2-BE-SAFE
2-WHEELER BEHAVIOUR AND SAFETY
Grant Agreement number: 218703
Funding Scheme: Collaborative project small scale
Start date of the contract: 01/01/2009
Project website address: *www.2besafe.eu*

Rider / Driver behaviours and road safety for PTW

Deliverable D1

Confidentiality level: public

Deliverable 1 of work package 1
Status: draft version
Date: 02/01/2010
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Amendments

Date of Issue	Description
DD/MM/YYYY	<comments>
DD/MM/YYYY	<comments>
DD/MM/YYYY	<comments>

Applicable Documents

Description
<comments>

Acknowledgements

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Executive summary

1. Introduction

The term Powered Two Wheeler (PTW) is a generic one used mainly in Europe to refer to motorcycles, scooters and mopeds. Riders of PTWs are over-involved in fatal crashes, worldwide. The OECD/ECMT International Road Accident Database (IRTAD) shows that, between 2002 and 2005, PTW deaths as a proportion of the total number of road deaths in European countries increased from 11,3% to 13,4%. Whilst the total number of road fatalities in the last decade has decreased in EU 14, this has coincided with a corresponding increase in fatalities for PTW riders. The risk of having an accident for PTW riders, taking into account vehicle mileage ridden per annum, varies considerably between European countries, and the accident risk for PTW riders is much greater than that for car drivers. Depending on the country, it is between about 5 and 25 times greater.

The European Community has through successive Framework Research Programs funded research to improve road safety. However, most large-scale research programs that have been undertaken in Europe and abroad to understand the behavioural and ergonomic factors that contribute, alone and in combination, to crashes have focussed on 4-wheeled vehicles. No comparable human factors and behavioural research programs have been initiated in the PTW domain. In large part, this is because there has to date been a chronic lack of suitable research tools, such as instrumented PTWs and PTW simulators, to study in detail the behaviour of PTW behaviours. The 2BESAFE project addresses this important gap in research. This project, funded under the European Commision (EC) 7th Framework Research Program FP7), involves partners from Europe, Israel and Australia. It directly focuses on behavioural and ergonomic factors cited in the European MAIDS[1] study (Motorcycle Accidents In-Depth Study) as contributing to PTW crashes. The project includes fundamental research on crash causes and human error (Work Package 1; WP1), the first known naturalistic driving study involving instrumented PTWs (WP2), experimental research on motorcycle rider risk awareness and perception (WP3), the development of research tools to support this human factors and behavioural research program (WP4), a large-scale research program on the factors that underlie driver failures to see PTWs and their riders (WP5), and the development of practical countermeasures for enhancing PTW rider safety deriving from all these activities (WP6). In this paper, we report on research activities deriving from Activity 1.1 of WP1.

Over the last decade, several studies have analysed PTW accidents in order to understand their causes. One of them, MAIDS (ACEM 2003), provides the most comprehensive in-depth data currently available for Powered Two-Wheelers (PTWs) accidents in Europe. The MAIDS study was conducted over 3 years and analysed 921 accidents from 5 countries using a common OECD-defined research methodology. The MAIDS study concluded that 88% of the primary contributing factors in PTW crashes were linked with a human error (37.5% for the PTW riders and 50.5% for the opponent vehicle drivers, respectively):

- 36% of all the primary contributing factors were perception failures related to the other vehicle driver. The other vehicle rider was unable to perceive the PTW or its rider.
- 13% of all the primary contributing factors were decision failures related to the PTW rider. Here, the rider failed to make the correct decision to avoid a dangerous condition.
- For 11% of the riders and 18% of the opponent vehicle drivers, inattention was a contributing factor.
- For 28% of the riders and 63% of the opponent vehicle drivers, a traffic scan error was a factor which contributed to the accident. A traffic-scan error was considered to be any situation in which the rider did not observe or perceive oncoming traffic or traffic that may have been entering the roadway from some other direction.
- For 19% of the riders and 23% of the opponent vehicle drivers, the presence of visual obstructions on the road of the user was a contributing factor.

An extensive review of the literature on interactions between drivers and riders in PTW accidents undertaken by the authors reveals the following factors that appear to contribute to increased crash risk:

[1] Motorcycle Accidents In-Depth Study, project fund by the European Commission and ACEM (the Motorcycle Industry in Europe)

- Riding/driving attitudes and patterns (such as sensation seeking, risk taking, speeding and so on)
- Age, gender and experience
- Licensing, education and training
- Type of PTW (relating to engine power, type of use, tampering with the PTW)
- Human errors (from the point of view of the PTW or the passenger car)
- Conspicuity and the perception by drivers of motorcycles
- Alcohol and other impairments (prescribed and illicit drugs, fatigue and so on)
- Personal protective equipment (helmet protection and other PTW apparel)

Whilst knowledge exists about the factors that contribute to PTW crashes, no study known to the authors has attempted to systematically classify accident data derived from in-depth studies of PTW crashes using any of the extant models of accident causation. The aims of this study, undertaken within Activity 1.1 of WP1 of the 2-BE-SAFE project, were to identify the most frequent PTW road accident configurations from a macro point of view and to analyse and determine from a micro point of view the underlying dysfunctions that give rise to these accidents, at different levels of specificity (personal determinants of the riders, riders/drivers interactions, vehicles etc.).

2. Methodology and data

The research was conducted in two phases (see Figure 1). In Phase 1, data from national accident databases (Finland, France, Greece, Italy and the United Kingdom) were used and statistical analysis were conducted to identify the impact of rider and road environment characteristics on PTW accidents.

All the PTW accident characteristics reported in national databases (mainly descriptive rather than causal characteristics such as the place and the weather conditions during the accident) provided a broad overview of which kinds of accidents frequently occur and the road safety issues associated with them (for instance, 33% of injury accidents involving PTWs are single vehicle accidents but these accidents represent 50% of the fatalities; young drivers and riders are riskier populations; etc).

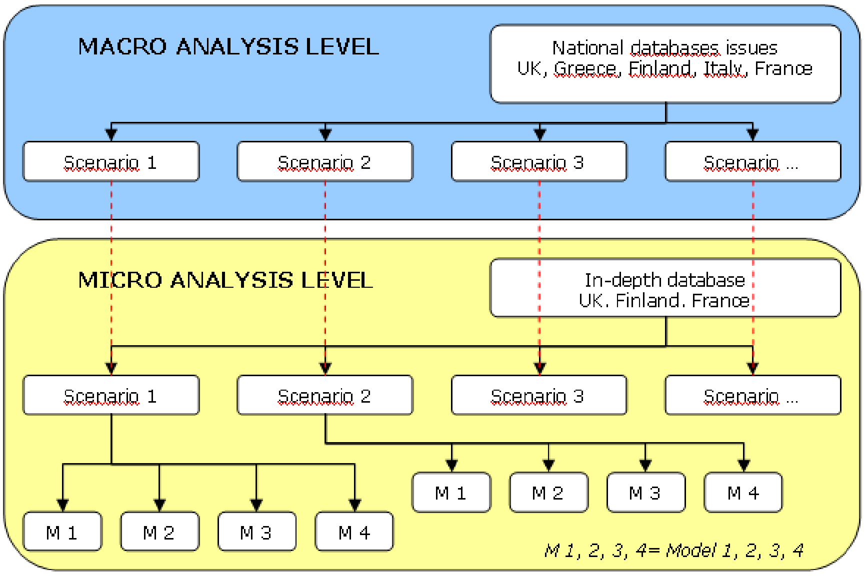

Figure 1: Rider / Driver behaviours study methodology

During Phase 2 of the analysis, four accident causation models were used to analyse and classify accident data derived from in-depth studies of PTW crashes previously conducted in the United Kingdom, Finland and France. The first model, which we labelled as the Driver-Vehicle-Environment system description model, documents detailed factual information relating to the rider (eg. the rider's professional status, family status, age, gender, etc), to the other party involved in the crash, to the vehicles involved (eg. vehicle type, vehicle age, vehicle defects, etc) and to the environment (eg. type of road, road geometry, traffic density, etc). The second model documents factual information relating to each phase in the evolution of the crash – the normal driving phase, the precipitating event, the emergency phase, the crash phase and the post-collision phase (Brenac, 1997; Fleury et al., 2001). The third model, the Human Functional Failure model (Van Elslande and Fouquet, 2007), classifies factors, characterizing the state of the system and their interactions, which explain human failures that contribute to crashes. This model considers that the driver, when driving, performs several sequential and inter-linked functions: detection, diagnosis, prognosis, decision and action. A rupture of one link in the chain can create an imbalance in the system; for example, a crash. The final model, which is the focus of this paper, is the DREAM 3.0 (Driving Reliability and Error Analysis Method) model (Warner et al., 2008). DREAM 3.0 provides a way of systematically classifying and recording accident causation information which has been gathered through in-depth crash investigations. It provides a structured way of sorting the accident causes into defined categories of contributing factors. Failures at the “sharp” end (eg. problems of driver inattention) as well as at the “blunt” end (eg. poor traffic management decisions) are taken into consideration. Each model has a different approach to the understanding and classification of the causal factors which contribute to crashes and incidents. All of the models, however, are complementary and, from each, it is possible to aggregate the classified data in order to provide an overall summary of causation factors.

3. Definition of PTW accident scenarios

In Phase 1 of the project, the main accident configurations in which PTW users are involved were identified by analysing available national accident databases (Italy, Greece, Finland, the United Kingdom and France). The accident configurations were selected mainly according to the other vehicles that were involved in the accident, the number of vehicles (including pedestrians) involved in the accident, the location of the accident and the road layout configuration. Table 1 summarizes the different PTW accident scenarios chosen for each country according to the kind of PTW (either moped or motorcycle) and the number of vehicles involved in the accident. We decided to distinguish between two kinds of PTW according to their engine cylinder capacity - mopeds and motorcycles - because:

- A review of the state of the art in another WP of 2BESAFE pointed us to these two kinds of PTW users.
- We believe that people riding these two forms of PTW are different because of the different “riding licences” required and because of the different reasons why they use such vehicles. The analysis was designed to confirm or not the differences between both users.
- The ways in which two types of PTW are ridden are different because of differences in their physical structure (weight, power capacity, presence of active safety systems, etc).

Only nine PTW accident configurations were selected for in-depth analysis (see Table 2) - because:

- some of them were relevant to only one or two countries: for instance moped / truck accidents – outside and inside intersection – no Intersection or single motorcycle accidents – outside urban area – intersection;
- and/or some of them did not occur frequently enough in the in-depth databases: considering the three in-depth databases, there were less than 10 accidents. For instance, single moped accidents outside and inside urban area – no intersection are issues for most countries, but the in-depth sample was not large enough to derive relevant results.

A total of 391 PTW in-depth accidents were analysed. The number of accidents studied per country differed depending on the amount of in-depth accident data available in each country. Table 2 shows the number of PTW in-depth accidents analysed per country for each of the above-mentioned PTW accident configurations. Pre-crash data are indispensable for the derivation of effective countermeasures to prevent road accidents. Since the focus on the relevant pre-crash data generally differs for accidents of different road users, there are activities on accident causation data gathering for car accidents, for motorcycle accidents and pedestrian accidents. Three national PTW in-depth databases were used that satisfied our requirements: from the United Kingdom (OTS database – On The Spot), from Finland (VALT[2] database) and from France (MAIDS and RIDER[3])

[2] VALT is the name of the Traffic Safety Committee of Insurance Companies in Finland

[3] Recherche sur les accidents Impliquant un Deux-Roues motorisé - Research on accidents involving a PTW

PTW Accident configuration	Finland		France		Greece		Italy		The United Kingdom	
	% (1)	%T (2)	% (1)	%T (2)	% (1)	%T (2)	% (1)	%T (2)	% (1)	%T (2)
Single moped accident – Inside urban area – No intersection			65,6%	19,5%	46,4%	13,5%	59,5%	12,0%		
Single moped accident – Outside urban area – No intersection	80,0%	16,7%	28,2%	8,4%	39,3%	11,5%	31,3%	6,3%		
Total Single moped accident	80,0%		93,8%		85,7%		90,8%			
Moped / Passenger car accident – Outside urban area – No intersection			28,8%	18,4%	26,6%	17,7%	13,2%	9,8%		
Moped / Passenger car accident – Inside urban area – No intersection			17,4%	11,1%	15,6%	10,4%	19,3%	14,4%		
Moped / Passenger car accident – Inside urban area –Intersection	5,6%	4,2%	9,8%	6,2%	26,6%	17,7%	28,4%	21,2%		
Moped / Passenger car accident – Outside urban area –Intersection	27,8%	20,8%					11,1%	8,3%		
Moped / Truck accident – Outside urban area – No intersection	16,7%	12,5%	10,7%	6,8%						
Moped / Truck accident – Inside urban area – No intersection			8,1%	5,2%						
Total Moped / Another vehicle	50,0%		74,8%		68,8%		72,0%			
TOTAL MOPED ACCIDENTS		54,2%		75,6%		70,8%		72,0%		
Single motorcycle accident – Outside urban area – No intersection	81,8%	36,0%	55,1%	19,4%	43,3%	18,1%	53,2%	15,3%	53,1%	12,3%
Single motorcycle accident – Inside urban area – No intersection	18,2%	8,0%	37,0%	13,0%	47,4%	19,9%	35,1%	10,1%	17,2%	4,0%
Single motorcycle accident – Outside urban area –Intersection									14,8%	3,4%
Single motorcycle accident – Inside urban area – Intersection									14,8%	3,4%
Total Singe motorcycle accident	100,0%		92,0%		90,6%		88,3%		100,0%	
Motorcycle / Passenger car accident – Outside urban area – No intersection	33,3%	14,0%	37,5%	20,8%	17,7%	9,6%	16,4%	10,5%	22,2%	11,5%
Motorcycle / Passenger car accident – Inside urban area – No intersection			14,7%	8,1%	25,2%	13,6%	19,6%	12,5%	5,1%	2,6%
Motorcycle / Passenger car accident – Inside urban area – Intersection	19,0%	8,0%	12,5%	6,9%	21,5%	11,6%	26,5%	16,9%	13,7%	7,0%
Motorcycle / Truck accident – Outside urban area – No intersection	14,3%	6,0%	13,5%	7,5%			4,5%	2,9%		
Motorcycle / Passenger car accident – Outside urban area – Intersection	14,3%	6,0%					13,0%	8,3%	22,1%	11,4%
Motorcycle / Truck accident – Inside urban area – Intersection					5,4%	2,9%	4,3%	2,7%		
Motorcycle / Truck accident – Outside urban area – Intersection					2,3%	1,2%				
Total Motorcycle / Another vehicle	81,0%		78,2%		72,1%		84,4%		63,0%	
More than three vehicles									100,0%	25,4%
TOTAL MOTORCYCLE ACCIDENTS		78,0%		75,8%		77,0%		79,2%		81,0%

Table 1: PTW accident configuration in Finland, France, Greece, Italy and the United Kingdom in 2006 and 2007.

Note 1. % (1) is the percentage of PTW accident configuration per number of vehicles involved in the accidents. For instance, 80% of fatal single moped accidents in Finland are outside the urban area and not at intersections. Note 2. %T (2) is the percentage of PTW accident configuration considering the kind of PTW. For instance, 16,7% of fatal moped accidents in Finland are outside the urban area and not at an intersection.

Scenario	PTW accident configuration	Number of in-depth accidents analysed per country			Total
		Finland	France	The United Kingdom	
1	Moped / Passenger car accident – Inside urban area – No intersection	0	13	2	**15**
2	Moped / Passenger car accident – Inside urban area –Intersection	3	36	10	**49**
3	Single motorcycle accident – Outside urban area – No intersection	16	10	25	**51**
4	Single motorcycle accident – Inside urban area – No intersection	4	26	16	**46**
5	Single motorcycle accident – Inside urban area – Intersection	0	19	17	**36**
6	Motorcycle / Passenger car accident – Outside urban area – No intersection	7	8	27	**42**
7	Motorcycle / Passenger car accident – Inside urban area – No intersection	0	31	10	**41**
8	Motorcycle / Passenger car accident – Inside urban area – Intersection	0	40	20	**60**
9	Motorcycle / Passenger car accident – Outside urban area – Intersection	3	18	30	**51**
	TOTAL	**33**	**201**	**157**	**391**

Table 2: Number of in-depth accidents analysed per country according to PTW accident configuration (or scenario)

The On-The-Spot Accident Research Project (OTS) provides in-depth data from the year 2000 onwards, with 500 cases per year covering the Midlands & South-East regions of England. Accident selection is based on standard notification from the police control room. The OTS data provides a representative sample of recent UK accidents including detailed information on causes. The objective of the VALT database (on fatal accidents) is to produce information and safety suggestions to improve road safety by studying road and cross-country traffic accidents. The file is built from accidents compensated under motor liability insurance. MAIDS is the most comprehensive source of in-depth accident data currently available for Powered Two Wheelers accidents in Europe. The investigation was conducted during 3 years on 921 accidents from 5 countries using a common research methodology. The investigation teams had to use a methodology developed by the Organization for

Economic Co-Operation and Development (OECD). The purpose of the study was to identify the causation factors of motorcycle accidents. The project focused on injury prevention, motorcycle improvements, and a better understanding of the human factor. For the 2BESAFE project, only accidents collected in France were used. The French RIDER project used the same accident investigation methodology as the MAIDS project. In addition to accident data gathering, RIDER probed more deeply into PTW accident and injury mechanisms. A total of 210 French accidents were investigated, using in-depth accident analysis methodology. All the accidents were reconstructed in detail in order to identify their causes and consequences.

4. Main Results

4.1. PTW accident causation – national databases analysis results

Single moped accidents mainly happen not at intersection and inside urban area: they constitute around 60% of single moped accidents for the five countries.

When fatal moped accidents involve another road user, these are mainly passenger cars and to a lesser extent trucks. Results are different according to the five countries as follows (fatal moped accidents in the United Kingdom are not considered as it was determined beforehand that they are not an issue):

- Moped accidents inside urban area at intersection, involving only a passenger car and a moped, are issues for the four countries.
- Moped accidents not at intersection (either inside urban area or outside urban area), involving only a passenger car and a moped, are issues in France, Greece and Italy.
- Moped accidents at intersection and outside urban area, involving only a passenger car and a moped, are issues in Finland and Italy.
- Moped accidents not at intersection and outside urban area, involving only a truck and a moped, are issues in Finland and France.
- Moped accidents not at intersection and inside urban area, involving only a truck and a moped, are issues only in France.

All these scenarios constitute around 70% of all fatal moped accidents (see Table 1).

Fatal single motorcycle accidents are mainly found not at intersection (either inside urban area or outside urban area), for the five 2BESAFE countries. Only in the UK, fatal single motorcycle accidents at intersection (either inside urban area or outside urban area) are issues. There are several reasons for this difference. First, the number of single motorcycle accidents is lower in UK than in the other countries (except in Finland). Secondly, the definition of an intersection according to the five countries is different[4]. Finally, this accident configuration is not uniquely defined. The motorcyclist can lose control of the PTW near an intersection or another vehicle can disturb the motorcyclist without any crash. In this case, depending on how the police report the accident, one or two vehicles can be counted.

When fatal motorcycle accidents involve another road user, these are mainly passenger cars and to a lesser extent trucks. Results are different according to the five countries as follows:

- Motorcycle accidents not at an intersection and outside the urban area, involving only a passenger car and a motorcycle, are an issue in all countries.
- Motorcycle accidents at an intersection and inside the urban area, involving only a passenger car and a motorcycle, are an issue in all countries.
- Motorcycle accidents not at an intersection and inside the urban area, involving only a passenger car and a motorcycle, are an issue in France, Greece, Italy and UK.

[4] Position on road more than 20m from a junction or roundabout (AT, GB, IE, NI, NL). Position on road more than 50m from a junction (FR).Opinion of the police (BE, DK, DK, ES, FI, IT, LU, SE).

- Motorcycle accidents at an intersection and outside the urban area, involving only a passenger car and a motorcycle, are an issue in Finland, Italy and UK.
- Motorcycle accidents not at an intersection and outside the urban area, involving only a truck and a motorcycle, are issues in Finland, France and Italy.
- Motorcycle accidents at an intersection and inside the urban area, involving only a truck and a motorcycle, are issues in Greece and Italy.
- Motorcycle accidents at an intersection and outside the urban area, involving only a truck and a motorcycle, are issues only in Greece.

All these scenarios gather around 75% of all fatal motorcycle accidents (see Table 1).

4.2. PTW accident causation – in-depth analysis results

The main conclusions deriving from the in-depth analysis are as follows:

- Moped riders are necessarily young users as most of them are under 18. When having their accidents, they had only less than one year of riding experience. They consider the moped as a mode of transport and they do not use it only for leisure. Their mopeds are in good state at the time of accident. The environmental conditions in which the accident happened (e.g. weather, lighting, etc) do not seem to be relevant factors. Nevertheless, night riding is riskier for these users. Moped users do not wear any PTW clothes (such as gloves, trousers, etc…), except a helmet (but it is not always well adapted to the user).
- If the moped rider is at the origin of the accident, he is often incorrectly positioned on the road or he voluntary takes risks. If the passenger car driver is at the origin of the accident, he fails to look, he looks but do not see. That is why, in the case of accidents between a moped and other vehicle, the most frequent human error is a failure in perceiving the moped by another vehicle driver (associated to the traffic environment, traffic scanning error, lack of other vehicle driver attention, faulty traffic strategy or low conspicuity of the moped).
- Single motorcycle accidents involve users who do not ride a lot each year compared to motorcyclists involved in accidents between a motorcycle and another vehicle. Single motorcycle accidents happen either during the day and in a curve, outside urban areas or during the night and on a straight road (when it is inside the urban area).
- Single motorcycle accidents, outside the urban area, happen later after departure than single motorcycle accidents inside the urban area. In the first configuration (single mortocycle accidents outside urban area), a conflict with another vehicle is possible and has caused the accident (even if there is no crash).
- The main human functional failures for single motorcycle accidents describe a loss of control when underlying a guidance problem or a poor control of an external disruption because of excessive or unadapted speeds, risk taking, etc.
- When the accident involved a motorcycle and a passenger car, at intersection, the motorcyclist is crossing the intersection, has a right of way and is confronted by a vehicle coming from a side road. The other vehicle is generally turning across traffic. Once again, such accidents underline the lack of perception (from the passenger car driver and of the motorcyclists) because they neglect the need to search for information or they cannot see the riders because of visibility masks. That is why motorcyclists misinterpret the driving situation. They are on a road where they have a right of way status, there is an absence of clues from the other road user, and they then do not understand the manoeuvre taken by the driver.
- When the accident involves a motorcycle and a passenger car, not at an intersection, the accident situations are more complex. Here the rider is realizing a manoeuvre legal or not (such as overtaking or splitting lanes) and is confronted by an oncoming vehicle or a vehicle in a lateral lane; or the rider does not perform any manoeuvre and is confronted by a passenger car driver realizing a manoeuvre (changing lane, overtaking, turning not at an intersection). In both cases, the drivers do not see the motorcyclist.

Accident configurations 1 and 2 dealt with accidents with a moped and a passenger car, inside the urban area. The first scenario revealed that inattention and late observation (because of reduced visibility) caused a large number of riders to miss seeing the opponent vehicle. In the second one, the rider had the right of way status and expected the passenger car driver to behave in a certain way. Alternatively, the rider did not have the right of way status and the main genotypes were late observation, inattention, priority error and reduced visibility. In both moped accident configurations, a lack of riding experience was identified.

Accident configurations 3, 4 and 5 dealt with accidents involving only one motorcycle. Inside the urban area (configurations 4 and 5), the force with which riders were realizing an action (braking, steering, accelerating) was highlighted. The main three factors explaining such accidents were reduced friction on the road, inattention and an overestimation of skills (which is in part a consequence of insufficient skill). In some cases, another vehicle could have been an unexpected event which generated the accident (without crashing with this vehicle). In Scenario 3, speed was revealed as the action which was the first observable effect on the accident. Several factors explain this phenotype: priority error because of excitement seeking, inadequate information transmission from the road environment because of an inadequate information design and an overestimation of skills.

Accident configurations 6 and 7 analyse accidents involving a motorcycle and a passenger, not at an intersection. In accidents, inside the urban area, the problems of observation (of the situation and of the opponent vehicle) were mainly linked to inattention and reduced visibility. Outside the urban area, riders missed observations because the other vehicle driver did not provide any information about the manoeuvre they were undertaking. In both situations, priority error was also a main factor.

In scenarios 8 and 9, accidents involved a motorcycle and a passenger, at intersections. In both situations, it seems that there were two ways in which to analyse the DREAM charts for riders. The first one is that riders had right of way status at the intersection. So, they were expecting a certain behaviour from the other road user (the passenger car driver). The possible second way shows that riders did not have a right of way status and did not drive in a safe way and missed some important information about the situation (because of a temporary obstruction of view).

5. Conclusions

The aims of this study, undertaken within Activity 1.1 of WP1 of the 2-BE-SAFE project, were to identify the most frequent PTW road accident configurations from a macro point of view and to analyse and determine from a micro point of view the underlying dysfunctions that give rise to these accidents, at different levels of specificity (personal determinants of the riders, riders/drivers interactions, vehicles etc.).

From the macro analysis, it can be concluded that PTW accidents are significant road safety problems for all of the 5 countries studied. The national statistics for the five 2BESAFE countries show several main results:

1. Fatal motorcycle accidents are issues in all countries: at least 68% of PTW fatalities involve motorcyclists.
2. Fatal moped accidents are not a significant issue in the United Kingdom[5].
3. Per 100 000 circulating PTW, the risk of a fatal motorcycle accident is higher than that for a fatal moped accident, for all 5 countries. Fatal motorcycle accident risk is at least 1.9 times higher than that for fatal moped accidents (from 1.9 times in Greece to 3.3 times in the United Kingdom).
4. France is the country where this risk is the highest for both kinds of PTW and Finland is the country where the risk is the lowest.

The macro analysis of the five national databases also resulted in the identification of 20 PTW accident configurations, of which 9 were selected for in-depth analysis, using four accident causation models. Each model provided a different approach to the understanding and classification of the causal factors which contributed to the crashes examined. All of the models, however, yielded complementary outputs.

[5] It could be due to UK law. Compulsory Basic Training (CBT) for all PTW users has been in effect since 2001; the earliest age for moped riding is 16 years, and mopeds are restricted to max design speed of 48kph.

Each of the analyses highlighted causative factors at different levels of analysis, capable of informing countermeasure development, from several different perspectives (e.g. PTW manufacturers, governments, etc).

The study was limited however by the number of in-depth accident cases available for the analysis. Specifically, at the micro level, the data yielded were limited due to the small number of in-depth moped accident cases available for analyses.

In this study, we used for the first time, the DREAM model, to classify, at the micro level, causative factors leading to fatal PTW crashes. It is clear however that the model, which was derived for four-wheeled vehicles, was not entirely suitable for the classification of PTW accidents. Further work is recommended in order to adapt the DREAM model for use in classifying factors that lead to PTW accidents.

1. Introduction

1.1. Project aims

Current statistics show that Powered Two Wheeler (PTW) users are over-involved in fatal crashes. The OECD/ECMT International Road Accident Database (IRTAD) shows that, between 2002 and 2005, PTW deaths as a proportion of the total number of road deaths in European countries increased from 11.3% to 13.4%. Whilst the total number of road fatalities in the last decade has decreased in EU-14, this has coincided with a corresponding increase in fatalities for PTW riders (see Figure 1). The risk of having an accident for PTW riders, taking into account vehicle mileage ridden per annum, varies considerably between European countries (see Figure 2). It can also be seen that the accident risk for PTW riders is much greater than for car drivers – depending on the countries, it is between about 5 and 25 times greater.

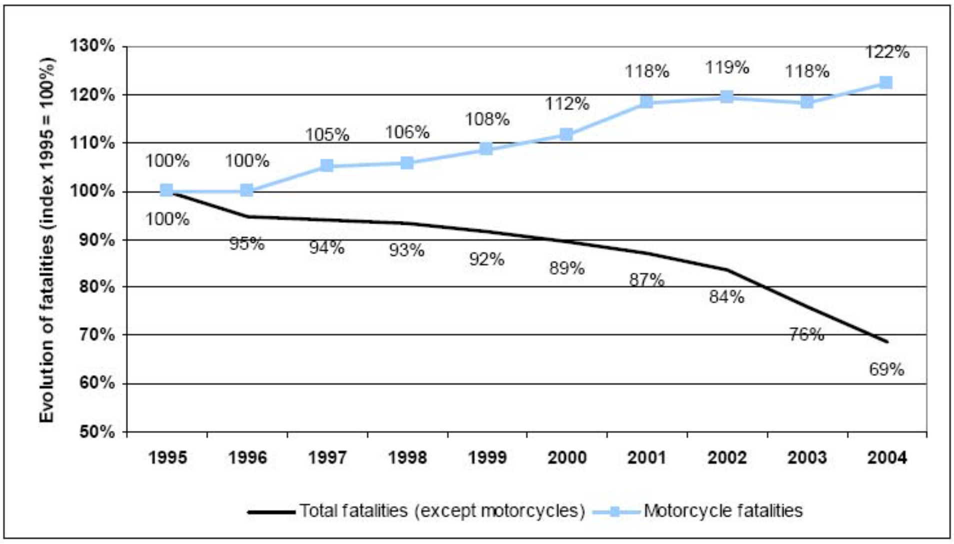

Figure 2: Evolution of total fatalities and of motorcycle in EU-14, 1995 - 2004 (Source: CARE)

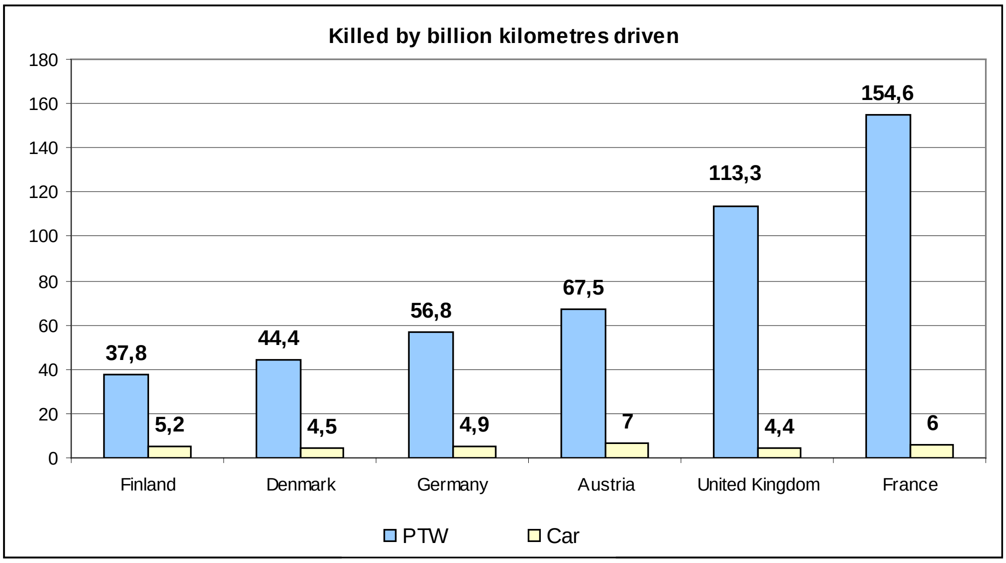

Figure 3: Killed by billion kilometres driven

The main findings from MAIDS[6] project can be summarised as follows:

- The primary accident cause for PTW crashes in Europe is the failure of drivers to perceive two-wheelers;
- Human error is a major contributing factor to all crashes – especially for car drivers;
- Younger riders are over-represented in crashes;
- Poor or incorrect collision-avoidance strategies are a significant factor in crashes;
- And the majority of PTW crashes that occur involve a collision with a car.

In short, behavioural and ergonomic/human factors issues appear to be major contributing factors to PTW crashes.

In this project we outline an innovative program of research, involving partners from Europe, Israel and Australia, that directly targets those behavioural and ergonomic factors cited in the MAIDS study as contributing to PTW crashes.

This includes fundamental research on crash causes and human error (WP1), the world's first naturalistic driving study involving instrumented PTWs (WP2), experimental research on motorcycle rider risk awareness and perception (WP3), the development of research tools to support this human factors and behavioural research program (WP4), a large-scale research program on the factors that underlie driver failures to see PTWs and their riders (WP5), and the development of practical countermeasures for enhancing PTW rider safety deriving from all these activities (WP6).

The work described in this report was undertaken in Activity 1.1 (Rider / Driver behaviours and road safety for PTW) – as a part of Work Package 1 – of the DG-RTD Transport – funded 2-Wheeler Behaviour and Safety ("2-BE-SAFE") project. The overall aim of the 2-BE-SAFE project is to understand the behavioural and ergonomic factors that contribute to crashes and incidents involving motorcycle and moped riders and, using this information, to formulate options for countermeasures to improve rider safety.

1.2. WP 1 description

The aim of Work Package 1 is to identify the exact causes that lead to an accident including PTW involvement. The methodology used involves in-depth accident analysis, hence detailed analysis on the different factors leading to an accident; mainly investigating behavioural, road infrastructure and weather related factors.g

Although in-depth accident studies now comprise a standard methodology for detailed research related to passenger car road safety, they comprise a rather recent application in the field of Powered Two Wheelers. In-depth accident studies for PTW have been conducted in Europe within the framework of the MAIDS (Motorcycle Accident in Depth Study) and APROSYS (Advanced Protective Systems; Motorcyclist accidents) EU projects. Within the MAIDS project the common methodology for motorcycle crashes data collection that was developed by the OECD was applied with data provided by several EU countries. The project resulted in several important quantitative findings involving the causes of motorcycle accidents. However, the depth of these studies may still be extended towards investigating more specific causes. In addition, the APROSYS project did not reveal significant findings in relation to accident causation and road infrastructure as the sample that was investigated was not sufficient. Another European initiative involves the "In-depth study of motorcycle accidents" conducted by the University of Nottingham for the Department of Transport (UK). In this study, the data used was extracted from police records and a questionnaire survey; however the parameters that were investigated were not that detailed. A Motorcycle Crash Causation Study which started in 2006 and is anticipated to finish in 2008 is underway (on behalf of NHTSA and FHWA) in the US. Part of the main objective is to acquire the necessary data that will allow determination of an effective method for performing a full scale motorcycle accident causation study. Last, an earlier application related to in-

[6] Motorcycle Accident In-Depth Study, project funded by the Association of European Motorcycle Manufacturers (ACEM) with the support of the European Commission and other partners, has characterised the nature and causes of PTW crashes. The researchers looked at 921 Powered Two-Wheeler (PTW) crashes during 1999 and 2000 in France, Germany, Italy, Netherlands and Spain.

depth analysis of PTW accidents was undertaken using data from Thailand by the Traffic Safety Center (University of South California) that led to the report "motorcycle accident cause factors and identification of countermeasures". The need for detailed analysis of the PTW risk/accident factors is evident as such data is still scarce.

The determination of the actual sub-causes leading to a PTW accident and the specific factors ("hot spots" of behaviour and road infrastructure) that compromise PTW safety is of vital importance. Therefore one of the objectives of this WP is to find out which elements from the rider/driver behaviours, from the road infrastructure (road design elements and road surface parameters) and from the weather conditions have a significant influence on PTW accidents. The analysis will involve a combination of rider/driver behaviours (Activity 1.1), infrastructure data - including road conditions data as well as road geometry data – (Activity 1.2) and weather related data (Activity 1.3) which if they are linked with accident data will lead to new results in modern crash-causes-research.

The findings of this WP should be used in two ways. First, safety-critical scenarios (related to rider/driver behaviours and road environment characteristics) at which an accident is most likely to happen can be defined to investigate and hence to understand rider behaviour and rider-driver interactions under such circumstances. This will help to identify the different aspects of rider/driver behaviour that would be needed to be modified to improve PTW safety. Second, recommendations and guidelines should be designed targeting at the identified risk/accident factors so that critical circumstances leading to PTW accidents are eliminated or reduced.

1.3. Activity 1.1: Interaction between rider / driver behaviour and PTW accidents

The aim of this activity is to identify the most frequent road accidents and the high-risk situations (intersection, rider age etc.) from a macro point of view and to analyse and determine the underlying dysfunctions at different levels (personal determinants of the riders, riders/drivers interactions, vehicles etc.) that cause such accidents from a micro point of view.

National accident databases (Finland, France, Greece, Italy and United Kingdom) are used and statistical analysis are conducted to identify the impact of rider / driver behaviour on PTW accidents: kind of vehicles involved in the accident, kind of accident scene, type of area, PTW collision partner, age of users, etc. All these items give a large overview of which kind of accidents appears frequently and what are the real issues.

For the micro study, analyses of existing in-depth data on PTW accidents are undertaken, using four different approaches: the ontological, functional, transformational and DREAM (Driving Reliability and Error Analysis Method) approaches. Collectively, these approaches allow the definition and characterisation of dysfunctions leading to PTW accidents.

