Deliverable 1.1

Accident Data Study

Dissemination Level	Public	
Written by	David Brookes, Giulia Padovan, Katerina Pasecnika	Thatcham Research
	Anita Fiorentino, Maria-Rosaria Busiello	Fiat Chrysler Automobiles
	Oana Robescu	Denso
Issue date	26/06/2019	

Acknowledgments

The authors wish to thank the Work Package 1 group for their support through the sourcing of data for analysis and providing feedback during group discussions. Particular thanks to Anita Fiorentino and Maria-Rosaria Busiello (FCA) for their analysis of ACI-ISTAT and iGLAD data, Rodrigo Núñez Miguel for coordinating the supply of national and in-depth data for France, Spain and Germany and also Niels Bos and Dimitris Margaritis for the supply of national data for The Netherlands and Greece respectively. A key concept of the analysis was the aggregation of 3-digit accident scenarios into similar accident types based on sensing requirements, this concept was kindly shared to the group by Oana Robescu courtesy of Denso.

Executive Summary

Despite representing a small part of the road users (e.g. 2% of the traffic in France) the percentage of Motorcyclist in the total deaths is the highest for the VRUs (World road deaths in 2010: 23% PTWs, 22% pedestrian and 5% Cyclist). A motorcyclist is between 9 to 30 times more likely to be killed in a traffic crash than a driver. (OECD, 2015)

In recent years, we have observed a decrease in the number of deaths on the roads. But this reduction is not equal for all the different road users. If we take a look at the evolution of the mortality depending of the type of road user we can see that, while in the case of cars it has been reduced by 50%, in the case of the motorcyclist this reduction it has been only of the 30%. (European Comission, Directorate General for Transport, 2016)

The main objective of Work Package 1 is to provide a set of accident scenarios that can be implemented into future test procedures, namely Euro NCAP active safety assessment, for the protection of vulnerable road users in the form of powered two-wheeler (PTW) users.

National datasets comprising of police recorded injurious accidents for the UK, France, Italy, Spain, Germany, Greece and The Netherlands were analysed through cluster analysis to derive a group of distinct scenarios incorporating key information, where available, on vehicle manoeuvres, impact locations, road type and speed limits. These scenarios were assigned a GDV code, a pictogram-based illustration of the conflict scenario. The GDV code themselves were grouped in accident groups based on common vehicle manoeuvres and conflicts. In addition to the national dataset analysis In-depth accident datasets from the UK, Italy, Spain, France and Germany were analysed to return the initial travel and impact speeds for the car and motorcycle by accident scenario and aggregated to an accident group summary.

Over the half of the 62% of identified car to motorcycle accident scenarios occur at junctions, the most frequent accident group is Left Turn Across Path – Opposite Direction Conflict (16.03%), typified by the GDV accident scenario 211, followed by Straight Crossing Path – Right Direction Conflict (12.84%), GDV accident scenario 321, Left Turn Across Path – Left Direction Conflict (11.29%), GDV accident scenario 302 and then Straight Crossing Path – Left Direction Conflict (5.83%), GDV accident scenario 301. The next most frequent accident type is front to rear (5.77%) where the car is the rear impacting vehicle against a slower moving or stationary motorcycle. Renaming accident scenarios are head on conflicts either while both vehicles are traveling straight or cornering, lane change conflicts in the same or opposite directions of travel and variations on the car turning or travelling straight across the path of the motorcycle at junctions. A notable accident group, that although not as frequent as others but worthy of consideration as it potentially has similar sensing requirements as lane change manoeuvres, is Left Turn Across Path – Same Direction Conflict, GDV accident scenario 202 and 721.

Table of Contents

Introduction

1.1 The MUSE project

Despite representing a small part of the road users (e.g. 2% of the traffic in France) the percentage of Motorcyclist in the total deaths is the highest for the VRUs (World road deaths in 2010: 23% PTWs, 22% pedestrian and 5% Cyclist). A motorcyclist is between 9 to 30 times more likely to be killed in a traffic crash than a driver. (OECD, 2015)

In recent years, we have observed a decrease in the number of deaths on the roads. But this reduction is not equal for all the different road users. If we take a look at the evolution of the mortality depending of the type of road user we can see that, while in the case of cars it has been reduced by 50%, in the case of the motorcyclist this reduction it has been only of the 30%. (European Comission, Directorate General for Transport, 2016)

Concerned by this problematic the French Government decide in 2015 to perform a study in collaboration with UTAC to evaluate the accidentology of the motorcyclist and the possibility of avoid them or mitigate the consequences using the new ADAS systems. Knowing the importance of EuroNCAP in motivating the OEMs to invest in security, in May 2016 the Interior Minister Mr Bernard Cazeneuve and the Transport Minister Ms Ségolène Royal write a letter to EuroNCAP claiming for a safety rating. At the beginning of 2017 EuroNCAP includes the scenarios with motorcycles in their Roadmap 2020/2025 and the possibility of start to assess the presence of security systems in motorcycles.

However, how will it be possible to evaluate the systems without the necessary tools to do so? At this moment it does not exists the testing equipment who will allow us to evaluate the systems, not even a protocol in which the main scenarios and their characteristics are defined.

In addition, which will be the best systems to avoid the accidents? Will it origin new accidents? What about ADAS systems in the motorcycle? Is feasible to perform real test to assess the systems in motorbikes?

The aim of this project is to answer these questions and to provide the OEMs and TIERs1with the tools that will allow them to develop their systems and evaluate them.

The main objective in MUSE is to improve safety of motorcyclist.

By studying in a first stage the main accident scenarios and possible systems that could help to avoid them or, at least, reduce their consequences. And, at the same time, by developing the tools that will allow as to improve these systems and to evaluate their performances.

1.2 Objectives of this report

The main objective of Work Package 1 is to provide a set of accident scenarios that can be implemented into future test procedures, namely Euro NCAP active safety assessment, for the protection of vulnerable road users in the form of powered two wheeler users. The accident scenarios are to be informed by analysing national and in-depth datasets from key European countries where absolute numbers of PTW injuries are the greatest.

The use cases will be largely informed by national dataset analysis and supplemented with in-depth data to potentially inform on such variables as travel speeds and impact locations both for the detailed test definition and also in support of Work Package 2 - Target characterisation and development

where such information will be important to ensure that a PTW test target is developed that is robust and valid in terms of sensor dependant physical attributes for the prescribed scenarios.

1.3 Literature Review

There have been numerous PTW studies involving European accident data in recent times often covering a board range of accident factors from causation through to rider injuries and the effect of environment. Of these studies the main projects that have been reviewed for the MUSE accident studies are Saferider, MAIDS, Aprosys, PISa, Saferwheels and the standard ISO 13232 with a focus on understanding the accident types identified from the national and in-depth data. In addition to PTW studies recent VRU studies appertaining to the development of ADAS and test procedures have been reviewed with a focus on methodology and reporting of use cases.

1.3.1 Saferider

SAFERIDER (CERTH, 2008) was a European consortium project that aimed to study the potential of motorcycle ADAS and In-Vehicle Information Systems (IVIS) – subsequently termed Advanced Rider Assist Systems (ARAS) and On-board Information Systems (OBIS) to increase rider safety.

A project objective was to develop priority use cases for ARAS/OBIS implementation on PTW's. The following use cases were identified (CERTH, 2008):

- 1a: Urban single motorcycle accident on a straight road
- 1b: Urban single motorcycle accident on bends
- 1c: Rural single motorcycle accident on straight road
- 1d: Rural single motorcycle accident on bends
- 2a: Front-side urban junction accident with cars
- 2b: Front-side rural junction accident with car
- 3a: Side-side urban non-junction accident with car
- 3b: Side-side rural non-junction accident with car
- 4a: Rear-end accident in urban non-junction accidents with cars
- 4b: Rear-end accidents in rural non-junction accidents with cars

An additional four use cases were also defined for car to moped accidents: 5a) Mopeds single urban accident, 5b) Mopeds single rural accident, 6a) Urban front-side accidents of mopeds with cars, 6b) Rural front-side accidents of mopeds with cars, 7a) Head-on accidents in urban areas, 7b) Head-on accidents in rural areas.

The six motorcycle and car accident scenarios, 2a – 4b, can be categorised into accident groups Left Turn Across Path/Opposite Direction conflict (GDV code 211), Straight Crossing Path/Left Direction (GDV code 301), Straight Crossing Path/Right Direction (GDV code 321) and Follow-Up driving (GDV code 601).

In addition to the derivation of the accident scenarios accident characteristics were also recorded and summarised by use case. Table 1.3.1-1, Table 1.3.1-2 and Table 1.3.1-3 detail the pertinent finding for the car and motorcycle accidents.

Front-side junction accident with car:

Table 1.3.1-1: SAFERIDER Analysis - Front-side junction accident with car

	2a	2b
Case name	Front-side urban junction accident with car	Front-side rural junction with car.
Goal	22% of all accidents	22% of all accidents
Accident causes	Inadequate speed of drivers and/or rider, Violation of right-of-way	
Accident characteristics		
Type of road	T or X-junction regulated by stop sign or not.	Rural junctions
Relative trajectories	Perpendicular	
Ego-vehicle Speed	Up to 50 km/h	
Other vehicle speed	Up to 50 km/h	
Time of the day	Majority in daylight	Majority in daylight. However, 18% at night.
Weather		
Visibility		
Scenario description	1. A motorcycle is near to an urban junction. 2. A converging car is recognised as approaching without braking.	1. A motorcycle is near to a rural junction. 2. A converging car is recognised as approaching without braking.

Side-side junction accident with car:

Table 1.3.1-2: SAFERIDER Analysis - Side-side junction accident with car

	3a	3b
Case name	Side-side urban non-junction accident with car	Side-side rural non-junction accident with car
Goal	6% of all accidents	6% of all accidents
Accident causes	Running side-by-side or motorcycle overtaking from left or right with excessive speed (93%)	Running side-by-side or motorcycle overtaking from left or right with excessive speed (93%)
Accident characteristics	In 50% of cases traffic violation by the rider, 10% of riders absent-minded, 10% of riders illegal overtaking, 2% of riders non-obeying on stop sign. Query car driver errors.	
Type of road		
Relative trajectories		
Ego-vehicle Speed		
Other vehicle speed		
Time of the day	90% under daylight conditions	90% under daylight conditions
Weather		
Visibility		
Scenario description	1. Motorcycle running at the side of the car or overtaking it. 2. Car drifting towards motorcycle on the next lane.	

Rear-end accidents at non-junctions with cars:

Table 1.3.1-3: SAFERIDER Analysis - Rear-end accidents, non-junctions with cars

	4a	4b
Case name	Rear-end accidents in urban non-junctions with cars	Rear-end accidents in rural non-junctions with cars
Goal	10% of all motorcycle accidents	10% of all motorcycle accidents
Accident causes	Illegal overtaking of the rider (8%). Too-short distance from the vehicle ahead (17%).	Illegal overtaking of the rider (8%). Too-short distance from the vehicle ahead (17%).
Accident characteristics		
Type of road		
Relative trajectories		
Ego-vehicle Speed		
Other vehicle speed		
Time of the day	8% during night without luminosity.	8% during night without luminosity.
Weather	Wet surface in 3% of cases. The rest dry.	Wet surface in 3% of cases. The rest dry.
Visibility	Restricted visibility in 5% of the cases.	Restricted visibility in 5% of the cases.
Scenario description	1. The rider is following a car and approaches too near to it, usually preparing an overtaking manoeuvre.	1. The rider is following a car and approaches too near to it, usually preparing an overtaking manoeuvre.

1.3.2 MAIDS

MAIDS was a European study conducted by the Association of European Motorcycle Manufacturers (ACEM) with the support of the European Commission and other partners (ACEM, 2009). Key to the analysis was a unified approach to accident data collection and analysis for the in-depth study of PTW accidents, this method was developed by the Organisation for Economic Co-Development (OECD) and was undertaken in five sampling areas by country – France, Germany, Netherlands, Spain and Italy during the period of 1999 – 2000.

A total of 921 accidents including mopeds and motorcycles, termed L1 and L3 vehicles respectively, were analysed and a full accident reconstruction conducted for each case and where possible rider injured were AIS coded. A further 923 cases were also studied involving riders and PTW's not involved in accidents in the sample areas to act as a case-control to account for any over-representation of causative factors in the injurious sample.

Key findings of the study with respect to accident characteristics were that 60% of accidents involved a passenger car as the collision partner of which 80.2% of these passenger car collisions involved only one other vehicle. 54.3% of all accidents occurred at an intersection, 72.3% in urban areas.

The data in Figure 1-1 gives the main accident scenarios for both L1 and L3 vehicles with other vehicles.

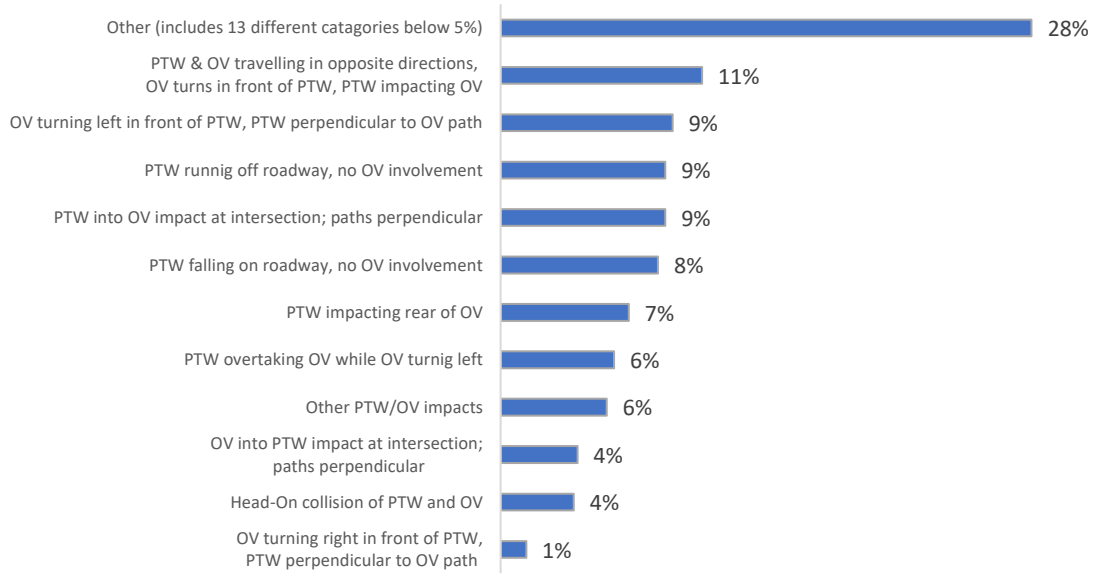


Figure 1-1: MAIDS L3 PTW accident configuration by legal category

Primary accident causation was assigned by the research teams as either human, vehicle or environmental, in 50.5% of cases it was consider that human error from the driver of the other vehicle was the primary cause with 37.4% assigned to the rider of the PTW, the third most frequent causative factors was environmental at just 7.7%. The driver and rider causative factors are further coded as perception, comprehension, decision or reaction failure. For the driver of the other vehicle perception failure was the most frequent contributing factor at 72% and for the PTW rider decision failure was the most frequent at 36% followed by perception failure at 32%. An example of perception failure is the other vehicle driver fails to check their side view mirrors and moves into the adjacent lane, striking the PTW that was in the adjacent lane.

The pre-crash motion of the PTW and OV that led to the accident showed that in 67.4% cases the PTW was traveling in a straight line followed by negotiating a bend at a constant speed, 12.1% and then at 5.8% performing a passing manoeuvre on the left. The most frequent pre-crash manoeuvre of the OV was also travelling in a straight line, 56.5%, followed by being stationary in 16.8% of cases.

MAIDS reported on pre-crash motion prior to the precipitating event and the pre-crash motion after the precipitating event. With respect to the MUSE project objectives for acquiring knowledge on how ADAS might prevent or mitigate the accident the interest is in the pre-crash motion after the precipitating event.

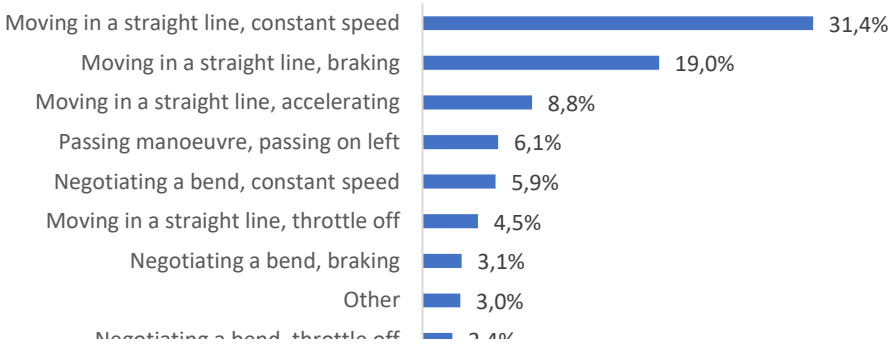


Figure 1-2: (Table 5.12) PTW pre-crash motion after precipitating event

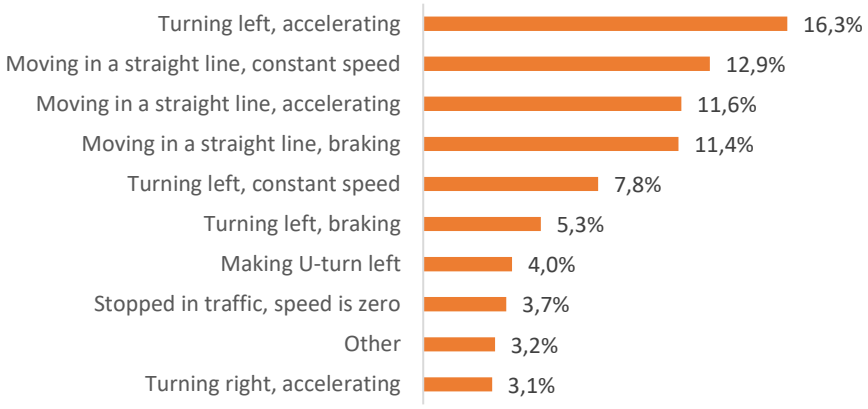


Figure 1-3: (Table 5.13) OV pre-crash motion after precipitating event

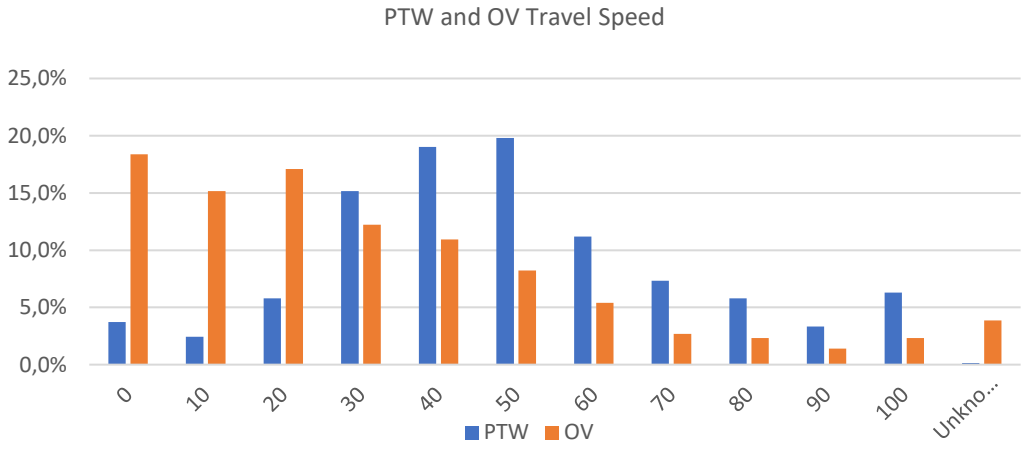


Figure 1-4: (Table 5.10 & 5.11) PTW and OV travel speed (two vehicle accidents)

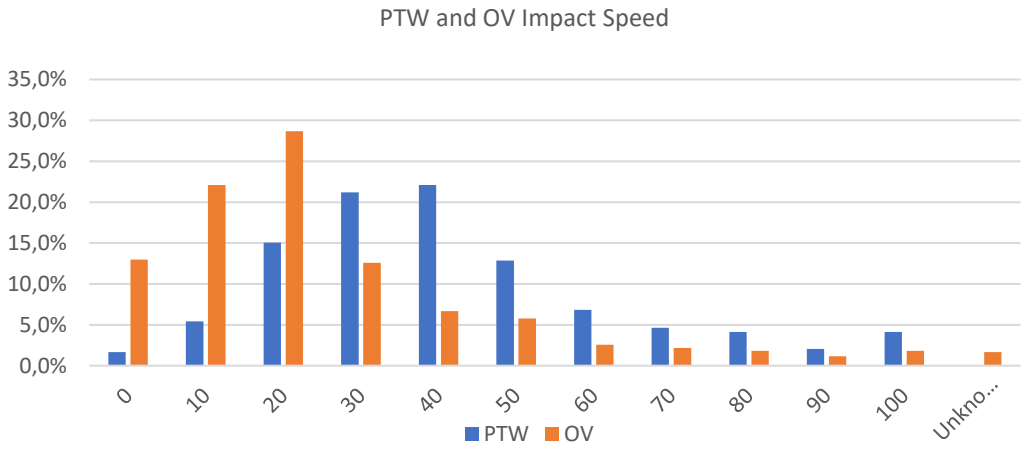


Figure 1-5: (Table 5.16 & 5.17) PTW and OV impact speeds (two vehicle accidents)

L1 and L3 accidents involving an OV were analysed separately to investigate if there is a speed characteristic difference between the two types of PTW vehicle. The median travel speed for a L3 PTW was 60.0 km/h with an associated OV travel speed of 21.0 km/h. Median impacts speeds were 48.0

km/h and 20.0 km/h for the L3 PTW and OV respectively. An analysis of L1 PTW to OV accidents gives a median travel speed of 37.0 km/h and 24.0 km/h respectively, respective impact speeds are 31.0 km/h and 21.0 km/h. These results are perhaps as expected given the engine capacities and potential use environment between the two PTW categories.

The most frequency collision configuration in terms of relative heading angle between the PTW and OV was between 337.5° and 22.5°, 25.1%, followed by 16.8% of configuration been between 67.5° and 112.5° and 12.7% been between 247.5° and 292.5°. These results highlight a tendency for parallel and perpendicular impact configurations between the two vehicle types.

1.3.3 APROSYS

APROSYS was a European co-operation project that started in 2004 and ran for 5 years (Pierrini, et al., 2004). It was co-funded by the European Commission and had a consortium of partners. The project objective was to offer a significant contribution to the reduction of road victims in Europe and as such contribute to the road safety goals of the European Commission. The project comprised seven sub-projects four of which related to accidents types. Sub-project 4, SP4, related to motorcycle accidents.

SP4 was informed by an accident analysis of national accident databases using the latest data available from Germany, Italy, The Netherlands and Spain for the latest 3-Years of available data (1999 through to 2002 dependant on country). The main objective was to identify accident scenarios for both mopeds and motorcycles with a focus on killed and serious accidents.

The number of accidents were returned for the variables of urban or rural area, time, month, junction and road geometry, road surface conditions, weather and light conditions but as disaggregated values, which to some extent limits the potential insight that could be derived from the data. Accidents scenarios were given as the combination of PTW to other vehicle types or road user.

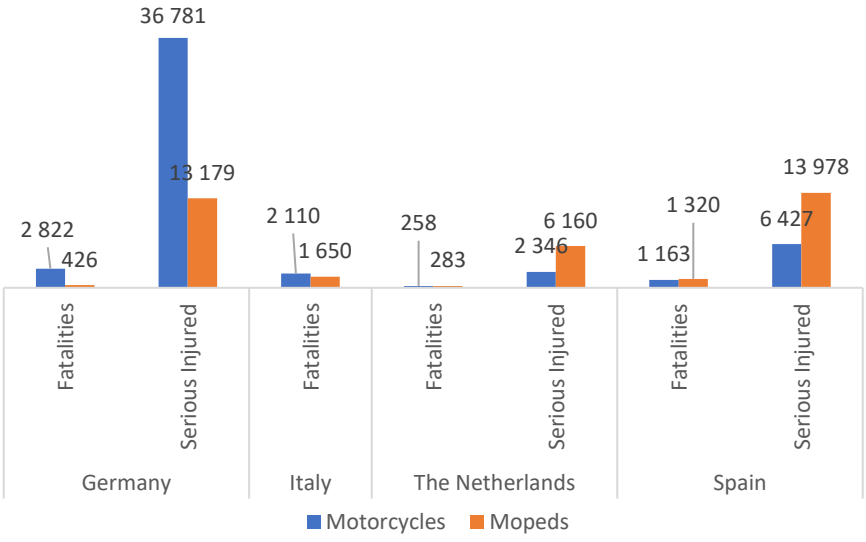


Figure 1-6: KSI accidents. 3-Year count

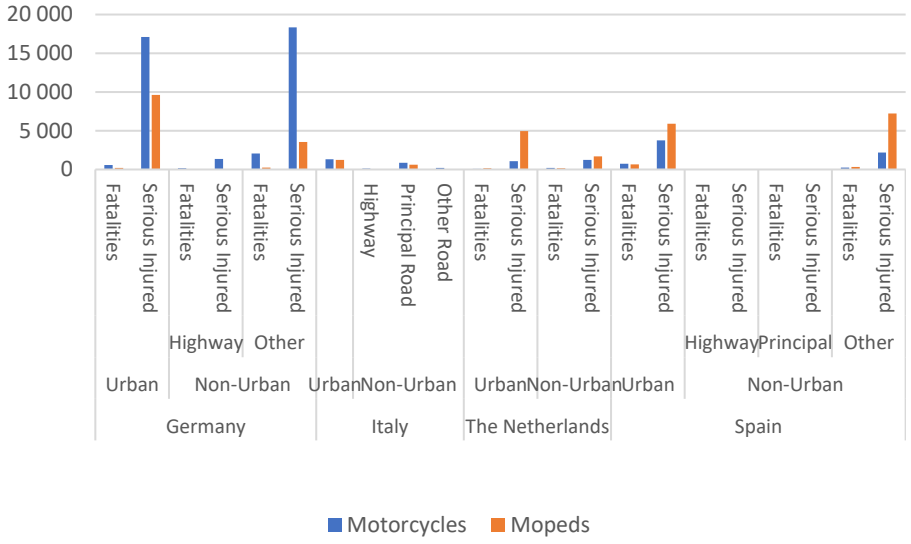


Figure 1-7: KSI accidents by Urban or Non-Urban Area and Road Class. 3-Year count.

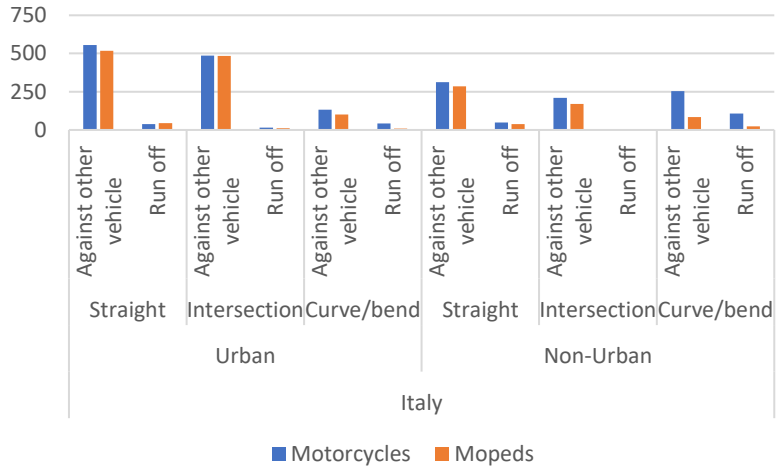


Figure 1-8: Accident in Italy by Accident Scenario. 3-Year count.

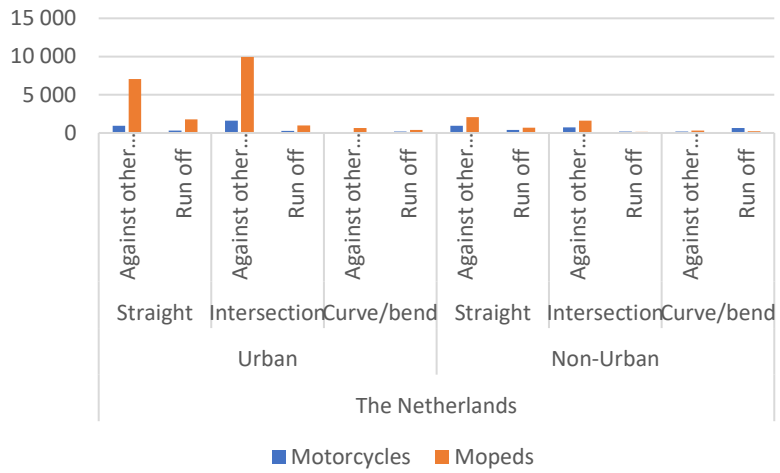


Figure 1-9: Accident Scenario in The Netherlands by Accident Scenario. 3-Year count.

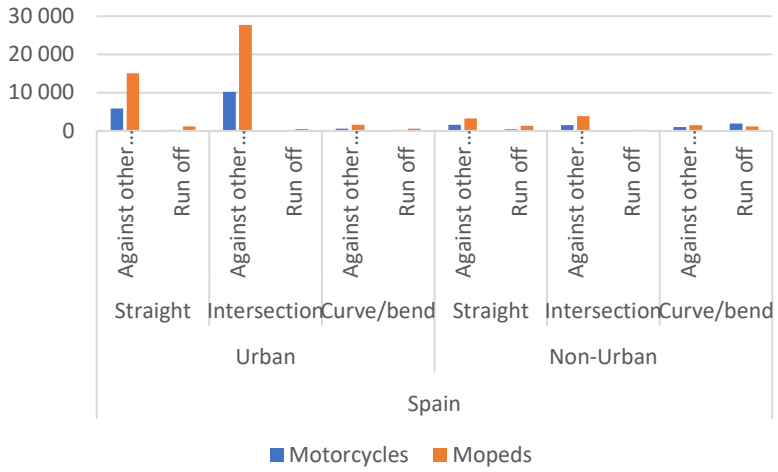


Figure 1-10: Accident Scenario in Spain. 3-Year Count.

1.3.4 PISa

The aim of the Powered Two-Wheeler Integrated Safety (PISa) project (2006-11) was to develop Advanced Rider Assist Systems (ARAS) (Vehicle Safety Research Centre, Loughborough University, 2010). Work package 2, User needs and requirements, focused on identifying accident scenarios through the review of pre-existing analysis of national and in-depth datasets. The main analysis of study was from the projects ARPOSYS SP4, MAIDS, SafetyNet and TRACE WP4 and analysis of the CARE-Database plus select research papers.

PISa reported that PTW accidents are varied with no single dominant configuration. Common accident types are right of way violations involving a car turning in front of the PTW, a PTW overtaking a turning car, overtaking/filtering accidents and loss of control on a bend at speed.

Most PTW accidents occur within urban areas and at intersections with most non-urban accidents occurring on straight sections. 54% of accidents occurred at an intersection with 33% of fatalities occurring at a junction, with 60% and 55% of PTW and cars, respectively, travelling in a straight line prior to the precipitating event.

With consideration to partner vehicles, only 15% of accidents only involve a single PTW. Where a partner vehicle is involved the main causation factors are failure to see and failure to give way and poor/manoeuvre.

1.3.5 Saferwheels

The SaferWheels study was conducted to investigate accident causation involving vulnerable road users in response to the disparity in the reduction of injuries for car occupant verses other users, namely PTWs and cyclists (CEESAR, CERTH-HIT, CTL, Directorate-General for Mobility and Transport (European Comission), ITS, Loughborough University, NTUA, SWOV., 2018). In 2014 18% of all road user fatalities in the EU were PTW riders.

The study analysed 500 in-depth cases in equal numbers from France, Greece, Italy, The Netherlands, Poland and the UK, 80% of the cases were PTW accidents with the remainder being bicycle accidents.

Codification of the cases into scenarios used the DaCoTA accident scenarios, these are the same scenarios used in the MUSE project albeit originating from the GDV accident coding manual. Figure 1-11 shows the distribution of KSI PTW accidents by these scenarios and Table the accident group aggregation.

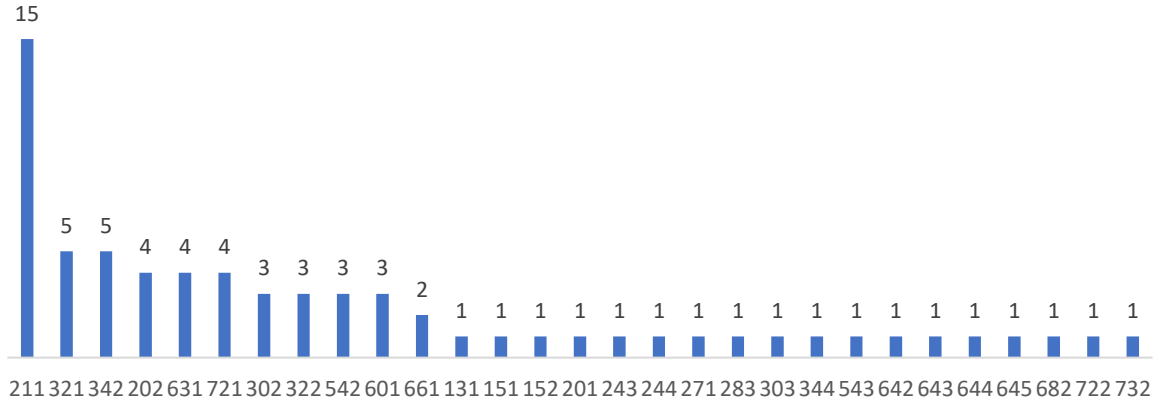


Figure 1-11: Distribution of KSI PTW vs. Car accidents (DaCoTA coding)

Figure 1-12: Distribution of KSI PTW vs. Car accidents (MUSE accident types)

With regard to KSI PTW accidents involving another vehicle the most common accident scenarios were 1) The opponent vehicle was turning left and the PTW was going straight and was coming from the opposite direction and 2) a crossing scenario where the PTW was perpendicularly coming from the right of the opponent vehicle. The third most common KSI PTW accident was single vehicle accidents (25%).

1.3.6 European Road Safety Observatory

A compendium of basic facts from the CARE database (European Commission, Directorate for Transport, 2017) and study insights (European Commission, Directorate General for Transport, 2015) on PTW accidents has been published by the European Road Safety Observatory offering details on accident frequency by PTW, rider demographics and high-level accident details.

From 2006-2015 moped fatalities have decreased by 57% and motorcycle fatalities by 28%, in 2015 moped fatalities were 701 compared to 3,939 motorcycles fatalities. The higher proportion of motorcycle fatalities is common for the 28 countries of study, across the EU 85% of fatalities were motorcyclists.

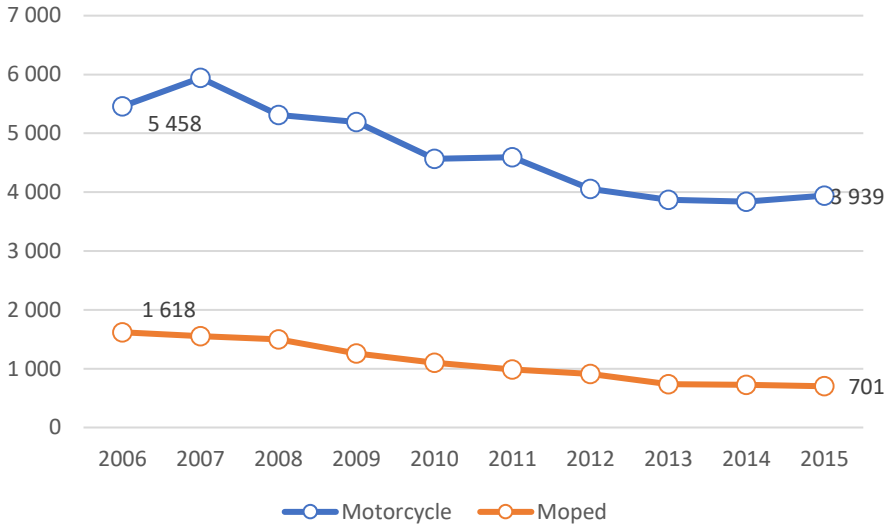


Figure 1-13: Motorcycle and Moped fatalities by country, 2006-2015

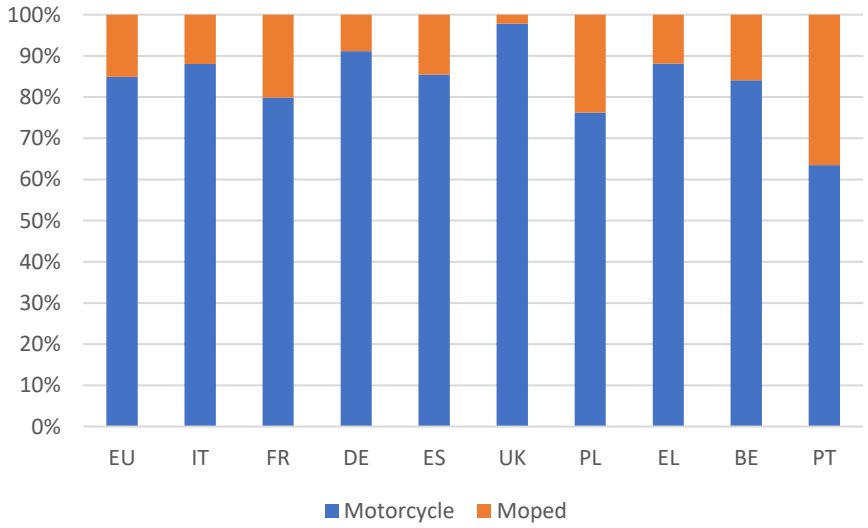


Figure 1-14: Distribution of Motorcycle and Moped fatalities (n > 100 by country, 2015

The high-level data collection in the CADAS database limit accident scenario information but the report detailed that 57.5% of motorcycle fatalities occurred outside urban areas and on non-motorway roads, the second most frequency area was inside an urban area at 37.3%. Accident information by junction detail is reported as an aggregate of motorcycle and moped fatalities – 72% of accidents occurred not at a junction with the most frequent junction accidents occurring at T or staggered junction (9%) or crossroads (8%).

An analysis of SafetyNet showed that accident causation in 37% of PTW accidents can be attributed to the driver of the other vehicle initiating their manoeuvre too early. The second most frequency causation was surplus speed of the PTW (24%).

The "European Commission, Power Two Wheelers, European Commission, Directorate General for Transport, September 2015." Report provides a holistic review of PTW safety issues from licencing initiatives through to accident scenarios. Three main scenarios were identified that are likely to be observed across national accident datasets:

- Scenario 1: motorcycle/moped rider having a single vehicle accident, riding between intersections, losing control in a curve.
- Scenario 2: motorcycle/moped rider reaching an intersection, being hit by a car driver coming from a side road who did not notice the motorcycle in time.
- Scenario 3: a car driver turning left and not noticing the motorcycle coming from the opposite direction.

A number of studies are cited that involve the detailed analysis of accident data from The Netherlands (1993 data) and Germany (2000 data), the results compare with the respective summaries:

(Noordzij, 1998):

- Equal numbers of accidents on built-up and non-built-up roads.
- 27% of the accidents were single vehicle accidents on non-built-up areas as compared to 17% on built-up areas.
- 60% of the accidents were collisions with a car, on non-built-up roads about equally often at intersections and road sections but on built-up roads more often at intersections.
- At intersections about 50% of the car drivers coming from a side road should have waited for the motorcyclist and another 20% turned left in front of an oncoming motorcycle
- In 80% of all collisions with a car at intersections the car driver had seen the motorcycle too late or not at all; on road sections this was the case in 60% of the collisions with a car
- On built-up roads about 40% of the motorcyclists were exceeding the speed limit before colliding with a car, in other situations this percentage was much lower.

(Kramlich, 2002):

- 45% at intersections with priority for the motorcyclist.
- 22% at intersections with the car turning left against an oncoming motorcyclist.
- 10% on road section with the motorcyclist passing a car which turns left.
- 6% on road section with the car making a full turn and the motorcyclist from behind or opposite direction.
- 8% on road section with car overtaking in front of an oncoming motorcyclist.

1.3.7 ISO 13232

The ISO13232 standard provides guidelines and methodologies for research on the effectiveness of protective devices fitted to motorcycles. There are 7 relevant accident scenario that have been developed for the testing of devices, but the accident database used to develop the standard was composed of two datasets from Hannover and Los Angeles, dating from 1996. (Alessandro Grassi, 2018) utilised the ACEM MAIDS database with the same methodology used in the ISO standard to define European scenarios. Figure 1-15 details the key accident scenarios identified.

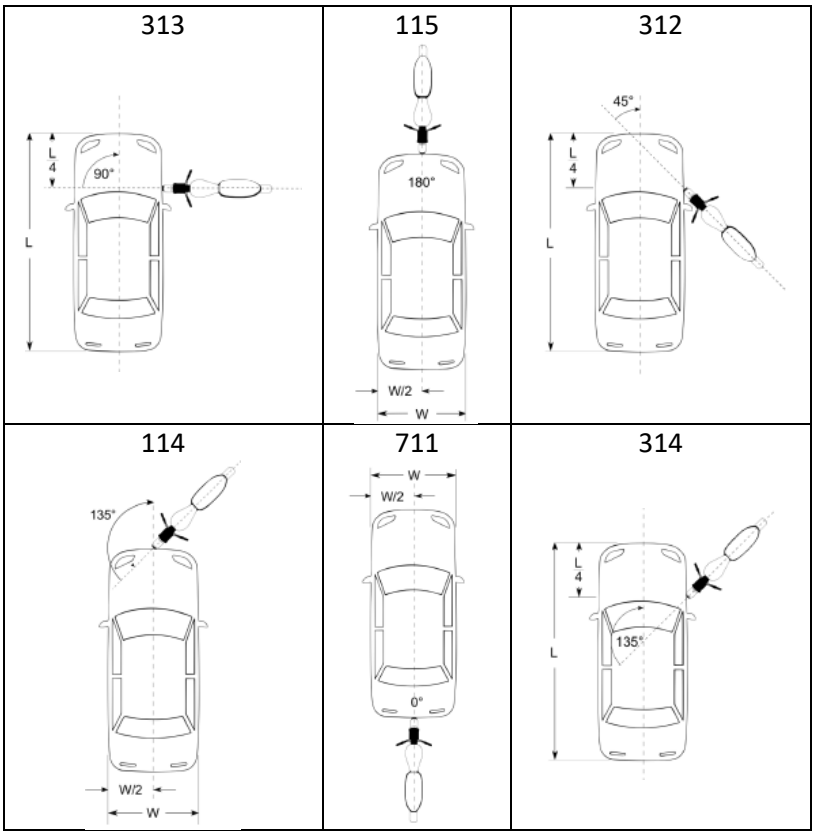


Figure 1-15: MAIDS based ISO 13232 scenarios

1.3.8 VRU Projects

1.3.8.1 Cats

CATS (Cyclist AEB-testing Systems) was project that aimed to develop a testing systems and test protocol (Jeroen Uittenbogaard, 2016). The rationale for the project was based on the trend of cyclist fatalities not improving compared to those of car occupants and many fatalities are due to a collision with a partner vehicle. Work Package 1 – Accident Analysis focused on KSI car-to-cyclist accident scenarios in the EU with the main data provision being from France, Germany, Italy, The Netherlands, Sweden and the United Kingdom. For Germany the GIDAS-based PCM database was chosen as representative of the national data. Whilst data from other countries was reviewed it was considered that the aforementioned datasets were the most usable albeit with differing levels of reliability.

With the aim that identified scenarios should be relevant and representative a number of limitations in the 6 datasets were noted that may affect comparative analysis. These limitations were namely high-level vs. in-depth data from different countries, time frame vs case quantity but insensitive for car-to-cyclist accidents with respect to an evolution of accident scenarios, quality of police recording and subjective witness information and definition of injury severity.

Aggregation of accident scenarios by country into a common format was accomplished by recoding the native data into the CATS scenarios, as detailed by description and pictogram. German and Italian data natively uses a 3-digit code (UFTYP/GDV) which allows a more granular recording of accidents compared to manoeuvre-based data like recorded in The Netherlands and UK datasets. To this extent there is element of data reduction or fitting of scenarios into the most similar scenarios due to ambiguity of the native data.

The aggregation of commonly coded accident scenarios by country into a single percentage per scenario was achieved through the weighing of cyclist fatalities per million inhabitants by country from the CARE database. This analysis gave a range of weighting from 10% (UK) through to 38% (The Netherlands), also an equal weighting of 20% per country was evaluated. For country specific weightings the three most common seriously injured accidents had a percentage distribution of 29%, 28% and 16%, by comparison the same scenarios when equally weighted had a percentage distribution of 27%, 24% and 17%, other scenarios also ranked in the same place between the weighting methods.

1.3.8.2 AsPeCSS

AsPeCCS concentrated on the safety of pedestrians and cyclists as vulnerable road users by developing test and assessment procedures for forward-looking ADAS function that can be used in regulation and consumer ratings protocols (Marcus Wisch, 2013).

Common to the MUSE project, accident datasets from Germany (Destatis and GIDAS), UK (STATS19) and France (ONSIR) were used to define the accident scenarios and also verified additional scenario data obtained from a literature review. Owing to the differences in the data sources derivation and structure of the scenario was unique to each country but main variables reported were pedestrian movement, location, obstruction and lighting conditions. Whilst data from the UK and Germany was mainly utilised for the scenario derivation, extrapolation of the data was undertaken to provide an

EU27 view on the representation of the scenarios with respect to KSI accidents to ensure the correct prioritisation/importance of the scenarios. Three methods weighting methods were undertaken 1) Raking, 2) Cluster Analysis and 3) an 'Averaging' method. Provisional analysis using the first two methods proved unsuccessful due to insufficient detail held at a European level by country in the CARE and IRTAD databases and cluster analysis of German data to infer similar scenarios in the larger datasets/European regions was unsuccessful due to unclear influence of predictors of interest (country, age and lighting conditions). The 'Averaging' method started with considering the percentage of car-to-pedestrian accident within the UK and Germany and then multiplying this global value by the scenario percentage (i.e. Germany – car-to-pedestrian Fatalities = 56%, Scenario 1 = 23%, Fatalities = 13%) and utilising the high-level car-to-pedestrian values from EU27 to estimate overall scenario coverage.

1.3.8.3 PROSPECT

Proactive Safety for Pedestrians and Cyclists, PROSPECT, aimed to improve the efficacy of VRU ADAS through an expanded scope of VRU scenarios addressed and improved overall system performance. Work Package 2 focused on the identification of accident scenarios and the characteristics required for the development of VRU ADAS, the analysis consider passenger car to pedestrians, cyclists, e-bikes and scooters, cyclist and pedestrians where considered the priority accident types.

European, national and in-depth database were studied (IRTAD, CARE, DESTATIS, STRADA, KSH – Hungarian, GIADAS, iGlad and Volvo Cars Cyclist Accident Database). KSI accidents were targeted for analysis of defining use cases with the rationale that focusing on the characteristics of these accident will bring about a greater benefit due to typically higher car impact speeds and it is often the case that more information is available for more severe accidents.

The most relevant accident scenarios were grouped and 75 use cases defined, a weighting process using accident severity and frequency reduced the use cases to 26 - 16 use cases for cyclists and 10 use cases for pedestrians. Initial and collision speed was derived for each use case plus the distribution of lighting and weather conditions (Johann Stoll, 2016).

The detailed information for the use cases was derived from GIDAS data but extrapolated into nationally representative frequencies through the weighting of the GIDAS data with respect to DESTATIS data to calculate a final ranking of cases. Weightings were based on the number of casualties per severity level.

2 Accident Data and Analysis Methods

2.1 Focus of the Analysis

There are three principle areas of analysis to be considered within the work package - vehicles involved (Mofa, Moped and Motorcycles), accident severity (Fatal, Serious and Sight) and countermeasures (Advanced Driver Assist Systems and Advanced Rider Assist Systems).

To inform the focus of the analysis, the working group analysed existing data from the French accident database VOIESUR, as performed by CEESAR (Centre Européen d'Etude de Sécurité et d'Analyse des Risques) in support of the MUSE forerunner project undertaken by UTAC and analysis of the UK National police accident database STATS19 by Thatcham Research and also data from the European Commission CARE database.

Analysis of the 2011 VOIESUR data showed that Motorcycles accounted for 77.4% of fatal PTW accidents and mopeds 19.9%. 2017 STATS 19 data report that Motorcycles account for 93.4% of KSI PTW accidents. An overview of PTW fatalities is given in Figure 2-1 for the EU and illustrates that there are more motorcyclist fatalities than moped riders, 84.5% vs. 15.5% respectively. When considering annual registrations to understand if the higher number of motorcycle fatalities is an exposure factor it is apparent that this is the case although there are scenarios where the ratio of motorcycle to moped fatalities is disparate to the registration ratio, notable countries are France and The Netherland where moped fatalities to registrations is low.

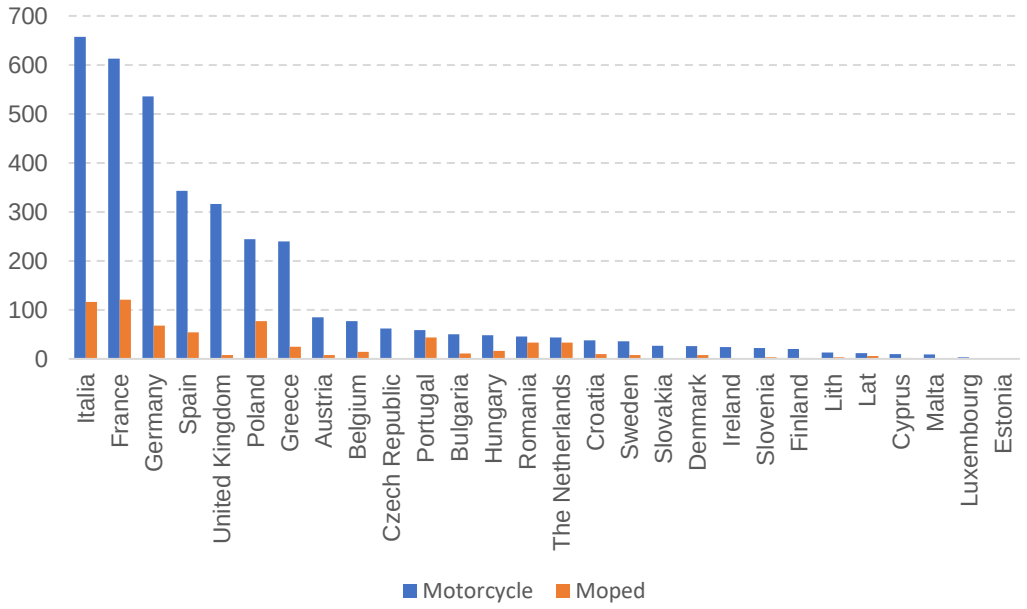


Figure 2-1: Fatalities at 30 days in EU countries in 2016

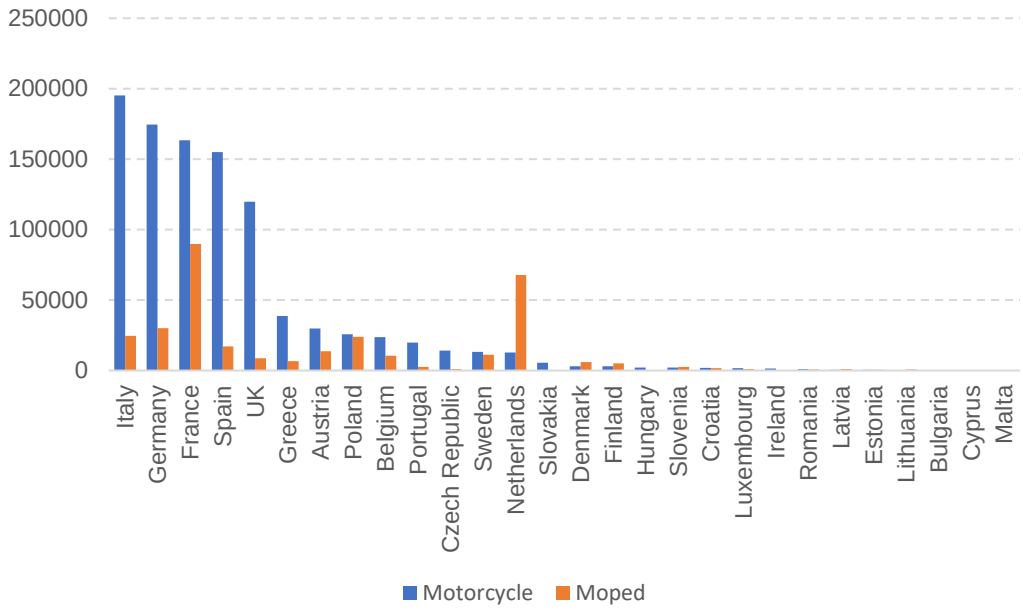


Figure 2-2: Motorcycle and Moped registration in the EU 2016

The VOIESUR and STATS19 analysis also showed that [STATS19 75%] of motorcycle accidents involve another vehicle, with [STATS19 84%] of these multiple vehicle accidents involving a passenger car. Single motorcycle accidents are only [STATS19 25%] of all accidents.

Based on the accident distribution the WP1 group decided that the focus of the analysis will be on motorcycle accidents and those between a motorcycle and passenger car only. From a pragmatic view this approach also has benefits for subsequent work packages in that only one test target and one set of accident scenarios need to be developed. From a safety perspective, focusing on ensuring that relevant test procedures and effective test targets are developed for vulnerable road user ADAS would be a priority over ARAS evaluation due to the ever-increasing fitment of such systems to passenger cars and the expectance of such assessments in Euro NCAP. To align to Euro NCAP assessments killed and seriously injured accidents will only be considered.

A project objective is to ensure that the accident analysis is as representative as possible for Europe and not based on one national dataset too much unless it can be proven that the dataset for that country is representative for Europe as a whole. CARE data was used to provide target countries for analysis of accident data.

