FACTORS IN NASS/CDS MOTORCYCLE CRASHES WITH PASSENGER CARS

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Abstract

Since 2005, the motorcycle crash fatalities in the US exceeded 10% of the overall annual traffic fatalities. Consequently, it has become critical to gain in-depth understanding of the factors and characteristics contributing to motorcycle crashes. Unfortunately, there currently exists no database gathering the necessary information for an in-depth analysis of the US motorcycle crashes. So this study utilizes the NASS/CDS database (National Automotive Sampling System, Crashworthiness Data System) in order to gain insights into the patterns and factors leading to a NASS/CDS motorcycle crash, from 1997 to 2007.

NASS/CDS samples about 5,000 passenger car tow-away crashes per year. Each case includes photographs and detailed data on crash and pre-crash characteristics, vehicle types, trajectories, types of impact, and other pertinent roadway and crash scene information, allowing an in-depth investigation of the crash mechanisms. However, the NASS/CDS sampling process specifically focuses on passenger car crashes, so the cases extracted only correspond to crashes in which a passenger vehicle was towed, and a motorcycle was somehow involved. Thus, a by-hand in-depth review of about 200 cases allowed retrieving 106 relevant crashes for this study, tending to represent the severe passenger vehicle(s) versus motorcycle(s) crashes on US roads.

The findings lead to the conclusion that these crashes mostly result from the low conspicuity of the motorcycle, and from the inability of the car drivers to fully appreciate and anticipate the behavior of a motorcycle. Indeed, it has been shown that, first, the car drivers involved in these cases did not attempt any avoidance maneuver, second, they were largely of ages under 25, and finally, the majority of the crashes were in an intersection scenario. In addition, the two major scenarios unveiled were the *car attempting a left turn from the opposite direction* and the *car attempting a left turn from the right*.

The paper mentions several solutions to enhance the motorcycle's conspicuity and to allow the car drivers to better anticipate its behavior, which seem to be key factors in the intersection-related crashes (and more generally in the passenger vehicle(s) versus motorcycle(s) crashes).

INTRODUCTION

According to the observations of the National Highway Traffic Safety Administration (NHTSA), the number of motorcycle fatalities in traffic crashes has been constantly increasing since 1997 (refer to [1], [3], [4], [7], and see also Samaha *et al.* 2007 and 2008, [9] & [10]). From 2002 to 2006 alone, the motorcyclist fatalities have shown a growth of 47%, making its proportion among overall fatalities to exceed 10% since 2005. That year (2005), the motorcycle fatalities even overshadowed the decrease in passenger car fatalities, leading to an overall increase of the traffic fatalities in the U.S. In 2006, 2007, and 2008 the number of motorcycle fatalities continued to increase (although the motorcyclist's fatality rate per 100M Vehicle Miles Traveled decreased). The annual motorcycle fatalities reached 5,290 in 2008, accounting for 14.2% of the total fatalities (from NHTSA's Fatality Analysis Reporting System data, [3], [6], [7] & [14]), despite the significant drop in total number fatalities reported on U.S. roads over the past decade.

Given this growth, it has become critical to gain a deeper understanding of the factors and characteristics contributing to motorcycle crashes. It has been observed that more than 50% of the motorcycle crashes (over 1992-2004) involved another vehicle, [6] & [9]. Thus the goals of this study were to gain insight into the factors and characteristics contributing to a crash (resulting in severe damages) between passenger cars and motorcycles, and to examine the safety improvements and possible countermeasures for the riders and/or the car drivers to prevent these crashes.

STUDY METHODOLOGY

In the U.S., the National Automotive Sampling System (NASS) is one of the two national traffic crash databases. Started in 1988, NASS is a stratified sample of police-reported crashes of all levels of severity, and is composed of two systems: the General Estimate System (GES), and the Crashworthiness Data System (CDS). NASS/GES samples around 55,000 cases per year with major property damage, injury, or death from the several millions police-reported crashes. It incorporates limited pre-event, rider, vehicle, environment and injury data. On the other hand, NASS/CDS includes detailed vehicle, crash scene, and occupant data of about 5,000 tow-away crashes per year, allowing an in-depth investigation of the crash mechanisms which is the reason why it was chosen for this study.

However, NASS/CDS currently does not specifically sample motorcycle crashes, hence the study only focuses on cases where a motorcycle and passenger vehicle(s) were involved severely enough for towing a passenger vehicle away from the crash scene. Even though the cases do not include detailed injury information on the motorcycle rider, it is still possible to examine each of them for crash and pre-crash characteristics, vehicle types, trajectories, types of impact, and other pertinent roadway and crash scene information.

Since 1988, there have been 192 cases reported in NASS/CDS involving "*Motored Cycles (Does Not Include all-Terrain Veh/Cycles)*", which have been identified with the GWU CDS Case Analysis Tool, [16]. From a quick review of all these cases, it has been established that the cases before 1995 do not include scene schemes (nor motorcycle information), which reduces considerably the investigation possibilities for the purpose of this study. Moreover, NHTSA's Case Viewer, [15], only accesses the cases from 1997 to 2007, so along the fact that the increase in motorcyclist fatalities has been observed from 1997, it has been decided to limit the study to the 106 relevant cases reported over this period.

Usually, national estimates can be calculated from NASS data by applying a national weighting factor for each case. This weighting factor is the product of inverse probabilities of selection in a three stage sampling process. Unfortunately, as NASS/CDS does not sample motorcycle crashes, this factor is not appropriate for the calculation of national estimates about passenger vehicle(s) versus motorcycle(s) crashes. However, as NASS is a stratified sample of police-reported crashes, we may expect that the comprehensive tendencies observed among the 106 cases do reflect the reality of the national crashes between motorcycle(s) and towed passenger vehicle(s).

The study involved a detailed review of the cases, to extract and analyze the pertinent data. The goal of this process was to determine the common patterns of these crashes, and to expose the possible interdependences between the different factors, using Pivot Tables in Microsoft Excel®.

STUDY POPULATION

As described in the paragraph above, this study was based on 106 cases involving at least one motorcycle in a towed passenger vehicle(s) crash sampled by NASS/CDS.