1.4. Structure of remainder of this report

This report is divided in six main sections:

1. Introduction: this section reminds the aim of the 2BESAFE project, of the Work Package 1 and finally of the activity 1.1. This report is the deliverable 1 of 2BESAFE project and is related to the activity 1.1 (Rider / Driver behaviours and road safety for PTW).
2. State of the art: this is a summary of what have been found in the literature review regarding to PTW accident configurations and PTW accident risk factors.
3. Methodology: this part of the report explains the methodology used to reach our activity 1.1 goals. The data analysed from national and in-depth databases are also presented.
4. PTW accident configuration: this chapter indicates how we have chosen PTW accident scenarios and shows which scenarios are studied during the in-depth analysis.
5. In-depth analysis: This is the heart of the report. Each PTW accident scenario is described in details.
6. Conclusion.

2. Rider / driver behaviour and PTW safety: State of the art

This chapter is focused on identifying the main characteristics of the Power Two Wheeler (PTW) accidents and factors which explain why the accident happened. It seems obvious that it is not possible to state the 'only cause' of the accident, but it is needed to point to several different factors that have contributed to generate the accident.

Different studies have been carried out in the past where the specific problems of PTW riders have been addressed. In this report, the majority of these studies have been reviewed in order to identify which factors have been identified as important regarding the causation of accidents. These factors will be further analysed using national and in-depth databases.

The consulted sources in this literature review vary from public studies performed by governments to published scientific papers from different research teams. Between these two groups, there are also reports from European associations related to the PTW world or results from other European research projects.

2.1. PTW Accident configurations

This paragraph is an important one. Indeed, one can work on all PTW accidents without considering any accident configurations. But, the state of the art highlights the fact that some accident scenarios are more relevant in frequency and in severity.

The main accident configurations emerging from national or European studies are single PTW accidents (due to a loss of control of the PTW), accidents at intersection and accidents during an overtaking manoeuvre. Of course, when the PTW is involved in an accident with another road user, this one is in most cases a passenger car. The main conclusions regarding the PTW accident scenario are summarized according to the projects or the studies (see Table 1).

Hernetkoski et al (2005, 2007) report that risk factors mentioned by the Finnish Road Accident Investigation Teams concerning the rider of the motorcycle included most notably: driving under the influence of alcohol, inexperience, unfamiliarity with the vehicle, and excessive driving speed. Deer animals were regarded as a risk factor especially in the accidents involving a motorcycle heavier than 125 cc. Of all fatal accidents of motorcycles heavier than 125 cc, 10% involved a collision with an elk. When only the single-vehicle accidents were considered, that proportion was 20%. Most collisions of moped riders happened at intersections: 40% of the injury accidents and 62% of the fatal accidents. In the fatal accidents, 19% of the moped riders were under the influence of alcohol.

Project	Accident Scenarios
UK (Clarke et al. 2000)	Right of way violations (ROWVs), most commonly caused by a party other than the motorcyclist Losing control on corners with excess speed Accidents that involve overtaking other traffic, often associated with the increased opportunity that motorcyclists have to perform, such manoeuvres (e.g. in queuing traffic)
RIDER (2005)	34% refusal to give away (75% by the opponent driver) 12 % loss of control (whom 11% at intersection)
AU2RM (2007)	33% of passenger car turn left 20% at intersection PTW having the right of way 10% PTW swerves or overtakes
TRACE (2008)	Motorcycle single accidents (27%) Front-side accidents in rural and urban junctions between motorcycles and passenger cars (13%) Side-side accidents in rural and urban non junctions between motorcycles and passenger cars (5%)

	Rear-end accidents in rural and urban non junctions between motorcycles and passenger cars (5%) Moped single accidents (21%) Front-side accidents in rural and urban areas (junction and non junction) between mopeds and passenger cars (30%) Head-on accidents in rural and urban areas (junction and non junction) between mopeds and passenger cars (8%)
SUMOTORI (2008)	Emergency braking on a straight road – 49% Avoidance and emergency braking – 17% Loss of control in a curve – speed limit – 11% Loss of control in a curve – road locally deteriorated – 9% Emergency braking in a curve – 9% Loss of control in a curve – speed limit not exceeded – 5%

Table 3: PTW accident scenarios as recorded by European projects

2.2. PTW accidents factors

The literature review on the factors, which contribute to PTW accidents, is quite extensive. The aim of this paragraph is to summarize the results of studies according to factors. Most of them are linked with the interaction between rider/driver behaviour and PTW safety.

2.2.1. Ridding attitudes and patterns

Previous research has reported that significant variability is observed in the motorcyclists' attitude towards safety. Most times PTWs pay attention to safety issues, but there are age groups and other driver/rider classes that, either unintentionally, or by belief, seem to disregard it. Risk taking, as well as sensation seeking is a typical behaviour of PTWs. This behaviour is usually reflected in activities such as disobeying traffic signal, give way or stop sign, non compliance to double white lines or pedestrian crossing, making illegal turns or speeding, maintaining low gaps with the following vehicles and so on. "Risk takers" and "Sensation seekers" are the groups correlated with negative safety attitudes (Jonah et al. 2001). Mannering and Grodsky (1995) state that, because motorcycle riding is well known to be a dangerous activity, it 'may tend to attract risk-seeking individuals, in all age and socio-economic categories', which would have a corresponding effect on the total motorcycle accident figures.

Older riders were likely to engage in recreational riding on weekends in rural areas and younger riders were likely to use their motorcycle for commuting and in an off-road context.
Harrison and Christie (Harrison and Christie, 2005) have reported the results of an exposure survey of 794 registered motorcycle riders, with an average of 18.1 years of riding experience, in the State of New South Wales in Australia:

- Aggregated riders behaviour regarding probability of crash risk is related to age and riding exposure. A period of absence from riding might result in a decline in safety-related motorcycle skills.
- High exposure appears to moderate crash risk. The rate of crash involvement (on per kilometre-travelled basis), as in car drivers, appears to decline as a function of current riding exposure.
- Riding patterns often match the place of residence, type of motorcycle, and age (and the likely motivational needs satisfied by riding)
- They have identified three high-risk groups of rides on rider's data from Sydney. The highest-risk group is composed of riders who tend to ride trail bikes off-road on weekends. The next high-risk group ride relatively often on urban and rural multi-lane highways and freeways on weekends for recreational reasons. The final high-risk group is composed of riders who tend to ride less each year than others in the sample, and who reported relatively more of their riding on urban roads, on weekends, and on traditional-style motorcycles for recreational reasons.

A compendium was produced by the UK Department for Transport as a central resource containing a comprehensive source of statistics on motorcycles and motorcycling (DfT, 2007). Four areas are covered by the compendium: the motorcyclist, the types of motorcycles owned, the types of journeys made, and rider safety. The key findings for motorcyclists where that fewer than 3% of households owned a motorcycle in 2005/06, the numbers of people taking the motorcycle test was at its lowest since 2001/02 (77,000), and the pass rate for the motorcycle test is 65% (higher than for cars, but this figure has been falling since the mid 1990's).

Furthermore, there are 1.2 million motorcycles in Great Britain; the number of motorcycles registered in 2007 was the lowest for nine years (135,000); scooters and sports motorcycles are the most popular types of new motorcycles.

Moreover, journeys made by motorcycle increased by 37% between 1996 and 2006; motorcycle traffic is higher in the summer than in the winter; motorcyclists are making fewer trips than they did in 1986, but those trips are over greater distance and take longer; motorcycles average speed is generally similar to cars.

Finally, concerning motorcycle safety, motorcyclists are 51 times more likely to be killed on the roads than car drivers; casualty rates for motorcyclists have been reducing (27% drop between 1994 and 2006); most collisions occurred on A-roads, at the weekends, in the summer and in the afternoon.

2.2.2. Age, gender and experience

Using the study of 1000 PTW accidents occurring in UK, Clark (Clark et al., 2000) found that young riders with no license, or only a provisional license, seem to lack the skills needed, and to take more risks, which contributes to their increased likelihood of this type of accident. The high speed, acceleration and manoeuvrability of motorcycles cause further accident risk. Riders, particularly younger riders on high-capacity machines, can be presented with overtaking opportunities that they find hard to resist

Clark et al. (2004) went deeper in the understanding of PTW accident causations. An approach is therefore clearly needed that targets riders' attitudes to risk, as well as the effective measures that can be taken in the area of defensive riding skills. The results of this study suggest that, as far as motorcyclists' specific problems are concerned, there are two main groups of riders that should be concentrated on using such an approach. The first is young and inexperienced riders of smaller capacity machines, such as scooters (which experienced a sales increase of 16% in 2003); and the second is older, more experienced riders of higher capacity machines (which now account for around half of all motorcycles registered today), who still come to grief even though they are relatively experienced road users.

The questionnaire revealed that older and more experienced riders tended to be quite aware of the risks of motorcycling and, with the possible exception of speeding, exhibited attitudes consistent with riding safely. However, a way must be found of getting the safety message to younger, more inexperienced riders. Clarke et al. (2002) have shown that younger road users tend to show more 'attitudinal' failings than skill failures in their accidents, and this also seems to occur in the younger motorcyclists in this study. More research into the failings of younger riders in particular may prove valuable.

Sexton et al. (2004) have explored and quantified the interacting influences, which determine motorcyclist collision (and casualty) liabilities. They reviewed existing data to identify trends in motorcycle collisions. A survey was also conducted to explore motorcycle collision risk and rider characteristics, such as age, annual mileage, experience and attitudes.

The gender of the rider, whether the rider had taken compulsory basic training, or he or she had 'taken a break from riding' did not enter the model as statistically significant variables.

Age, gender and experience may influence both attitudes and behaviour, and may also have a direct influence on collisions. When age and experience were not permitted to influence collisions directly in the model, stunt/high risk behaviours became significant predictors of collisions. Risk taking behaviours are associated with young and inexperienced riders, which increase their risk of being involved in a collision. Riding style, getting pleasure from motorcycling, and a liking for speed were identified as predictors of behavioural errors leading to collisions.

The age of the motorcyclist is a major factor in the fatal motorcycle accidents in Finland (Hernetkoski et al. 2005, 2007): the older the motorcyclist, the lower the accident risk. Compared to men, women had a 1.75-fold risk of accidents.

Mattsson and Summala (2008) and Björketun and Nilsson (2007) conclude that in Finland young motorcyclists, i.e. 16–24-year-olds, made anticipation or assessment mistakes more often than older motorcyclists, while most accidents to motorcyclists over the age of 25 were caused by the lack of handling skills. The older the motorcyclist, the more rarely he or she was the party causing the accident. When considered in combination with the change in age structure, this means that more and more accidents – especially those occurring at an intersection – are caused by other road users and not the motorcyclist.

Rutter and Quine (1996) showed that the highest number of injured persons is typically found in age groups close to the lowest legal age limit for use of the vehicle. Older motorcyclists are more likely to be involved severe-injury crashes (Savolainen and Mannering 2007; Pai and Saleh 2007).

Most of the fatal moped accidents in Finland involve a 15-year old rider (Hernetkoski et al. 2005, 2007). The proportion of female moped riders was 12% in the injury accidents and 5% in the fatal accidents. The boys' moped driving involves more risk-oriented driving. In addition, the boys' mopeds were illegally tuned more often than was the case with the girls. The average moped top speed, as reported by survey participants, was 72 km/h. Illegal tuning and rising moped speeds are clear threat factors in moped driving.

Riding experience seems more important for motorcyclists than for drivers of vehicles with more than two wheels (Haworth and Mulvihill 2005). Limited experience and poor driving skills due to a loose motorcycle licensing system are critical for young riders, particularly young female riders in increasing accident risk (Chang and Yeh 2007). Males from 10 to 19 years of age had the highest risk of injuries following accidents with mopeds. For accidents with motorcycles, the highest risk was found in the age group of 20 to 29 years (Barsi et al. 2002).

Young riders and male riders also perceived themselves to be at a greater risk of accidents (Mannering and Grodsky 1995). Rutter and Quine (1996) identified particular patterns of youth behaviours, such as a willingness to break the law and to violate the rules of safe riding, which had a much greater role in accident involvement than inexperience.

The increased crash risk of these young riders may be contributed to the factors of less experience and immaturity (Yeh and Chang 2009). Young and male motorcycle riders have a stronger propensity for risky behaviours, and these behaviours have been shown to be associated with increased risks of accidents and at-fault crashes (Lin et al. 2003, Rutter and Quine 1996, Sexton et al. 2004, Haque et al. 2009). Young and male riders were more likely to disobey traffic regulations, and that young riders also had a higher tendency towards negligence of potential risk and motorcycle safety checks (Chang and Yen 2007).

2.2.3. Education and training

Elliott et al. (2003) have realized a study on PTW in order to review the current research and identify existing gaps in the literature. The report also made suggestions on future research. It was concluded that road behaviour seems to be strongly linked to attitudes and motivations of riders. Training was suggested as a way to increase awareness of negative behaviour, and to may encourage the rider to behave safely. It is indicated that law and rule breaking behaviour is mainly habitual and needs tackling early on.

Suggestions for enhancing the effects of training were to change attitudes towards safety through improving the content or design of training programmes e.g. emphasise on skill limitation. Effects of training may also increase if more information on the risks involved and cognitive aspects of riding was passed onto riders. An alternative suggestion within the study was to use simulation as a training tool, allowing for assessment of risk taking behaviours within a controlled environment. Additionally simulated environments could be created to re-enact potentially dangerous situations, to enable the riders to learn the ability to ride safely.

Sexton et al. (2008) focused their study on the training given to motorcyclists and how this could be improved. Specifically, current core training competencies in motorcycle training were identified leading to the establishment of 'best' practice in this type of training. The views of a wide range of training organisations and 'umbrella' organisations were garnered. Data was collected by three methods: in-depth expert interviews, a postal survey and an observational study. The in-depth interviews examined the skills and techniques of expert trainers representing a wide range of motorcycle organisations. In order to ensure a comprehensive view of current training practice the results of these interviews were used to design a postal survey which was sent to motorcycle training organisations. Finally, an observational study was completed which involved an expert rider from TRL following trainees as they received instruction using TRL's Databike (the Databike has sound and video recording capabilities; whilst following the trainees, the rider recorded observations).

The views of several motorcycle training organisations and similar 'umbrella' organisations concerning the results were sought once data had been gathered. Recommendations for good practice in training were identified, as were means by which the current system could be improved. These recommendations were:

- "Improvements to pre and post-test training content and delivery",
- "Scope for inducing better training by changing the testing requirements",
- "Making some aspects of post-CBT[7] and/or post-test training compulsory",
- "Making changes to the licensing system".

In Finland, a meta-analysis revealed that there is no evidence to show that voluntary motorcycle training programs, meaning programs completed voluntary by riders who possesses a riders' licence, reduce crash risk (Ulleberg 2003). On the contrary, such programs seem to increase the crash risk. One possible explanation is that riders feel more competent after completing the course, without actually having improved their skills. Another reason may be that they have improved riding skills that are irrelevant concerning accident prevention. On the other hand, compulsory training through licensing programs seems to result in a weak, but consistent reduction of crashes. This means that the accident preventive effect of training programs cannot be completely ruled out. It should be noted that both the content and the manner the compulsory programs were carried out are poorly described in the different studies. A challenge for future research is to identify characteristics of training programs associated with a decrease in future accident risk.

Several researchers have criticised motorcycle training programs for merely focusing on rider skill training, and ignoring motivational factors (i.e. the motivation causing deliberate risk taking on the road). Accident involvement is not necessary the result of poor riding skills, a more relevant issue is what the rider chooses to do with his skills. Training programs are further criticised for not focusing on hazard perception training in order to avoid accidents.

Students affiliated with a vocational senior high school, male students, and students in districts with a higher motorcycle ownership rate had a greater chance of experiencing unlicensed riding and thus had an earlier riding age (Yeh and Chang 2009). Motorcyclists usually receive relatively little formal training and opportunities for supervised on-road riding are limited (Elliot et al. 2003).

Skill acquisition and learning in general proceed according to a power function (Swezey and Llaneras 1997) — a curve in which the rate of change in skill declines with experience or learning trials. The similarity between learning curves and the power function fitted to the exposure-crash risk data suggests that exposure to riding may have an ongoing effect on crash risk that is similar to the effect of learning.

However, caution must be taken with educational efforts aimed at expanding motorcyclists' skill set (Savolainen and Mannering 2007).

The challenge for training is likely to be made more difficult by the facts that sensation-seeking motives are important for some riders, and that training concentrating on control skills may lead to more accidents if riders become over-confident (Elliot et al. 2003).

One might speculate that **incompatibilities between the hazard-detection and decision-making** skills required for driving and riding could result in a higher crash risk for low-exposure riders, who may drive more often than ride.

[7] Compulsory Basic Training

2.2.4. Type of PTW

In France, Chapelon (2009) found that the motorbike risk is first a problem of middle and big-engined motorbikes (Motorbikes under 125cc represent less than 15% of fatalities). In the MAIDS project (ACEM 2003), the kind of PTW involved in the accidents was scooters for L1 vehicles and sport or conventional street PTW for L3 vehicles.

Sexton et al. (2004) have explored and quantified the interacting influences which determine motorcyclist collision (and casualty) liabilities. They reviewed existing data to identify trends in motorcycle collisions. A survey was also conducted to explore motorcycle collision risk and rider characteristics, such as age, annual mileage, experience and attitudes.

Collision liability fell with increasing age and increasing experience. Motorcycle riders with engine sizes over 125cc were 15% less liable for a collision than riders of smaller bikes. However, the severity of injuries obtained in a collision was more severe for riders of motorcycles with larger engines.

Based on in-depth-studies of fatal motorcycle accidents in Sweden 2000-2003, Strandroth (2005) conclude that more than half of the riders were riding Supersport (a type of motorcycle designed and constructed as a copy of road racing cycles).

2.2.5. Tampered PTW

Moped driving gives a young person the first contact to moving in traffic with a motor-powered vehicle independently. It increases the young person’s opportunities for independent movement. The technical features of the mopeds have evolved tremendously in recent years. However, the added safety brought on by the technical development, does not count for much, if the tuning practises and driving speeds increase. The recognition of moped driving related risk factors could be improved by additional education and a driving test, held in relation to getting a moped license. In addition, moped driving safety would improve if the use of protective driving equipment would become more common. (Hernetkoski et al. 2005, 2007).

Berg et al. (2008) worked on young moped riders, in Sweden, and especially on two specific topics: unrestricted or so-called trimmed mopeds and speeding which are experienced as an increasing traffic safety problem. They have concluded concerning young Swedish moped drivers that:

- It is not the trimming itself which is experienced as a problem among police, but the way the mopeds are driven at high-speeds by young moped riders. It is felt that it is hard to get to the root of the problem without risking the youths feeling "chased".
- There is a connection between trimming and risky behaviour such as criminality (theft, troublemaking and vandalism) and the use of drugs. The connection is however not very strong and conclusions cannot be drawn that everyone that trims their moped is criminal.
- Those that trim mopeds commit many traffic offenses compared with others.
- Those that trim mopeds, have a detached relationship to their parents, they are not as committed to organised activities in leisure time, they do not enjoy school and do not have as strict parents as those that do not trim their mopeds.
- Those that have driven a moped during the last year but do not own a moped of their own are a group who are quite positive towards risk-taking and not especially aware of risks. They should be considered a risk group even if they do not own a moped.
- There is a positive attitude towards high speeds among all groups. Many would consider driving 65 km/h on a 50-road and see nothing wrong with exceeding the speed limits within city limits. This is alarming considering the clear link between accidents and speeding but also the probability that this attitude will remain when they start to drive a car.
- The efforts of the police in the targeted towns do not seem to have any influence on the attitudes and views of the youths towards traffic safety.
- Parent responsibility is important in changing behaviour among youths and achieving results from police work.

Berg et al. (2008) conclude after studying young Swedish moped drivers that there is a connection between trimming and risky behaviour such as criminality (theft, troublemaking and vandalism) and the use of drugs. The connection is however not very strong and conclusions cannot be drawn that everyone that trims their moped is criminal.

2.2.6. Human error

A standard approach in accident causation is that somebody made a mistake, an error, which made the accident inevitable. The main error scenarios highlighted depend on the type of user (AU2RM 2007):

- From the motorcycle rider viewpoint:
    - Excessive confidence in their prognosis abilities as to how the interaction situation will evolve (39%).
    - In accidents with several vehicles, motorcycle riders are not at the origin of the accident-causing disturbance but contribute to the breakdown in the situation by the mode of driving or by the absence of adjustments (48%).
- From the moped rider viewpoint:
    - The main problem lies in making the decision to undertake a manoeuvre contrary to socially accepted codes of behaviour (23%)
    - Half of cases, moped riders are at the origin of the disturbance leading to an accident.
- From the passenger car driver viewpoint:
    - When they are confronted to a PTW, passenger car drivers have more perceptive failures (60%) than passenger car drivers confronted to other vehicles (45%).

MAIDS study (ACEM 2003) concludes that 88% of the main primary contributing factors are linked with a human error (respectively 37% for the PTW riders and 50% for the opponent vehicle drivers):

- 36% of all the primary contributing factors are perception failures related to the opponent vehicle driver. This one was unable to perceive the PTW or its rider.
- 13% of all the primary contributing factors are decision failures related to the PTW rider. This one failed to make the correct decision to avoid a dangerous condition.
- For 11% of the riders and 18% of the opponent vehicle drivers, inattention was a factor which has contributed to the accident.
- For 28% of the riders and 63% of the opponent vehicle drivers, a traffic scan error was a factor which has contributed to the accident. A traffic-scan error was considered to be any situation in which the user did not observe or perceive oncoming traffic or traffic that may have been entering the roadway from some other direction.
- For 19% of the riders and 23% of the opponent vehicle drivers, the presence of visual obstructions on the road of the user was a factor which has contributed to the accident.

TRACE project (2008) has identified the main human errors according to the PTW accident configuration and the PTW involved in the accident. The final most common scenarios detected are the following ones:

- Motorcycle single accidents[8] (27%): The corresponding failures are mainly related to skill-based behaviours:
    - Poor control of a difficulty (E1 failure),
    - Incorrect evaluation of a road difficulty(T1 failure),

[8] Accidents which involved just one motorcycle on a rural road (run-offs, rollover on the carriageway and collisions with road restraint systems).

  - Impairment of sensorimotor and cognitive abilities(G2 failure).

- Front-side accidents in rural and urban junctions between motorcycles and passenger cars (13%). The failures identified in those cases show that PTW users have encountered prognosis difficulty concerning the other's behaviour (T5: 'Not expecting manoeuvre by another user' and T6: 'Expecting adjustment by another user').
- Side-side accidents in rural and urban non junctions between motorcycles and passenger cars (5%). The 3 failures connected to this configuration are:
  - Cursory information acquisition (P3 failure),
  - Neglecting information acquisition demands (P5 failure),
  - Incorrect understanding of manoeuvre undertaken by another user (T4 failure).
- Rear-end accidents in rural and urban non junctions between motorcycles and passenger cars (5%). The main failure is when the rider was realizing a critical overtaking when the accident occurred and he did not understand the manoeuvre undertaken by another user (T4 failure). Four elements have been found to explain this failure:
  - Manoeuvre over-familiarity;
  - Trivialization of the situation (potentially dangerous but treated as 'pain killer'),
  - Ambiguity of clues coming from other users,
  - Atypical manoeuvres from other users.
- Moped single accidents[9] (21%): Those losses of control are related to ability to drive, would the rider meet an external difficulty (curve, wind blast…) as in 'Failure to detect in visibility constraints' (T1 Failure) or 'Poor control of a difficulty' (E1 failure), or would the failure originate from attention processes or psycho-physiological capacities as encountered in 'Guidance problem' (E2 failure), 'Lost of psycho-physiological ability' (G1 failure) and 'Impairment of sensorimotor and cognitive abilities' (G2 failures).
- Front-side accidents in rural and urban areas (junction and non junction) between mopeds and passenger cars (30%). The failures identified for configuration F are mainly related to perception (P1 failure - 'Failure to detect in visibility constraints' - coded in 3 out of 11 cases) and prognosis (T5 - 'Not expecting (by default) manoeuvre by another user' - and T6 failures - 'Expecting adjustment by another user).
- Head-on accidents in rural and urban areas (junction and non junction) between mopeds and passenger cars (8%). Accidents mostly happened when the moped was going ahead on a straight road, and the rider was designated as passive so no failure has been identified for him. Consequently, there is also no explanatory element for this user.

2.2.7. Conspicuity, perception of drivers for motorcycles

Due to their size, PTWs may become difficult to be detected by other users (PTW conspicuity). That is why this factor is a recurrent subject in the studies. In France, a critical factor is that the passenger car drivers did notice the motorcyclist leading to mean scenarios (RIDER 2005, Chapelon 2009):

- Turn-left of the passenger car (35.8% of fatal accidents),
- Priority conflict (35.2% of fatal accidents),
- Dangerous manoeuvre of the passenger car driver (U-turn, wrong way… 3%).

Clabaux (2009) has studied motorcyclist conspicuity related to accidents in urban areas. She concludes that, in an urban environment, accident cases related to the low conspicuity of motorcycles are indeed associated with generally higher speeds (for motorcycles) compared with other accident cases involving motorcyclists.

[9] Accidents which involved just one moped on a rural or urban road (run-offs, rollover on the carriageway and collisions with road restraint systems).

In UK, 1,790 cases involving motorcycles have been analysed so far (nearly 1,003 of them in detail) from Midland police forces, from 1997 to 2002 (Clarke et al. 2004, Huang and Preston 2004). The main causes of such accidents were that other road-users observing motorcyclists, looked but failed to see and that some road-users have a poor perceptual 'schema' for motorcycles in the traffic scene, and therefore do not process the information fast enough, particularly at intersections.

Wells et al. (2004) conducted interviews with 463 motorcycle riders and next of kin, who had required hospital treatment or died, following involvement in a collision. A roadside survey of 1,233 motorcycle riders acted as a control dataset. The interviews identified that the use of reflective or fluorescent clothing, headlight operation and the colour of the helmet, clothing, and motorcycle were key factors in increasing motorcycle conspicuity.

Although only 20% of motorcycle riders in the control group wore reflective or fluorescent clothing, this research identified that those who wore such clothing had a lower risk of crash related injury. This reduction in risk was reported as 37% less when comparing riders who were not wearing reflective or fluorescent clothing to those who did wear this type of safety clothing. Improving conspicuity by wearing reflective and fluorescent clothing was particularly beneficial with falling levels of light.

Black, white and red (base colour) helmets were the most frequent colours worn for control drivers. Both statistical analysis and self nominated descriptions indicated that wearing a white helmet compared to a black helmet was associated with a lower risk of "collision-related" injury.

Horswill and Helman (2003) conclude that, motorcyclists cannot be considered as unique group in terms of risk taking behaviour, in the cases examined, they may have better hazard perception than the car drivers. Behaviours exhibited by motorcyclists that may increase or decrease (hazard perception) their accident risk, relative to car drivers are speed, gap acceptance and overtaking (Horswill and Helman 2003).

Perception of drivers while approaching a motorcycle in junctions engages a three-step process: looking, processing and appraising the risk.

Labbett and Langham (2006) demonstrated drivers' propensity to fixate at the focus of expansion, and even suggested that novice drivers might fixate an oncoming motorcycle sooner than their more experienced counterparts. Moreover, the failure to correctly appraise the risk is mainly due to size arrival effect - the size of an approaching vehicle can influence the perception of its speed and the time it will arrive at the junction - (DeLucia, 1991).

Crundall et al. (2008) suggested that perceptual errors within a single fixation discriminate between approaching vehicles more than appraisal errors of the same static images.

2.2.8. Alcohol

As for passenger car accidents (where the literature is very abundant on the topic), alcohol is an important factor related to PTW accidents. Indeed, Chapelon (2009) and Van Eslande (2006) estimated that alcohol is overrepresented in fatal accidents compared to passenger car accidents (25% vs 16%).

The literature review on motorcycle collision underlines the fact that for fatal accidents, motorcycle running off the road is the most common type (Huang and Preston 2004). And these ones happened often late night, weekend crashes involving a drunken motorcyclist. As single accidents only account for a small proportion of total accidents, it appears that impairment has a much more deadly effect on motorcyclists.

Moskal (2009) has studied and quantified the effect of the main factors related to motorized two-wheel drivers on the injury crash risk (Odds ratios of responsibility were estimated using a logistic model). The most important risk factor for both moped and motorcycle riders was alcohol with estimated odds-ratios greater than 10 with an alcohol consumption of 2g/l or more.

In Finland, for motorcyclists, riding under the influence was a contributing factor due to which the rider swerved off the road; however, it was rarely a factor in accidents involving other road users (Hernetkoski et al. 2005). This statement is not valid for moped riders. Indeed, in the fatal accidents, 19% of the moped riders were under the influence of alcohol (Hernetkoski et al. 2005).

Clarke et al (2004) found no difference between proportion of riders under the influence of alcohol who had an injury accident, and proportion of all road users who failed a roadside alcohol test.

2.2.9. Speed

Speed is a factor which has been analyzed in many studies. Motorcycles only have two wheels and their dynamics are completely different (comparing to passenger cars dynamics) and then they are more sensitive to speed.

In France, on the whole, the drivers respect more and more the speed regulation except the rider population. 35% ride 10km/h over the speed limit (11% for passenger car drivers and 10% for truck drivers) (Chapelon 2009).

In RIDER project (2005), 12.2% of the accidents are single PTW accidents. In most cases the cause for those accidents is the badly adapted speed (not necessarily over the legal speed).

Cook et al. (2007) conducted a literature review on “speeding” of current PTW accident data which suggests that 37% of collisions leading to a fatality result from loss of control by the rider. This loss of control was attributed to travelling at an excessive speed. It was also noted that motorcyclists admitted to a hospital in Germany following a collision tended to agree that speeding was the main reason for their collision. This was especially apparent in cases where riders were using larger capacity motorcycles. This project also indicated that previous research has shown that younger riders have an increased tendency to speed when compared with older drivers; with this excessive speeding being a major contributory factor in motorcycle collisions involving riders aged between 20 and 30 years of age.

Based on in-depth-studies of fatal motorcycle accidents in Sweden between 2000 and 2003, Strandroth (2005) concludes that it has been estimated that 4 out of 10 killed drivers have ridden significantly faster than the speed limit.

2.2.10. Helmet protection

The RIDER study (2005) has shown well known results: the rate of helmet wearing is very high and varies from 94% to 99% whatever is the type of PTW used or the type of road on which PTW users are riding. Chapelon (2009) confirm this fact as in France, in 2008, only 3% of the PTW users did not wear the helmet.

Norvell and Cummings (2002) demonstrated that little evidence was found to suggest that the effect of helmet use varied with age or gender. The analysis also examined the effect of helmet use and risk of fatal injuries depending on seat position on the motorcycle. The “relative risk” of death for “helmeted” riders compared to “un-helmeted” riders is much higher than for passengers in a collision.

When state law required a rider to wear a helmet, 72% of the sample did so in the US. In Greece, nearly 26% of motorcycle riders are found not to obey legislation on helmet use; the percent rises to 29% for moped riders. Overall, there are indications that wearing a helmet in a motorcycle crash can prevent 40% of fatalities that would have otherwise not occurred (Norvell and Cummings 2002).

Ferrando et al. (2000) suggested that the proportion of deaths with severe head injuries was also reduced after the introduction of the helmet law in the USA (a US federal law required the use of safety helmets by all two wheel motor vehicle occupants in urban areas in 1992). However, other anatomical regions such as the thorax and abdomen obtained a greater severity of injuries. This research also noted that the use of helmets does not increase the risk of spine injuries in PTW collisions; as the severity of spine injuries did not vary after the helmet law came into effect.

Chinn et al. (2001) was involved in the European project COST 327. During the course of the project it was estimated that improvements in helmet performance could lead to a reduction in serious head injury rates of at least 20% per annum.

2.2.11. PTW apparel

The PTW riders can not be protected by the body of the PTW itself (such as for passenger car) in case of an accident. With the exception of the C1 BMW which has been designed with a survival unit (which protect the users during a crash) or the Honda Goldwing which propose an airbag, only few of the other PTWs have such passive safety systems. Then, it means that PTW users can only rely on their protection equipments in case of accident. We have seen previously that helmet is one of the main passive safety systems for a PTW rider. Nevertheless, studies and research centres tries to develop PTW protective clothing.

Ulleberg (2003) demonstrates that the use of protective clothing reduces the severity of injuries on hands, feet, legs and arms (a 33-50 % reduction in injury severity). Today there are several new developments of protective clothing available for motorcyclists. Even though the protective effects of these remain to be estimated on basis of actual motorcycle accidents, there is reason to believe that the use of these kinds of protective clothing will result in a further reduction of injury severity. The proportion of riders and passengers wearing protective clothing while riding is, however, unknown. He indicates that there is a large potential for increasing the wearing rate of protective clothing among motorcyclists. Measures aimed at increasing the wearing rate of protective clothing can therefore be expected to have a potential for injury reduction. It is not known whether wearing protective clothing can cause the rider to feel safer while riding, and thus be more likely to take more chances while riding. A challenge for future research is to determine whether this type of behavioural adoption will occur or not.

MAIDS project (ACEM 2003) and RIDER project (2005) confirm the previous facts. Indeed, RIDER project conclude that the proper and adapted (good size, no crash impact…) wearing of crash helmet (92%) and gloves (84%) is satisfactory for big engine PTW users. Nevertheless when examining the other safety equipments such as jackets, boots and trousers, the rate is lower: 55%, 40% and 19% respectively. For small engine PTW users, the correct use of safety equipment is rare whatever the equipment is. For instance, 52% of these drivers do not wear any crash helmet or wear an unadapted one. 57% of PTW passengers do not wear any gloves and 83% of these users do not have any specific trousers.

The result of the estimation is that with crash helmet, many injuries can be avoided. Such a result is not surprising as the head is weak and any impact can cause injury. Potentially, 59% of the injuries of the PTW users who did not wear any helmet or did not wear it properly could be avoided. For the feet (35%) and the arms (25%), the injury saving is high. But it mainly concerns moderate injuries (with AIS[10] 1 and 2). For the legs, the hands, the thorax, the abdomen and the spine the results confirm what we found above, PTW protection equipments need improvement to be efficient. MAIDS project tends to the same conclusions (ACEM 2003).

2.2.12. Sociological studies

One of the main issues of the French project AU2RM was to consider the safety of riders from the PTW's viewpoint, from the automobile driver's viewpoint, from the road infrastructure viewpoint, and especially from the viewpoint of the many interactions between them. To reach these goals sociological inquiries have taken place. For the sociology part of the project, the main results are (AU2RM 2007):

- Rider's population is changing influencing PTW use in the way that a PTW was used by passionate users ("traditionalist users") whereas now a PTW is a useful mode of transport ("opportunist users"). Traditionalist users consider that most of the opportunist users are scooter users, have a selfish behaviour and do not consider driving rules.
- PTW users think that car drivers are at the origin of unsafe situations because of an envy feeling (drivers are in traffic jam) and a lack of attention (no turning light from drivers)
- Car drivers are not enough informed about the PTW risk in the traffic.
- Some behave in a way that seems to be "out of law", but expect some rider conventions to be respected. This can be problematic for other drivers who are not aware of such rules.

Watson et al. (2007) have examined the psychosocial factors influencing on-road riding, using an extended version of the theory of planned behaviour. Conceptual content analysis of data was used to determine the following six major types of behaviour that characterise both safer and riskier riding as identified by riders:

- Handling the motorcycle skilfully,
- Maintaining concentration and focus on the road environment,

[10] The Abbreviated Injury Scale (AIS) is an anatomical scoring system which provides a reasonably accurate ranking of the severity of injury: from AIS 1 – minor injury – to AIS 6 – Unsurvivable injury.

- Not riding whilst impaired,
- Obeying the road rules,
- Not pushing the limits,
- Not performing stunts or riding at extreme speeds.

Banet (2009) has led a research aiming at studying motorcyclists “risk awareness” at two complementary levels. First, at the level of “cognitive abilities” and driving skills that is to say studying the way the motorcyclists become aware or not of the criticality of a driving situation. Second, at the level of “social attitudes”, which more specifically, focuses on motorcyclist attitudes towards risk and risk-taking. The aim of this research was to build bridges between cognitive psychology and social psychology. The main conclusion drawn is that there is no homogeneous population of motorcyclist but different groups of motorcyclists differing in their attitudes towards risks in their practices and in their driving abilities for critical assessment. The different populations are:

- “Sports” motocyclists, enthousiastic for powerful, nervous and fast motorbikes
- “Bikers”, enthousiastic for Harley Davidson-type motorbikes
- “Utilitarian”, riding scooter (125cc) in urban area mainly to avoid traffic jam and urban congestion problems.

Sports and Bikers performances are quite similar. By contrast, the Utilitarians are distinguished by an underestimation of the situations criticality.