Figure 2-3 shows that 80.5% of all fatalities are covered by Italy, France, Germany, Spain, United Kingdom, Poland and Greece. Working group members have familiarity and potential access to databases that are based on Italian, French, German, Spanish, UK, Greek and The Netherlands data, a 75.0% coverage.

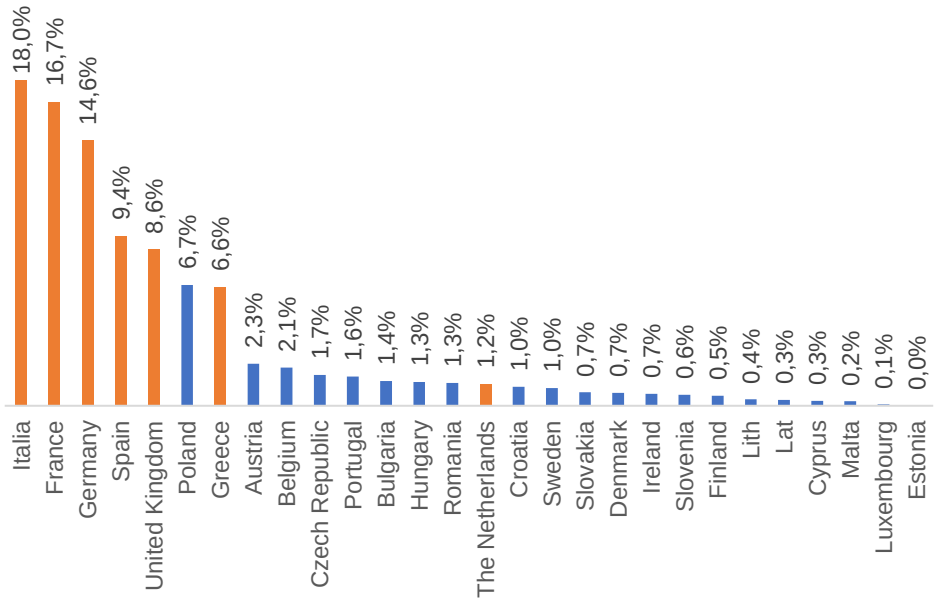


Figure 2-3: Percentage of Motorcycle fatalities at 30 days by EU country plus countries of study (indicated orange)

2.2 Accident Databases

To inform the main accident scenarios and provide supplementary information on vehicle pre-impact and impact speeds the primary type of databases identified for use are national and in-depth respectively.

National databases are typified by being police recorded injurious road accidents covering all regions of the country. Data is usually organised in a hierarchy of accident, vehicle and casualty tables with data coded against a pre-defined variable and values list. The benefits of national data are many cases, well recorded road and environmental variables and generally good vehicle type information, but some datasets have limited vehicle manoeuvre information or accident type information which can lead to ambiguity around accident scenarios.

In-depth databases are led by accident investigation teams in specific regions of the country but due to the rigorous data collection required and limited investigation teams the number of cases recorded can be as low and as 400 cases annually within the country of study. Whilst the frequency of cases is limited the benefit of In-depth databases is that between 2000 to 4000 variables are recorded with a focus on scene and vehicle information. At the most basic level this information can be readily used to inform of travel and impact speeds and vehicle paths, a more through use of the data would be accident reconstruction with time series data being derived. Due to the limited number of cases that can be attended the accident types, and characteristics, may not be fully representative of the national distribution. The frequency of accident scenarios can be adjusted, through statistical inference/weighting, to correct for any over or under representation. Of the in-depth datasets used in this work package only GIDAS and VOIESUR have weighted data available using data from the national datasets Destatis and BAAC respectively. Weighting the RAIDS, OTS, iGLAD and DIANA in-depth datasets to their respective national datasets is beyond the scope of the work package.

To provide an up to date review, where available, the latest data from the last 3 years (2014-2016) is used from the national datasets but to maximise sample sizes all data or a wider year range from the in-depth datasets has been used.

2.2.1 National Data

The national datasets analysed are the Italian ACI-STATS, French BAAC ONSIR, German Destatis (represented within the GIDAS weighted analysis), Spanish DGT, UK STATS19, Greek ELSTAT and The Netherlands SWOV/BRON datasets. Most of these datasets record comparable variables so the resulting analysis is consistent but there are a few variable exclusions, for example speed limit is not recorded in the ACI-ISTAT data and the not at fault vehicle manoeuvre is not recorded in the ELSTAT data and in STATS19 accident type is not recorded (this is derived in the WP1 analysis from vehicle manoeuvre, impact points and junction detail). The following sections detail which variables and a pertinent selection of values are given by country/dataset for comparison of the initial level of detail available for the analysis. Highlighted values are those used in the cluster analysis.

2.2.1.1 Italy - ACI ISTAT

ISTAT is the Italian National Institute of Statistics, main supplier of official statistical information in Italy. It collects and produces information on Italian economy and society and make it available for study and decision-making purpose.

ISTAT works in cooperation with the Automobile Club of Italy (ACI) to standardize the accident data, collecting Police reports.

Table 2.2.1-1 details the variables used in the analysis and the corresponding values. The speed limit of the road is not recorded nor are the lighting conditions.

Accident Variables and Values:

Table 2.2.1-1: ACI_ISTAT Accident Table - Variable and Values

Accident Severity	Fatal, Serious, Slight
Accident Type	Head on, Head on side, Lateral, Rear end, Stopping vehicle
Road Type	One carriageway only one way, One carriageway two ways, Two carriageways, More than two carriageways
Intersection	At an intersection: Crossroad, Roundabout, Signalised Intersection, Intersection with traffic signals, Not signalised Intersection Not at an intersection: Straight, Curve, Bump, Level, Lighted tunnel, Not lighted tunnel
Road condition	Dry, Wet, Slippery, Ice, Snow.
Weather condition	Sun, Fog, Rain, Hail, Snow, Wind, Other

Vehicle Variables and Values:

Only vehicle types appertaining to the study are listed. Vehicle manoeuvres are categorised within accident types, Table 2.2.1-3 lists the possible vehicle manoeuvres for “Head On”, “Head On -Side”, “Lateral” and “Rear end” accident types. Table 2.2.1-4 lists the manoeuvres for “Stopping Vehicle” accident types. Single vehicle and non-Car to PTW accident types are listed but omitted from this analysis.

Table 2.2.1-2: ACI_ISTAT Vehicle Table – Vehicle Types

Vehicle type	Private Car, Car with trailer, Public car, Moped, Motorcycle, Motorcycle with passenger

Table 2.2.1-3: ACI_ISTAT Vehicle Table - Variable and Values for Head On, Head On-Side, Lateral and Rear-End type accidents

Vehicle manoeuvre at an intersection	Going straight, Turn to the right, Turn to the right in a wrong way, Turn to the left, Turn to the left in a wrong way, Overtaking at the intersection Distracted driving: without safety distance, without yielding the vehicle coming from the right, without respect of the Stop signal, wrong way, without respect of the traffic lamp, without respect of the no transit signal, with over speeding, without respect of the speed limit, with high beams
Vehicle manoeuvre not at an intersection	Going straight, Overtaking, Overtaking in a wrong way on the right side: at a curve, bump or with low visibility, a vehicle which was overtaking another vehicle,

	without respect of the prohibition signal, Reversing, <u>Reverse:</u> in order to enter in the traffic flow, in order to turn on the left, in order to stop or park, irregularly in order to stop or park, <u>Distracted driving:</u> without safety distance, with over speeding, without respect of the speed limit, not close to the right side of the carriageway, wrong way, without respect of the no transit signal, with high beams, Going close to two-wheeled vehicles irregularly

Table 2.2.1-4: ACI_ISTAT Vehicle Table - Variable and Values for Stopping Vehicle type accidents

Vehicle A manoeuvre	Going straight, Overtaking, Crossing irregularly the level crossing <u>Distracted driving:</u> without safety distance, wrong way, with over speeding, without respect of the speed limit, without respect of the no transit signal.
Vehicle B manoeuvre/object	Accidental obstacle, Stationary vehicle in regular position, Stationary vehicle in irregular position, Signalised vehicle with a mechanical failure, Not signalised vehicle with a mechanical failure, fixed obstacle on the carriageway, train.

Casualty data is restricted to the number of injured and fatal casualties by vehicle.

2.2.1.2 France - BAAC ONSIR

The National road traffic accidents (RTA) file, referred to as the BAAC database, gathers all the report of road accidents involving physical injury registered by police forces for any road traffic accident brought to their attention.

The number of variables and values recorded in the BAAC database is comprehensive and with respect to the work package analysis benefits from accident type classification, comprehensive manoeuvre information and impact locations.

Table 2.2.1-5 lists the variables recorded with the accident, vehicle and casualty tables and Table 2.2.1-6 to Table 2.2.1-9 list the pertinent variable and their values considered in the cluster analysis.

Variables

Table 2.2.1-5: BAAC Data Tables and recorded variabes

Accidents	Num_Acc, Year, Month, Day, Time, Light_Conditions, Location, Intersection, Weather_Conditions, Collision_Type, com, Address, gps, Latitude, Longitude, dep.
Locations	Accident_Index, Category, Road_Number, v1, v2, Traffic_System, nbv, pr, pr1, Special_Paths, Longitudinal_Profile, Horizontal_Alignement, Impact_Point, Metres, Road_Surface, Infrastucture, Accident_Location, env1.
Vehicles	Num_Acc, senc, Vehicle_Type, Number_of_Occupants, Fixed_Object_Hit, Mobile_Object_hit, Impact_Point, Vehicle_Maneouvre, num_veh.
Casualties	Num_Acc, place, Casualty_Type, Severity, Gendersexe, Journey_Purpose, secu, Pedestrian_Location, Pedestrian_Movement, Ped_Accompanied, Year_of_Birth, num_veh.

Variables and Values

Table 2.2.1-6: BAAC Locations Table – Variables and Values

Road Category	Motorway - Trunk road - Country road - Communal road - Outside public network - Car park open to public traffic - Others
Traffic System	One-way, Single carriageway, Dual carriageway, With variable lane allocation
Road Surface	Normal, Wet, Puddles, Flooded, Snow, Mud, Icy, Greasy-Oil, Other
Accident Location	On carriageway, On hard shoulder, On shoulder, On pavement, On cycle path

Table 2.2.1-7: BAAC Accidents Table – Variables and Values

Light	Daylight, Twilight or dawn, Night without public lighting, Night with public lighting turned off, Night with public lighting turned on
Location	Outside built-up area, In built-up area
Weather conditions	Normal, Light rain, Heavy rain, Snow-hail, Fog-smoke, Strong wind-storm, Blinding sun, Overcast, Other
Type of collision	Two Vehicles: -Head on collision, -Rear, -Side. Three vehicles and more: -In series, -Multiple collisions. Other collisions, Without collision.

Table 2.2.1-8: BAAC Vehicles Table – Variables and Values

Vehicle Type	Moped <50cm3, Scooter <50cm3, Scooter >50cm3 <125cm3, Scooter >125cm3, Motorcycle >50cm3 <125cm3, Motorcycle >125cm3, Light vehicle alone
Main movements before the accident	Without changing direction, Same direction same queue, Between two lanes, In reverse, The wrong way, By encroaching on the central reserve, In the bus lane – in the same direction, In the bus lane – in the opposite direction, By joining traffic, By turning around on the carriageway, Changing lane to the left, Changing lane to the right, Moving to the left, Moving

	to the right, Turning to the left, Turning to the right, Passing to the left, Passing to the right, Crossing the carriageway, Parking manoeuvre, Avoiding manoeuvre, Opening door, Stopping, Parking

Table 2.2.1-9: BAAC Users Table – Variables and Values

Category	Driver, Passenger, Pedestrian, Pedestrian on roller skates or scooter
Seriousness	Unhurt, Killed (30 days), Injured & hospitalised, Slightly injured

2.2.1.3 Germany - Destatis

National road traffic accident data registered by the police is collated by The Federal Statistical Office (Destatis). Data is provided in an aggregated format mainly reporting top-level frequency statistics for road users. As the data is not available in disaggregated tables the level of analysis is limited. The Destatis data is readily used to weight GIDAS data (Hautzinger, 2004), to this extent GIDAS is used as a proxy for the national data.

Table 2.2.1-10 Destatis variables and values

Accident Characteristics	Junction
Light condition	Daylight, Twilight, Darkness.
Weather conditions (Witterungseinflüsse)	Fog, mist, smoke etc - Heavy rain - Dazzling sunshine - Severe winds - Storm or other weather influences.
Road surface condition (Straßenverhältnisse)	Impurity through oil leakage, Other impurities caused by road users, Snow or ice, Rain, Other influences, Grooves in connection with rain or snow or ice, Damage to the road surface, Other road condition, Irregular condition of traffic signs or installations, Insufficient road lighting, Insufficiently secured railway crossings.
Kind of Accident	Accident of another kind, Collision with another vehicle which starts, stops or is stationary, Collision with another vehicle moving ahead or waiting, Collision with another vehicle moving laterally in the same direction, Collision with another oncoming vehicle, Collision with another vehicle which turns into or crosses a road, Collision between vehicle and pedestrian, Collision with an obstacle in the carriageway, Leaving the carriageway to the right, Leaving the carriageway to the left.
Type of accident (Unfalltyp)	Driving accident, Accident caused by turning off the road, Accident caused by turning into a road or by crossing it, Accident caused by crossing the road, Accident involving stationary vehicles, Accident between vehicles moving along in carriageway, Other accident.

2.2.1.4 Spain - DGT

Spanish Road Accidents database is carried out by the public organisation DGT, dependent of the Ministry of the Interior.

DGT Spanish Road Accidents Database contains the entire population of accidents with casualties in Spain. Approximately 100,000 accidents take place on Spanish roads annually with 5,000 fatalities, 25,000 serious injured and 120,000 slight injured. Information contained in DGT Spanish Road Accidents Database is collected by police forces.

Table 2.2.1-11 lists the variables recorded with the accident, vehicle and casualty tables and Table 2.2.1-12 to Table 2.2.1-14 list the pertinent variable and their values considered in the cluster analysis.

Variables

Table 2.2.1-11: DGT Data Tables and recorded variabes

Accident	Id_Accidente, Anio, Month, Hour, Day Week, Province, Autonomous Community, Island, Municipality, Tot Victims, Tot Victims 30D, Tot Dead, Tot Dead 30D, Tot Serious Hurt, Tot Serious Wound 30D, Tot Injuries Leves, Tot Injured Leves 30D, Tot Vehicles Involved, Zone, Grouped Area, Highway, Road Network Type Via, Layout Not Intersec, Type Intersec, Acond Calzada, Priority, Shoe Surface, Brightness, Atmospheric Factors, Restricted Visibility, Another Circumstance, Sidewalk, Type Accident, Circulation Density, Special Measures, Casualty.
Vehicle	Id Accident, Vehicle Id, Anio Enrolled Vehicle, Month Enrolment Vehicle, Vehicle Type, State Vehicle, Number Occupants Veh, Dangerous Goods, Fire Vehicle, Anio.
Casualty	Id Accident, Vehicle Id, Id Person, Driver Id, Passenger Id, Id Peaton, Age, Sex Anio Permission, Position, Security Accessories, Dead 24H, Dead 30D, Serious Hurt 24H, Serious Hurt 30D, Mild Hurt 24H, Mild Wound 30D, Ileso 24H, Ileso 30D, Lesiv No Esp 24H, Lesiv No Esp 30D, Maneuver, Infracc Speed, Infracc No Speed, Peaton Action, Infracc Peaton, Anio.

Variables and Values

Table 2.2.1-12: DGT Accident Table – Variables and Values

Zone	Highway, Urban Zone, Crossing, Variant.
Grouped Area	Interurban Roads, Urban Roads.
Road Type	Freeway, Dual Carriageway, Route For Automobiles, Conventional Via With Slow Lane, Conventional Route, By Road, Service Area, Liaison Branch, Another Type
None intersection layout	Does Not Apply, Straight, Smooth Curve, Fort Bend Unmarked, Strong Signal Curve With And Without Speed Signalized, Curve With Strong Signal And Speed Signalized.
Intersection	Does Not Apply, T Or Y, X Or +, Inbound Link, Output Link, Rotary, Others.
	No Data, Nothing Special, Isletas Alone Or Pedestrian Crossing, Step Pedestrian O Isletas Home Track In Center, Central Lane Waiting, Turning Left Racket, Another Type.
	No Data, Agent, Traffic Light, Stop Signal", Signal "Yield", Only Brands Viales, Pedestrian Crossing, Another Sign, No (Single Standard)
Road Surface	Dry And Clean, Umbría, Wet, Frost, Snow, Barrillo, Loose Gravel, Oil, Another Type.
Lighting	Day, Twilight, Night: Lighting Enough, Night: Insufficient Lighting, Night: Unlit
Weather	Good Time, Intense Fog, Fog Light, Drizzling, Strong Rain, Hailing, Snowy, Strong Wind, Other.
Restricted Visibility	No Data, Buildings, Of The Land, Vegetation, Atmospheric Factors, Glare, Dust Or Smoke, Another Cause, Without Restrictions.
Accident Type*	Launch vehicle collision (Front), Launch vehicle collision (frontolateral), Launch vehicle collision (side), Launch vehicle collision (Scope), Launch vehicle collision (Multiple or caravan).

Table 2.2.1-13: DGT Vehicle Table – Variables and values

Vehicle Type	Moped, Disabled car, Motorcycle, Car.

Table 2.2.1-14: DGT Casualty Table - Variables and Values

Manoeuvre	NA, ahead on the left, braking action, changing the left lane, changing the right lane, circulando backward, circulating in parallel, circulating reverse, circulating U-180 or U-turn, crossing intersection, crossing the road, following roundabout trajectory, following straight path, following the route, it is ignored, it is unknown, joining a path higher level is on the left, joining a way higher level is on the right, joining route from another or access, joining the circulation, leaked out, other, overtaking on the right, overtaking the left, parked on the left , parked right, parking or leaving stationing, quick manoeuvre to save animals, quick manoeuvre to save obstacle / vehicle, quick manoeuvre to save pedestrian, retention by imperative of circulation, standing in two rows, standing on the left , standing right, stationing or leaving parking, stopped or parked, sudden manoeuvre obstacle to save or vehicle, sudden manoeuvre to save or pedestrian isolated group , sudden speed reduction, taking left curve, taking right curve, turning in “U”, turning or going to another avenue left to right, turning or going to another road that is on the left, turning out to another way or access right, turning to another way or exiting the left or access, waiting on a priority signal / light

2.2.1.5 UK - STATS19

The STATS19 database is a collection of all road traffic accidents that resulted in a personal injury and were reported to the police within 30 days of the accident. The data is collected by the police at the roadside or when the accident is reported to them by a member of the public in a police station. The statistics relate only to accidents on public roads.

STATS19 does not have the provision for recording or classifying the accident type so for this report the accident type has been derived from the junction detail, vehicle manoeuvre and first impact point.

Table 2.2.1-11Table 2.2.1-15 lists the variables recorded within the accident, vehicle and casualty tables and Table 2.2.1-16 to Table 2.2.1-17 lists the pertinent variables and their values considered in the cluster analysis.

Variables

Table 2.2.1-15: STATS19 data tables and recorded variables

Accident	Accident Index, Police Force, Accident Severity, Number of Vehicles, Number of Casualties, Date (DD/MM/YYYY), Day of Week, Time (HH:MM), Location Easting OSGR (Null if not known), Location Northing OSGR (Null if not known), Longitude (Null if not known), Latitude (Null if not known), Local Authority (District), Local Authority (Highway Authority - ONS code), 1st Road Class, 1st Road Number, Road Type, Speed limit, Junction Detail, Junction Control, 2nd Road Class, 2nd Road Number, Pedestrian Crossing, Human Control, Pedestrian Crossing-Physical Facilities, Light Conditions, Weather Conditions, Road Surface Conditions, Special Conditions at Site, Carriageway Hazards, Urban or Rural Area, Did Police Officer Attend Scene of Accident, Lower Super Output Area of Accident Location (England & Wales only).
Vehicles	Accident Index, Vehicle Reference, Vehicle Type, Towing and Articulation, Vehicle Manoeuvre Vehicle Location-Restricted Lane, Junction Location, Skidding and Overturning, Hit Object in Carriageway, Vehicle Leaving Carriageway, Hit Object off Carriageway, 1st Point of Impact, Was Vehicle Left Hand Drive, Journey Purpose of Driver, Sex of Driver, Age of Driver, Age Band of Driver, Engine Capacity, Vehicle Propulsion Code, Age of Vehicle (manufacture), Driver IMD Decile, Driver Home Area Type.
Casualty	Accident Index, Vehicle Reference, Casualty Reference, Casualty Class, Sex of Casualty, Age of Casualty, Age Band of Casualty, Casualty Severity, Pedestrian Location, Pedestrian Movement, Car Passenger, Bus or Coach Passenger, Pedestrian Road Maintenance Worker (From 2011), Casualty Type, Casualty IMD Decile, Casualty Home Area Type.

Variables and Values:

Table 2.2.1-16: STATS19 – Selected accident variables and values

Accident Severity	Fatal, Serious, Slight
Road Type	Roundabout, One way street, Dual carriageway, Single carriageway, Slip road, Unknown.
Road Class	Motorway, A(M), A, B, C, Unclassified.
Junction Detail	Not at or within 20 metres of junction, Roundabout, Mini roundabout, T or staggered junction, Slip road, Crossroads, Multiple junction Using private drive or entrance, Other junction.
Speed limit (mph)	20, 30, 40, 50, 60, 70.
Junction Control	Not at junction or within 20 metres, Authorised person, Auto traffic signal, Stop sign, Give way or uncontrolled, Data missing or out of range.
Light Conditions	Daylight, Darkness - lights lit, Darkness - lights unlit, Darkness - no lighting, Darkness - lighting unknown, Data missing or out of range.
Weather	Fine no high winds, Raining no high winds, Snowing no high winds, Fine + high winds, Raining + high winds, Snowing + high winds, Fog or mist, Other, Unknown, Data missing or out of range.

Table 2.2.1-17: STATS19 – Selected vehicle variables and values

Vehicle Type*	Motorcycle 50cc and under, Motorcycle 125cc and under, Motorcycle over 125cc and up to 500cc, Motorcycle over 500cc, Car.
Vehicle Manoeuvre	Reversing, Parked, Waiting to go ahead but held up, Slowing or stopping, Moving off, U turn, Turning left, Waiting to turn left , Turning right, Waiting to turn right, Changing lane to left, Changing lane to right, Overtaking moving vehicle on its offside, Overtaking stationary vehicle on its offside, Overtaking on nearside, Going ahead left hand bend, Going ahead right hand bend, Going ahead other.
First Point of Impact	Did not impact, Front, Back, Offside, Nearside.

2.2.1.6 Greece - ELSTAT

Data for road traffic accidents occurring in Greece between 2013 and 2016 have been supplied to MUSE by CERTH in an aggregated format to comply with confidentiality policies. Accident data is collected by the Hellenic Statistical Society (ELSTAT) and are not available to the public: CERTH is authorised to use the row data, for research purposes only.

Primary data derive from administrative sources such as police and port authorities through the completion of a specially designed statistical questionnaire providing information on the place of the accident, the type of the first collision, any manoeuvres which caused the accident, specific data on the vehicles involved in the accident, data on the driver and persons injured, as well as data on the use of safety equipment.

The questionnaires are then transmitted to the Section of Justice and Public Order Statistics of ELSTAT who oversees the quality control, data validation and compilation (ELSTAT, 2017).

Table 2.2.1-18 and Table 2.2.1-19 list the variables and corresponding values recorded in the accident and vehicle tables respectively.

Table 2.2.1-18: ELSTAT Accident Table - Select Variables and Values

Accident Severity	Fatal, Serious, Slight
Accident Type	Frontal, Frontal-side, Side, Rear, Against train, Against parked vehicle, Stopping vehicle, Braking vehicle, Against pole or tree, Against fixed object, e.g. wall, With pedestrian, Animal, Entering opposite lane, Leaving road right, Leaving road left, Capsize on road, Capsize out of road, Other
Area	Urban, Rural
Highway	Highway, Not on a highway, Unknown
Junction	At a junction, Not at a junction

Table 2.2.1-19: ELSTST Vehicle Table - Select variables and Values

Car Type	Passenger car, Passenger car (taxi), Passenger car (public sector vehicle), Commercial vehicles (e.g. small van)
PTW Type	Moped <49 κ.ε, **50-115 κ.ε, 116-269, 270-730, 730 κ άνω**, Three wheeler
Vehicle Manoeuvre	Normal driving, Entering traffic lane, Entering traffic when turning left in junction, Entering traffic when turning right in junction, Entering opposite direction, Leaving traffic lane, Overtaking from left, Overtaking from right, Not giving right of way, Not giving right of way at pedestrian crossing, Turning left, Turning right, U-turn, Moving from zero speed, Parking, Reversing, Stopping, Braking, Hard braking, Lane change, Over speeding (than limit), Stopping at traffic light, Not stopping at traffic light, Not stopping at STOP sign, Not stopping at yield sign, Not stopping at policeman sign, Not using the indicator, Other.

2.2.1.7 The Netherlands - BRON/SWOV

All road traffic crashes in the Netherlands that are recorded by the police in reports or registration sets are included in the national road crash register BRON. The registration is compiled by the Centre for Transport and Navigation (DVS) which is part of the Ministry of Infrastructure and the Environment. BRON contains a large number of characteristics of the crash and the drivers and casualties involved. Data is available from 1976. BRON contains 90% of the fatal crashes. For crashes of lesser severity the registration is less complete.

SWOV links the LBZ data (National Basic Register Hospital Care) and the BRON data of injured casualties, based on which the real number of serious road injuries is estimated. The crash data is available on the SWOV website from 1993 onward. The data of the years from 2004 onward is BRON data; the older data has been converted from the earlier system called 'Crashes and Network'.

Table 2.2.1-11Table 2.2.1-20 lists the recorded accident, vehicle and casualty variables and Table 2.2.1-21 to Table 2.2.1-22 lists the corresponding variables used in the cluster analysis. Note that vehicle manoeuvre is described as in the casualty table as 'Intended mov Casualty'.

Table 2.2.1-20: BRON/SWOV Variables

Accident Severity, Accident type, Manoeuvre, Location, Road situation, Area type, Road authority, Max Speed, Surface, Surface condition, Weather, Lighting, Severity, Vehicle type, Class, Start position, Intended mov, Contact, Movement, Cause 1, Engine size, MaxAIS90.

Table 2.2.1-21: BRON/SWOV Accident and Vehicle Table – Variables and Values

Accident Severity	1 Fatal, 2 Hospitalisation, 3 Accident/Emergency, 4 Slight.
Accident type	2 Parked, 3 Animal, 4 Fixed object, 5 Loose object, 6 Frontal, 7 Lateral, 8 Rear-end, multiple collision, 9 Single vehicle, Unknown.
Manoeuvre	A01 Into water, A02 Not off the road, A99 Other single vehicle, B01 Parked vehicle hit at the rear, B02 Parked vehicle - hit at the front, B99 Other crashes with parked vehicle, C01 Animals crossing, C02 Crash into tree or other stationary objects, C03 Crash into lamppost, C04 Crash into other infrastructural elements, C05 Crash into object on the road, F01 On intersection - side impact, F02 On intersection - side impact with vehicle standing still, F03 On intersection = side impact while changing lane, G01 Front - rear while overtaking, G02 Front - rear while join /exit, G03 Front - rear without turning, G04 Front - rear with vehicle standing still, G05 Front - rear while changing lane to the left, G06 Front - rear while changing lane to the right, G99 Other crashed - same direction, no turning, H01 Frontal impact - join / exit, H02 Frontal impact - one vehicle changing lane, H03 Frontal impact - both vehicles changing lane, H04 Frontal impact without changing lane, H99 Frontal impact – other, I01 Front - rear while turning right, I02 Front - rear while turning left, J01 Right side while turning right, J02 Left side while turning right, J03 Left side while turning left, J04 Right side while turning left, J05 Left side while U-turn left, J06 Right side while U-turn left, J07 Right side - crossing vehicle, J08 Both turning right, J09 Both turning left, J10 Grazed, J99 Other side impacts, K01 Other.
Location	20 Intersection, 21 Road section.
Road situation	1 Straight road, 2 Bend, 3 Roundabout, 4 Intersection - 3 arms, 5 Intersection - 4 arms, 6 Straight road - separated carriageway, 7 Entry, acceleration lane – motorway, 8 Exit, deceleration lane – motorway, Unknown.
Area type	1 Urban area, 2 Rural area, Unknown.
Road authority	1 State, 2 Province, 3 Borough, 4 Water board, Other/Unknown.
Max Speed	15, 30, 50, 60, 70, 80, 90, 100, 120, 130, Unknown.
Surface	1 Porous asphalt, 2 Asphalt (other), 3 Concrete, 4 Brick, Unknown.
Surface condition	1 Dry, 2 Wet/damp, 3 Snow/black ice, Unknown.
Weather	Unknown, 1 Dry, 2 Rain, 3 Fog, 4 Snow/hale, 5 Hard gusts of wind.
Lighting	Unknown, 1 Not burning, 2 Burning, 3 Not present.

Table 2.2.1-22: BRON/SWOV Casualty Table including vehicle movement

Severity casualty	1 Killed, 2 Hospitalised, 3 Accident/Emergency, 4 Slight.
Vehicle type Casualty	01 car, 31 motorcycle, 61 moped, 62 light moped.
Class	driver/rider, passenger.
Start position Casualty	1 Lane, 2 Cycle track / lane, 3 Pavement / shoulder, 4 Refuge / shoulder (middle), 5 Entry or exit, 7 Parking lot, 8 Tram track / bus lane, Unknown
Intended mov Casualty	1 Crossing, 10 Turn right, 11 Parking, 2 Moving forwards, 3 Changing lane left, 4 Stand still, 5 Changing lane right, 6 Turning left, 7 U-turn left, 8 Backwards, Unknown.
Contact Casualty	11 Left front, 12 Centre front, 13 Right front, 14 Right side, 15 Right rear, 16 Centre rear, 17 Left rear, 18 Left side, Unknown.
Movement Casualty	10 Standing still, 20 Sliding, 30 Skidding, 40 Jack-knifing 50 Turn over, 60 Rollover, 70 Roll out, 80 Into water, 85 Against collision partner, 90 Other, Unknown.
Cause 1 Casualty	1 Not giving right-of-way, 11 Driving round bend wrongly, 13 Driving too much to the right, 14 Driving insufficiently to the right, 15 Join / exit wrongly, 16 Overtaking / cutting in, 17 Wrong lane/carriageway, 18 Crossing over incorrectly, 2 Not giving way through, 21 Skidding, 22 Driving too fast, 23 Losing vehicle control, 3 Keeping insufficient distance, 4 Red light violation, 41 Sleeping, fatigue, 42 Unwell, ill, 51 Fault of 3rd party, Unknown / Not applicable.
Engine size Casualty	0, 1 50 cc and under, 2 51-125cc, 3 126-500cc, 4 over 500cc.

2.2.2 In-depth

2.2.2.1 Italy - IGLAD

IGLAD (initiative for the global harmonization of accident data) was started in 2010 by European car manufacturers and is an initiative for the harmonisation of global in-depth traffic accident data to improve road and vehicle safety through the compilation of a standardised in-depth international accident data thus allowing comparison across countries of accident types.

The project has existed in three phases covering accident years 2007 to 2018 with 9 to 10 contributing members by country. The countries reporting into the database are Austria, Australia, Brazil, China, Czech Republic, France, Germany, India, Italy, Spain and USA. At the end of Phase 2 there were 4,100 cases with between 150 to 800 cases submitted by each member country.

The analysis of IGLAD was provided to the working group by the MUSE partner FCA and cover accidents occurring in Italy.

2.2.2.2 France - Voisuer

VOIESUR – Vehicle Occupant Infrastructure Road User Safety Study is an in-depth study of more than 9000 road accident police reports in France in 2011 involving injured and fatal road users. The data collation was initiated to provide an update to road safety issues especially with respect to vulnerable users such as pedestrians and two-wheelers. The database can be considered a hybrid of an in-depth and national dataset.

The analysis of VOIESUR was provided to the working group by the MUSE partner CEESAR.

2.2.2.3 Germany – GIDAS

The German In-Depth Accident Study (GIDAS) is a joint venture between BASt and the Automotive Research Association (FAT). GIDAS is the largest in-depth accident study project in Germany and it was initiated in July 1999.

Approximately 2,000 accidents involving personal injury are recorded in the area of Dresden and Hannover annually. The investigation team documents all relevant information on vehicle equipment, vehicle damage, injuries of persons involved, the rescue chain, as well as the accident conditions, at the scene. Individual interviews of persons involved are followed by detailed surveying of the accident scene based on existing evidence. In addition to documentation at the scene of the accident, all information available retrospectively is collected in close collaboration with police, hospitals and rescue services. Each documented accident is reconstructed in a simulation program. The entire course of the accident is reconstructed, starting with accident lead-in phase and the reaction of the involved vehicles, to the collision and finally vehicle end position. Characteristic variables such as braking deceleration, starting speeds and collision speed, as well as angle-changes are determined. The documentation scope obtained in GIDAS reaches up to 3,000 encoded parameters per accident.

The initial analysis of GIDAS was provided to the working group by the MUSE partner Denso, this analysis utilised the GIDAS database from 2005 – 2016/7 with 2015 German national statistics weighting, plus initial and impact speeds by accident type. Subsequent analyses were provided by

Verkehrsunfallforschung an der TU Dresden GmbH (VUFO) using 2015, 2016 and 2017 German national statistics weightings for data collection years 1999 to 2018.

2.2.2.4 Spain - DIANA

CIDAUT perform in-depth road accident analysis, recording over 1000 variables from the accident scene, vehicle analyses, police reports, medical reports, interviews and other sources of information. The compiled data is recorded in a database known as DIANA.

2.2.2.5 UK - RAIDS

RAIDS – Road Accident In-Depth Studies is an aggregation of previous and ongoing in-depth studies. Investigations are either on scene at the time of the collision while the emergency services are still present - these focus on the vehicle, the road user and the highway issues and can include non-injury crashes and those with relatively minor vehicle damage or a retrospective investigation that typically involves more serious vehicle damage and where the occupants have attended hospital due to their injuries.

Data collected is extensive and relates to vehicle, highway and injury details. Vehicle damage is recorded both by written observation and by photograph. Expert investigators will interpret the damage to understand the nature and severity of the collision and how the damage to the vehicle may have caused the injuries to the casualty (driver and rider, passengers and pillions, cyclists or pedestrians). At the scene of the collision, details of the road layout, road condition and roadside objects (e.g. road signs, lamp posts, vegetation) are recorded to understand if they may have had an influence on the collision. If the investigation is being carried out immediately after the collision the environmental conditions (weather, visibility due to lighting conditions) are also recorded.

2.3 Analysis Methods

2.3.1 National Data

Cluster analysis of the national accident datasets was proposed early in the work package due to the use of the method in previous accidentology studies to develop AEB assessment protocols for Euro NCAP. Cluster analysis allows the many real-life accident permutations to be categorised into a small number of scenarios that can then form a practical subset of scenarios that are largely representative of the accident population.

Clustering is an unsupervised learning technique which aims to group a set of objects into clusters so that objects in the same cluster should be similar as possible, whereas objects in another cluster should be as dissimilar as possible from objects in other cluster(s). Cluster analysis aims to group a collection of patterns into clusters based on similarity of native values for continuous data or assigned values for categorical data.

Two forms of distance/similarity-based clustering have been used, Hierarchical clustering and Partitional clustering. Partitional clustering was used to analyse the Italian ACI-ISTAT data and Hierarchical for all other national datasets. The choice of method was dependant on which gave the best validation of a cluster structure existing in the data as represented by the Average Silhouette Width – a measure of cohesion of the data to the assigned cluster.

The specific method used for the Hierarchical clustering was agglomerative with the Manhattan dissimilarity matrix and Ward linkage method – this approach gave the smallest increase in the overall sum of squares within cluster distances (i.e. variance). In the agglomerative method, clustering begins with a single data object in a single cluster and continues to cluster the closest pairs of clusters until all the data objects are grouped together in just one cluster. The partition method used K-means clustering with Euclidean metric and K-means algorithm.

Input is in the form of a matrix where rows are observations and columns variables, as such this matches the data structure of the national datasets – each row representing an accident, vehicle or casualty value.

Initial analysis included the subjective selection of accident and vehicle variables to best describe the accident scenario - accident attributes like road class, junction type and speed limit and other variables describing weather conditions, lighting, road surface conditions were included. Values for weather and lighting conditions were also aggregated into binary categories of ‘Fine’, ‘Not Fine’ and ‘Daylight’, ‘Darkness’ to remove unnecessary granularity from the data (see Table 2.3.1-1). However, while including many variables can in theory help describe the accident in as much detail as possible the inclusion of too many variables can distort the cluster analysis performance (see Table 2.3.1-3: Average Shilouette Width categories) and can lead to biased results as was observed in the initial analysis.

Due to the low cluster performance of the initial analysis a second stage of analysis was performed removing some of the previously included variables. The selection of the key variables was done by performing an experimental design on STATS19 KSI accidents occurring at a junction. This dataset and accident type was chosen due to STATS19 being well populated with variables and the junction accident type can be viewed as the most complex to describe based on principle information of road type, vehicle manoeuvres and impact points – potentially the accident type with the greatest dis-similarity of values.

Table 2.3.1-2 illustrates the iterative approach to variable selection, in iteration number 1 the minimum variable to describe the accident scenario are included, vehicle manoeuvre and 1st impact point, through to all weather, lighting and road condition variables. It was decided that the best combination of variables relative to the validity of the cluster with respect to the ASW was iteration number 4, incorporating 'Road Type', 'Speed Limit', 'Vehicle Manoeuvre' and '1st Point of Impact' with an ASW of 0.61 giving a reasonable structure to the cluster analysis based on these variables.

Based on the STATS19 analysis weather and lighting conditions and other miscellaneous variables were omitted from the cluster analysis of the other national datasets, instead focusing on road/junction type, vehicle manoeuvres, speed limit and impact location where available.

Table 2.3.1-1: Aggregation of values into recoded binary categories

VARIABLE	STATS19	BAAC	SWOV	DGT	**RECODING**
Weather conditions	Fine + high wind Fine no high winds	Normal	Dry	Good	**Fine**
	Other Raining + high winds Raining + no high winds Snowing no high winds Unknown Fog or mist Snowing + high winds	Light rain Heavy rain Snow hail Fog smoke Strong wind storm Blinding sun Overcast Other	Rain For Hard gusts of wind Snow/hale Unknown	Drizzling Fog light Hailing Intense fog It is unknown Other Snowy Strong rain Strong wind	**Not fine**
Light conditions	Daylight	Daylight	Burning	Daylight No artificial lighting and light on	**Daylight**
	Darkness - lights lit Darkness - lighting unknown Darkness - lights unlit Darkness - no lighting	Twilight or dawn Night without public lighting Night without public lighting turning off. Night without public lighting turning on	Not present Not burning Unknown	Sunrise or sunset Without light	**Darkness**

Table 2.3.1-2 STATS19 Iteration to find best variable selection to maximise detail and validity of the cluster

	Junction Scenario - Iterations											
Variables	1	2	3	4	5	6	7	8	9	10	11	12
Road Type				✓	✓	✓	✓	✓	✓	✓	✓	✓
Speed Limit		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Junction Detail			✓		✓	✓	✓	✓	✓	✓	✓	✓
Light Conditions							✓1	✓2		✓2	✓1	✓1
Weather Conditions									✓1	✓	✓1	✓1
Road Surface Conditions												✓
Vehicle Manoeuvre	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Junction Location						✓	✓	✓	✓	✓	✓	✓
1st Point of Impact	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

ASW	67%	59%	59%	61%	55%	46%	45%	46%	46%	44%	45%	44%

1 = Grouped values, 2 = Ungrouped values

Table 2.3.1-3: Average Shilouette Width categories

ASW range	Interpretation
≤ 0.25	No substantial structure has been found
≤ 0.50	A weak structure has been found that could be artificial
≤ 0.70	A reasonable structure has been found
≤ 1.00	A strong structure has been found

To ensure that the clustering is accurate and not influenced by invalid or anomalous input data a pre-filter is applied to the datasets. The pre-filters are the given accident types, the removal of null values and specifically for STATS19, in the absence of an accident type definition, pre-filtering of 'Junction Detail', 'Vehicle Manoeuvre' and '1st Point of Impact' (see Table 2.3.1-4 and Table 2.3.1-5).

Table 2.3.1-4 STATS 19 Accident Variable and Values used in the analysis

		Accident Type			
Variable	Value	Junction	Head On	Lane Change	Front to Rear
Junction Detail	Not at junction or within 20m		✓	✓	✓
	Roundabout	✓		✓	✓
	Mini-roundabout	✓		✓	✓
	T or staggered junction	✓		✓	✓
	Slip road	✓		✓	✓
	More than 4 arms	✓		✓	✓
	Private drive or entrance	✓		✓	✓
	Other junction	✓		✓	✓
	Data missing or out of range			✓	✓

Table 2.3.1-5 STATS19 Vehicle Variables and Values used in the analysis

		Junction		Head On		Lane Change		Front to Rear	
		Car	PTW	Car	PTW	Car	PTW	Car	PTW
Vehicle Manoeuvre	Reversing	✓	✓	✓	✓		✓		
	Parked	✓	✓	✓	✓		✓		
	Waiting to go ahead but held up	✓	✓	✓	✓		✓		✓
	Slowing or stopping	✓	✓	✓	✓		✓	✓	✓
	Moving off	✓	✓	✓	✓		✓	✓	✓
	U turn	✓	✓	✓	✓		✓	✓	✓
	Turning left	✓	✓	✓	✓		✓	✓	✓
	Waiting to turn left	✓	✓	✓	✓		✓		✓
	Turning right	✓	✓	✓	✓		✓	✓	✓
	Waiting to turn right	✓	✓	✓	✓		✓		✓
	Changing lane to left			✓	✓	✓			
	Changing lane to right			✓	✓	✓			
	Overtaking moving vehicle on its offside			✓	✓	✓			
	Overtaking stationary vehicle on its offside			✓	✓	✓			
	Overtaking on nearside			✓	✓	✓			
	Going ahead left hand bend	✓	✓	✓	✓		✓		
	Going ahead right hand bend	✓	✓	✓	✓		✓		
	Going ahead other	✓	✓	✓	✓		✓		
	Did not impact								

1st Point of Impact	Front	✓	✓	✓	✓	✓	✓	✓	
	Back					✓	✓		✓
	Offside	✓	✓			✓	✓		
	Nearside	✓	✓			✓	✓		

2.3.2 In-depth data

With respect to the accident scenario, which is derived from free text description of the accident or recorded directly in the database, initial vehicle speeds preceding the accident and impact speeds have been analysed. The result of this analysis is presented as pairwise results in scatter plots for the Car and PTW and where there are sufficient data points the Inter-Quartile Range and Medium values are also presented. The minimum and maximum values are also presented in the analysis and expressed as the range. Box plots and whisker charts are also used to represent the Inter-Quartile Range and minimum and maximum values.

2.4 Accident Type Classification

2.4.1 Accident Groupings

The distinctions between GDV accident types at three-digit level can be very granular to the extent that from the ego vehicle perspective, based on direction of approach and manoeuvre, many of the accidents are the same conflict situation. Aggregating the three-digit GDV code to the two-digit accident type would result in a reduction in detail and mixed scenarios from a sensor perspective. To address this the accident grouping used by the MUSE partner Denso in their GIDAS analysis shall be used to aggregate the cluster analysis results. The accident grouping is based on the conflict situation and direction of travel.

There are 19 accident groupings comprising the following three-digit GDV accident types:

1. Left Turn Across Path - Opposite Direction
2. Left Turn Across Path – Same Direction
3. Left Turn Across Path – Left Direction
4. Lane Change – Same Direction
5. On Coming – Turning
6. Straight Crossing Path – Left Direction
7. Straight Crossing Path – Right Direction
8. Follow-Up Driving
9. Right Turn Into Path – Left Direction
10. Left Turn Into Path – Right Direction
11. Parallel Driving
12. Reverse Crossing Path – Right Direction
13. Parallel Turn – Same Direction
14. On Coming – Straight Driving
15. Right Turn Across Path – Right Direction
16. Lane Change – Opposite Direction
17. Reverse Driving – Opposite Direction
18. Reverse Crossing Path – Left Direction
19. Other

2.4.2 GDV Categories

To categorise accident types into a common description across the multiple national and in-depth datasets this report uses the German Insurance Association (GDV) accident type definitions to describe the manoeuvre or "conflict situation" which resulted in the accident.

There are seven basic types of accident described which are subdivided into two or three-digit accident types. For example, accident type 6 is an accident in longitudinal traffic, type 60 is rear-end collision with the vehicle in front and type 601 is a rear-end collision with the vehicle in front on a in the nearside lane. Many of the accident types depicted are rare scenarios and the distinction between the types are very fine – this is to make it as easy as possible to classify accidents. Each two and three-digit accident type is visually represented by a pictogram illustrating the conflict situation. The arrows used in the pictogram describe the movement and manoeuvre of the road user, if they are travelling straight ahead, turning , braking, stationary etc.

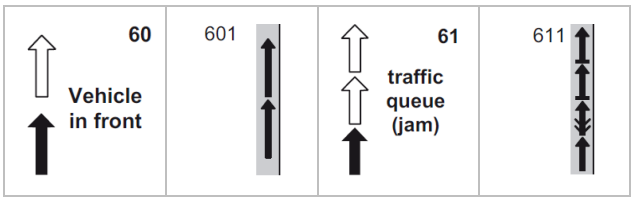


Figure 2-4: GDV Rear-end collision accident types in moving traffic and stationary traffic

The seven basic accident types are:

1. Driving accident (D) - The accident was caused by a loss of control of the vehicle (due to inappropriate speed or incorrect judging of the road ahead, the condition of the street, etc.). Others were not involved in the accident. Uncontrolled vehicle movement can then, however, result in a collision with other road users.

2. Turning-off accident (TO) - The accident was caused by a conflict between a turning vehicle and another vehicle (or even a pedestrian) travelling in the same or opposite direction at an intersection, junction, or an entrance to a property/car park.

3. Turning-into/crossing accident (TC) - The accident was caused by a conflict between a vehicle which had to give way when turning into a road or crossing the road and a vehicle with the right of way at an intersection, junction or exit from a property or car park.

4. Crossing-over accident (CO) - The accident was caused by a conflict between a vehicle and a pedestrian on the street, as long as the pedestrian was not walking along the street and the vehicle was not turning off the road. The accident is still a crossing-over accident even if the pedestrian was not hit.

5. Accident caused by stopping/parking (SP) - The accident was caused by a conflict between a vehicle in moving traffic and a vehicle parking/stopped or attempting to stop/park.

6. Accident in longitudinal traffic (LT) - The accident was caused by a conflict between road users moving in the same or opposing directions, provided the conflict does not correspond to any of the other accident types.

7. Other accident (O) - An accident which cannot be classified as one of types 1 to 6. For example, u-turns, reversing, collisions between parking vehicles, obstacle or animal on the road, sudden vehicle damage (brake failure, tyre damage, etc.)

Further details of the GDV accident types used in this report is given in Appendix A.

3 Results

3.1 Italy

3.1.1 National – ACI-ISTAT

For the years 2013-2016 there were 29,921 Motorcycle to Car accidents in Italy. No information about accident severity was available for inclusion in the cluster analysis but all accidents involved at least one injured participant. Accident clusters are calculated with respect to the recorded accident types, Head-On Side, Lateral Impact, Rear-End, Head-On and Stopping vehicle and based on three main variable types – Road Type, Intersection detail and vehicle manoeuvres.

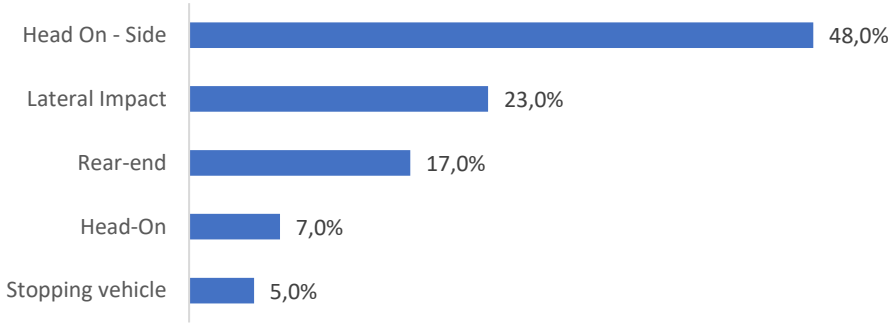
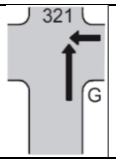
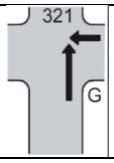
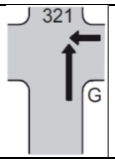
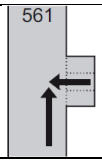


Figure 3-1: Distribution of Car to PTW accident types in the ACI-ISTAT data 201X – 201X

3.1.1.1 Head-On Side

Five clusters have been derived which can be categorised into two accident groups - **Straight Crossing Path – Right Direction,** GDV code **321** and **Straight Crossing Path – Left Direction,** GDV code **561.** Clusters 1-3 represent 70.5% of 'Head-On Side' accidents where the car fails to give-way to the PTW emerging from the right. Whilst there is sufficient information with regard to the car manoeuvre for clusters 2 and 3, not giving way at an intersection, to apply an accident type code there is ambiguity on the correct accident type codification for clusters 1 and 5. Cluster 1 describes both vehicles going straight with no indication of priority at the crossroads, it is assumed that due to very similar options under vehicle manoeuvres that this is just a coding factor where the basic descriptors have been used, at 5% of scenarios this could be viewed as a low occurrence of error and codifying as accident scenario 321 is not detrimental to/likely to skew the analysis given the 65.5% proportionality of cluster 2 and 3 that are also coded 321. Cluster 5 is described as occurring on a straight, not at an intersection, with both vehicles going straight. Given the classification of the accident type as 'Head-On Side', the impact of the front of one vehicle into the side of the other it can be inferred that this cluster could be describing a parking type accident, code 561, where the vehicle exists the parking space to join the main carriageway. Whilst it is impossible to identify whether it is the car or motorcycle entering the main carriageway, either scenario could be considered within the scope of the project in terms of sensing requirements so not detrimental to the overall objectives. Cluster 5 could also be interpreted as scenario 661, two vehicles travelling side by side and the resulting impact locations, front and side, have led to the accident been categorised as 'Head-On Side'. However, given that the ACI-ISTAT data is not limited to KSI accidents only, the potentially low speed scenario 561 could be a frequent accident type where a portion of slight injuries occur. No scenario has been applied to cluster 4 due to no vehicle manoeuvre details to do so.

Table 3.1.1-1: ACI-ISTAT Cluster Analysis - Head-On Side

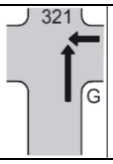
	Cluster #1 5,0%	Cluster #2 51,0%	Cluster #3 14,5%	Cluster #4 4,0%	Cluster #5 34,5%
Road Type	One carriageway, two lanes	One carriageway, two lanes	One carriageway, two lanes	One carriageway, two lanes	One carriageway, two lanes
Intersection	Crossroad	Crossroad	Crossroad with traffic lamp	Straight (no intersection)	Straight (no intersection)
Car Manoeuvre	Go straight	Go straight or distracted driving without respect to yield signal	Go straight or distracted driving without yielding vehicle coming from the right	Not available	Go straight
PTW Manoeuvre	Go straight	Go straight	Go straight	Not available	Go straight
Pictogram				N/A	
ASW	0.71				

3.1.1.2 Lateral

Two notable cluster, 1 and 3, have been defined for 'Lateral' accident types and can be categorised into the accident groups **Straight Crossing Path – Right Direction Conflict**, accident scenario **321** and **Parallel Driving**, accident scenario **651**, respectively. Cluster 1 describes both vehicles going straight at a crossroads on a single carriageway, as a lateral accident type it is probable that the accident could be scenario 651, parallel travel of two vehicles, or 321 where the impact location are such and/or the interpterion of the coding officer is that a 'Head-On Side' type accident has been coded as 'Lateral'. As cluster 1 occurs at a crossroad it has been viewed that the most likely accident scenario is 321. Cluster 3 described two vehicles travelling straight, on a straight road and on a single carriageway – given these details the accident scenario 651 is applied to best describe the cluster. Clusters 2 and 4 do not have sufficient detail to describe the accident scenario but both represent less than 1% of the lateral accident dataset.

Table 3.1.1-2: ACI-ISTAT Cluster Analysis - Lateral

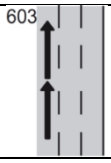
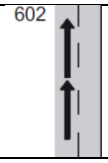
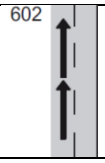
	Cluster #1 40,9%	Cluster #2 0,3%	Cluster #3 58,6%	Cluster #4 0,2%
Road Type	One carriageway, two lanes	One carriageway, two lanes	One carriageway, two lanes	One carriageway, two lanes
Intersection	Crossroad	Straight (no intersection)	Straight (no intersection)	Signalised intersection
Car Manoeuvre	Go straight	Go straight	Go straight	Not available
PTW Manoeuvre	Go straight	Not available	Go straight	Not available

Pictogram		N/A		N/A
ASW	0.67			

3.1.1.3 Rear end

Of the four defined clusters, cluster 4, categorised as **Follow-Up Driving**, code **602,** is the only valid accident scenario from the perspective of the car as the ego-vehicle where it impacts the rear of the motorcycle. This interpretation is due to the car manoeuvre being 'Distracted driving without safety distance' whilst the motorcycle manoeuvre is going straight. Clusters 1-2 describe the motorcycle being the at fault vehicle – these clusters are omitted from any further analysis due to been invalid accident types with respect to the report objective of identifying car based ADAS test procedures.