Please note that in all the following figures, the "99" label always refers to unknown data.

The Figure 1 plots the number of NASS/CDS cases per year, from 1997 to 2007. As observed in recently published papers (see [6], [9], [14]), this graph follows the national upward trend in total motorcycle crashes and two vehicles motorcycle crashes.

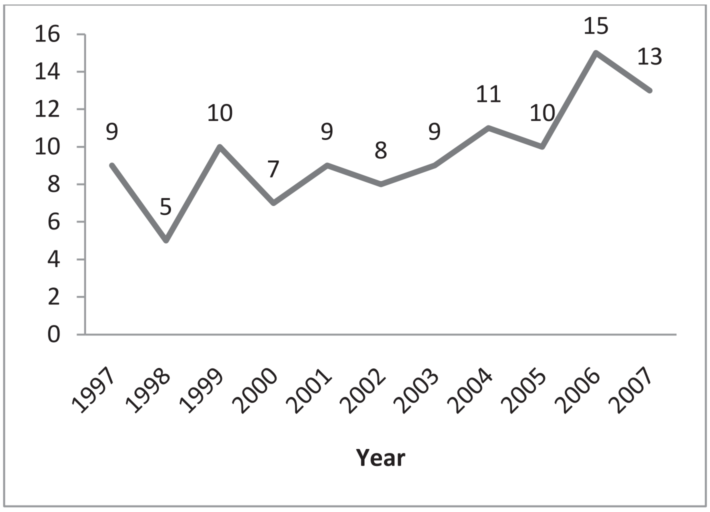

Figure 1: Number of NASS/CDS cases involving at least one motorcycle

Figure 2 displays the engine sizes and makes of the motorcycles involved. We may first observe that a lot of motorcycles' engine sizes are unknown (coded "99" on the graph). But along the review of the cases, we noticed that unknown engine sizes most probably occurred when the on-scene policemen were not able to get this information. That is when the engine size was not written on the bike, mainly corresponding to the high U.S. sales by Harley-Davidson and Honda, i.e. 750cc and over (customized) motorcycles. As a consequence, the large majority of the bikes involved in a passenger vehicle(s) versus motorcycle(s) crash are in the category 750cc and over.

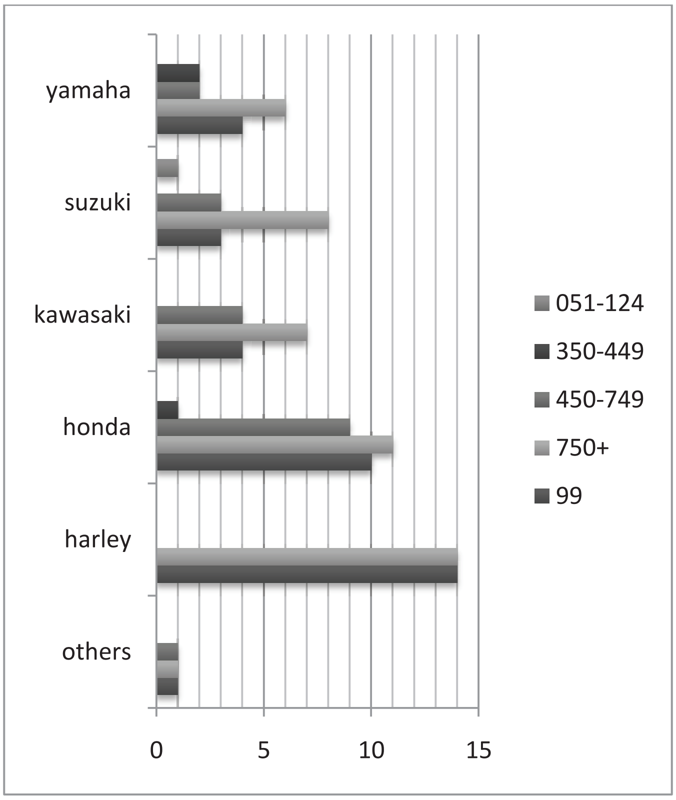

Figure 2: Make and engine size of the motorcycles involved in the NASS/CDS cases

The second indication provided by this graph lies in the distribution of the engine sizes per makes: most of the motorcycles are 750+ and 99 (unknown) Harley-Davidson or Honda, which correspond mostly to cruiser or touring motorcycles, followed by 450-749 and 750+ Japanese made motorcycles, which usually correspond to sport bikes. Further investigations could study the difference in driving behavior associated with the types of motorcycles, though we will see in this study that this might be of secondary importance when considering the opportunities to reduce the passenger vehicle(s) versus motorcycle(s) crashes.

Figures 3a and 3b, depict the distribution of the types of passenger vehicle(s) involved in these crashes, for the two periods 1997-2001 and 2002-2007. For these charts – as well as for all the following data on the passenger vehicles – the only vehicle accounted for was the one best assessed as causing (directly or, for some rare cases, indirectly) the motorcycle's involvement in the crash. The most involved vehicles are the passenger cars from the 4DR SEDAN/HDTOP category, which almost covers ½ of the recent cases. Overall, the distributions observed on these graphs outline the distribution of passenger vehicles on U.S. roads.

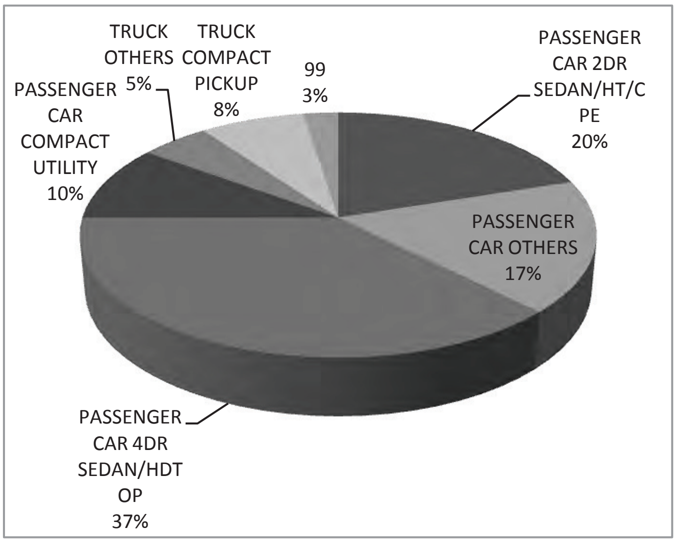

Figure 3a: Type of vehicles (other than the motorcycles) involved in the NASS/CDS cases between 1997 and 2001 included

