collisions for each of the two vehicle types and the LTV/Auto ratio.

We note that, for both male and female drivers and most age groups, the rollover ratio is higher for LTVs than it is for automobiles; the exceptions (shaded in Table 18) are:

- the 60 to 64 year old drivers (both male and female),
- the 35 to 39 year old and 45 to 49 year old female drivers, and
- the 40 to 44 year old male drivers.

We also note that the proportion of fatal single vehicle collision involving a rollover is higher for female drivers than it is for male drivers. In fatal single vehicle collisions involving a female driver, a rollover occurred in 39% of the automobile collisions and 51% of the LTV collisions; the proportions for male drivers are 33% and 43% respectively. The TRAID data do not contain any element that could explain this finding.

Table 18. Number of Fatal Single LDV Collisions by Driver Gender and Age, Vehicle Type and Occurrence of Rollover (1993 to 1997) – Canada excluding Alberta

Driver Gender	Driver Age	Automobile		LTV		Rollover / Total		
		No Rollover	Rollover	No Rollover	Rollover	Automobile	LTV	LTV / Auto
Female	≤19 yrs old	58	45	10	17	44%	63%	1.44
	20 to 24 yrs old	47	23	9	6	33%	40%	1.22
	25 to 29 yrs old	45	28	8	8	38%	50%	1.30
	30 to 34 yrs old	43	32	7	8	43%	53%	1.25
	35 to 39 yrs old	36	27	10	7	43%	41%	0.96
	40 to 44 yrs old	30	21	9	12	41%	57%	1.39
	45 to 49 yrs old	19	12	6	3	39%	33%	0.86
	50 to 55 yrs old	13	7	4	6	35%	60%	1.71
	55 to 59 yrs old	16	3	1	3	16%	75%	4.75
	60 to 64 yrs old	8	10	4	1	56%	20%	0.36
	≥ 65 yrs old	45	20	4	5	31%	56%	1.81
Female Total		360	228	72	76	39%	51%	1.32
Male	≤19 yrs old	243	127	47	46	34%	49%	1.44
	20 to 24 yrs old	267	162	83	70	38%	46%	1.21
	25 to 29 yrs old	166	94	77	54	36%	41%	1.14
	30 to 34 yrs old	156	75	63	72	32%	53%	1.64
	35 to 39 yrs old	125	61	58	47	33%	45%	1.36
	40 to 44 yrs old	86	44	56	24	34%	30%	0.89
	45 to 49 yrs old	80	42	33	23	34%	41%	1.19
	50 to 55 yrs old	63	21	30	20	25%	40%	1.60
	55 to 59 yrs old	50	11	17	16	18%	48%	2.69
	60 to 64 yrs old	35	18	24	8	34%	25%	0.74
	≥ 65 yrs old	155	50	36	20	24%	36%	1.46
Male Total		1,426	705	524	400	33%	43%	1.31
Total		1,786	933	596	476	34%	44%	1.29

Finally, some age groups appear to be considerably more susceptible to be involved in a rollover if they are driving a LTV as opposed to an automobile; this is the case for young (19 years old or younger) or older drivers (50 years old and older) as well as male drivers aged 30 to 34 years old. The data in Table 18 needs to be interpreted carefully as some of the 5-year totals are quite small.

5. DISCUSSION

Vehicle Identification Numbers (VINs) became available only recently for some of the reviewed years for Quebec (1996, 1997 and 1998, Quebec plates only) and Ontario (1997, 1998 and 1999, 6-character Ontario plates only). The 1999 VINs were not used since the TRAID data were not available for this calendar year.

The VIN data were decoded using the Highway Loss Data Institute VIN decoding software (VINdicator); the Quebec data were also decoded using the R.L. Polk VIN decoding software (VINA). VINA can decode the VINs of automobiles, LTVs, heavy trucks and motorcycles whereas VINdicator can only process 17-character VINs for automobiles and LTVs. The VINdicator vehicle classification scheme is easier to deal with; vehicles are classified as Automobiles, Pickup Trucks, Sport Utility Vehicles, Passenger Vans or Cargo Vans. VINA uses a vehicle type (motorcycle, passenger vehicle or truck) combined with a body style (15 styles of motorcycles, 36 styles of passenger vehicles and 72 styles of trucks).

One of the first analyses performed was to compare the vehicle type yielded by VINdicator to the vehicle type recorded in TRAID for the Ontario data (1997 and 1998 only). We found that 77.5% of the SUVs (11,766 out of 15,190) were incorrectly classified (mostly as Automobiles) in the 1997 TRAID data; for 1998, this proportion increased to 81.8% (10,151 out of 12,412). For other types of LTVs, the misclassification proportion varied between 3.4% and 10.9% depending on the particular vehicle type and the calendar year. In the case of automobiles, the misclassification rate was about 0.4% (616 vehicles out of 146,193 in 1997) for both 1997 and 1998. An in-depth review was performed and this review confirmed the findings that a large proportion of the SUVs involved in collisions in Ontario were classified as automobiles in the TRAID data.

The net effect of the misclassification problem is to understate the number of LTVs that rolled over in the 5-year period and to overstate (to a lesser degree) the number of automobile that rolled over. One would therefore expect that the rollover ratios computed in this report would actually increase (LTVs would become worse than what is depicted in this report) once the vehicle type issue has been resolved. Similarly, the injury ratios computed in Section 4.2 would likely increase for LTVs and decrease for automobiles.

In view of the above finding, it was decided to suspend the data analysis and to report only on fatal collisions; also, the decision was made to report on light trucks and vans as a group, not subdivided into subclasses of SUVs, pickup trucks, etc. Once the VIN data are available for a 5-year period, the analysis will be resumed using vehicle type derived from Vehicle Identification Numbers.