Table 3.1.1-3: ACI-ISTAT Cluster Analysis - Rear End

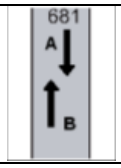
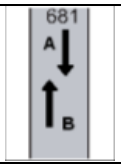
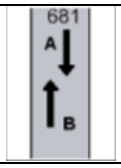
	Cluster #1 17,0%	Cluster #2 28,3%	Cluster #3 0,5%	Cluster #4 54,2%
Road Type	Two carriageways	One carriageway, two lanes	One carriageway, two lanes	One carriageway, two lanes
Intersection	Straight (no intersection)	Crossroads	Straight (no intersection)	Straight (no intersection)
Car Manoeuvre	Go straight	Go straight	Not available	Distracted driving without safety distance
PTW Manoeuvre	Distracted driving without safety distance	Distracted driving without safety distance	Not available	Go straight
Pictogram			N/A	
ASW	0.68			

3.1.1.4 Head-On

Clusters 1, 3 and 4 can be categorised as accident group **On Coming – Straight Driving**, accident scenario **681** due to the accident type being 'Head-Om' and both vehicles going straight without any overtaking manoeuvre. Except for cluster 4 there is no inference on which vehicle is at fault.

Table 3.1.1-4: ACI-ISTAT Cluster Analysis - Head-On

	Cluster #1 55,4%	Cluster #2 1,4%	Cluster #3 42,2%	Cluster #4 1,0%
Road Type	One carriageway, two lanes	One carriageway, two lanes	One carriageway, two lanes	One carriageway, two lanes
Intersection	Straight (no intersection)	Straight (no intersection)	Crossroads	Straight (no intersection)

Car Manoeuvre	Go straight	Not available	Go straight	Go straight or distracted driving with violations
PTW Manoeuvre	Go straight	Not available	Go straight	Go straight
Pictogram		N/A		
ASW	0.61			

3.1.1.5 *Stopping Vehicle*

'Stopping Vehicle' is an ambiguous term for the accident type, to this extent as it cannot be determined if the accident scenario is a front to rear into a stationary vehicle or other scenario and the combination of both vehicle been distracted, clusters 1 and 3, this analysis has been omitted from any subsequent work.

Table 3.1.1-5: ACI-ISTAT Cluster Analysis - Stopping Vehicle

	Cluster #1 19,5%	Cluster #2 17,6%	Cluster #3 60,9%	Cluster #4 2,0%
Road Type	One carriageway, two lanes	Two carriageways	One carriageway, two lanes	One carriageway, two lanes
Intersection	Crossroad	Straight (no intersection)	Straight (no intersection)	Straight (no intersection)
Car Manoeuvre	Distracted driving	Distracted driving	Distracted driving	Distracted driving
PTW Manoeuvre	Distracted driving	Go straight	Distracted driving	Not available
Pictogram	N/A	N/A	N/A	N/A
ASW	0.63			

3.1.2 In-Depth – IGLAD

There are 289 Car to Motorcycle accidents in the IGLAD database for the European countries Austria, Czech Republic, Germany, France, Italy, Sweden and Spain for the years 2007-2015. Italy has the highest proportion of these accident at 40%, Figure 3-2 shows the distribution of accident type in the Italian data. Within the accident types initial and impact speed, for Italian data only, has been determined with respect to GDV code accident scenarios for Left Turn Across Path/Opposite Direction, Left Turn Across Path/Left Direction, Left Turn Across Path/Same Direction and Straight Crossing Path.

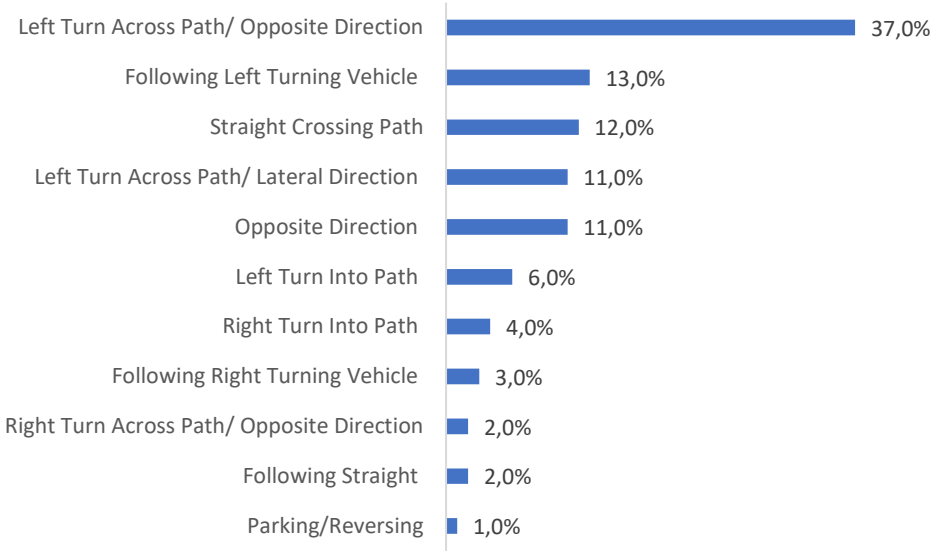


Figure 3-2: iGLAD Italian KSI Accident Type Distribution

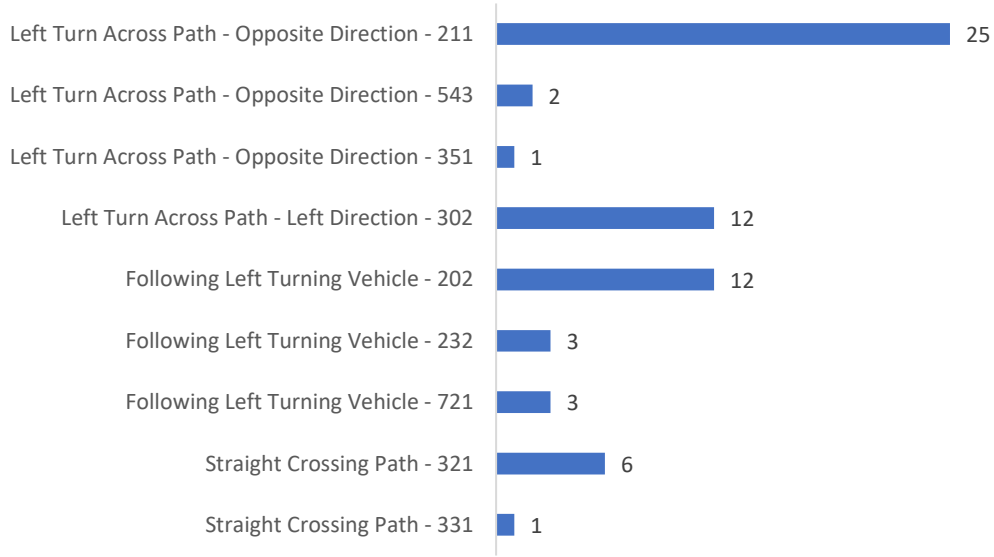
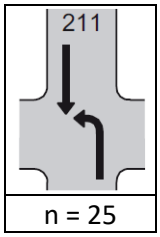


Figure 3-3:IGLAD Italian KSI Accident Scenario Distribution

3.1.2.1 Left Turn Across Path – Opposite Direction



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead

Figure 3-4: iGLAD Accident Types – LTAP/OD

Initial Speed

Car (n = 25)

- Range: 0-36 kmh^{-1}
- IQR: 12-25 kmh^{-1}
- Median: 18 kmh^{-1}

PTW (n = 25):

- Range: 20-120 kmh^{-1}
- IQR: 51-86 kmh^{-1}
- Median: 65 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: 20, 64 kmh^{-1}

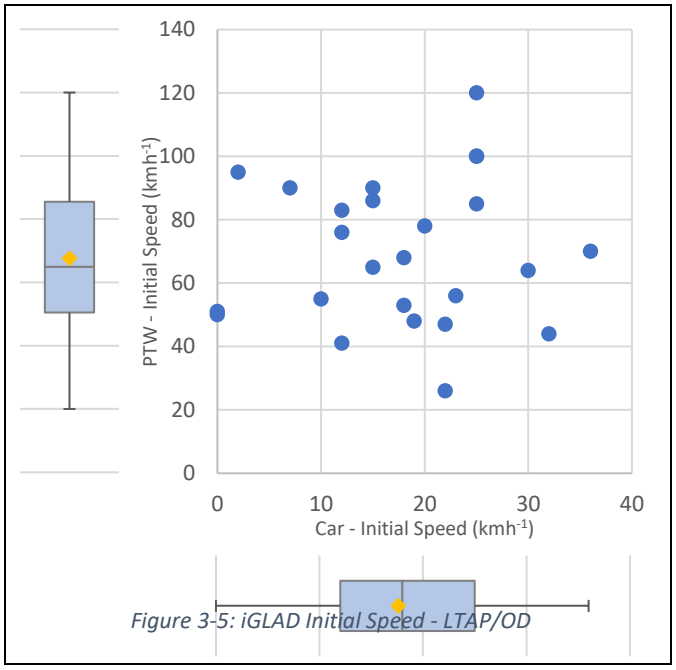


Figure 3-5: iGLAD Initial Speed - LTAP/OD

Impact Speed

Car (n = 25)

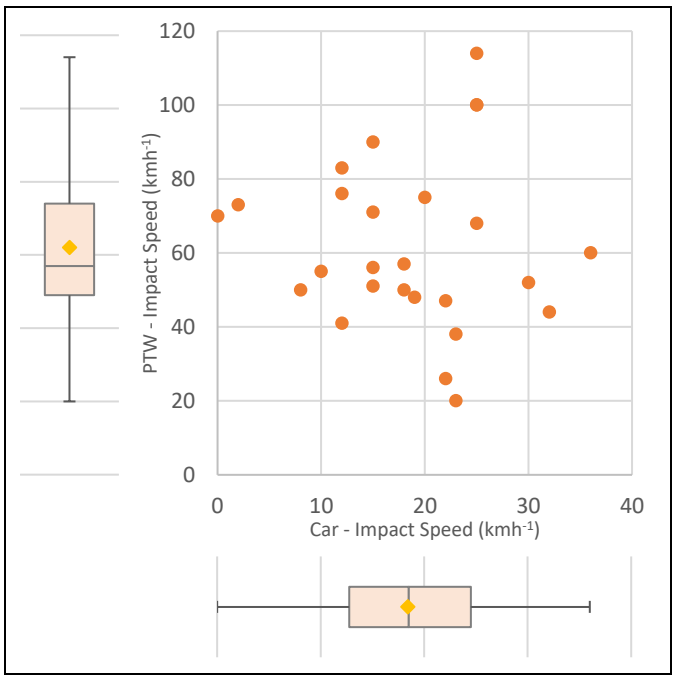
- Range: 0-36 kmh^{-1}
- IQR: 13-25 kmh^{-1}
- Median: 19 kmh^{-1}

PTW (n = 25):

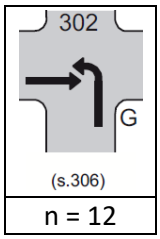
- Range: 20-114 kmh^{-1}
- IQR: 49-74 kmh^{-1}
- Median: 57 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: 64 kmh^{-1}



3.1.2.2 Left Turn Across Path – Left Direction



n = 12

Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead from the left

Figure 3-7: iGLAD Accident Types - LTAP/LD

Initial Speed

Car (n = 12)

- Range: 0-20 kmh^{-1}
- IQR: 2-5 kmh^{-1}
- Median: 4 kmh^{-1}

PTW (n = 11):

- Range: 54-100 kmh^{-1}
- IQR: 65-89 kmh^{-1}
- Median: 80 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 20 kmh^{-1}
- PTW: (N/A)

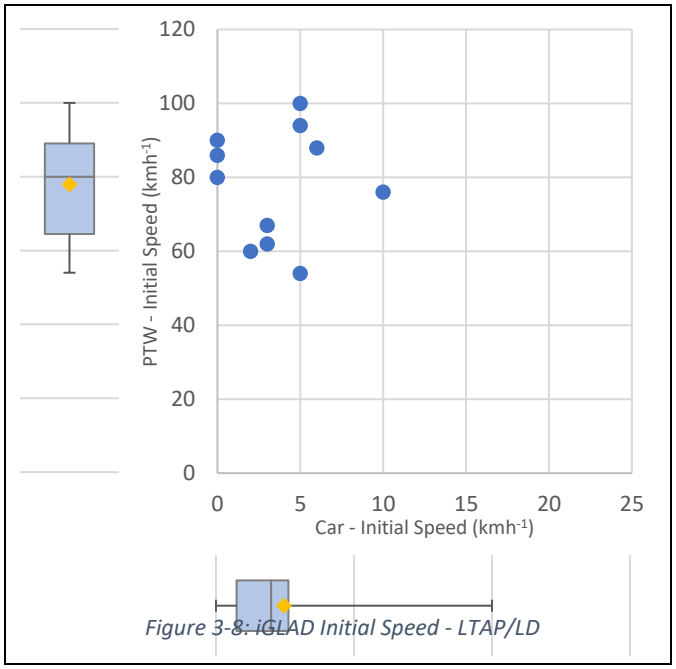


Figure 3-8: iGLAD Initial Speed - LTAP/LD

Impact Speed

Car (n = 12)

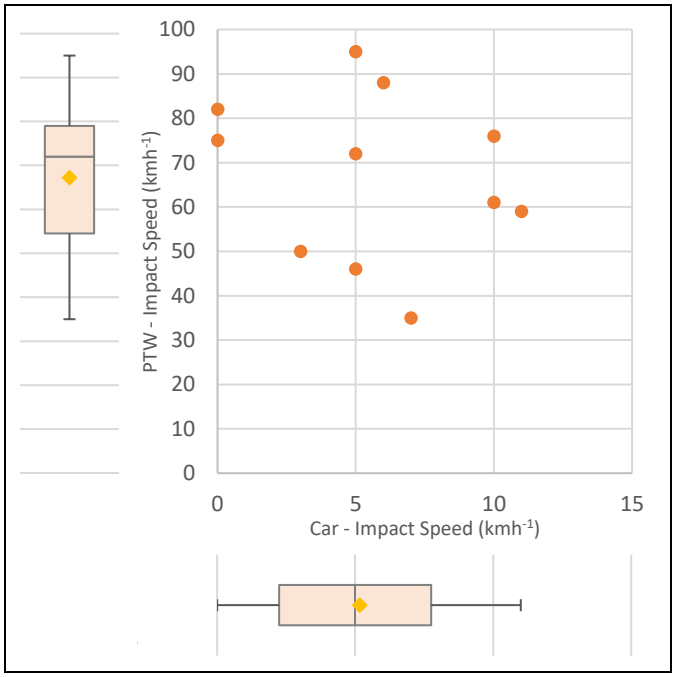
- Range: 0-11 kmh^{-1}
- IQR: 2-8 kmh^{-1}
- Median: 5 kmh^{-1}

PTW (n = 11):

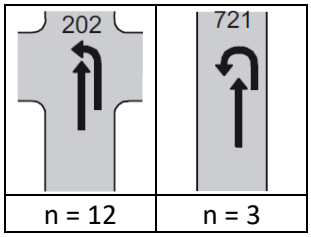
- Range: 35-95 kmh^{-1}
- IQR: 55-79 kmh^{-1}
- Median: 72 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 0 kmh^{-1}
- PTW: (N/A)



3.1.2.3 *Left Turn Across Path – Same Direction*



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead from behind

Figure 3-10: iGLAD Accident Types – LTAP/SD

Initial Speed

Car (n = 11)

- Range: 0-66 kmh^{-1}
- IQR: 11-30 kmh^{-1}
- Median: 21 kmh^{-1}

PTW (n = 10):

- Range: 0-94 kmh^{-1}
- IQR: 25-63 kmh^{-1}
- Median: 50 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 10, 15 kmh^{-1}
- PTW: (N/A)

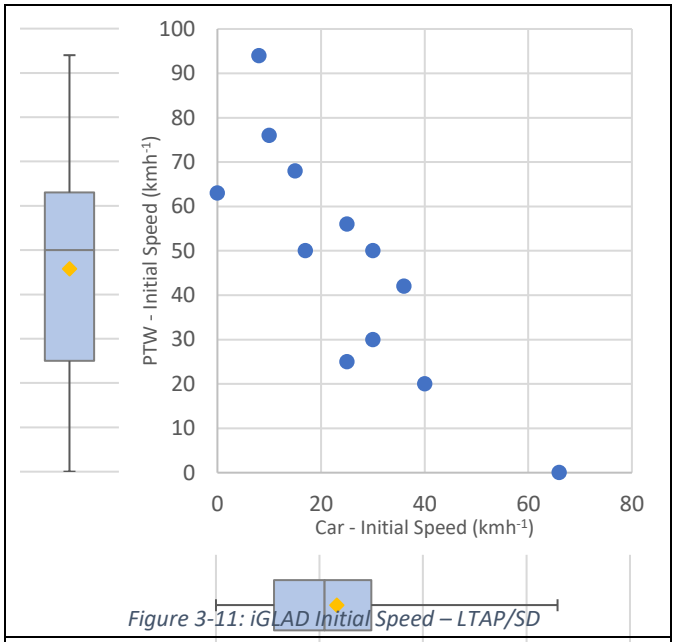


Figure 3-11: iGLAD Initial Speed – LTAP/SD

Impact Speed

Car (n = 10)

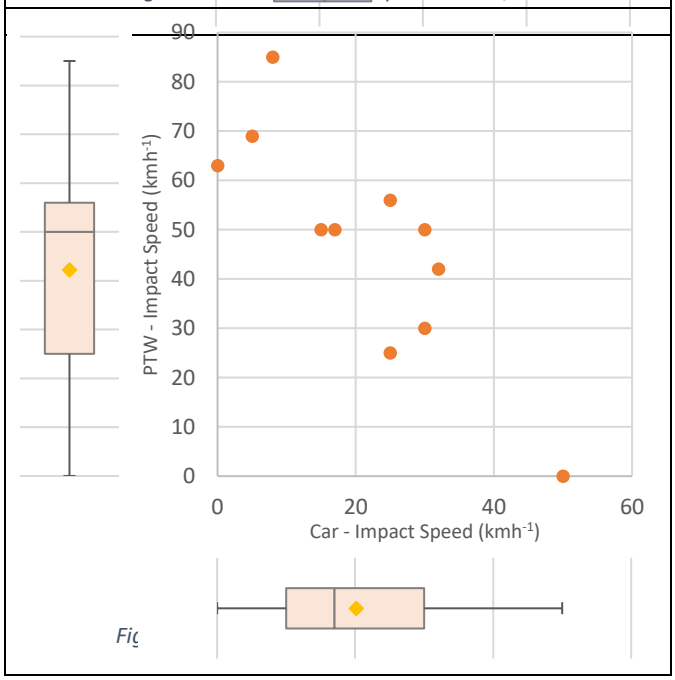
- Range: 0-50 kmh^{-1}
- IQR: 10-30 kmh^{-1}
- Median: 17 kmh^{-1}

PTW (n = 10):

- Range: 0-85 kmh^{-1}
- IQR: 25-56 kmh^{-1}
- Median: 50 kmh^{-1}

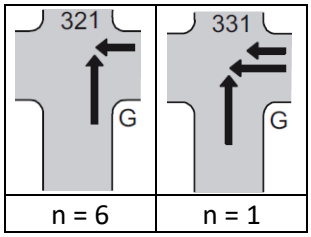
Unpaired Car and PTW cases:

- Car: 10, 15 kmh^{-1}
- PTW: (N/A)



Fig

3.1.2.4 Straight Crossing Path – (Right Direction)



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead from the right

Figure 3-13: iGLAD Accident Types - SCP

Initial Speed

Car (n = 5)

- Range: 12-44 kmh^{-1}
- IQR: 17-36 kmh^{-1}
- Median: 30 kmh^{-1}

PTW (n = 6):

- Range: 25-60 kmh^{-1}
- IQR: 29-54 kmh^{-1}
- Median: 30 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: 40 kmh^{-1}

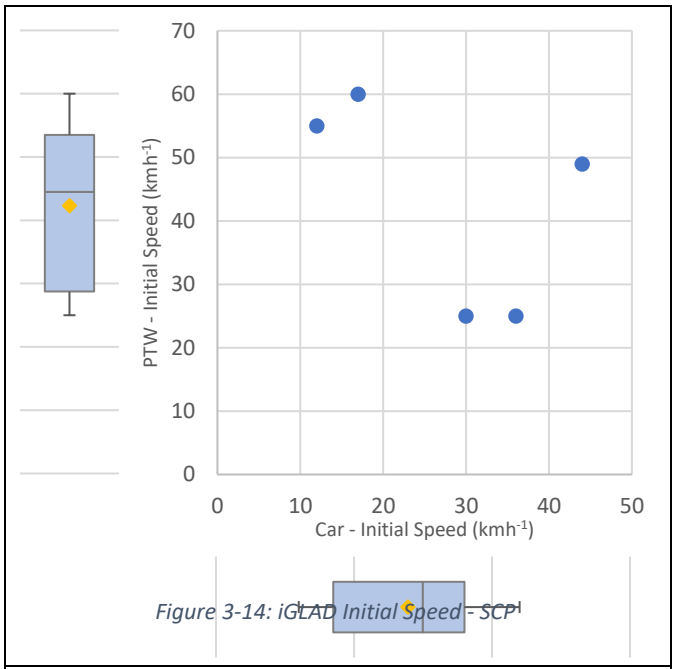


Figure 3-14: iGLAD Initial Speed - SCP

Impact Speed

Car (n = 5)

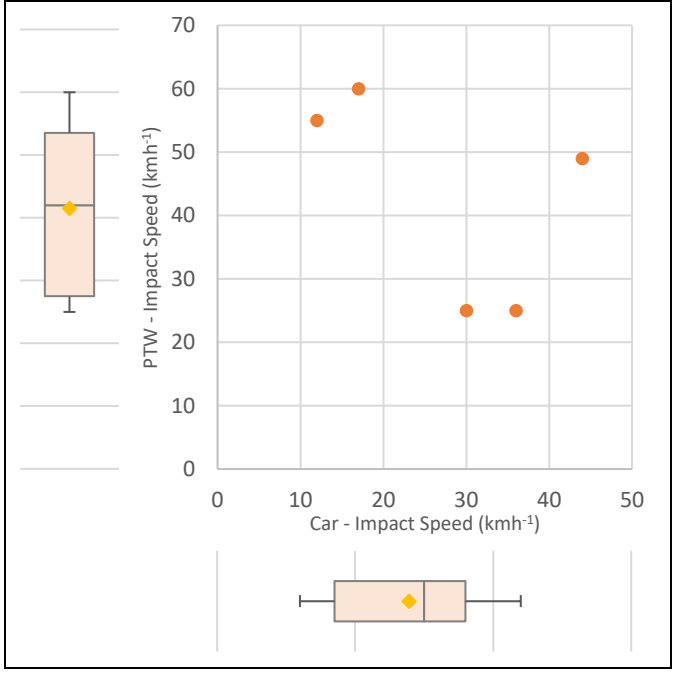
- Range: 12-44 kmh^{-1}
- IQR: 17-36 kmh^{-1}
- Median: 30 kmh^{-1}

PTW (n = 6):

- Range: 25-60 kmh^{-1}
- IQR: 28-54 kmh^{-1}
- Median: 42 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: 35 kmh^{-1}



3.2 France

3.2.1 National Data - BAAC

In the period 2014-2016 there were 95,872 accidents involving two vehicles, 11,584 of these involved a car and PTW of which 4,848 were KSI accidents, Figure 3-16 shows the distribution of these KSI accidents by given accident type in the BAAC dataset. The accidents types Two vehicle -Side, Two vehicle – Rear and Two vehicle – Head On Collision were selected for cluster analysis, KSI proportions were normalised based on these three accident types for ranking purposes.

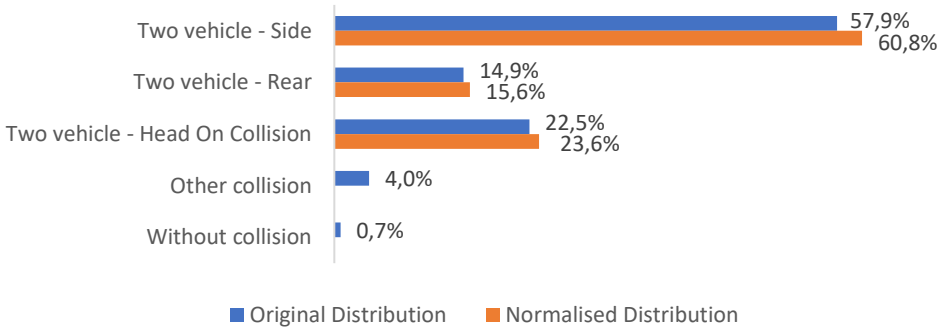
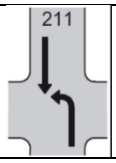
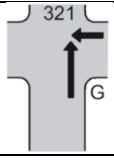
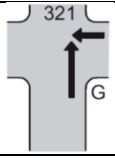


Figure 3-16: BAAC KSI Accident Type Distribution

3.2.1.1 Side

Cluster 1 describes the car turning right across the path of the PTW and can be categorised into accident group **Left Turn Across Path – Opposite Direction Conflict** and GDV code **211**. Clusters 2 and 3 can be categorised into accident group **Straight Crossing Path – Right Direction Conflict** and GDV code **321**.

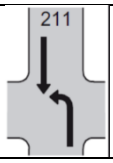
Table 3.2.1-1: BAAC Cluster Analysis - Side

	Cluster #1 62,0%	Cluster #2 8,1%	Cluster #3 29,9%
Location	In built up area	In built up area	In built up area
Intersection	Outside of intersection, in intersection or immediate vicinity	Outside of intersection, in intersection or immediate vicinity	Outside of intersection, in intersection or immediate vicinity
Road Type	Country road	Communal road	Country road
Car Manoeuvre	Turning to the left	Without changing direction	Crossing the carriageway
PTW Manoeuvre	Without changing direction	Between two lanes	Without changing direction
Car Impact Point	Front	Front	Front
PTW Impact Point	Front left	Front left	Front left
Pictogram			
ASW	0.45		

3.2.1.2 Head-On

Clusters 1 and 3 can be categorised into accident group **Lane Change – Opposite Direction Conflict** and GDV code **661**. In Cluster 1 it is the PTW that moves left resulting in a front to front collision with the car and in Cluster 3 the manoeuvre scenario is reversed. Cluster 2 is best categorised as **Left Turn Across Path – Opposite Direction Conflict** with GDV code **211,** a junction scenario**.**

Table 3.2.1-2: BAAC Cluster Analysis - Head-On

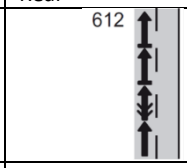
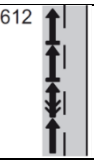
	Cluster #1 36,6%	Cluster #2 46,2%	Cluster #3 17,2%
Location	Outside built up area	In built up area	In built up area
Intersection	Outside of intersection, in intersection or immediate vicinity	Outside of intersection, in intersection or immediate vicinity	Outside of intersection, in intersection or immediate vicinity
Road Type	Country road	Country road	Country road
Car Manoeuvre	Without changing direction	Turning to the left	Moving to the left
PTW Manoeuvre	Moving to the left	Without changing direction	Without changing direction
Car Impact Point	Front	Front	Front
PTW Impact Point	Front left	Front	Front left
Pictogram			
ASW	0.56		

3.2.1.3 Rear

Three clusters proportioned 76%, 13% and 12% represent accidents where the car goes into the rear of the PTW, all clusters can be categorised into the accident group **Follow-up Driving** witch the distinct that clusters 1 and 2 involve a slowing or stationary PTW and cluster 3 involves moving traffic on a motorway.

Table 3.2.1-3: BAAC Cluster Analysis - Rear

	Cluster #1 75,8%	Cluster #2 12,5%	Cluster #3 11,6%
Location	In built up area	Outside built up area	Outside built up area
Intersection	Outside of intersection, in intersection or immediate vicinity	Outside of intersection, in intersection or immediate vicinity	Outside of intersection, in intersection or immediate vicinity
Road Type	Country road	Country road	Motorway
Car Manoeuvre	Same direction same queue	Same direction same queue	Without changing direction
PTW Manoeuvre	Same direction same queue	Without changing direction	Between 2 lanes
Car Impact Point	Front	Front	Front

PTW Impact Point	Rear	Rear	Rear Left
Pictogram			
ASW	0.51		

3.2.2 In-Depth VOIESUR Updated

223 car and motorcycle accidents were provided for analysis by the work package members CEESAR, 5 ambiguous cases were omitted from the analysis. The VOIESUR analysis provides a written summary of the accident, accident scenario classification code, road details, vehicle paths, any evasive actions and impact locations. The initial and impact speeds for the car and motorcycle are also recorded, although these are not determined at all or just in part, Figure 3-17 and Figure 3-18 detail the completeness of the speed data relative to the total number of cases.

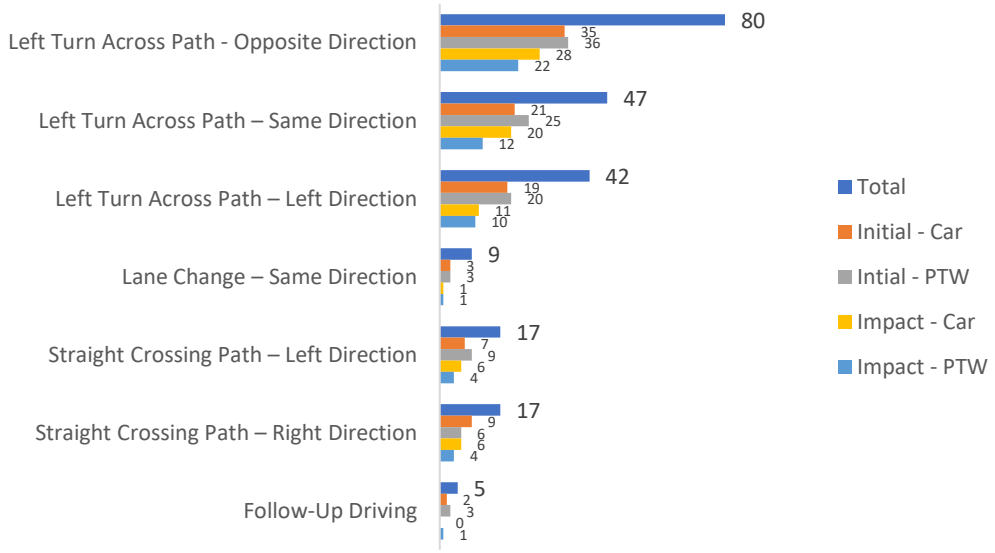


Figure 3-17: VOIESUR - Population of initial and impact speeds for the PTW and Car by Accident Group

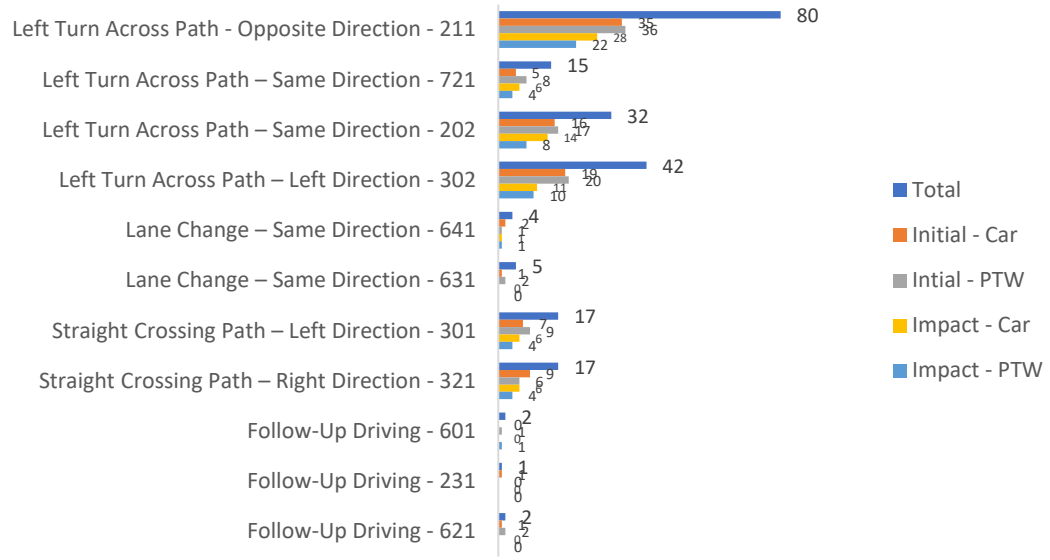
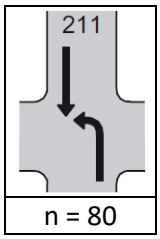


Figure 3-18: VOISUR - Population of initial and impact speed for the PTW and Car by Accident Scenario

3.2.2.1 *Left turn across path – Opposite direction*



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead

Figure 3-19: VOIESUR Accident Types – LTAP/OD

Initial Speed

Car (n = 35)

- Range: 0-70 kmh^{-1}
- IQR: 12-26 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 36):

- Range: 50-145 kmh^{-1}
- IQR: 50-97 kmh^{-1}
- Median: 80 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 0, 0, 0, 5, 5, 14, 30, 30, 70
- PTW: 30, 40, 45, 50, 50, 60, 75, 80, 90, 90, 120

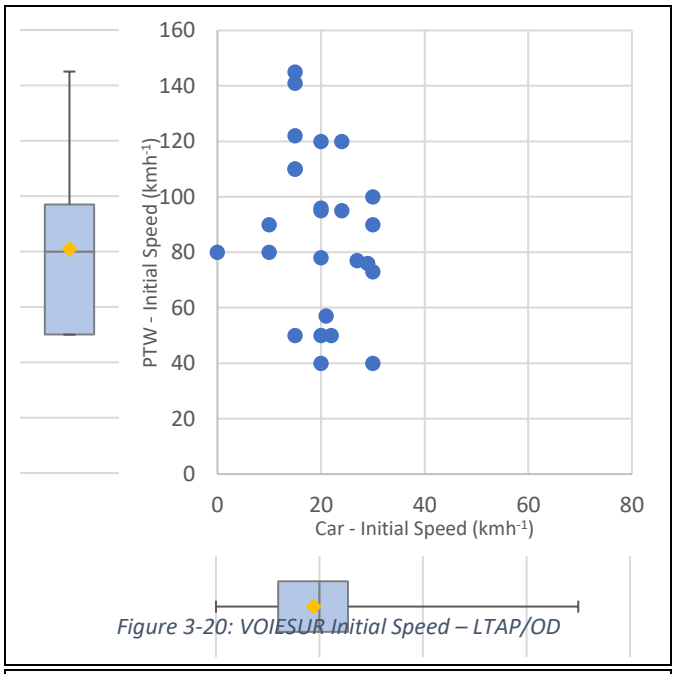


Figure 3-20: VOIESUR Initial Speed – LTAP/OD

Impact Speed

Car (n = 28)

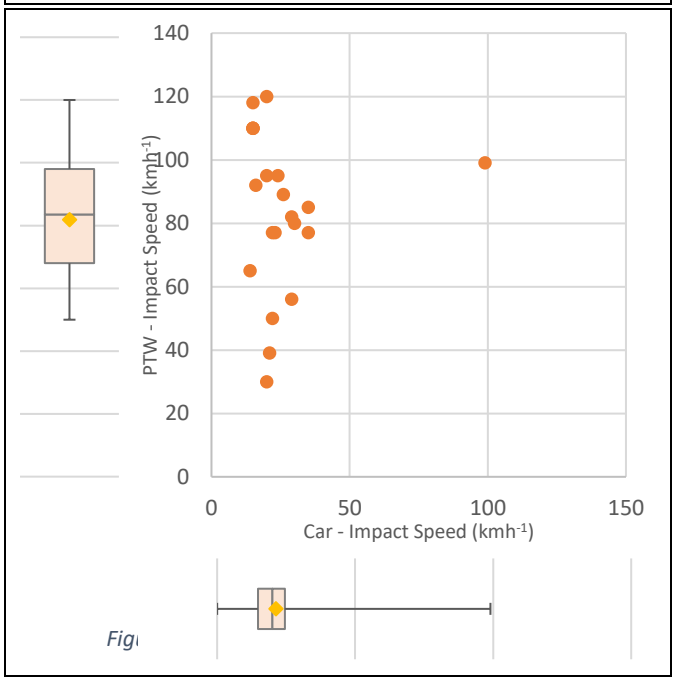
- Range: 0-99 kmh^{-1}
- IQR: 15-25 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 22):

- Range: 30-120 kmh^{-1}
- IQR: 68-98 kmh^{-1}
- Median: 84 kmh^{-1}

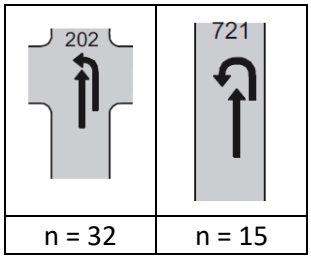
Unpaired Car and PTW cases:

- Car: 0, 0, 5, 5, 10, 10, 20
- PTW: 45



Figu

3.2.2.2 *Left turn across path – Same direction*



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead from behind the car

Figure 3-22: VOIESUR Accident Types – LTAP/SD

Initial Speed

Car (n = 21)

- Range: 0- 60 kmh^{-1}
- IQR: 10-20 kmh^{-1}
- Median: 10 kmh^{-1}

PTW (n = 25):

- Range: 25-148 kmh^{-1}
- IQR: 45-90 kmh^{-1}
- Median: 80 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 0, 10, 10, 10 ,20
- PTW: 25, 40, 40, 40, 45, 65, 80, 80

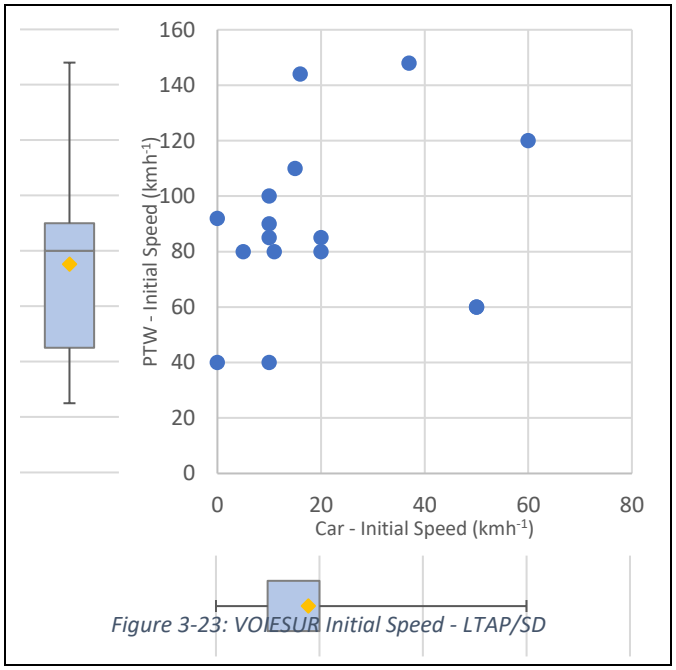


Figure 3-23: VOIESUR Initial Speed - LTAP/SD

Impact Speed

Car (n = 20)

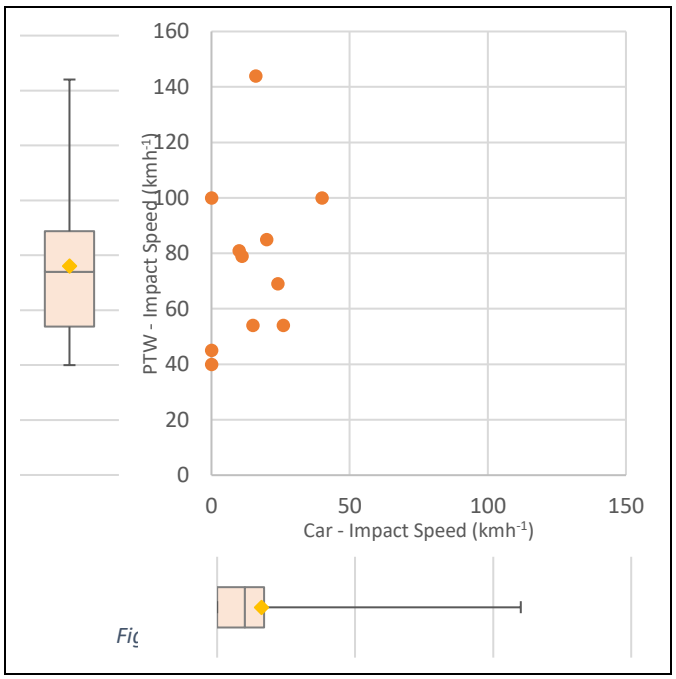
- Range: 0-110 kmh^{-1}
- IQR: 0-17 kmh^{-1}
- Median: 10 kmh^{-1}

PTW (n = 12):

- Range: 40-144 kmh^{-1}
- IQR: 54-89 kmh^{-1}
- Median: 74 kmh^{-1}

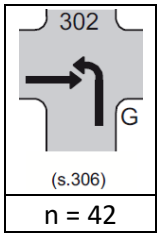
Unpaired Car and PTW cases:

- Car: 0, 0, 0, 5, 9, 10, 10, 15, 110
- PTW: 62



Fig

3.2.2.3 *Left turn across path – Left direction*



n = 42

Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead from the left

Figure 3-25: VOIESUR Accident Types – LTAP/LD

Initial Speed

Car (n = 19)

- Range: 0-50 kmh^{-1}
- IQR: 3-20 kmh^{-1}
- Median: 10 kmh^{-1}

PTW (n = 20):

- Range: 50-113 kmh^{-1}
- IQR: 66-90 kmh^{-1}
- Median: 70 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 5, 10, 10 ,50
- PTW: 50, 55, 70, 70, 80

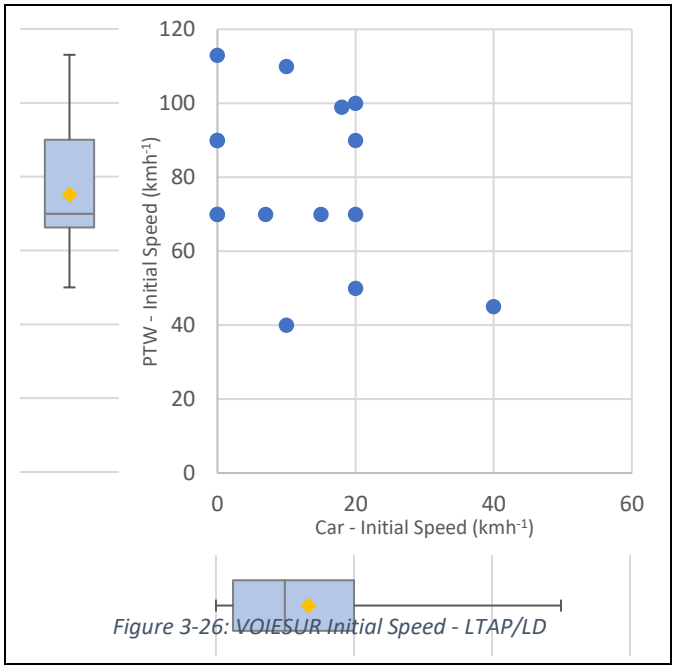


Figure 3-26: VOIESUR Initial Speed - LTAP/LD

Impact Speed

Car (n = 11)

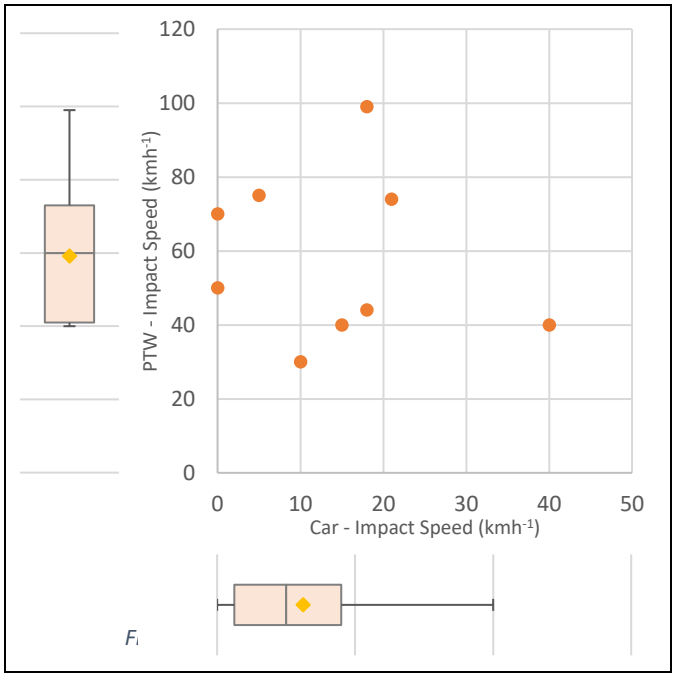
- Range: 0-40 kmh^{-1}
- IQR: 3-18 kmh^{-1}
- Median: 10 kmh^{-1}

PTW (n = 10):

- Range: 30-99 kmh^{-1}
- IQR: 41-73 kmh^{-1}
- Median: 60 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 0, 10
- PTW: 70



F

3.2.2.4 Lane change – Same direction

631	641
	Lane change due to vehicle in front
n = 5	n = 4

Car manoeuvre: Changing lane
PTW manoeuvre: Travelling straight ahead

Figure 3-28: VOIESUR Accident Types – LC/SD

Initial Speed

Car (n = 3)

- Range: 40-80 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 3):

- Range: 70-80 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 80
- PTW: 70

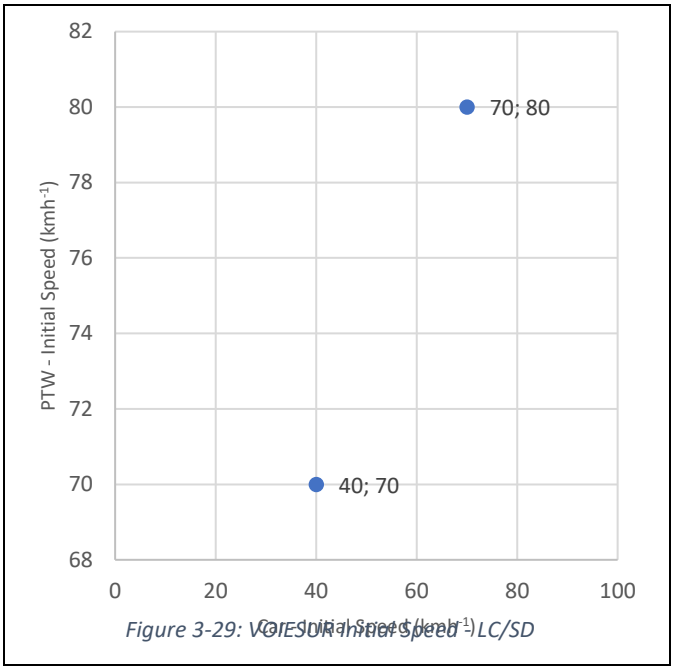


Figure 3-29: VOIESUR Initial Speed - LC/SD

Impact Speed

Car (n = 1)

- Range: 40 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 40 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

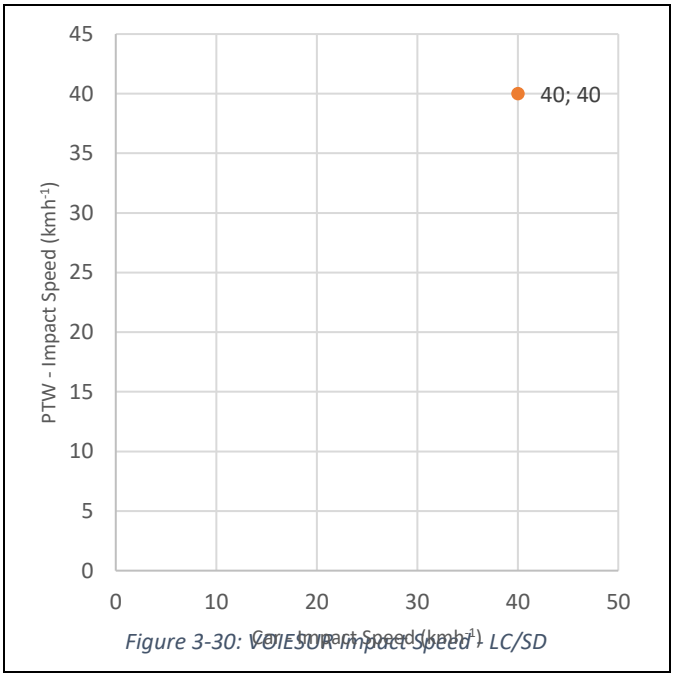
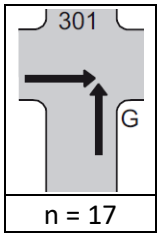


Figure 3-30: VOIESUR Impact Speed - LC/SD

3.2.2.5 Straight crossing path – Left direction



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead from the right

Figure 3-31: VOIESUR Accident Types – SCP/LD

Initial Speed

Car (n = 7)

- Range: 0-30 kmh^{-1}
- IQR: 15-20 kmh^{-1}
- Median: 17 kmh^{-1}

PTW (n = 11):

- Range: 50-150kmh^{-1}
- IQR: 50-110 kmh^{-1}
- Median: 60 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 20
- PTW: 15, 50, 50, 60, 80

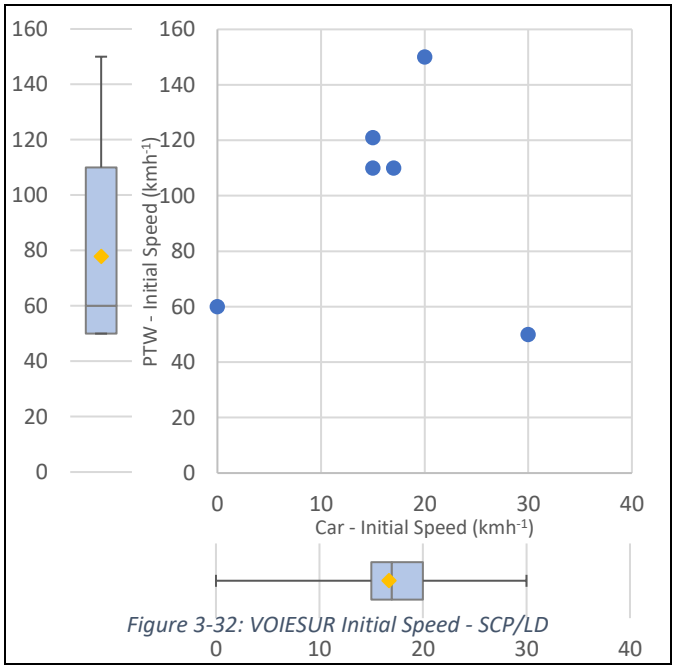


Figure 3-32: VOIESUR Initial Speed - SCP/LD

Impact Speed

Car (n = 6)

- Range: 17-40 kmh^{-1}
- IQR: 19-29 kmh^{-1}
- Median: 22 kmh^{-1}

PTW (n = 4):

- Range: 29-104 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 30, 40
- PTW: (N/A)

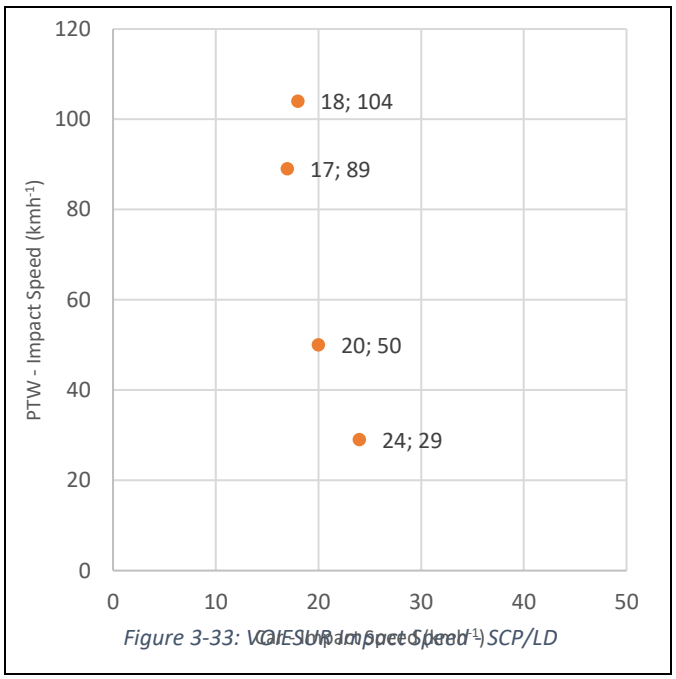
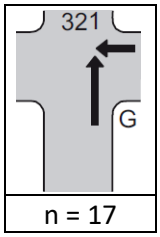


Figure 3-33: VOIESUR Impact Speed - SCP/LD

3.2.2.6 *Straight crossing path – Right direction*



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead from the right

Figure 3-34: VOIESUR Accident Types – SCP/RD

Initial Speed

Car (n = 10)

- Range: 0-45 kmh^{-1}
- IQR: 10-24 kmh^{-1}
- Median: 15 kmh^{-1}

PTW (n = 8):

- Range: 20-80 kmh^{-1}
- IQR: 28-49 kmh^{-1}
- Median: 38 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 0, 0, 10, 25, 45
- PTW: 20, 30, 35

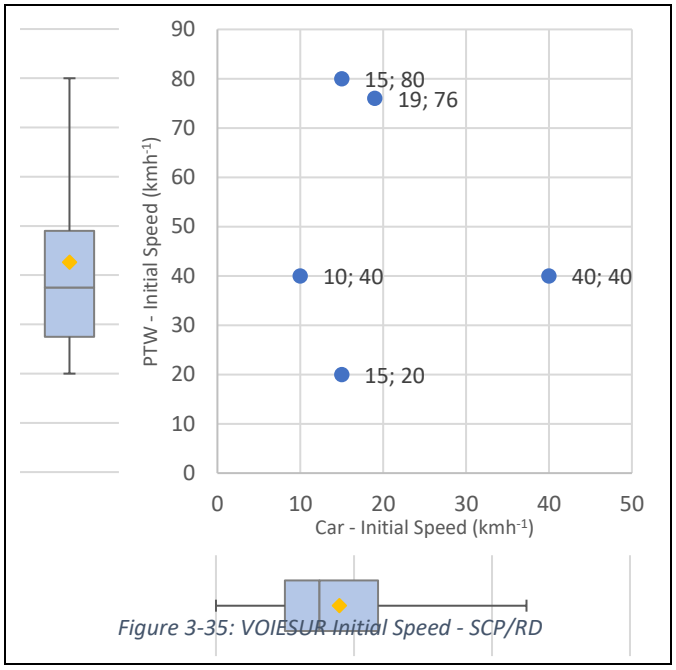


Figure 3-35: VOIESUR Initial Speed - SCP/RD

Impact Speed

Car (n = 6)

- Range: 0-45 kmh^{-1}
- IQR: 15-35 kmh^{-1}
- Median: 17 kmh^{-1}

PTW (n = 4):

- Range: 46-99 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 0, 45
- PTW: (N/A)

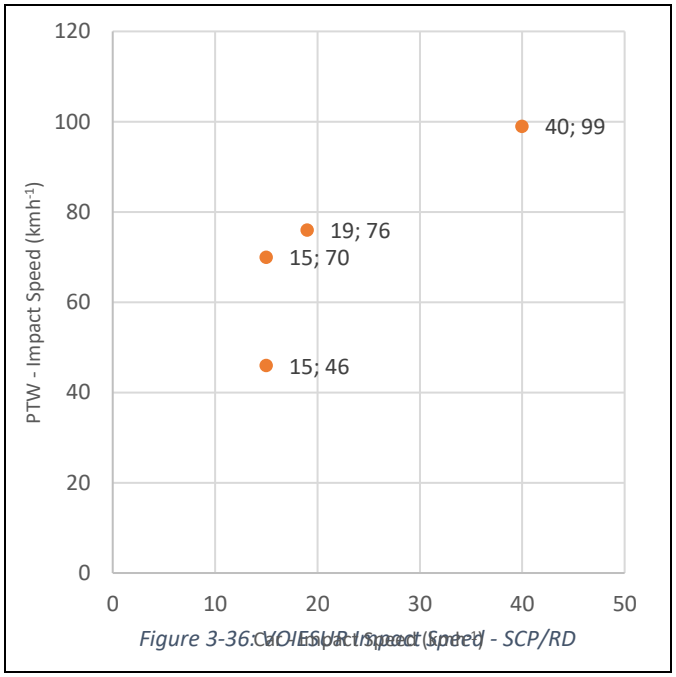
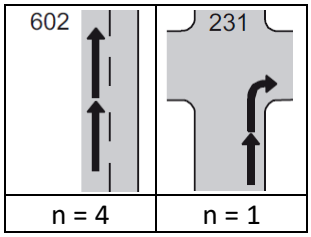


Figure 3-36: VOIESUR Impact Speed - SCP/RD

3.2.2.7 Follow-up driving



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead or turning – moving, slowing or stationary

Figure 3-37: VOIESUR Accident Types – FUD

Initial Speed

Car (n = 2)

- Range: 5-70 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 3):

- Range: 0 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 70 kmh^{-1}
- PTW: 0, 0 kmh^{-1}

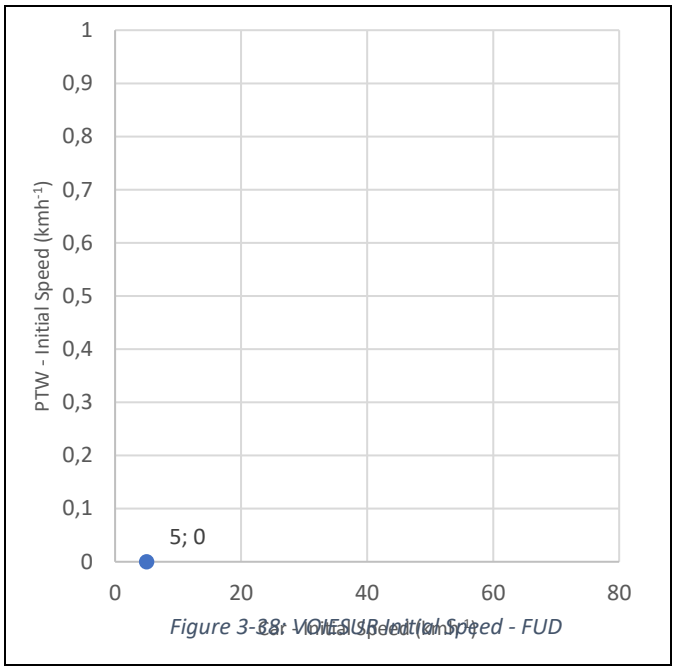


Figure 3-38: VOIESUR Initial Speed - FUD

Impact Speed

Car (n = 0)

- Range: (N/A)
- IQR: (N/A)
- Median: (N/A)

PTW (n = 5):

- Range: 0 kmh^{-1}
- IQR: (N/A)
- Median: kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: 0, 0, 0, 0, 0 kmh^{-1}

3.3 Germany

3.3.1 National Data - Destatis

Police reported accidents in Germany are summarised in the national accident statistics by the 'Kind of accident' and 'Type of accident' plus environmental variables. In addition to the limited variables the data is presented only in a disaggregated format therefore it was deemed that the data was not appropriate to undertake cluster analysis and given that the GIDAS accident distribution is, when weighted, considered representative of the national dataset GIDAS data is used instead with each scenario treated as an individual cluster.