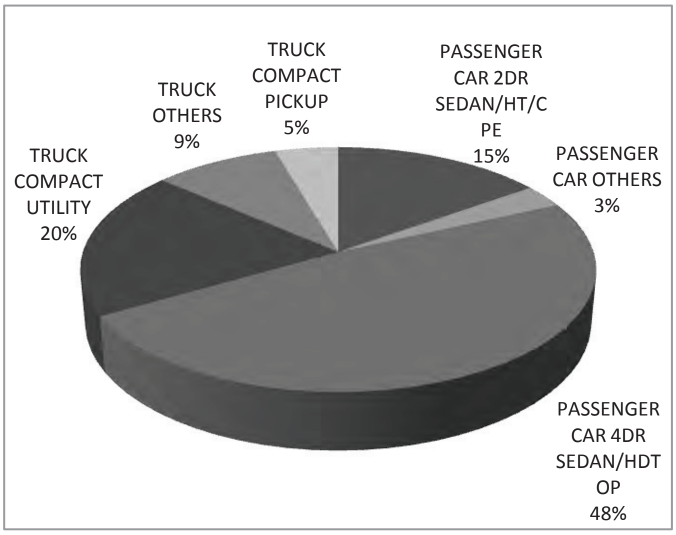

Figure 3b: Type of vehicles (other than the motorcycles) involved in the NASS/CDS cases between 2002 and 2007 included

For more brevity, the passenger vehicle(s) will be referred as the "car(s)" or "passenger car(s)" from now on.

To finish with, Figure 4 is revealing an interesting fact: this chart is showing the proportion of car drivers per age-group. Each group covers a 10 year range (16-25, 26-35, etc…), except for the 56-and-more group. This explains why this group is so wide, whereas it actually does not mean that the drivers from this group are particularly more involved in motorcycle(s) versus towed passenger car(s) crashes than the other drivers. On the other hand, the 25 or less group is substantially larger than the other groups (and could be even larger if these data had been weighted by a factor based on the national distribution of car drivers per age).

This last pie chart illustrates that, even if older car drivers might have slower reaction times – which would have been expected to be critical in motorcycles crashes –, it is actually the youngest car drivers that are more concerned. Consequently, the most important factor until now seems to be the driving experience (and the maybe less aggressive driving style) of the car driver.

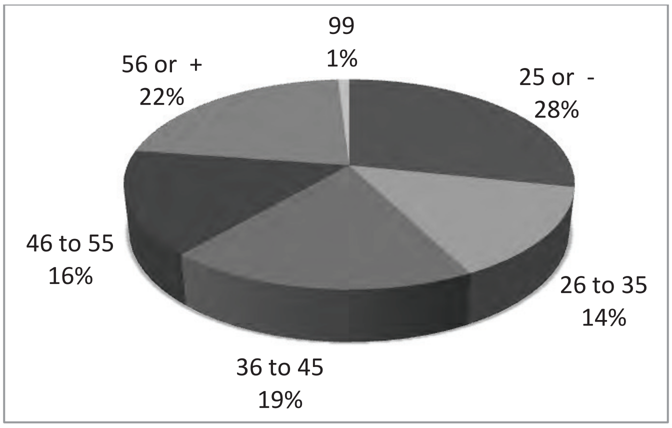

Figure 4: Age of the car drivers involved in the NASS/CDS cases

DRIVER-RELATED FACTORS

ALCOHOL

First of all, the alcohol factor was studied. Figures 5a and 5b respectively show the number of cases in which alcohol was reported either for the motorcyclist, or for the car driver; and Figure 5c displays the proportion of cases involving alcohol in at least one of the drivers since 2002 (cf. [2]).

On Figures 5a and 5b, the number of cases involving no alcohol is rising over the years, whereas the number of "yes" remains steady at a low level. At the same time, and especially for the motorcyclists, the number of "99" (unknown) cases present a significant decline. Compared to other reports of motorcyclist impairment (see [6]), this suggests the alcohol factor is not critical in the motorcycle(s) versus towed passenger car(s) crashes, which is confirmed on Figure 5c with only 17% of "alcohol involved" cases since 2002.