Sexton et al. (2006) have analysed a survey in order to investigate the levels of risk accepted by motorcyclists, their attitudes to risk and their perceptions of personal risk. Findings of the study demonstrated that, in general, motorcyclists are aware of the risks they face and are accepting these risks. Motorcyclists can be divided into three groups: "risk deniers", "optimistic accepters", “realistic accepters”. In other words, those who are aware of the risks but do not think they apply to themselves, those who are optimistic that they will not be involved in a collision, and those who have the most accurate understanding of the risks they face. It was also apparent that most riders in the surveys were dedicated to riding and would not consider giving it up because of the risk.

In the study of Sexton et al. (2006), those that have driven a moped during the last year but do not own a moped of their own are a group who are quite positive towards risk-taking and not especially aware of risks. They should be considered a risk group even if they do not own a moped. There is also a positive attitude towards high speeds among all groups. Many would consider driving 65 km/h on a 50 km/h road and see nothing wrong with exceeding the speed limits within city limits. This is alarming considering the clear link between accidents and speeding but also the probability that this attitude will remain when they start to drive a car.

Regarding police enforcement, the efforts of the police in the targeted towns do not seem to have any influence on the attitudes and views of the youths towards traffic safety. Berg et al. (2008) conclude by underlining that parent responsibility is important in changing behaviour among youths and achieving results from police work.

2.2.13. Fatigue

Fatigue is a factor influencing the frequency and severity of motorcycle accidents. Driver/Rider fatigue can be defined in terms of the following two dimensions as (NTC 2001): *“Impaired performance (loss of attentiveness, slower reaction times, impaired judgment, poorer performance on skilled control tasks and increased probability of falling asleep) and subjective feelings of drowsiness or tiredness. Long periods awake, inadequate amount or quality of sleep over an extended period, sustained mental or physical effort, disruption of circadian rhythms……inadequate rest breaks and environmental stress (such as heat, noise and vibration)”*.

Some of the causes and effects of rider fatigue, such as lack of prior sleep or time of day of riding, are shared with those of driver fatigue (Horberry et al. 2008). Factors that appear to increase the likelihood of fatigue in motorcycling include the physical effort to control the motorcycle, concentration on the road surface, adverse weather, alcohols and other impairments.

2.3. Summary of findings

PTW accidents present several complex interactions with the manner riders or drivers behave on the road system. These interactions are magnified in certain accident configurations, such as accidents at intersection and accidents during an overtaking manoeuvre, right of way violations (ROWVs) most frequently caused by a party other than the motorcyclist, loss of control, speeding, influencing greatly the severity of PTW injuries.

From the extensive analysis of the literature concerning the interactions of drive/rider behaviour with the PTW accidents several critical factors have emerged:

- riding/driving attitudes and patterns (such as sensation seeking, risk taking, speeding and so on)
- age, gender and experience
- licensing, education and training
- type of PTW (relate to the power engine, type of use, tampered PTW)
- perception of drivers/riders and human errors (from the point of view of the PTW or the passenger car)
- collision type (rural or urban, PTW single accident or more than one vehicle accidents, more than one, front side crash, side-side and so on)
- conspicuity, perception of drivers for motorcycles
- alcohol and other impairments (medical prescriptions, drugs, fatigue and so on)
- personal protective equipment (helmet protection and other PTW apparel)

These factors form a conceptual basis for the following macroscopic analysis of PTW accident risk factors based on the National and European PTW accident databases.

3. Methodology

The aim of this chapter is to describe in detail:

- The overall methodology of the activity 1.1 which is to deal with rider /driver behaviours and road safety.
- The data on which the analysis have been done (macro and micro data).
- The different accident analysis models.

3.1. Overall methodology of the activity 1.1

The aims of this activity are to identify the most frequent road accidents configurations from a macro point of view and to analyse and determine the underlying dysfunctions at different levels (personal determinants of the riders, riders/drivers interactions, vehicles etc.) that cause such accidents regarded from a micro point of view.

The research is hence conducted in two phases (see Figure 3); for the *first phase* data from national accident databases (Finland, France, Greece, Italy and the United Kingdom) have been used and statistical analysis have been conducted to identify the impact of rider and road environment characteristics on PTW accidents.

All the accident characteristics reported in national databases, mainly descriptive characteristics and not analytic ones – such as the place and the weather during the accident and not the causes of them - give us a large overview of which kind of accidents frequently appears and what are the road safety issues (for instance, 33% of injury accidents are single vehicle accidents but these accidents represent 50% of the fatalities, young drivers and riders are riskier population).

For the *second phase*, analysis of existing in-depth accident data have been realized using appropriately designed techniques.

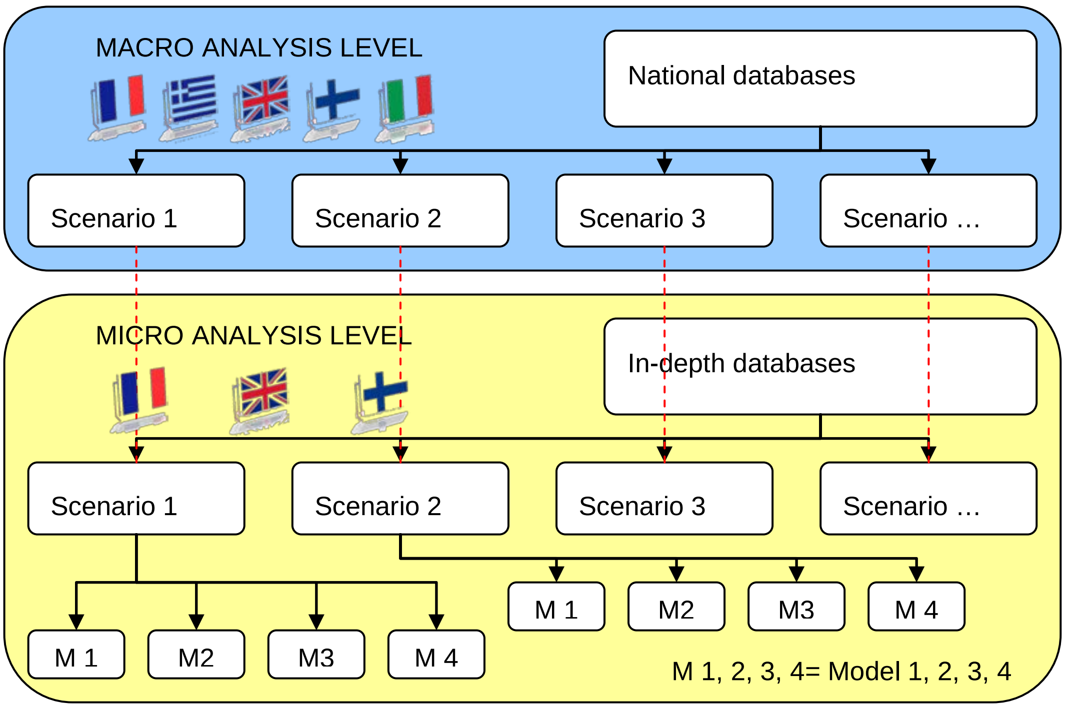

Figure 4: Rider / Driver behaviours study methodology

3.2. Macro analysis level: databases

The macro analysis, using national road accidents databases, is focused on a 2 years period, from 2006 to 2007. When analyzing the data of the different countries, it was always possible to get full information for the entire period of 2 years.

The accidents analyzed covered all fatal accidents, in which, at least, one PTW user was involved and fatally injured. The death is defined as a result of the accident within 30 days from the day of the accident.

The databases used are from Finland, France, Greece, Italy and the United Kingdom and are described as follow:

3.2.1. British national database

British National Road Accident Data are commonly called 'STATS19' due to the name of the form that the Police complete for every road traffic accident involving an injury on a public highway.

For each accident, there are 3 types of records: accident, vehicle and casualty. For an accident to be included in the records, the criteria require that a person must have been injured in an accident on a public highway with one or more vehicles involved. An accident record is completed for each accident. A vehicle record is completed for every vehicle involved in the accident, even if that vehicle does not have an injured person in it. A casualty record is completed for every injured person in the accident. These forms are submitted to the Department for Transport (DfT) by each police force in Great Britain (some 50 forces in total).

Data are available for Great Britain, which includes England, Scotland and Wales. Data for the United Kingdom (UK), which includes Northern Ireland, the Channel Islands and the Isle of Man, is not available in this dataset.

Typically there are around 300,000 casualties recorded in the data per year (although this figure has been dropping in more recent years). Indeed, latest published whole year figures from UK DfT for 2008 are 230,905 casualties per year (all severities).

3.2.2. French national database

Source data - i.e. police report - is collected in order to determine judicial responsibilities, rather than to clarify the events and circumstances that led to the accident. Data for the national road accident database are derived from the police reports. The national database produces general statistical information on road safety. So, this database gathers all injury accidents investigated by Police forces

Data are primarily used by the ONISR, who publishes the official road safety statistics and other material based on this data. Other data users include different services of the Ministry of infrastructure, such as SETRA and CETE (Centre d’Etudes Techniques de l’Equipement).

Outside the Ministry, data are used by transport safety research oriented organisations like INRETS (the French National Institute for Transport and Safety Research), ASFA (The Federation of French Motorway and Toll Facility Companies), LAB (the Laboratory of Accidentology, Biomechanics and the Study of Human Behaviour) and CEESAR (European centre for safety studies and risk analysis).

3.2.3. Finnish national database

Road accident statistics are used for evaluating the level of road safety at both national and international levels. Data are collected by the police. Statistics Finland receives from the police the data on road traffic accidents that are entered into the PATJA information system of police affairs. Statistics Finland is responsible for the maintenance and controls access to the database. The principal users of the statistics at the national level are Ministries as well as various central agencies and transport organisations. The main users at the local level are municipalities. Monthly statistics are available for public consultation in electronic form on the website of Liikenneturva (the Central Organization for Traffic Safety in Finland). The tables of annual publication are available in electronic file format. Data can also be acquired as files.

3.2.4. Greek national database

The National Statistical Service of Greece (NSSG) is a general secretariat of the Ministry of Economy and Finance, with the following structure: a central service, with two general directorates, twelve central divisions and seven decentralised divisions.

Individuals, households, public and private enterprises of almost all the branches of economic activity (agricultural, industrial and commercial enterprises, enterprises providing services), state services, local government, public utility organizations, educational establishments, hospitals, social insurance organizations etc are the sources from which the NSSG collects data. These data are then tabulated after the appropriate processing. The response rate of the above sources is considered satisfactory and facilitates the collection of data by the NSSG.

The Greek Traffic Accident Database consists of almost the whole population of accidents with casualties in Greece. It is assumed that 95% of the accidents are recorded. Approximately, 17000 records have been entered in the database in the year 2006.

The source of data is the Traffic Police Unit and in particular the police officer who has investigated the accident and the accident scene. The police officer has to fill in an eight pages form with general data about the accident place, vehicle and people involved. The variables do not require a thorough investigation of the accident or an accident reconstruction in order to be answered.

The police forward the form to the National Statistics region office and the office staff digitizes the data and stores them in a tabular format. During the digitization of the data, a quality control takes place. In case of insufficiencies, the office agent contacts the responsible for the case police officer and ask for additional information and proceeds to correction or changes.

3.2.5. Italian national database

In Italy, the national road accident database is maintained by the National Institute of Statistics (ISTAT). The accident database contains information about all traffic accidents that occurred in Italy and caused injuries to persons.

The purpose is to inform citizens of all aspects related to road safety. For this reason ISTAT produces annually official statistics on road accidents.

Provisional data become definitive after 300 days from the start of data gathering. For instance, data of year 2005 will be available at the end of 2006. Data are available in aggregated form on the internet without any cost; raw data can only be requested by research institutes.

3.3. Micro analysis level: databases

We know that descriptive analysis is required to evaluate the stakes linked to a situation such as intersection situation or to a group of users such as passenger car users. Indeed, national and moreover European data are collected by police teams whose aim is to define the responsibilities of the accident. Despite the fact that most of national data from different European countries are not completely compatible together because of the different parameter definitions and the different manner to code an event (CARE aim is to erase the differences with correction factors), these data are accurate enough to identify the main situations in term of number of accidents and severity. These results are very useful to help the stakeholders with their decisions and actions. But if we want to understand the accident mechanisms, these data are not detailed enough to answer the question: why accidents happened?

The databases contain hardly any data on the pre-crash phase of the accidents, on post-crash data. Self evidently pre-crash data are indispensable for the analysis of effective countermeasures to prevent road accidents. Since the focus on the relevant pre-crash data generally differs for accidents of different road users, there are activities on accident causation data gathering for car accidents, for motorcycle accidents and pedestrian accidents; the latter two for obvious reasons also include data that are relevant for the causation of injuries.

These databases exist for selection of severe accidents in a few regions of some countries in the EU, some states of the USA, and in Japan, especially where car industries are located.

3.3.1. British in-depth database

The On-The-Spot Accident Research Project (**OTS**) is available from VSRC (Vehicle Safety Research Centre). This provides in-depth data from the year 2000 onwards, with 500 cases per year covering the Midlands & South-East regions of England.

The investigation roster is on a 30 day cycle repeated without interruption (inc. holidays). Shifts progress over 6 days: 7am-3pm, 3pm-11pm, 11pm-7am followed by 4 rest days. Accident selection is based on standard notification from the police control room. The OTS data is a representative sample of recent UK accidents including detailed information on causes. A common police accident reference number allows some dataset comparison between OTS and the UK statistical database, STATS19. Key variables are also compared with local police accident records.

Data available cover the road user, the accident situation, participants (inc. cars, motorcycles, pedestrians, cyclists and trucks), accident cause, injury cause, human factors and vehicle technologies.

3.3.2. French In-depth databases

3.3.2.1. MAIDS[11] database

MAIDS is the most comprehensive in-depth data currently available for Powered Two Wheelers (PTWs) accidents in Europe. The investigation was conducted during 3 years on 921 accidents from 5 countries using a common research methodology. By CEESAR, 200 PTW accidents as well as 200 reference cases were researched during this period from 1999 to 2001. The investigation teams had to use a certain methodology developed by the Organization for Economic Co-Operation and Development (OECD).

The purpose of the study was to identify the causation factors of motorcycle accidents. The project focused on injury prevention, motorcycle improvements, and a better understanding of the human factor.

For 2BESAFE project, only accidents collected in France have been used.

3.3.2.2. RIDER[12] database

CEESAR has initiated the project RIDER using the accident investigation methodology of MAIDS project. In addition to accident data gathering, RIDER went deeper in the knowledge of powered two-wheelers accidents and injury mechanisms, in the understanding and explanation of the failures of the drivers, the riders, the infrastructures or the vehicles. Finally, this study gave guidelines to policy, decision makers, scientific community, protective clothing manufacturers, vehicles and powered two-wheelers industry for future actions contributing to the improvement of road safety.

In order to take up the challenge, CEESAR PTW experts have investigated 210 French accidents, using in-depth accident analysis methodology. It means that all the accidents have been reconstructed in detail in order to identify their causes and consequences. Moreover, all the information about the infrastructure, the riders, their safety equipments, their injuries and the vehicles have been collected in a complete database. Around 1800 parameters per accident were informed.

The project has begun in 2003 and has been achieved in 2005. Thanks to the database, the role of the infrastructure in the accident sequence and in the injury mechanism has been determined. Rider protective clothes and helmets have been analyzed (usage and deficiencies). The use and the efficiency of a better braking system for PTW during an emergency situation have been evaluated. Relevant scenarios of accidents were underlined according to their frequencies and risks.

3.3.3. Finnish in-depth database

The objective of VALT[13] database (on fatal accidents) is to produce information and safety suggestions to improve road safety by studying road and cross-country traffic accidents. In practice,

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[11] Motorcycle Accidents In-Depth Study – founded by the European Commision and the ACEM

[12] Recherche sur les accidents Impliquant un Deux-Roues motorisé - Research on accidents involving a PTW

[13] VALT is the name of the Traffic Safety Committee of Insurance Companies in Finland

files are collected in the field investigation and they are available to the traffic safety work as laid down in the data protection legislation. According to the Road Accident Investigation Act and its preamble, accident investigation serves to strengthen the information base made available for road safety work done in an effort to increase safety. The use of data obtained in road accident investigation is restricted for this purpose.

The file is built from accidents compensated under motor liability insurance. Insurers' claims handlers record the data in the company's database and also forward certain files to Finnish Insurance Data Ltd, who makes the database available to VALT. The database of insurance claims can be complemented in insurance companies to include data originating from police examination records or any other documents that may have been issued on the case.

3.4. The in-depth analysis

« Behavior in road accidents is complex, within a complex system that consists of the triptych Driver-Vehicle-Environment…the systemic approach assumes that to handle a complex behavior, it is fundamental to make the junction between several viewpoints »

Ben Ahmed, 2006

On that basis, we have decided to analyse accidents with an in-depth approach according to four approaches or accident analysis models which are complementary and help us to better understand the role of driver and rider behaviours in the accident genesis. These models are explained in this section.

The first model, which we refer to as the Driver-Vehicle-Environment system description model, documents detailed factual information relating to the rider (eg. the rider's professional status, family status, age, gender, etc), to the other party involved in the crash, to the vehicles involved (eg. vehicle type, vehicle age, vehicle defects, etc) and to the environment (eg. type of road, road geometry, traffic density, etc).

The second model documents factual information relating to each phase in the evolution of the crash – the normal driving phase, the precipitating event, the emergency phase, the crash phase and the post-collision phase (Brenac, 1997; Fleury et al., 2001).

The third model, the human functional failure model (Van Elslande and Fouquet, 2007), classifies factors, characterizing the state of the system and their interactions, which explain human failures that contribute to crashes. This model considers that the driver, when driving, performs several sequential and inter-linked functions: detection, diagnosis, prognosis, decision and action. A rupture of one link in the chain can create an imbalance in the system; for example, a crash.

The final model, which is the focus of this paper, is the DREAM 3.0 model (Driving Reliability and Error Analysis Method; Warner et al., 2008). DREAM 3.0 provides a way to systematically classify and record accident causation information which has been gathered through in-depth crash investigations. It provides a structured way of sorting the accident causes into defined categories of contributing factors. Failures at the "sharp" end as well as at the "blunt" end are taken into consideration.

Each model has a different approach to the understanding and classification of the causal factors which contribute to crashes and incidents. All of the models, however, are complementary and, from each, it is possible to aggregate the classified data in order to provide an overall summary of causation factors.

3.4.1. The description of the system Driver-Vehicle-Environment

The description of the system Driver-vehicle-Environment allows a structure-oriented and contextual analysis of the system. In other words, it represents the sub-systems (the driver, infrastructure, traffic, ambient conditions, vehicle, etc.), their taxonomic groups, their contexts (the drivers' professional status, family status, etc.), their structures, as well as the various interactions between these sub-systems and their components.

It can be considered as an introduction of the in-depth analysis in order to have a good overview of who is involved in accidents? In which conditions? With which kind of vehicles?

3.4.2. The accident evolution analysis

The second stage of the in-depth analysis consists of drawing up the accident scenario in terms of the sequence of events and, in particular, describing the initial system status, identifying the triggering event and reconstructing the emergency manoeuvre. The accident is shared into four phases which are described below (Brenac, 1997; Fleury et al., 2001): the driving phase, the rupture phase, the emergency phase and the crash phase.

The identification of these phases (or 'situations') enables the different sequential stages of the accident to be reconstituted in a homogeneous manner, which makes it possible not only to analyse each case from the viewpoint of the process that engenders it, but also to set up horizontal studies of several accidents by comparing the successive stages in their development.

We are particularly interested in the analysis that follows in the so-called 'accident' situation, which is a key stage that pitches the driver from a normal driving situation into an impaired one. That transitional phase is a good place for comparing accidents, to the extent that it marks the start of a malfunction process. In the sequence of failures that follows the accidental impact, we thus sought to identify those which characterise this moment of rupture and explain the fact that the driver suddenly finds himself in a critical situation.

3.4.2.1. The driving phase

The driving situation can be described as the one in which the user is before a problem arises. It is the 'normal' situation, which is characterised for the driver by the performance of a specific task in a given context, with certain objectives, certain expectations, and so on. It is 'normal' because no unexpected demands are made upon him. The driver can adapt effectively, the events unfold in line with his predictions, expectations and anticipations. He is not overloaded with information. He controls his speed and course; he is 'master of his vehicle'. In more general terms, this means that there is a balance between the demands and ability of the system components to respond one to another: alignment, skid-resistance, sight distance, tyre wear and pressure, condition of shock absorbers, speed, degree of driver awareness, etc. It should be noted that 'normality' in this case refers to effectiveness, but not necessarily to compliance with traffic regulations.

The advantage of studying this particular driving phase is to reveal what the driver considers to be both desirable and feasible in a particular place, and in a particular context.

The driving phase is described according to two criteria: “the manoeuvre and location” and the conflict. The “manoeuvre and location” indicator illustrates the type of driving task being performed by rider or driver and the location of the vehicle. The conflict describes potential opponent manoeuvres that the road user could be faced with during the pre-accident driving situation (see Appendix 1).

3.4.2.2. The rupture phase

The 'rupture' is an unexpected event that interrupts the driving situation by upsetting its balance and thus endangering the system. That event could be an unforeseen presence or manoeuvre by another user, the advent of an infrastructure configuration which takes the driver by surprise, or provokes a sudden high workload, and so on. The effect of the rupture situation is to switch the system components from a bearable level of demand to a suddenly excessive demand in terms of ability to respond.

It should be noted that an 'unexpected event' does not necessarily mean 'unpredictable'. Which raises the question of to what extent it really was unpredictable, and if not, why it was unexpected. Information gained on the driving situation is of considerable use when seeking this explanation.

The precipitating events are divided in 8 categories: state of the user, behaviour, internal condition of the task, driver environment, vehicle, vehicle environment, infrastructure and road environment (see Appendix 2).

3.4.2.3. The emergency phase

It is the period during which the driver tries to return to the normal situation by carrying out an emergency manoeuvre. A particular feature of this stage is that the driver faces very severe constraints (both temporal and dynamic) as regards to the options open to him (braking, accelerating, swerving, etc).

The emergency phase covers the space and time between rupture and impact. If the rupture situation gives a statement of the problem in hand, the emergency situation defines the space-time 'credit' available in which to solve it. This 'credit' is, by definition, extremely limited.

The emergency situation can be determined in relation to the driving situation by the sudden excessive demand level imposed on the system components. The driver must solve, within a given time, a problem that is, in principle, entirely new to him. The range of solutions depends on the environment in terms of hostile obstacles or the space available for evasive action, or on the driver skills, driving experience, drivers long-term-memory, etc. The capacity of the vehicle to perform the required manoeuvre depends not only on its design and state of repair but also, when referring to vehicle-ground liaison, on the state of the infrastructure. The emergency situation reveals the insufficiencies or defects in one or another of the system components, weaknesses that remain tolerable when faced with normally moderate driving situation demands.

The emergency manoeuvre is an attempt to find a solution to a problem. It sometimes succeeds, but in accident databases this manoeuvre has failed. So the emergency situation is followed by the crash phase.

3.4.2.4. The crash phase

The crash phase comprises the crash and its consequences. It determines the severity of the accident in terms of material damage and bodily injury. Once again, the situational circumstances depend on what has occurred previously and the interaction between the three components: thus an elderly person is more vulnerable to injury, modern vehicles are better designed to crashworthiness, a protection rail prevents impact with a hostile obstacle, etc.

From a safe-system model point of view, each of these phases should be considered specifically with the purpose of not generating hazards for the driver. So the driving system should not generate ruptures, should be forgiving (i.e. giving the possibility to recuperate) in emergency phase, and protecting in impact phase.

3.4.3. The human functional failure analysis

Most safety studies come to the conclusion that human error is the main cause of accidents. Nevertheless, such a conclusion has not proved to be efficient in its capacity to offer adequate means to fight again this error. In a purpose of better qualifying accident causation, TRACE (Traffic Accident Causation in Europe project), has investigated the different types of 'errors' with the help of a classification model formalizing typical 'Human Functional Failures' (HFF) involved in road accidents. These failures are not seen as the causes of road accidents, but as the result of the driving system malfunctions which can be found in its components (user/road/vehicle) and their defective interactions (unfitness of an element with another). Such a view tries to extend 'accident causation' analysis toward understanding, not only the causes, but also the processes involved in the accident production. So the purpose is to go further than establishing the facts, toward making a diagnosis on their production process. The usefulness of this diagnosis is to help defining countermeasures suited to the malfunction processes in question. Three main information have been studied during the in-depth analysis, using the Human Functional Failure analysis: the Human Functional Failure, the explanatory element and the degree of involvement of the user. They are developed in the following paragraphs (using the following references Van Elslande et al. (2007) and Naing et al. (2007):

3.4.3.1. Human functional failures

Failures are delineated below following a sequential theoretical chain of human functions involved in information gathering, processing, decision and action (see Figure 4). It does not imply at all that drivers function in a linear way. In the common functioning of the individual, there are numerous feedbacks between the various modules, and the data processing is strongly looped. But involving accidents as in the analysis which follows, we stop this functional buckle in the stage of rupture in the progress of the driver, as he is confronted with an unexpected difficulty which is going to lead him to lose the control of the situation which was more or less suitably regulated so far. It is thus a grid of analysis of the dysfunctions and not a model of functioning or dysfunction of the operator.

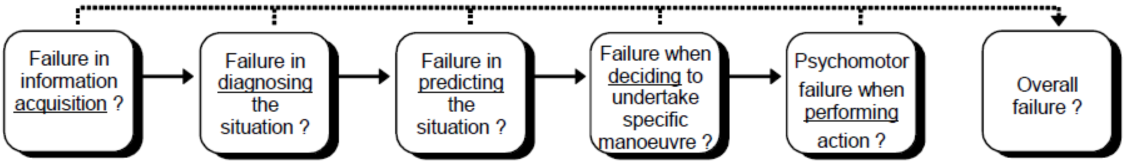

Figure 5: Stages of Human Function failure

Each functional stage is associated with a certain number of potential failures (see Figure 5). For instance, the detection category can be derived in 5 specific human functional failures: a failure to detect in visibility constraints, a focalised or a cursory acquisition of information which led to a problem of detection, etc.

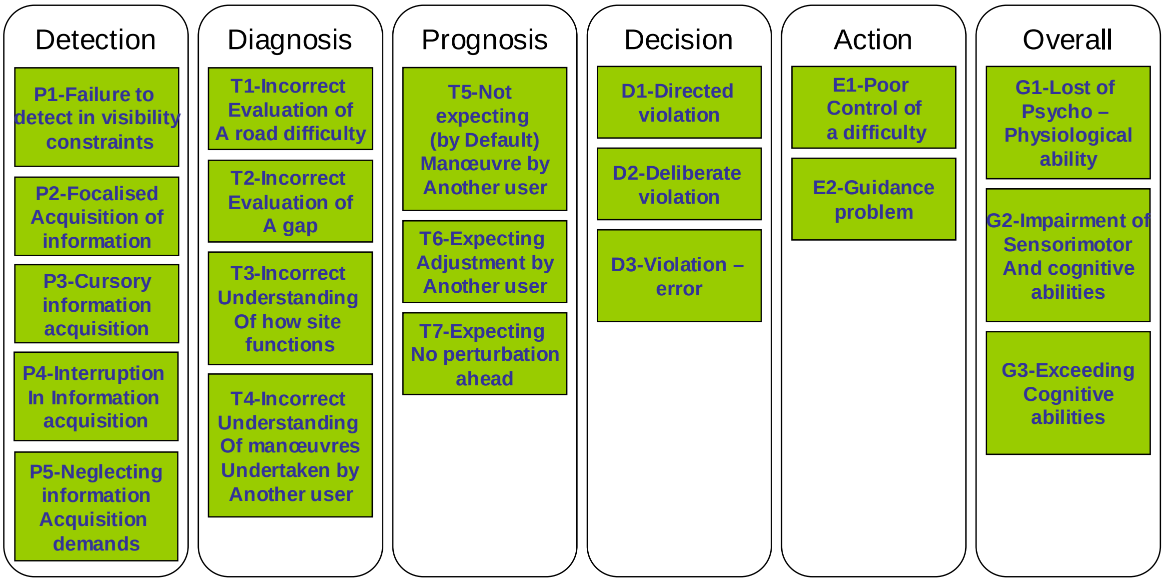

Figure 6: Human functional failures per stages (the capital letters combined with the number ahead are the code used, in the whole report, for each human functional failure)

3.4.3.2. Explanatory elements

Explanatory elements are factors which lead to human functional failures. Human failures are explained by factors characterizing the state of system, i.e. the defects of its components (human and other) and of their interactions. These factors are then considered as the explanatory elements of the road users' incapacity to adapt to the situation in hand. The combination of these elements explains the fact that the appropriate function failed in attaining the wanted outcome.
They are classified according to three main categories which are the three components of the system Driver-Vehicle-Environment.
A grid of all the relevant elements contributing to human failures has been used (Van Elslande, 2007). These elements differentiate those factors coming from the "human" part of the system, from those coming from the layout, the traffic interaction and the vehicle.
For instance, a user has incorrectly evaluate a road difficulty (it is a problem of diagnosis, see Figure 5) because of his speed, his over experience of the route, his state (he is in a hurry), etc. All these factors are the ones which explain the failure.

3.4.3.3. Degree of involvement

This variable defines the role played by the driver in the genesis of the accident. Close to the notion of 'responsibility', it differs from this latter by the reference not to a legal code but by the recourse to a strictly behavioural reference ('code'). In an ergonomic approach, we try only to clarify the respective degree of participation of the various users involved in the same accident, from the point of view of the degradation of the situations. Four modalities are so defined which show in a decreasing way the degree to which the driver participates by his behaviour to the fact that the critical situation turned to an accident:

Primary active

This modality designates the drivers who 'provoke the disturbance'. They have a determining functional involvement in the genesis of the accident: they are directly at the origin of the destabilization of the situation. Following the functional failure, the drivers provoke for themselves or for the other interfering users in the system, a critical situation in which the accident situation is going to take place.

Examples: a manoeuvre bringing the driver toward a trajectory of collision with the other, generating an unpredictable disturbance for the other users, provoking a loss of control, etc. In certain extreme situations, we can isolate two primary actives in the same accident, when they are both contributing to the destabilisation of the situation, when they are both contributing to the destabilisation of the situation (for example: when two drivers decide to overtake face to face on the third way).

Secondary active

These drivers are not at the origin of the disturbance which precipitates the conflict, but they are however part of the genesis of the accident by not trying to resolve this conflict. We cannot attribute them a direct functional implication in the destabilization of the situation but they participate in the non-resolution of the problem by a wrong anticipation of the events evolution. In situation of preaccident, they did not envisage a possible degradation of the events, although this degradation was theoretically detectable according to more or less alarming indications that they had. Potentially able to anticipate whereas they do not, they so contribute to the genesis of the accident by the absence of adapted preventive strategies.

Examples: absence of behavioural adaptation because they expect an adjustment from the other user, no anticipation of a possible conflicting pathway with others although alarming indications, etc.

Non-active

These drivers are confronted with an atypical manoeuvre of others that is hardly predictable, whether it is or not in contradiction with the legislation. As a general rule, the human functional failure observed among these drivers does not feature any endogenous (human) explanatory element[8]. They are not considered as 'active' subjects because the information they had did not enable them to prevent the failure of others. They were not able to anticipate, for lack of information, the degradation of the situation, while the avoidance of the accident would have been possible in theory if this information had been supplied to them in time. But we differentiate them from 'passive' users in the strict sense, for whom no information would *a priori* have allowed to avoid the collision.

Examples: drivers confronted with visibility constraints, drivers that must face an atypical manoeuvre of others and who do not have warning indications at disposal, etc.

Passive

These drivers are not involved in the destabilization of the situation but they are nevertheless an integral part of the system. Their only role consists in being present and they cannot be considered as an engaging part in the disturbance. No measure may a priori be beneficial to them, except to act on the other driver.

Examples: drivers who are collided when stopped at a traffic light or on a parking spot, drivers confronted with stone falls, etc.

3.4.4. The DREAM analysis

DREAM is the acronym for Driving Reliability and Error Analysis Method. It is a method that enables researchers and others to systematically classify and store information about factors contributing to accidents which have been collected by the conduct in-depth accident investigations (Warner et al., 2008). It is "…an organiser of explanations – not a provider of explanations" (Warner et al., p. 5).

The model was originally developed with the aim of identifying traffic situations for which the development of technical solutions had the potential to decrease the incidence of future accidents. Hence, the causation categories in DREAM, as well as the underlying accident model, focus on risk avoidance (Warner et al., 2008).

No study till now has used this methodology in order to analyse PTW accidents. Indeed, the latest version of the methodology was written in 2007 as a deliverable of Safetynet project. It is an innovative approach which does not only consider the driver as the main cause of accidents. It is a more systemic approach, where causes are considered at different levels: human level (drivers), technology level (vehicles) and organisation level.

This section of the report summarizes the aim the DREAM methodology and its use.

3.4.4.1. Evolution and Previous Use

DREAM is an adaptation of the Cognitive Reliability and Error Analysis Method (CREAM) (Hollnagel, 1998; cited in Warner et al., 2008). CREAM was originally developed to analyse accidents within process control domains (eg in nuclear power plants). CREAM was subsequently adapted for use in the road transport domain, and became DREAM (Warner et al., 2008).

Several versions of DREAM have evolved over time (Warner et al., 2008). DREAM Version 2.1 was first used in 2002, in the Swedish project FICA (Factors Influencing the Causation of Accidents and incidents). It was later adapted for further use in the EC-funded SafetyNet project (at which time it was called SNACS 1.1) Both versions have been used to analyse accident data in Sweden and other European countries, especially in the SafetyNET project. DREAM 3.0 is the latest version, which evolved mainly from the SafetyNET project

DREAM is bi-directional; that is, it can be used to analyse past accidents as well as predict future accidents(Warner et al., 2008). DREAM has not been used previously to classify factors contributing to accidents involving motorcycle riders.

DREAM is not the only tool that has been developed to store and classify accident and incident data. Other models exist, such as HFACS (Human Factors Accident Analysis Classification System and ICAM (Incident, Cause, Analysis Method). The main advantage of DREAM over other models is that it was developed and adapted specifically to structure and categorise accident data collected by in-depth studies of motor vehicle crashes. The HFACS and ICAM tools were developed for the military aviation and process control industries, respectively.

3.4.4.2. The DREAM accident model

DREAM has 3 main elements: an accident model; a classification scheme; and a method (Warner et al., 2008).

The accident model derives from two accident models: the Contextual Control model (COCOM; Hollnagel, 1998, cited in Warner et al, 2008); and the Extended Control Model (ECOM; Hollnagel and Woods, 2005; cited in Warner et al, 2008). These models suppose that cognition, in the road traffic domain, involves observation, interpretation and planning, and that control in the traffic domain involves working towards multiple parallel goals on different timeframes. These theoretical standpoints are reflected in how the contributing factors in the classification scheme are defined and linked to each other.

Accidents are seen as the result of "…an unsuccessful interplay between driver, vehicle and traffic environment…", as well as failures of organisations responsible for shaping the conditions under which driving takes place (Warner et al., 2008, p. 6).

The model takes into account failures that occur at the "sharp" end as well as the "blunt" end. Sharp end failures are ones that occur at close proximity to the accident (eg a driver fails to see a red traffic light which contributes to two cars colliding). Blunt end failures occur at other times or at other locations (for example a mechanic fails to maintain the brakes properly, which later contributes to two cars crashing) (Warner et al., 2008).

3.4.4.3. The DREAM Classification Scheme

The classification scheme in DREAM 3.0 consists of so-called “phenotypes” and “genotypes” – and the links between them (Warner et al, 2008).

Phenotypes - Phenotypes are the “observable effects” of an accident and include human actions and system events.

The purpose of the phenotypes is to classify the observable effects into a relatively limited set of categories from which the DREAM analysis can begin. In DREAM 3.0 there are 6 general phenotypes which are all linked to one or more specific phenotypes.

The 6 general phenotypes are - timing, speed, distance, direction, force, and object.

The 10 specific phenotypes are: too early action; too late action; no action; too high speed; too low speed; too short distance; wrong direction; surplus force; insufficient force; and adjacent object.

Genotypes - Genotypes are the factors that may have contributed to the observable effects – in other words, the contributing factors. Usually they cannot be observed, and hence have to be deduced eg from interviews with drivers and accident reports (Warner et al., 2008).

In DREAM 3.0, there are 51 genotypes, some of which are linked with one or more specific genotypes.

The genotypes are divided into 4 broad categories and each of them in sub-categories (see Table 2) – *driver, vehicle, traffic environment and organisation*. Driver categories include – observation, interpretation, planning, temporary personal factors, and permanent personal factors. Vehicle categories include – temporary HMI problems; permanent HMI problems and vehicle equipment failure. Traffic environment includes – weather conditions, obstruction of view due to objects, state of the road and communication. Organisation categories include organisation, maintenance, vehicle design and road design.