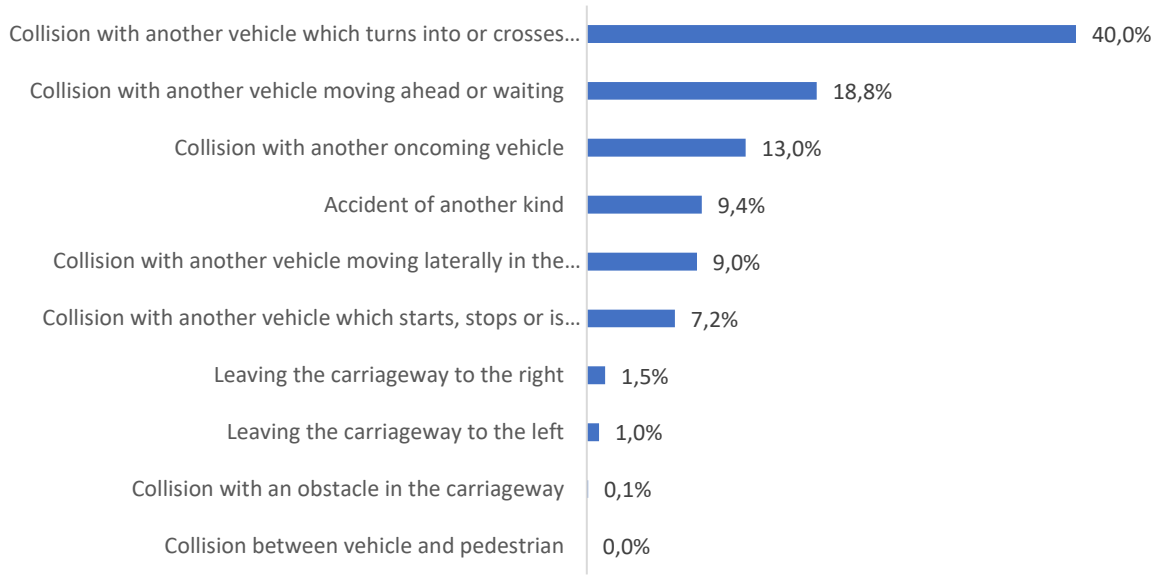


Figure 3-39: Destatis - 'Kind of accident'

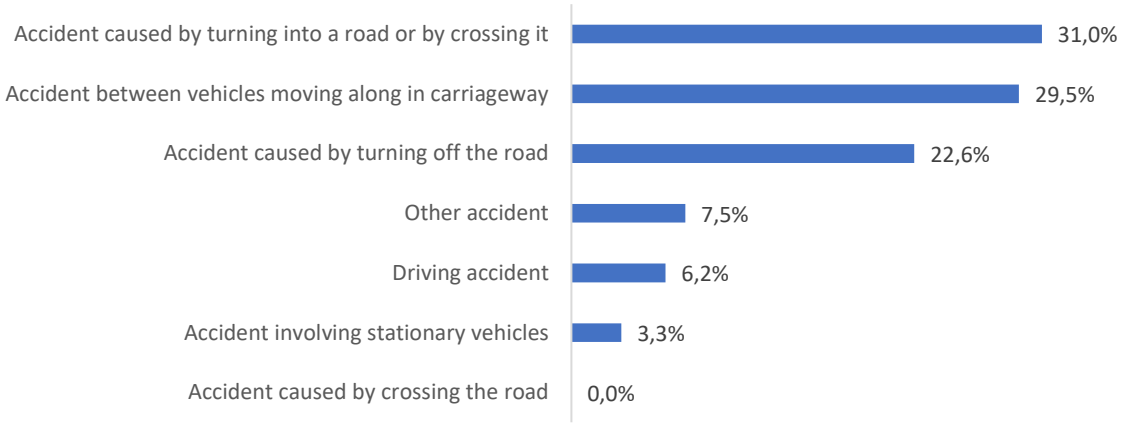


Figure 3-40: Destatis - 'Type of accident'

3.3.2 In-Depth - GIDAS

Two analyses of the GIDAS data have been performed, KSI accident type distribution at a national level based on Destatis weighting (Figure 3-41 and Accident Scenarios Figure 3-42) and initial and impact speeds of the recorded cases for years 2005-2017, 196 cases in total. Accident scenarios are natively recorded as GDV codes as Uftype codes.

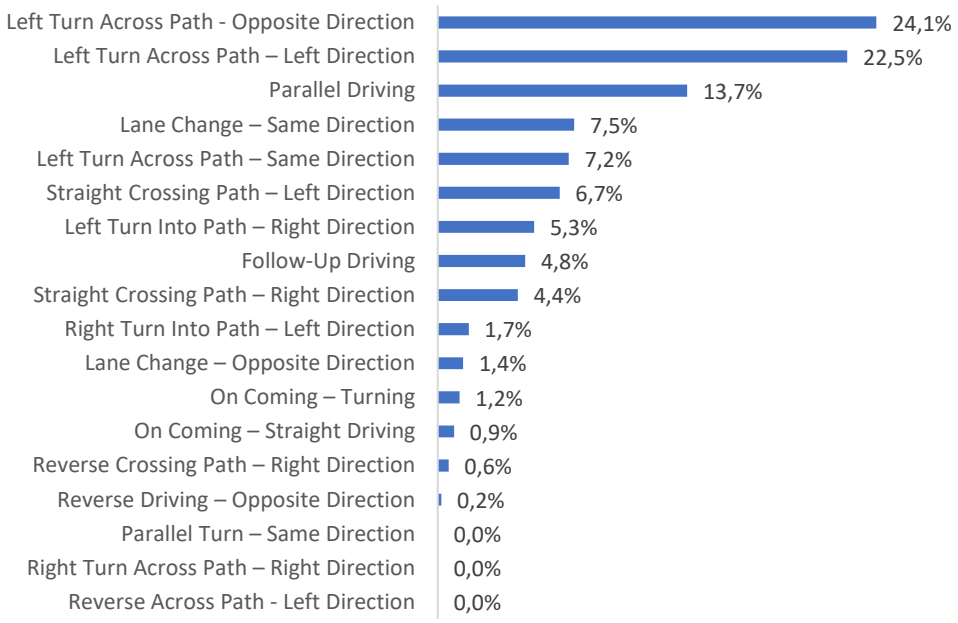


Figure 3-41: GIDAS - Car to Motorcycle Accident Group Distribution

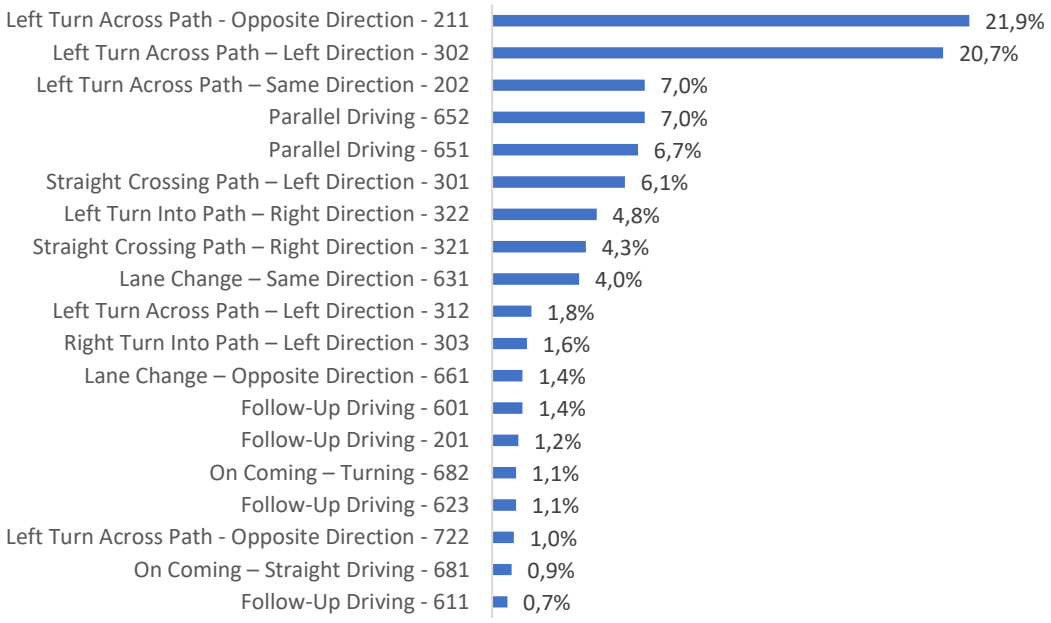
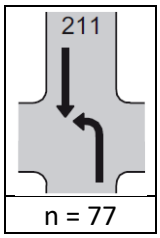


Figure 3-42: GIDAS - Car to Motorcycle Accident Scenario Distribution (95% coverage)

3.3.2.1 *Left turn across path – Opposite direction*



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead

Figure 3-43: GIDAS Accident Types – LTAP/OD

Initial Speed

Car (n = 76)

- Range: 5-55 kmh^{-1}
- IQR: 20-30 kmh^{-1}
- Median: 30 kmh^{-1}

PTW (n = 76):

- Range: 30-125 kmh^{-1}
- IQR: 45-60 kmh^{-1}
- Median: 50 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

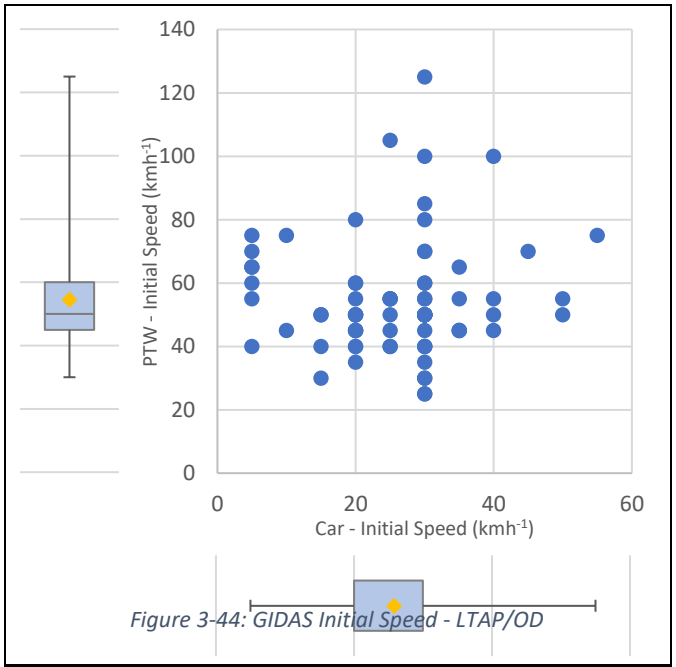


Figure 3-44: GIDAS Initial Speed - LTAP/OD

Impact Speed

Car (n = 77)

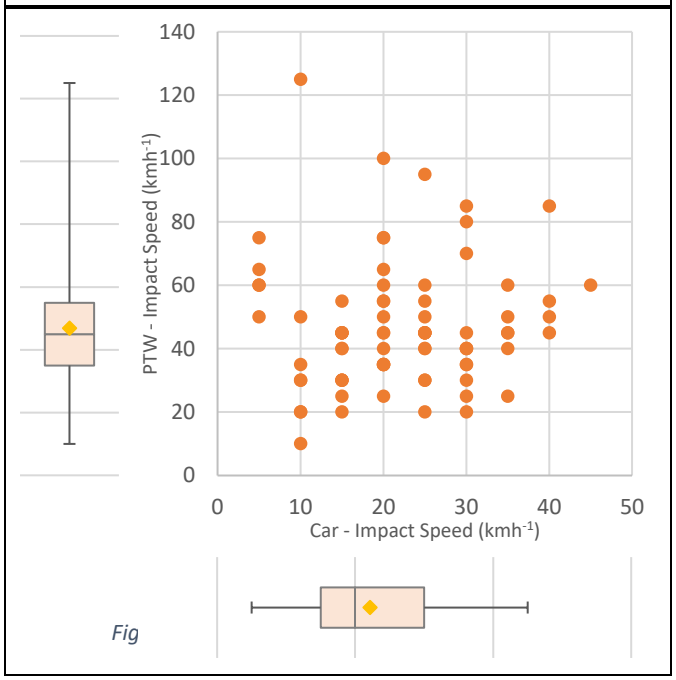
- Range: 5-45 kmh^{-1}
- IQR: 15-30 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 77):

- Range: 10-125 kmh^{-1}
- IQR: 35-55 kmh^{-1}
- Median: 45 kmh^{-1}

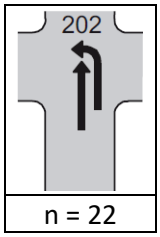
Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



Fig

3.3.2.2 *Left turn across path – Same direction*



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead

Figure 3-46: GIDAS Accident Types – LTAP/OD

Initial Speed

Car (n = 22)

- Range: 5-100 kmh^{-1}
- IQR: 20-35 kmh^{-1}
- Median: 23 kmh^{-1}

PTW (n = 22):

- Range: 35-110 kmh^{-1}
- IQR: 56-70 kmh^{-1}
- Median: 68 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

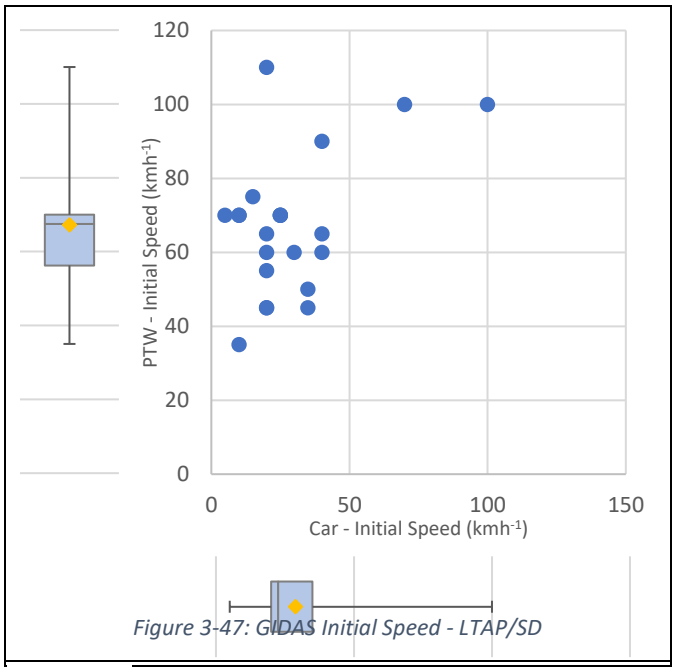


Figure 3-47: GIDAS Initial Speed - LTAP/SD

Impact Speed

Car (n = 22)

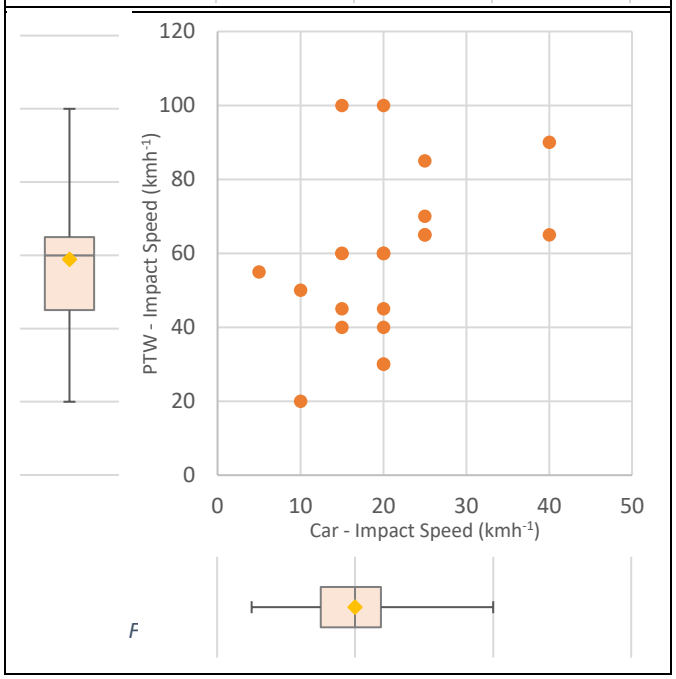
- Range: 5-40 kmh^{-1}
- IQR: 15-24 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 22):

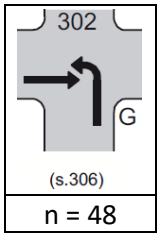
- Range: 20-100 kmh^{-1}
- IQR: 45-65 kmh^{-1}
- Median: 60 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



3.3.2.3 *Left turn across path – Left direction*



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead from the left

Figure 3-49: GIDAS Accident Types – LTAP/OD

Initial Speed

Car (n = 48)

- Range: 5-40 kmh^{-1}
- IQR: 5-20 kmh^{-1}
- Median: 15 kmh^{-1}

PTW (n = 48):

- Range: 30-95 kmh^{-1}
- IQR: 45-65 kmh^{-1}
- Median: 50 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

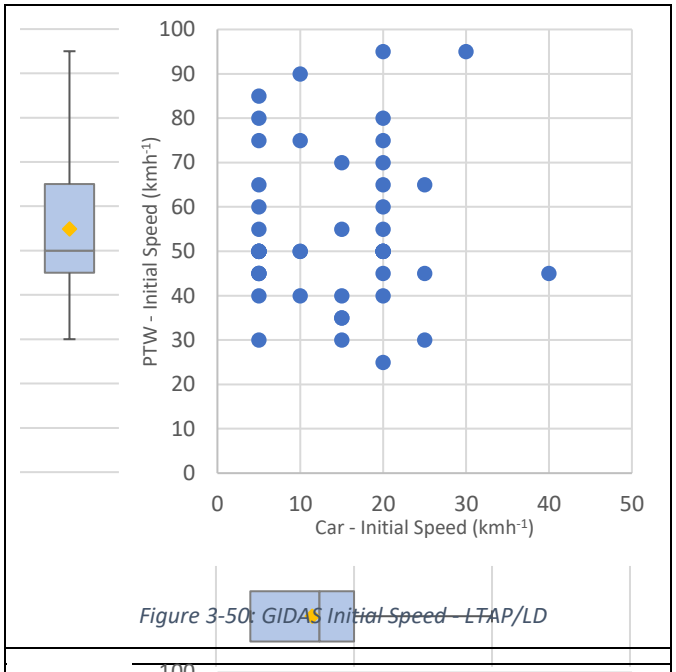


Figure 3-50: GIDAS Initial Speed - LTAP/LD

Impact Speed

Car (n = 48)

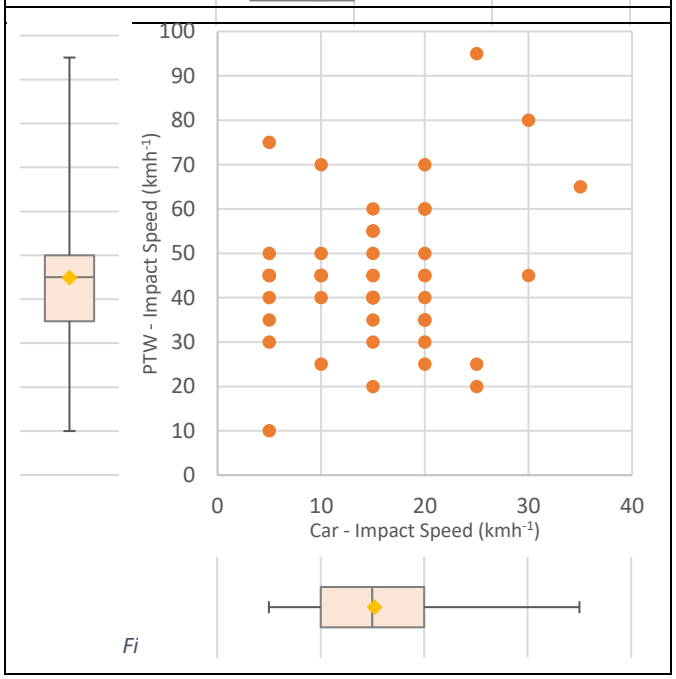
- Range: 5-35 kmh^{-1}
- IQR: 10-50 kmh^{-1}
- Median: 45 kmh^{-1}

PTW (n = 48):

- Range: 10-95 kmh^{-1}
- IQR: 35-50 kmh^{-1}
- Median: 45 kmh^{-1}

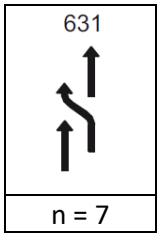
Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



Fi

3.3.2.4 *Lane change – Same direction*



Car manoeuvre: Lane change
PTW manoeuvre: Travelling straight ahead from behind

Figure 3-52: GIDAS Accident Types – LC/SD

Initial Speed

Car (n = 6)

- Range: 30-80 kmh^{-1}
- IQR: 41-73 kmh^{-1}
- Median: 48 kmh^{-1}

PTW (n = 6):

- Range: 50-110 kmh^{-1}
- IQR: 59-93 kmh^{-1}
- Median: 70 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

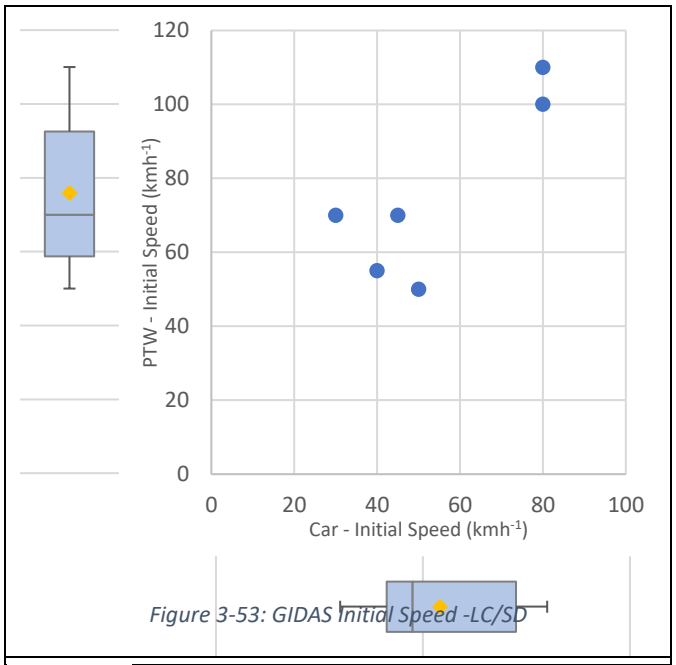


Figure 3-53: GIDAS Initial Speed -LC/SD

Impact Speed

Car (n = 7)

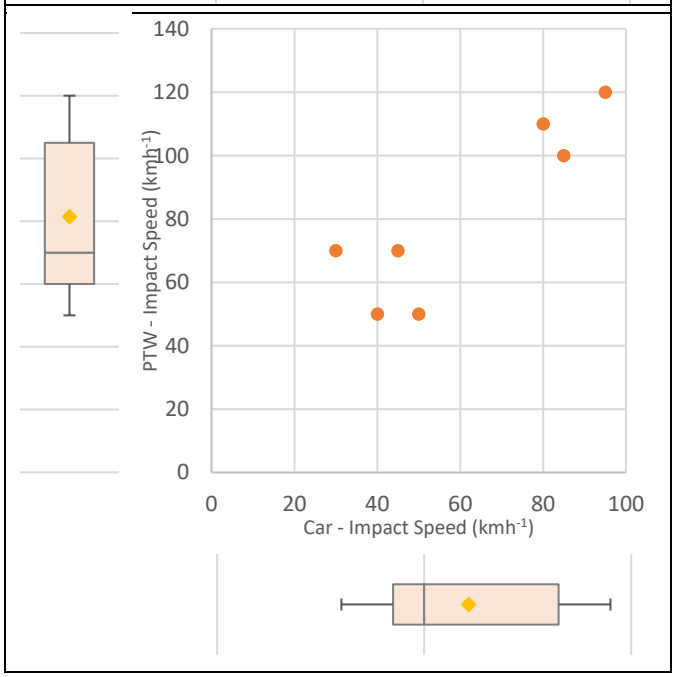
- Range: 30-95 kmh^{-1}
- IQR: 43-83 kmh^{-1}
- Median: 50 kmh^{-1}

PTW (n = 7):

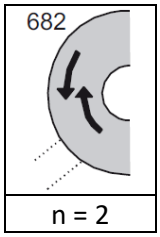
- Range: 50-120 kmh^{-1}
- IQR: 60-105 kmh^{-1}
- Median: 70 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



3.3.2.5 On coming - Turning



Car manoeuvre: Following bend
PTW manoeuvre: Following bend

Figure 3-55: GIDAS Accident Types – LC/SD

Initial Speed

Car (n = 2)

- Range: 45-75 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 65-70 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

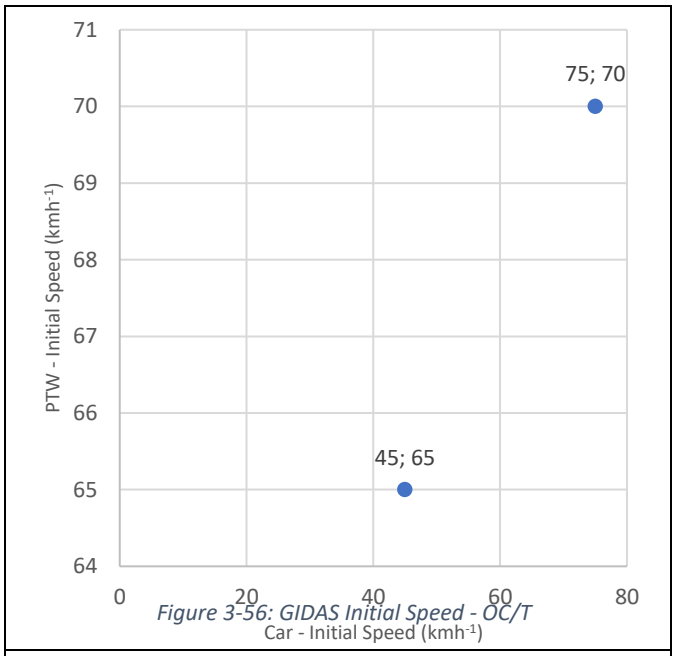


Figure 3-56: GIDAS Initial Speed - OC/T

Impact Speed

Car (n = 2)

- Range: 45-60 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 65 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

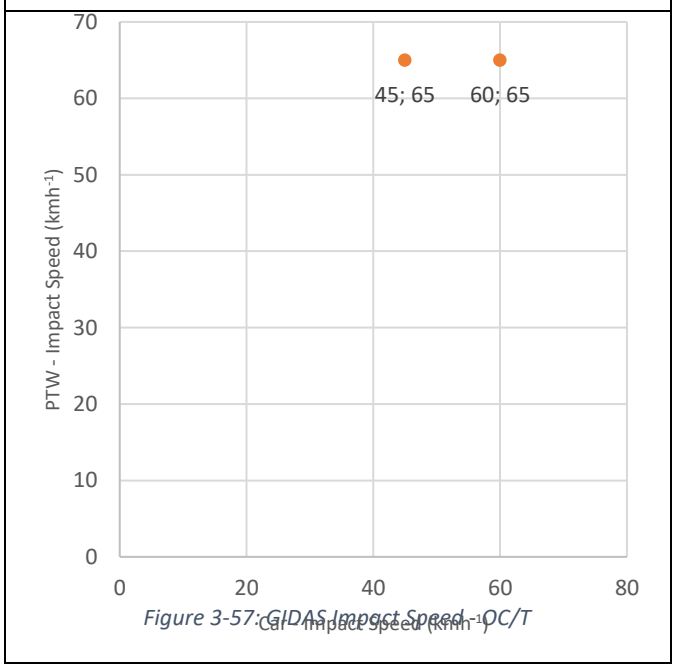
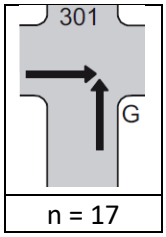


Figure 3-57: GIDAS Impact Speed - OC/T

3.3.2.6 Straight crossing path – Left direction



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead from the right

Figure 3-58: GIDAS Accident Types – LC/SD

Initial Speed

Car (n = 17)

- Range: 5-55 kmh^{-1}
- IQR: 5-20 kmh^{-1}
- Median: 15 kmh^{-1}

PTW (n = 17):

- Range: 20-90 kmh^{-1}
- IQR: 45-60 kmh^{-1}
- Median: 50 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

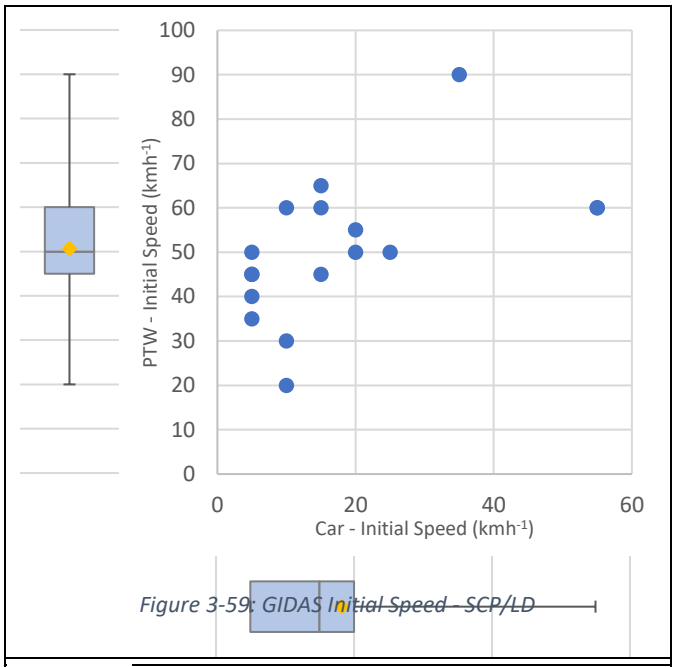


Figure 3-59: GIDAS Initial Speed - SCP/LD

Impact Speed

Car (n = 17)

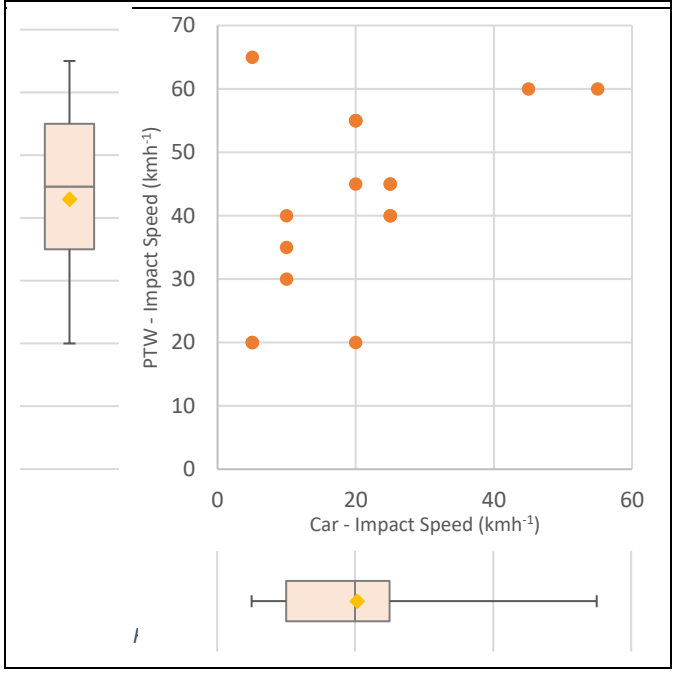
- Range: 5-55 kmh^{-1}
- IQR: 10-25 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 17):

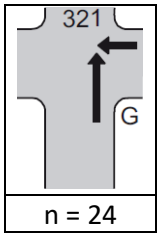
- Range: 20-65 kmh^{-1}
- IQR: 35-55 kmh^{-1}
- Median: 45 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



3.3.2.7 Straight crossing path – Right direction



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead from the right

Figure 3-62: GIDAS Accident Types – LC/SD

Initial Speed

Car (n = 23)

- Range: 5-75 kmh^{-1}
- IQR: 15-33 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 23):

- Range: 25-75 kmh^{-1}
- IQR: 35-48 kmh^{-1}
- Median: 45 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

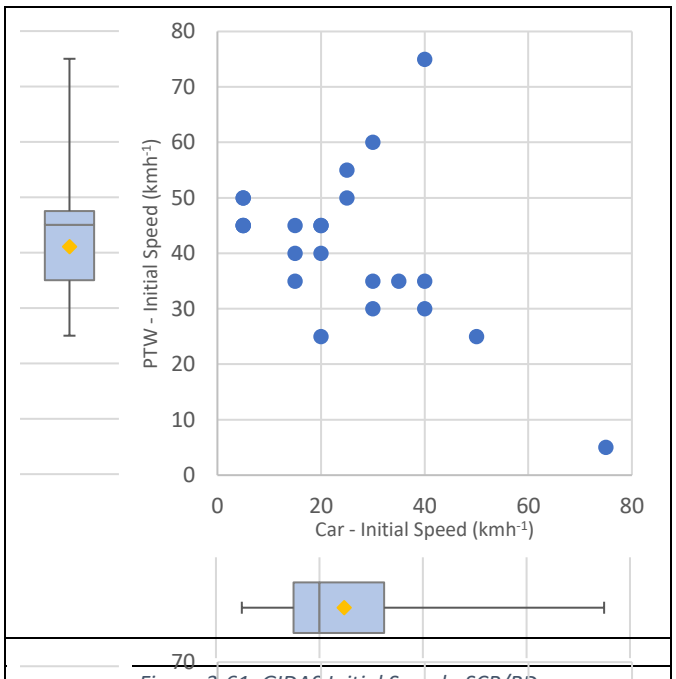


Figure 3-61: GIDAS Initial Speed - SCP/RD

Impact Speed

Car (n = 19)

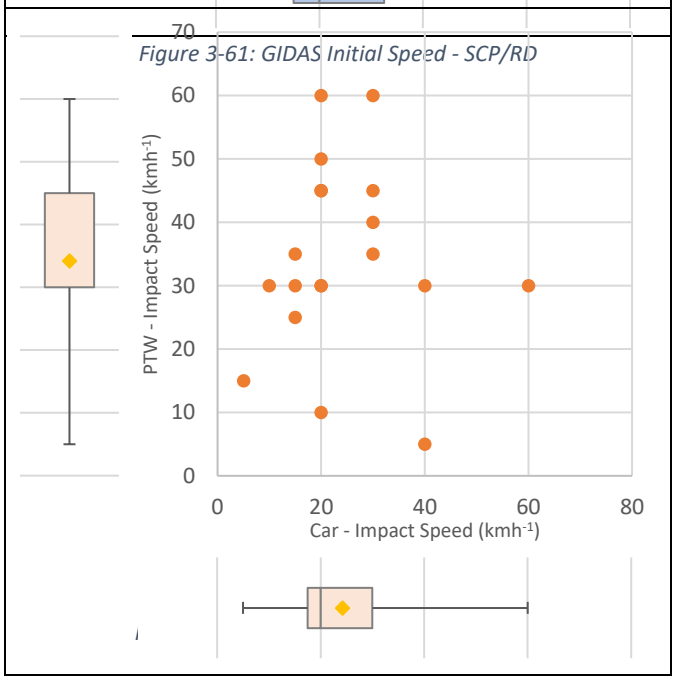
- Range: 5-60 kmh^{-1}
- IQR: 18-30 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 19):

- Range: 5-60 kmh^{-1}
- IQR: 30-45 kmh^{-1}
- Median: 30 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



3.4 Spain

3.4.1 National Data- DGT

In the period 2014 – 2015 there were 100,900 accidents, 11,900 of these involved a car and PTW of which 978 were KSI accidents, Figure 3-64 shows the distribution of these KSI accidents by the given accident type in the DGT dataset. Of the 18 accident types the list was restricted to 'Fronto lateral', 'Front to rear' and 'Side' for cluster analysis. The KSI percentages were normalised to this selection for calculating ranking percentages.

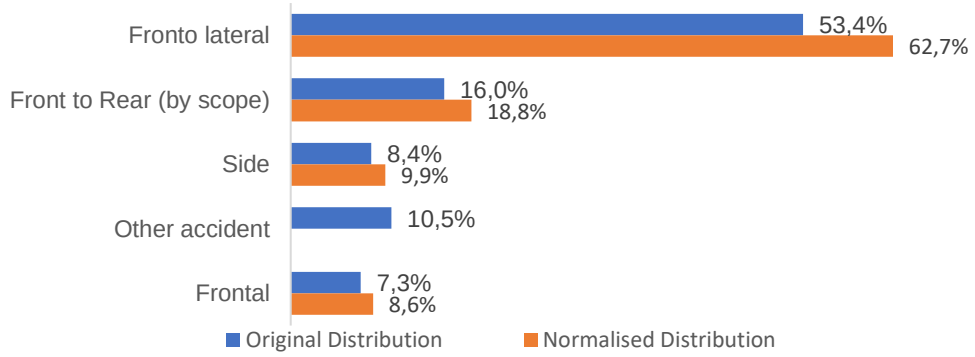
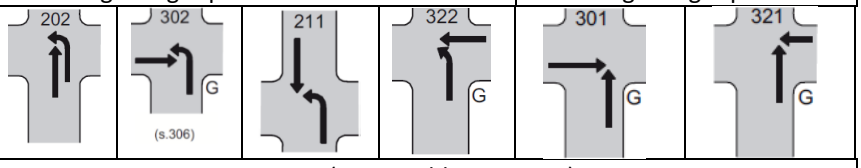


Figure 3-64: DGT KSI Accident Type Distribution

3.4.1.1 Frontal Lateral

Two clusters proportioned 41% and 60% represent Car to PTW junction accidents. Both clusters describe the car turning left across the path of the PTW and can be categorised into the accident groups of **Left Turn Across Path – Opposite Direction Conflict**, **Left Turn Across Path – Same Direction Conflict** and **Left Turn Across Path – Left Direction Conflict**. GDV codes **202**, **302** and **211** can be correlated to Cluster 1 based on the given information in the datasets. With both vehicle manoeuvres being 'Following straight path' and the high-level accident type front to side, it is inferred in the absence of any further information that Cluster 2 is best categorised into accident groups **Straight Crossing Path – Left Direction Conflict** and **Straight Crossing Path – Right Direction Conflict**, with GDV codes **301** and **321** respectively.

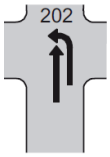
Table 3.4.1-1: DGT Cluster Analysis - Frontal Lateral

	Cluster #1 40,5%	Cluster #2 59,5%
Grouped Area	Urban Roads	Urban Roads
Road Type	Street	Street
Intersection	T junction	Does not apply
Car Manoeuvre	Turning or going to another road that is on the left	Following straight path
PTW Manoeuvre	Following straight path	Following straight path
Pictogram		
ASW	0.61 (Reasonable structure)	

3.4.1.2 Side

Two clusters proportioned 44% and 55% represent side impact conflicts. Based on the Average Silhouette Width value of 0.39, it is considered that these clusters have a weak structure that could be artificial and there is the potential anomaly in Cluster 2 of the car turning left not at junction however this could also be a left turn into a private drive or equivalent and not recorded as such in the data. Cluster 1 is best categorised as accident group **Parallel Driving** and GDV code **651**. Due to the car turning left and with a side conflict the accident group **Left Turn Across Path – Same Direction Conflict** and GDV code **202** best describe the potential scenario.

Table 3.4.1-2: DGT Cluster Analysis - Side

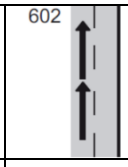
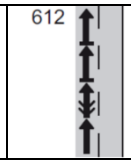
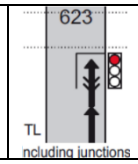
	Cluster #1 44,0%	Cluster #2 28,7%	Cluster #3 26,8%
Grouped Area	Urban roads	Urban roads	Urban roads
Road Type	Street	Street	Street
Intersection	Does not apply	In T or Y junction	Does not apply
Car Manoeuvre	Following straight path	Turning or going to another road that is on the left	Following straight path
PTW Manoeuvre	Following straight path	Following straight path	Overtaking the left
Pictogram	651 	202 	631 
ASW	0.39		

3.4.1.3 Front to Rear

Three clusters proportioned 63%, 31% and 6% represent front to rear impacts. It is only Cluster 3 where the scenario is such that the car is the ego vehicle going into the rear of the PTW, this is derived from the vehicle manoeuvres in absence of impact locations.

Table 3.4.1-3: DGT Cluster Analysis - Front to Rear

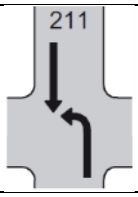
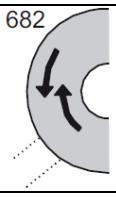
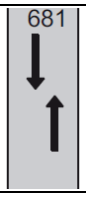
	Cluster #1 63,4%	Cluster #2 30,7%	Cluster #3 5,9%
Grouped Area	Interurban roads	Interurban roads	Urban roads
Road Type	Street	Street	Street
Intersection	Does not apply	Does not apply	Does not apply
Car Manoeuvre	Following straight path	Stopped due to traffic conditions	Following straight path
PTW Manoeuvre	Following straight path	Following straight path	Waiting on a priority signal/light

Pictogram			
ASW	0.60		

3.4.1.4 *Frontal*

Frontal categorised accident types are clustered into two distinct types Left Turn Across Path and On Coming. The identification of **Left Turn Across Path – Opposite Direction Conflict** GDV code 211 (35.1%) within the frontal accident type category shows a distinction in the relative positions and/or speeds of the car and motorcycle that result in a front to front, or a front to side impact as identified in Cluster #1 in Frontal Lateral accident types (**Erreur ! Source du renvoi introuvable.**). Cluster 2 (22.3%) and Cluster 3 (42.6%) are best categorised as **On Coming - Turning Conflict** GDV code **682** and **On Coming – Straight Driving Conflict** GDV code **681**.

Table 3.4.1-4: DGT Cluster Analysis – Frontal

	Cluster #1 35,1%	Cluster #2 22,3%	Cluster #3 42,6%
Grouped Area	Urban roads	Interurban roads	Interurban roads
Road Type	Street	Conventional route	Conventional route
Intersection	In T or Y junction	Does not apply	Does not apply
Car Manoeuvre	Turning or going to another road that is on the left	Taking right curve	Following straight path
PTW Manoeuvre	Following straight path	Taking left curve	Following straight path
Pictogram			
ASW	0.58		

3.4.2 In-Depth – DIANA

95 motorcycle accident cases were supplied by CIDAUT, 31 of these cases were car to motorcycle cases were the car was the at fault vehicle. GDV codes were applied to the cases based on the accident description. Initial and impact speeds.