The provision of VIN data will also allow the detailed study of rollover collisions for specific types of vehicles.

6. CONCLUSIONS

The results of this study suggest that there are approximately 25,000 collisions involving a light-duty vehicle (LDV) rollover per year in Canada; these collisions result in the death of approximately 500 persons and in non-fatal injury to another 15,000 to 17,000 persons.

The large majority of collisions involving a LDV rollover are single vehicle collisions; it is estimated that there are 20,000 to 21,000 such collisions per year in Canada; these collisions result into the death of approximately 350 persons per year and non-fatal injuries to another 12,000 to 14,000 persons. The remainder of rollovers occur in two or more vehicle collisions; rollovers may occur because of the impact, or may result from post-collision vehicle movements, such as when a vehicle leaves the road following the impact and rolls over in a ditch.

We found that, in proportion to the number of single vehicle crashes, LTVs rolled over 54% more often than automobiles; in addition, single vehicle crashes resulted in a fatal rollover 43% more often for LTVs than for automobiles. We also found that automobiles were involved in 1220 rollover collisions per million automobiles registered; for LTVs, this proportion was 1510 collisions or 24% more often than automobiles. It is not possible to separate the LTV category into pickup trucks, vans and SUVs because VINs were not available. Some VINs did become available towards the end of the study and an initial analysis showed that a large proportion of SUVs were classified as automobiles in the Ontario collision data. A study of rollover occurrence using VIN data is being considered.

We found that a smaller number of vehicle occupants are being killed or injured in a LTV than in an automobile in any given rollover (16.4 occupants killed and 629 occupants injured per thousand reported LTV rollover versus 18.2 occupants killed and 731 occupants injured per thousand reported automobile rollover). However, because LTVs roll over more often than automobiles as a proportion of the number of single vehicle crashes, more LTV occupants are killed or injured than automobile occupants in a rollover in proportion to the number of reported single vehicle collision. The data showed that vehicle rollover resulted in 2.1 occupants killed and 85 occupants injured per thousand single automobile collisions whereas 2.9 occupants were killed and 113 others injured per thousand single LTV collisions.

Some factors and conditions are reported more often in collisions involving a fatal single-vehicle collision with rollover. Alcohol consumption, speeding, slippery road surface are reported more often in rollover collisions than in non-rollover collisions for both automobiles and LTVs. “Road defects/construction” is reported more often in collisions involving LTV rollovers than in non-rollover collisions; in the case of automobile collisions, this factor is reported in the same proportion in collisions with rollover as in collisions without rollover.

This study shows that the large majority of rollovers occur on roads where the posted speed limit is 70 to 90 km/h and on undivided roads. Comparing fatal collisions with and without rollovers, we find that:

- 48% of LTV fatal single-vehicle collisions occurring on roads with a posted speed limit of 70 to 90 km/h result in a rollover; on roads with a posted limit of 100 to 110 km/h, the proportion increases to 56%. For automobiles, the proportions are 39 and 46% respectively. Also, one-third (32%) of all fatal LTV collisions that occurred on roads with a posted speed limit of 10 to 60 km/h resulted in a vehicle rollover.
- 40% of the LTV fatal single-vehicle collisions on non-deformable surfaces resulted in a rollover; for deformable surfaces such as gravel or dirt, the proportion increased to 48%. For automobiles, these proportions were 32% and 38% respectively.

- Road alignment did not affect the proportion of rollovers for LTVs; 44% of LTV fatal single-vehicle collisions resulted in a rollover regardless of whether the road was straight or curved. In the case of automobiles, road alignment did have an influence; on straight roads, 31% of the collisions resulted in a rollover while, on curved roads, the proportion increased to 38%.
- Vehicle age appeared to have only a small influence on rollover; newer vehicles (both automobiles and LTVs) had a higher tendency to roll over than older vehicles. Without a more detailed analysis of vehicle size and characteristics, it is not possible to determine the reason for this influence.
- The proportion of fatal single vehicle collision involving a rollover is higher for female drivers than it is for male drivers. In fatal single vehicle collisions involving a female driver, a rollover occurred in 39% of the automobile collisions and 51% of the LTV collisions; the proportions for male drivers are 33% and 43% respectively. The TRAID data do not contain any element that could explain this finding.
- For most driver age groups, LTV drivers were involved in rollovers in a higher proportion than automobile drivers of the corresponding age group. Exceptions were the 60 to 64 years old (both male and female drivers), the 40 to 44 years old (male drivers) and the 45 to 49 years old (female drivers) groups. For these three driver groups, the proportion of rollovers to single-vehicle collisions was lower for LTVs.
- Although TRAID contains only a small number of fatal single-vehicle collisions occurring on interchange ramps (20 over the 1993 to 1997 period), 71% of the LTVs rolled over in such collisions (5 out of 7). For automobiles, the proportion was 46% (6 out of 13).

7. REFERENCES

1. Statistics Canada — "Catalogue 53-219, Road Motor Vehicles - Registrations", Statistics Canada, 1997

2. — "Proposed Rules; Consumer Information Regulations; Federal Motor Vehicle Safety Standards; Rollover Resistance", Federal Register Vol 65, No. 106, pp 34998-35024, 1 June 2000

3. — "Consumer Information Regulations; Federal Motor Vehicle Safety Standards; Rollover Resistance", Federal Register, Vol 66, No. 9, pp 3388-3437, 12 January 2001

4. National Highway Traffic Safety Administration — "Traffic Safety Facts 1999 – Overview", National Center for Statistics & Analysis, NHTSA, 400 Seventh Street, S.W., Washington, D.C., DOT HS 809 092.

5. Transport Canada — "Canadian Motor Vehicle Traffic Collision Statistics – 1999", Transport Canada, TP 3322, October 2000.