HUMAN Driver	TECHNOLOGY Vehicle and traffic environment	ORGANISATION Organisation
Observation	**Vehicle**	**Organisation**
Missed observation	**Temporary HMI* problems**	Time pressure
Late observation	Temporary illumination problems	Irregular working hours
False observation	Temporary noise problems	Heavy physical activity before drive
	Temporary sight obstructions	Inad. training
Interpretation	Temporary access limitations	
Misjudgement of time gaps	Incorrect ITS-information	**Maintenance**
Misjudgement of situation		Inad. vehicle maintenance
	Permanent HMI* problems	Inad. road maintenance
Planning	Permanent illumination problems	
Priority error	Permanent sound problems	**Vehicle design**
	Permanent sight obstruction	Inad. design of driver environment
Temporary Personal Factors		Inad. design of communication devices
Fear	**Vehicle equipment failure**	Inad. construction of vehicle parts and/or structures
Inattention	Equipment failure	
Fatigue		Unpredictable system characteristics
Under the influence of substances	**Traffic environment**	
Excitement seeking	**Weather conditions**	**Road design**
Sudden functional impairment	Reduced visibility	Inad. information design
Psychological stress	Strong side winds	Inad. road design
Permanent Personal Factors	**Obstruction of view due to object**	
Permanent functional impairment	Temporary obstruction of view	
Expectance of certain behaviours	Permanent obstruction of view	
Expectance of stable road environment		
Habitually stretching rules and recommendations	**State of road**	
	Insufficient guidance	
Overestimation of skills	Reduced friction	
Insufficient skills/knowledge	Road surface degradation	
	Object on road	
	Inadequate road geometry	
	Communication	
	Inad. transmission from other road users	
	Inad. transmission from road environment	

Inad. = inadequate
**HMI: Human-Machine-Interface*

Table 4: Description of genotypes of DREAM 3.0

The classification scheme in DREAM also includes ***links*** between the phenotypes and genotypes – as well as between different genotypes. These links represent existing knowledge about how different factors can interact with each other.

The output of the DREAM analysis is a “DREAM-chart” (see Figure 6) which shows, from left to right, the genotypes (Inadequate training) that contribute to the phenotype (e.g., too late action or no action) that best describes the observable effects of the accident. Each driver or rider involved in an accident analysed according to DREAM analysis has his own “DREAM-Chart”. All of them are then gathered in order to highlight problems for one scenario.

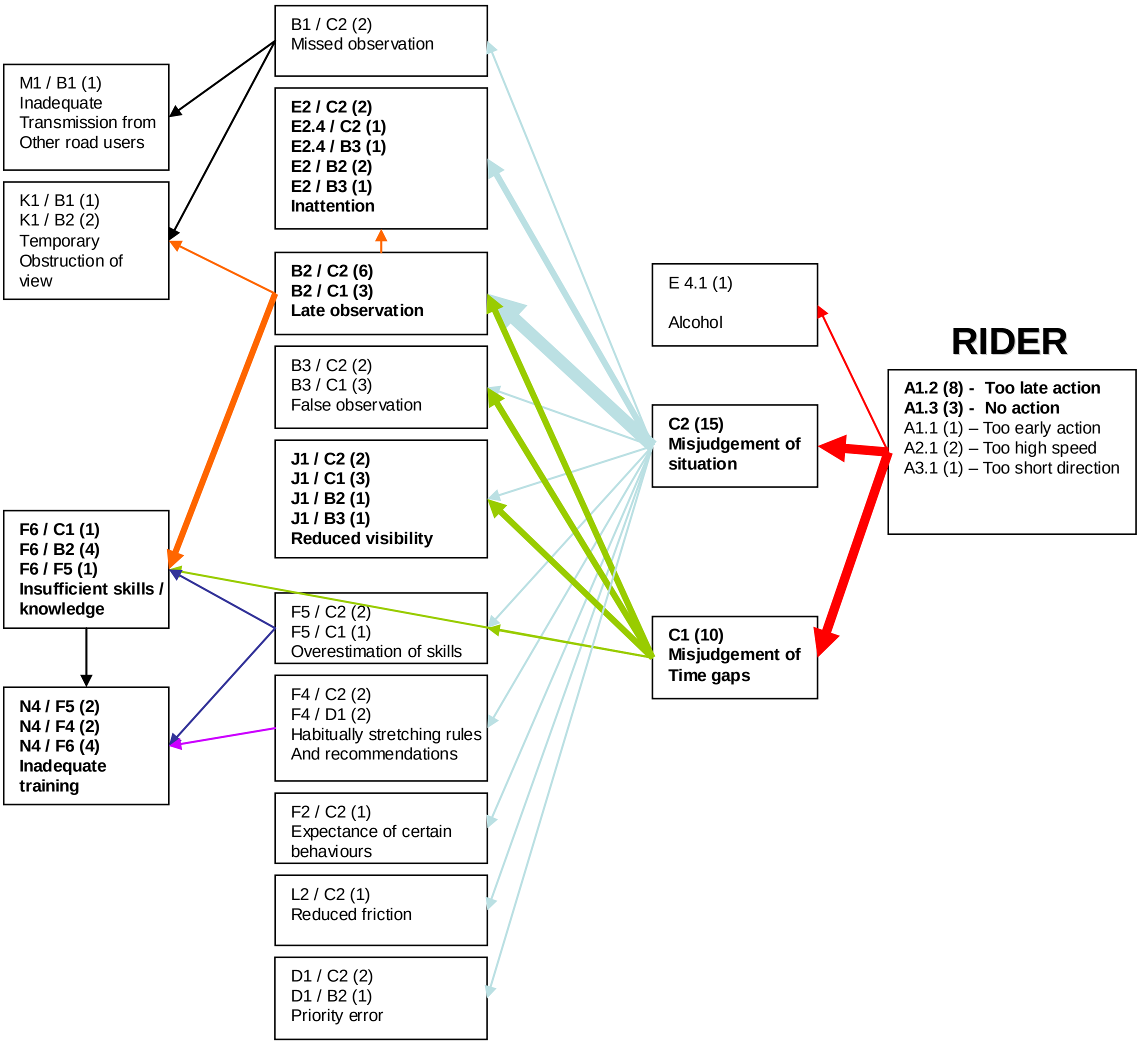

Figure 7: Example of DREAM chart for one driver in one accident

The arrows illustrate the link between the phenotypes and the genotypes and between the genotypes. These links are structured according to what is proposed when using DREAM methodology. Colours have been used in "DREAM-Chart" in order to make it easier to read. Links that occur often are represented with proportionally thicker lines.

Finally, DREAM is a useful way of analysing the possible causal factors occurring in the "pre-crash" phase of an accident, regarding the interaction between driver, road system and vehicle, as well as the background contributing factors.

4. PTW accident configuration

This chapter presents an overview of the general PTW accident situations, using national data from each country presented in chapter 3 (see 3.2 Macro analysis level: databases). The aim of this part of the report is to have a good knowledge of the PTW accidents issues in Finland, France, Greece, Italy and the United Kingdom and to determine which accident scenario is relevant in each country.

The results obtained from 2BESAFE extensive databases are focused on PTW fatal accidents (accidents in which at least one PTW user died) for years 2006 and 2007.

In the first step, PTW accident issues are summarized. Then for both mopeds and motorcycles users, and of course for each country, accident configurations will be highlighted. Moped and motorcycle users will always be analysed separately assuming the fact (also, basing our judgement on the results of the state of the art) that both users have different behaviours, do not use their vehicle for the same reasons, and do not have the same training, etc.

4.1. Introduction

In the five countries studied in 2BESAFE project (Finland, France, Greece, Italy and the United Kingdom), from 0.3 to 2.9% of road injury accidents are fatal PTW accidents. The average is 0.7% in 2006 and 2007. Nevertheless, every 4 or 5 road fatalities, it is a PTW user. These figures are homogeneous between countries (see Table 3).

2006+2007	All injury accident		PTW fatal accidents		PTW fatalities	
	Accidents	Fatalities	Accidents	%	Fatalities	%
Finland	13538	716	74	0,5%	75	10,5%
France	161581	9329	2221	1,4%	2292	24,6%
Greece	31689	3269	912	2,9%	954	29,2%
Italy	468995	10800	2768	0,6%	2891	26,8%
The United Kingdom	382894	6357	1154	0,3%	1187	18,7%
Total	**1058697**	**30471**	**7129**	**0,7%**	**7399**	**24,3%**

Table 5: PTW accidents issues comparing to injury accidents in Finland, France, Greece, Italy and the United Kingdom (2006, 2007)

Moreover, ACEM[14] has published on its website the number of PTW used per European country and per year, from 2001 to 2008. These figures are very interesting to determine the risk of PTW accidents for the five countries involved in 2BESAFE. Here is PTW “circulating park” per country, from 2006 to 2007:

Country	PTW used (2006 – 2007)		
	Moped	Motorcycle	Total
Finland	354 548	360 427	714 975
France	2 611 709	2 568 547	5 180 256
Greece	460 000[15]	2 039 610	2 499 610
Italy	7 740 000	10 879 077	18 619 077
The United Kingdom	337 242	2 506 188	2 843 430
Total	**11 503 499**	**18 353 849**	**29 857 348**

Table 6: PTW circulating park in 2006 and 2007 per country

In Finland, the percentage of fatal PTW accidents is the lowest (see Table 3) and the risk of PTW fatal accident risk for 100,000 circulating PTW is the lowest also comparing with the 4 others countries.

[14] The Motorcycle Industry in Europe

[15] The number of moped used in 2007 is not known in Greece. We have supposed that for 2006 and 2007, the figures were the same.

In Italy, this risk is one of the lowest (1.5 higher than in Finland, see Figure 7) but the percentage of PTW fatalities is high. So it can be considered as a real issue in this country.

In France, Greece and United Kingdom, the number of PTW fatalities is also high and comparing with Italy and Finland, the risk is higher (from 3.5 times in Greece to 4.1 times in France compared with Finland, see Figure 7).

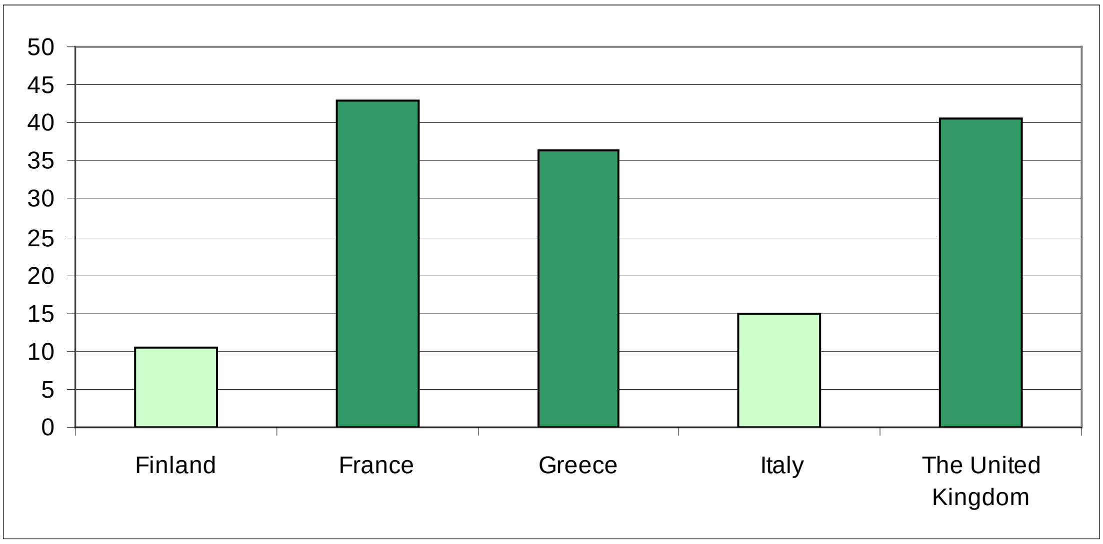

Figure 8: PTW fatal accident risk for 100,000 circulating PTW

We have decided to distinguish two kinds of PTW according to their engine cylinder capacity: mopeds and motorcycles. The reasons are:

- The findings in the state of the art advice us in differencing these two kind of users and PTW.
- We are convinced that people riding such PTW are different because of the different “riding licences” and probably because of the reasons they are using such vehicles. The in-depth analysis should confirm or not the differences between both users.
- Even if mopeds and motorcycles are PTW, the way you drive them are different (weight, power capacity, active safety system…).

So we saw that PTW accidents are issues for all countries and now we distinguish mopeds and motorcycles in order to see where are issues for these two kinds of PTW.

The first national statistics on the five 2BESAFE countries (see Figure 8) show several main results:

1- Fatal motorcycle accidents are issues in all countries: at least 68% of PTW fatalities are motorcyclists.

2- Fatal moped accidents are not issues in the United Kingdom[16].

3- Fatal motorcycle accidents are riskier comparing with fatal moped accidents (see Figure 9), for all countries, and considering 100,000 circulating PTW.

4- Fatal motorcycle accidents risk is at least 1.9 times higher than fatal moped accidents one (from 1.9 times in Greece to 3.3 times in the United Kingdom, see Figure 9).

5- France is the country where this risk is the highest for both kinds of PTW and Finland is the country where the risk is the lowest.

[16] It could be due to UK law. Compulsory Basic Training (CBT) for all PTW users has been in effect since 2001; the earliest age for moped riding is 16 years, and mopeds are restricted to max design speed of 48kph.

PTW fatal accidents

	Accidents	Fatalities
Finland	74	75
France	2221	2292
Greece	912	954
Italy	2768	2891
The United Kingdom	1154	1187
Total	**7129**	**7399**

Moped fatal accidents

	Accidents	Fatalities
Finland	24 (32%)	24 (32%)
France	657 (30%)	667 (29%)
Greece	96 (11%)	101 (11%)
Italy	651 (24%)	679 (23%)
The United Kingdom	45 (4%)	46 (4%)
Total	**1473 (21%)**	**1517 (21%)**

Motorcycle fatal accidents

	Accidents	Fatalities
Finland	50 (68%)	51 (68%)
France	1564 (70%)	1625 (71%)
Greece	816 (89%)	853 (89%)
Italy	2117 (76%)	2212 (77%)
The United Kingdom	1109 (96%)	1141 (96%)
Total	**5656 (79%)**	**5882 (79%)**

Figure 9: PTW fatal accidents (2006, 2007)

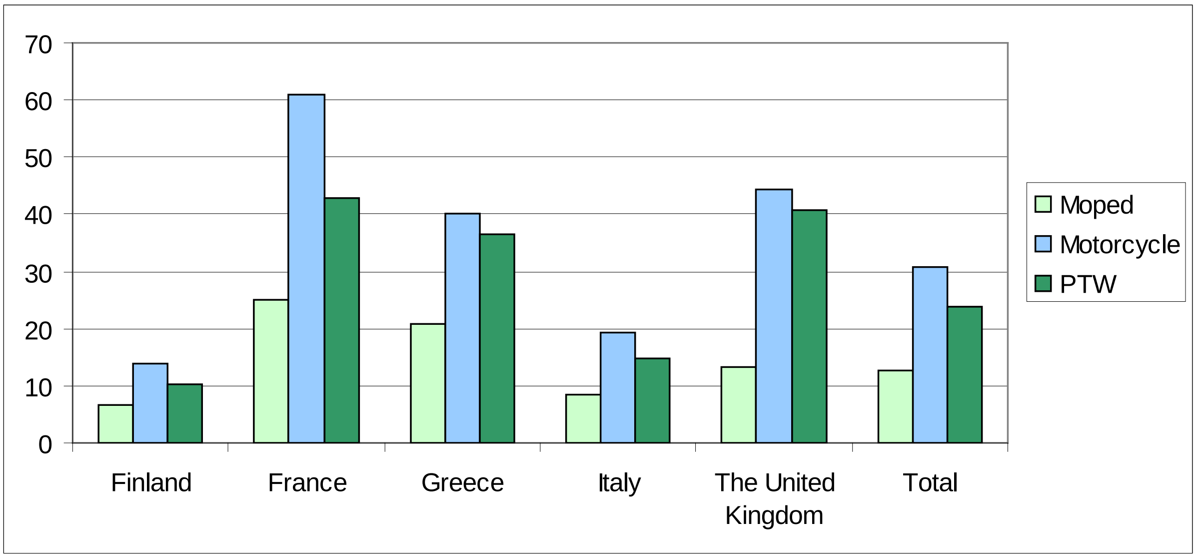

Figure 10: PTW fatal accident risk for 100,000 circulating PTW per country and per kind of PTW

To identify PTW accidents scenarios, we have selected some parameters:

- The number of vehicles (including pedestrians) involved in the accident. Single vehicle accidents and accidents involving another vehicle are completely different. And the in-depth analysis should confirm this difference.
- The area of the accident (outside or inside urban area). In bother areas, behaviours, issues conflicts are probably different (see state of the art).
- Accident happens in a junction or not. The state of the art results showed that accidents in a junction are a real issue and considering it in our analysis seems essential.
- The opponent in the accident. With which kind of vehicle is PTW involved and what are the problems in such accidents?

4.2. Moped accident configuration

4.2.1. Number of vehicles (including pedestrians) involved in the accidents

Considering, first, the number of vehicles (including pedestrians) involved in fatal moped accidents, two vehicles accidents and single ones are really issues in all countries (at least 85% of fatal moped accidents, see Figure 10). So, we consider for the accident scenario selection, only this two kinds of accidents, except for UK; as we said in the previous paragraph that fatal moped accidents were not a big issue in the United Kingdom (3.9% of fatal PTW accidents).

Moped fatal accidents	Accidents	Fatalities
Finland	24	24
France	657	667
Greece	96	101
Italy	651	679
The United Kingdom	45	46
Total	**1473**	**1517**

Single moped accidents	Accidents	Fatalities
Finland	5 (21%)	5 (21%)
France	195 (30%)	199 (30%)
Greece	28 (29%)	28 (28%)
Italy	131 (20%)	131 (19%)
The United Kingdom	11 (24%)	11 (24%)
Total	**370 (25%)**	**374 (25%)**

2 vehicles accidents (including a pedestrian)	Accidents	Fatalities
Finland	18 (75%)	18 (75%)
France	420 (64%)	425 (64%)
Greece	64 (67%)	69 (68%)
Italy	486 (75%)	507 (75%)
The United Kingdom	27 (60%)	27 (59%)
Total	**1015 (69%)**	**1046 (69%)**

More than 3 vehicles	Accidents	Fatalities
Finland	1 (4%)	1 (4%)
France	42 (6%)	43 (6%)
Greece	4 (4%)	4 (4%)
Italy	34 (5%)	38 (6%)
The United Kingdom	7 (16%)	7 (15%)
Total	**88 (6%)**	**93 (6%)**

Figure 11: Moped accidents configurations according to the number of vehicles involved (2006, 2007)

4.2.2. Moped accident scenarios

Moped accidents scenarios selection is based on results of national statistics showed in appendix 3 and 4.

Single moped accidents mainly happen not at intersection and inside urban area: around 60% single moped accidents for the five countries.

When fatal moped accidents involve another road user, these ones are mainly passenger cars and in a lesser extent trucks. Results are different according to the five countries. Here are the conclusions (we do not consider fatal moped accidents in the United Kingdom as we determined before that it was not an issue):

- Moped accidents inside urban area at intersection, involving only a passenger car and a moped, are issues for the four countries.
- Moped accidents not at intersection (either inside urban area or outside urban area), involving only a passenger car and a moped, are issues in France, Greece and Italy.
- Moped accidents at intersection and outside urban area, involving only a passenger car and a moped, are issues in Finland and Italy.
- Moped accidents not at intersection and outside urban area, involving only a truck and a moped, are issues in Finland and France.
- Moped accidents not at intersection and inside urban area, involving only a truck and a moped, are issues only in France.

All these scenarios gather around 70% of all fatal moped accidents.

4.3. Motorcycle accident configuration

4.3.1. Number of vehicles (including pedestrians) involved in the accidents

Considering, first, the number of vehicles (including pedestrians) involved in fatal motorcycle accidents, two vehicles accidents and single ones are really issues in all countries (at least 75% of fatal motorcycle accidents, see Figure 11). So, we consider for the accident scenario selection, only this two kinds of accidents.

Indeed, fatal motorcycle accidents involving at least three vehicles (including pedestrians) is only a problem in the United Kingdom. So we have not considered this kind of accident as a scenario that we will study in the in-depth analysis.

Motorcycle fatal accidents	Accidents	Fatalities
Finland	50	51
France	1564	1625
Greece	816	853
Italy	2117	2212
The United Kingdom	1109	1141
Total	**5656**	**5882**

Single motorcycle accidents	Accidents	Fatalities
Finland	22 (44%)	22 (43%)
France	552 (35%)	564 (35%)
Greece	342 (42%)	351 (41%)
Italy	607 (29%)	621 (28%)
The United Kingdom	256 (23%)	262 (23%)
Total	**1779 (31%)**	**1820 (31%)**

2 vehicles accidents (including a pedestrian)	Accidents	Fatalities
Finland	21 (42%)	22 (43%)
France	866 (55%)	905 (56%)
Greece	441 (54%)	466 (55%)
Italy	1351 (64%)	1418 (64%)
The United Kingdom	571 (51%)	584 (51%)
Total	**3250 (57%)**	**3395 (58%)**

More than 3 vehicles	Accidents	Fatalities
Finland	7 (14%)	7 (14%)
France	146 (9%)	156 (10%)
Greece	33 (4%)	36 (4%)
Italy	159 (8%)	173 (8%)
The United Kingdom	282 (25%)	295 (26%)
Total	**627 (11%)**	**667 (11%)**

Figure 12: Motorcycle accidents configurations according to the number of vehicles involved (2006, 2007)

4.3.2. Motorcycle accident scenarios

Motorcycle accidents scenarios selection is based on results of national statistics showed in appendix 5 and 6.

Fatal single motorcycle accidents are mainly found not at intersection (either inside urban area or outside urban area), for the five 2BESAFE countries. Only in UK, fatal single motorcycle accidents at intersection (either inside urban area or outside urban area) are issues This difference is explained by several reasons. First the number of single motorcycle accidents is lower in Uk than in the other countries (except in Finland). Then the definition of an intersection according to the five countries is different[17]. Finally, this accident configuration is particular: the motorcyclist can lost the control of his PTW near an intersection or another vehicle can disturb the motorcyclist without any crash. In this case, depending on how police reports the accident, one or two vehicles can be counted.

When fatal motorcycle accidents involve another road user, these ones are mainly passenger cars and in a lesser extent trucks. Results are different according to the five countries. Here are the conclusions:

- Motorcycle accidents not at intersection and outside urban area, involving only a passenger car and a motorcycle, is an issue in all countries.
- Motorcycle accidents at intersection and inside urban area, involving only a passenger car and a motorcycle, is an issue in all countries.
- Motorcycle accidents not at intersection and inside urban area, involving only a passenger car and a motorcycle, is an issue in France, Greece, Italy and UK.

[17] Position on road more than 20m from a junction or roundabout (AT, GB, IE, NI, NL). Position on road more than 50m from a junction (FR).Opinion of the police (BE, DK, DK, ES, FI, IT, LU, SE).

- Motorcycle accidents at intersection and outside urban area, involving only a passenger car and a motorcycle, is an issue in Finland, Italy and UK.
- Motorcycle accidents not at intersection and outside urban area, involving only a truck and a motorcycle, are issues in Finland, France and Italy.
- Motorcycle accidents at intersection and inside urban area, involving only a truck and a motorcycle, are issues in Greece and Italy.
- Motorcycle accidents at intersection and outside urban area, involving only a truck and a motorcycle, are issues only in Greece.

All these scenarios gather around 75% of all fatal motorcycle accidents.

4.4. PTW accident configuration summary

The following table summarizes the different PTW accident scenarios chosen for each country according to the kind of PTW (either moped or motorcycle) and the number of vehicles involved in the accident. In total, there are 20 PTW accident configurations, common or not to the five countries involved in the activity 1.1, which need to be analysed in-depth.

% (1) is the percentage of PTW accident configuration per number of vehicles involved in the accidents. For instance, 80% of fatal single moped accidents in Finland are outside urban area and not at intersection.

%T (2) is the percentage of PTW accident configuration considering the kind of PTW. For instance, 16.7% of fatal moped accidents in Finland are outside urban area and not at intersection.

PTW Accident configuration	Finland		France		Greece		Italy		The United Kingdom	
	%	%T	%	%T	%	%T	%	%T	%	%T
Single moped accident – Inside urban area – No intersection			65.6%	19.5%	46.4%	13.5%	59.5%	12.0%		
Single moped accident – Outside urban area – No intersection	80.0%	16.7%	28.2%	8.4%	39.3%	11.5%	31.3%	6.3%		
Total Single moped accident	80.0%		93.8%		85.7%		90.8%			
Moped / Passenger car accident – Outside urban area – No intersection			28.8%	18.4%	26.6%	17.7%	13.2%	9.8%		
Moped / Passenger car accident – Inside urban area – No intersection			17.4%	11.1%	15.6%	10.4%	19.3%	14.4%		
Moped / Passenger car accident – Inside urban area –Intersection	5.6%	4.2%	9.8%	6.2%	26.6%	17.7%	28.4%	21.2%		
Moped / Passenger car accident – Outside urban area –Intersection	27.8%	20.8%					11.1%	8.3%		
Moped / Truck accident – Outside urban area – No intersection	16.7%	12.5%	10.7%	6.8%						
Moped / Truck accident – Inside urban area – No intersection			8.1%	5.2%						
Total Moped / Another vehicle	50.0%		74.8%		68.8%		72.0%			
TOTAL MOPED ACCIDENTS		**54.2%**		**75.6%**		**70.8%**		**72.0%**		
Single motorcycle accident – Outside urban area – No intersection	81.8%	36.0%	55.1%	19.4%	43.3%	18.1%	53.2%	15.3%	53.1%	12.3%
Single motorcycle accident – Inside urban area – No intersection	18.2%	8.0%	37.0%	13.0%	47.4%	19.9%	35.1%	10.1%	17.2%	4.0%
Single motorcycle accident – Outside urban area –Intersection									14.8%	3.4%
Single motorcycle accident – Inside urban area – Intersection									14.8%	3.4%
Total Singe motorcycle accident	100.0%		92.0%		90.6%		88.3%		100.0%	
Motorcycle / Passenger car accident – Outside urban area – No intersection	33.3%	14.0%	37.5%	20.8%	17.7%	9.6%	16.4%	10.5%	22.2%	11.5%
Motorcycle / Passenger car accident – Inside urban area – No intersection			14.7%	8.1%	25.2%	13.6%	19.6%	12.5%	5.1%	2.6%
Motorcycle / Passenger car accident – Inside urban area – Intersection	19.0%	8.0%	12.5%	6.9%	21.5%	11.6%	26.5%	16.9%	13.7%	7.0%
Motorcycle / Truck accident – Outside urban area – No intersection	14.3%	6.0%	13.5%	7.5%			4.5%	2.9%		
Motorcycle / Passenger car accident – Outside urban area – Intersection	14.3%	6.0%					13.0%	8.3%	22.1%	11.4%
Motorcycle / Truck accident – Inside urban area – Intersection					5.4%	2.9%	4.3%	2.7%		
Motorcycle / Truck accident – Outside urban area – Intersection					2.3%	1.2%				
Total Motorcycle / Another vehicle	81.0%		78.2%		72.1%		84.4%		63.0%	
More than three vehicles									100.0%	25.4%
TOTAL MOTORCYCLE ACCIDENTS		**78.0%**		**75.8%**		**77.0%**		**79.2%**		**81.0%**

Table 7: Main accident scenarios per country according to the number of vehicles involved in the accident, the location and the intersection (PTW fatal accidents, 2006 and 2007)

5. PTW accident configuration in-depth analysed

This chapter details the results of the in-depth PTW accidents analysed according to what has been presented in the paragraph 3.4. The aim of the in-depth analysis is to understand the causes of PTW accidents and then to determine accident factors.

To reach our goal, we have analyzed the accident in details through the available European in-depth databases. These ones gather lot of information about the accident development and are largely more detailed than intensive databases. The idea of 2BESAFE for this accident causations identification is to harmonize the different accident causations approaches from all the databases available and to apply the methodology presented in paragraph 3.4.

So, each partner was invited to initiate the analysis within his own data and to use the partner databases in order to support the trends within a more representative sample gathering accidents from different countries, result of differences such as social, economical, political differences as road network, vehicle fleets etc.

The interest of using such databases is that they gather analytic information. It means that they explain us what is the accident and injury genesis and identify complex interactions between causes and factors.

In the first part of the chapter, an introduction presents the accident configurations selected for the in-depth analysis and explains why only several scenarios have been selected. Then, 9 scenarios are described in details. The framework used to present the results of the in-depth analysis is the same for each scenario and is defined as follow:

- Who is involved in such accidents? Where did the accidents happen and with which kind of vehicles? The purpose of this section is to describe the different components of the system driver / vehicle / environment. It allows a structure-oriented and contextual analysis of the system. In other words, it represents the sub-systems (the driver, infrastructure, traffic, ambient conditions, vehicle, etc.), their taxonomic groups, their contexts (the driver's professional status, family status, etc.), their structures, as well as the various interactions between these sub-systems and their components.
- How the accidents evolved from the driving phase to the crash? This part identifies when the driving situation of riders or drivers switched to an accidental situation which led to an accident and sometimes injuries. The crash itself is also characterized. This analysis integrates the accident's sequential and causal models developed by the INRETS (Brenac, 1997; Fleury et al., 2001).
- When did the rider or the driver fail? This paragraph specifies the impairment of one (at least) of the cognitive, sensori-motor or psycho-physiological functions that usually allows the operator to adapt to the difficulties he meets when fulfilling his task. Failures found in accident cases are delineated below following a sequential theoretical chain of human functions involved in information gathering, processing, decision and action
- What is the degree of influence of an accident factor? An accident is the result of the interaction of several accident factors. Nevertheless, some of them are very close (sharp end failures) to the accident (for instance, a secondary task which leads to an accident) and others have more organizational influences (blunt end failures, for instance social behaviours or inadequate training which lead to an accident), (see Figure 12). This paragraph shows the results of this accident factors structuring.

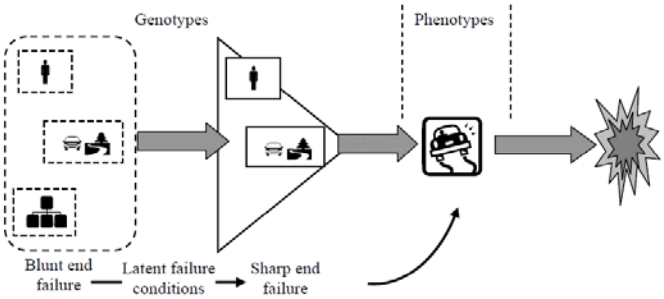

Figure 13: Blunt end and sharp end failures

5.1. Introduction

For the in-depth analysis, 391 PTW accidents have been analysed according to what has been presented in section 3.4. The number of accident studied per country is different because it depends on the in-depth accident potential of each country and the man month allocation of each of them.

Comparing Table 5 and Table 6, some PTW accident configurations are missing in the in-depth analysis. The reasons are that:

- some of them concerned only one or two countries: for instance moped / truck accidents – outside and inside intersection – no Intersection or single motorcycle accidents – outside urban area – intersection;
- and/or some of them are not enough frequent in the in-depth databases: considering the three in-depth databases, there are less than 10 accidents. For instance, single moped accidents outside and inside urban area – no intersection are issues for most countries, but the in-depth sample is not large enough to have relevant results.

PTW accident configuration	Number of in-depth accidents analysed per country			Total
	Finland	France	The United Kingdom	
Moped / Passenger car accident – Inside urban area – No intersection	0	13	2	15
Moped / Passenger car accident – Inside urban area –Intersection	3	36	10	49
Single motorcycle accident – Outside urban area – No intersection	16	10	25	51
Single motorcycle accident – Inside urban area – No intersection	4	26	16	46
Single motorcycle accident – Inside urban area – Intersection	0	19	17	36
Motorcycle / Passenger car accident – Outside urban area – No intersection	7	8	27	42
Motorcycle / Passenger car accident – Inside urban area – No intersection	0	31	10	41
Motorcycle / Passenger car accident – Inside urban area – Intersection	0	40	20	60
Motorcycle / Passenger car accident – Outside urban area – Intersection	3	18	30	51
TOTAL	33	201	157	391

Table 8: Number of in-depth accidents analysed per country

Finally, 9 scenarios have been selected because of the reasons presented in the previous paragraph of this section and are defined as follow:

- Scenario 1: Moped / passenger car accident – Inside urban area – No intersection,
- Scenario 2: Moped / passenger car accident – Inside urban area – Intersection,
- Scenario 3: Single motorcycle accident – Outside urban area – No intersection,
- Scenario 4: Single motorcycle accident – Inside urban area – No intersection,
- Scenario 5: Single motorcycle accident – Inside urban area –Intersection,
- Scenario 6: Motorcycle / passenger car accident – Outside urban area – No intersection,
- Scenario 7: Motorcycle / passenger car accident – Inside urban area – No intersection,
- Scenario 8: Motorcycle / passenger car accident – Inside urban area – Intersection,
- Scenario 9: Motorcycle / passenger car accident – Outside urban area – Intersection.

5.2. Scenario 1: Moped / Passenger car accident – Inside urban area – No intersection

5.2.1. Who is involved in such accidents? Where and with which kind of vehicles?

The description of the three components of the system DVE comes from two kinds of information sources: from national databases and from in-depth ones. The reason is that this paragraph only states on descriptive data and national databases contain such information.

Information from national databases

All fatalities were moped users. It means that no user inside the passenger car died. Moreover, in this kind of accident, only few moped users were injured (13% of moped users were injured) whereas passenger car users were most of them unharmed (only 18% of passenger car users were injured).

The majority of fatal accidents happened during good weather conditions (80% of accidents), on a dry surface (82% of accidents) and on a straight road (75% of accidents).

The lighting conditions in which this kind of accidents happened are equally shared between dark and day. Assuming that there is less traffic during night, it can be strongly concluded that night driving for moped users is riskier. The next paragraphs should help us to better understand what are the main problems in such accidents, that is to say accidents between a moped and a passenger car, inside urban area, out of intersection.

Young riders were over represented in such accidents. Indeed, more than one out of 4 riders involved in these fatal accidents were under 18 years old and one out of five was between 18 and 25. No exposure data about the age of moped users are available; so it is quite difficult to estimate the risk of these users according to their age.

95% of moped users were male.

Information from in-depth databases

All mopeds capacities were of course 50 cc. The mean age of mopeds was 2.7 years and of kilometre-age 18,580 kilometres. There was no technical and/or mechanical problem on the mopeds analysed for this scenario.

Almost one rider out of two had less than one year of riding experience. No riding licence was necessary except in France where you needed one. In the sample, when the rider was over 18 years old, he had the passenger car driving licence (it is not mandatory in France or in another country, it is just a result from the macro analysis for this scenario).

Riders were riding around 3,800 kilometres per year and considered the moped as a mode of transport (for instance to go to school or to see friends) and not only for leisure. More than 80% of accidents happened less than 15 minutes after departure. Alcohol, drug or medicine were not issues for these riders as only 1 rider was drunk.

All of them were using a helmet but in 25% of cases, the helmet was not fastened and/or the size was not adapted to the rider. Most of them did not wear any specific PTW protection when riding: only 30% of the riders wore gloves.

60% of drivers (that is to say the user inside the passenger car) were under 30 years old. Only two drivers had their driving licence for less than 1 year. None of them had another driving licence except the one necessary to drive a passenger car. More than 50% of drivers have had the accident less than 10 minutes after their departure. 40% of drivers were female and 60% male.

5.2.2. How the accident evolved from the driving phase to the crash?

Riders

Before having the accident, more than 50% of riders were realizing a manoeuvre: whether they were splitting lanes or overtaking correctly the passenger car (that is to say, on the correct lane). In other cases, the pre-accident situation corresponds to a guidance activity (he was going on a straight road or negotiating a curve.

There is no evidence of riskier conflict situations as mopeds are equally involved in the accidents with passenger cars coming from a lateral lane travelling in the same direction or from ahead and the passenger car is stopped or they are oncoming vehicles.

The event which disturbed their "normal" driving situation is mainly linked to the internal conditioning of performed task. It is related to the task that driver is performing, but refers more specifically to the 'conditioning' of the driver to the task (i.e. the informal rules the driver follows, either consciously or sub-consciously). Indeed, they have misinterpreted the driving situation or they were incorrectly positioned on the road.

Following this disturbing event, most riders have realized an emergency manoeuvre:

- 10 riders only braked,
- 4 riders braked and turned or turned and braked,
- 1 did not react.

Before impacting the passenger car, all users were still on their moped (and not sliding separately on the ground). The impact during the collision with the passenger car was a frontal one in most cases (11/15) and then only few of them were side ones.