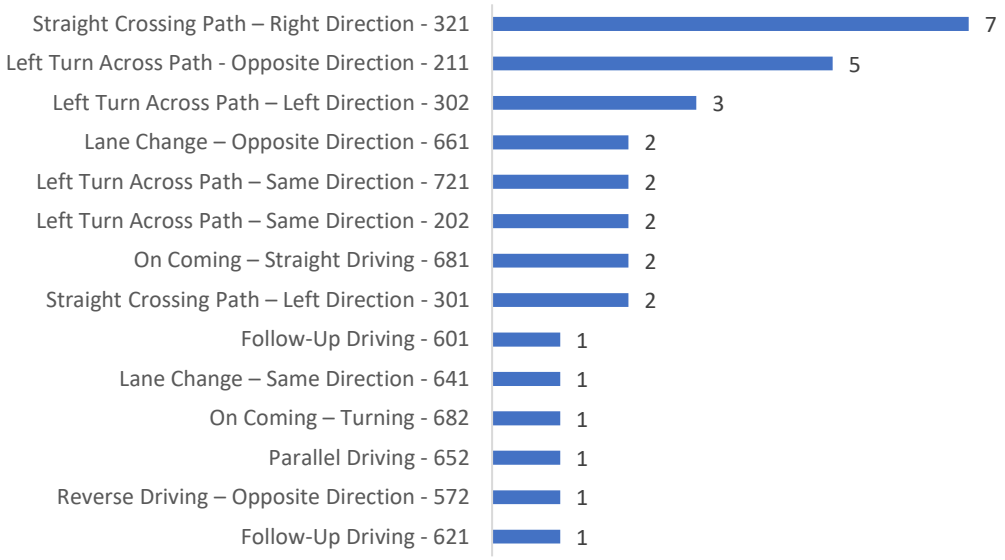
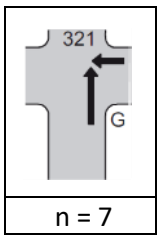


Figure 3-65: DIANA Accident Scenario Distribution

3.4.2.1 Straight Crossing Path – Right Direction



n = 7

Car Manoeuvre: Travelling straight ahead
PTW Manoeuvre: Travelling straight ahead from the right

Figure 3-66: DIANA Accident Types – SCP/RD

Initial Speed

Car (n = 4)

- Range: 25-110 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 3):

- Range: 10-60 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 25 kmh^{-1}
- PTW: (N/A)

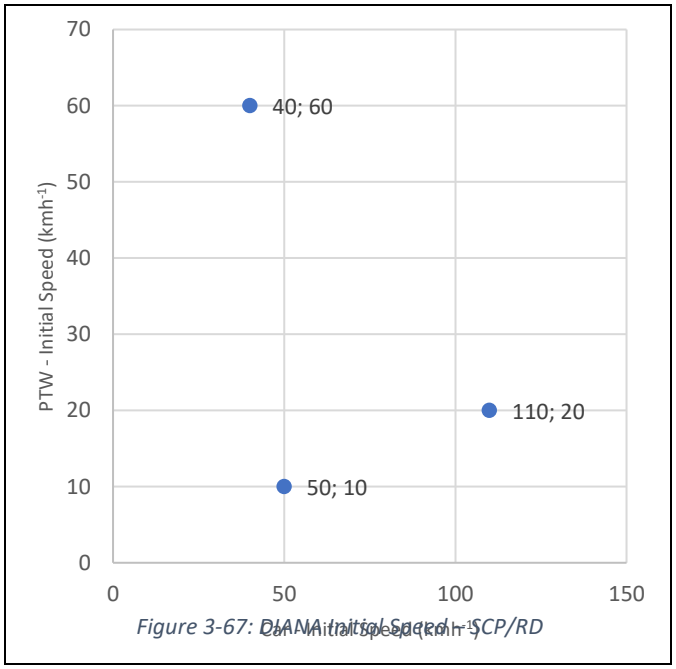


Figure 3-67: DIANA Initial Speed – SCP/RD

Impact Speed

Car (n = 4)

- Range: 20-87 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 4):

- Range: 10-95 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

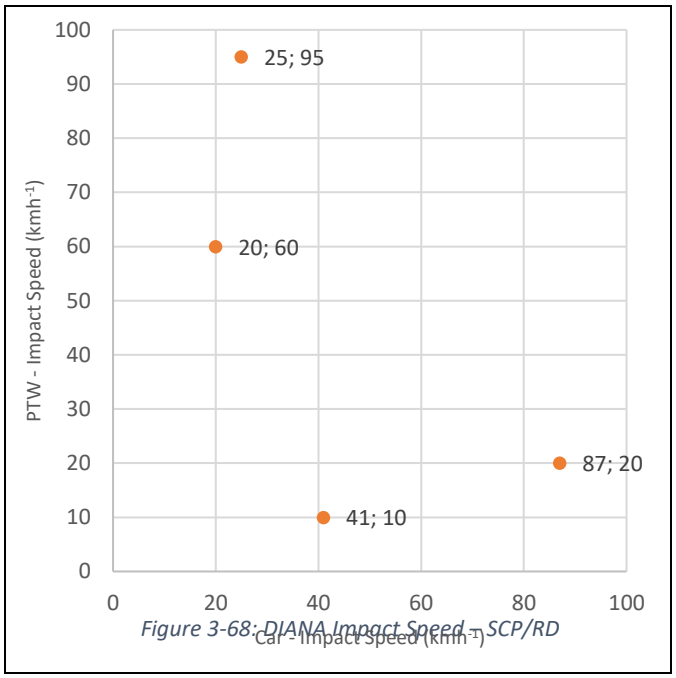
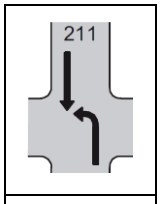


Figure 3-68: DIANA Impact Speed - SCP/RD

3.4.2.2 Left Turn Across Path – Opposite Direction



n = 5

Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead

Figure 3-69: DIANA Accident Type - LTAP/OD

Initial Speed

Car (n = 4)

- Range: 8-40 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 5):

- Range: 50-105 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: 65 kmh^{-1}

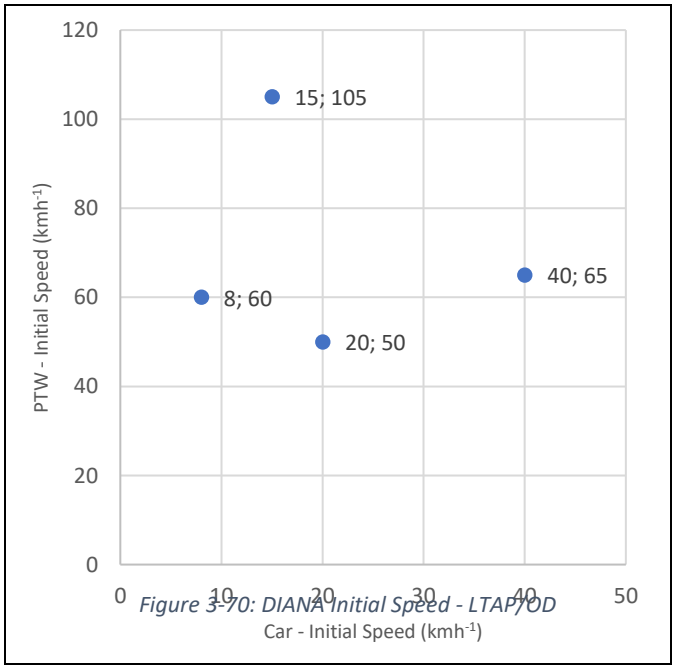


Figure 3-70: DIANA Initial Speed - LTAP/OD

Impact Speed

Car (n = 5)

- Range: 8-39 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 5):

- Range: 40-85 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

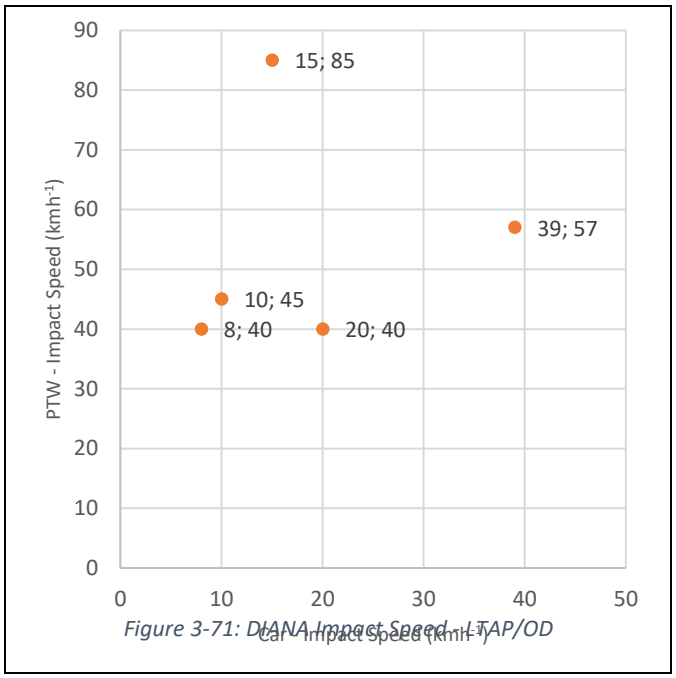
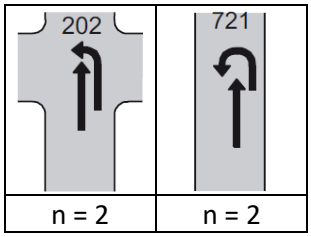


Figure 3-71: DIANA Impact Speed - LTAP/OD

3.4.2.3 *Left Turn Across Path – Same Direction*



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead

Figure 3-72: DIANA Accident Types - LTAP/SD

Initial Speed

Car (n = 3)

- Range: 10-30 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 3):

- Range: 25 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

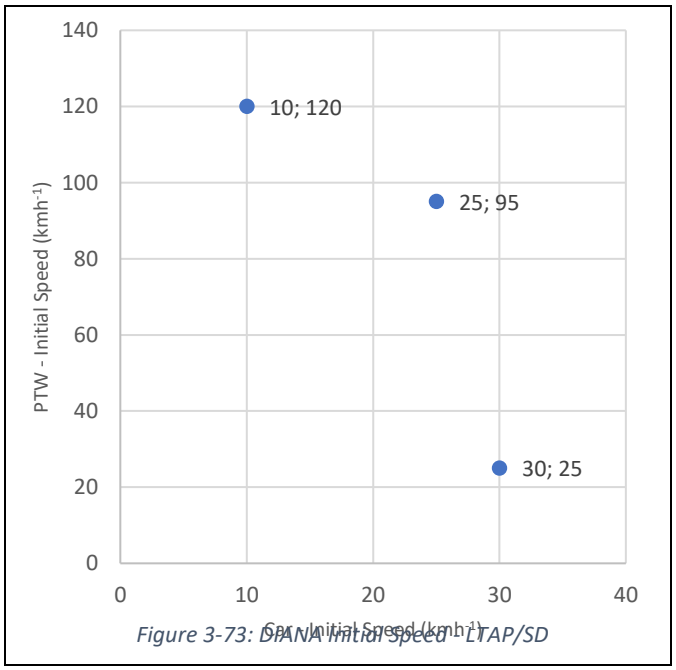


Figure 3-73: DIANA Initial Speed - LTAP/SD

Impact Speed

Car (n = 3)

- Range: 10-30 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 3):

- Range: 20-105 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

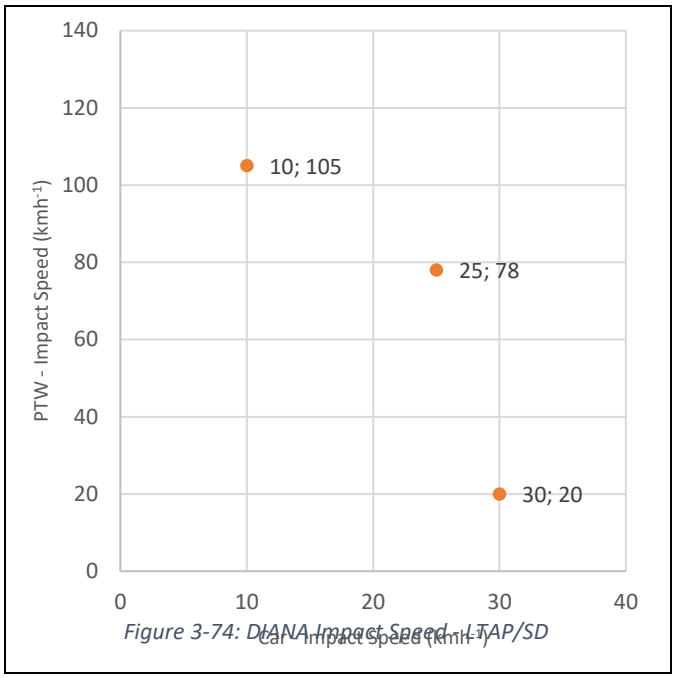
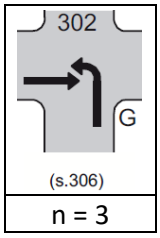


Figure 3-74: DIANA Impact Speed - LTAP/SD

3.4.2.4 *Left Turn Across Path – Left Direction*



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead from the left

Figure 3-75: DIANA Accident Types - LTAP/LD

Initial Speed

Car (n = 2)

- Range: 15 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 50-95 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

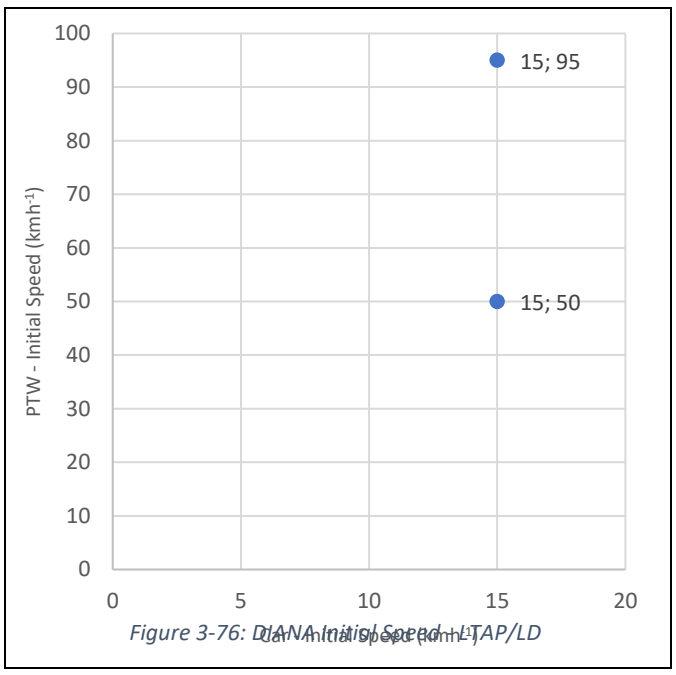


Figure 3-76: DIANA Initial Speed - LTAP/LD

Impact Speed

Car (n = 2)

- Range: 15 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 40-60 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

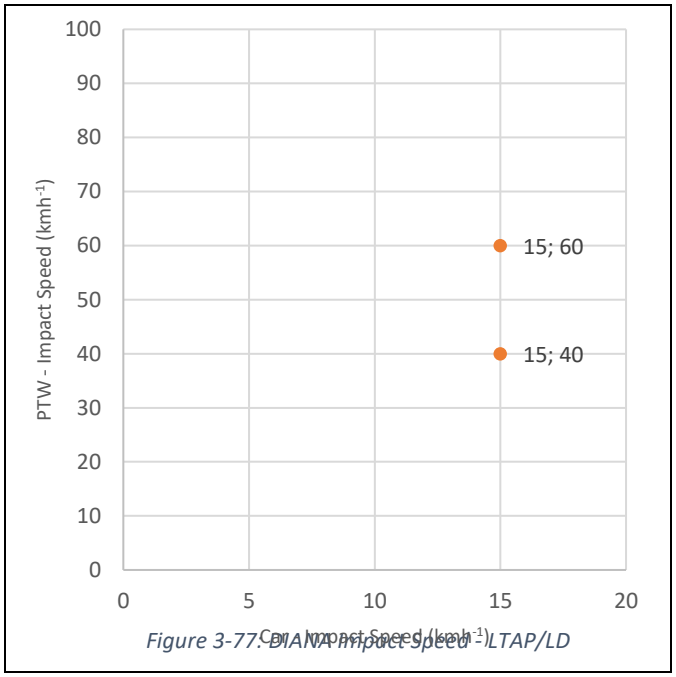
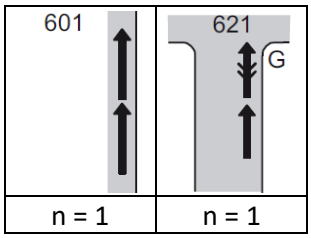


Figure 3-77: DIANA Impact Speed - LTAP/LD

3.4.2.5 Follow-Up Driving



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead– moving, slowing or stationary

Figure 3-78: DIANA Accident Types - FUD

Initial Speed

Car (n = 1)

- Range: 105 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 65 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

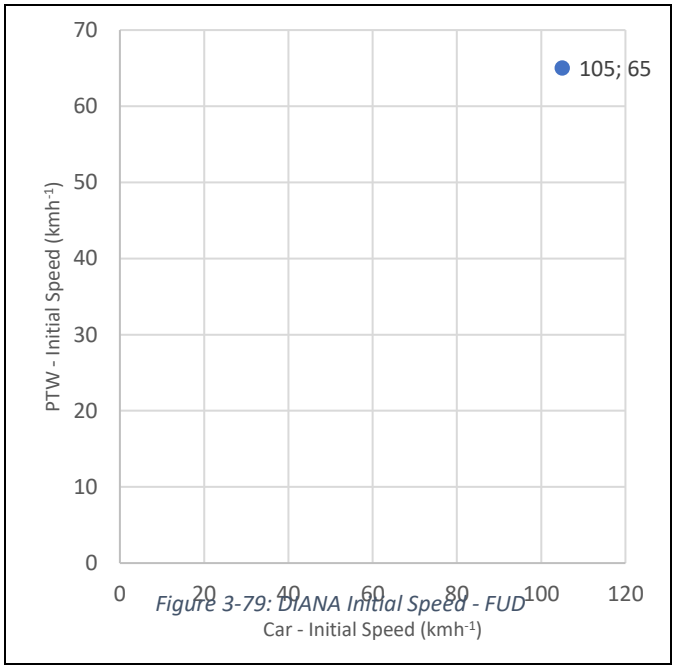


Figure 3-79: DIANA Initial Speed - FUD

Impact Speed

Car (n = 1)

- Range: 91 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 65 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

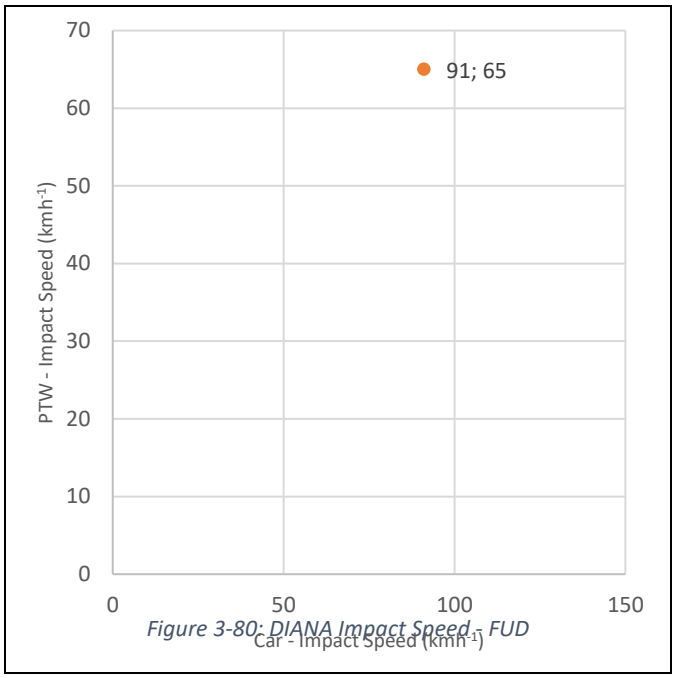
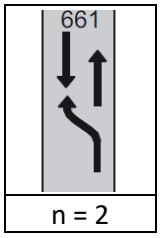


Figure 3-80: DIANA Impact Speed - FUD

3.4.2.6 Lane Change – Opposite Direction



Car manoeuvre: Overtaking
PTW manoeuvre: Travelling straight ahead

Figure 3-81: DIANA Accident Types - LC/OD

Initial Speed

Car (n = 1)

- Range: 105 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 100 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

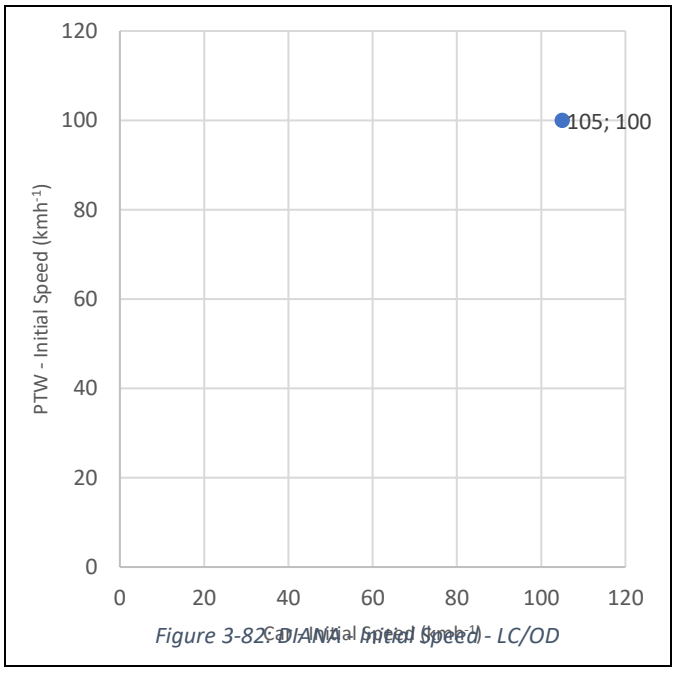


Figure 3-82: DIANA - Initial Speed - LC/OD

Impact Speed

Car (n = 1)

- Range: 95 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 100 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

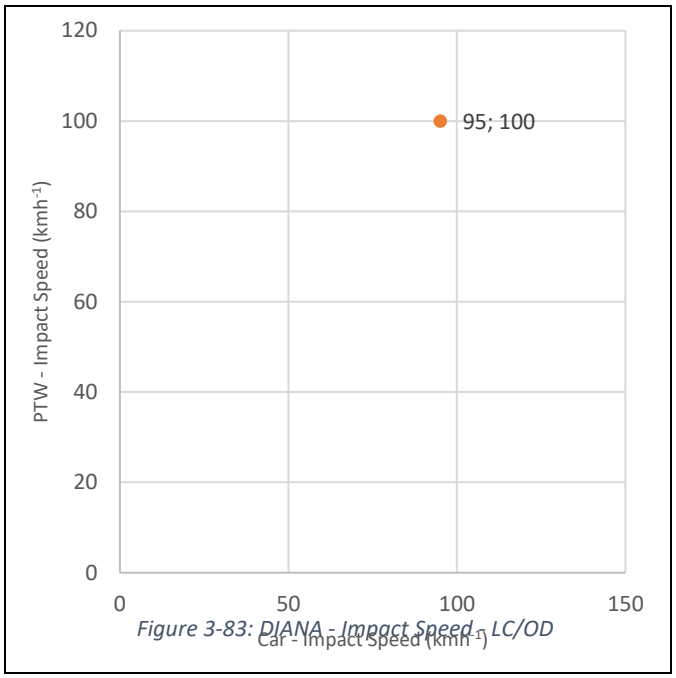
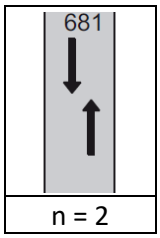


Figure 3-83: DIANA - Impact Speed - LC/OD

3.4.2.7 On Coming – Straight Driving



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead

Figure 3-84: DIANA Accident Types - OC/SD

Initial Speed

Car (n = 2)

- Range: 130-150 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 90-100 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

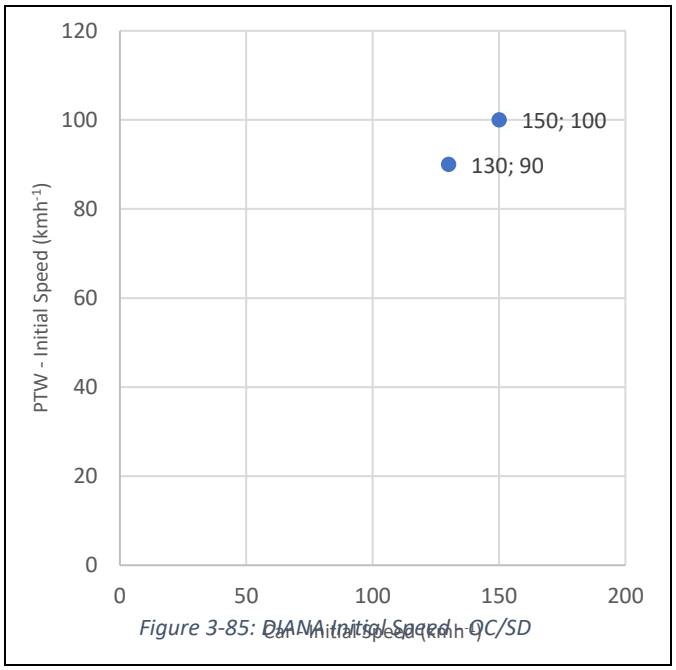


Figure 3-85: DIANA - Initial Speed - OC/SD

Impact Speed

Car (n = 2)

- Range: 120-150 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 60-70 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

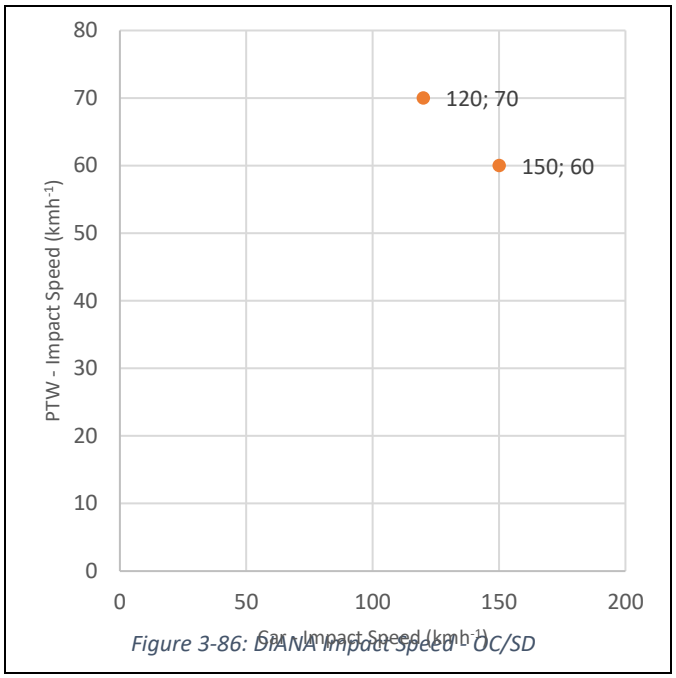
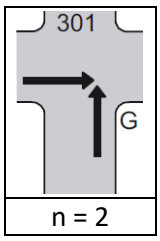


Figure 3-86: DIANA Impact Speed - OC/SD

3.4.2.8 Straight Crossing Path – Left Direction



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead from the left

Figure 3-87: DIANA Accident Types - SCP/LD

Initial Speed

Car (n = x)

- Range: 15-90 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = x):

- Range: 42-55 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

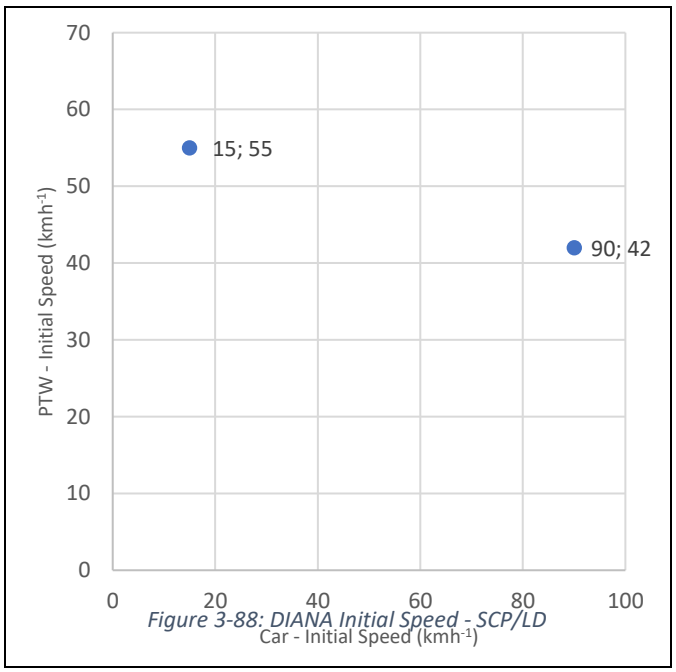


Figure 3-88: DIANA Initial Speed - SCP/LD

Impact Speed

Car (n = 2)

- Range: 35-42 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 15-60 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

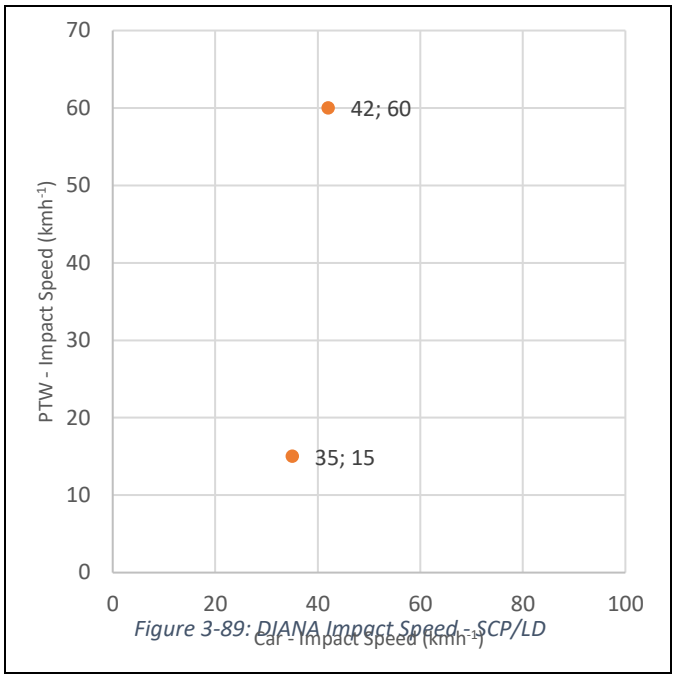
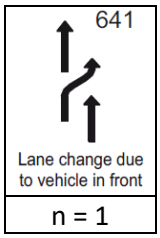


Figure 3-89: DIANA Impact Speed - SCP/LD

3.4.2.9 *Lane Change – Same Direction*



Car manoeuvre: Changing lane
PTW manoeuvre: Travelling straight ahead

Figure 3-90: DIANA Accident Types - LC/SD

Initial Speed

Car (n = 1)

- Range: 60 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 65 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

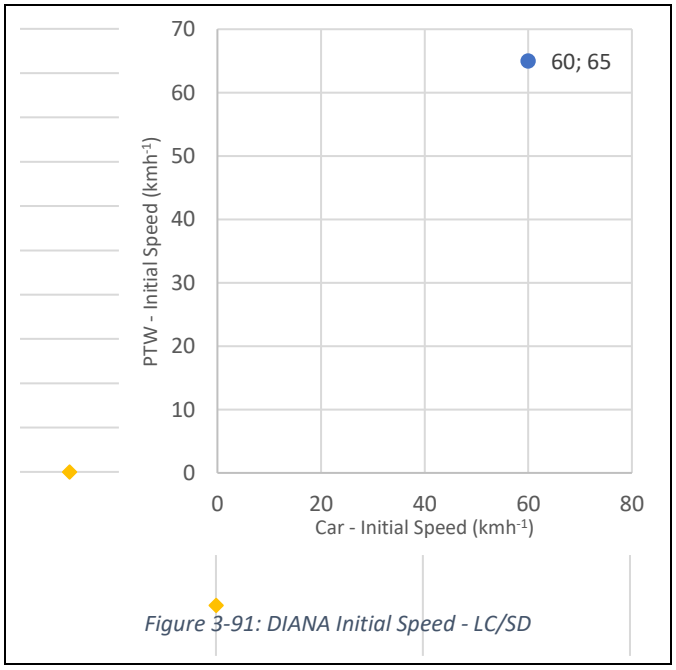


Figure 3-91: DIANA Initial Speed - LC/SD

Impact Speed

Car (n = x)

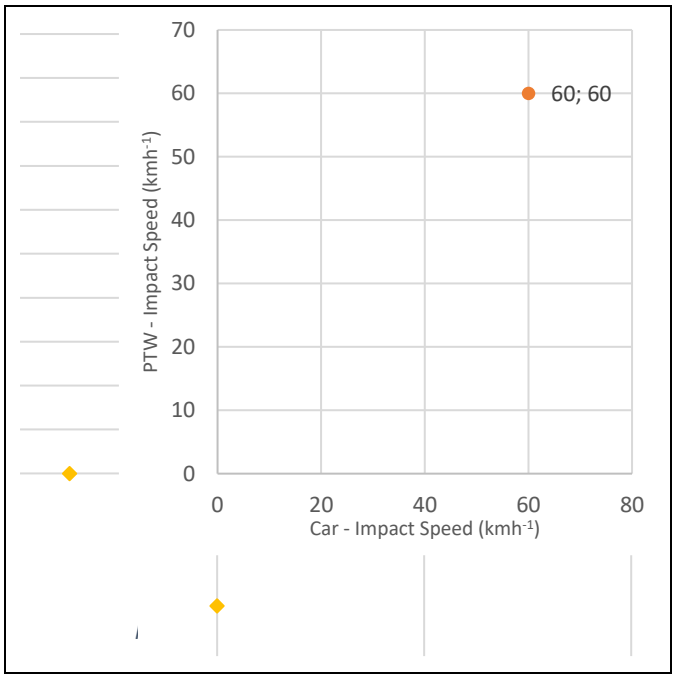
- Range: x-x kmh^{-1}
- IQR: x-x kmh^{-1}
- Median: x kmh^{-1}

PTW (n = x):

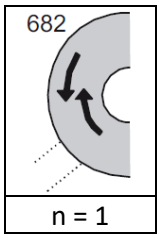
- Range: x-x kmh^{-1}
- IQR: x-x kmh^{-1}
- Median: x kmh^{-1}

Unpaired Car and PTW cases:

- Car: x and x kmh^{-1}
- PTW: (N/A)



3.4.2.10 On Coming - Turning



Car manoeuvre: Following bend
PTW manoeuvre: Following bend

Figure 3-93: DIANA Accident Types - OC/.T

Initial Speed

Car (n = 1)

- Range: 90 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 80 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

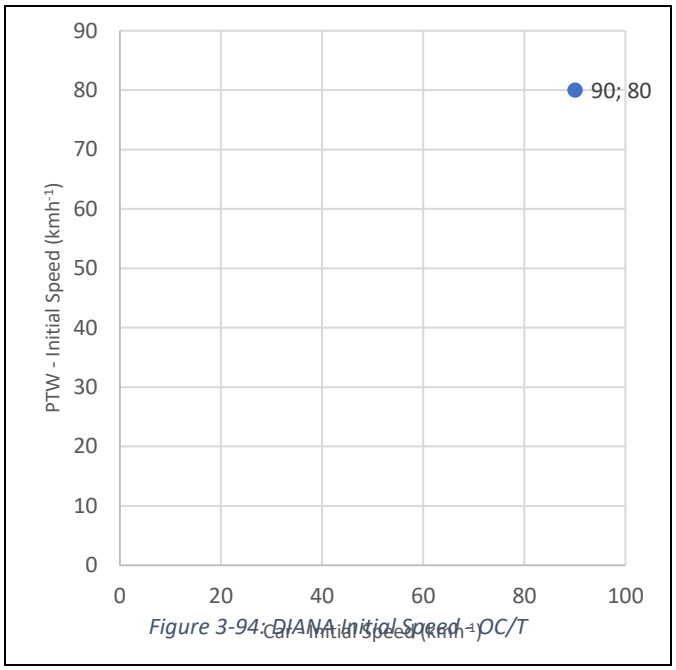


Figure 3-94: DIANA Initial Speed - OC/T

Impact Speed

Car (n = 1)

- Range: 70 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 65 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

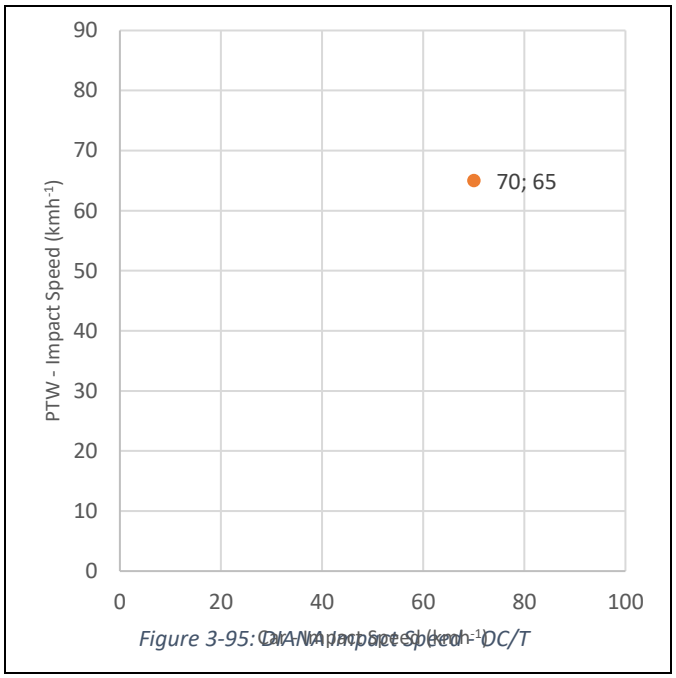
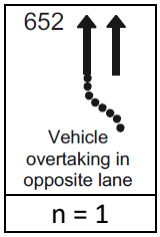


Figure 3-95: DIANA Impact Speed - DC/T

3.4.2.11 Parallel Driving



Car manoeuvre: Travelling straight ahead

PTW manoeuvre: Travelling straight ahead

Figure 3-96: DIANA Accident Types - PD

Initial Speed

Car (n = 1)

- Range: 85 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 155 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

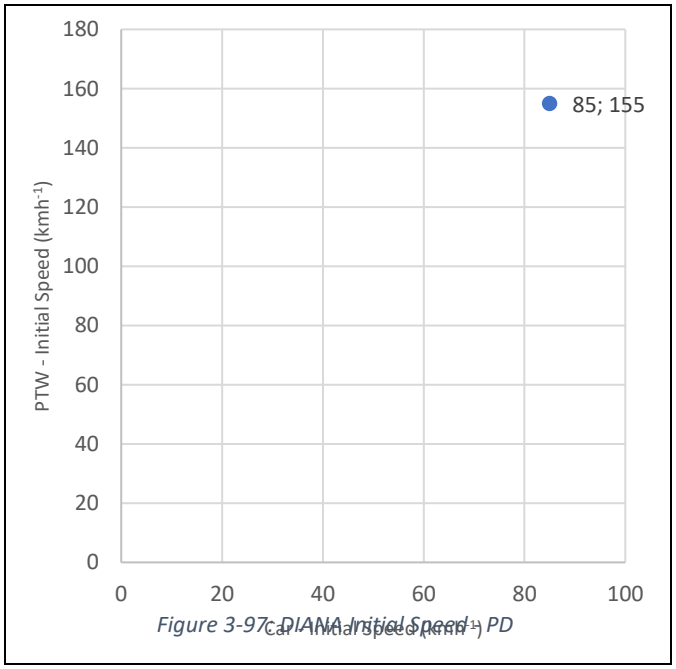


Figure 3-97: DIANA Initial Speed - PD

Impact Speed

Car (n = 1)

- Range: 85 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 155 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

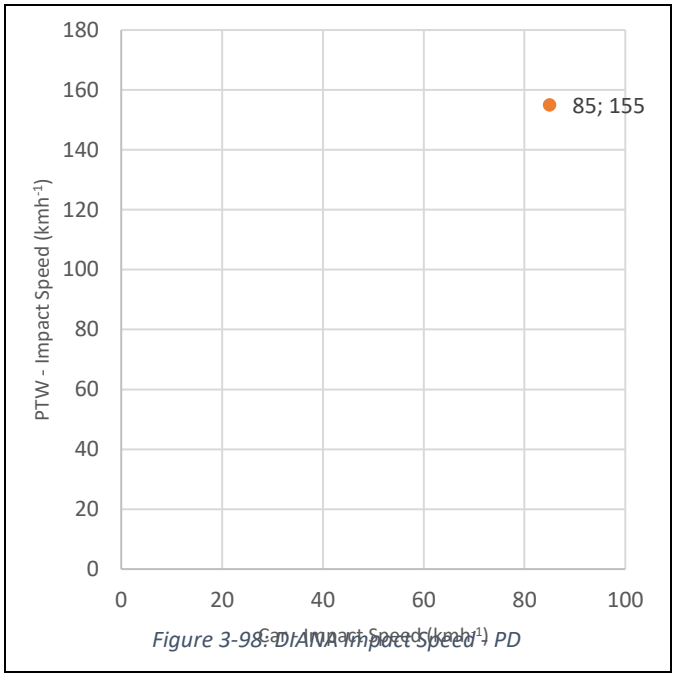
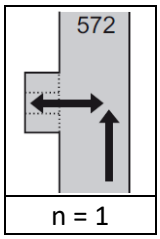


Figure 3-98: DIANA Impact Speed - PD

3.4.2.12 Reverse Driving – Opposite Direction



Car manoeuvre: Reversing
PTW manoeuvre: Travelling straight ahead

Figure 3-99: DIANA Accident Types RD/OD

Initial Speed

Car (n = 1)

- Range: 10 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 120 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

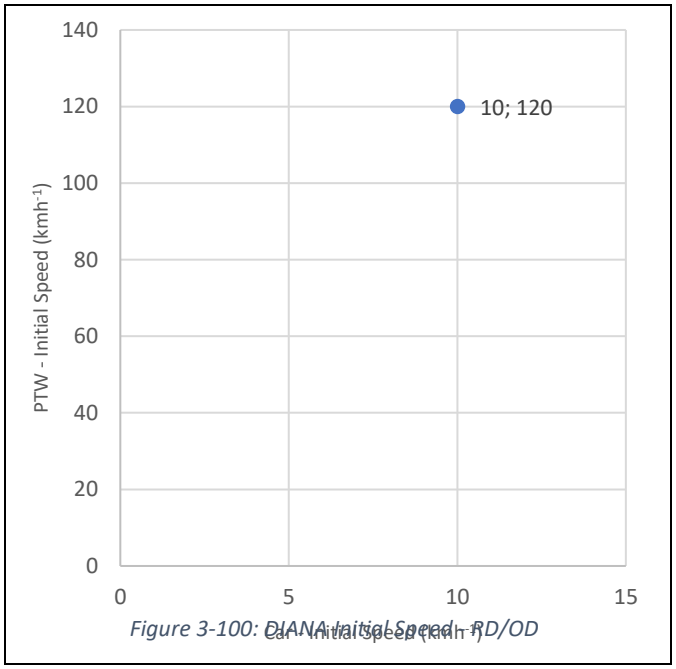


Figure 3-100: DIANA Initial Speed - RD/OD

Impact Speed

Car (n = 1)

- Range: 10 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 103 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

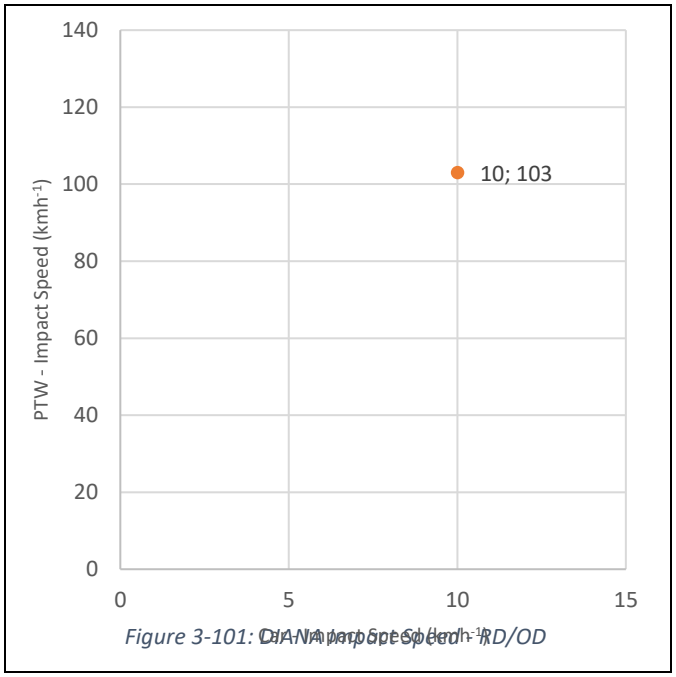


Figure 3-101: CARNAP Impact Speed - RD/OD

3.5 United Kingdom

3.5.1 National Data – STATS19

For the analysis period 2014-16 there are 256,073 accidents involving two vehicles, 31,769 of these involved a car and PTW of which 8,179 were KSI accidents. Figure [] shows the distribution of these KSI accidents by high-level accident type. Note that due to no accident type recording in STATS19 these are subjective categories derived from vehicle manoeuvres, impact points and road details (state the exact variables used here – i.e. junction detail, if fact use the correct variable references)..

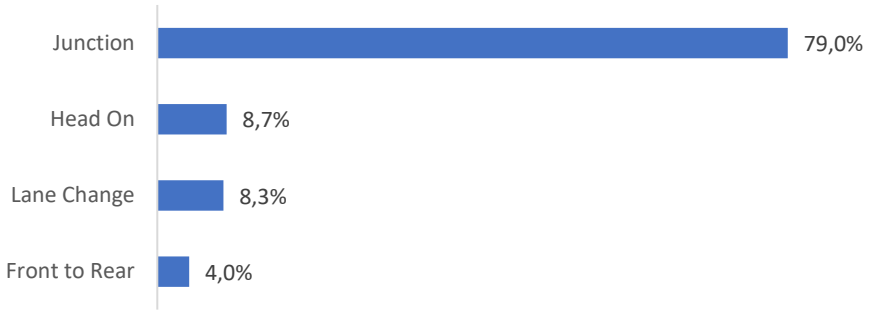


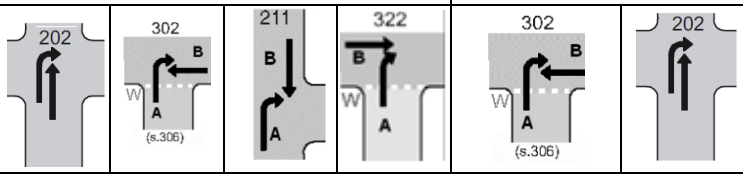
Figure 3-102: STATS19 High-level accident type distribution

3.5.1.1 Junction Accidents

Both clusters describe the car turning right across the path of the PTW and can be categorised into the left-hand drive equivalent accident groups of **Left Turn Across Path – Opposite Direction Conflict**, **Left Turn Across Path – Same Direction Conflict** and **Left Turn Across Path – Left Direction Conflict**. GDV codes **202**, **302**, **211** and **322** can be correlated to cluster 1 and **302** and **202** to cluster 2. The application of multiple GDV codes to the clusters is due to a lack of an accident description in STATS19 which can lead to some ambiguity were a few accident permutations could exist based on manoeuvre and impact point alone. The difference in impact point of the car, front vs. offside, potentially signifies that in the lower speed limit road the car is only partially in the path of the PTW/beginning the turn

right manoeuvre whereas the offside impact point suggests that the car is further into the path of the PTW.

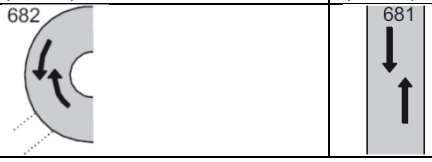
Table 3.5.1-1: UK National data - KSI Junction accident clusters

	Cluster #1 69,2%	Cluster #2 30,8%
Road Type	Single carriageway	Single carriageway
Speed Limit	30mph (≈ 50kmh)	60mph (≈ 100kmh)
Junction Detail	T or staggered junction	T or staggered junction
Car Manoeuvre	Turning right	Turning right
PTW Manoeuvre	Going ahead other	Going ahead other
Car Impact Point	Front	Offside
PTW Impact Point	Front	Front
Pictogram		
ASW	0.61 (Reasonable structure)	

3.5.1.2 Head-On Accidents

Cluster 1 can be categorised into the accident group **On Coming – Turning**, GDV code **682** and Cluster 2 can be categorised into the accident group **On Coming – Straight Driving**, GDV code **681**. There is no indication of fault from the respective vehicle manoeuvres or impact point. Based on the accident descriptions in RAIDS and OTS for On Coming accidents typically it is a loss of control from the PTW rider causing them to enter the opposite lane.

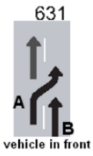
Table 3.5.1-2: UK National data – KSI Head-On accident clusters

	Cluster #1 46,3%	Cluster #2 53,7%
Road Type	Single carriageway	Single carriageway
Speed Limit	60mph (≈ 100kmh)	30mph (≈ 50kmh)
Junction Detail	(Not at a junction)	(Not at a junction)
Car Manoeuvre	Going ahead right-hand bend	Going ahead other
PTW Manoeuvre	Going ahead left-hand bend	Going ahead other
Car Impact Point	(Front)	(Front)
PTW Impact Point	(Front)	(Front)
Pictogram		
ASW	0.67 (Reasonable structure)	

3.5.1.3 Lane Change

Both clusters can be categorised into the accident group **Lane Change – Same Direction Conflict**, GDV code **631** however there is the distinction between clusters in the likely travel speed based on road type and speed limit.

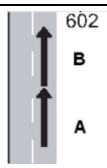
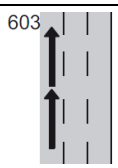
Table 3.5.1-3: UK National data – KSI Lane change accident clusters

	Cluster #1 64,3%	Cluster #2 35,7%
Road Type	Single carriageway	Dual carriageway
Speed Limit	30mph	70mph
Junction Detail	Not at a junction or within 20 metres	Not at a junction or within 20 metres
Car Manoeuvre	Changing lane to right	Overtaking moving vehicle – offside
PTW Manoeuvre	Going ahead other	Going ahead other
Car Impact Point	Offside	Offside
PTW Impact Point	Front	Front
Pictogram		
ASW	0.53 (Reasonable)	

3.5.1.4 Front to Rear

Both clusters can be categorised into the accident group **Follow-up Driving**, GDV code **602** and **603** – rear impact with a moving vehicle.

Table 3.5.1-4: UK National data – KSI Front to rear accident clusters

	Cluster #1 70,5%	Cluster #2 29,5%
Road Type	Single carriageway	Dual carriageway
Speed Limit	30mph	60mph
Junction Detail	T or staggered junction	Not at a junction or within 20 metres
Car Manoeuvre	Going ahead other	Going ahead other
PTW Manoeuvre	Going ahead other	Going ahead other
Car Impact Point	(Front)	(Front)
PTW Impact Point	(Back)	(Back)
Pictogram		
ASW	0.54 (Reasonable)	

3.5.2 In-Depth – RAIDS and OTS

There are 97 and 133 car and motorcycle cases in RAIDS and OTS respectively, in the RAIDS database PTWs are recorded and classified by the engine capacity (Figure 3-103) in OTS PTWs are only classified into one category 'Motorcycles'. So that the sample size is not restricted through the omission of unknown PTW types all cases have been used in the analysis. GDV codes were applied to the RAIDS and OTS cases based on the accident investigator description of the accident.

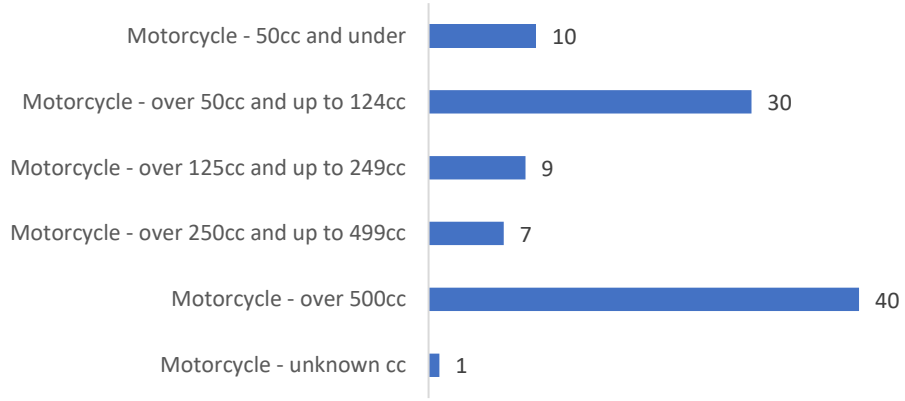


Figure 3-103: RAIDS PTW distribution by engine capacity

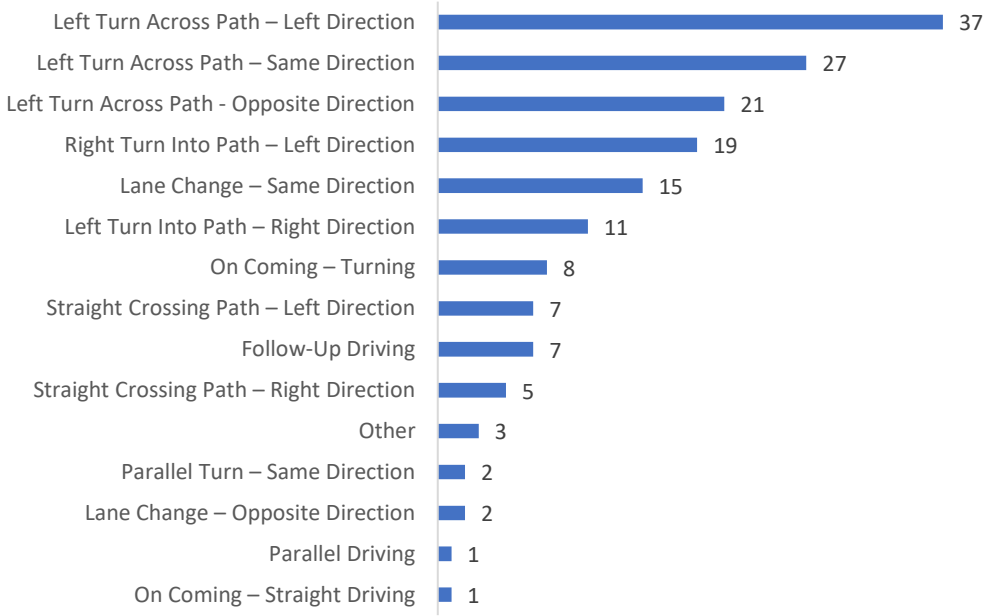
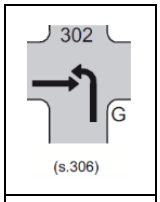


Figure 3-104: RAIDS Accident Group distribution

3.5.2.1 Left Turn Across Path – Left Direction



n = 22

Car Manoeuvre: Turning left
PTW Manoeuvre: Travelling straight ahead

Figure 3-105: RAIDS/OTS Accident Types – LTAP/LD

Initial Speed

Car (n = 14)

- Range: 0-24 kmh^{-1}
- IQR: 8-8 kmh^{-1}
- Median: 8 kmh^{-1}

PTW (n = 12):

- Range: 32-97 kmh^{-1}
- IQR: 48-56 kmh^{-1}
- Median: 48 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 0, 8 kmh^{-1}
- PTW: (N/A)

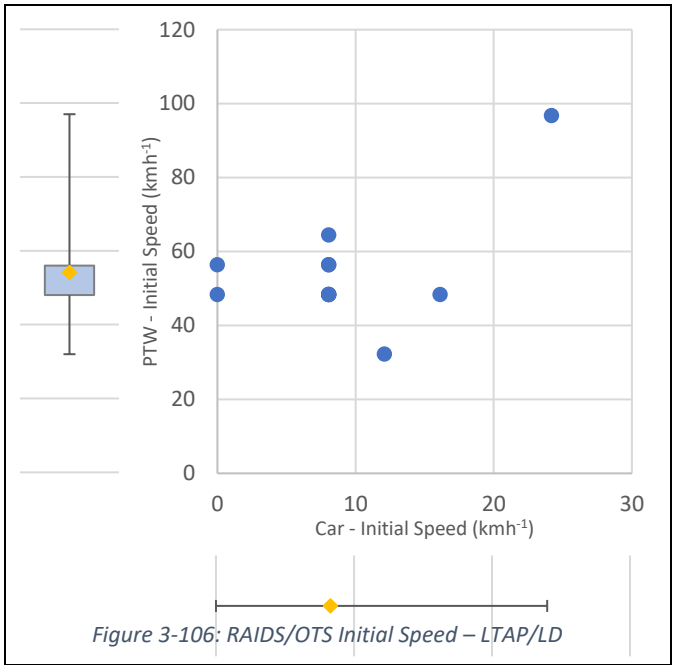


Figure 3-106: RAIDS/OTS Initial Speed – LTAP/LD

Impact Speed

Car (n = 15)

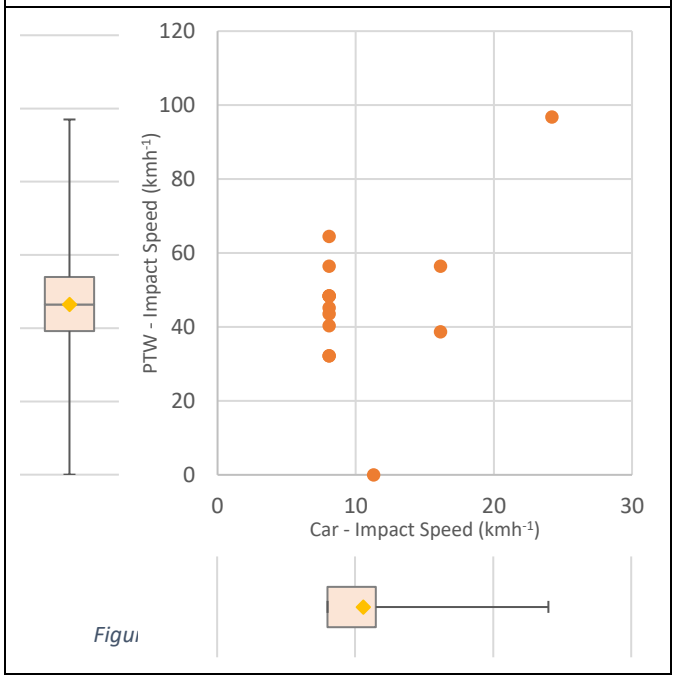
- Range: 8-24 kmh^{-1}
- IQR: 8-12 kmh^{-1}
- Median: 8 kmh^{-1}

PTW (n = 14):

- Range: 0-97 kmh^{-1}
- IQR: 39-54 kmh^{-1}
- Median: 47 kmh^{-1}

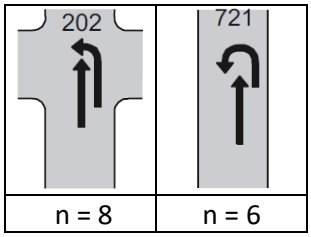
Unpaired Car and PTW cases:

- Car: 12 kmh^{-1}
- PTW: (N/A)



Figu

3.5.2.2 Left Turn Across Path – Same Direction



Car Manoeuvre: Turning left
PTW Manoeuvre: Travelling straight ahead from behind

Figure 3-108: RAIDS/OTS Accident Types – LTAP/SD

Initial Speed

Car (n = 12)

- Range: 0-16 kmh^{-1}
- IQR: 2-9 kmh^{-1}
- Median: 8 kmh^{-1}

PTW (n = 8):

- Range: 24-113 kmh^{-1}
- IQR: 46-54 kmh^{-1}
- Median: 48 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 0, 3, 8, 13, 16 kmh^{-1}
- PTW: 48 kmh^{-1}