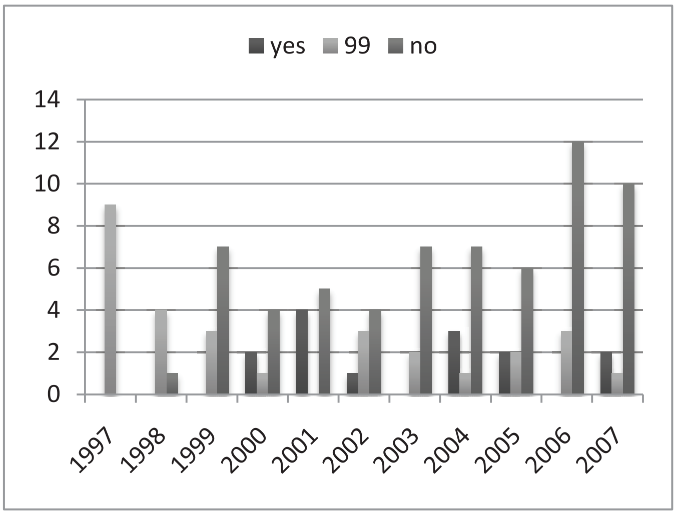

Figure 5a: Presence of alcohol in the motorcyclist in number of cases per year

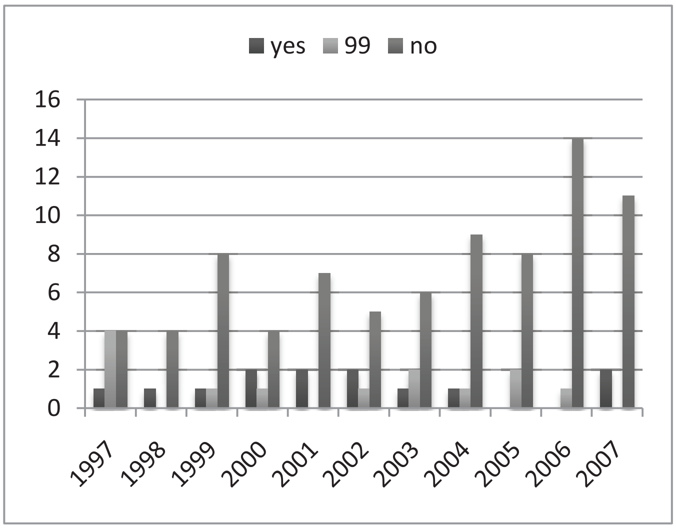

Figure 5b: Presence of alcohol in the car driver in number of cases per year

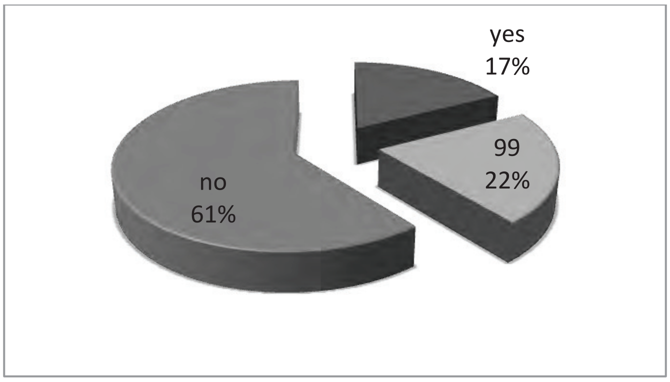

Figure 5c: Presence of alcohol in at least one of the drivers for each case, after 2002

Another interesting graph would have displayed the distribution of alcohol involvement per age range. But given the low number of confirmed “yes”, our set of cases is not providing enough data to draw significant conclusions about the alcohol/age phenomenon.

SPEED

Unfortunately, for most of the cases (72%), the speed of the motorcycle before the first impact was unknown. Indeed, in NASS/CDS, the speed of the vehicles is assessed using the software CRASH3D or WinSMASH (cf. [11]). These calculate the delta V of the crash by evaluating the potential energy absorbed during the crash, from the extent of direct & induce damage on the vehicles. The algorithms used require to evaluate the damaged area on each vehicle, and to assume *linear crush stiffness* and *common velocity at some point of time*. But, for a motorcycle, the damaged area is very difficult to assess, and the two assumptions almost never apply. At impact, the front wheel makes initial contact, which bends the fork and then crushes the body of the motorcycle (hence the crush stiffness is not linear). Moreover – depending on the situations – the motorcycle may rotate and slap the other vehicle or be ejected from the point of impact (and consequently, the common velocity is not reached). However, from the few exploitable data, it has been possible to extract an approximate ratio of ¼ between the cases where the bike was over the speed limit and the cases the limit was respected.

For the same reasons, the speed of the cars were also mostly unknown, and the few known cases often corresponded to multiple crash or other special situations, so that this factor presented no interest for the study.

AVOIDANCE MANEUVERS

Regarding the avoidance maneuvers attempted by the motorcyclists, in the same way as for the speed factor, most of them were reported unknown. Actually, from what we observed during the review of the cases, the policemen generally reported a “99” avoidance maneuver as soon as the bike was down before the impact, or had lost control in some way, or if it was unclear whether the rider had the possibility to try an evasive maneuver or not. Figure 6a depicts the distribution of the different avoidance maneuvers attempted by the motorcyclists. From the “known” part of this graph, it is shown that the major avoidance maneuver attempted is braking, with 80% of lockups (which suggests that there is still room for the spreading of motorcycle’s anti-lock brakes).

On the contrary, from the car point of view, Figure 6b reports that 43% did not attempt any avoidance maneuvers, plus 37% of unknown maneuvers (which here mainly correspond to situations where the driver had no possibilities to attempt any effective maneuvers). This observation suggests that in most of the cases, the car driver did not see the crash coming, which means that the car driver was somehow unable to correctly detect, evaluate and/or anticipate the motorcycle presence and its behavior.

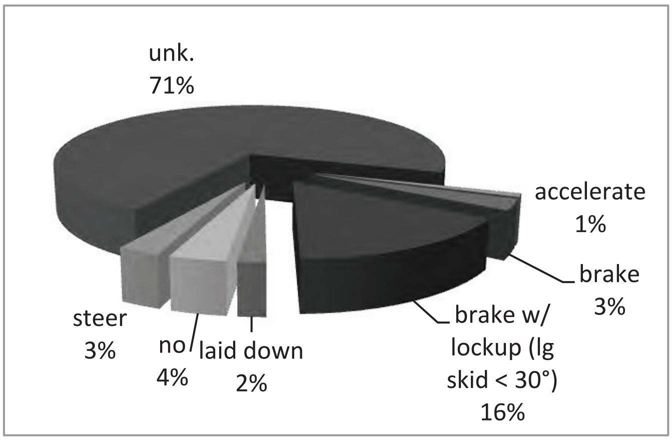

Figure 6a: Avoidance maneuvers attempted by the motorcyclist

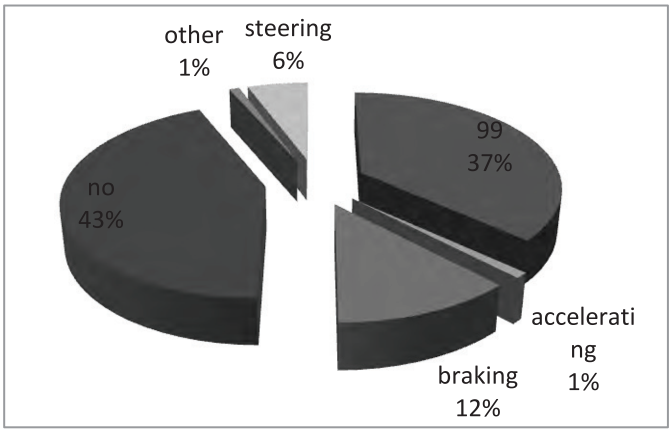

Figure 6b: Avoidance maneuvers attempted by the car driver

INJURIES

As expected, Figures 7a and 7b highlight the gap in severity for a same crash, whether it is observed from the motorcycle occupants' perspective, or from the car occupants.