Impact speeds were not very high as 50% of these speeds were lower than 35 Km/h and 80% of them lower than 55 Km/h (see Figure 13).

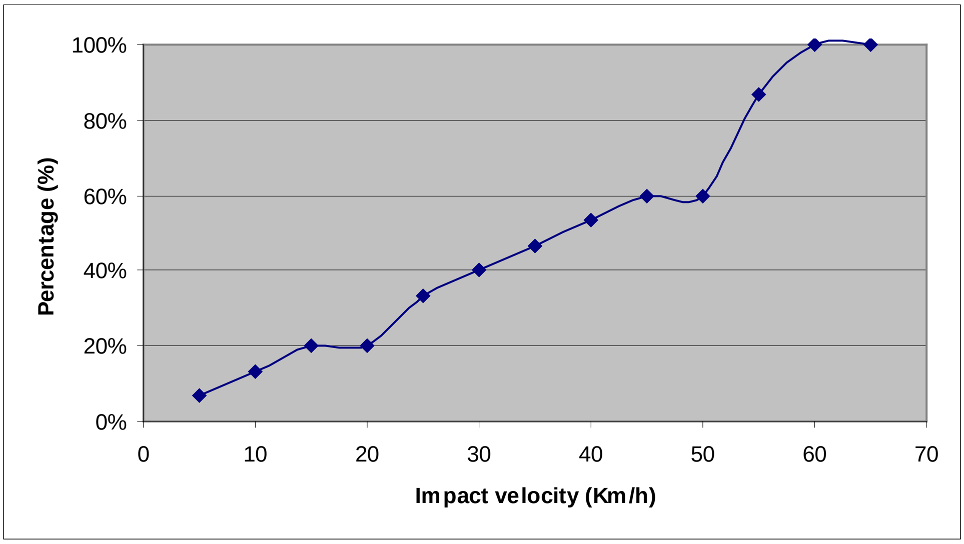

Figure 14: Scenario 1 - Cumulative frequency of impact velocity – Rider

Drivers

The pre-accident situations for drivers were mainly a guidance activity. Indeed, they were going ahead on a straight road. In a lesser extent, the road user was undertaking a specific manoeuvre which did not occur at an intersection. In details, the passenger car driver was leaving a parking space or undertaking a turning manoeuvre not at an intersection; he was coming from private driveway or path.

The main conflicts, drivers were confronted with, were oncoming PTW or vehicle from side (from side road or path or from lateral lane travelling in same direction).

The main events which disturbed the driving phase of drivers were linked to their behaviour. Indeed, they failed to look, they looked but did not see, or they were inattentive because they were concentrated on whether on another driving related task or a non-driving task.

4 drivers did not react following the disturbing event because they did not notice the danger. 7 drivers braked to avoid the accident, 2 steered on the left or the right to avoid the moped, 1 steered and braked and for the last one, his emergency manoeuvre was unknown..

The main impact with the moped was the side one (7/15) and the other ones were equally shared between frontal and rear impacts. The impact speed was a bit lower than what has been found for moped users as 50% of impact speeds are lower than 20 Km/h and 80% lower than 45 Km/h (see Figure 14).

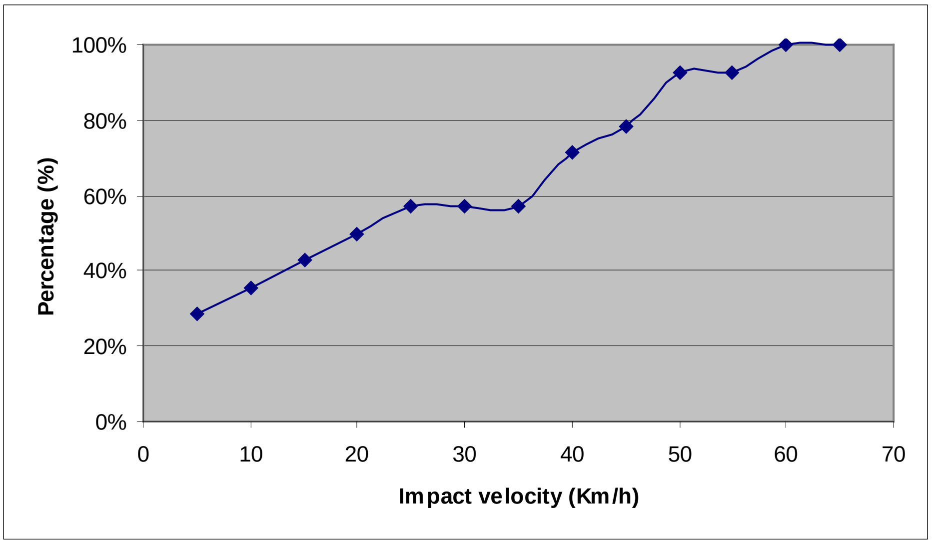

Figure 15: Scenario 1 - Cumulative frequency of impact velocity – Driver

5.2.3. When did the rider or the driver fail?

Riders

Most riders were primary active (they were at the origin of the disturbance or the critical situation which led to the accident) in the genesis of the accident or secondary active (the rider participated to the non-resolution of the problem by a wrong anticipation of the events evolution whereas this one was possible detectable). The degrees of involvement of riders were as follow:

- 9 riders were primary active,
- 2 riders were secondary active
- 4 were non active.

The main human functional failures identified for this scenario, when considering the rider are perception, prognosis and diagnosis failures. The analysis underlines a problem of perception between the moped users and the opponent ones and a problem of understanding (see Figure 15):

- P5 failure: Neglecting the need to search for information.
- T6 failure: Actively expecting another user to take regulation action.
- T1 failure: Erroneous evaluation of a passing road difficulty

.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	1	T1	3	T5	1	D1	0	E1	0	G1	0
P2	1	T2	0	T6	3	D2	0	E2	2	G2	0
P3	0	T3	0	T7	0	D3	0			G3	0
P4	0	T4	0								
P5	4										
Tot.	**6**	**Tot.**	**3**	**Tot.**	**4**	**Tot.**	**0**	**Tot.**	**2**	**Tot.**	**0**

Figure 16: Scenario 1 - Rider human functional failure

The most occurring elements explaining these failures are:

- Narrow road (6),
- Excessive speed (4),
- Other road user(s) failed to give any clues as to what their next manoeuvres would be (4),
- The rider has a high experience of the road and his attention is low (4).
- The rider has a rigid attachment to his right of way status (4).
- Visibility impaired due to other vehicles parked on the side (3).
- New rider (3).
- Atypical manoeuvre of other road users, not a legal manoeuvre (3).

Drivers

Drivers were also active in the genesis of the accident. It means that they were also at the origin of the disturbance. The degrees of involvement of drivers were as follow:

- 9 drivers were primary active,
- 2 drivers were secondary active
- 4 were passive.

The only difference with riders is that four drivers were passive. It means that they could not be considered as an engaging part in the disturbance and no measure may a priori be beneficial to them, except to act on the rider.

The main human functional failures for drivers were perception. The driver did not detect all the relevant data required to perform his driving task (see Figure 15) and then to anticipate the coming moped user:

- P5 failure: Neglecting the need to search for information.
- P1 failure: Non detection in visibility constraints conditions.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	2	T1	0	T5	0	D1	0	E1	0	G1	0
P2	1	T2	0	T6	0	D2	1	E2	0	G2	0
P3	1	T3	0	T7	0	D3	0			G3	0
P4	0	T4	0								
P5	6										
Tot.	**10**	**Tot.**	**0**	**Tot.**	**0**	**Tot.**	**1**	**Tot.**	**0**	**Tot.**	**0**

No Human Functional Failure 4

Figure 17: Scenario 1 - Driver human functional failure

These problems of perception which whether refer to a problem relating to information conspicuity or a failure to search actively for information are explained by the following elements:

- Visibility impaired due to other vehicles parked on the side (3).
- Narrow road (3).
- Searching for directional information (3).
- Excessive confidence in the signs given to the others (2).
- Visibility impaired due to darkness (2).

5.2.4. What are the blunt end failures, the latent and sharp end ones?

The DREAM analyses of 15 accidents of the scenario 1 are summarized in Figure 17 and Figure 18, considering first the rider and their failures and then the driver and their failures also. Each DREAM analysis is separately described in order to underline the accident factors linked to each user.

Riders

It is notable that the most frequent phenotype is “too late action”. It means that the rider made an emergency manoeuvre too late to avoid the collision with the passenger car. It is completely relevant with the results from paragraph 5.2.2 as most riders tried to avoid the accident by braking.

The most frequent antecedents to this phenotype are “misjudgement of situations” and “misjudgement of time gaps” (for this last genotype, it means that the rider did not estimate correctly a time gap, for instance, the time left to approaching passenger car).

These factors are the results of a “late or false observation”. “Inattention”, “reduced visibility” (because of bad weather conditions) and “insufficient skills or knowledge” explains these problems of perception.

Rider behaviour factors are quite frequent also as riders overestimate their skills and habitually they stretch rules and recommendations which are the consequences of “insufficient skills or knowledge” and / or an “inadequate training”.

Drivers

The most frequent phenotypes for the drivers are “too late action” or “too early action”. This last phenotype means that the driver started his manoeuvre (considering paragraph 5.2.2, he is coming from side road) before having a good visibility of the situation.

The most frequent antecedents to this phenotype are “misjudgement of situations” and “misjudgement of time gaps”.

These phenotypes are strongly explained by a “late or false observation”. The last factor “false observation” refers to the fact that some information is misinterpreted as something else. For instance, a passenger car is coming from private driveway or path. He wants to turn across the traffic out of this path. Vehicles on the main road are stopped and let him do his manoeuvre. The passenger car driver thinks it is safe to turn across traffic whereas a moped is overtaking stopped vehicles.

This lack of observation is mainly considered as the result of “inattention”.

Drugs and alcohol are other frequent “second-order” genotypes and they explain most factors presented before.

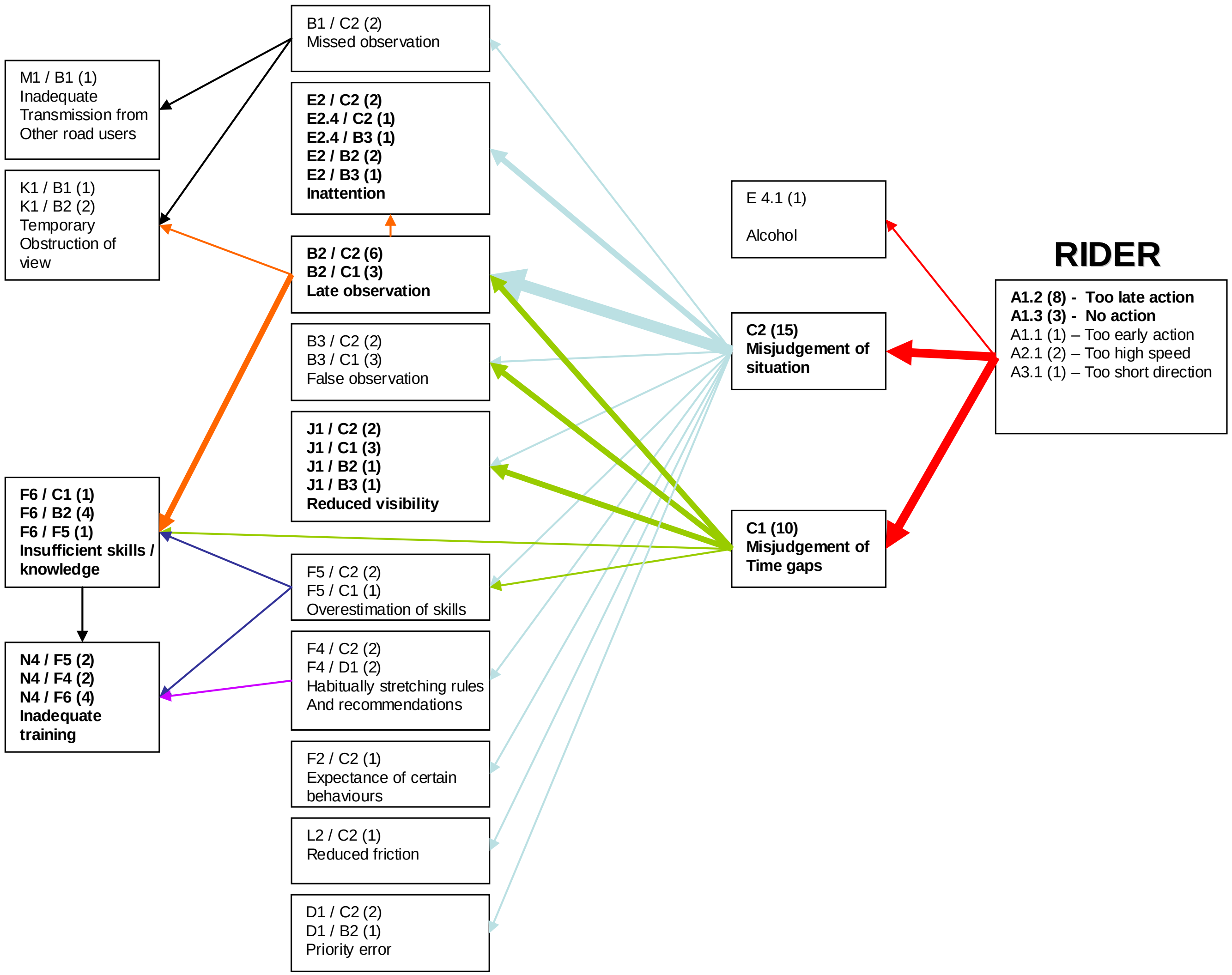

Figure 18: Scenario 1 - DREAM Analysis for the riders

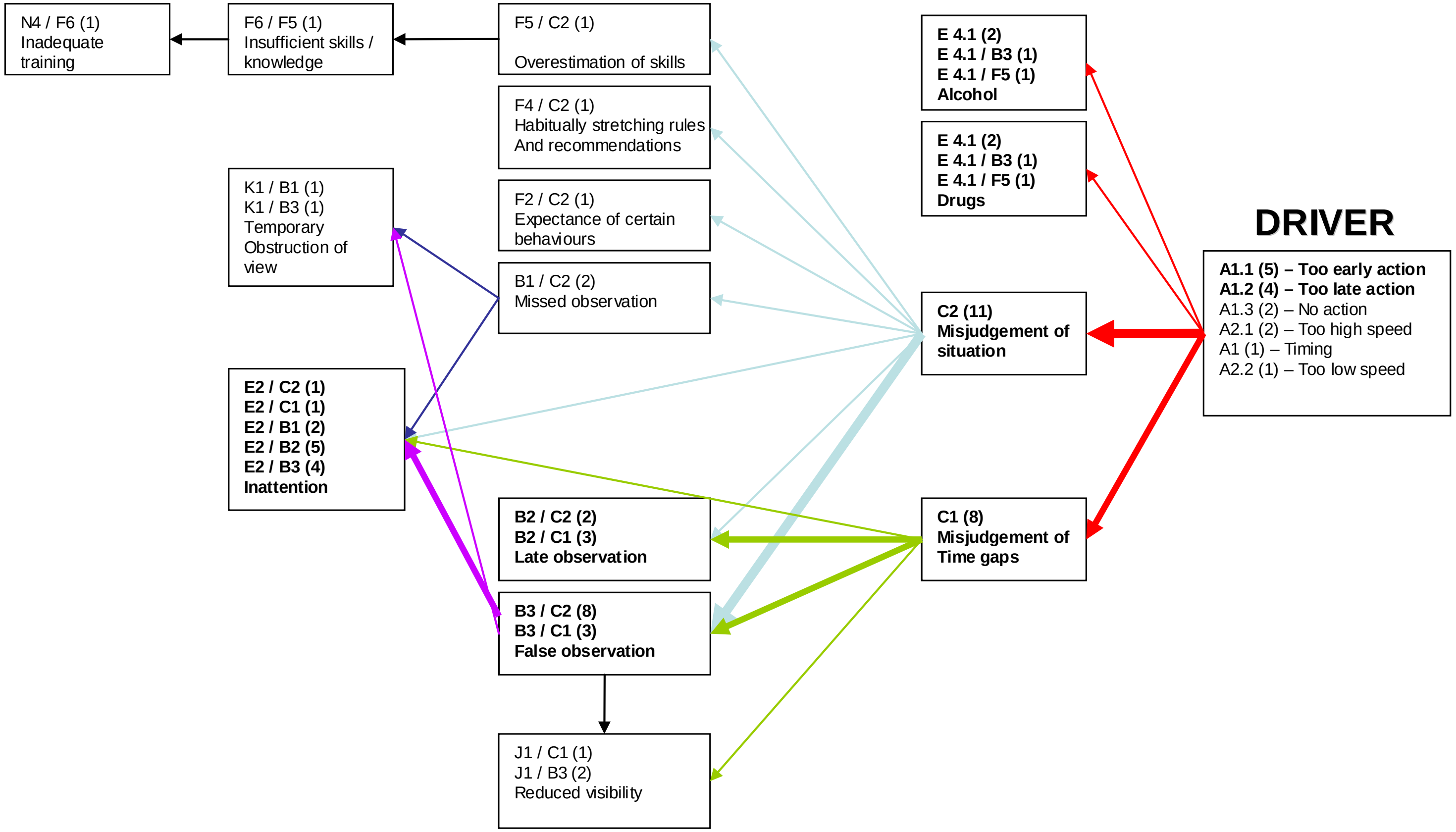

Figure 19: Scenario 1 - DREAM Analysis for the drivers

5.3. Scenario 2: Moped / Passenger car accident – Inside urban area – Intersection

5.3.1. Who is involved in such accidents? Where and with which kind of vehicles?

The description of the three components of the system DVE (Driver Vehicle Environment) comes from two kinds of information sources: from national databases and from in-depth ones. The reason is that this paragraph only states on descriptive data and national databases contain such information.

Information from national databases

Only one user inside the passenger car died. Then, most fatalities were moped users. 13% of moped users were injured and 29% of passenger car users were injured. Comparing with the previous scenario (scenario 1), more passenger car users were injured. It can be due to the fact that, at intersection, they can be involved in a side impact where the risk to be injured is higher. The next paragraph 5.3.2 will try to answer to this observation.

The majority of fatal accidents happened during good weather conditions (86% of accidents) and on a dry surface (89% of accidents).

As for scenario 1, accidents were equally shared between day and night. Considering a low traffic during the night, it can be assumed and deduced that the risk to be involved in a fatal accident for a moped user is higher during the night.

Moped users over 50 years old were over represented in such accidents (30% of accidents and fatalities). Then moped users under 18, between 18 and 25 and between 25 and 50 had the same proportion of fatalities and accidents (around 23%). We do not have access to data presenting the age distribution of users driving mopeds. So, it is impossible to conclude on the risk of moped accidents according the age of users. Nevertheless, if this distribution follows what we know for passenger car drivers, it is possible that this risk is higher for young and over 50 years old riders.

89% of moped users were male.

Information from in-depth databases

All mopeds were propelled by a motor of a capacity of 50cc or less. They were either step through or scooter (no difference of distribution). The moped average age wass 4 years and 60% of mopeds were under 3 years old. The moped average kilometre-age was 12,500 kilometres and the kilometre-age of 50% of mopeds was lower than 9,000 kilometres. 10% of PTW had defects (tyres defects, mechanical problems or lights which did not work).

The average of moped riding experience was 3.3 years but 44% of moped riders had less than one year of riding experience. 12% of users had a motorcycle driving licence and 10% a passenger car one.

51% of riders were students and 31% farmers or skilled workers. They were riding around 5,000 kilometres per year (it is an average) and 68% of them drove less than 5,000 per year. 55% of these users considered mopeds as a mode of transport. It means that they do not use it for leisure. They have had the accident 17 minutes after departure on average and for 50% of them, it was 10 minutes after leaving home or friends. Alcohol, drug or medicine were not issues for these riders as only 2 riders were drunk (in total, they are 49 riders).

All of them were using a helmet but in 25% of cases, the helmet was not fastened and/or the size was not adapted to the rider. Gloves and jackets were the most frequent equipments, moped users wore, respectively 35% and 21%.

50% of car-drivers were under 40 years old. And only 3 drivers also had a PTW driving licence. Nothing was relevant about the driving experience. 50% of drivers have had the accident less than 10 minutes after their departure. 37% of drivers were females and 63% males.

5.3.2. How the accident evolved from the driving phase to the crash?

Riders

In such accidents, the main pre-accident situations for riders appear when they were crossing intersection where they had right of way. They were confronted with a vehicle coming from side road.

Other pre-accident situations seem to be important: when they were realizing a manoeuvre, an illegal one when they were splitting lanes or they were overtaking on the right side (or left in UK) or a legal one, when they were overtaking on the left side. The conflict (or the passenger car) was coming from side road or from ahead (the passenger car was moving in the same direction than the rider).

The event which disturbed their "normal" driving situation is mainly linked to the internal conditioning of performed task or in other words their driving task. Indeed, they have misinterpreted the driving situation (16 events), they have voluntarily taken risks when realizing a legal manoeuvre (7 events) (in this case, they have overtaken vehicles whereas it was not safe to do it) or an illegal one when they have split lanes (7 events) and they finally did not have enough anticipated or evaluated the situation (7 events).

Following this disturbing event, most riders have realized an emergency manoeuvre:

- 27 riders only braked,
- 15 did not react because of a lack of time or space, because they were astonished or they did not perceive any danger.
- 4 turned then braked.

Before impacting the passenger car, all moped users were still on their PTW (they were not sliding on the road linked or not to the moped). 61% of impacts for PTW are frontal ones, 35% side ones and 4% rear ones.

Impact speeds are lower than those found in scenario 1 as 50% of them are lower than 35 Km/h and 80% lower than 40 Km/h (see Figure 19).

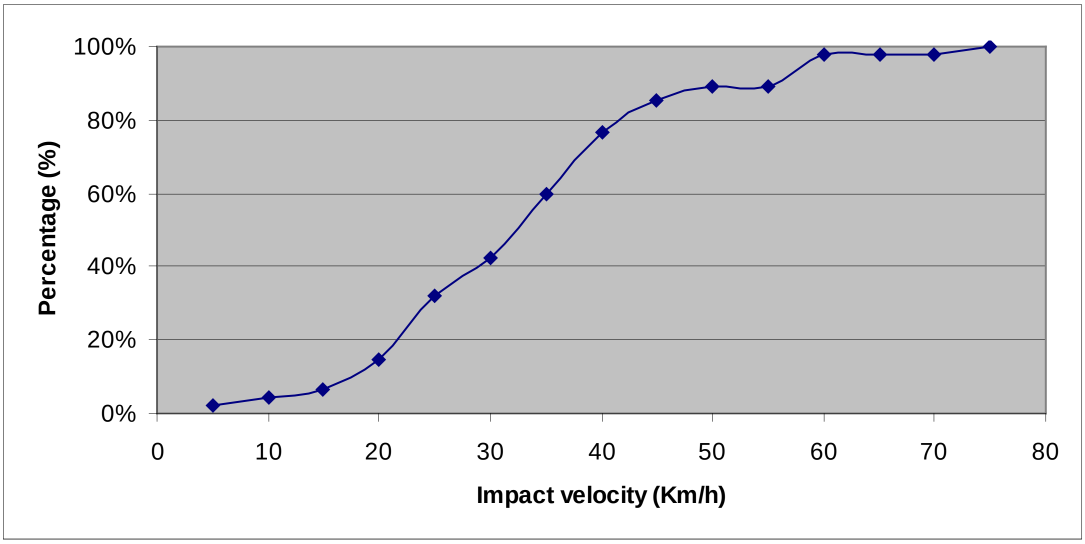

Figure 20: Scenario 2 - Cumulative frequency of impact velocity – Rider

Drivers

Main pre-accident situations for drivers happen when they wanted to turn whether across traffic or away from traffic. In such situations, they were confronted with a moped user coming from a side road.

Other frequent pre-accident situations are also important: when drivers were crossing intersection where they had a right of way status and they had an accident with a moped coming from the side.

To a lesser extent, there is a specific manoeuvre which caused an accident: the driver was realizing a u-turn when approaching a junction.

Most precipitating events which disturbed the driver driving phase are linked to their behaviour. They failed to look, they looked but did not see, they were concentrated in another driving task or a non driving one, with respectively 32%, 22% and 4% of all precipitating events. 26% of drivers realized an incorrect driving manoeuvre and caused the disturbance (such as a u-turn).

47% of drivers did not react following the precipitating event. Indeed, they did not perceive the oncoming moped or they had not enough time to do an emergency manoeuvre.

Main impacts were on the side and the front of the vehicle, with respectively 53% and 42% of all impacts.

The impact speed when the passenger car crashed the moped was very low as 50% of impacts speeds were under 15 Km/h and 80% under 25 Km/h.

The fact that these accidents happened at intersection and inside urban area explains why impact speeds are lower in this scenario than in scenario 1 and 2 (see Figure 20).

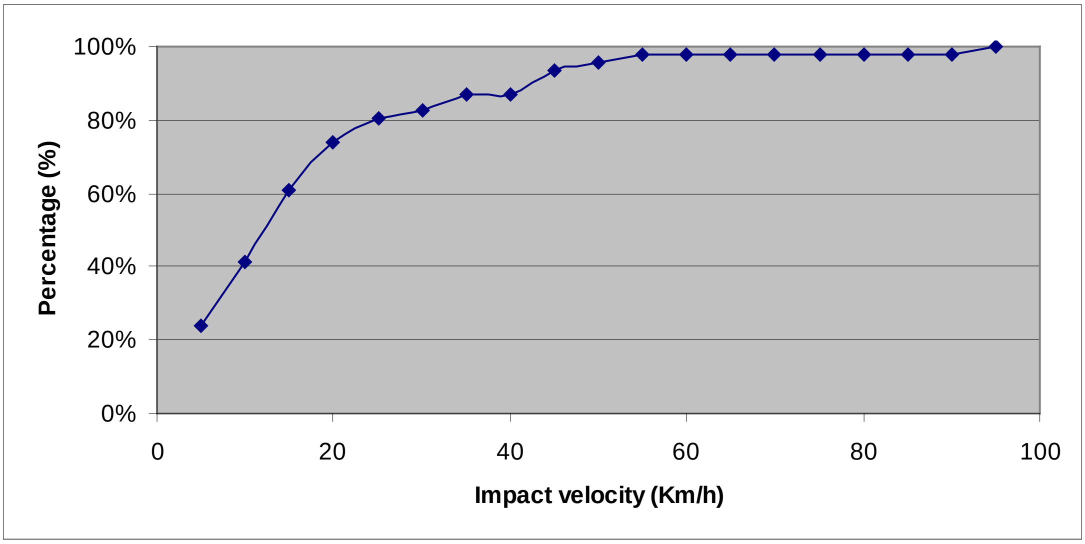

Figure 21: Scenario 2 - Cumulative frequency of impact velocity – Driver

5.3.3. When did the rider or the driver fail?

Riders

47% of riders were primary active (they were at the origin of the disturbance or the critical situation which led to the accident) in the genesis of the accident and 25% secondary active (the rider participated to the non-resolution of the problem by a wrong anticipation of the events evolution whereas this one was possible detectable). But it has to be also considered that 25% of riders were non active users. They were not able to anticipate, because of a lack of information, the degradation of the situation, while the avoidance of the accident would have been possible in theory if this information had been supplied to them in time.

The main human functional failures identified for these scenario, when considering the rider are diagnosis, decision, prognosis and perception failures. These ones show that PTW users well saw the driving situation but failed to well understand the information acquired or took the wrong decision. It reveals a lack of communication or understanding between passenger car drivers and moped riders (see Figure 21):

- T4 failure: Mistaken understanding of another user's manoeuvre.
- D2 failure: Deliberate violation of a safety rule.
- P5 failure: Neglecting the need to search for information.
- T5 failure: Expecting another user not to perform a manoeuvre.
- T6 failure: Actively expecting another user to take regulation action.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	1	T1	3	T5	4	D1	0	E1	1	G1	0
P2	0	T2	1	T6	1	D2	11	E2	2	G2	0
P3	0	T3	0	T7	3	D3	0			G3	1
P4	0	T4	13								
P5	6										
Tot.	**7**	**Tot.**	**17**	**Tot.**	**8**	**Tot.**	**11**	**Tot.**	**3**	**Tot.**	**1**

No Human Functional Failure 2

Figure 22: Scenario 2 - Rider human functional failure

The most occurring elements explaining those rider failures are:

- A speed non adapted to the situation (12). The speed is not over the legal limit but too high considering the situation. For instance, it is raining and the visibility is reduced and the rider is driving at the legal speed limit..
- The rider has a rigid attachment to his right of way status (12).
- The user has a high experience of the road and his attention is low (11).
- New rider (8).
- Excessive confidence in the signs given to the others (7).
- Other road user(s) failed to give any clues as to what their next manoeuvre would be (6).
- Atypical manoeuvre of other road users, not a legal manoeuvre (6).
- The rider took risk in ignoring road markings (4).
- The visibility was impaired due to other vehicles (4).

Drivers

67% of car drivers were primary active. Because of them the accidents happened. And 27% were non active. In theory, the accident could have been avoided if the information of the situation would have been given to them. Only 6% of them took a part in the genesis (secondary active) of the accident but were no at the origin of the disturbance.

Comparing to riders, the human functional failure analysis shows a lack of perception of the situation and especially of riders. To a lesser extent, there are problems of diagnosis or decision (see Figure 22):

- P5 failure: Neglecting the need to search for information.
- P2 failure: Information acquisition focused on a partial component of the situation.
- P1 failure: Non-detection in visibility constraints conditions.
- P3 failure: Cursory or hurried information acquisition.
- D2 failure: Deliberate violation of a safety rule.
- T1 failure: Erroneous evaluation of a passing road difficulty.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	6	T1	5	T5	4	D1	1	E1	0	G1	0
P2	7	T2	0	T6	1	D2	7	E2	1	G2	0
P3	5	T3	0	T7	0	D3	1			G3	0
P4	0	T4	4								
P5	7										
Tot.	**25**	**Tot.**	**9**	**Tot.**	**5**	**Tot.**	**9**	**Tot.**	**1**	**Tot.**	**0**

Figure 23: Scenario 2 - Driver human functional failure

These problems of perception which whether refer to a problem related to information conspicuity or a failure in searching actively for information, to lesser extent to a problem of diagnosis and decision are explained by the following elements:

- Atypical manoeuvre of other road users (13).
- The driver has a high experience of the road and his attention is low (8).
- The driver has a rigid attachment to his right of way status (7).
- The road user has identified a potential risk but only about part of the situation (7).
- The driver has a high experience of the manoeuvre and his attention is low (7).
- The driver has some difficulties to enter the traffic because of its high density (6).
- The visibility was impaired due to other vehicles (6).
- The driver does not know the road on which he is driving (6).
- The driver follows the vehicle in front of him in order to insert the traffic without controlling if it was safe to do it (5).

5.3.4. What are the blunt end failures, the latent and sharp end ones?

The DREAM analyses of 49 accidents of the scenario 2 are summarized in Figure 23 and Figure 24, considering first the rider and their failures and then the driver and their failures also. Each DREAM analysis is separately described in order to underline the accident factors linked to each user.

Riders

The most frequent phenotype for riders is "too late action". It means that the rider made an emergency manoeuvre too late to avoid the collision with the passenger car and to avoid entering the intersection before it is free.

The most frequent antecedents to this phenotype are "misjudgement of situations" and "misjudgement of time gaps" (for this last genotype, it means that the rider did not estimate correctly a time gap, for instance, the time left to approaching passenger car).

They misjudged the situation because:

- The rider prioritised something else above safe arrival at the destination (such as splitting lanes), as a result of psychological stress (for instance being late).
- The rider expected the other road user to behave in certain ways following praxis. For this scenario, he expected the passenger car driver to let him cross the intersection.
- The rider misinterpreted the information given by others or has correctly observed information but too late, and did not have enough time to react. The lack of visibility explains such problems and especially parked or driven vehicles which cause temporary obstruction of view. Inattention is also a factor which contributes to these observation failures.
- It appears that insufficient skills or knowledge, as a result of an inadequate training can indicate why moped users misjudged the situation.

Drivers

The most frequent phenotypes for drivers are "no action" and "too early action". This last phenotype confirms the fact that, as found in the previous paragraph, the drivers entered the intersection or turned too early, that is to say before the road is free.

The most frequent antecedent to this phenotype is "misjudgement of situations" and is explained by the following genotypes:

- The driver missed some important information which enable him to realize his manoeuvre in safe conditions. The reasons for this are that the driver was inattentive or he did not have a good visibility to detect the other road users and of course the moped users.
- The driver prioritised something else above safe arrival at the destination (such as entering intersection by following other vehicle), as a result of psychological stress (for instance being late).
- The driver was also expecting certain behaviours from moped users. But this factor is less frequent comparing to the DREAM analysis of riders. It shows that drivers identify moped users less often and can expect a certain behaviour from moped users less often also.

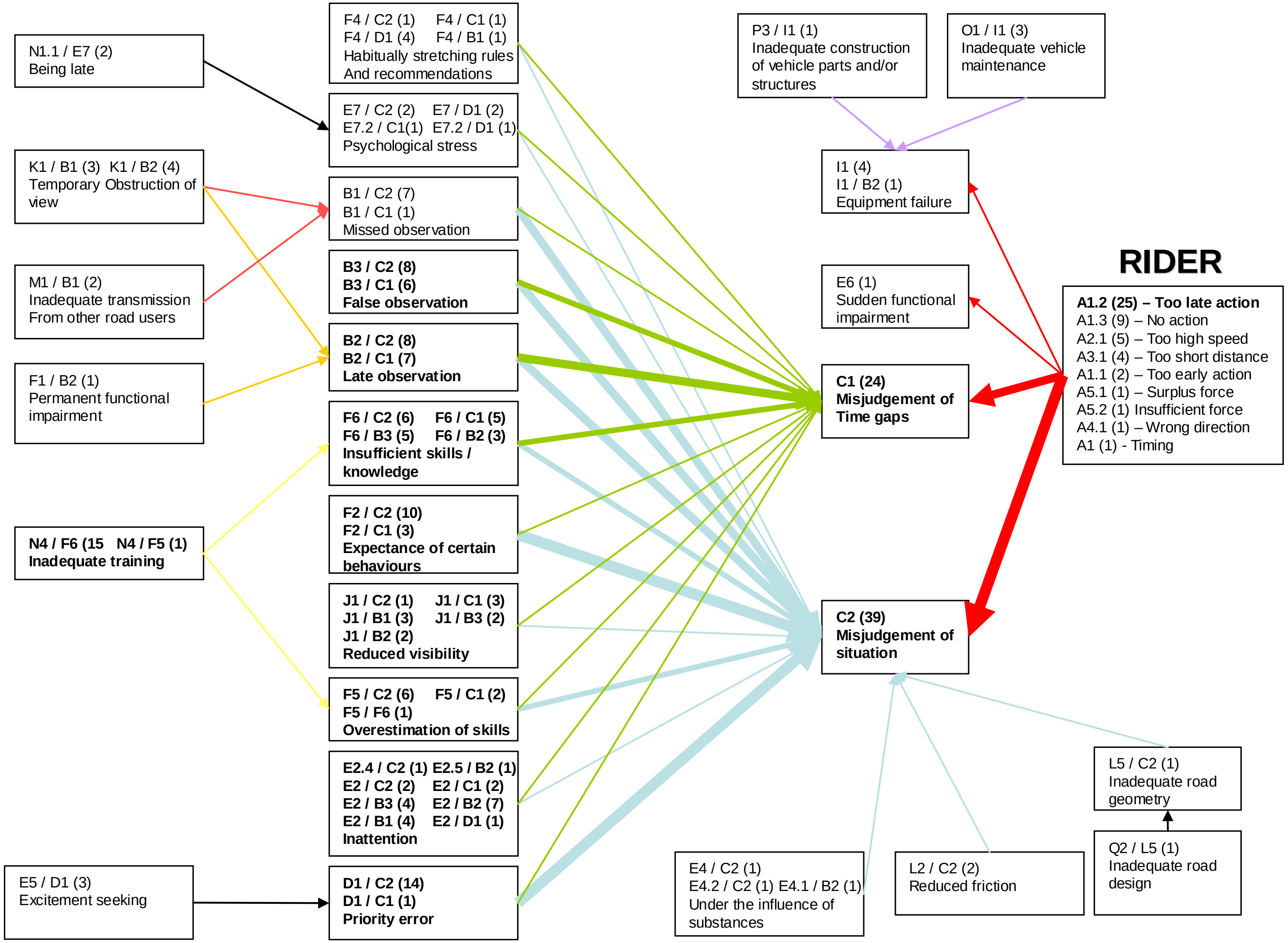

Figure 24: Scenario 2 - DREAM Analysis for the riders

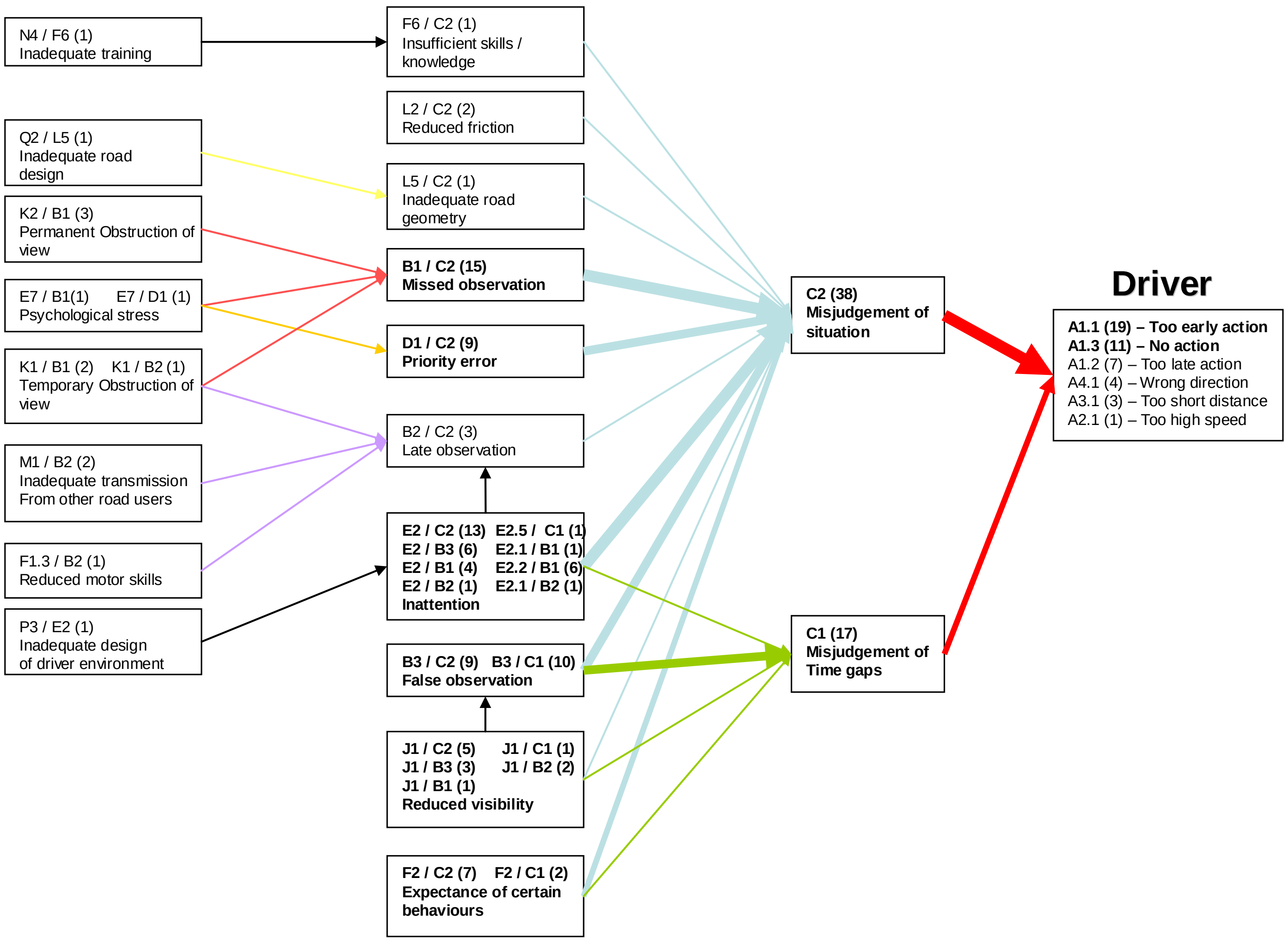

Figure 25: Scenario 2 - DREAM Analysis for the drivers

5.4. Scenario 3: Single motorcycle accident – Outside urban area – No intersection

5.4.1. Who is involved in such accidents? Where and with which kind of vehicles?

The description of the three components of the system DVE comes from two kinds of information sources: from national databases and from in-depth ones. The reason is that this paragraph only states on descriptive data and national databases contain such information.