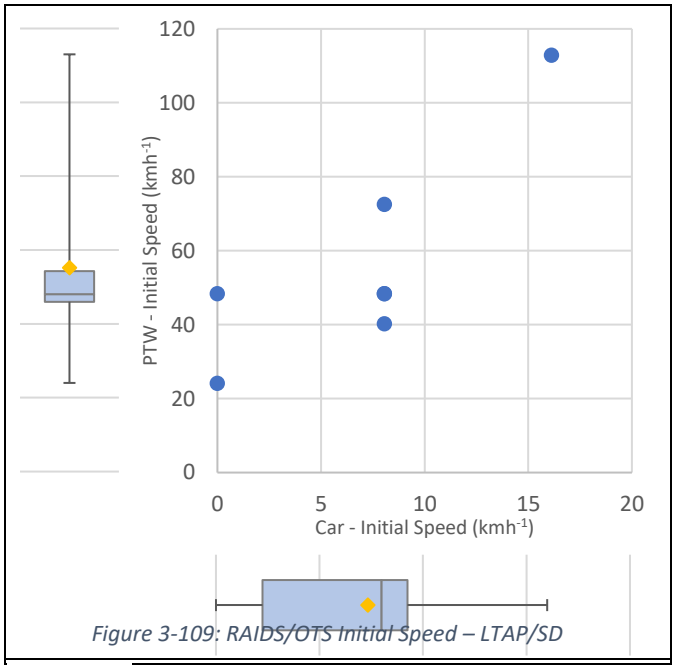


Figure 3-109: RAIDS/OTS Initial Speed – LTAP/SD

Impact Speed

Car (n = 12)

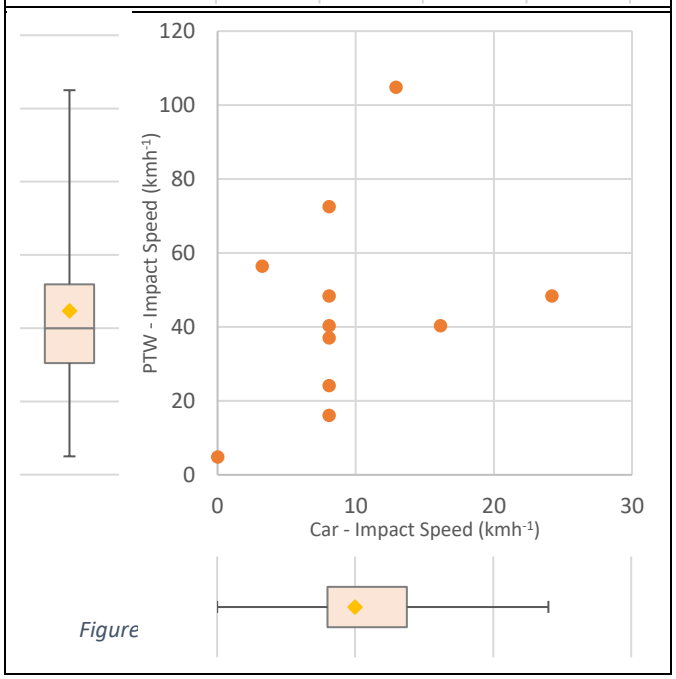
- Range: 0-24 kmh^{-1}
- IQR: 8-14 kmh^{-1}
- Median: 8 kmh^{-1}

PTW (n = 11):

- Range: 5-105 kmh^{-1}
- IQR: 31-52 kmh^{-1}
- Median: 40 kmh^{-1}

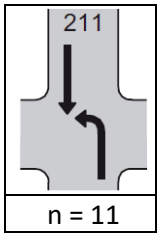
Unpaired Car and PTW cases:

- Car: 16 kmh^{-1}
- PTW: (N/A)



Figure

3.5.2.3 *Left Turn Across Path – Opposite Direction*



Car Manoeuvre: Turning left
PTW Manoeuvre: Travelling straight ahead

Figure 3-111: RAIDS/OTS Accident Types – LTAP/OD

Initial Speed

Car (n = 7):

- Range: 0-32 kmh^{-1}
- IQR: 4-20 kmh^{-1}
- Median: 8 kmh^{-1}

PTW (n = 5):

- Range: 29-80 kmh^{-1}
- IQR: 48-64 kmh^{-1}
- Median: 48 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 24 kmh^{-1}
- PTW: (N/A)

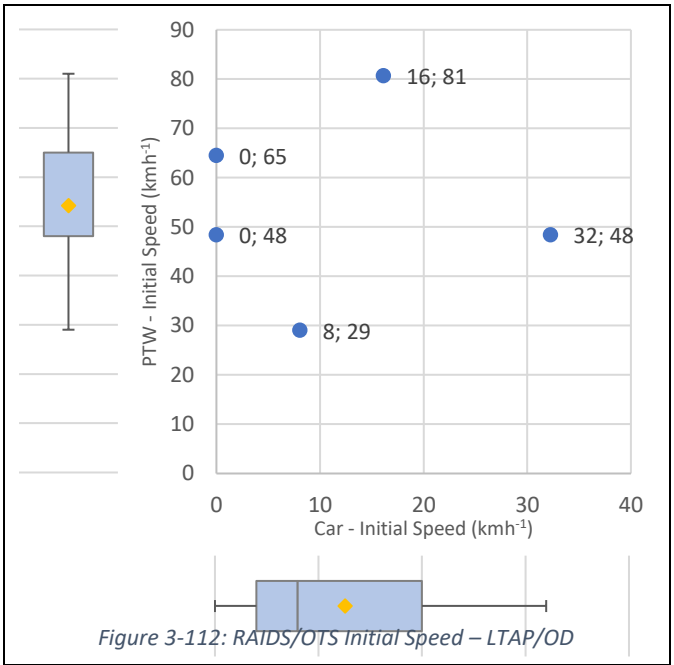


Figure 3-112: RAIDS/OTS Initial Speed – LTAP/OD

Impact Speed

Car (n = 6):

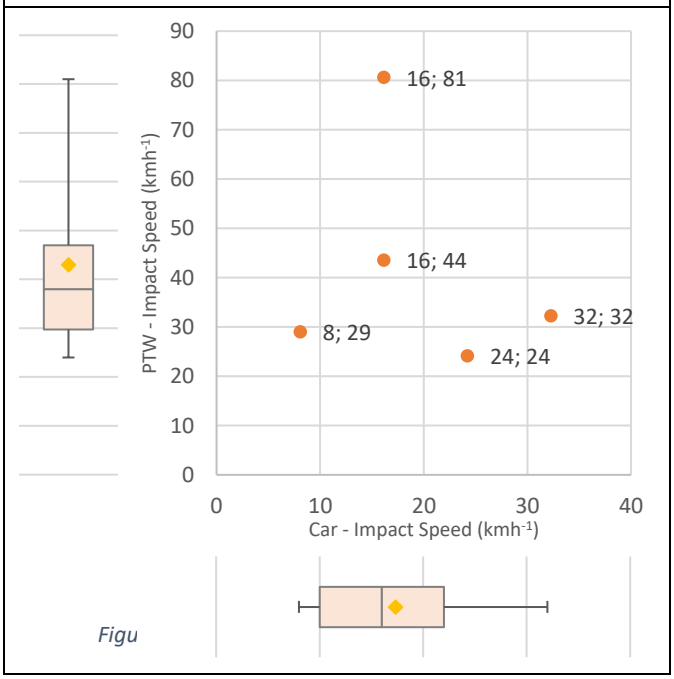
- Range: 8-32 kmh^{-1}
- IQR: 10-22 kmh^{-1}
- Median: 16 kmh^{-1}

PTW (n = 6):

- Range: 24-80 kmh^{-1}
- IQR: 30-47 kmh^{-1}
- Median: 38 kmh^{-1}

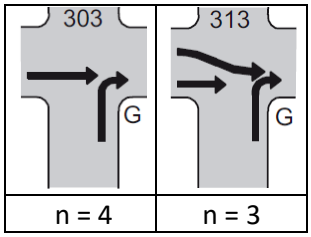
Unpaired Car and PTW cases:

- Car: 8 kmh^{-1}
- PTW: 48 kmh^{-1}



Figu

3.5.2.4 Right Turn Into Path – Left Direction



Car Manoeuvre: Turning right
PTW Manoeuvre: Travelling straight ahead

Figure 3-114: RAIDS/OTS Accident Types – RTIP/LD

Initial Speed

Car (n = 4)

- Range: 0-8 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 0-40 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 0, 8 kmh^{-1}
- PTW: (N/A)

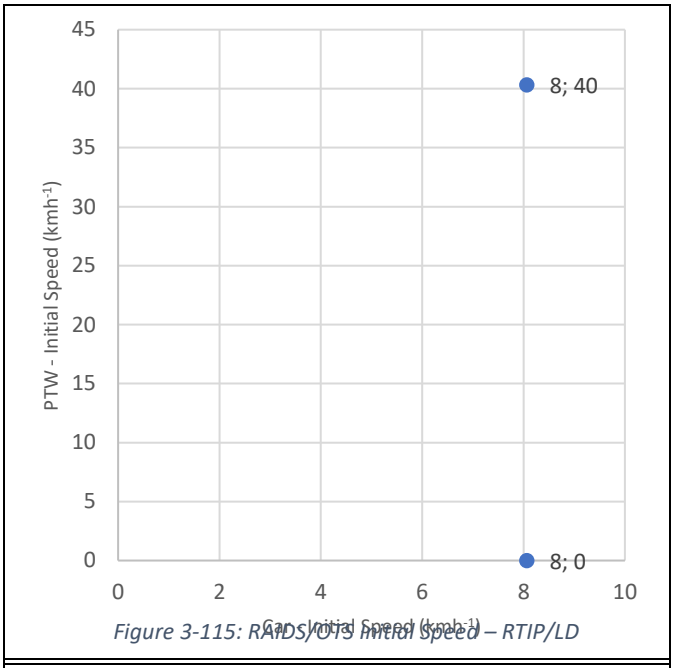


Figure 3-115: RAIDS/OTS Initial Speed – RTIP/LD

Impact Speed

Car (n = 5)

- Range: 5-24 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 4):

- Range: 21-58 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 8 kmh^{-1}
- PTW: (N/A)

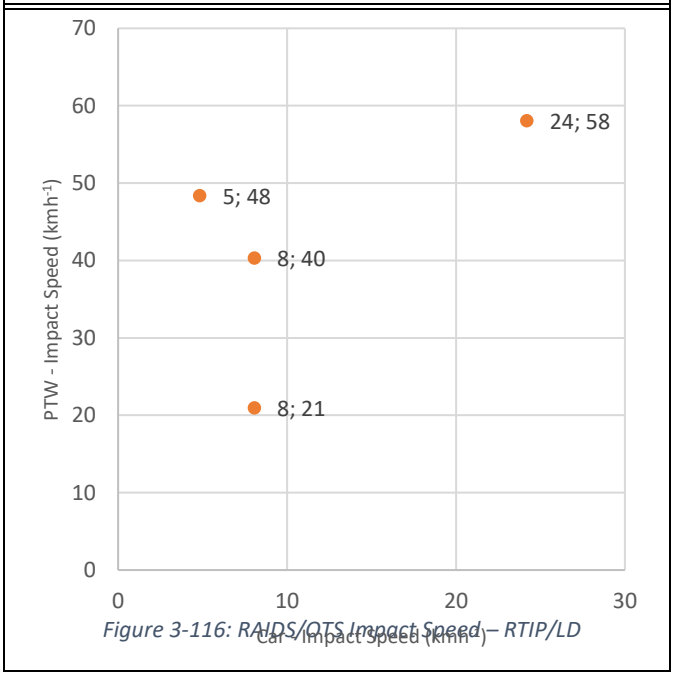


Figure 3-116: RAIDS/OTS Impact Speed – RTIP/LD

3.5.2.5 Lane Change – Same Direction

551	632	634	644
		Filter lane for turning	Filter lane for turning
n = 1	n = 1	n = 1	n = 1

Car Manoeuvre: Changing lane
PTW Manoeuvre: Travelling straight ahead

Figure 3-117: RAIDS/OTS Accident Types – LC/SD

Initial Speed

Car (n = 3)

- Range: 0-16 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 3):

- Range: 24-48 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

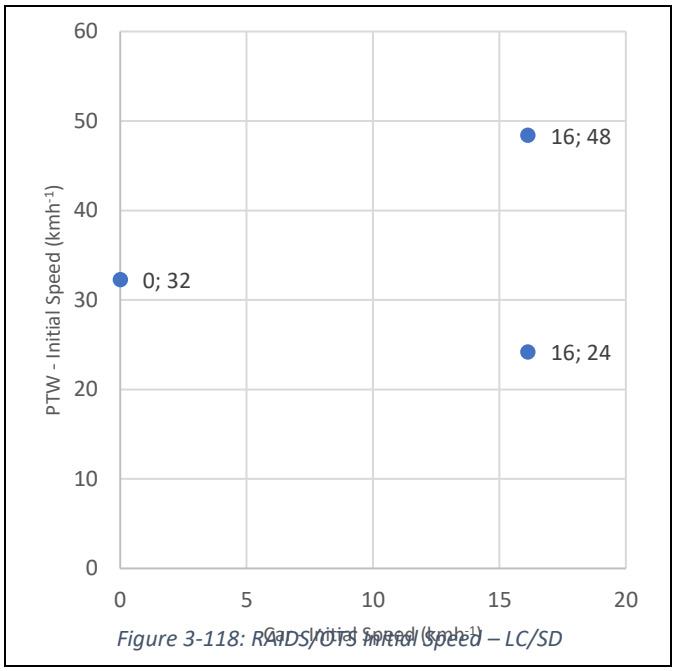


Figure 3-118: RAIDS/OTS Initial Speed – LC/SD

Impact Speed

Car (n = 3)

- Range: 5-16 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 24-26 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 16 kmh^{-1}
- PTW: (N/A)

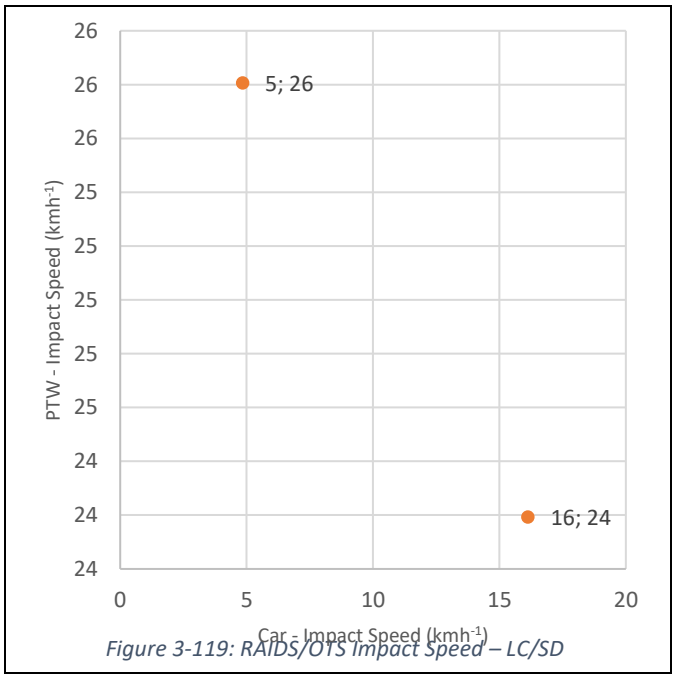
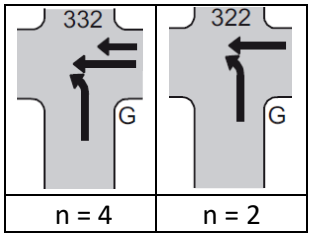


Figure 3-119: RAIDS/OTS Impact Speed – LC/SD

3.5.2.6 *Left Turn Into Path – Right Direction*



Car Manoeuvre: Turning left
PTW Manoeuvre: Travelling straight ahead from the right

Figure 3-120: RAIDS/OTS Accident Types – LTIP/RD

Initial Speed

Car (n = 4)

- Range: 0-13 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 4):

- Range: 52-105 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

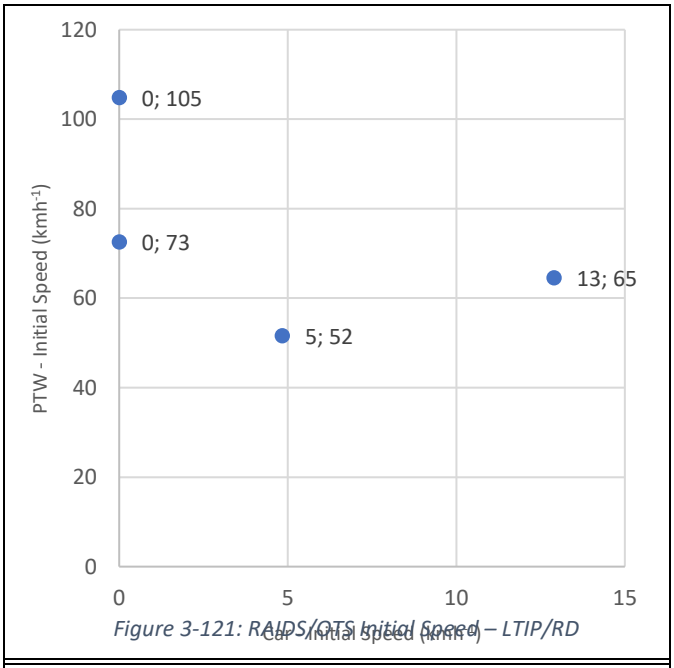


Figure 3-121: RAIDS/OTS Initial Speed – LTIP/RD

Impact Speed

Car (n = 4)

- Range: 0-8 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 3):

- Range: 32-45 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 0 kmh^{-1}
- PTW: (N/A)

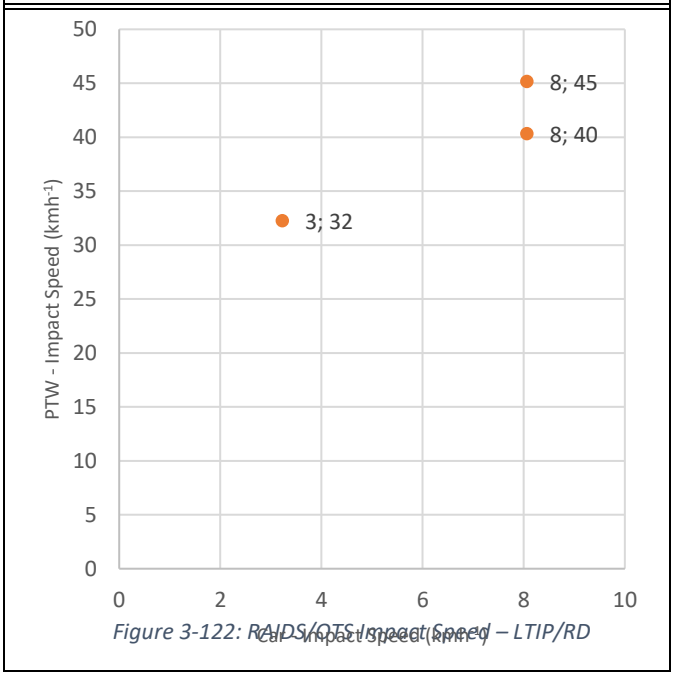
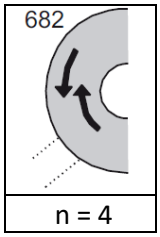


Figure 3-122: RAIDS/OTS Impact Speed – LTIP/RD

3.5.2.7 On Coming - Turning



Car Manoeuvre: Following the bend
PTW Manoeuvre: Following the bend

Figure 3-123: RAIDS/OTS Accident Types – OC/T

Initial Speed

Car (n = 2)

- Range: 0-65 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 0):

- Range: (N/A)
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 0, 65 kmh^{-1}
- PTW: (N/A)

Impact Speed

Car (n = 2)

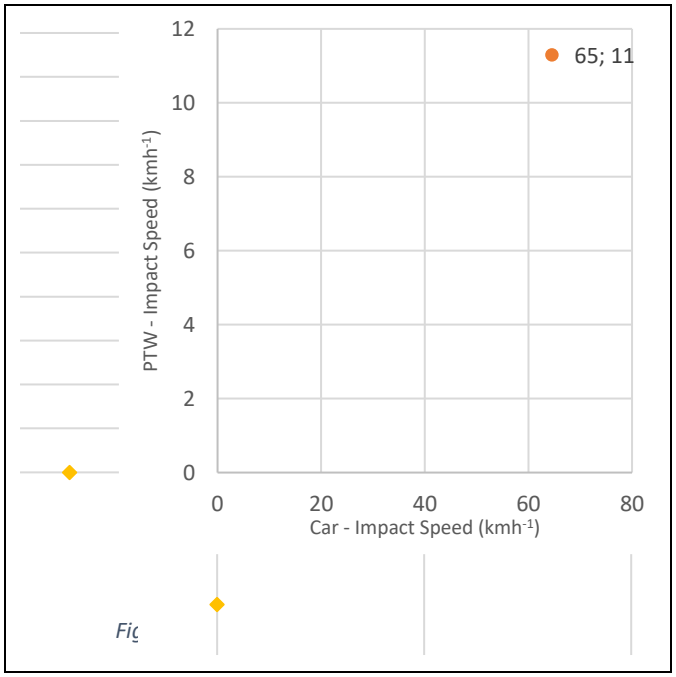
- Range: 32-65 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 11 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

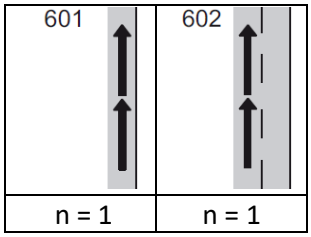
Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



Fig

3.5.2.8 Follow Up Driving



Car Manoeuvre: Travelling straight ahead
PTW Manoeuvre: Travelling straight ahead – moving/slowing

Figure 3-125: RAIDS/OTS Accident Types - FUD

Initial Speed

Car (n = 2)

- Range: 53-103 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 65-113 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

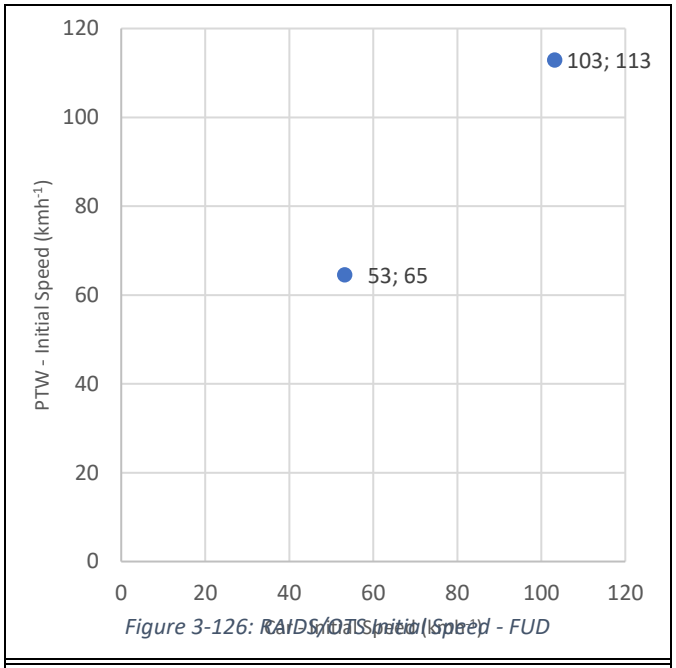


Figure 3-126: RAIDS/OTS Initial Speed - FUD

Impact Speed

Car (n = 2)

- Range: 53-103 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 0-81 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

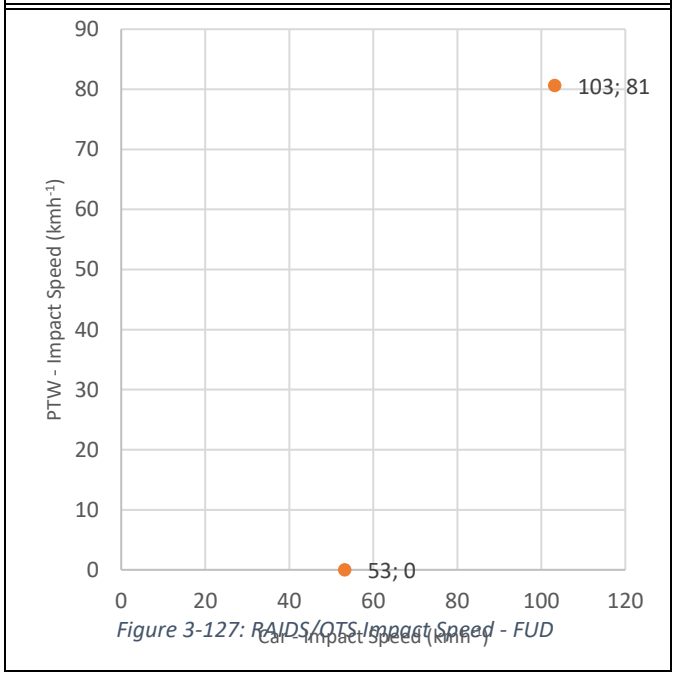
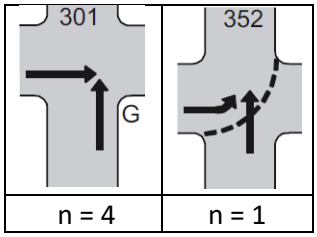


Figure 3-127: RAIDS/OTS Impact Speed - FUD

3.5.2.9 Straight Crossing Path – Left Direction



Car Manoeuvre: Travelling straight ahead
PTW Manoeuvre: Travelling straight ahead from the right/following left-hand bend

Figure 3-128: RAIDS/OTS Accident Types – SCP/LD

Initial Speed

Car (n = 5)

- Range: 40-103 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 4):

- Range: 32-113 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 52 kmh^{-1}
- PTW: (N/A)

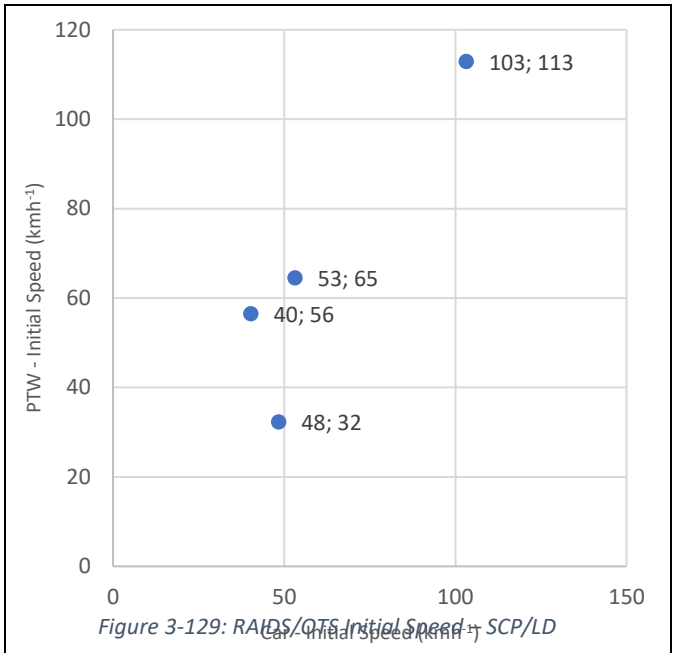


Figure 3-129: RAIDS/OTS Initial Speed – SCP/LD

Impact Speed

Car (n = 6)

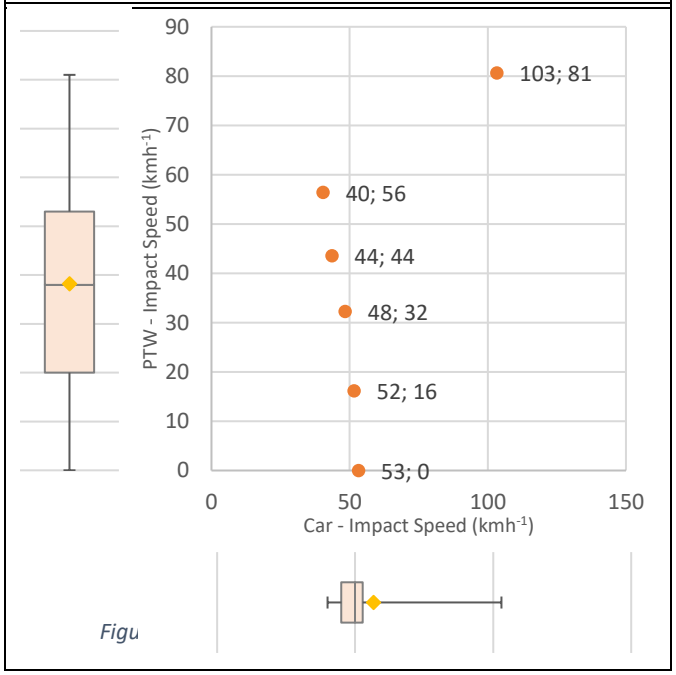
- Range: 40-113 kmh^{-1}
- IQR: 45-53kmh^{-1}
- Median: 50 kmh^{-1}

PTW (n = 6):

- Range: 0-81 kmh^{-1}
- IQR: 20-53kmh^{-1}
- Median: 38 kmh^{-1}

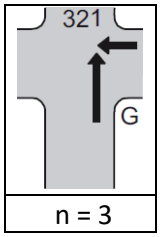
Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



Figu

3.5.2.10 Straight Crossing Path – Right Direction



Car Manoeuvre: Travelling straight ahead
PTW Manoeuvre: Travelling straight ahead from the right

Figure 3-131: RAIDS/OTS Accident Types – SCP/RD

Initial Speed

Car (n = 2)

- Range: 16-35 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 65-194 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

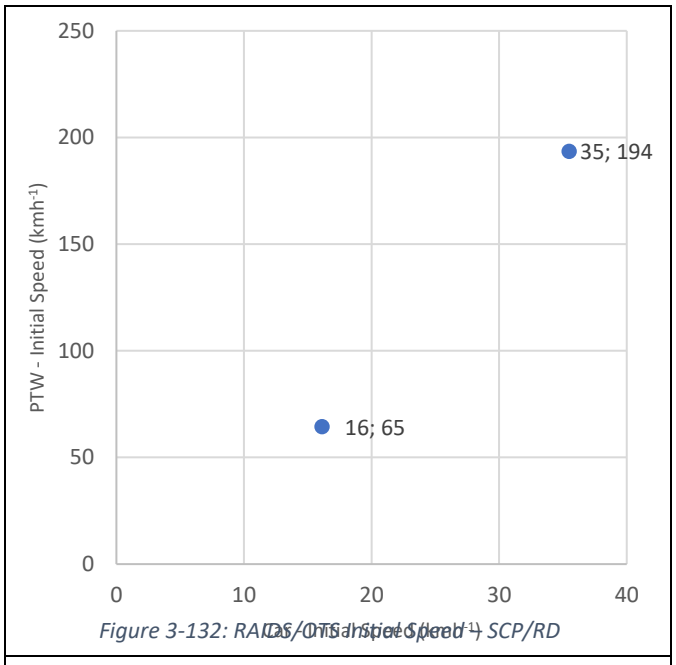


Figure 3-132: RAIDS/OTS Initial Speed – SCP/RD

Impact Speed

Car (n = 2)

- Range: 16-35 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 48-144 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

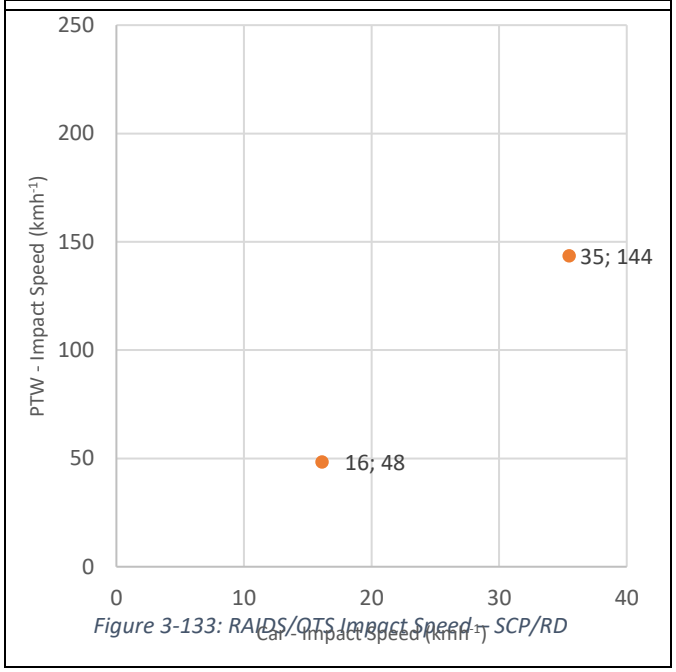
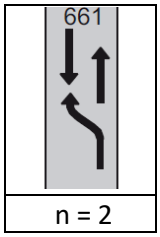


Figure 3-133: RAIDS/OTS Impact Speed – SCP/RD

3.5.2.11 Lane Change – Opposite Direction



Car Manoeuvre: Changing lane
PTW Manoeuvre: Travelling straight ahead

Figure 3-134: RAIDS/OTS Accident Types – LC/OD

Initial Speed

Car (n = 1)

- Range: 48 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 129 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

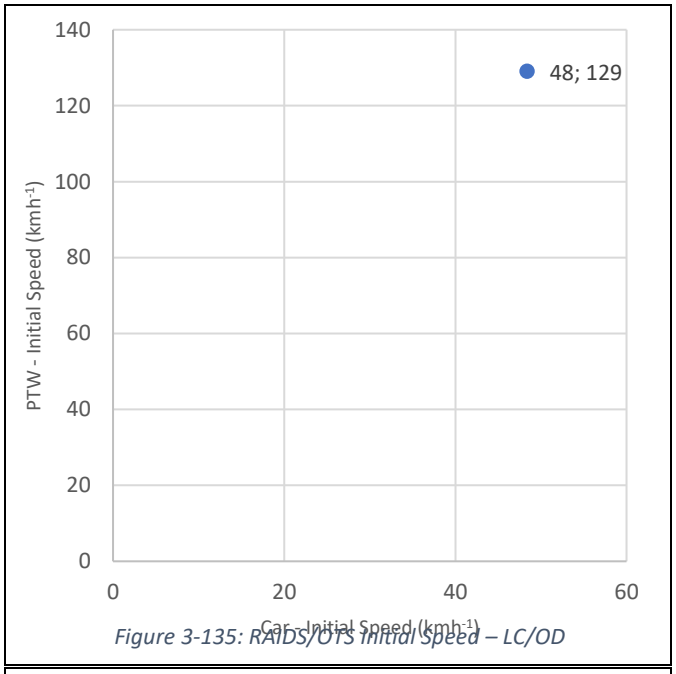


Figure 3-135: RAIDS/OTS Initial Speed – LC/OD

Impact Speed

Car (n = 1)

- Range: 48 kmh^{-1}
- IQR: kmh^{-1}
- Median: kmh^{-1}

PTW (n = 1):

- Range: 81 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

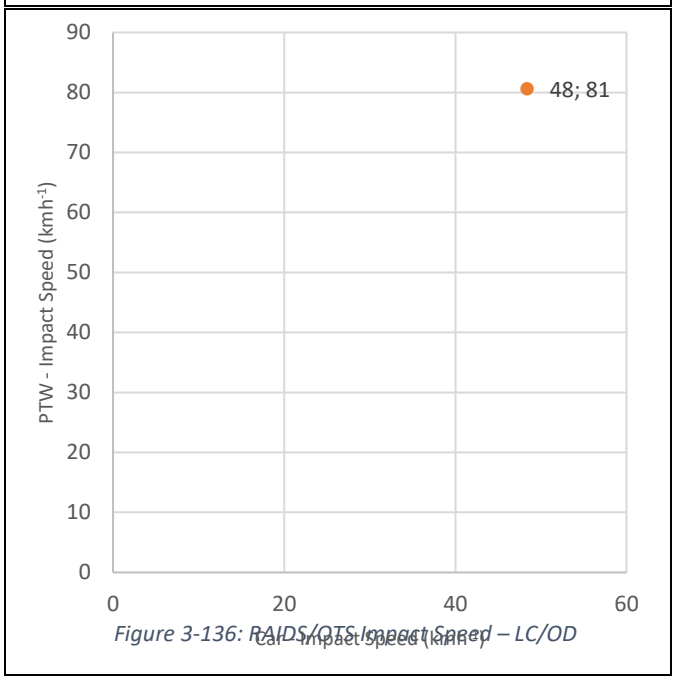
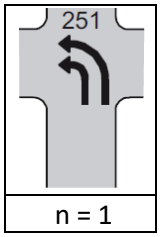


Figure 3-136: RAIDS/OTS Impact Speed – LC/OD

3.5.2.12 Parallel Turn – Same Direction



Car Manoeuvre: Turning
PTW Manoeuvre: Turning

Figure 3-137: RAIDS/OTS Accident Types – PT/SD

Initial Speed

Car (n = 1)

- Range: 56 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 56 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

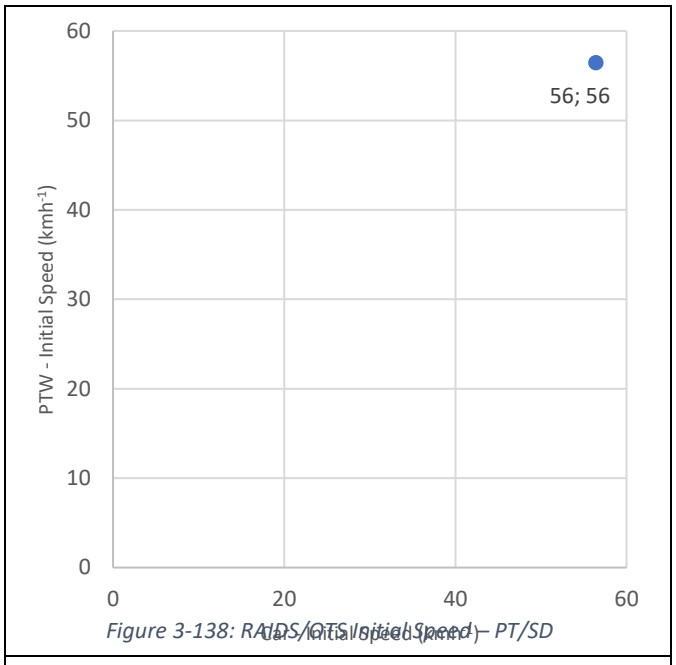


Figure 3-138: RAIDS/OTS Initial Speed – PT/SD

Impact Speed

Car (n = 1)

- Range: 56 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 56 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

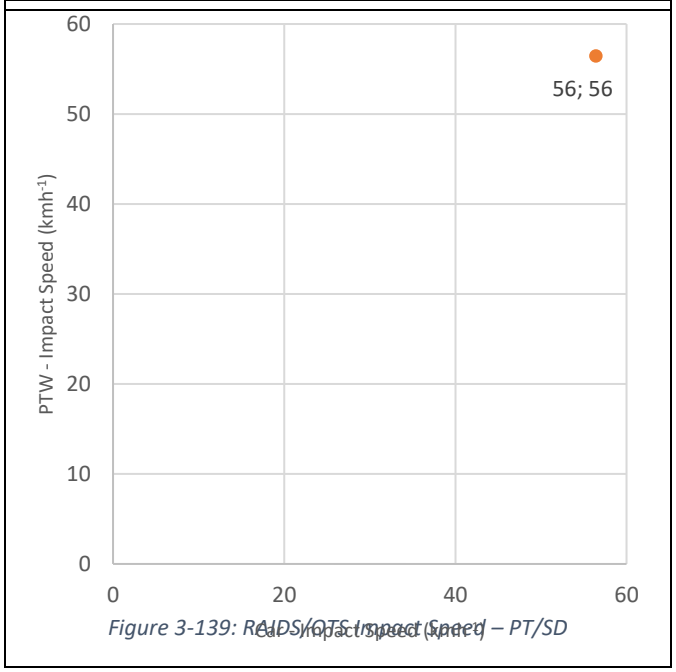


Figure 3-139: RAIDS/OTS Impact Speed – PT/SD

3.6 Greece – National Data

In the period 2013-2016 there were 8,131 accidents involving a car and motorcycle, 575 of these accidents were KSI accidents. Figure 3-140:ELSTAT KSI Accident Type Distribution for cluster analysis

'Frontal Side', 'Frontal', 'Side' and 'Rear' accident types were used only based on the frequency relative to other accident types. The KSI percentages were normalised to this selection for calculating ranking percentages.

A characteristic of the ELSTAT data is that only the vehicle manoeuvre of the at fault vehicle is recorded, whilst this could be detrimental to defining the accident scenario it does eliminate a degree of potential ambiguity about the at fault party, to this extent the data is pre-filtered for where only the car has a manoeuvre listed and the PTW manoeuvre is inferred through the accident type detail, intersection detail and the car manoeuvre.

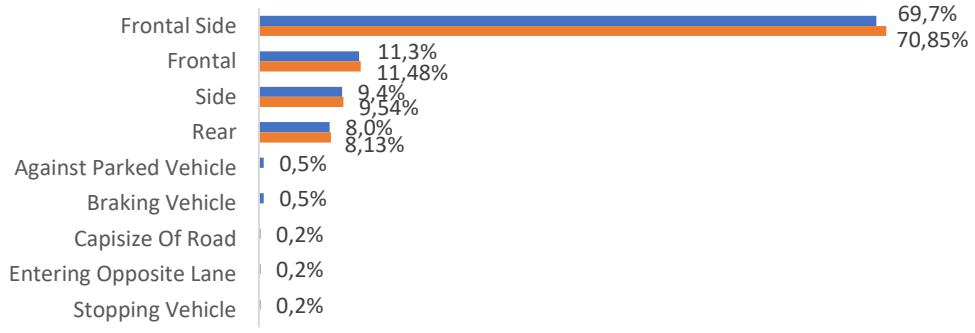


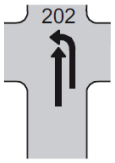
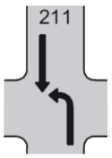
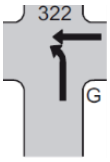
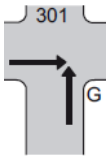
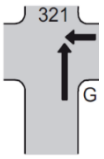
Figure 3-140:ELSTAT KSI Accident Type Distribution

3.6.1 Frontal Side

Three clusters proportioned 35%, 26% and 39% describe front to side type accidents. Cluster 1 describes the car turning left at a junction therefore these accidents are categorised into the groups **Left Turn Across Path for On Coming, Same Direction and Left Direction** conflict and **Left Turn Into Path with Right Direction** conflict in the absence of any information on the PTW manoeuvre. The accident scenarios for these groups are best represented by GDV codes **202, 211, 302** and **322** although further scenarios could be applied the manoeuvres are fundamentally the same. Cluster 3 describes the car not stopping at a stop sign at a junction, it is therefore inferred that the intended direction of travel is straight ahead at the junction with no turning manoeuvre, as the direction of travel of the PTW is unknown the accident is grouped as **Straight Crossing Path-Left Direction** conflict and **Straight Crossing Path-Right Direction** conflict, GDV codes **301** and **321** respectively. Cluster 2 describes the car manoeuvre as 'Entering opposite direction' not at a junction – given this ambiguity this cluster has not been assigned to an accident group or scenario.

Table 3.6.1-1: ELSTAT Cluster Analysis - Frontal Side

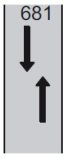
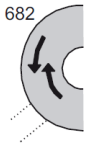
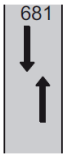
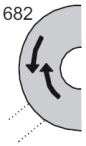
	Cluster #1 34,6%	Cluster #2 26,4%	Cluster #3 39,0%
Grouped Area	Urban Area	Urban Area	Urban Area
Intersection	At a junction	Not at a junction	At a junction

Car Manoeuvre	Turning left				Entering opposite direction	Not stopping at a stop sign	
(PTW Manoeuvre)	N/A				N/A	N/A	
Pictogram					N/A		
ASW	0.74						

3.6.2 Frontal

Cluster 1 describes the car as 'Entering opposite direction', in the context of frontal impacts with another vehicle it is interpreted as the car crossing the lane centre demarcation and impacting with the PTW in the opposite lane. In vehicle manoeuvres there is no value that describes a vehicle negotiating a bend or any details on road geometry so both possible head on accident scenarios of **On Coming – Turning** and **On Coming – Straight Driving**, GDV codes **681** and **682** respectively.

Table 3.6.2-1: ELSTAT Cluster Analysis - Frontal

	Cluster #1 70,7%	Cluster #2 29,3%
Grouped Area	Urban Area	Urban Area
Intersection	Not at a junction	Not at a junction
Car Manoeuvre	Entering opposite direction	Normal driving
(PTW Manoeuvre)	N/A	N/A
Pictogram	 	 
ASW	0.69	

3.6.3 Side

'Side' accident types are considered as accidents occurring in longitudinal traffic where both vehicles are travelling in the same direction, it is possible that these accidents could also be where the vehicles are travelling in opposite direction with offside to offside impact but in these scenarios the resulting impact type might be recorded as 'Frontal' accidents. All three clusters are categorised as **Lane Change – Same Direction** conflict and correlated to the accident scenarios **651, 652** and **641.**

Table 3.6.3-1: ELSTAT Cluster Analysis - Side

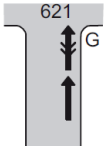
	Cluster #1 24,1%	Cluster #2 20,4%	Cluster #3 55,5%
Grouped Area	Urban Area	Urban Area	Urban Area
Intersection	At a junction	Not at a junction	Not at a junction
Car Manoeuvre	Normal driving	Entering opposite direction	Lane change
(PTW Manoeuvre)	N/A	N/A	N/A

Pictogram	651 	652  Vehicle overtaking in opposite lane	641  Lane change due to vehicle in front
ASW	0.56		

3.6.4 Rear

Three clusters describe front to rear accidents where the car impact the rear of the motorcycle. Clusters 1 and 2 describe the accident occurring not at a junction therefore these are categorised as GDV code **602** on the assumption that both vehicles are travelling straight ahead, whereas cluster 3 is categorised as GDV code **621** based on the junction detail – it is assumed that the PTW is slowing or stationary at the junction.

Table 3.6.4-1: ELSTAT Cluster Analysis - Rear

	Cluster #1 39,1% 	Cluster #2 39,1% 	Cluster #3 21,7% 
Grouped Area	Urban Area	Urban Area	Urban Area
Intersection	Not at junction	Not at a junction	At a junction
Car Manoeuvre	Normal driving	Over speeding	Other
(PTW Manoeuvre)	(?)	(?)	(?)
Pictogram	602 	602 	621 G 
ASW	0.65		

3.7 The Netherlands – National Data

For the year 2009-2014 there were 11,042 accidents and 1,928 accidents involving a car and motorcycle. The accident severity in the SWOV database is categorised as fatal, hospitalised, accident and emergency admission and slight. As a proxy for KSI accidents fatal and hospitalisation categories were used of which there were 1,088 accidents. The KSI percentages for the relevant accident types, Lateral, Frontal and Rear-End were normalised to this selection for calculating ranking percentages.

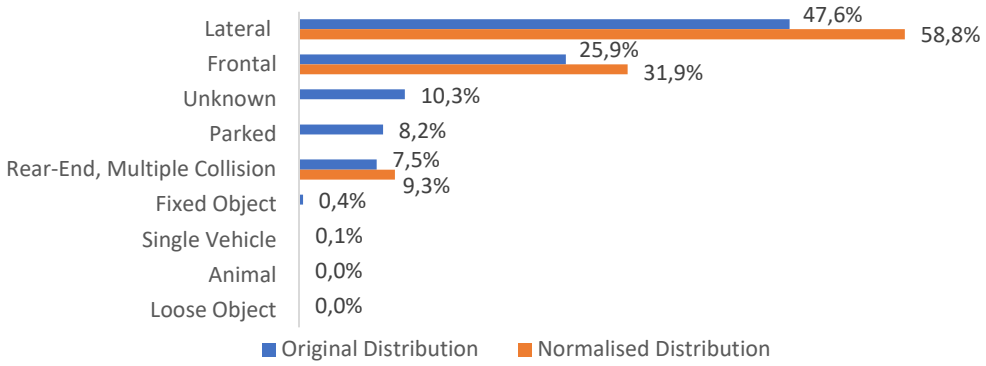
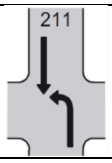
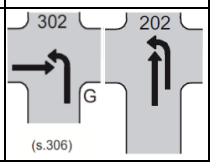
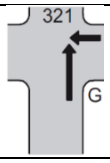
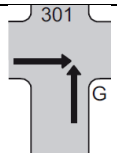


Figure 3-141: SWOV KSI Accident Type Distribution

3.7.1 Lateral

Four clusters describe accidents occurring at junctions, cluster 1 and 3 can be accurately categorised, through the vehicle manoeuvre and impact locations, into Left Turn Across Path – Opposite Direction, code 211 and Straight Crossing Path – Right Direction conflict, code 321, respectively. Clusters 2 can be categorised as Left Turn Across Path – Left Direction conflict, code 302, or Left Turn Across Path – Same Direction, code 202, this is due to the ambiguity on the relative orientation of the vehicles. Cluster 4 is categorised as a Straight Crossing Path with two accident scenarios. It is possible to interpret that either the car is violating the give-way to the PTW emerging from the left, code 301, or the PTW is failing to give-way to the car, code 321. Both codes are included as they are scenarios that the car as the ADAS ego-vehicle could be effective in avoiding or mitigating the accident. The ASW is low at 0.32 which indicate that some artificial structure may exist, this could be a factor of the additional variables in the SWOV datasets causing more dissimilarity compared to dataset with fewer variables and/or less potentially complex accident scenarios i.e. junction vs. front-to-rear.

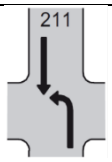
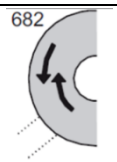
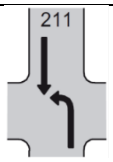
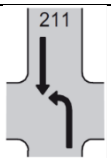
Table 3.7.1-1: SWOV Cluster Analysis - Lateral

	Cluster #1 22,3%	Cluster #2 29,6%	Cluster #3 28,6%	Cluster #4 19,5%
Road Situation	Intersection – 3 arms	Straight road	Intersection – 4 arms	Intersection – 4 arms
Speed Limit	50 km/h	50 km/h	50 km/h	50 km/h
Car Manoeuvre	Turning left	Turning left	Moving forward	Moving forward
PTW Manoeuvre	Moving forward	Moving forward	Moving forward	Moving forward
Car Impact Point	Right side	Left side	Centre front	Left side
PTW Impact Point	Centre front	Centre front	Left side	Centre front
Pictogram				
ASW	0.32			

3.7.2 Frontal

Two distinct accident groups have been described within the 'Frontal' data subset, **Left Turn Across Path – Opposite Direction** and **On Coming**, inferred through the vehicle manoeuvres, impact location and road detail. For the Left Turn Across Path accidents, given the front impact location, gives an indication of the orientation of the vehicles compared to the scenario defined in the 'Lateral' group where the impact location is front to side. Cluster 5 describes the PTW turning left across the path of the oncoming car.

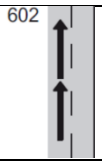
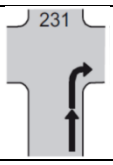
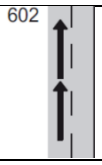
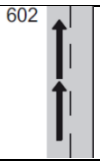
Table 3.7.2-1: SWOV Cluster Analysis - Frontal

	Cluster #1 26,1%	Cluster #2 33,8%	Cluster #3 3,0%	Cluster #4 17,4%	Cluster #5 19,7%
Road Situation	Straight road	Bend	Straight road	Intersection – 4 arms	Intersection – 4 arms
Speed Limit	50km/h	50km/h	80km/h	80km/h	50km/h
Car Manoeuvre	Turning left	Moving forward	Turning left	Moving forward	Moving forward
PTW Manoeuvre	Moving forward	Moving forward	Moving forward	Moving forward	Turning left
Car Impact Point	Centre front	Centre front	Centre front	Centre front	Left front
PTW Impact Point	Centre front	Centre front	Centre front	Centre front	Centre front
Pictogram					
ASW	0.63				

3.7.3 Rear

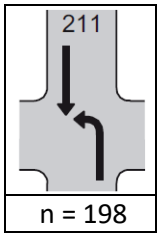
Pre-filtering of data has defined a subset of front-to-rear accidents were the car impact the rear of the PTW. Clusters 1, 3-5 describe an impact were both vehicles are travelling straight ahead, given these manoeuvres it can be viewed as incidental that clusters 3 and 4 describe the accidents occurring at junctions. An potential influence on any differences in these basic accident group could be the travel speed of both vehicles, the analysis describes front-to-rear on roads with speed limits of 50, 80 and 100 km/h.