Please note that the pie charts' legends are always listed clockwise (see Figure 8 for demonstration).

On Figure 7a, the severity of the injuries has been retrieved from the summaries of each case, because NASS/CDS did not provide detailed information on the motorcycle occupants. These summaries correspond to the crash reports written by the on-scene policemen, who use the KABCO PAR code for the injuries. Hence Figure 7a uses of the KABCO scale, whereas Figure 7b reports the Maximum AIS. The KABCO scale is a measure of the functional injury level of the victim at the crash scene (refer to [5]). The codes are selected based on the on-site judgment of the investigating police officer completing the crash report.

- K = Killed;
- A = Incapacitating Injury;
- B = Non-Incapacitating Injury;
- C = Possible Injury;
- O = No Injury, Property Damage Only;
- U (or 99) = Injured, severity unknown.

Although this study occasionally showed A-injuries corresponding to AIS 3 or 2 (because even AIS 2 injuries may cause a rider to be incapable of riding his motorcycle), in most of the cases the A-injuries were associated with an admission at the medical facility.

Also, Figure 7b uses the data on the occupants of the car that was in contact with the motorcycle(s), which may differ ("for some rare cases") from the *vehicle causing (directly or, for some rare cases, indirectly) the involvement of a motorcycle in the crash* that have been used for the rest of the study.

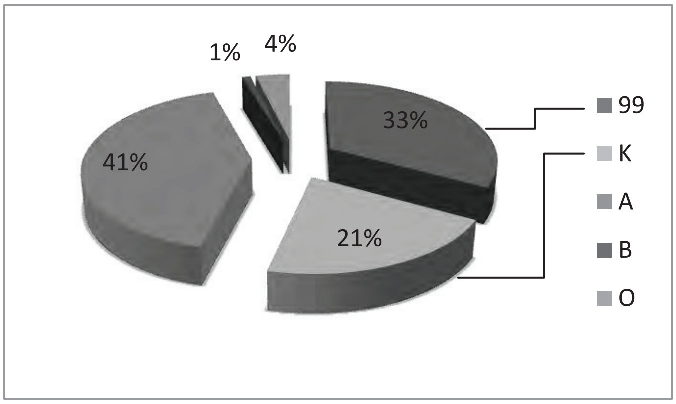

Figure 7a: Maximum PAR reported injury on the occupant(s) of the motorcycle(s)

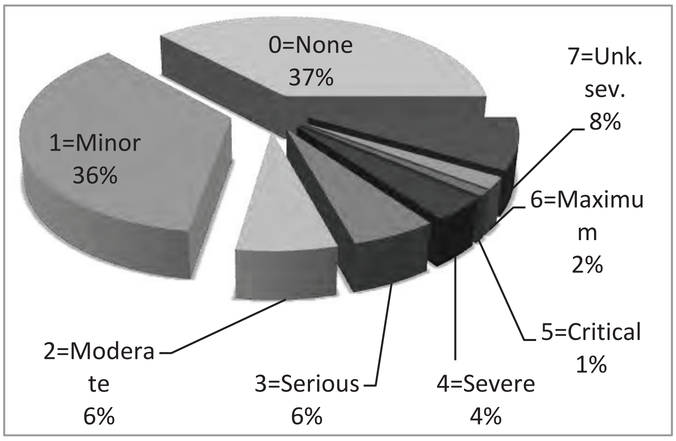

Figure 7b: Maximum AIS of the occupants of the contacted car

ENVIRONMENT-RELATED FACTORS

Next, the influence of every factor related to the road characteristics, configurations and conditions of each crash was checked. Moreover, any possible interdependence between the different factors of these motorcycle(s) versus towed passenger car(s) crashes was investigated.

As expected, many environment-related factors presented no interest by themselves. But it has been revealed that there exists a typical road on which our cases seemed to be more likely to happen. That would be a *straight – leveling off – not divided – asphalt* type of road, under *daylight*, *dry*, and *clear* atmospheric conditions. This typical road covers 33% of the total cases. With little deviation from this typical road characteristics (concrete instead of asphalt, or divided instead of not divided), it covers another 17%, which brings the typical-alike roads to 50%. Another 39% of the crashes involved curved road alignments or uphill/downhill grade road profiles. The remaining cases are anecdotic, though we may notice that not-dry roads only account for 5% (and even then, they may have been of secondary importance in the crash causation).

Aside from this general approach, the “relation to junction” factor happened to be the most important factor in this study. Figure 8 summarizes the distribution of its entries with some additive sub-divisions (obtained from the summaries of the cases). Eventually, Figure 8 details if the crash was due to a loss a control of the vehicle – when the location is not related to any kind of intersection –, and if the intersection was controlled by signs or traffic lights – when the location is related to an intersection –. Please note that the “others” category also includes the “unknown” situations.

The striking fact on this next chart is that only 28% of the motorcycle(s) versus towed passenger car(s) crashes are not related to a road junction. As a consequence, we investigated deeper into the road organization of the crash locations, the pre-crash situations, and the pre-crash movements of the vehicles. This investigation unearthed a new factor summarizing the different scenarios encountered. As this factor will be used extensively in the following of this paper, the next paragraph is dedicated to its description.