In these accidents, there is no collision with another vehicle. Even if one could have played a role in the genesis of the accident, the road users inside the other vehicle were not considered for our statistics because most of the time, these one were not reported in police reports.

Information from national databases

Main fatal accidents happened during good weather conditions (93% of accidents) and on a dry surface (95% of accidents).

There were more accidents during the day comparing to the night, as 65% of them occurred during the day and 34% during the night. It is difficult to estimate the risk of accidents according to the lighting conditions as we do not know the traffic during these two periods.

Accidents not on a straight road (curve, a winding road…) were over represented. Indeed, they represented 63% of accidents in this scenario. The road profile seems to be an important factor which contributes to generate single motorcycle accidents.

Considering the age of motorcyclists, 70% of them were between 25 and 50 years old, 19% between 18 and 25 and 10% over 50. Only few users under 18 years were involved in fatal accidents. These users were not allowed to drive motorcycles and in most cases, these vehicles were stolen.

2% of these accidents involved a female motorcyclist.

Information from in-depth databases

47% of motorcycles were sport motorcycles, 25% conventional street ones and 14% sport touring ones. 50% of PTW were propelled by a motor of a capacity of 600cc or less and 80% by a motor of a capacity of 1,000cc or less. The most frequent PTW regarding to its capacity were 600cc motorcycles. The motorcycle average age was 5.16 years and 54% of them were 3 years old or less. It has to be noted that 25% of them were new as they were under 1 year. Their kilometre-age average was 37,530 kilometres and the kilometre-age of 53% of motorcycles was lower than 25,000 kilometres. 8% of PTW had defects (tyres defects or braking system problems).

The average of motorcycle riding experience was 7 years but 48% of riders had less than three years of riding experience and 25% less than one year. All riders had at least their passenger car driving licence valid and their PTW one when it was necessary (in France, from 2006 to 2008, you needed only passenger car driving licence to drive a 125cc PTW).

The work of motorcyclists, the number of kilometres driven per year and the aim of the PTW use were not relevant information for this scenario as they were unknown for more than half of the sample. On average, they have had the accident 49 minutes after departure and for 47% of them, it was 20 minutes after leaving home or friends. Alcohol, drug or medicine were issues as 10% of riders were drunk or have taken medicines.

All of them were using a helmet but in 6% of cases, the helmet was not fastened and/or the size was not adapted to the rider. 50% of riders were fully equipped with PTW specific clothes: jacket, trousers, gloves, boots and helmet. Then, jackets and gloves were the most used equipments (33%).

5.4.2. How the accident evolved from the driving phase to the crash?

There are two kinds of pre-accident driving situations in which the rider was before a problem arises. First, the rider was not undertaking any manoeuvre and he was going ahead on a bend (whether on a left or right bend, there is no difference) or on a straight road. For the second pre-accident situation, the rider was overtaking a vehicle (a legal overtaking; it means on the correct side of the vehicle).

In most situations, there was no conflict with another road user. It means that because of reasons that will be developed in the next paragraphs, the riders lost the control of his vehicle and has had an accident. Then, no other road user disturbed his driving phase.

Nevertheless, it has to be noticed that in 25% of these accidents, there was a conflict with another road user or an object (animal, lorry shedding its load, etc), but no collision with them. This conflict has perturbed the driving situation of riders and has caused an accident. The conflict, in other words, the other road user was ahead travelling in the same direction than the rider.

The precipitating event is the event which has disturbed the rider driving situation. And due to this event, the situation of the rider became critical. The main events are linked to the internal conditions of the driving task (it is the way they are realizing their manoeuvre or they are trying to follow a road), to the vehicle environment and to the infrastructure. Here is the list of the main precipitating events:

- Excessive speed when riding on a straight road or a bend (7).
- Misinterpreted the driving situation (5).
- Incorrect driving manoeuvre (such as splitting lanes or overtaking vehicle whereas it is not safe to do it), (5).
- Inappropriate reaction (3).
- Animal outside the vehicle which disturb the rider driving phase (4).
- A poor, polluted, wet road surface (4).
- A defect on the vehicle (3).
- Inattention (3).

Following this disturbing event, most riders have realized an emergency manoeuvre:

- 33% of riders only braked.
- 33% did not react because of a lack of time or space, because they were astonished or they did not perceive any danger.
- 16% braked then turned.
- 10% only tried to control their vehicle.

In this scenario, there was no impact with another road user. For 45% of riders, the main impact was the impact when they fell down. But in the other cases, riders have impacted infrastructure equipments (post, tree, pavement, crash barrier).

The impact velocity is described in Figure 25 only when the impact speed was known and when the rider was still linked to his motorcycle. The impact speeds are higher than those found in previous scenarios as 50% of them are lower then 75 Km/h and 80% lower than 115 Km/h (see Figure 25). It is not so surprising as this scenario deals with accidents outside urban area and involving motorcycles.

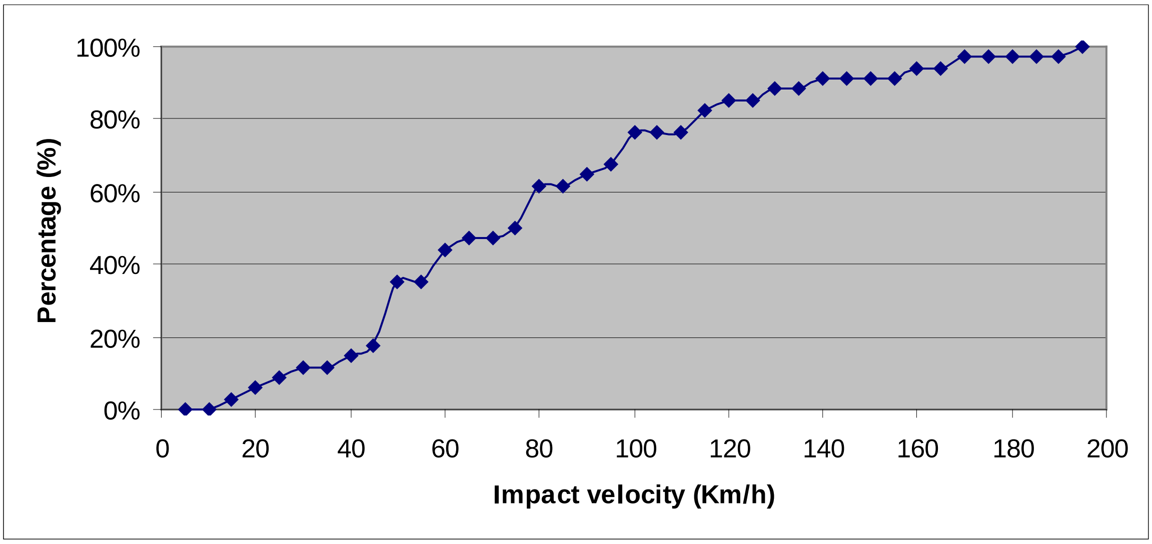

Figure 26: Scenario 3 - Cumulative frequency of impact velocity – Rider

5.4.3. When did the rider or the driver fail?

As riders were the only users involved in this accident scenario, it is not surprising to find that 90% of them were primary active in the accident. 10% of riders were secondary active in the accident. It means that they took part in the disturbance of accident situations but did not provoke it. The analysis of the conflict shows that in such accidents, they were sometimes confronted with another vehicle or an animal but did not crash them.

The main human functional failures identified for these scenario, when considering the rider are first, action, then diagnosis and finally decision failures. It is not surprising to find so many action failures as we are analysing single motorcycle accidents and as a significant number of accidents were running-off-the-road crashes. Diagnosis failures refer to a difficulty to evaluate an infrastructure related difficulty (for instance a bend or a reduced adherence on a road) and decision failures underline the fact they took risk when driving. So, in details, the main human functional failures are:

- E2 failure: Guidance problem. In most cases, due to a lack of attention on the driving task, the rider has some difficulties to keep its trajectory.
- E1 failure: Poor control of an external disruption. In situations where he meets severe constraints, riders are no longer able to control the trajectory of their motorcycle.
- T1 failure: Erroneous evaluation of a passing road difficulty. This failure illustrates the fact that the rider has had difficulties to evaluate a difficulty regarding the infrastructure.
- D2 failure: Deliberate violation of a safety rule.

Detection	
P1	3
P2	0
P3	0
P4	1
P5	0
Tot.	**4**

Diagnosis	
T1	9
T2	0
T3	0
T4	3
Tot.	**12**

Prognosis	
T5	0
T6	0
T7	0
Tot.	**0**

Decision	
D1	0
D2	9
D3	0
Tot.	**9**

Action	
E1	10
E2	13
Tot.	**23**

Overall	
G1	2
G2	0
G3	1
Tot.	**3**

Figure 27: Scenario 3 - Rider human functional failure

These failures are explained by the following explanatory elements:

- Excessive speed or speed over the legal limit (18).
- Non adapted speed for the driving situation (6).

- Intentional risk taking (10); Riders disobeyed road markings when overtaking other vehicles or they try to experience thrill riding. In this last case, whether the riders admitted that they were seeking ‘thrill riding’ or it inferred from the fact that they appear to be deliberately disobeying road markings.
- Riders do not know very well their motorcycle as it is a new one (10).
- New rider (9).
- Visibility impaired due to darkness or rain (9).
- The road surface is polluted or in bad condition (maintenance) (8)
- Wet road surface (4).
- In a hurry (6).
- Visibility impaired due to other moving vehicles (6).
- Insufficient traffic signs in order to anticipate the driving situation (5).
- Other explanatory elements linked to the infrastructure (5). For instance, the visibility is impaired because of the road profile or the road geometry is not really adapted to the PTW (too tight bend).
- Poor vehicle maintenance (5): tyres and mechanical defects.

5.4.4. What are the blunt end failures, the latent and sharp end ones?

The DREAM analyses of 51 accidents of the scenario 3 are summarized in Figure 27, considering only the rider and their failures because no other road user was involved in these accidents.

Most frequent phenotypes for riders are “too high speed”, “no action”, “wrong direction” and “surplus force”.

The first phenotype is not surprising as the previous paragraphs showed that speed was a critical factor which was whether at the origin of the action, or a factor contributing to human functional failures.

For the second phenotype “no action”, the rider was surprised by a sudden event (an atypical manoeuvre made by another road user or an animal on the road) and was not able to do anything to avoid the accident.

The third phenotype “wrong direction” reflects partly the fact that most of accidents are running-off accidents.

The last phenotype “surplus Force” consolidates the idea that riding PTW is much more complex than driving a car and that braking or steering to hard can cause an accident.

The most frequent antecedents to these phenotypes are “misjudgement of situation” and “equipment failure”. This last genotype explained the fact that the motorcycle was badly maintained. The first genotype or antecedents is the result of the following genotypes:

- The rider overestimated his own driving skill because of a lack of practical skills and/or theoretical knowledge.
- The rider observed lately some information about the situation because of the infrastructure. Indeed, the road geometry was inadequate (curve, camber) or the road environment failed to transmit information to the rider (road signs are not sufficient and enable the rider to anticipate the situation)
- The rider expected other road users to behave in certain ways following praxis. This genotype illustrates the conflict with another road user but without no collision.
- The rider paid less attention than required for the driving task and it explains why he misjudged a situation or why he observed lately an information or missed it.
- The rider prioritised something else above safe arrival at the destination (such as splitting lanes or overtaking vehicles when it is illegal), as a result of psychological stress (for instance being late) or excitement seeking.
- A genotype linked to the infrastructure is also frequent: “inadequate road maintenance”. This factor explains why the friction of the road was reduced or why the road surface was degraded. All of them contributed to a misjudgement of a driving situation.

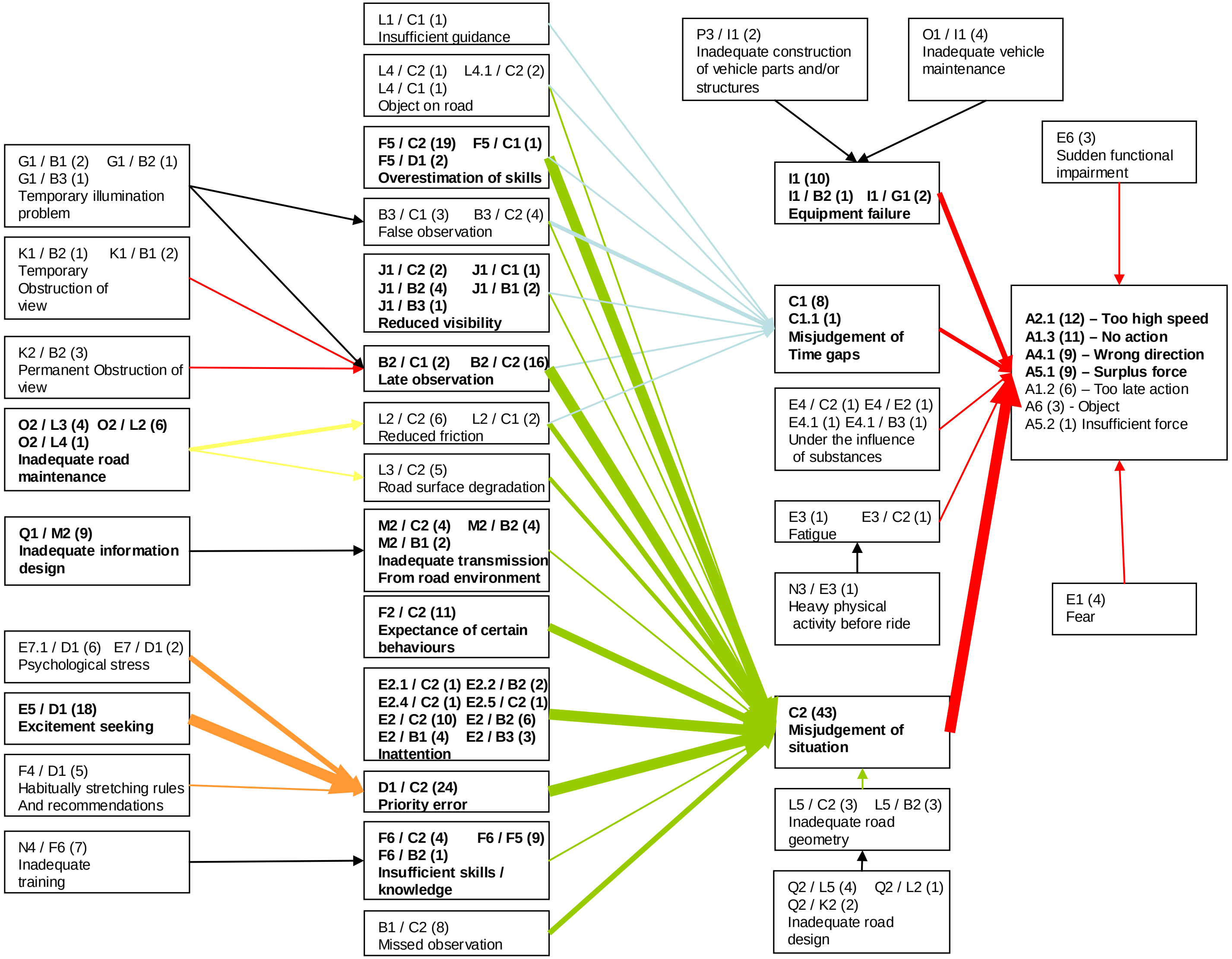

Figure 28: Scenario 3 - DREAM Analysis for the riders

5.5. Scenario 4: Single motorcycle accident – Inside urban area – No intersection

5.5.1. Who is involved in such accidents? Where and with which kind of vehicles?

The description of the three components of the system DVE comes from two kinds of information sources: from national databases and from in-depth ones. The reason is that this paragraph only states on descriptive data and national databases contain such information.

In these accidents, there is no collision with another vehicle. Even if one could have played a role in the genesis of the accident, the road users inside the other vehicle were not considered for our statistics because most of the time, these one were not reported in police reports.

Information from national databases

Main fatal accidents happened during good weather conditions (92% of accidents) and on a dry surface (91% of accidents). There was no significant conclusion regarding to the road profile as 56% of them happened on a straight road.

In this scenario, accidents inside urban area, out of intersection, occurred more often during the night than during the day, with respectively 59% and 40% of accidents. Considering a low traffic during the night, it can be assumed and deduced that the risk to be involved in a fatal accident for a motorcyclist is riskier during the night, inside urban area.

Considering the age of motorcyclists, 63% of them were between 25 and 50 years old, 27% between 18 and 25 and 6% over 50. 3% of PTW users under 18 years were involved in fatal accidents. These users were not allowed to drive motorcycles and in most cases, these vehicles were stolen.

3% of these accidents involved a female motorcyclist.

Information from in-depth databases

As for the previous scenario, main types of PTW were sport (24%) and conventional street ones (57%). The only difference lies in the fact that the proportions are reversed. 61% of PTW were propelled by a motor of a capacity of 600cc or less and 94% by a motor of a capacity of 1,000cc or less. The most frequent PTW regarding to its capacity was 600cc motorcycles. The motorcycle average age was 4.8 years and 52% of them were 3 years old or less. It has to be noted that 26% of them were new as they were under 1 year. Their kilometre-age average was 32,200 kilometres and the kilometre-age of 49% of motorcycles was lower than 25,000 kilometres and for 85% lower than 50,000 kilometres. Only 2% of PTW had defects (tyres defects).

The average of motorcycle riding experience was 5.7 years but 53% of riders had less than three years of riding experience and 32% less than one year. When the information was known, here are some results on riders:

- 40% of riders in our sample rode less than 5,000 kilometres per year.
- 50% of them considered the motorcycle as a mode of transport (for instance to go from home to work).
- 33% of them used it exclusively for leisure.

On average, they have had the accident 25 minutes after departure and for 57% of them, it was 20 minutes after leaving home or friends.

96% of riders were using a helmet and it was correctly used (size adapted to the head of the user and fastened). Only 17% of riders were fully equipped with PTW specific clothes: jacket, trousers, gloves, boots and helmet. Then, gloves (41%), jackets (37%) and boots (30%) were the most used equipments.

5.5.2. How the accident evolved from the driving phase to the crash?

In main pre-accident situations, riders did not realize any manoeuvre. they were just going ahead on a straight road or on a left bend or right one.

Comparing this scenario (only one motorcycle, inside urban area and out of intersection) and the previous one (only one motorcycle, outside urban area and out of intersection), the only difference is in the fact that the accident happened inside urban area or not and we can notice that pre-accident situations are different. Indeed, outside urban area, going ahead on a bend are more frequent pre-accident situations; whereas inside urban area, more accidents happen when the riders is going ahead on a straight road.

In most cases, there was no other road user involved and no obstacle ahead, therefore there was no potential conflict.

The precipitating event is the event which has disturbed the rider driving situation. And due to this event, the situation of the rider became critical. The main events are linked to the internal conditions of the driving task (it is the "conditioning" of the rider to realize their manoeuvre or to follow a road), the rider behaviour, the road environment and the infrastructure. Here is the list of the main precipitating events:

- Poor evaluation or anticipation of the situation (6).
- The weather conditions disturbed the "normal" driving task because of black ice and road surface pollutions (6).
- Alcohol or drugs impairment (5).
- Incorrect driving manoeuvre (4).
- Avoidance manoeuvre due to other vehicle (4).
- Inappropriate speed (3).

Following this disturbing event, more riders have realized an emergency manoeuvre, comparing to the previous scenario where accidents happened outside urban area. It could be because accidents inside urban area are at lower speeds and riders have "more time" to react:

- 41% of riders only braked.
- 27% did not react because of a lack of time or space, because they were astonished or they did not perceive any danger.
- 11% braked then turned or turned then braked.
- 14% only tried to control their vehicle.

In this scenario, there was no impact with another road user. For 67% of riders, the main impact was the impact when they fell down. But in the other cases, the riders have impacted infrastructure equipments (post, tree, pavement, crash barrier).

The impact velocity is described in Figure 28 only when the impact speed was known and when the rider was still linked to his motorcycle. Impact speeds are higher than those found in the previous scenario as 50% of them are lower than 45 Km/h and 80% lower than 65 Km/h (see Figure 28). It is not so surprising as this scenario deals with accidents inside urban area.

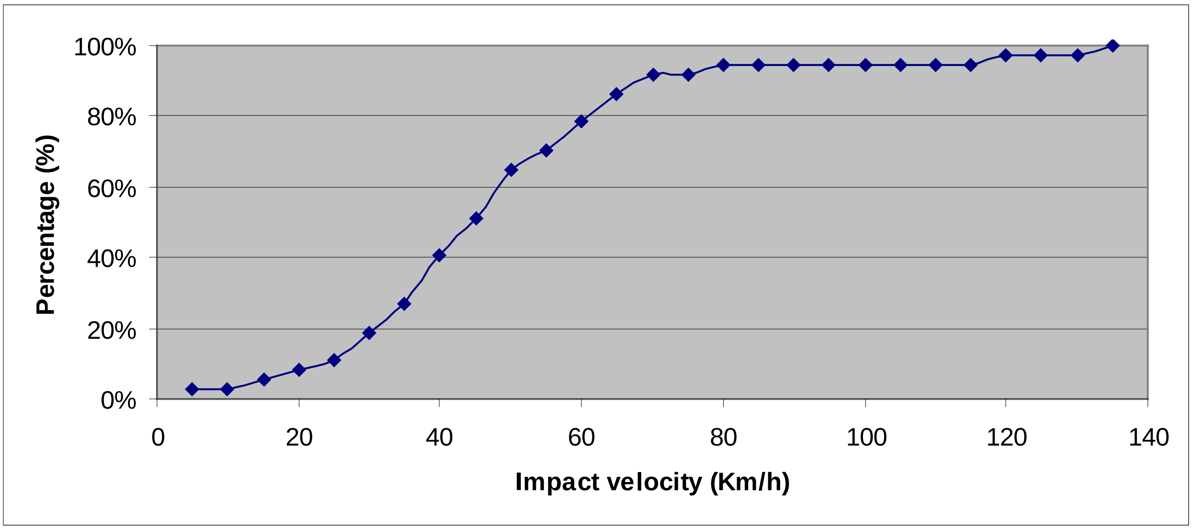

Figure 29: Scenario 4 - Cumulative frequency of impact velocity – Rider

5.5.3. When did the rider or the driver fail?

As riders were the only users involved in this accident scenario, it is not surprising to find that 78% of them were primary active in the accident. 22% of riders were secondary active in the accident. It means that they took part in the disturbance of accident situations but did not provoke it. The analysis of the conflict shows that in very few accidents, they were confronted with another vehicle or an animal (and did not crash them).

The main human functional failures identified for this scenario, when considering the rider are first, action, then diagnosis, perception and to a lesser extent an overall failure.

It is not surprising to find so many action failures as we are analysing single motorcycle accidents and as a significant number of accidents were running-off-the-road crashes.

Diagnosis failures refer to a difficulty to evaluate an infrastructure related difficulty (for instance a bend or a reduced adherence on a road). Inside urban area, motorcycles are much more confronted to conflicts with other vehicles, as traffic speed is low and denser comparing to traffic outside urban area.

And that is why, we find in this scenario, several perception failures (especially a lack of perception) which disturbed the rider driving phase.

The last failure linked to an overall failure considers that the problem does not settle anymore in terms of functions failures but in terms of capacities. So, in details, the main human functional failures are (Figure 29):

- E2 failure: Guidance problem. In most cases, due to a lack of attention on the driving task, the rider had some difficulties to keep its trajectory.
- E1 failure: Poor control of an external disruption. In situations where he meets severe constraints, the riders are no longer able to control the trajectory of their motorcycle.
- T1 failure: Erroneous evaluation of a passing road difficulty. This failure illustrates the fact that the rider has difficulties to evaluate a difficulty regarding the infrastructure.
- P5 failure: Neglecting the need to search for information.
- G2 failure: Alteration of sensorimotor and cognitive capacities.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	0	T1	7	T5	1	D1	3	E1	8	G1	1
P2	3	T2	0	T6	0	D2	0	E2	10	G2	5
P3	0	T3	0	T7	0	D3	0			G3	0
P4	0	T4	2								
P5	5										
Tot.	**8**	**Tot.**	**9**	**Tot.**	**1**	**Tot.**	**3**	**Tot.**	**18**	**Tot.**	**6**

No Human Functional Failure 1

Figure 30: Scenario 4 - Rider human functional failure

These failures are explained by the following explanatory elements:

- Speed not adapted to the situation (8).
- Excessive speed (over the legal limit) (3).
- The user has a high experience of the route. His attention level is low (7).
- The conditions of the road surface affect the road user's ability to be able to control its motorcycle on the road. In our sample, road are icy or wet and cause a loss of control of the motorcycle (7).
- New rider (7).
- Atypical manoeuvre of other road users (6).
- Alcohol, over the legal limit (5).
- The vehicle was new or was new to the road user (5).
- Visibility impaired due to darkness or rain (5).
- The road surface is polluted or in bad condition (maintenance) (4)
- In a hurry (4).
- Visibility impaired because of the road profile or the road geometry (4).
- Fatigue (4).

5.5.4. What are the blunt end failures, the latent and sharp end ones?

The DREAM analyses of 46 accidents of the scenario 4 are summarized in Figure 30, considering only the rider and their failures because no other road user is involved in these accidents.

The most frequent phenotypes for the riders are “surplus force”, “too late action”, “too high speed” and “wrong direction”.

It is not surprising to find “surplus force” as one of most frequent phenotypes as it illustrates the fact that the force with which an action is conducted is too hard. We know that a PTW is not as stable as passenger cars and any manoeuvre (braking, steering, accelerating...) not realized correctly could cause a loss of controllability of the motorcycle.

For the phenotype “too late action”, the rider saw at the last time an event (an atypical manoeuvre made by another road user or an animal on the road) and realized an emergency manoeuvre when it was already too late.

The “too high speed” just confirms the results from previous paragraphs, where speed was an accident generating factor. The high speed was the first observable effect during the rupture phase.

“Wrong direction” partly reflects that most accidents in this scenario are running-off-the-road crashes.

The most frequent genotypes to these phenotypes are “misjudgement of situation” and “misjudgement of time gaps”. For this last genotype, the estimation of time gaps (for instance time left to approaching vehicle, stop sign...) is incorrect and the object (approaching vehicle, stop sign) has been observed by the rider. Both genotypes are explained by the following genotypes:

- The friction was reduced because of an inadequate road maintenance and a PTW equipment failure. This last genotype is explained by the fact that the maintenance of the PTW and especially of tyres was inadequate.
- Some information about the situation were correctly observed but late and other were misunderstood or misinterpreted as something else. These are the results of visibility masks (buildings, trees, moving vehicle, road geometry...) which obstructed, permanently or temporary, the view of riders. Inattention and reduced visibility (due to darkness, rain) were also found as a factor which indicates this lack of observation.
- The rider prioritised something else above safe arrival at the destination (such as splitting lanes or riding over the legal speed limit) as a result of excitement seeking or a high confidence in the way they are riding. They habitually stretched rules and recommendations as previous performance had not resulted in any negative consequences.
- Overestimation of riders’ skills and insufficient skills or knowledge are also linked to several genotypes. It means that they are not only linked to a misjudgement of situation.

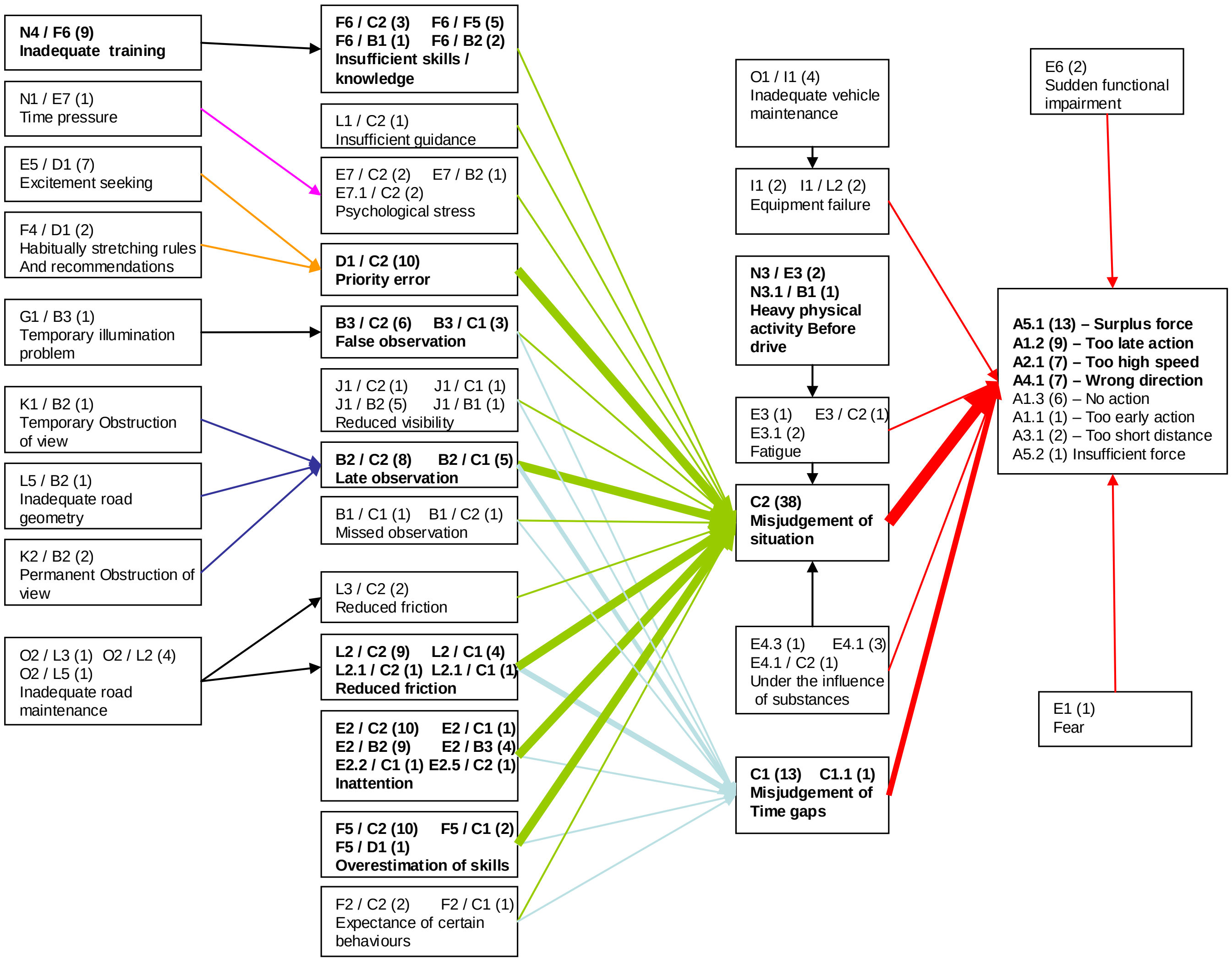

Figure 31: Scenario 4 - DREAM Analysis for the riders

5.6. Scenario 5: Single motorcycle accident – Inside urban area – Intersection

5.6.1. Who is involved in such accidents? Where and with which kind of vehicles?

The description of the three components of the system DVE comes from two kinds of information sources: from national databases and from in-depth ones. The reason is that this paragraph only states on descriptive data and national databases contain such information. Nevertheless, such accidents, that is to say single motorcycle accidents, inside urban area at intersection are issues only in the United Kingdom.

In these accidents, there is no collision with another vehicle. Even if one could have played a role in the genesis of the accident, road users inside the other vehicle were not considered for our statistics because most of the time, these one were not reported in police reports.

Information from the national United Kingdom databases

Main fatal accidents, in UK, happened during good weather conditions (76% of accidents), on a dry surface (68% of accidents) and on a straight road (66% of accidents).

More accidents happened during night (58%) and supposing as in the previous scenarios that there is less traffic during night, it can be concluded that night riding inside urban area is riskier for motorcyclists.

Considering the age of motorcyclists, 50% of them were between 25 and 50 years old, 32% between 18 and 25 and 8% over 50. 10% of PTW users under 18 years were involved in fatal accidents. Indeed, in UK, the minimum age to drive a light (up to 125cc and 11 kW) or medium-sized (up to 25 kW and a power to weight ratio of up to 0.16 kW/kg) motorcycles or motorcycles with sidecar (a power to weight ratio of up to 0.16 kW/kg) is 17.

No accident involved a female motorcyclist.

Information from in-depth databases

Main PTW types in these accidents were sport (33%), sport touring (11%) or conventional street ones (39%). 61% of PTW were propelled by a motor of a capacity of 700cc or less and 94% by a motor of a capacity of 1,100cc or less. The most frequent PTW regarding to its capacity were 600cc motorcycles. The motorcycle average age was 4.6 years and 56% of them were 3 years old or less. It has to be noticed that 29% of them were new as they were under 1 year. Their kilometre-age average was 37,400 kilometres and the kilometre-age of 53% of motorcycles was lower than 25,000 kilometres and for 84% lower than 75,000 kilometres. 8% of PTW had defects (tyres and braking system defects).