Table 3.7.3-1: SWOV Cluster Analysis - Rear

	Cluster #1 14,8%	Cluster #2 7,4%	Cluster #3 29,6%	Cluster #4 33,3%	Cluster #5 14,8%
Road Situation	Straight road	Straight road	Intersection – 4 arms	Intersection – 4 arms	Straight road separated carriageway
Speed Limit	80km/h	50km/h	80km/h	80km/h	100km/h
Car Manoeuvre	Moving forward	Moving forward	Moving forward	Moving forward	Moving forward
PTW Manoeuvre	Moving forward	Turning right	Moving forward	Moving forward	Moving forward
Car Impact Point	(Front*)	(Front*)	(Front*)	(Front*)	(Front*)
PTW Impact Point	(Rear*)	(Rear*)	(Rear*)	(Rear*)	(Rear*)
Pictogram					
ASW	0.54				

3.8 Aggregated In-Depth

3.8.1 Left Turn Across Path – Opposite Direction



Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead

Figure 3-142: Accident Types - LTAP/OD

Initial Speed

Car (n = 145)

- Range: 0-70 kmh^{-1}
- IQR: 15-30 kmh^{-1}
- Median: 22 kmh^{-1}

PTW (n = 148):

- Range: 20-145 kmh^{-1}
- IQR: 47-79 kmh^{-1}
- Median: 55 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 0, 0, 0, 5, 5, 10, 14, 16, 30, 30, 48, 70
- PTW: 20, 30, 40, 45, 48, 50, 50, 60, 64, 65, 75, 80, 90, 90, 120

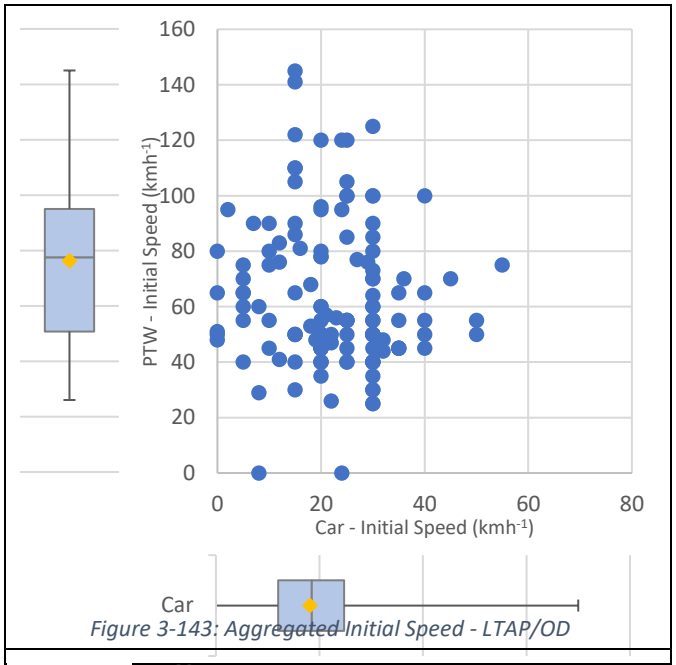


Figure 3-143: Aggregated Initial Speed - LTAP/OD

Impact Speed

Car (n = 113)

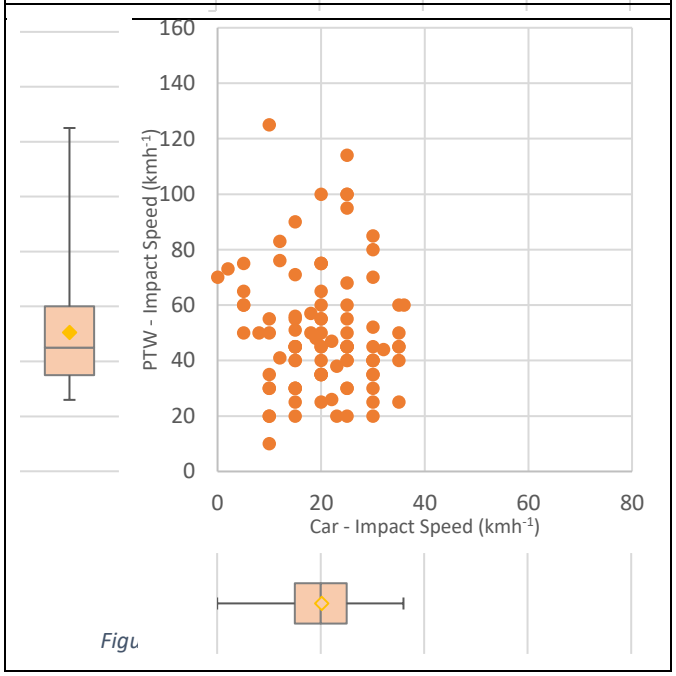
- Range: 0-45 kmh^{-1}
- IQR: 15-25 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 114):

- Range: 10-125 kmh^{-1}
- IQR: 35-60 kmh^{-1}
- Median: 45 kmh^{-1}

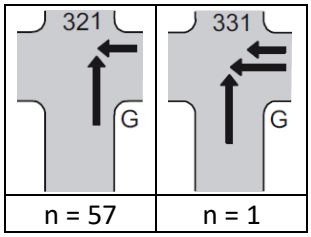
Unpaired Car and PTW cases:

- Car: 8
- PTW: 48, 60



Figu

3.8.2 Straight Crossing Path – Right Direction Conflict



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead from the right

Figure 3-145:Accident Types - SCP/RD

Initial Speed

Car (n = 42)

- Range: 0-110 kmh^{-1}
- IQR: 15-39 kmh^{-1}
- Median: 23 kmh^{-1}

PTW (n = 40):

- Range: 5-80 kmh^{-1}
- IQR: 30-50 kmh^{-1}
- Median: 40 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 0, 10, 25, 25
- PTW: 20, 30, 35, 40

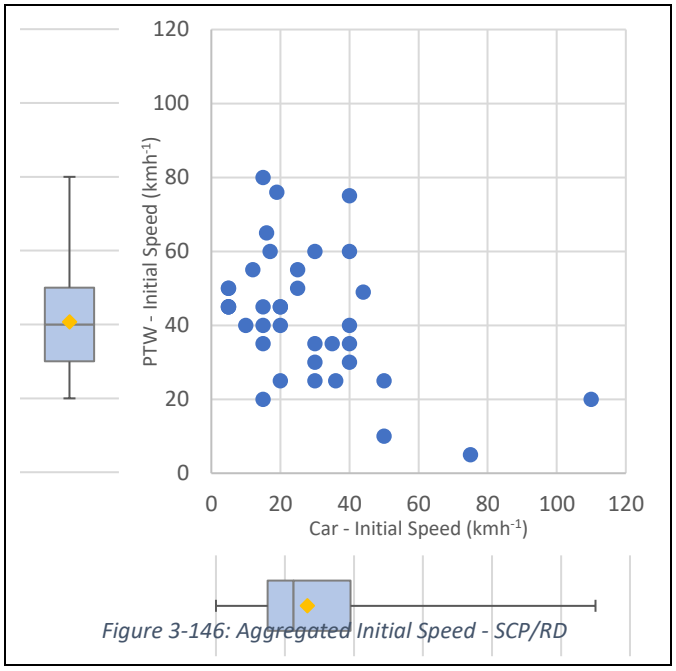


Figure 3-146: Aggregated Initial Speed - SCP/RD

Impact Speed

Car (n = 34)

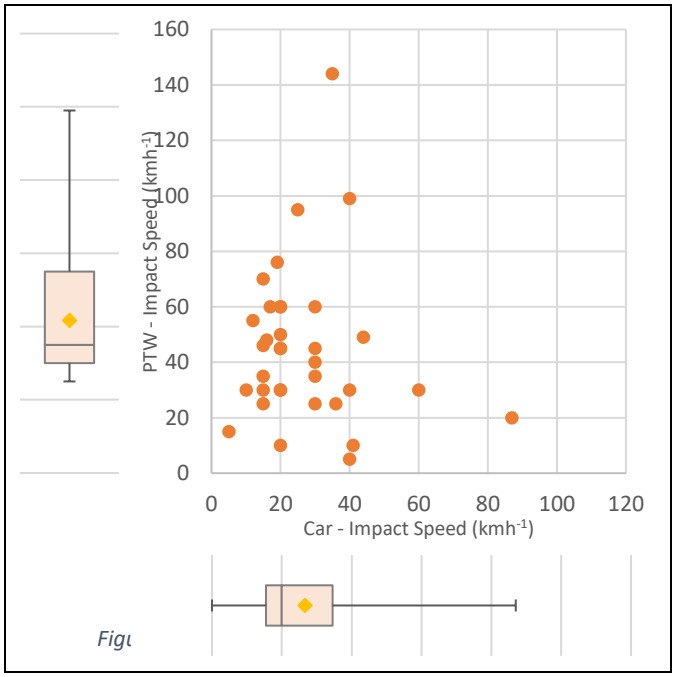
- Range: 0-87 kmh^{-1}
- IQR: 16-35 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 33):

- Range: 5-99 kmh^{-1}
- IQR: 30-55 kmh^{-1}
- Median: 35 kmh^{-1}

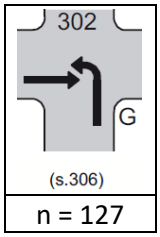
Unpaired Car and PTW cases:

- Car: 0, 45
- PTW: 35



Figu

3.8.3 Left Turn Across Path – Left Direction Conflict



n = 127

Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead

Figure 3-148: Accident Types - LTAP/LD

Initial Speed

Car (n = 83)

- Range: 0-40 kmh^{-1}
- IQR: 5-20 kmh^{-1}
- Median: 6 kmh^{-1}

PTW (n = 81):

- Range: 25 -113 kmh^{-1}
- IQR: 48-75 kmh^{-1}
- Median: 55 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

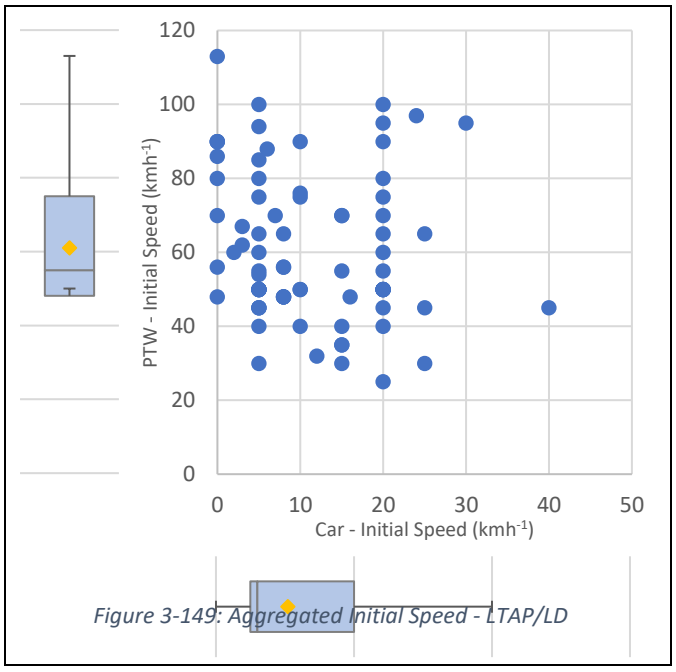


Figure 3-149: Aggregated Initial Speed - LTAP/LD

Impact Speed

Car (n = 69)

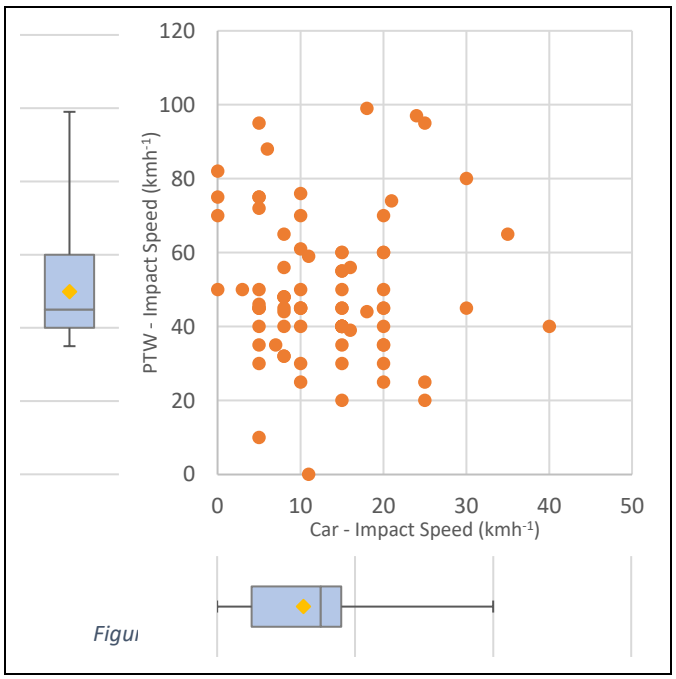
- Range: 0-40 kmh^{-1}
- IQR: 5-18kmh^{-1}
- Median: 15 kmh^{-1}

PTW (n = 67):

- Range: 10-99 kmh^{-1}
- IQR: 40-60 kmh^{-1}
- Median: 45 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



Figu

3.8.4 Follow-Up Driving

602	601	621 G	231
n = 5	n = 2	n = 1	n = 1

Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead – moving, slowing or stationary

Figure 3-151: Accident Types - FUD

Initial Speed

Car (n = 17)
- Range: 0-105 kmh^{-1}
- IQR: 10-36 kmh^{-1}
- Median: 25 kmh^{-1}

PTW (n = 17):
- Range: 0-94 kmh^{-1}
- IQR: 20-63 kmh^{-1}
- Median: 50 kmh^{-1}

Unpaired Car and PTW cases:
- Car: (N/A)
- PTW: (N/A)

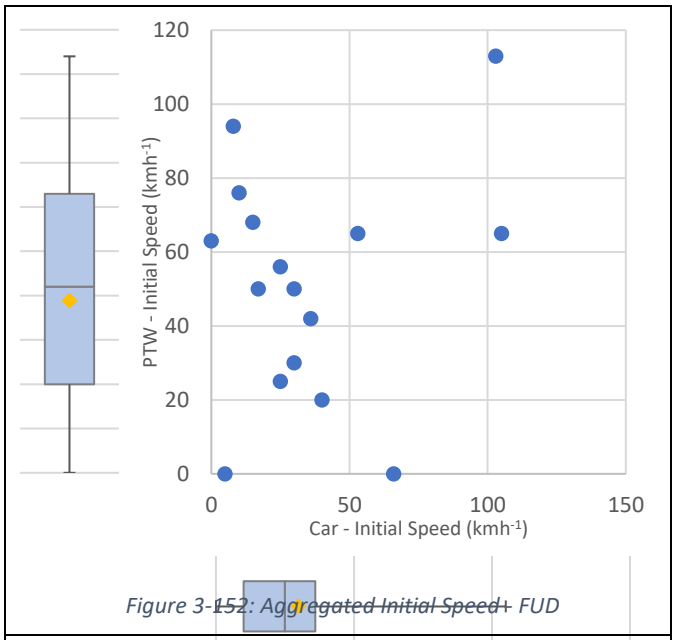


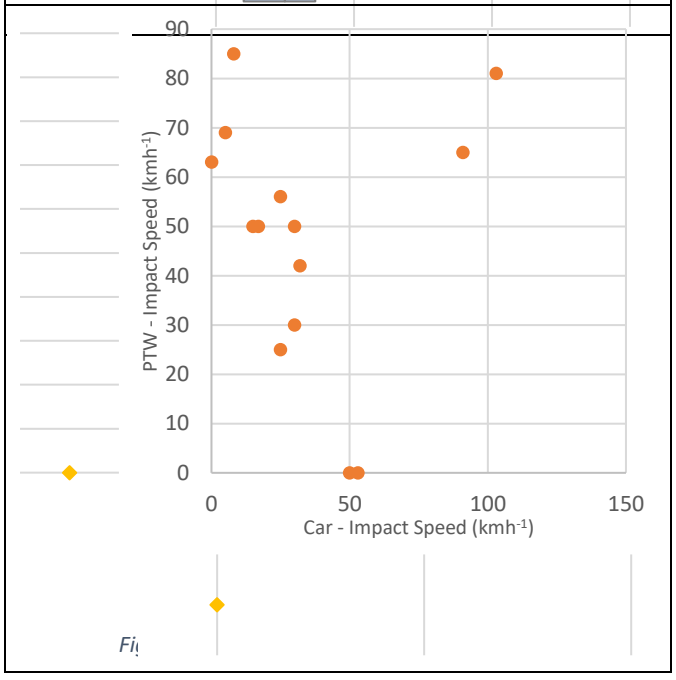
Figure 3-152: Aggregated Initial Speed FUD

Impact Speed

Car (n = 16)
- Range: 0-103 kmh^{-1}
- IQR: 14-37 kmh^{-1}
- Median: 25 kmh^{-1}

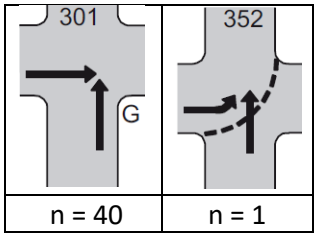
PTW (n = 16):
- Range: 0-85 kmh^{-1}
- IQR: 24-85 kmh^{-1}
- Median: 50 kmh^{-1}

Unpaired Car and PTW cases:
- Car: 10, 15 kmh^{-1}
- PTW: 9, 20 kmh^{-1}



Fi

3.8.5 Straight Crossing Path – Left Direction Conflict



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead from the right/following left-hand bend

Figure 3-154: Accident Types -

Initial Speed

Car (n = 31)

- Range: 0-90 kmh^{-1}
- IQR: 10-28 kmh^{-1}
- Median: 15 kmh^{-1}

PTW (n = 36):

- Range: 15-150 kmh^{-1}
- IQR: 44-60 kmh^{-1}
- Median: 50 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

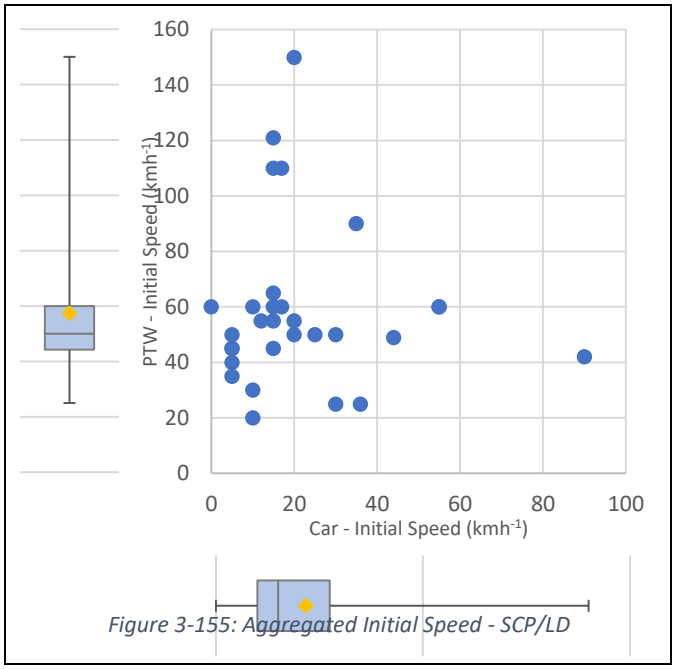


Figure 3-155: Aggregated Initial Speed - SCP/LD

Impact Speed

Car (n = 30)

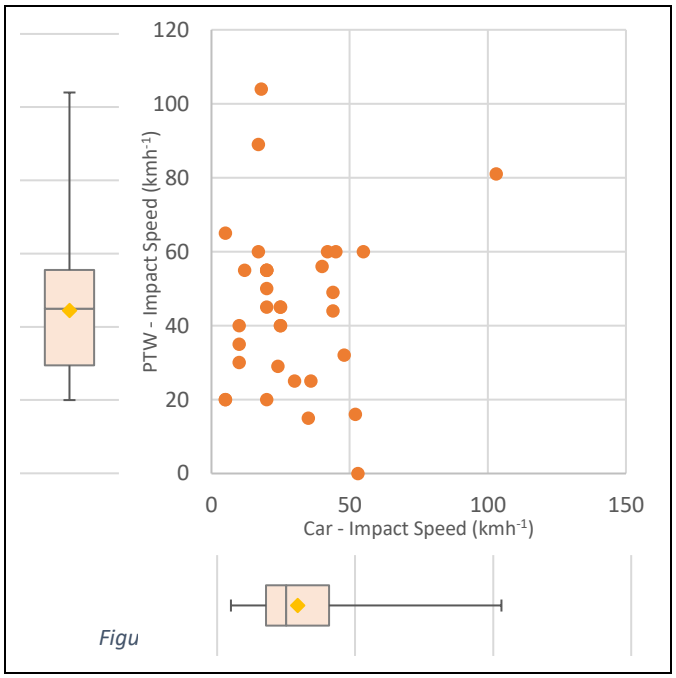
- Range: 5-55 kmh^{-1}
- IQR: 17-30 kmh^{-1}
- Median: 20 kmh^{-1}

PTW (n = 29):

- Range: 15-104 kmh^{-1}
- IQR: 30-55 kmh^{-1}
- Median: 45 kmh^{-1}

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)



Figu

3.8.6 Left Turn Across Path – Same Direction Conflict

202	721	232
n = 76	n = 26	n = 1

Car manoeuvre: Turning left
PTW manoeuvre: Travelling straight ahead from behind the car

Figure 3-157: Accident Types - LTAP/SD

Initial Speed

Car (n = 59)
- Range: 0-100 kmh^{-1}
- IQR: 10 -28 kmh^{-1}
- Median: 16 kmh^{-1}

PTW (n = 60):
- Range: 24-148 kmh^{-1}
- IQR: 47-85 kmh^{-1}
- Median: 65 kmh^{-1}

Unpaired Car and PTW cases:
- Car: (N/A)
- PTW: (N/A)

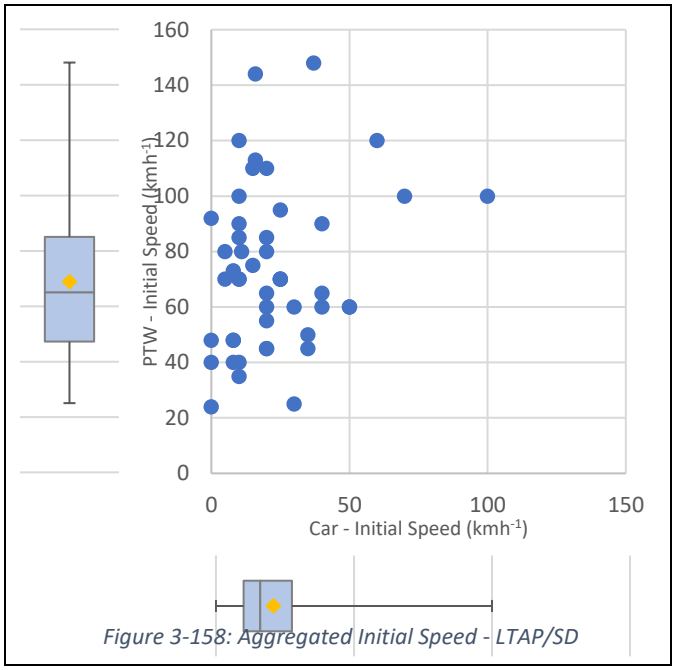


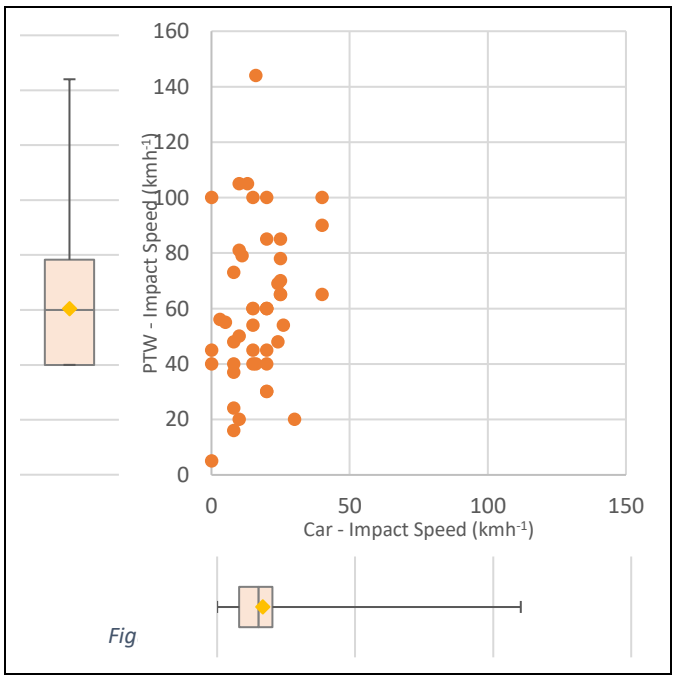
Figure 3-158: Aggregated Initial Speed - LTAP/SD

Impact Speed

Car (n = 57)
- Range: 0-110 kmh^{-1}
- IQR: 8-20 kmh^{-1}
- Median: 15 kmh^{-1}

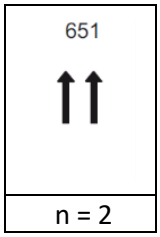
PTW (n = 48):
- Range: 5-144 kmh^{-1}
- IQR: 40-78 kmh^{-1}
- Median: 60 kmh^{-1}

Unpaired Car and PTW cases:
- Car: (N/A)
- PTW: (N/A)



Fig

3.8.7 Parallel Driving



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead/overtaking

Figure 3-160: Accident Types - PD

Initial Speed

Car (n = 2)

- Range: 56-85 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 56-155 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

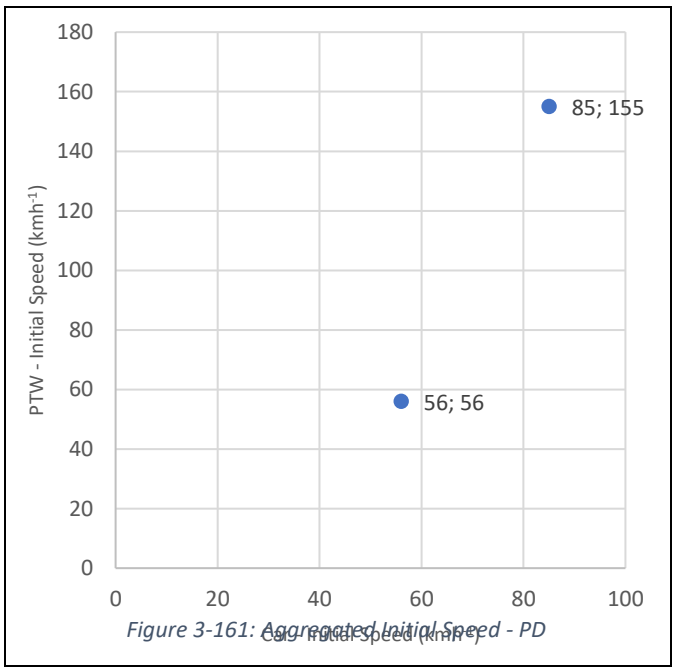


Figure 3-161: Aggregated Initial Speed - PD

Impact Speed

Car (n = 2)

- Range: 56-85 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 56-155 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

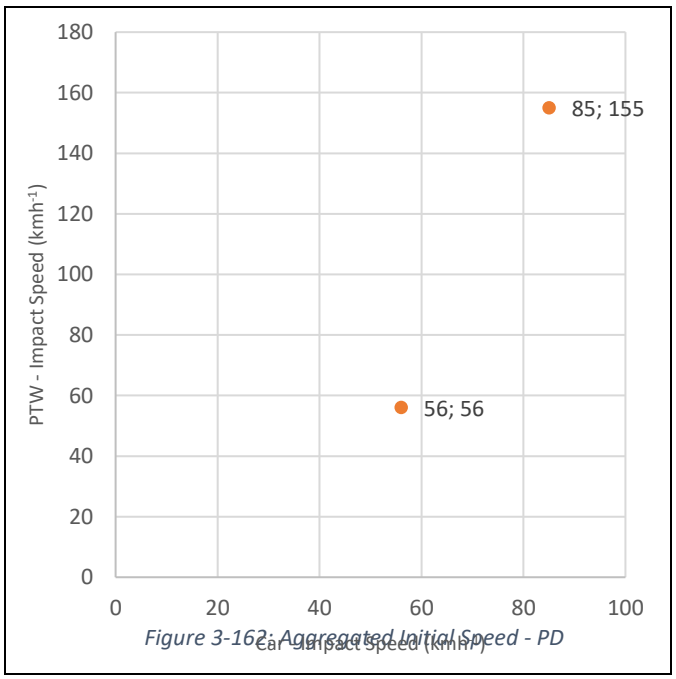


Figure 3-162: Aggregated Initial Speed - PD

3.8.8 Lane Change – Same Direction Conflict

631	641	632	634	644	511
	Lane change due to vehicle in front		Filter lane for turning	Filter lane for turning	
n = 12	n = 5	n = 1	n = 1	n = 1	n = 1

Car manoeuvre:
Overtaking
PTW manoeuvre:
Travelling straight ahead

Figure 3-163: Accident Types - LC/SD

Initial Speed

Car (n = 15)

- Range: 3-97 kmh^{-1}
- IQR: 40-75 kmh^{-1}
- Median: 56 kmh^{-1}

PTW (n = 13):

- Range: 48-129 kmh^{-1}
- IQR: 65-80 kmh^{-1}
- Median: 70 kmh^{-1}

Unpaired Car and PTW cases:

- Car: 32, 65, 80 kmh^{-1}
- PTW: 70 kmh^{-1}

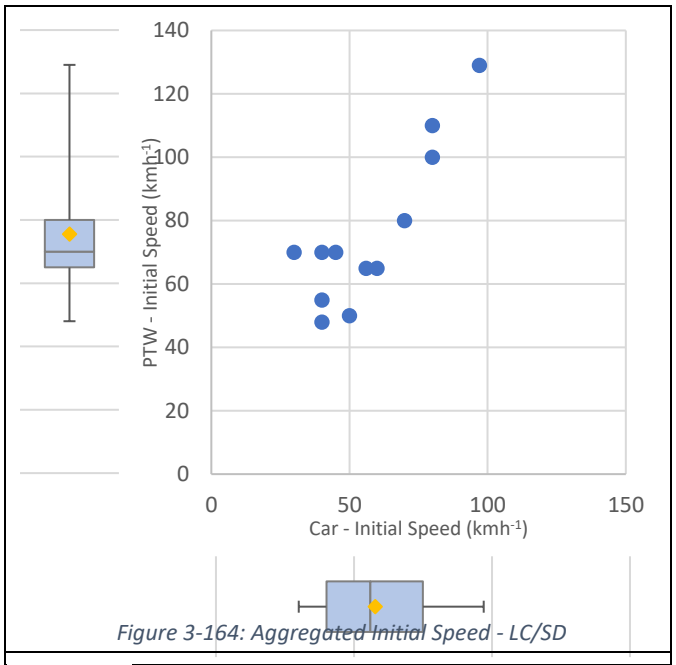


Figure 3-164: Aggregated Initial Speed - LC/SD

Impact Speed

Car (n = 15)

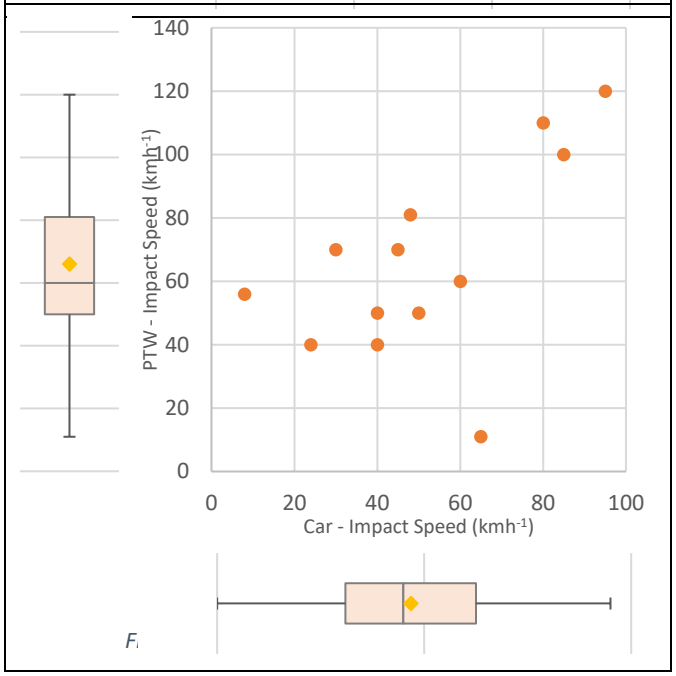
- Range: 0-95 kmh^{-1}
- IQR: 31-65 kmh^{-1}
- Median: 45 kmh^{-1}

PTW (n = 13):

- Range: 11-120 kmh^{-1}
- IQR: 50-81 kmh^{-1}
- Median: 60 kmh^{-1}

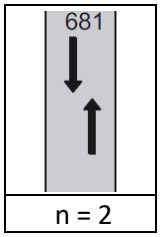
Unpaired Car and PTW cases:

- Car: 0, 32 kmh^{-1}
- PTW: (N/A)



F

3.8.9 On Coming – Straight Driving



Car manoeuvre: Travelling straight ahead
PTW manoeuvre: Travelling straight ahead

Figure 3-166: Accident Types - OC/SD

Initial Speed

Car (n = 2)

- Range: 130-150 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 90-100 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

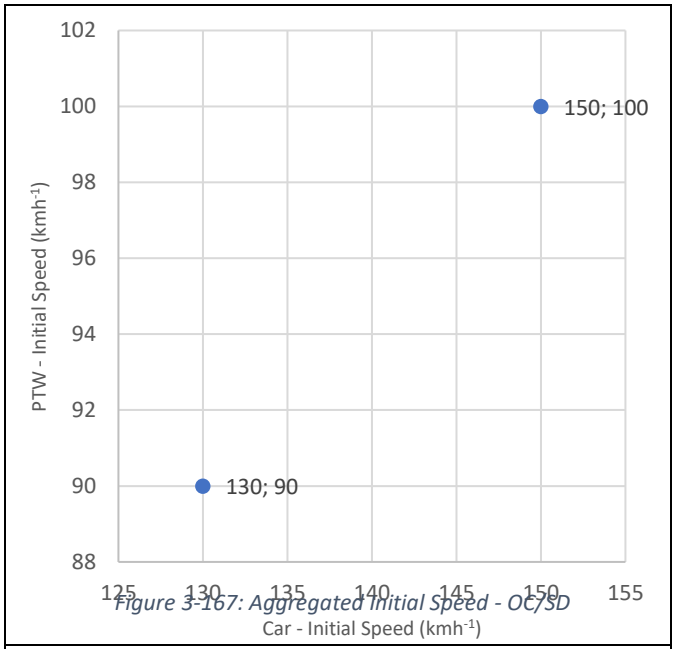


Figure 3-167: Aggregated Initial Speed - OC/SD

Impact Speed

Car (n = 2)

- Range: 120-150 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 60-70 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

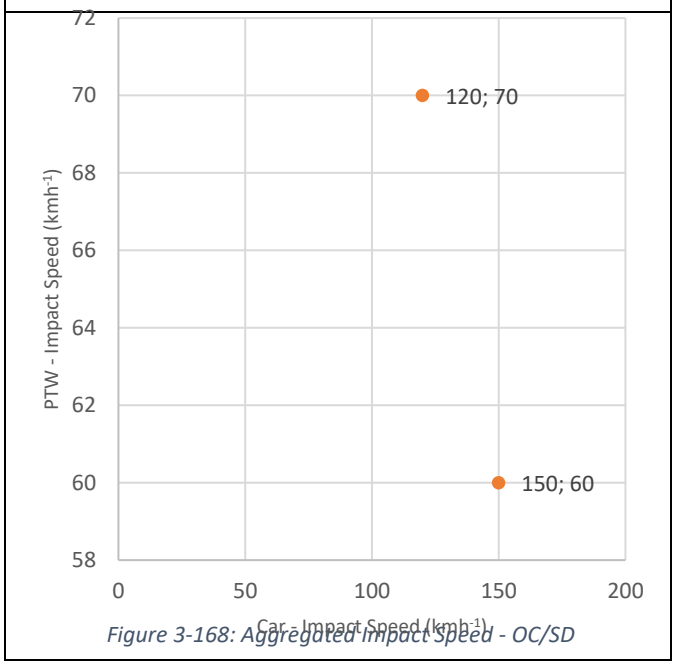
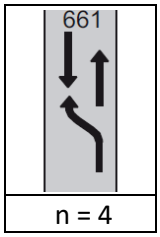


Figure 3-168: Aggregated Impact Speed - OC/SD

3.8.10 Lane Change – Opposite Direction Conflict



Car manoeuvre: Overtaking
PTW manoeuvre: Travelling straight ahead

Figure 3-169: Accident Types - LC/OD

Initial Speed

Car (n = 2)

- Range: 48-105 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 100-129 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

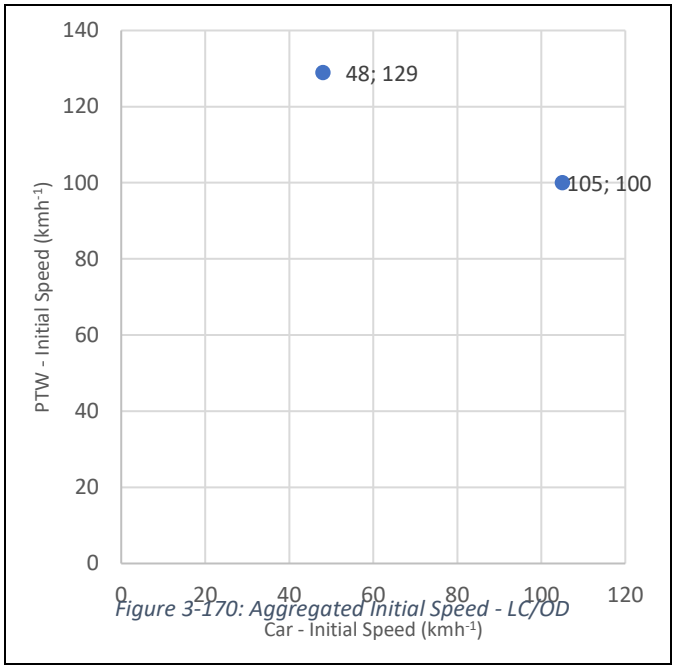


Figure 3-170: Aggregated Initial Speed - LC/OD

Impact Speed

Car (n = 2)

- Range: 48-95 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 81-100 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

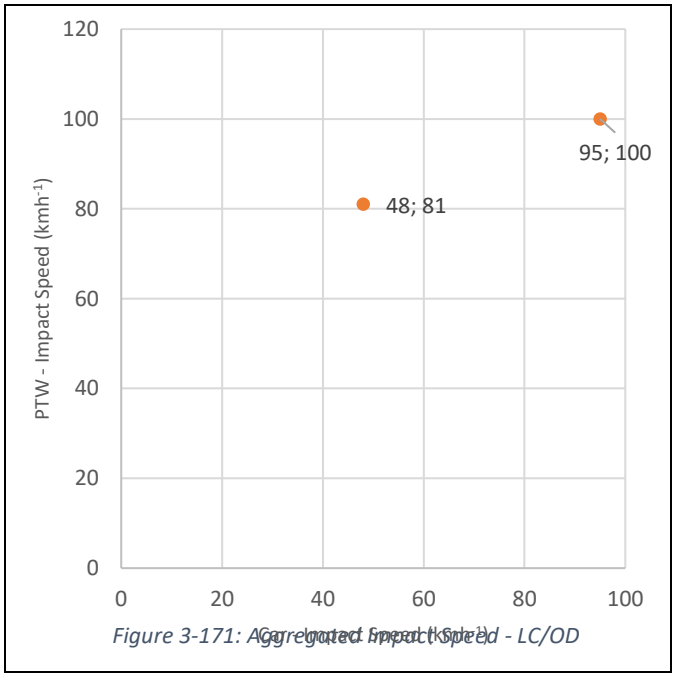
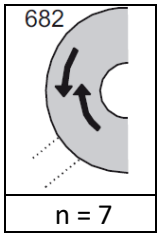


Figure 3-171: Aggregated Impact Speed - LC/OD

3.8.11 On Coming – Turning Conflict



Car manoeuvre: Following bend
PTW manoeuvre: Following bend

Figure 3-172: Accident Types - OC/T

Initial Speed

Car (n = 5)

- Range: 0-90 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 3):

- Range: 65-80 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 0, 65 kmh^{-1}
- PTW: (N/A)
-

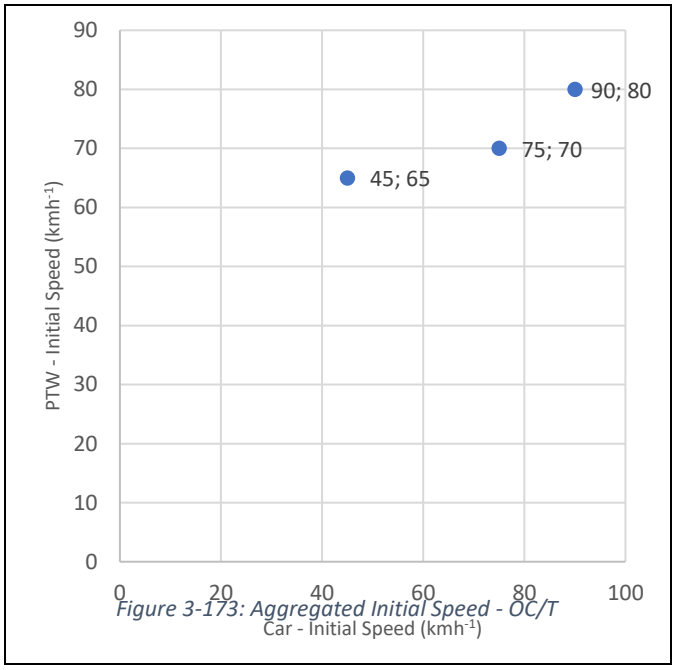


Figure 3-173: Aggregated Initial Speed - OC/T

Impact Speed

Car (n = 5)

- Range: 32-70 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 4):

- Range: 11-65 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 32 kmh^{-1}
- PTW: (N/A)

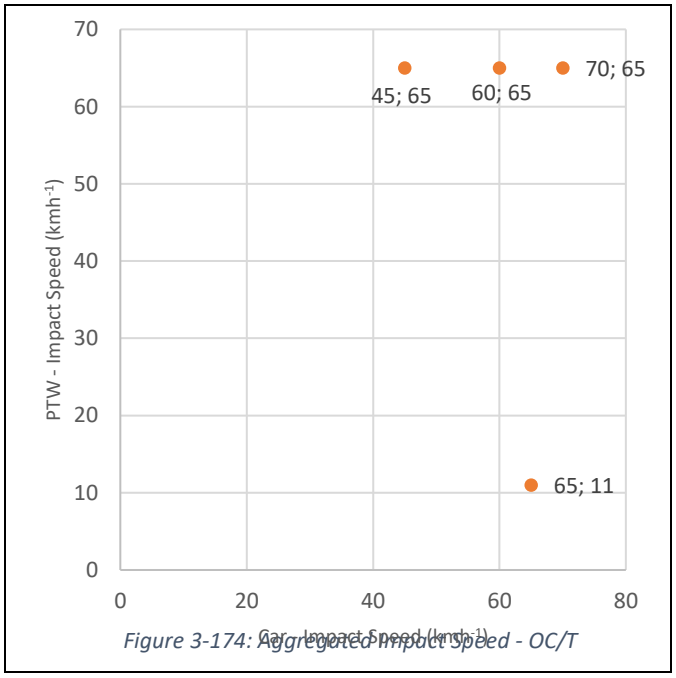
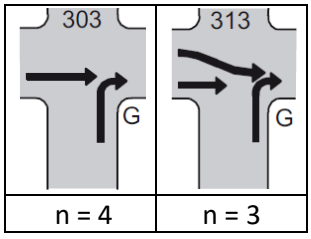


Figure 3-174: Aggregated Impact Speed - OC/T

3.8.12 Right Turn Into Path – Left Direction Conflict



Car manoeuvre: Turning right
PTW manoeuvre: Travelling straight ahead/overtaking

Figure 3-175: Accident Types - RTIP/LD

Initial Speed

Car (n = 4)

- Range: 0-8 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 2):

- Range: 0-40 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: 0, 8 kmh^{-1}
- PTW: (N/A)

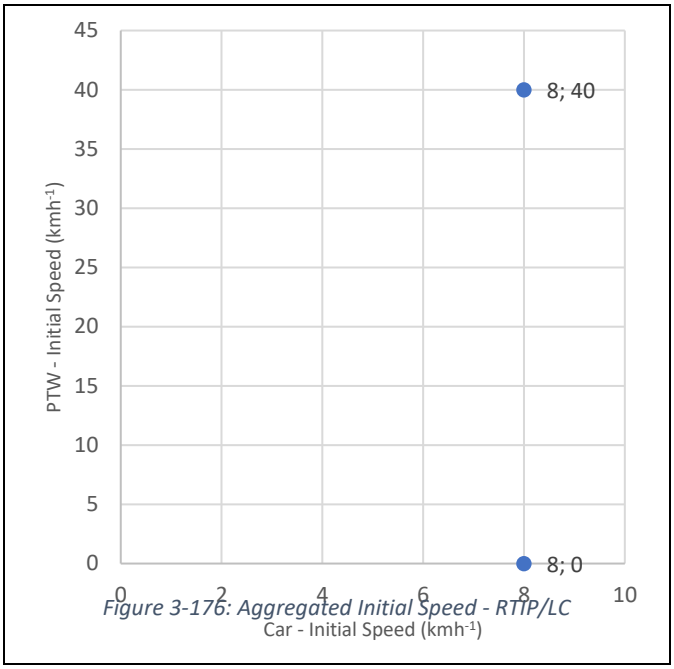


Figure 3-176: Aggregated Initial Speed - RTIP/LC

Impact Speed

Car (n = 5)

- Range: 5-24 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 4):

- Range: 21-58 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

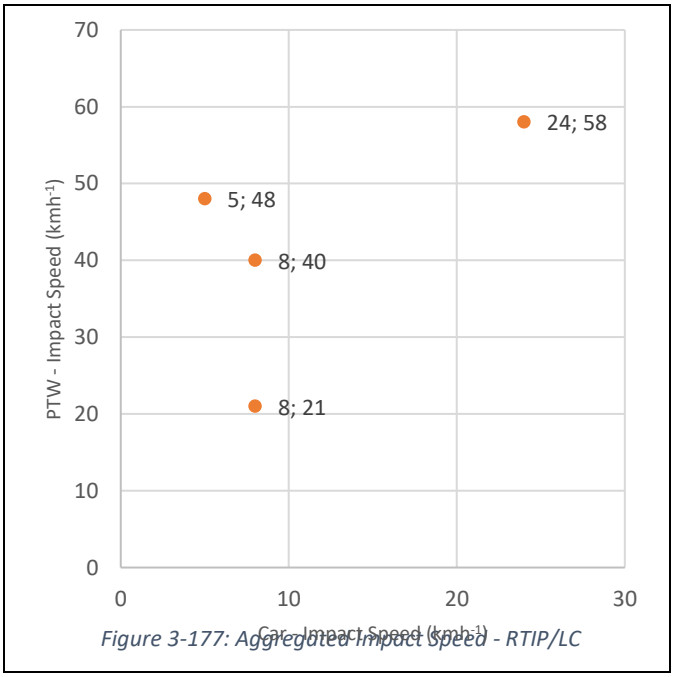
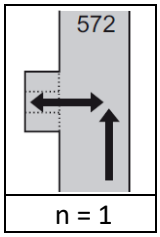


Figure 3-177: Aggregated Impact Speed - RTIP/LC

3.8.13 Reverse Driving – Opposite Direction



Car manoeuvre: Reversing
PTW manoeuvre: Travelling straight ahead

Figure 3-178: Accident Types - RD/OD

Initial Speed

Car (n = 1)

- Range: 10 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 120 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

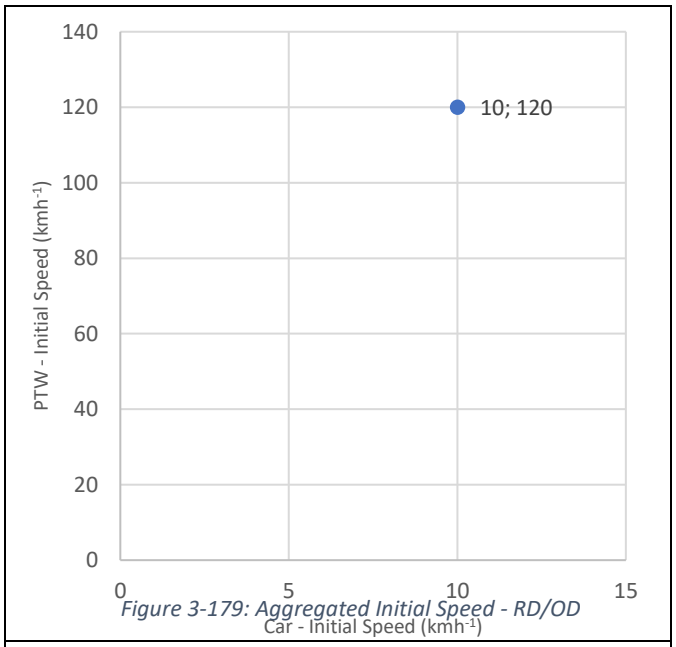


Figure 3-179: Aggregated Initial Speed - RD/OD

Impact Speed

Car (n = 1)

- Range: 10 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

PTW (n = 1):

- Range: 103 kmh^{-1}
- IQR: (N/A)
- Median: (N/A)

Unpaired Car and PTW cases:

- Car: (N/A)
- PTW: (N/A)

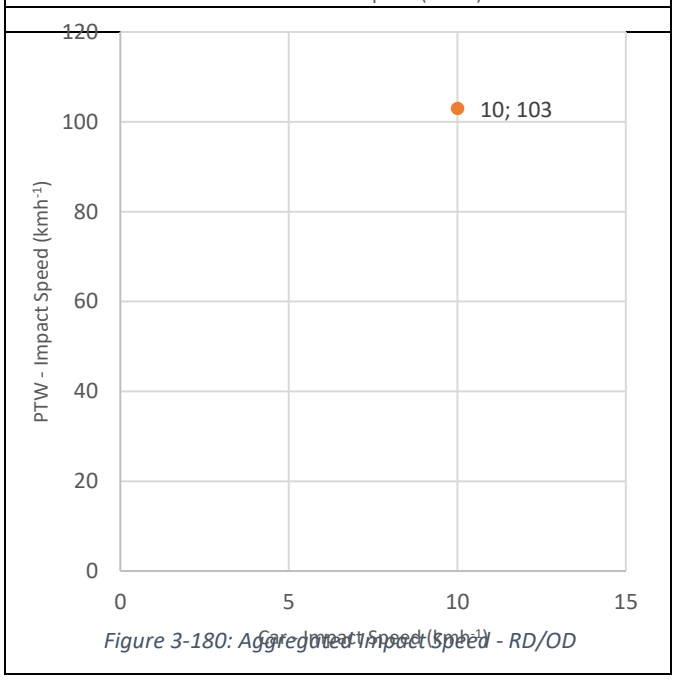


Figure 3-180: Aggregated Impact Speed - RD/OD

3.9 Use Cases

Use cases are based on the aggregated percentages of each accident scenario from the countries of study. These aggregated percentage are the product of the individual cluster percentage, accident type subset percentage and the Figure 2-3: Percentage of Motorcycle fatalities at 30 days by EU country (Figure 2-1: Fatalities at 30 days in EU countries in 2016) - in the absence of Car to Motorcycle KSI statistic in the EU, Motorcycle fatalities are used as a proxy. This approach allows the accident scenarios to be ranked by frequency and inform which scenario should be included in the test development.

There are instances where more than one accident scenario has been assigned to a cluster (Table 3.4.1-1: DGT Cluster Analysis - Frontal Lateral,

Table 3.5.1-1: UK National data - KSI Junction accident clusters Table 3.6.1-1: ELSTAT Cluster Analysis - Frontal Side, Table 3.6.2-1: ELSTAT Cluster Analysis - Frontal and Table 3.7.1-1: SWOV Cluster Analysis - Lateral) due to a lack of detail in the accident data on vehicle orientation relative to each other. To ensure that any accident scenario is not under or over represented three provisional aggregations were made to understand the influence of different approaches to weighting the scenarios 1) equal weighting of 100% given to each scenario within the cluster, 2) equal weighting of 1/n scenarios (e.g. 33.3% if there are three scenarios assigned within the cluster) and 3) weighting based on the proportionality of the accident scenarios as reported in the GIDAS analysis.

GIDAS weighting is used instead of the native in-depth data from the UK and Spanish in-depth dataset due to low sample and therefore concerns about how representative the in-depth data is to national data. GIDAS weighting is also used as a proxy for The Netherlands and Greek accident scenario distributions in the absence of any in-depth data. It is acknowledged that this is an imperfect solution but is a pragmatic approach to identifying the pertinent accident scenarios.

Table 3.8.13-1 to Table 3.8.13-6 summarise the three approaches to weighting of the accident scenarios in terms of accident scenario distribution and the effect on accident group percentages. The shared and GIDAS weighted accident groups are very similar in their percentages with the equal weighted groupings been greater and potentially giving an over-representation albeit not significantly changing the ranking of the groups and the constituent accident scenarios. **Left Turn Across Path – Opposite Direction** is the predominant group, followed by **Left Turn Across Path – Left Direction** or **Straight Crossing Path – Right Direction** then **Left Turn Across Path – Same Direction.**

Sections 3.9.1 to 3.9.14 summarise the accident groupings including notable findings from the cluster analysis and information on initial and impact speeds from the analysis of the in-depth databases. Where equal, shared or GIDAS weighting have been used the accident scenario weightings are respectively given.