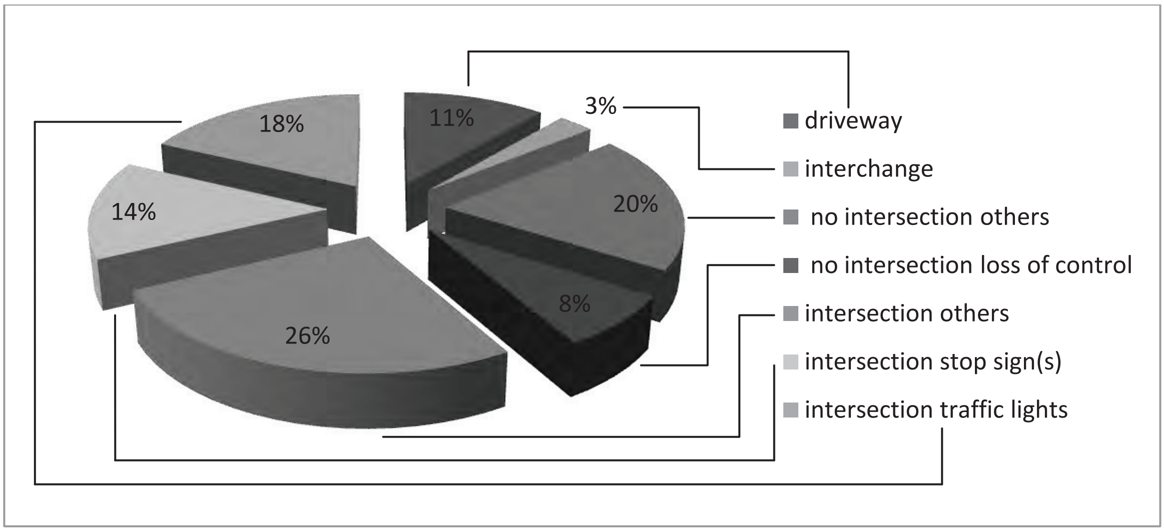

Figure 8: Road relation to junction
at the location of the crash

The scenario factor is divided in seven components that cover all the situations of our set of crashes:

- *sth (something) encroaching into lane*: covers all the cases where an object is encroaching into the lane of at least one of the vehicle involved in the motorcycle crash (in this category, animals, detached parts from crashed vehicles, or rolling-over vehicles are also considered as objects).
- *both veh. Xing intersection*: gathers the cases where all vehicles have been crossing an intersection at the same time, in an attempt to go straight (or unknown). Eventually, this category covers all the cases happening at an intersection which do not enter in the two next categories.
- *car attempting L turn from opp. dir.*: covers the situations where the car was on the same road than the motorcycle(s), but approaching the intersection from the opposite direction. Then the car attempted a left turn across the motorcycle's way.
- *car attempting L turn from R*: all vehicles were approaching the same intersection, but this time, the car was on a road oncoming from the right of the motorcycle(s). Again, the car attempted a left turn across the motorcycle's way.
- *same lane, same dir., difference in speed*: both (or more) vehicles were traveling in the same lane, in the same direction, but not with the same speed (includes the cases where one of the vehicle was stopped in the lane).
- *U-turn*: one of the vehicles (i.e. the passenger car, except for one case) attempted a U-turn.
- *vehicle over L side's lane line*: (at least) one of the vehicles crossed over the lane line demarcating the right side from the left side of the road.

Please note that here, the word "intersection" is used in its broad meaning and actually refers to all kind of road junctions.

Next, Figure 9 confirms the impression gotten from the Figure 8: 60% of the motorcycle(s) versus towed passenger car(s) are due to an intersection-related maneuver. Moreover, it shows that in 46% of the total cases, the crash happened when the car was attempting a left turn. These observations emphasize our previous remarks on the inability of the car driver to correctly detect, evaluate and anticipate the motorcycle and its behavior. Again, in most of these cases, the car driver did not see the crash coming, which suggests that he probably had not seen the motorcycle at all.

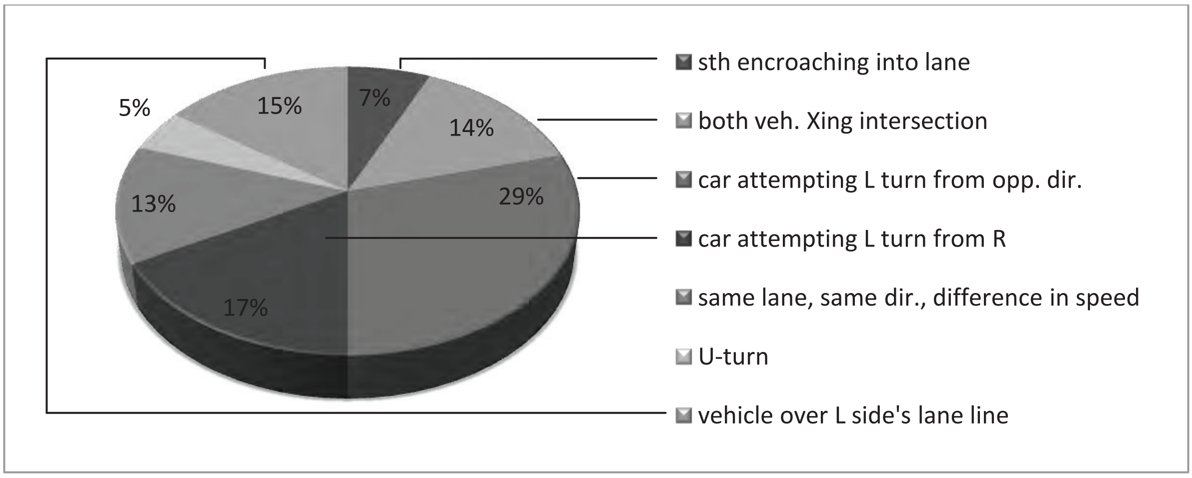

Figure 9: Scenarios of the crashes

On Figure 10, the traffic flow characteristics of the road are plotted for each scenario. This graph reveals that the roads were mainly not divided or with no barriers, for the crashes happening at an intersection (and this is actually true for all the crashes). This suggests that, even though our crashes are caused by the car drivers' difficulties to detect the motorcycles, the road infrastructure were actually not obstructing the visibility.