The average of motorcycle riding experience was 7.3 years but 46% of riders had less than three years of riding experience and 33% less than one year. When the information was known, here are some results on the riders:

- 55% of riders in our sample rode less than 5,000 kilometres per year (average per year: 6,045 kilometres)
- The accidents happened around 20 minutes after departure but for 65% of them, it was during the first 15 minutes.

85% of riders were using a helmet and it was correctly used (size adapted to the head of the user and fastened). Only 26% of riders were fully equipped with PTW specific clothes: jacket, trousers, gloves, boots and helmet. Then, gloves (70%), jackets (48%) and boots (43%) were the most used equipments.

5.6.2. How the accident evolved from the driving phase to the crash?

In the pre-accident situations, riders have realized only few manoeuvres. Most accidents happened when they were crossing the intersection to go ahead and especially when they were travelling on a roundabout.

Then 8 accidents (36 in total in the sample) occurred on approach of the intersection where the road users had a right of way status.

As explained before, in previous single motorcycle accident scenarios, there was no conflict with the motorcyclist. If it was the case, there was no collision with the opponent vehicle. Main conflict appeared when a vehicle was coming from the opposite direction and was inside his lane or when it was coming from a side road.

The precipitating event is the event which has disturbed the rider driving situation. And due to this event, the situation of the rider became critical. The main events are linked to the internal conditions of the driving task (it is the “conditioning” of the rider to realize their manoeuvre or to follow a road), to the road environment and to the vehicle environment. Here is the list of the main precipitating events:

- Inappropriate reaction (panic, exaggerated movements…), (6).
- Incorrect driving manoeuvre (4)
- Avoidance manoeuvre due to other vehicle (3).
- Inappropriate speed (3)
- Fog (2).
- Wet road surface (2).

Even if more than half of riders reacted to avoid the accident, there was a large number of riders who did not do anything:

- 36% of riders only braked.
- 36% of riders did not react because of a lack of time or space or because they were astonished.
- 17% turned (to the right or to the left) then braked.

As in the previous single motorcycle accident scenario, there was no impact with another road user. For 78% of riders, the main impact was the impact when they fell down. But in the other cases, the riders have impacted infrastructure equipments (post, tree, pavement, crash barrier).

The impact velocity is described in Figure 31 only when the impact speed was known and when the rider was still linked to his motorcycle. Impact speeds are lower than those found in previous single motorcycle accident scenarios as 50% of them are lower than 35 Km/h and 80% lower than 60 Km/h (see Figure 31). It could be explained by the facts that motorcyclists are inside urban area and at intersections and that the interaction with other road users is more frequent.

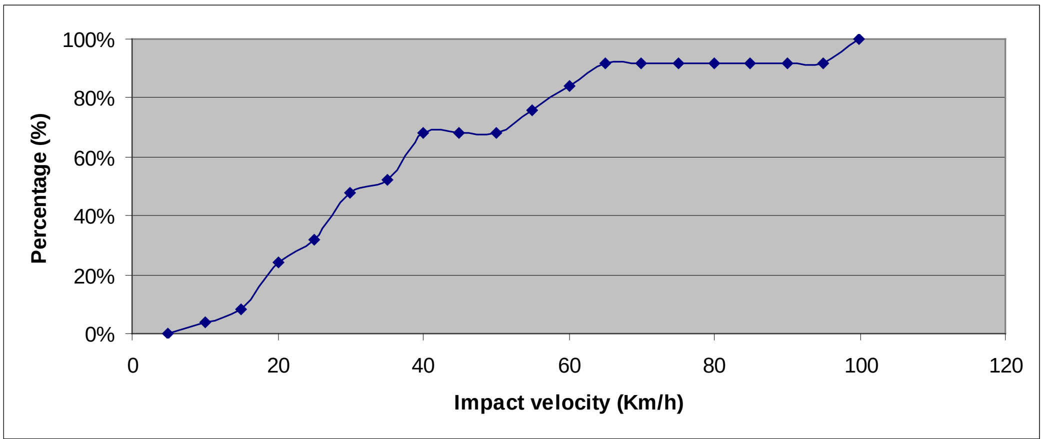

Figure 32: Scenario 5 - Cumulative frequency of impact velocity – Rider

5.6.3. When did the rider or the driver fail?

In these accidents, at intersections and outside urban area, 92% of riders were primary active users. They provoked the disturbance which has caused the accident.

The main human functional failures identified for this scenario, when considering the rider are first, action, then diagnosis, and to a lesser extent perception. Action failures include accidents in which a problem of vehicle control is the direct cause of the emergence of an accident situation, meaning that they occur after the rider has successfully negotiated the other stages (detection, diagnosis…). That is why so many accidents in this scenario refer to action failures. So, in details, the main human functional failures are (see Figure 32):

- E1 failure: Poor control of an external disruption. In situations where he meets severe constraints, the riders are no longer able to control the trajectory of their motorcycle.
- T1 failure: Erroneous evaluation of a passing road difficulty. This failure illustrates the fact that the rider has difficulties to evaluate a difficulty regarding the infrastructure.
- P1 failure: Non-detection in visibility constraints conditions. The riders do not have access to useful information about the situation because of environmental constraints.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	3	T1	7	T5	3	D1	1	E1	15	G1	0
P2	0	T2	0	T6	1	D2	3	E2	0	G2	0
P3	0	T3	0	T7	0	D3	0			G3	0
P4	1	T4	0								
P5	1										
Tot.	**5**	**Tot.**	**7**	**Tot.**	**4**	**Tot.**	**4**	**Tot.**	**15**	**Tot.**	**0**

No Human Functional Failure 1

Figure 33: Scenario 5 - Rider human functional failure

These failures are explained by the following explanatory elements:

- Excessive speed (over the legal limit) (9).
- In a hurry (7).
- Speed not adapted to the situation (6).
- Atypical manoeuvre of other road users (6).
- New rider (4).
- The road is wet (4).
- Alcohol above legal limit (3).
- Fatigue (3).
- Rigid attachment to the right of way status (3).

5.6.4. What are the blunt end failures, the latent and sharp end ones?

The DREAM analyses of 46 accidents of the scenario 5 are summarized in Figure 33, considering only the rider and their failures because no other road user was involved in these accidents.

The most frequent phenotypes for riders are “surplus force” and “too late action”.

As explained previously, in the two last scenario, “surplus force” explains the fact the force with which an action is conducted is too hard. We know that a PTW is not as stable as passenger cars and any manoeuvre (braking, steering, accelerating...) not realized correctly could cause a loss of controllability of the motorcycle.

For the phenotype “too late action”, the rider saw at the last time an event (an atypical manoeuvre made by another road user or an animal on the road) and realized an emergency manoeuvre when it was already too late.

The most frequent genotypes to these phenotypes are “misjudgement of situation” and “fear”. Fear means that the rider was scared by a sudden event and in our cases, it could be by a vehicle coming from a side road at intersection.

The genotypes which contribute to these main genotypes are:

- The friction was reduced because of an inadequate road maintenance and an inadequate road design. This one defines the inadequacy of the planning and/or the construction of the road (for instance, inadequate road surface, curve, camber…).
- The rider prioritised something else above safe arrival at the destination (such as splitting lanes or speed not adapted to the situation) as a result of an excitement seeking or a high confidence in the way they were riding. They habitually stretched rules and recommendations as previous performance had not resulted in any negative consequences.
- The rider expected other road users to behave in certain ways following praxis. This genotype illustrates the conflict with another road user but without any collision.
- Some information of the situation were correctly observed but late. These were the results of visibility masks (buildings, trees, moving vehicle, road geometry...) which obstructed, permanently or temporary, the view of riders. Inattention and reduced visibility (due to darkness, rain) were also factors which indicates this lack of observation.
- Overestimation of riders’ skills and insufficient skills or knowledge are also linked to several genotypes. It means that they are not only linked to a misjudgement of situation.

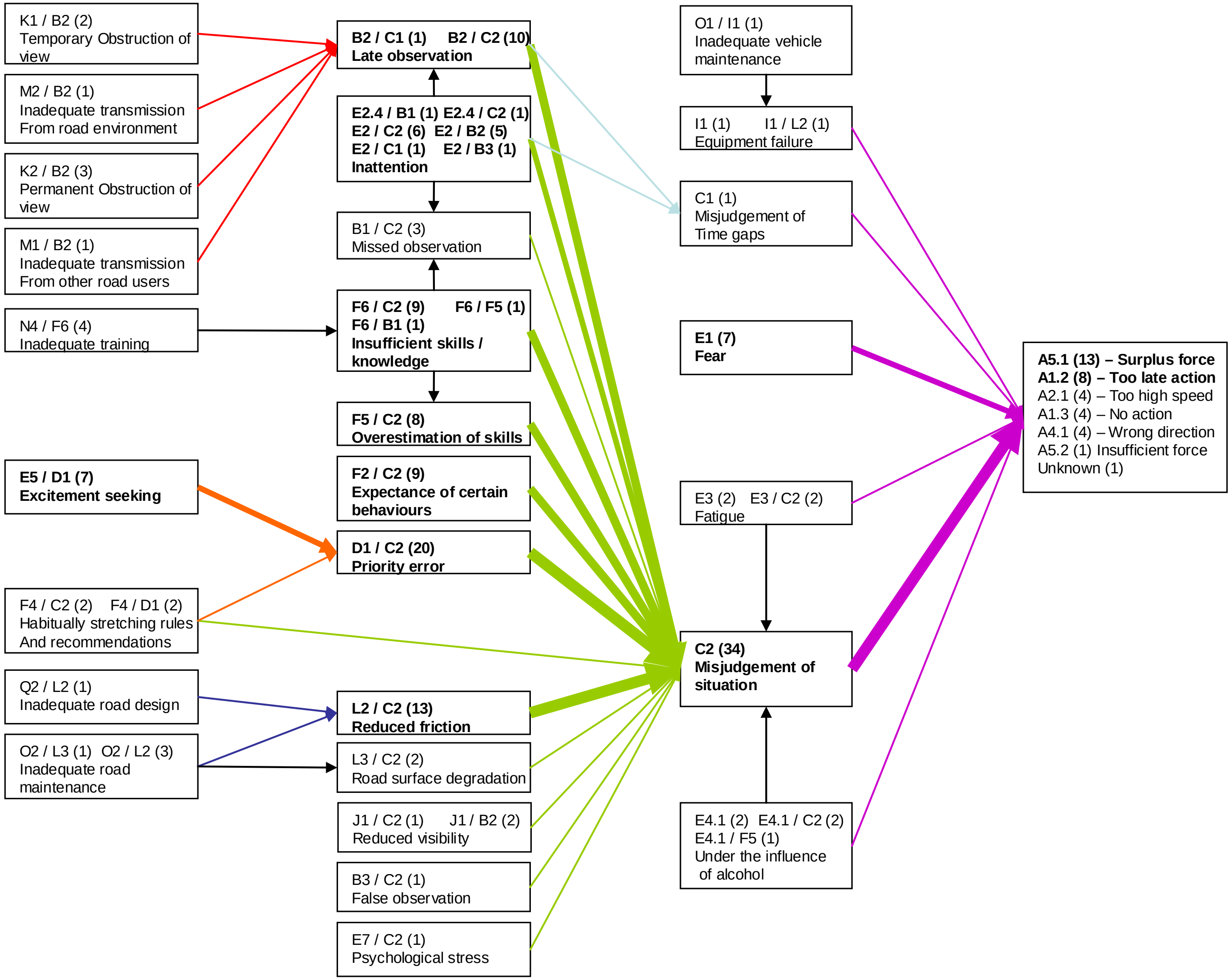

Figure 34: Scenario 5 - DREAM Analysis for the riders

5.7. Scenario 6: Motorcycle / Passenger car accident – Outside urban area – No intersection

5.7.1. Who is involved in such accidents? Where and with which kind of vehicles?

The description of the three components of the system DVE comes from two kinds of information sources: from national databases and from in-depth ones. The reason is that this paragraph only states on descriptive data and national databases contain such information.

Information from national databases

44% of users involved in this kind of accidents were motorcyclists and were fatally injured. Passenger car users were more protected as they represented 30% of users uninjured, 20% of injured users and 0.8% of fatally injured users.

Most fatal accidents occurred during good weather conditions (92% of accidents), on a dry surface (95% of accidents) and during the day (71% of accidents). These conditions in which the accidents happened seem to be more clement, especially when comparing with the results of moped accidents (Scenario 1 and 2). Does it mean that motorcyclists are more aware of the risk to drive during bad conditions? No exposure data exist on this topic but WP5 (in-depth behavioural studies) is trying to give first answers to this question.

Accidents in scenario 3 and 6 happened in the same conditions, that is to say outside urban area and not at intersection. The only difference is that in this scenario 6, the motorcyclist crashed a passenger car. And the road profile did not have the same impact in the two accident configurations. Indeed, in scenario 6, 61% of accidents happened on a straight road whereas in scenario 3, in the same proportion, it was in a curve. The next paragraphs will probably explain why we find this difference.

Young riders (under 25) and older ones (over 50) were probably over represented (but we do not have any exposure data to confirm these facts) as they represented respectively 20% and 14% of riders involved in such accidents.

97% of motorcycle users were male.

Information from in-depth databases

Most motorcycles in this sample were conventional street PTW (36%), sport (29%) or sport touring ones (19%). 50% of PTW were propelled by a motor of a capacity of 600cc or less and 90% by a motor of a capacity of 1,000cc or less. The most frequent PTW regarding to its capacity were 600cc motorcycles. The motorcycle average age was 6.1 years and 50% of them were 4 years old or less. It has to be noticed that 21% of them were new as they were under 1 year. Their kilometre-age average was 40,000 kilometres and the kilometre-age of 50% of motorcycles was lower than 35,000 kilometres. 8% of PTW had defects (tyres defects or gear system problems).

The average of motorcycle riding experience was 7 years but 53% of riders had less than two years of riding experience and 30% less than one year. Motorcycle riders rode 18,000 kilometres per year on average and for 50% of them it was less than 15,000 kilometres. Most riders considered PTW as a mode of transport and as a leisure. On average, they have had the accident 40 minutes after departure and for 47% of them, it was during the first 30 minutes. Alcohol, drug or medicine were not issues for these riders.

All of them were correctly using a helmet (the helmet was fastened and the size was adapted to the rider). 60% of riders were well equipped. It means that they were wearing a jacket, a pair of trousers and gloves and boots. All of them were PTW specific clothes. And at least 50% of other riders (not fully equipped) were wearing at least one of specific equipments.

On average, passenger car drivers were 40 years old and 47% of them were less than 35. Too many information linked to the passenger car drivers are not available.

5.7.2. How the accident evolved from the driving phase to the crash?

Riders

The first main pre-accident situations appear when the rider was going ahead on a straight road, on a left bend or on a right bend and he was in conflict with an oncoming passenger car which was in correct lane or with a passenger car ahead moving in the same direction.

Other pre-accident situations are critical for the riders. Indeed, 22 riders were splitting lanes or overtaking a passenger car on the correct side. Then, they were confronted with a vehicle travelling in a lateral lane and in the same direction.

The precipitating event is the event which has disturbed the rider driving situation. And due to this event, the situation of the rider became critical. The main events are linked to the internal conditions of the driving task (it is the way "internally" they are realizing their manoeuvre or they are trying to follow a road) and the vehicle environment. Here is the list of the main precipitating events:

- Incorrect driving manoeuvre (risk taking, poor overtaking…), (15). This event reflects pre-accident situations where riders were realizing a manoeuvre. This one has caused a disturbance in their "normal" driving phase.
- Misinterpreted the driving situation (8).
- Excessive speed (3).
- Avoidance manoeuvre due to other vehicle (3).

Following this event, 24% of riders did not react because of the lack of time and/or space. 55% of them only braked and 12% braked and turned or turned and braked.

Before the impact against the passenger car, 80% of riders were still on their motorcycles (the rider is not ejected from the PTW or the rider and the motorcycle are not separately sliding on the road). For the riders, 50% of main impacts were frontal ones, 26% sides ones. For 21% of cases, there were multiple impacts and it was difficult to identify where the main one was.

The impact velocity is described in Figure 34 only when the impact speed was known and when the rider was still linked to his motorcycle. There are few impacts at low speed (between 0 km/h and 30 km/h). 50% of them are lower than 55 Km/h (mainly between 35 km/h and 55 km/h) and 80% lower than 100 Km/h (see Figure 34). It is not so surprising to find such high speed as this scenario deals with accidents outside urban area.

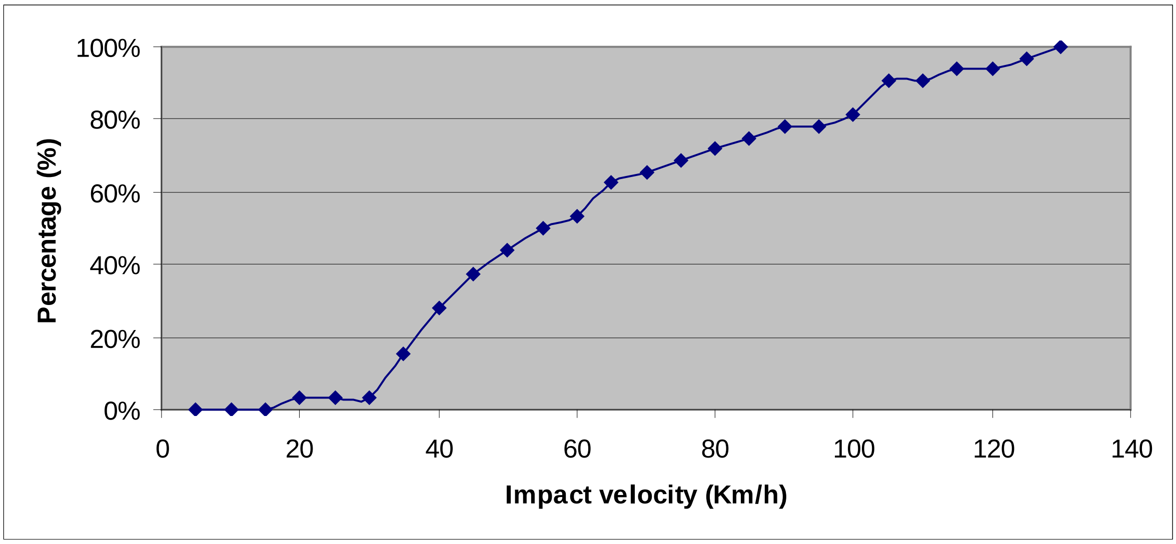

Figure 35: Scenario 6 - Cumulative frequency of impact velocity – Rider

Drivers

The first main pre-accident situations appear when the driver was going ahead on a straight road, on a left bend or on a right bend and he was in conflict with an oncoming motorcycle which was not in the correct lane. It probably shows that motorcyclists lost the control of their PTW and crashed the oncoming passenger car.

The second main pre-accident situations are when the passenger car driver wanted to change lane and he was in conflict with a PTW travelling in a lateral lane and in the same direction.

The last critical driving situations happened when the driver was turning (not at an intersection) across traffic from main road into private drive or when he was turning across traffic (not at an intersection) out of private drive. The conflict was coming from oncoming PTW which were in their own and correct lane or from PTW from side road.

The precipitating event is the event which has disturbed the driver driving situation. And due to this event, the situation of the driver became critical. The main events are linked to the driver behaviour and the internal conditions of the driving task (it is the way they are realizing their manoeuvre or they are trying to follow a road). Here is the list of the main precipitating events:

- Failed to look, looked but did not see (16).
- Misinterpreted the driving situation (6).
- Incorrect driving manoeuvre (5).

The emergency manoeuvres realized by drivers coincide completely with the main precipitating event. Indeed, 65% of drivers did not react after their driving situation disturbance because they failed to look the opponent user who was the rider.

The main impacts for passenger cars were side and frontal ones (respectively 55% and 26%)

The impact speeds for passenger car are lower than those found for PTW. Indeed, 50% of them are lower than 35 km/h and 80% lower than 65 km/h.

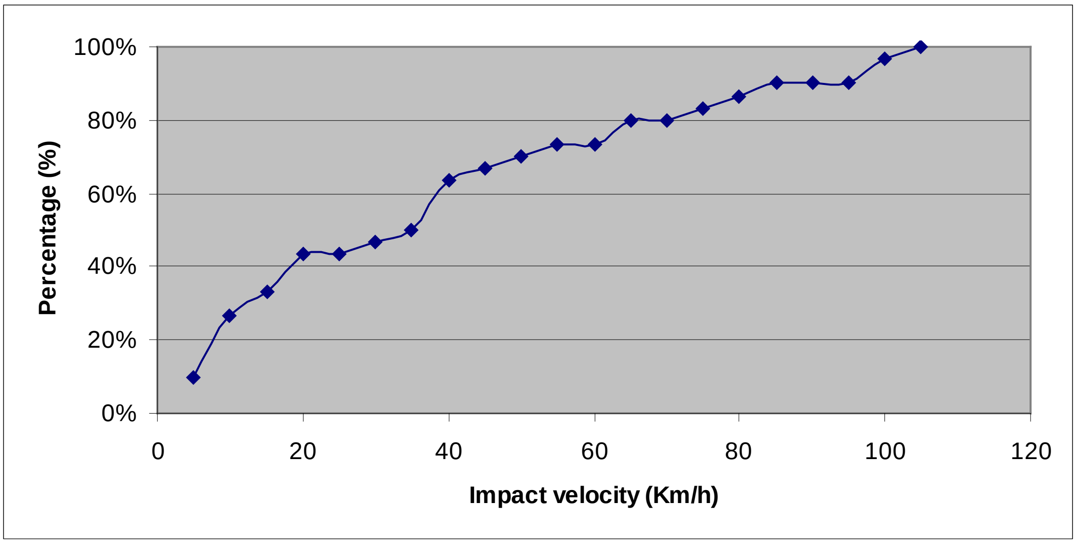

Figure 36: Scenario 6 - Cumulative frequency of impact velocity – Driver

5.7.3. When did the rider or the driver fail?

Riders

Most riders were active in the genesis of the accident. 52% of them were primary active (they have “provoked the disturbance”) and 36% were secondary active (they have taken part in the genesis of the accident by not trying to resolve the conflict).

The main human functional failures identified for this scenario, when considering the rider are prognosis and detection failures. Whether they made a bad prognostic of the probable evolution of the situation or they did not see important information about the situation. So, in details, the main human functional failures are:

- T5 failure: Expecting another user not to perform a manoeuvre. The rider did not expect the driver to change lane or to turn into a side road.
- P5 failure: Neglecting the need to search for information.
- E2 failure: Guidance problem. In most cases, due to a lack of attention on the driving task, the rider has some difficulties to keep its trajectory. It explains why the rider who was not performing a manoeuvre (he was going ahead on a road) was involved in a crash with an oncoming vehicle which was travelling in the correct lane. He lost the control of its PTW.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	1	T1	2	T5	14	D1	0	E1	1	G1	0
P2	1	T2	2	T6	2	D2	1	E2	5	G2	0
P3	1	T3	0	T7	4	D3	0			G3	0
P4	1	T4	1								
P5	6										
Tot.	**10**	**Tot.**	**5**	**Tot.**	**20**	**Tot.**	**1**	**Tot.**	**6**	**Tot.**	**0**

Figure 37: Scenario 6 - Rider human functional failure

These failures are explained by the following explanatory elements:

- Risk taking – lateral positioning (17).
- Identification of potential risk about only part of the situation (15).
- Non adapted speed for the driving situation (not over the legal limit) (8).
- Excessive speed or speed over the legal limit (6).
- Atypical manoeuvre from other road user (13).
- Other road user: absence of clues to manoeuvre (9).
- Heavy traffic (8).
- Visibility impaired due to terrain profile (8).
- In a hurry (7).

Drivers

Passenger car drivers were either primary active or non active. It means that they contributed to the accident genesis or the manoeuvre from others (the riders in our cases) was hardly predictable because the information they had, did not enable them to prevent the failure of others.

The main human functional failure category is the detection phase. Drivers were not able to well perceive all information about the situation. In details, human functional failures are:

- P3 failure: Cursory or hurried information acquisition.

- P1 failure: Non detection in visibility constraints.
- P5 failure: Neglecting the need to search for information.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	8	T1	0	T5	2	D1	1	E1	0	G1	0
P2	1	T2	1	T6	2	D2	1	E2	1	G2	0
P3	11	T3	0	T7	1	D3	0			G3	0
P4	0	T4	3								
P5	6										
Tot.	**26**	**Tot.**	**4**	**Tot.**	**5**	**Tot.**	**2**	**Tot.**	**1**	**Tot.**	**0**

No Human Functional Failure 4

Figure 38: Scenario 6 - Driver human functional failure

These failures are explained by the following explanatory elements:

- Atypical manoeuvre from other road user (17).
- Heavy traffic (12).
- Identification of potential risk about only part of the situation (11).
- Visibility impaired due to terrain profile (9).
- Visibility impaired due to other vehicle (7).
- The user has a high experience of the route. His attention level is low (5).
- New driver (5).
- Visibility impaired due to darkness (5).

5.7.4. What are the blunt end failures, the latent and sharp end ones?

The DREAM analyses of 49 accidents of the scenario 6 are summarized in Figure 38 and Figure 39, considering first the rider and their failures and then the driver and their failures also. Each DREAM analysis is separately described in order to underline the accident factors linked to each user.

Riders

The four main phenotypes, which are the first observable effects during the rupture phase (see 5.7.2) are each of them linked to four different phenotype categories. The first one is a problem of timing for initiating an action which was too late (for instance, the rider has started to make an avoidance manoeuvre too late in order to avoid an accident with a passenger car). The second one concerns the force with which the rider conducted an action (in our cases, the rider has braked too hard resulting him loosing the control of his PTW). The third one shows that the manoeuvre, the rider was realizing, was made in the wrong direction (especially when he has ignored road markings to overtake a vehicle). The last one underlines the fact that the rider rode too fast (the rider was riding faster than the general traffic flow or he was riding too fast to take the bend).

The most frequent genotype to these phenotypes is “misjudgement of situation” and this one is explained by the following antecedents:

- The rider expected a certain behaviour from the passenger car with which he was crashed.
- The rider missed an information which was critical to well understand the situation and the way it would have evolved. The reasons are that the view was obstructed because of driven vehicles and traffic environment and the passenger car driver failed to transmit information (it was ambiguous or incorrect).
- The rider failed in observing the situation. Indeed when the observation was made, there was insufficient time to act in an optimal way. This fact is explained by most reasons presented in the previous paragraph. But we can notice that infrastructure seems to be more critical when explaining the late observation. Indeed, the road environment failed to transmit information to the rider because of a lack warning signs (in particular when approaching a bend) or the road geometry was not adapted to PTW.
- In many accidents in this sample, inattention is a critical factor. Indeed, it is preponderant and it contributes to several antecedents. It explains the late or missed observation and the misjudgement of the situation.
- The last main genotype is the priority error. The riders were looking for adrenaline-kicks and that is why a safe arrival at destination was not a priority.

Drivers

From the driver point of view, the main phenotype refers to the timing for initiating an action. This one was initiated, in main cases, too early (before it is safe to do it) which is completely coherent with the too late action initiated by the rider. The rider had not enough time to react because the driver initiated an action before having all information needed to do it. Then, some drivers did not initiate any action. They were not realizing any manoeuvre or emergency manoeuvre to avoid the accident.

The most frequent genotype to these phenotypes is “misjudgement of situation”. This one is explained by the same main antecedents presented in the DREAM analysis of the rider for this scenario. Both riders and drivers expected from each other to behave in a way following praxis.

Nevertheless, missed observation is more frequent than late observation. It means that drivers had not access to some critical information which would have helped them to avoid the accident. In addition to the obstruction of view due to road geometry, traffic environment and driven vehicles, which explain why the observations have been missed, other factors stand out. Indeed, the DREAM analysis shows that darkness, permanent (because of parts of the vehicle) or temporary obstructions (passengers, dirty windows, luggage) contribute too to the non detection of the rider.

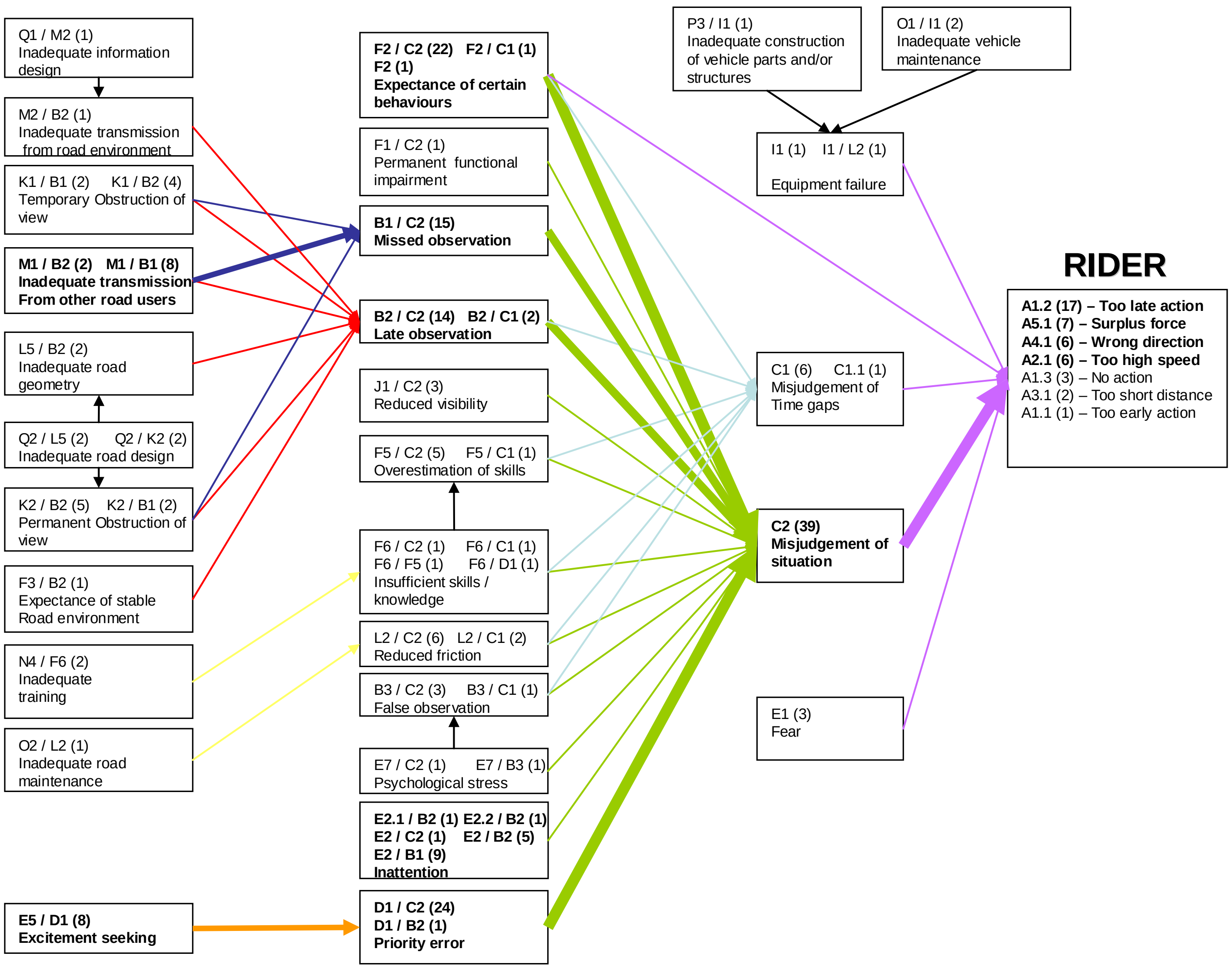

Figure 39: Scenario 6 - DREAM Analysis for the riders

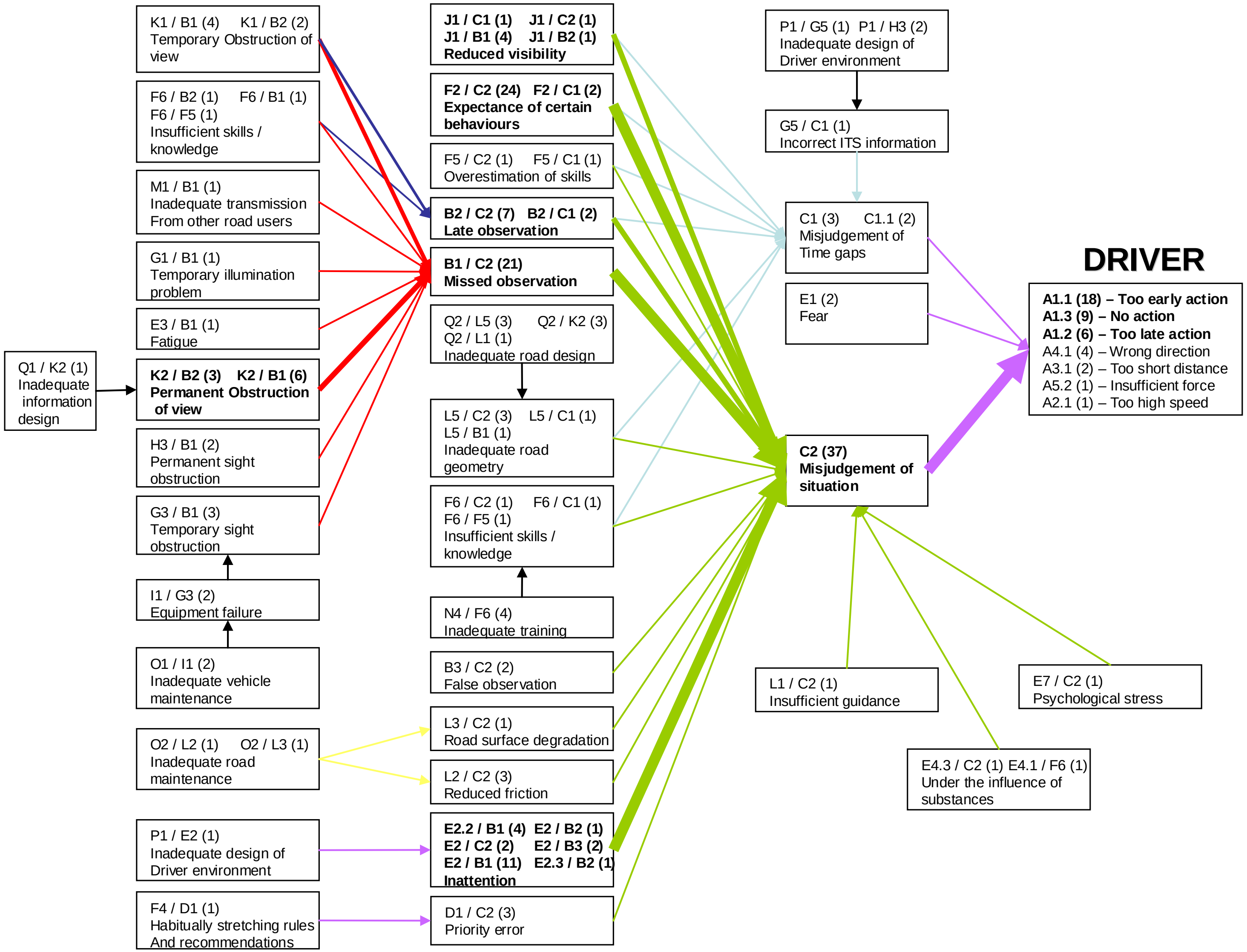

Figure 40: Scenario 6 - DREAM Analysis for the drivers

5.8. Scenario 7: Motorcycle / Passenger car accident – Inside urban area – No intersection

5.8.1. Who is involved in such accidents? Where and with which kind of vehicles?

The description of the three components of the system DVE comes from two kinds of information sources: from national databases and from in-depth ones. The reason is that this paragraph only states on descriptive data and national databases contain such information.

Information from national databases

Most fatal accidents occurred during good weather conditions (93% of accidents), on a dry surface (92% of accidents) and on a straight road (79% of accidents). The lighting conditions for these accidents involving a motorcycle and a passenger car, inside urban area and out of intersection seem to be more relevant for this scenario (comparing with the previous one where accidents happened outside urban area). Indeed, 58% of them happened during the day, but 42% during the night or dusk. The next paragraphs should explain why lighting condition is an important factor in such accident configuration.

22% of PTW users involved in these accidents were under 25, 10% were over 50 and 62% were between 25 and 50 years old (6% are unknown).

96% of motorcycle users were male.

Information from in-depth databases

Most motorcycles in this sample were conventional street PTW (34%), sport (34%) and enduro/offroad ones (12%). 51% of PTW were propelled by a motor of a capacity of 600cc or less and 90% by a motor of a capacity of 1100cc or less. The most frequent PTW regarding to its capacity were 600cc (22%), 125cc (15%) and 900 cc (15%) motorcycles. The motorcycle average age was 4.7 years and 54% of them were 3 years old or less. It has to be noted that 20% of them were new as they were under 1 year. Their kilometre-age average was 33,900 kilometres and the kilometre-age of 48% of motorcycles was lower than 20,000 kilometres.