Table 3.8.13-1: Accident Scenario - Equal Weighting

Accident Type	Cluster Reference	Cluster %	Equal Weighting %	KSI %	Country Weighting %	Rank %	GDV	Accident Grouping
Junction (UK)	1	69.2%	100.0%	79.0%	8.6%	4.7%	202	Left Turn Across Path - Same Direction Conflict
Junction (UK)	1	69.2%	100.0%	79.0%	8.6%	4.7%	302	Left Turn Across Path - Left Direction Conflict
Junction (UK)	1	69.2%	100.0%	79.0%	8.6%	4.7%	211	Left Turn Across Path - Opposite Direction Conflict
Junction (UK)	1	69.2%	100.0%	79.0%	8.6%	4.7%	322	Left Turn Into Path - Right Direction Conflict
Junction (UK)	2	30.8%	100.0%	79.0%	8.6%	2.1%	302	Left Turn Across Path - Left Direction Conflict
Junction (UK)	2	30.8%	100.0%	79.0%	8.6%	2.1%	202	Left Turn Across Path - Same Direction Conflict
Fronto Lateral (Spain)	1	40.5%	100.0%	70.3%	9.4%	2.7%	202	Left Turn Across Path - Same Direction Conflict
Fronto Lateral (Spain)	1	40.5%	100.0%	70.3%	9.4%	2.7%	302	Left Turn Across Path - Left Direction Conflict
Fronto Lateral (Spain)	1	40.5%	100.0%	70.3%	9.4%	2.7%	211	Left Turn Across Path - Opposite Direction Conflict
Fronto Lateral (Spain)	1	40.5%	100.0%	70.3%	9.4%	2.7%	322	Left Turn Into Path - Right Direction Conflict
Fronto Lateral (Spain)	2	59.5%	100.0%	70.3%	9.4%	3.9%	301	Straight Crossing Path - Left Direction Conflict
Fronto Lateral (Spain)	2	59.5%	100.0%	70.3%	9.4%	3.9%	302	Left Turn Across Path - Left Direction Conflict
Lateral (The Netherlands)	2	29.6%	100.0%	58.8%	1.2%	0.2%	302	Left Turn Across Path - Left Direction Conflict
Lateral (The Netherlands)	2	29.6%	100.0%	58.8%	1.2%	0.2%	202	Left Turn Across Path - Same Direction Conflict
Frontal Side (Greece)	1	34.6%	100.0%	70.9%	6.6%	1.6%	302	Left Turn Across Path - Left Direction Conflict
Frontal Side (Greece)	1	34.6%	100.0%	70.9%	6.6%	1.6%	202	Left Turn Across Path - Same Direction Conflict
Frontal Side (Greece)	1	34.6%	100.0%	70.9%	6.6%	1.6%	211	Left Turn Across Path - Opposite Direction Conflict
Frontal Side (Greece)	1	34.6%	100.0%	70.9%	6.6%	1.6%	322	Left Turn Into Path - Right Direction Conflict
Frontal Side (Greece)	3	39.0%	100.0%	70.9%	6.6%	1.8%	301	Straight Crossing Path - Left Direction Conflict
Frontal Side (Greece)	3	39.0%	100.0%	70.9%	6.6%	1.8%	321	Straight Crossing Path - Right Direction Conflict
Frontal (Greece)	1	70.7%	100.0%	11.5%	6.6%	0.5%	681	On Coming - Straight Driving
Frontal (Greece)	1	70.7%	100.0%	11.5%	6.6%	0.5%	682	On Coming - Turning

Table 3.8.13-2: Accident Scenario - Shared Weighting

Accident Type	Cluster Reference	Cluster %	Equal Weighting %	KSI %	Country Weighting %	Rank %	GDV	Accident Grouping
Junction (UK)	1	69.2%	25.0%	79.0%	8.6%	1.2%	202	Left Turn Across Path - Same Direction Conflict
Junction (UK)	1	69.2%	25.0%	79.0%	8.6%	1.2%	302	Left Turn Across Path - Left Direction Conflict
Junction (UK)	1	69.2%	25.0%	79.0%	8.6%	1.2%	211	Left Turn Across Path - Opposite Direction Conflict
Junction (UK)	1	69.2%	25.0%	79.0%	8.6%	1.2%	322	Left Turn Into Path - Rigth Direction Conflict
Junction (UK)	2	30.8%	50.0%	79.0%	8.6%	1.1%	302	Left Turn Across Path - Left Direction Conflict
Junction (UK)	2	30.8%	50.0%	79.0%	8.6%	1.1%	202	Left Turn Across Path - Same Direction Conflict
Fronto Lateral (Spain)	1	40.5%	25.0%	70.3%	9.4%	0.7%	202	Left Turn Across Path - Same Direction Conflict
Fronto Lateral (Spain)	1	40.5%	25.0%	70.3%	9.4%	0.7%	302	Left Turn Across Path - Left Direction Conflict
Fronto Lateral (Spain)	1	40.5%	25.0%	70.3%	9.4%	0.7%	211	Left Turn Across Path - Opposite Direction Conflict
Fronto Lateral (Spain)	1	40.5%	25.0%	70.3%	9.4%	0.7%	322	Left Turn Into Path - Rigth Direction Conflict
Lateral (The Netherlands)	2	29.6%	50.0%	58.8%	1.2%	0.1%	302	Left Turn Across Path - Left Direction Conflict
Lateral (The Netherlands)	2	29.6%	50.0%	58.8%	1.2%	0.1%	202	Left Turn Across Path - Same Direction Conflict
Frontal Side (Greece)	1	34.6%	25.0%	70.9%	6.6%	0.4%	302	Left Turn Across Path - Left Direction Conflict
Frontal Side (Greece)	1	34.6%	25.0%	70.9%	6.6%	0.4%	202	Left Turn Across Path - Same Direction Conflict
Frontal Side (Greece)	1	34.6%	25.0%	70.9%	6.6%	0.4%	211	Left Turn Across Path - Opposite Direction Conflict
Frontal Side (Greece)	1	34.6%	25.0%	70.9%	6.6%	0.4%	322	Left Turn Into Path - Rigth Direction Conflict
Frontal Side (Greece)	3	39.0%	50.0%	70.9%	6.6%	0.9%	301	Straight Crossing Path - Left Direction Conflict
Frontal Side (Greece)	3	39.0%	50.0%	70.9%	6.6%	0.9%	321	Straight Crossing Path - Right Direction Conflict
Frontal (Greece)	1	70.7%	50.0%	11.5%	6.6%	0.3%	681	On Coming - Straight Driving
Frontal (Greece)	1	70.7%	50.0%	11.5%	6.6%	0.3%	682	On Coming - Turning
Frontal (Greece)	2	29.3%	50.0%	11.5%	6.6%	0.1%	681	On Coming - Straight Driving
Frontal (Greece)	2	29.3%	50.0%	11.5%	6.6%	0.1%	682	On Coming - Turning

Table 3.8.13-3: Accident Scenario - In-Depth Weighting

Accident Type	Cluster Reference	Cluster %	In-Depth Weighting %	KSI %	Country Weighting %	Rank %	GDV	Accident Grouping
Junction (UK)	1	69.2%	12.9%	79.0%	8.6%	0.6%	202	Left Turn Across Path - Same Direction Conflict
Junction (UK)	1	69.2%	37.7%	79.0%	8.6%	1.8%	302	Left Turn Across Path - Left Direction Conflict
Junction (UK)	1	69.2%	40.2%	79.0%	8.6%	1.9%	211	Left Turn Across Path - Opposite Direction Conflict
Junction (UK)	1	69.2%	9.1%	79.0%	8.6%	0.4%	322	Left Turn Into Path - Rigth Direction Conflict
Junction (UK)	2	30.8%	74.4%	79.0%	8.6%	1.6%	302	Left Turn Across Path - Left Direction Conflict
Junction (UK)	2	30.8%	25.6%	79.0%	8.6%	0.5%	202	Left Turn Across Path - Same Direction Conflict
Fronto Lateral (Spain)	1	40.5%	12.9%	70.3%	9.4%	0.3%	202	Left Turn Across Path - Same Direction Conflict
Fronto Lateral (Spain)	1	40.5%	37.7%	70.3%	9.4%	1.0%	302	Left Turn Across Path - Left Direction Conflict
Fronto Lateral (Spain)	1	40.5%	40.2%	70.3%	9.4%	1.1%	211	Left Turn Across Path - Opposite Direction Conflict
Fronto Lateral (Spain)	1	40.5%	9.1%	70.3%	9.4%	0.2%	322	Left Turn Into Path - Rigth Direction Conflict
Lateral (The Netherlands)	2	29.6%	74.4%	58.8%	1.2%	0.2%	302	Left Turn Across Path - Left Direction Conflict
Lateral (The Netherlands)	2	29.6%	25.6%	58.8%	1.2%	0.1%	202	Left Turn Across Path - Same Direction Conflict
Frontal Side (Greece)	1	34.6%	37.7%	70.9%	6.6%	0.6%	302	Left Turn Across Path - Left Direction Conflict
Frontal Side (Greece)	1	34.6%	12.9%	70.9%	6.6%	0.2%	202	Left Turn Across Path - Same Direction Conflict
Frontal Side (Greece)	1	34.6%	40.2%	70.9%	6.6%	0.6%	211	Left Turn Across Path - Opposite Direction Conflict
Frontal Side (Greece)	1	34.6%	9.1%	70.9%	6.6%	0.1%	322	Left Turn Into Path - Rigth Direction Conflict
Frontal Side (Greece)	3	39.0%	59.8%	70.9%	6.6%	1.1%	301	Straight Crossing Path - Left Direction Conflict
Frontal Side (Greece)	3	39.0%	40.2%	70.9%	6.6%	0.7%	321	Straight Crossing Path - Right Direction Conflict
Frontal (Greece)	1	70.7%	44.4%	11.5%	6.6%	0.2%	681	On Coming - Straight Driving
Frontal (Greece)	1	70.7%	55.6%	11.5%	6.6%	0.3%	682	On Coming - Turning
Frontal (Greece)	2	29.3%	44.4%	11.5%	6.6%	0.1%	681	On Coming - Straight Driving
Frontal (Greece)	2	29.3%	55.6%	11.5%	6.6%	0.1%	682	On Coming - Turning

Table 3.8.13-4: Accident Groups - Equal Weighting

Accident Group	Weighted Percentage
Left Turn Across Path - Opposite Direction Conflict	21.41%
Left Turn Across Path - Left Direction Conflict	18.37%
Straight Crossing Path - Right Direction Conflict	13.93%
Left Turn Across Path - Same Direction Conflict	14.56%
Straight Crossing Path - Left Direction Conflict	9.59%
Follow-up Driving	5.77%
Parallel Driving	3.52%
Lane Change - Same Direction Conflict	3.20%
On Coming - Straight Driving	2.82%
Lane Change - Opposite Direction	2.02%
On Coming - Turning	1.64%
Left Turn Into Path - Right Direction Conflict	0.00%
Right Turn Into Path - Left Direction Conflict	0.35%
Reverse Across Path - Right Direction Conflict	0.20%
Reverse Crossing Path - Left Direction	0.00%
Parallel Turn - Same Direction	0.00%
Reverse Driving - Opposite Direction	0.00%
Right Turn Across Path - Right Direction	0.00%

Table 3.8.13-5: Accident Groups - Shared Weighting

Accident Group	Weighted Percentage
Left Turn Across Path - Opposite Direction Conflict	14.66%
Straight Crossing Path - Right Direction Conflict	13.02%
Left Turn Across Path - Left Direction Conflict	8.50%
Follow-up Driving	5.77%
Left Turn Across Path - Same Direction Conflict	6.66%
Straight Crossing Path - Left Direction Conflict	6.73%
Parallel Driving	3.52%
Lane Change - Same Direction Conflict	3.20%
On Coming - Straight Driving	2.44%
Lane Change - Opposite Direction	2.02%
On Coming - Turning	1.26%
Left Turn Into Path - Right Direction Conflict	2.65%
Right Turn Into Path - Left Direction Conflict	0.35%
Reverse Across Path - Right Direction Conflict	0.20%
Reverse Crossing Path - Left Direction	0.00%
Parallel Turn - Same Direction	0.00%
Reverse Driving - Opposite Direction	0.00%
Right Turn Across Path - Right Direction	0.00%

Table 3.8.13-6: Accident Groups - In-Depth Weighting

Accident Group	Weighted Percentage
Left Turn Across Path - Opposite Direction Conflict	16.03%
Straight Crossing Path - Right Direction Conflict	12.84%
Left Turn Across Path - Left Direction Conflict	11.29%
Follow-up Driving	5.77%
Straight Crossing Path - Left Direction Conflict	5.83%
Left Turn Across Path - Same Direction Conflict	5.01%
Parallel Driving	3.52%
Lane Change - Same Direction Conflict	3.20%
On Coming - Straight Driving	2.40%
Lane Change - Opposite Direction	2.02%
On Coming - Turning	1.30%
Left Turn Into Path - Right Direction Conflict	1.22%
Right Turn Into Path - Left Direction Conflict	0.35%
Reverse Across Path - Right Direction Conflict	0.20%
Reverse Crossing Path - Left Direction	0.00%
Parallel Turn - Same Direction	0.00%
Reverse Driving - Opposite Direction	0.00%
Right Turn Across Path - Right Direction	0.00%

3.9.1 Left Turn Across Path - Opposite Direction Conflict

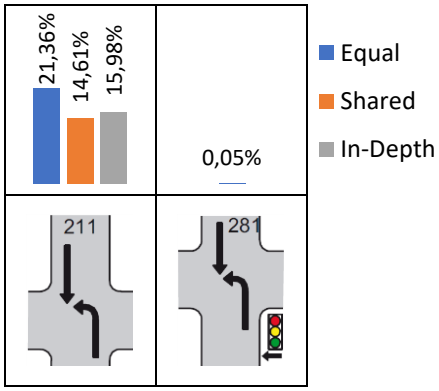


Figure 3-181: Use cases - LTAP/OD

21.41%, 14.66% or 16.03% of KSI accidents have been classified as **Left Turn Across Path – Opposite Direction Conflict**. In this scenario the car is represented as the ego-vehicle performing the left turn across the path of the oncoming PTW.

Cluster analysis results describe the accident occurring on urban roads and where speed limit data is available in areas with limits of 50km/h, 80km/h and 100km/h. Typically the impact location for both the car and PTW is the front.

Initial travel and impact speeds describe two possible manoeuvres for the car at the junction, starting stationary and slowly turning into the priority road or continuing at a low speed approaching the junction and turning. The PTW maintains a near constant speed between the start and end of the travel phase.

Table 3.9.1-1: Phase Speeds- LTAP/OD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	0-32	29-80	4-20	-	8	-
	Impact	8-32	24-80	10-22	30-47	16	38
VOIESUR	Initial	0-70	50-145	12-26	50-97	20	80
	Impact	0-99	30-120	15-25	68-98	20	84
IGLAD	Initial	0-36	20-120	12-25	51-86	18	65
	Impact	0-36	20-114	13-25	49-74	19	57
GIDAS	Initial	5-55	30-125	20-30	45-60	30	50
	Impact	5-45	10-125	15-30	35-55	20	45
DIANA	Initial	8-40	50-105	-	-	-	-
	Impact	8-39	40-85	-	-	-	-
Aggregated	Initial	0-70	20-145	15-30	47-79	22	55
	Impact	0-45	10-125	15-25	35-60	20	45

3.9.2 Straight Crossing Path - Right Direction Conflict

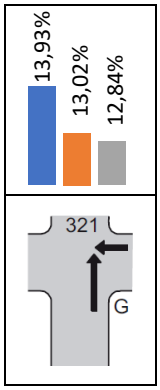


Figure 3-182: Use Cases - SCP/RD

13.93%, 13.02% or 12.84% of KSI accidents have been classified as **Straight Crossing Path – Right Direction Conflict**. In this scenario the car is represented as the ego-vehicle, failing to give way to priority traffic, traveling straight across the path of the PTW travelling from the car's nearside PTW at a crossroads.

Cluster analysis results describe the accident occurring on urban roads and where speed limit data is available in areas with limits of 50km/h. Typically the impact location of the car is the front and for the PTW it is the front left.

Initial travel and impact speeds describe two possible manoeuvres for the car at the junction, starting and slowly turning into the priority road or continuing at a low speed towards the junction and turning. The PTW maintains a near constant speed between the start and end phase.

Table 3.9.2-1: Phase Speeds - LTAP/OD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	16-35	65-194	-	-	-	-
	Impact	16-35	48-144	-	-	-	-
VOIESUR	Initial	0-45	20-80	10-24	28-49	15	38
	Impact	0-45	46-99	15-35	-	17	-
IGLAD	Initial	12-44	25-60	-	29-54	30	30
	Impact	12-44	25-60	-	28-54	-	42
GIDAS	Initial	5-75	25-75	15-33	35-48	20	45
	Impact	5-60	5-60	18-30	30-45	20	30
DIANA	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
Aggregated	Initial	0-110	5-80	15-39	30-50	23	40
	Impact	0-87	5-99	16-35	30-55	20	35

3.9.3 Left Turn Across Path - Left Direction Conflict

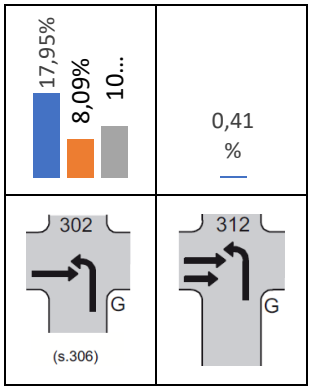


Figure 3-183: Use Cases – LTAP/LD

18.37%, 8.50%, 11.29% of accidents have been classified as **Left Turn Across Path – Left Direction Conflict**. In this scenario the car is represented as the ego vehicle performing the left turn across the path of the oncoming PTW. In a small number of cases, the PTW is overtaking or travelling parallel with a vehicle in the same direction on the offside. Several accident descriptions in the UK in-depth database describe the PTW filtering along the offside of stationary traffic and the conflict occurs when the car turns left into a gap in the traffic queue.

Cluster analysis results describe the accident occurring on urban roads and where speed limit data is available in areas with speed limits of 50km/h and 100km/h. Typically the impact location on the car is the offside and for the PTW it is the front.

Initial travel and impact speeds describe two possible manoeuvres for the car at the junction, starting and slowly turning into the priority road or continuing at a low speed towards the junction and turning. The PTW maintains a near constant speed between the start and end phase.

Table 3.9.3-1: Phase Speeds - LTAP/LD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	0-24	32-97	8-8	48-56	8	48
	Impact	8-24	0-97	8-12	39-54	8	47
VOIESUR	Initial	0-50	50-113	3-20	66-90	10	70
	Impact	0-40	30-99	3-18	41-73	10	60
IGLAD	Initial	0-20	54-100	2-5	65-89	4	80
	Impact	0-11	35-95	2-8	55-79	5	72
GIDAS	Initial	5-40	30-95	5-20	45-65	15	50
	Impact	5-35	10-95	10-50	35-50	45	45
DIANA	Initial	15	50-95	-	-	-	-
	Impact	15	40-60	-	-	-	-
Aggregated	Initial	0-40	25-113	5-20	48-75	6	55
	Impact	0-40	10-99	5-18	40-60	15	45

3.9.4 Follow-up Driving

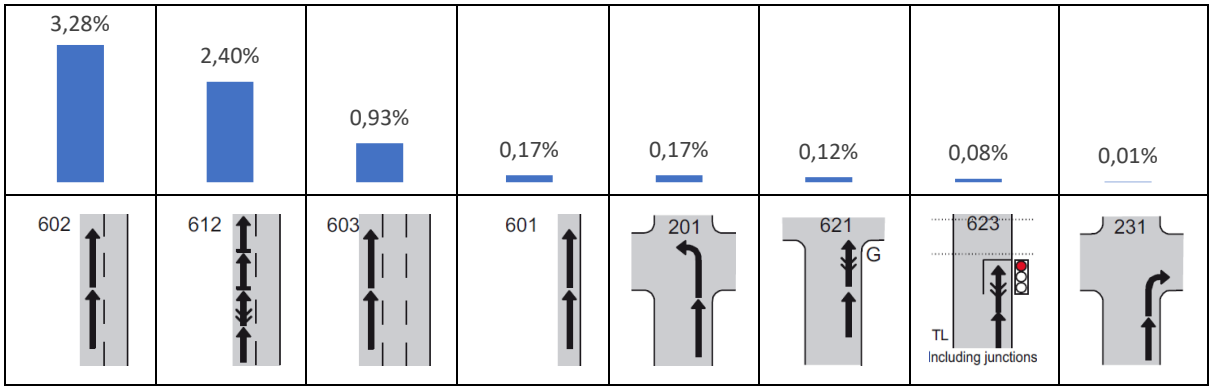


Figure 3-184: Use Cases - FUD

5.77% of accidents have been classified as **Follow-Up Driving**. In this scenario the car is represented as the ego vehicle travelling straight ahead and impacting the rear of the PTW whilst it is also travelling straight ahead, slowing, stationary or turning.

Cluster analysis results describe the accident occurring mainly urban roads, not at junctions and on single carriage way roads with both vehicles travelling straight ahead. Where accident occur at junctions the vehicle manoeuvres are mostly with both vehicles travelling ahead so the junction detail maybe incidental to the accident. Where speed limit data is available in areas with speed limits of 50km/h and 100km/h.

Initial travel and impact speed data is limited in the in-depth datasets, but it does represent two scenarios where the PTW is either stationary/slowing or travelling slower than the following car.

Table 3.9.4-1: Phase Speeds - FUD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	53-103	65-113	-	-	-	-
	Impact	53-103	0-81	-	-	-	-
VOIESUR	Initial	50-70	0	-	-	-	-
	Impact	-	0	-	-	-	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
DIANA	Initial	105	65	-	-	-	-
	Impact	91	65	-	-	-	-
Aggregated	Initial	0-105	0-94	10-36	20-63	25	50
	Impact	0-103	0-85	14-37	24-85	25	50

3.9.5 Straight Crossing Path - Left Direction Conflict

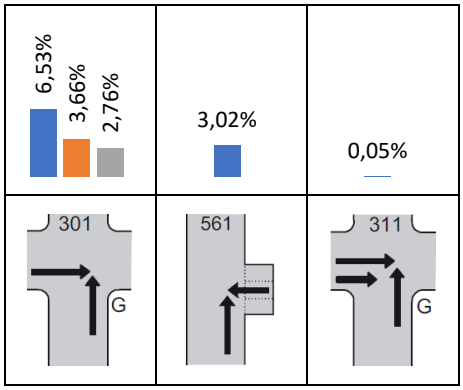


Figure 3-185: Use Cases - SCP/LD

9.59%, 6.73% or 5.83% of KSI accidents have been classified as **Straight Crossing Path – Left Direction Conflict**. In this scenario the car is represented as the ego-vehicle, failing to give way to priority traffic, traveling straight across the path of the PTW travelling from the car's nearside at a crossroads or parking space.

Cluster analysis results describe the accident occurring on urban roads and where speed limit data is available in areas with limits of 50km/h, 80km/h and 100km/h. Typically the impact location for both the car and PTW is the front.

Initial travel and impact speeds describe the car approaching and crossing the junction at low to moderate speeds given the priority nature, potentially suggesting minimal slowing at the junction whilst the PTW tends to be travelling at moderate speeds but slows slightly at impact probably due to braking intervention.

Table 3.9.5-1: Phase Speeds - SCP/LD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	40-103	32-113	-	-	-	-
	Impact	40-113	0-81	45-53	20-53	50	38
VOIESUR	Initial	0-30	50-150	15-20	50-110	17	60
	Impact	17-40	29-104	19-29	-	22	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	5-55	20-90	5-20	45-60	15	50
	Impact	5-55	20-65	10-25	35-55	20	45
DIANA	Initial	15-90	42-55	-	-	-	-
	Impact	35-42	15-60	-	-	-	-
Aggregated	Initial	0-90	15-150	10-28	44-60	15	50
	Impact	5-55	15-104	17-30	30-55	20	45

3.9.6 Left Turn Across Path - Same Direction Conflict

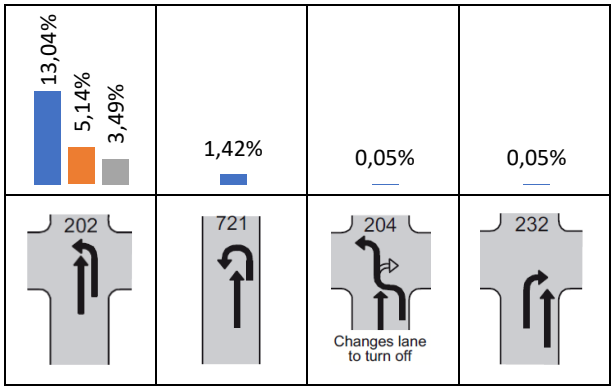


Figure 3-186: Use Cases - LTAP/SD

14.56%, 6.66% or 5.01% of KSI accidents have been classified as **Left Turn Across Path - Same Direction Conflict**. In this scenario the car is represented as the ego-vehicle performing the left turn across the path of the approaching PTW from behind the car. Based on accident descriptions in the in-depth datasets this accident group is typically the PTW filtering alongside stationary or slow-moving traffic and failing to observe the turning car and/or the car fails to observe the PTW. This scenario can be considered the same as Right Turn Across Path – Same Direction Conflict.

Cluster analysis results describe the accident occurring in urban areas, 50 km/h speed limit zone impact areas, impact locations for the car is the front, front left and offside with the impact location of the PTW being the front.

Initial travel and impact speeds describe the car mostly travelling between 10-28 km/h with the PTW travelling at a much higher speed of between 47-85 km/h. Impact speeds are only marginally lower than the travel speeds for both vehicles.

Table 3.9.6-1: Phase Speeds - LTAP/SD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	0-16	24-113	2-9	46-54	8	48
	Impact	0-24	5-105	8-14	31-52	8	40
VOIESUR	Initial	0-60	25-148	10-20	45-90	10	80
	Impact	0-110	40-144	0-17	54-89	10	74
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	5-100	35-110	20-35	56-70	23	68
	Impact	5-40	2-100	15-24	45-65	20	60
DIANA	Initial	10-30	25	-	-	-	-
	Impact	10-30	20-105	-	-	-	-
Aggregated	Initial	0-100	24-148	10-28	47-85	16	65
	Impact	0-110	5-144	8-20	40-78	15	60

3.9.7 Parallel Driving

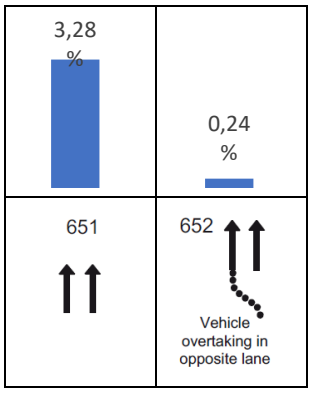


Figure 3-187: Use Cases - PD

3.52% of KSI accidents have been classified as **Parallel Driving**. In this scenario both vehicles are travelling straight ahead and it is assumed that one vehicle violates the demarcation of the lane, unfortunately none of the vehicle manoeuvre description cover this potential scenario only describing travelling straight ahead with the majority of the scenarios occurring on a straight road and not at a junction therefore the inference is a parallel driving accident.

There are only two in-depth cases one describes the car and PTW travelling at the same speeds and the in the other cases the PTW is travelling faster than the car.

Table 3.9.7-1: Phase Speeds - PD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
VOIESUR	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
DIANA	Initial	85	155	-	-	-	-
	Impact	85	155	-	-	-	-
Aggregated	Initial	56-85	56-155	-	-	-	-
	Impact	56-85	56-155	-	-	-	-

3.9.8 Lane Change - Same Direction Conflict

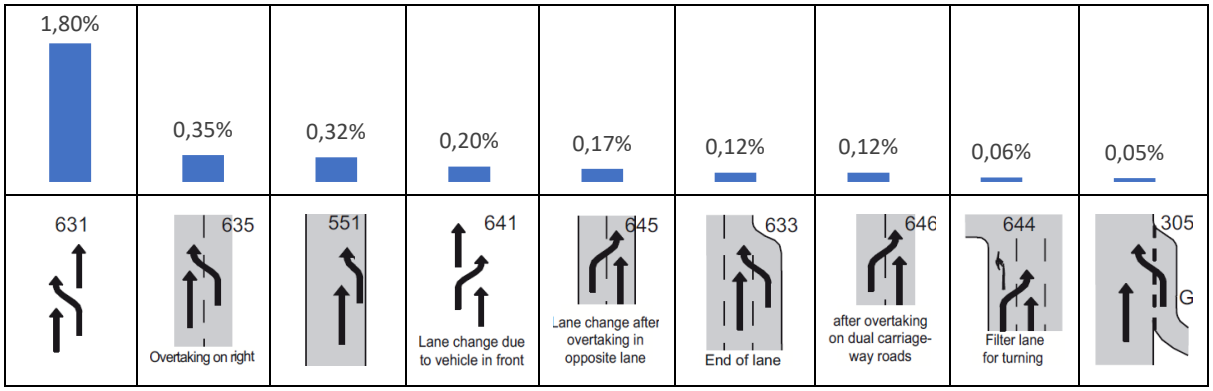


Figure 3-188: Use Cases - LC/SD

3.20% of KSI accidents have been classified as **Lane Change – Same Direction Conflict**. In this scenario the car is represented as the ego-vehicle performing the lane change in front on the path of the PTW. The reason for the lane change can be considered incidental to the conflict scenario – where the car changes lane when it is unsafe to do so.

Cluster analysis results describe the accident occurring in mostly urban areas, not at junctions, 50 km/h speed limit zone.

Initial travel and impact speeds describe the car mostly travelling between 10-28 km/h with the PTW travelling at a much higher speed of between 47-85 km/h. Impact speeds are only marginally lower than the travel speeds for both vehicles.

Table 3.9.8-1: Phase Speeds – LC/SD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	0-16	24-48	-	-	-	-
	Impact	5-16	24-26	-	-	-	-
VOIESUR	Initial	40-80	70-80	-	-	-	-
	Impact	40	40	-	-	-	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	30-80	50-110	41-73	59-93	48	70
	Impact	30-95	50-120	43-83	60-105	50	70
DIANA	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
Aggregated	Initial	3-97	48-129	40-75	65-80	56	70
	Impact	0-95	11-120	31-65	50-81	45	60

3.9.9 On Coming - Straight Driving

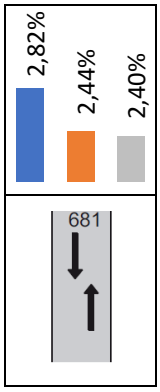


Figure 3-189: Use Cases - OC/SD

2.82%, 2.44% or 2.40% of KSI accidents have been classified as **On Coming – Straight Driving**. In this scenario both vehicles are travelling straight ahead in opposite directions.

Cluster analysis results describe the accident occurring on single carriageways, as expected, frontal impact locations and were speeds limits are recorded in the datasets the accidents occur in 50 and 80 km/h zones and on urban roads.

Table 3.9.9-1: Phase Speeds - OC/SD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
VOIESUR	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
DIANA	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
Aggregated	Initial	130-150	90-100	-	-	-	-
	Impact	120-150	60-70	-	-	-	-

3.9.10 Lane Change - Opposite Direction

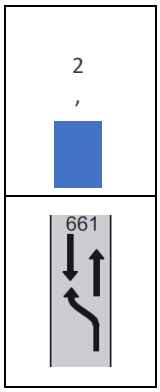


Figure 3-190; Use Cases - LC/OD

2.02% of KSI accidents have been classified as **Lane Change – Opposite Direction**. This scenario is only identified in the BAAC ONSIR Head-On data where three clusters exist, two of these are classified as 661 but in one cluster the PTW is the vehicle changing lanes (36.6%) and in the second cluster it is the car changing lanes (17.2%). Both clusters are included in the aggregated data on the proviso that a countermeasure manoeuvre could possibly exist for the not at fault car.

Cluster analysis results describe the accident occurring on single carriageways frontal impact locations and where speeds limits are recorded in the datasets the accidents occur in 50 and 80 km/h zones and on urban roads.

Table 3.9.10-1: Phase Speeds - LC/OD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	48	129	-	-	-	-
	Impact	48	81	-	-	-	-
VOIESUR	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
DIANA	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
Aggregated	Initial	48-105	100-129	-	-	-	-
	Impact	48-95	81-100	-	-	-	-

3.9.11 On Coming – Turning

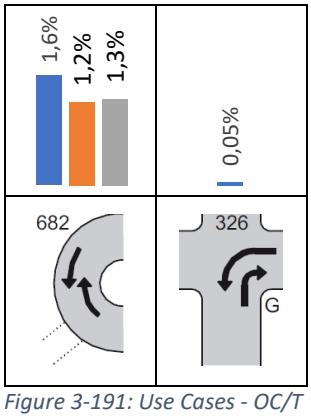


Figure 3-191: Use Cases - OC/T

1.64%, 1.26% or 1.30% of KSI accidents have been classified as **On Coming - Turning**. In this scenario both vehicles are cornering either whilst following a bend or at a junction. From analysis of in-depth datasets it is typical that it is the PTW that crosses the lane demarcation.

Cluster analysis results describe the accident occurring in 50 and 100 km/h speed limit zones.

Initial travel and impact speeds are comparable for both the car and PTW.

Table 3.9.11-1: Phase Speeds - OC/T

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	0-65	-	-	-	-	-
	Impact	32-65	11	-	-	-	-
VOIESUR	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	45-75	65-70	-	-	-	-
	Impact	45-60	65	-	-	-	-
DIANA	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
Aggregated	Initial	0-90	65-80	-	-	-	-
	Impact	32-70	11-65	-	-	-	-

3.9.12 Left Turn Into Path - Right Direction Conflict

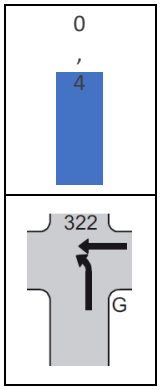


Figure 3-192: Use Cases - LTIP/RD

0.40% of KSI accidents have been classified as **Left Turn Into Path – Right Direction Conflict**. In this scenario the car is represented as the ego-vehicle performing the right turn into the path of the PTW approaching from the right.

Cluster analysis results describe the accident occurring in urban areas in a 50 km/h speed limit zone and with front to front impact locations. This cluster is limited to being defined in the STATS19, ELSTAT and GIDAS datasets, in the former two datasets the scenario is listed as one of many possible scenarios.

Initial travel and impact speeds describe the car travelling between 0-13 km/h with the PTW travelling at a much higher speed of between 52-105 km/h. Impact speeds for the PTW are lower than the travels speeds potentially suggesting a degree of braking intervention by the PTW rider.

Table 3.9.12-1: Phase Speeds - LTIP/RD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	0-13	52-105	-	-	-	-
	Impact	0-8	32-45	-	-	-	-
VOIESUR	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
DIANA	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
Aggregated	Initial	0-13	52-105	-	-	-	-
	Impact	0-8	32-45	-	-	-	-

3.9.13 Right Turn Into Path - Left Direction Conflict

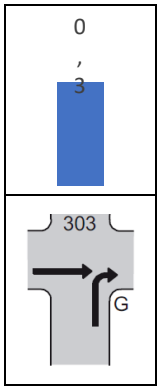


Figure 3-193: Use Cases - RTIP/LD

0.35% of KSI accidents have been classified as **Right Turn Into Path – Left Direction Conflict**. In this scenario the car is represented as the ego-vehicle performing the right turn into the path of the PTW approaching from the left.

The only occurrence of this scenario with regard to national data is in the GIDAS dataset so no further details on the accident scenario are available.

Initial travel and impact speeds describe the car mostly travelling between 0-8 km/h with the PTW travelling at a speed of between 0-40 km/h. Impact speeds for the car suggest that for these recorded cases the car has accelerated whilst turning.

Table 3.9.13-1: Phase Speeds – RTIP/LD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	0-8	0-40	-	-	-	-
	Impact	5-24	21-58	-	-	-	-
VOIESUR	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
DIANA	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
Aggregated	Initial	0-8	0-40	-	-	-	-
	Impact	5-24	21-58	-	-	-	-

3.9.14 Reverse Across Path - Right Direction Conflict

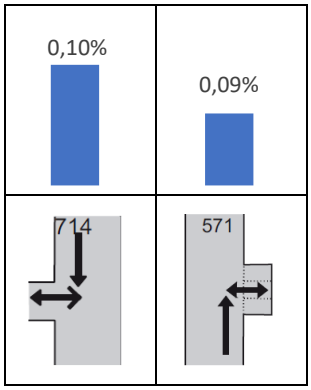


Figure 3-194: Use Cases - RAP/RD

0.19% of KSI accidents have been classified as **Reverse Across Path – Right Direction Conflict**. In this scenario the car is represented as the ego-vehicle reversing from a parking space or road perpendicular to the main road on which the PTW is travelling.

Both scenarios are referenced from the GIDAS national data inference therefore no further details on the accident scenario are available.

Speed data is limited but describes the typical scenario of a low speed reversing manoeuvre with the PTW travelling at a much higher speed on the main road.

Table 3.9.14-1: Phase Speeds - RAP/RD

Dataset	Phase	Range (km/h)		IQR (km/h)		Median (km/h)	
		Car	PTW	Car	PTW	Car	PTW
RAIDS, OTS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
VOIESUR	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
IGLAD	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
GIDAS	Initial	-	-	-	-	-	-
	Impact	-	-	-	-	-	-
DIANA	Initial	10	120	-	-	-	-
	Impact	10	103	-	-	-	-
Aggregated	Initial	10	120	-	-	-	-
	Impact	10	103	-	-	-	-

4 Conclusion

Over the half of the 62% of identified car to motorcycle accident scenarios occur at junctions, the most frequent accident group is Left Turn Across Path – Opposite Direction Conflict (16.03%), typified by the GDV accident scenario 211, followed by Straight Crossing Path – Right Direction Conflict (12.84%), GDV accident scenario 321, Left Turn Across Path – Left Direction Conflict (11.29%), GDV accident scenario 302 and then Straight Crossing Path – Left Direction Conflict (5.83%), GDV accident scenario 301. The next most frequent accident type is front to rear (5.77%) where the car is the rear impacting vehicle against a slower moving or stationary motorcycle. Renaming accident scenarios are head on conflicts either while both vehicles are traveling straight or cornering, lane change conflicts in the same or opposite directions of travel and variations on the car turning or travelling straight across the path of the motorcycle at junctions. A notable accident group, that although not as frequent as others but worthy of consideration as it potentially has similar sensing requirements as lane change manoeuvres, is Left Turn Across Path – Same Direction Conflict, GDV accident scenario 202 and 721.

Analysis of the national datasets was approached based on prior knowledge of the UK datasets and analysis methods used to derive car-to-car and car-to-pedestrian accident scenarios, namely cluster analysis. While it proved that many of the national datasets (STATS 19, BAAC ONSIR, DGT) had a good level of detail recorded others lacked in detail leading to inference/assumption of details or in the cases of the German national data only reporting on high-level accident types and necessitating the use of weighted GIDAS data in lieu. In terms of the cluster analysis it was found that the inclusion of environmental factors was detrimental to the cluster derivations possibly suggesting, that with no valid cluster ASW values, weather and lighting conditions do not have a significant effect on accident propensity, the main influence being the road geometry (i.e. junctions) and injudicious actions from the car driver.

In-depth databases were analysed to provide initial travel and impact speeds for the car and motorcycle by accident scenario. Whilst these datasets are very insightful due to the high number of variables recorded there is an inherent issue of a small number of analysed cases, but a good number of data samples have been returned for the more frequent accident scenarios identified in from the national dataset analysis that help form the basis for test procedures.

In summary WP1 has identified the most frequency car to motorcycle accident scenarios and the analysis is based on relevant data with respect to the countries of study and their PTW accident proportionality in the EU. Given the identified scenarios the countermeasures for the ego-vehicle being the car would be side-ways looking ADAS and further development of forward and rearward looking systems.

5 References

ACEM, 2009. *The MAIDS Report - version 2.0 (April 2009).* [Online]
Available at: http://www.maids-study.eu/pdf/MAIDS2.pdf
[Accessed 17 October 2017].

Alessandro Grassi, N. B. D. B. &. M. P., 2018. A comparative analysis of MAIDS and ISO13232 databases for the identification of the most representative impact scenarios for powered 2-wheelers in Europe. *Traffic Injury Prevention,* 19(7), pp. 766-772.

CEESAR, CERTH-HIT, CTL, Directorate-General for Mobility and Transport (European Comission), ITS, Loughborough University, NTUA, SWOV., 2018. *Publication Office of the European Union. Study on powered two-wheeler and bicycle accidents in the EU : final report.* [Online]
Available at: https://publications.europa.eu/en/publication-detail/-/publication/8eddd110-c52a-11e8-9424-01aa75ed71a1/language-en/format-PDF/source-search
[Accessed 10 October 2018].

CERTH, 2008. *1st User Forum Meeting Brussels.* [Online]
Available at: http://www.saferider-eu.org/assets/docs/1st-user-forum/Annex_4_Saferider_User_Forum_Nikolaou.pdf
[Accessed 7 September 2018].

CERTH, 2008. *About SAFERIDER.* [Online]
Available at: http://www.saferider-eu.org/about.html
[Accessed 7 September 2018].

European Comission, Directorate General for Transport, 2016. *Traffic Safety Basic Facts On Motorcycles & Mopeds.* s.l.:s.n.

European Commission, Directorate for Transport, 2017. *Traffic Safety Basic Facts on Motorcycles & Mopeds,* s.l.: European Commission.

European Commission, Directorate General for Transport, 2015. *Power Two Wheelers,* s.l.: European Commission.

Hautzinger, H. &. P. M. &. S. J., 2004. *Expansion on GIDAS sample data to the regional level: Statistical methodology and practical experiences.* s.l., 1st International Conference on ESAR.

Jeroen Uittenbogaard, O. O. d. C. S. v. M., 2016. *CATS Deliverable 2.2: CATS car-to-cyclist accident parameters and test scenarios,* s.l.: TNO.

Johann Stoll, A. S. M. W. P. S. T. S., 2016. *Public deliverables.* [Online]
Available at: http://www.prospect-project.eu/download/public-files/public_deliverables/PROSPECT-Deliverable-D3.1.-The-addressed-VRU-scenarios-within-PROSPECT-and-associated-test-catalogue.pdf.pdf
[Accessed 27 April 2018].

Kramlich, T., 2002. *Noch immer gefährliche Begegnungen: die häufigsten Gefahrensituationen für Motorradfahrer und die resultierenden Verletzungen..* s.l., In: Safety environment future IV: proceedings of the 4th International Motorcycle Conference, München, 16-17 September 2002, IfZ Forschungshefte Zweiradsicherheit No. 10, p. 55-84.

Marcus Wisch, P. S. C. P. M. E. C. V. C. R., 2013. *Scenarios and weighting factors for pre-crash assessment of integrated pedestrian safety systems,* s.l.: European Commission.

Noordzij, P. ,. V. A., 1998. *Safety of motorcycling in The Netherlands..* s.l., In: Safety environment future II: proceedings of the 1998 International Motorcycle Conference, IfZ Forschungshefte Zweiradsicherheit No. 8, p. 123-132.

OECD, 2015. *Improving Safety for Motorcycle, Scooter and Moped Riders,* s.l.: s.n.

Pierrini, M. et al., 2004. *APROSYS SP4: Motorcyclists: Accident National Data AP-SP41-0001-C,* s.l.: s.n.

Rousseeuw, P., 1986. Silhouettes: a graphical aid to the interpretation and validation of the cluster analysis. *Journal of Computational and Applied Mathematics,* pp. 53-65.

Vehicle Safety Research Centre, Loughborough University, 2010. *Final Report Summary - PISA (Powered Two-wheelers (PTW) Integrated Safety).* [Online]
Available at: https://cordis.europa.eu/project/rcn/81503/reporting/en
[Accessed October 2017].

6 Acknowledgements:

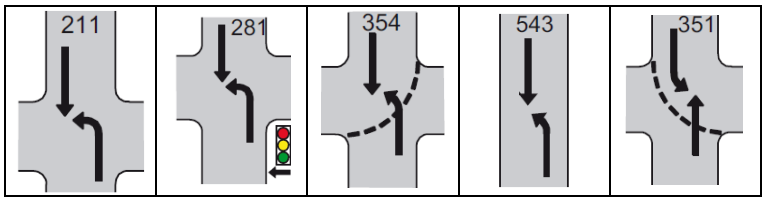
The MUSE consortium would like to acknowledge for their support and work:

4active SYSTEMS
AB Dynamics
BMW
BOSCH
DENSO
DRI Dynamic Research, Inc.
FCA FIAT CHRYSLER AUTOMOBILES
Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
HONDA
OPEL
UTAC CERAM
SUBARU
Volkswagen
Valeo
ZF
TRW
GROUPE RENAULT
veoneer

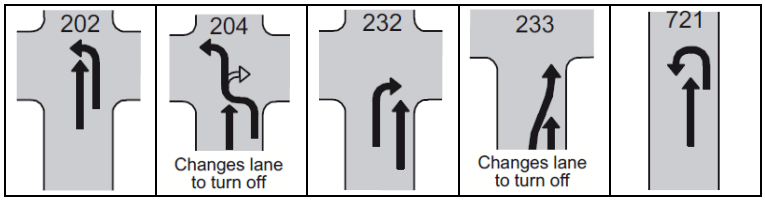
Appendix A: Accident Groupings and GDV Accident Types

There are 19 accident groupings comprising the following three-digit GDV accident types:

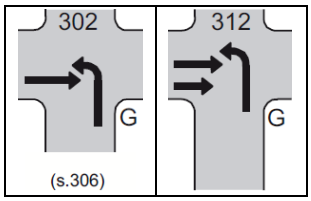
1. Left Turn Across Path - Opposite Direction



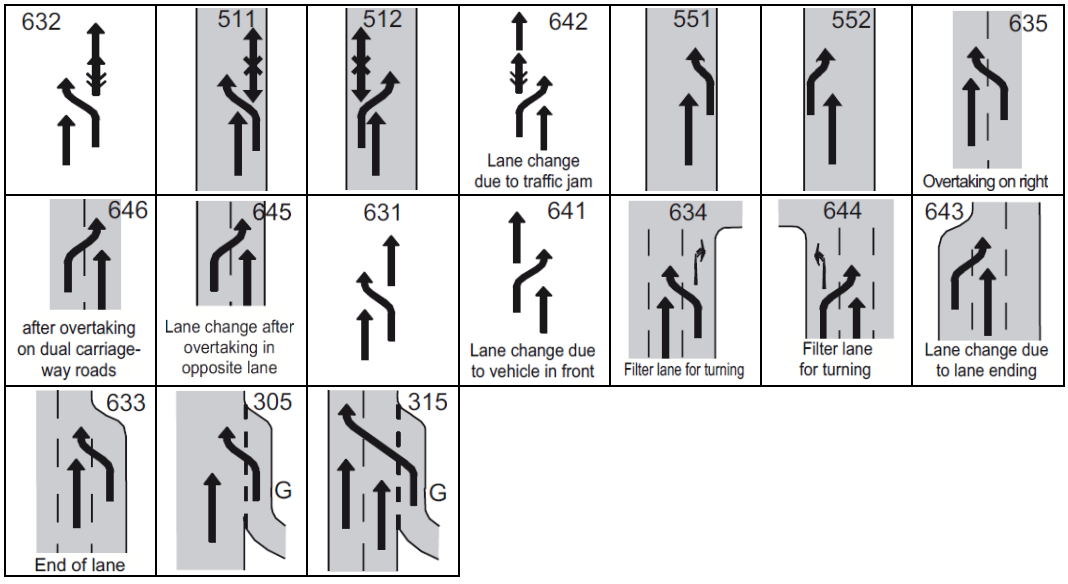
2. Left Turn Across Path – Same Direction



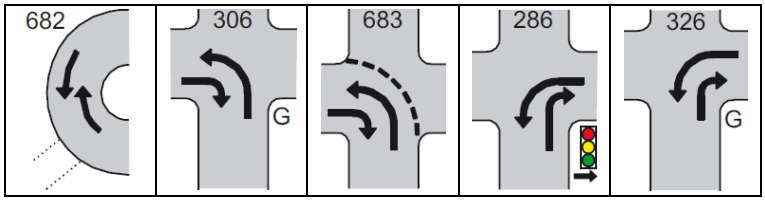
3. Left Turn Across Path – Left Direction



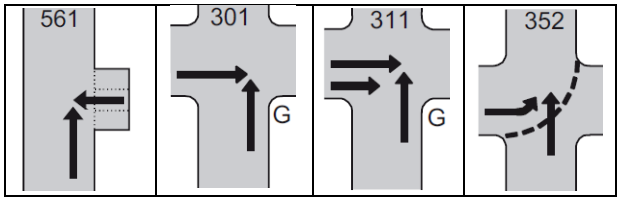
4. Lane Change – Same Direction



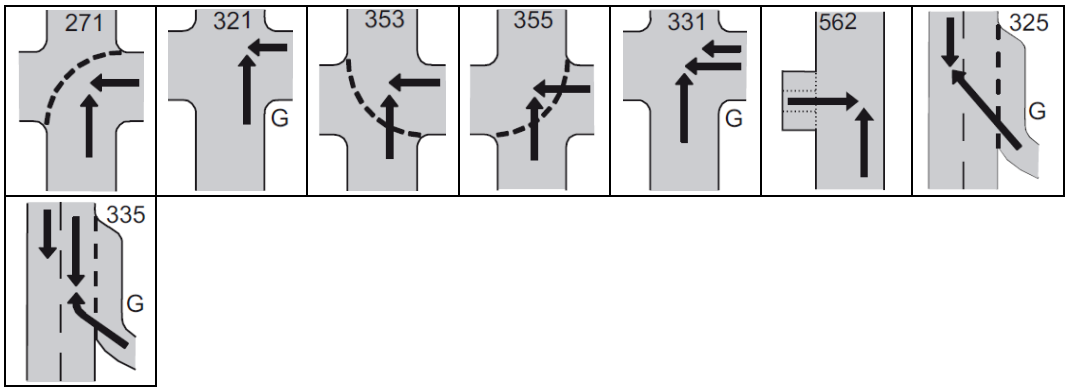
5. On Coming – Turning



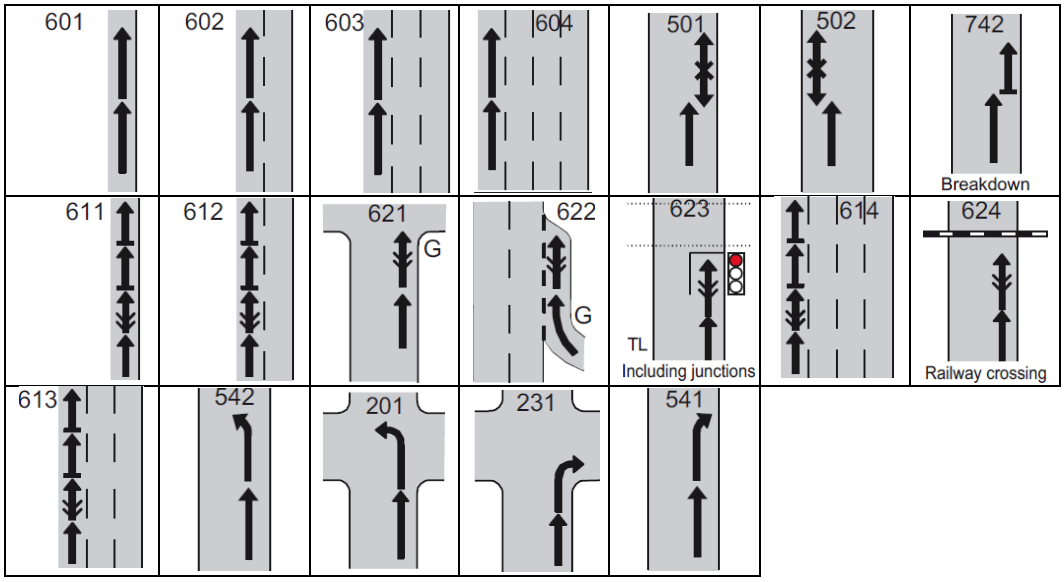
6. Straight Crossing Path – Left Direction



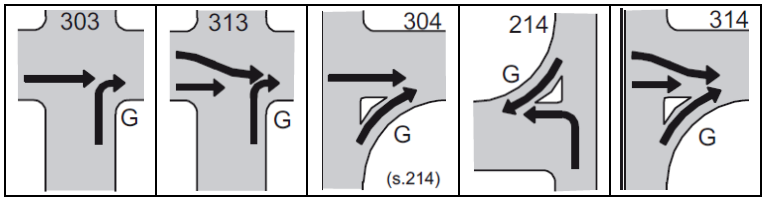
7. Straight Crossing Path – Right Direction



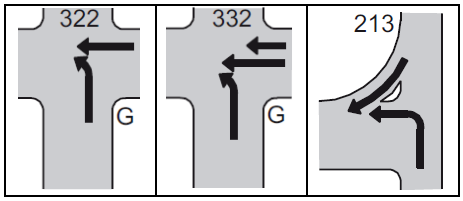
8. Follow-Up Driving



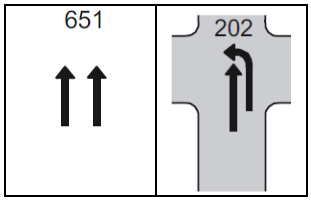
9. Right Turn Into Path – Left Direction



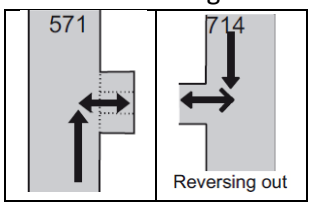
10. Left Turn Into Path – Right Direction



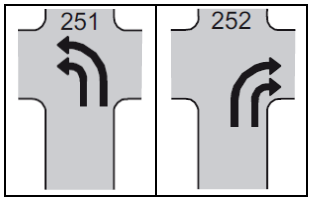
11. Parallel Driving



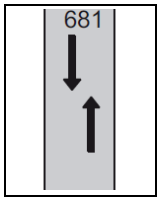
12. Reverse Crossing Path – Right Direction



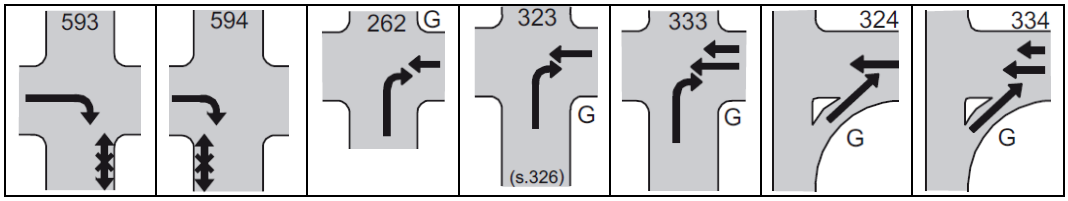
13. Parallel Turn – Same Direction



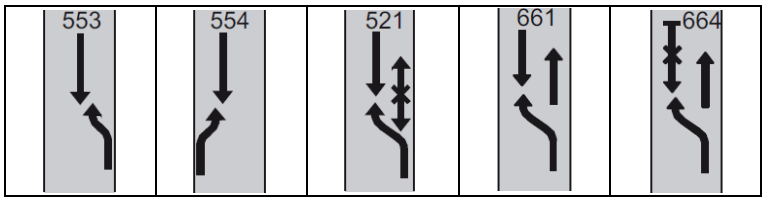
14. On Coming – Straight Driving



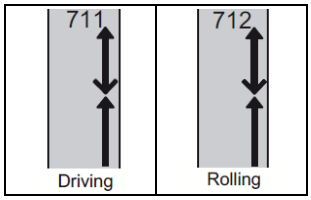
15. Right Turn Across Path – Right Direction



16. Lane Change – Opposite Direction



17. Reverse Driving – Opposite Direction



18. Reverse Crossing Path – Left Direction