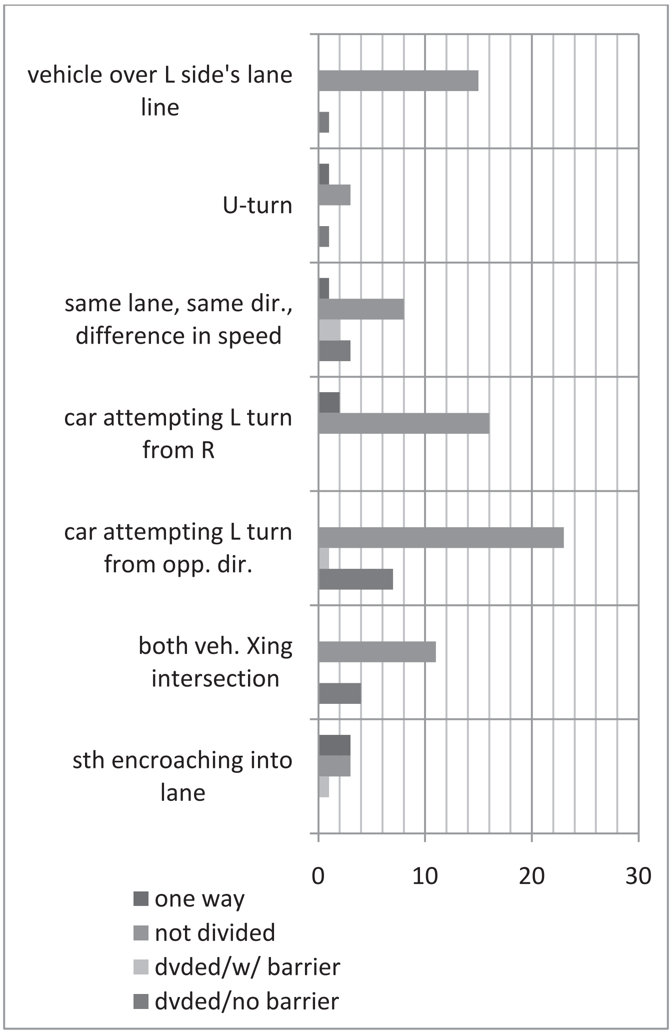

Figure 10: Traffic flow characteristics per crash scenario
(in number of cases)

Consequently, we may assert that either the motorcycle was hidden by other vehicles at the time the car driver checked the road (which is more likely to happen when there are more than two travel lanes, see Figure 11), or the car driver did not see and estimate correctly the distance to the motorcycle and its speed, probably because of its low conspicuity (see [8] and [12]). Figure 12, which displays the light conditions at the crash scene for each case, supports the fact that the motorcycle(s) versus towed passenger car(s) crashes happening at an intersection are mainly due to a problem of motorcycle conspicuity. Indeed, this figure shows – as expected – that a large proportion of crashes happened during daytime, however nighttime crashes are here over-represented compared to the whole 106-cases of this study. This indicates that the crashes happening in low luminosity conditions have a higher rate in intersection-related scenarios. Especially for the *car attempting L turn from opp. dir.* scenario, the nighttime crashes are even greater than the daytime crashes.

Even though the motorcycle population in the US is fairly different than in Europe, these observations and conclusions on intersection-related crashes between motorcycles and towed passenger cars are consistent with the results drawn from the research conducted in Europe under the MAIDS research project [13].

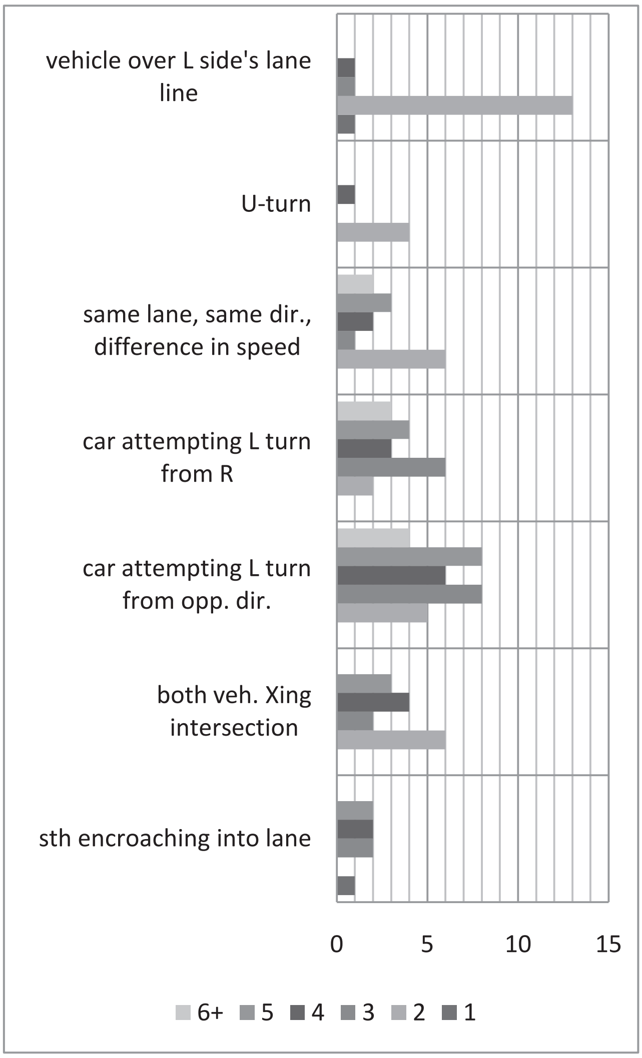

Figure 11: Number of travel lanes per crash scenario (in number of cases)

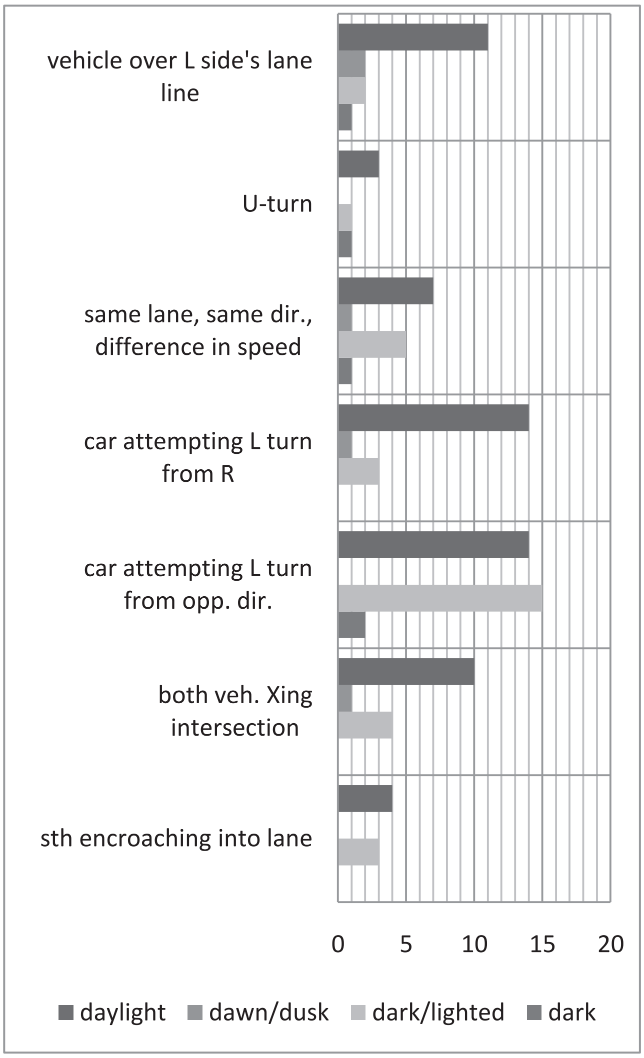

Figure 12: Light conditions per crash scenario (in number of cases)

CONCLUSION

From the review of 106 NASS/CDS cases distributed increasingly between 1997 and 2007, it has been shown in this study that the motorcycle(s) versus towed passenger car(s) crashes could be reduced by increasing the ability of the car driver to correctly detect, evaluate and anticipate the motorcycle's behavior.

Indeed, our data suggest that the national policies and prevention against drunk driving are efficiently assessing (and probably reducing – cf. [2] –) the involvement of alcohol in these crashes. Due to a lack of data on the speed factors, it has not been established to what extent over-speeding motorcycles have influenced these crashes.
However, we pointed out the larger proportion of young car drivers involved in the reviewed cases, the relative absence of avoidance maneuver from the car drivers, and the predominance of the intersection-related scenarios (with a surprisingly high proportion of car attempt to make a left turn). Consequently, the main factors leading to motorcycle(s) versus towed passenger car(s) crashes seem to reside in the low conspicuity of the motorcycle, and/or in the inability of the car drivers to accurately grasp the behavior of the motorcycle.

Some key papers on this topic have already unveiled several safety systems (such as the Honda Long *Lighting System for enhanced conspicuity of motorcycles*, [12]), and proposed improvements in safety strategies (see [9]).
Inspired directly from the Honda lighting system, the motorcycles conspicuity may be improved by developing turning lights so that they would work in the same way as on U.S. cars: always on, and flashing to indicate a turn. This measure would need some further investigations, but its advantage would lie in the fact that it could be widely spread if applied to the motorcycles already in circulation, by implementing minor modifications to their turning light circuit (which could be easily done during the maintenance of the vehicle). This measure would also need a stricter regulation of the size and location of the turning lights.
Still in order to increase the conspicuity of the riders, it would be interesting to study the efficiency of putting reflecting stripes on the rider's clothes, and/or of wearing a fluorescent jacket.
And, as it has been proposed in some other papers ([9] & [10]), prevention campaigns for riders (about typical scenarios involved in these crashes, among other topics…) may be helpful.

From the car's point of view, some of the detection devices implemented on the recent cars might result in enhanced avoidances of these crashes.
Finally, since the car attempting left turn scenarios have been identified as of major importance in this study, it might be interesting to investigate the role of the left A-pillar in removing a motorcycle from the car driver's field of vision.

REFERENCES

[1] NHTSA, Traffic Safety Facts – A Brief Statistical Summary Published by the Mathematical Analysis Division *Motorcycle Riders In Fatal Crashes*, DOT HS 809 734, June 2004.

[2] NHTSA, Traffic Safety Facts – A Brief Statistical Summary *Impaired Motorcycle Operators Involved In Fatal Crashes 2005*, DOT HS 809 939, October 2005.

[3] NHTSA, Traffic Safety Facts - A Brief Statistical Summary *Comparison of Motorcycle Rider Fatalities in Traffic Crashes 2005-06*, DOT HS 810 820, August 2007.

[4] NHTSA, Traffic Safety Facts – A Brief Statistical Summary *Fatal Injured Motorcycle Operators By License Status 2008*, DOT HS 810 892, January 2008.

[5] NHTSA NASS General Estimates System, *Coding and Editing Manual*, 2008

[6] NHTSA FARS/GES *2008 Data Summary*, DOT HS 811 171, March 2010

[7] NHTSA, Traffic Safety Facts – A Brief Statistical Summary *Early Estimate of Motor Vehicle Traffic Fatalities in 2009*, DOT HS 811 291, March 2010

[8] Miura T. *A preliminary study of gap acceptance behavior and its perceptual factors*, Bulletin of the Faculty of Human Sciences, Osaka University, Vol.6 pp.37-41, 1980.

[9] Samaha R. S., Kuroki K., Digges K. H., Ouellet J. O. *Opportunities for Safety Improvements in Motorcycle Crashes In the United States*, The 20th ESV Conference Proceedings, Paper Number 07-0370, 2007.

[10] Samaha R. R., Scullion P. *Presentation to TRB*, 2008.

[11] Sharma D., Stern S., Brophy J., Choi E. *An overview of NHTSA's crash reconstruction software WinSMASH*, The 19th ESV Conference Proceedings, Paper Number 07-0211, 2005.

[12] Tsutumi Y., Maruyama K. *Long Lighting System for Enhanced Conspicuity of Motorcycles*, Honda R&D Co. Ltd., Paper Number 07-0182.

[13] ACEM, with the support of the European Commission – MAIDS research project, (downloaded: May 2009) *MAIDS, In-depth investigations of accidents involving powered two wheelers*, Final Report 2.0

[14] FARS Encyclopedia, (last accessed: May 2010) *http://www-fars.nhtsa.dot.gov/Main/index.aspx*

[15] NHTSA Public Case Viewer, (last accessed: May 2009) *http://www-nass.nhtsa.dot.gov/BIN/NASSCaseList.exe/SETFILTER?CASETYPE=PUBLIC*

[16] The George Washington University CDS Case Analysis Tool, (last accessed: May 2009) *https://www.cdscat.com/*