All of them were in good state and no defect on the vehicle has been found.

The average of motorcycle riding experience was 7 years but 54% of riders had less than three years of riding experience and 15% less than one year. Motorcycle riders rode 11,700 kilometres per year on average and for 50% of them it was less than 10,000 kilometres. 41% of riders considered PTW as a mode of transport and as a leisure and 35% of them only used it because it was useful. On average, they have had the accident 20 minutes after departure and for 40% of them, it was during the first 15 minutes.

Most riders (95%) were correctly using a helmet (the helmet was fastened and the size was adapted to the rider). No rider were not using helmet. Only 26% of riders were well equipped. It means that they were wearing a jacket, a pair of trousers, gloves and boots. All of them wore PTW specific clothes. The most used PTW clothes were gloves (49% of riders) and jackets (38%).

On average, passenger car drivers were 38 years old and 45% of them were under 35.

Differences between scenario 6 and 7 which differ only from the place of the accident, either outside or inside urban area.

Inside urban area, enduro or offroad PTW were more involved, vehicles were less old (age and kilometre-age). Riders involved in accidents inside urban area seemed to have more PTW riding experience considering the date they succeed in having their PTW driving licence. But, in reality, they did not drive so much comparing to the motorcyclists involved in scenario 6 (outside urban area). Many accidents, inside urban area, happened few minutes after departure whereas outside urban area, it happened later.

5.8.2. How the accident evolved from the driving phase to the crash?

Riders

Most riders were not performing any manoeuvre. Indeed, they were going ahead on a straight road. The conflict mainly came from ahead (a vehicle in the same direction): a vehicle moving ahead, a stationary vehicle ahead, an oncoming vehicle which was not in its correct lane and a vehicle coming from a side road or path.

The precipitating event is the event which has disturbed the rider driving situation. And due to this event, the situation of the rider became critical. The main events are linked to the internal conditions of the driving task (it is the way "internally" they are realizing their manoeuvre or they are trying to follow a road) and the behaviour of the rider. Here is the list of the main precipitating events:

- Incorrect driving manoeuvre (risk taking, poor overtaking…), (7). This event reflects pre-accident situations where riders were realizing a manoeuvre. This one has caused a disturbance in their "normal" driving phase.
- Misinterpreted the driving situation (7).
- Inattention – concentrated on another driving related task (6).
- Excessive speed – over the legal limit (5).
- Poor evaluation or anticipation (i.e. other vehicle's speed), (4).

Following this event, 93% of riders were able to realize an emergency manoeuvre. And of course, the main one was the braking (73% of riders only braked). 10% of riders tried to control their PTW: it illustrates the fact that probably they were losing the control of their PTW. Only 7% were not able to perform an emergency manoeuvre.

Before the impact against the passenger car, 84% of riders were still on their motorcycles (the rider is not ejected from the PTW or the rider and the motorcycle are not separately sliding on the road). For riders, 56% of main impacts were frontal ones and 41% side ones.

The impact velocity is described in Figure 40 only when the impact speed was known and when the rider was still linked to his motorcycle. There are few impacts at low speed (between 0 km/h and 20 km/h). 47% of them are lower than 45 Km/h (mainly between 20 km/h and 25 km/h and between 40 km/h and 45 km/h) and 80% lower than 60Km/h (see Figure 40).

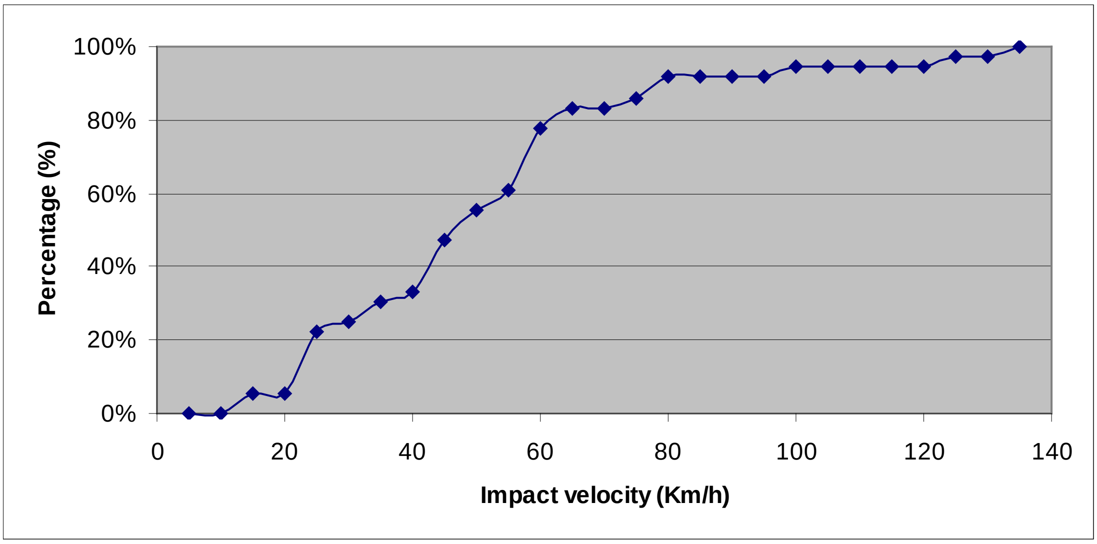

Figure 41: Scenario 7 - Cumulative frequency of impact velocity – Rider

Drivers

In this scenario, drivers were performing a manoeuvre. Indeed, only 25% of drivers were going ahead on a straight road and were confronted with a motorcycle coming from the opposite direction.

Most manoeuvres drivers realized were a changing lane or an overtaking or a turning (not at an intersection in order to go into private drive). In these cases, the conflict (the motorcyclist) was mostly coming from a side road or from a lateral lane (the rider is in a lateral lane travelling in the same direction).

It has to be noticed that in several accidents, the PTW was following the passenger car when the accident happened.

The precipitating event is the event which has disturbed the driver driving situation. And due to this event, the situation of the driver became critical. The main events are linked to the driver behaviour and the internal conditions of the driving task (it is the way they are realizing their manoeuvre or they are trying to follow a road). Here is the list of the main precipitating events:

- Failed to look, looked but did not see (7).
- Incorrect driving manoeuvre (7).
- Decision making error (4).
- Poor evaluation or anticipation (i.e. other vehicle's speed or the distance with the vehicle approaching), (4).
- Incorrect lane positioning (3).

58% of drivers did not react after the precipitating event and after the situation in which they were during the pre-accident phase. They did not see danger and conflict and they were not able to react. 23% of them tried to brake to avoid the accident but failed.

The main impacts for passenger cars were side and rear ones (respectively 39% and 37%)

The impact speeds for passenger car are lower than those found for PTW. Indeed, 50% of them are lower than 25 km/h and 80% lower than 50 km/h.

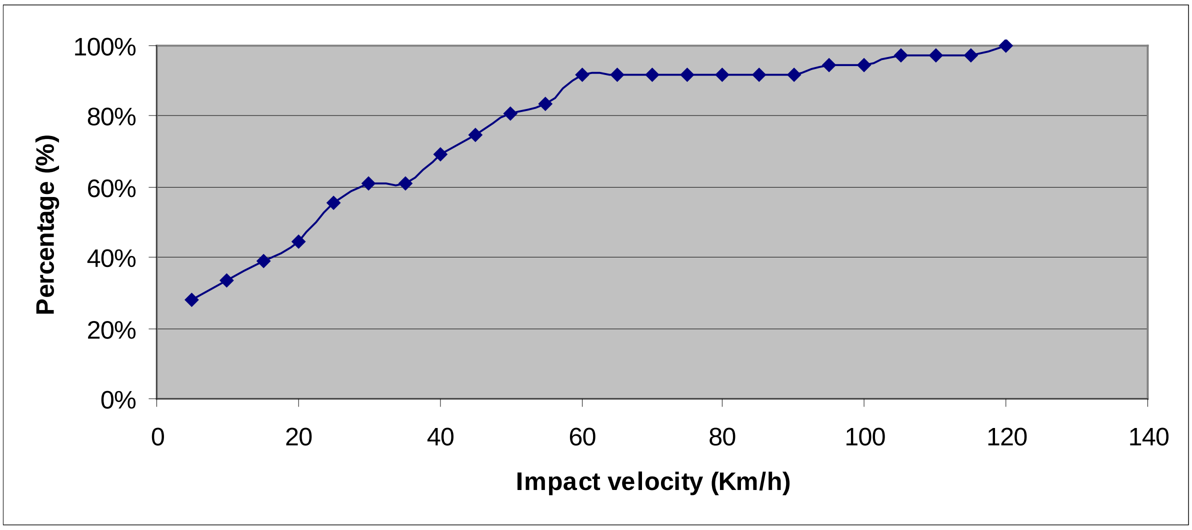

Figure 42: Scenario 7 - Cumulative frequency of impact velocity – Driver

5.8.3. When did the rider or the driver fail?

Riders

Most riders were active in the genesis of the accident. 54% of them were primary active (they have “provoked the disturbance”) and 22% were secondary active (they have taken part in the genesis of the accident by not trying to resolve the conflict). Only 24% of riders were non active and if the information would have been given to them, the accident could have probably been avoided.

The main human functional failures identified for this scenario, when considering the rider are detection, diagnosis and decision failures. Whether they have not seen critical information about the situation or they have not understood what they saw or the strategy they have chosen was not correct. So, in details, the main human functional failures are (see Figure 42):

- P5 failure: Neglecting the need to search for information.
- T4 failure: Incorrect understanding of manoeuvre undertaken by another road user.
- D1 failure: Directed violation. The rider was confronted with a situation in which he was directed to take a certain level of risk in order to attend his goals.
- E2 failure: Guidance problem. Most of the time, because of a lack of attention, the rider was not able to control his lateral trajectory.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	0	T1	0	T5	2	D1	8	E1	0	G1	0
P2	1	T2	0	T6	1	D2	1	E2	5	G2	0
P3	0	T3	0	T7	0	D3	0			G3	0
P4	1	T4	11								
P5	11										
Tot.	**13**	**Tot.**	**11**	**Tot.**	**3**	**Tot.**	**9**	**Tot.**	**5**	**Tot.**	**0**

Figure 43: Scenario 7 - Rider human functional failure

These failures are explained by the following explanatory elements:

- Excessive speed or speed over the legal limit (6).
- Non adapted speed for the driving situation (not over the legal limit) (6)
- Other road user: absence of clues to manoeuvre (12).
- Atypical manoeuvre from other road user (11).
- The user has a high experience of the route. His attention level is low (8).
- Rigid attachment to the right of way status (6).
- New rider (6).
- In a hurry (4).
- Distraction (4).
- New vehicle (4). The user does not know the PTW.

Drivers

The role of the passenger car driver in the genesis of the accident is comparable with what has been found for riders. Indeed, 59% of them were primary active, 24% non active and 10% completely passive in the accident.

The main human functional failure categories are linked to the detection, decision and prognosis phases. Drivers were not able to well perceive all information about the situation, to take the right decision according to the strategy needed to reach their goals and to understand how the situation will evolve. In details, human functional failures are (see Figure 43):

- P5 failure: Neglecting the need to search for information.
- D2 failure: Deliberate violation of a safety rule. It describes risk taking in the performance of a manoeuvre.
- T5 failure: Expecting another user not to perform a manoeuvre.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	0	T1	0	T5	7	D1	0	E1	0	G1	0
P2	3	T2	0	T6	1	D2	9	E2	0	G2	0
P3	2	T3	0	T7	0	D3	0			G3	0
P4	0	T4	1								
P5	14										
Tot.	**19**	**Tot.**	**1**	**Tot.**	**8**	**Tot.**	**9**	**Tot.**	**0**	**Tot.**	**0**

No Human Functional Failure 4

Figure 44: Scenario 7 - Driver human functional failure

These failures are explained by the following explanatory elements:

- The user has a high experience of the route. His attention level is low (6).
- Heavy traffic (6).
- Atypical manoeuvre from other road user (5).
- Navigation problem (5).
- Excessive confidence in the signs given to others (3).
- Distraction (3).

5.8.4. What are the blunt end failures, the latent and sharp end ones?

The DREAM analyses of 41 accidents of the scenario 7 are summarized in Figure 44 and Figure 45, considering first the rider and their failures and then the driver and their failures also. Each DREAM analysis is separately described in order to underline the accident factors linked to each user.

Riders

The four main phenotypes, which are the first observable effects during the rupture phase, are each of them linked to four different phenotype categories (same results comparing to the DREAM analysis of the rider in the previous scenario 6). The first one is a problem of timing for initiating an action which was too late (for instance, the rider has started to make an avoidance manoeuvre too late in order to avoid an accident with a passenger car). The second one underlines the fact that the rider rode too fast (the rider was riding faster than the general traffic flow or he was riding too fast to take the bend). The third one concerns the force with which the rider has conducted an action (in our cases, the rider has braked too hard resulting him loosing the control of his PTW). And the last one explains the fact that the distance between the PTW and the passenger car was too short.

The most frequent genotypes to these phenotypes are “misjudgement of situation” and “misjudgement of time gaps” (bad estimation of the time needed to perform a manoeuvre) and these ones are explained by the following antecedents:

- The observation of some information was correct but late. It means that when the observation was made, there was insufficient time to act in an optimal way. Inattention is the main genotype which explains this problem.
- Inattention also indicates why riders made a mistake when observing some information.
- The riders were looking for adrenaline-kicks: for instance, they were competing with car drivers for fun or thrills and that is why they were riding at illegal speed.
- A safe arrival at destination was not a priority. For instance, the rider thought that it was possible to overtake car in a safe way because all of them were stopped.
- The rider expected a certain behaviour from the passenger car with which he was crashed.
- The skills of riders are insufficient or they have overestimated their own skills because of an inadequate training.

Drivers

From the driver point of view, the main phenotype refers to the timing for initiating an action. This one was initiated, in main cases, too early (before it is safe to do it) which is completely coherent with the too late action initiated by the rider. One user did not have enough time to react because the other road user initiated an action before having all information needed to do it. Then, some drivers did not have initiated any action. They were not realizing any manoeuvre or emergency manoeuvre to avoid the accident. These phenotypes are similar with the DREAM analysis of drivers in scenario 6.

The most frequent genotypes to these phenotypes are “misjudgement of situation” and “misjudgement of time gaps” (bad estimation of the time needed to perform a manoeuvre) and these ones are explained by the following antecedents:

Observation is really an important genotype in the explanation of problems. Indeed, late and false observations are the main genotypes. They are the results of inattention (the driver is distracted by his thoughts) and psychological stress. We find in the previous analysis (human functional failure) that many accidents happen during high traffic conditions.

The driver expected a certain behaviour from the rider with whom he was crashed.

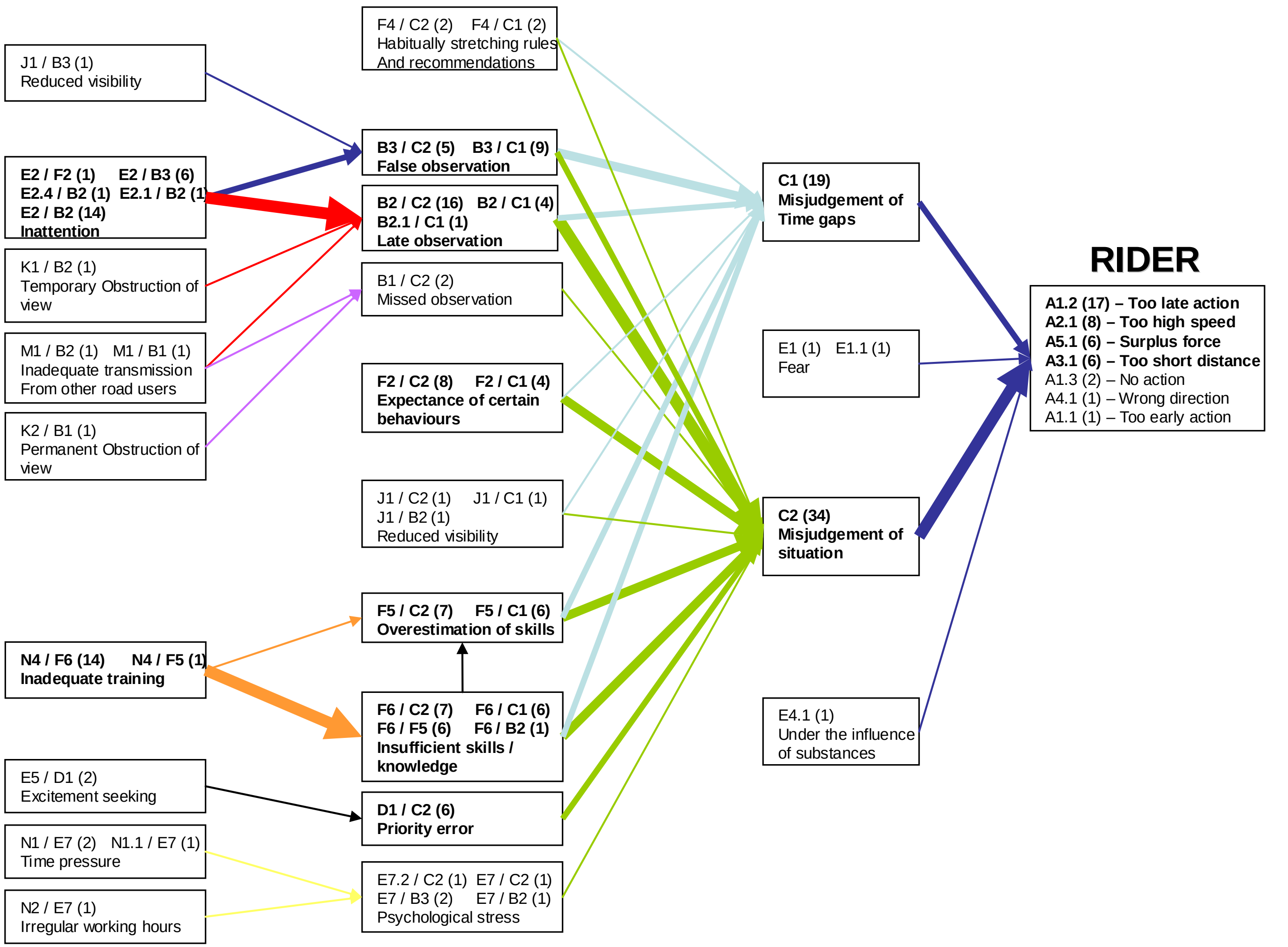

Figure 45: Scenario 7 - DREAM Analysis for the riders

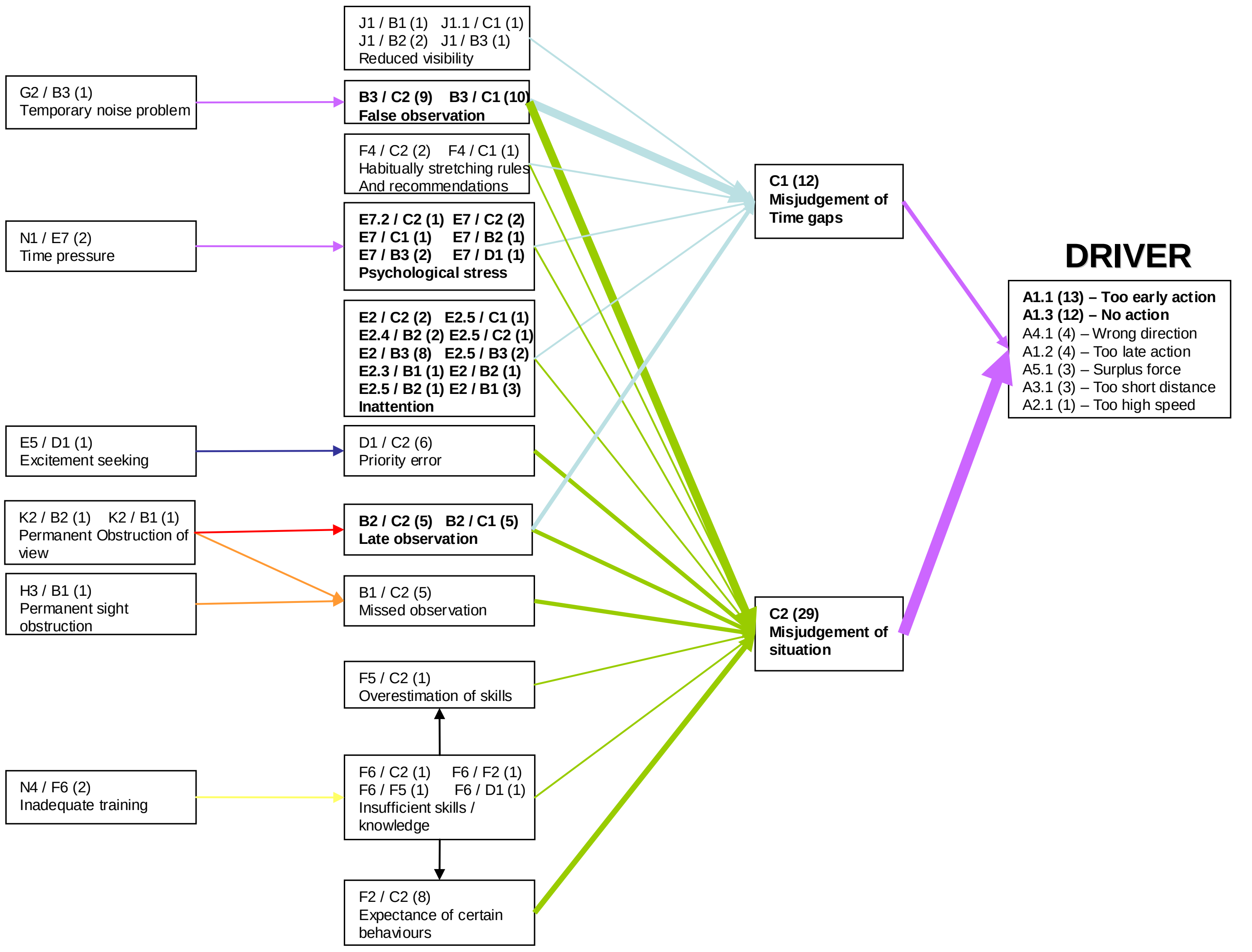

Figure 46: Scenario 7 - DREAM Analysis for the drivers

5.9. Scenario 8: Motorcycle / Passenger car accident – Inside urban area – Intersection

5.9.1. Who is involved in such accidents? Where and with which kind of vehicles?

The description of the three components of the system DVE comes from two kinds of information sources: from national databases and from in-depth ones. The reason is that this paragraph only states on descriptive data and national databases contain such information.

Information from national databases

Most fatal accidents occurred during good weather conditions (93% of accidents), on a dry surface (93% of accidents) and on a straight road (93% of accidents). As found in the previous accident scenario, lighting conditions seem to be critical. Indeed, 59% of them happened during the day, but 41% during the night or dusk. The next paragraphs should explain why lighting condition is an important factor in such accident configuration.

27% of PTW users involved in these accidents were under 25, 12% were over 50 and 61% were between 25 and 50 years old.

97% of motorcycle users were male.

Information from in-depth databases

Most motorcycles in this sample were sport (37%), conventional street PTW (35%), or enduro/offroad ones (17%). 47% of PTW were propelled by a motor of a capacity of 600cc or less and 93% by a motor of a capacity of 1,000cc or less. The most frequent PTW regarding to its capacity were 600cc (28%) and 1,000cc (20%) motorcycles. The motorcycle average age was 4.4 years and 58% of them were 3 years old or less. It has to be noted that 29% of them were new as they were under 1 year. Their kilometre-age average was 22,650 kilometres and the kilometre-age of 52% of motorcycles was lower than 20,000 kilometres.

All of them were in good state and no defect on the vehicle has been found (there was 1 PTW with a tyre defect).

The average of motorcycle riding experience was 6.3 years but 51% of riders had less than two years of riding experience. Motorcycle riders rode 11,200 kilometres per year on average and for 53% of them it was less than 10,000 kilometres. 49% of riders considered PTW as a mode of transport and 35% of them used it only for leisure. On average, they have had the accident 23 minutes after departure and for 65% of them, it was during the first 20 minutes.

Most riders (98%) were correctly using a helmet (the helmet was fastened and the size was adapted to the rider). No rider was not using helmet. Only 28% of riders were well equipped. It means that they were wearing a jacket, a pair of trousers, gloves and boots. All of them were PTW specific clothes. The most popular PTW clothes were gloves (48% of riders) and jackets (48%).

On average, passenger car drivers were 38 years old and 57% of them were under 35.

Differences between scenario 7 and 8 which differ only from the place of the accident, either at intersection or not.

There is no big difference between the two samples. Motorcyclists involved in both scenarios look like similar.

5.9.2. How the accident evolved from the driving phase to the crash?

Riders

The main pre-accident situations for riders, in this scenario, are:

- They are going ahead at an intersection, especially when they are crossing an intersection where they have a right of way status. The conflict (the passenger car) is coming from a side road.
- They are on approach of the intersection and most of the time the rider has a right of way status. As for the previous pre-accident situation, main conflicts are coming from side roads. It means that the accident happens before the intersection and that the passenger car is coming from a private road on the side or it could mean that the rider lost the control of its PTW when he was approaching the intersection and crashed a vehicle coming from a side road.
- Approaching the intersection or inside the intersection, riders are overtaking or splitting lanes and are in conflict with a vehicle from a lateral lane travelling in the same direction.

The precipitating event is the event which has disturbed the rider driving situation. And due to this event, the situation of the rider became critical. Main events are linked to the internal conditions of the driving task (it is the way “internally” they are realizing their manoeuvre or they are trying to follow a road). Here is the list of the main precipitating events:

- Misinterpreted the driving situation (19).
- Poor evaluation or anticipation of the evolution of the situation (14).
- Incorrect driving manoeuvre (risk taking, poor overtaking…), (8). This event reflects pre-accident situations where riders were realizing a manoeuvre. This one has caused a disturbance in their “normal” driving phase.
- Incorrect lane positioning (6).

Following this event, 82% of riders were able to realize an emergency manoeuvre. And of course, the main one was the braking (57% of riders only braked). 12% turned then braked or braked then turned in order to avoid the collision with the passenger car. 7% of riders tried to control their PTW: It illustrates the fact that probably they were losing the control of their PTW. 18% were not able to perform any emergency manoeuvre.

Before the impact against the passenger car, 87% of riders were still on their motorcycles (the rider is not ejected from the PTW or the rider and the motorcycle are not separately sliding on the road). For the riders, 60% of main impacts were frontal ones and 35% sides ones.

The impact velocity is described in Figure 46 only when the impact speed was known and when the rider was still linked to his motorcycle. 52% of them are lower than 35 Km/h (mainly between 20 km/h and 35 km/h) and 76% lower than 45Km/h (see Figure 46). Comparing these results with what we found in the previous scenario, impact speeds are lower and it could be explained by the fact that in this scenario, accidents happen at intersections where users need to regulate their speed because of potential conflicts at intersection.

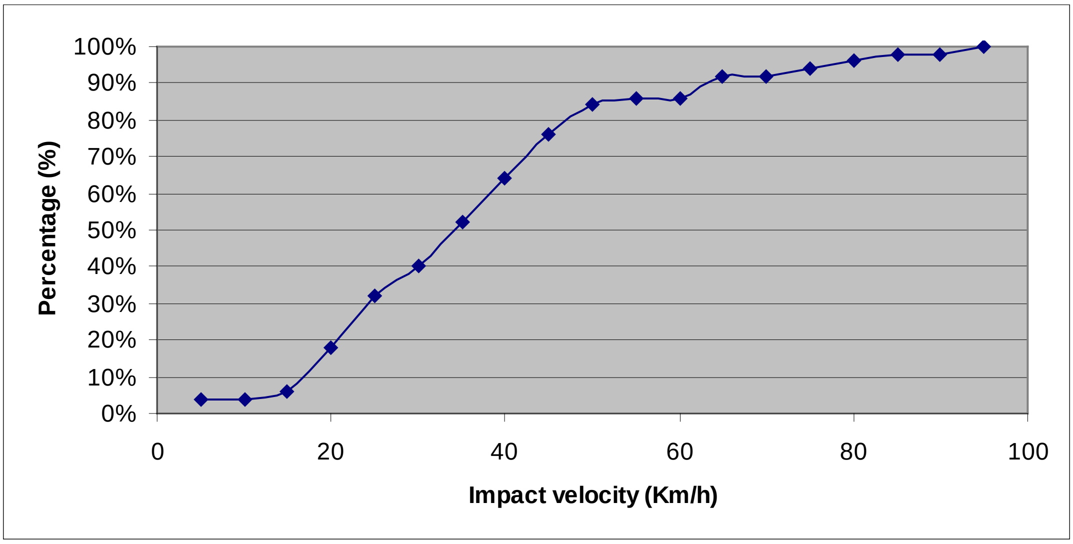

Figure 47: Scenario 8 - Cumulative frequency of impact velocity – Rider

Drivers

The main pre-accident situations, for drivers, in this scenario are:

- Drivers are turning across traffic. The intersection is controlled by a “give way” sign, a “stop” sign or a traffic signal. Drivers are turning across traffic from main road into side road. In most cases, they are confronted with a motorcyclist who is coming from a side road.
- Drivers are turning away from traffic. In most accidents, in these pre-accident situations, the intersection is controlled by a ‘give-way” sign and to a lesser extent by a “traffic signal”. Conflicts or riders are coming from a side road or from a lateral lane (assuming that riders are travelling in the same direction as drivers).
- Drivers are stopped before entering an intersection. They are stopped at an intersection whether because it is regulated by a traffic signal, a “stop” sign, a “give way” sign, or because they are waiting to turn and are stopped in road or a turning lane. Before the accidents happened, riders followed drivers or were ahead and were stopped because of congestion or traffic regulation.
- Drivers are going ahead at the intersection. But pre-accident situations analysed in details show that in most accidents whether they are going straight on at a “traffic signal” intersection or they are travelling on a roundabout. Riders are situated on a lateral lane travelling in the same direction as drivers or on a side road.

The precipitating event is the event which has disturbed the driver driving situation. And due to this event, the situation of the driver became critical. The main events are linked to the internal conditions of the driving task (it is the way “internally” they are realizing their manoeuvre or they are trying to follow a road) and the behaviour of the driver. Here is the list of the main precipitating events:

- Failed to look, looked but did not see (16).
- Inattention, concentrated on another driving related task (11).
- Poor evaluation or anticipation of the situation (8).
- Misinterpreted the driving situation (6).

All precipitating events related to the driver illustrate a problem of perception of the situation and/or the rider involved in these accidents. That is why there are so many drivers who did not react after the rupture of the driving phase (48%). 35% of them only braked and 7% turned then braked or braked then turned.

70% of impacts were side ones for the passenger car and the main obstacle was the motorcycle. Then 25% of impacts were frontal ones.

Impact speeds (when the passenger car is crashed by the motorcycle) are very low. 51% are lower than 15 km/h and 80% lower than 25 km/h (see Figure 47).

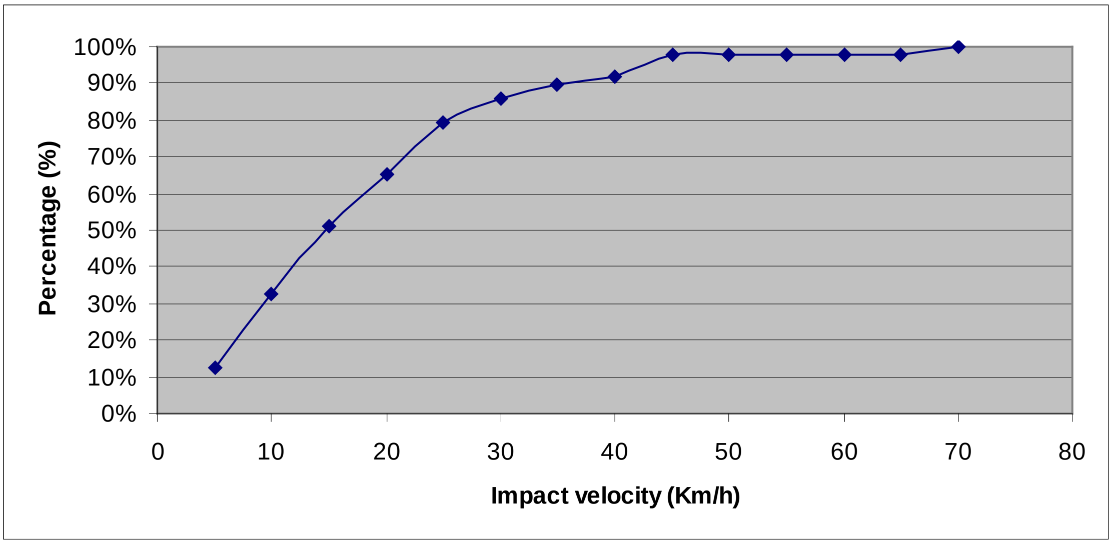

Figure 48: Scenario 8 - Cumulative frequency of impact velocity – Driver

5.9.3. When did the rider or the driver fail?

Riders

Most riders were active in the genesis of the accident. 40% of them were primary active (they have “provoked the disturbance”) and 25% are secondary active (they have taken part in the genesis of the accident by not trying to resolve the conflict). Nevertheless 35% of them were non active, indeed passive. It means that the solution of the problem (to avoid the accident) needs to be focused on the other driver involved in the accident or on the infrastructure or the environment (such as visibility mask removal).

The main human functional failures identified for this scenario, when considering the rider are prognosis, diagnosis and detection failures. Whether the rider has difficulties to anticipate the potential changes in the currently encountered situation or fail in understanding the information acquired concerning the type of situation with which he is confronted or he did not see critical information about the situation (which could have been useful in order to avoid the collision). So, in details, the main human functional failures are (see Figure 48):

- T5 failure: Expecting another user not to perform a manoeuvre.
- T4 failure: Incorrect understanding of manoeuvre undertaken by another road user.
- P5 failure: Neglecting the need to search for information.
- T6 failure: Actively expecting another user to take regulation action.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	2	T1	0	T5	14	D1	0	E1	0	G1	0
P2	0	T2	1	T6	6	D2	3	E2	5	G2	0
P3	1	T3	0	T7	0	D3	3			G3	0
P4	0	T4	14								
P5	8										
Tot.	**11**	**Tot.**	**15**	**Tot.**	**20**	**Tot.**	**6**	**Tot.**	**5**	**Tot.**	**0**

No Human Functional Failure 3

Figure 49: Scenario 8 - Rider human functional failure

These failures are explained by the following explanatory elements:

- Rigid attachment to the right of way status (23).
- Atypical manoeuvre from other road user (17).
- Other road user: absence of clues to manoeuvre (14).
- The rider has a high experience of the route. His attention level is low (10).
- Visibility masks (10): vehicle stopped due to congestion and parked.
- Excessive speed or speed over the legal limit (4).
- Non adapted speed for the driving situation (not over the legal limit) (4)
- Heavy traffic (7).
- The rider has a high experience of the manoeuvre he is realizing. His attention level is low (6).
- Excessive confidence in signs given to others (5).
- New driver (4).
- Risk taking – lane positioning (4).

Drivers

All drivers were active in the genesis of the accident. Indeed, the analysis of drivers in this scenario shows that many drivers were primary active drivers in the accident (85%), 10% secondary active and only 5% of them were non active. None of them were passive.

The main human functional failure categories are linked to the detection and diagnosis phases. Drivers were not able to well perceive all information about the situation and to understand how the situation will evolve. In details, human functional failures are (see Figure 49):

- P5 failure: Neglecting the need to search for information.
- P1 failure: Non detection in visibility constraints.
- P2 failure: Information acquisition focused on a partial component of the situation.
- P3 failure: Cursory or hurried information acquisition.
- T4 failure: Incorrect understanding of manoeuvre undertaken by another road user.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	8	T1	0	T5	0	D1	0	E1	2	G1	0
P2	7	T2	0	T6	3	D2	2	E2	3	G2	0
P3	6	T3	1	T7	0	D3	4			G3	0
P4	0	T4	6								
P5	18										
Tot.	**39**	**Tot.**	**7**	**Tot.**	**3**	**Tot.**	**6**	**Tot.**	**5**	**Tot.**	**0**

Figure 50: Scenario 8 - Driver human functional failure

These failures are explained by the following explanatory elements:

- The driver has a high experience of the manoeuvre he is realizing. His attention level is low (13).
- Heavy traffic (12).
- Atypical manoeuvre from other road user (10).
- Visibility masks (9): vehicle stopped due to congestion and parked.
- The driver has a high experience of the route. His attention level is low (8).
- New route (7).
- Distraction (6).
- Identification of potential risk about only part of the situation (4).
- Excessive confidence in signs given to others (4).
- Inattention (4).

5.9.4. What are the blunt end failures, the latent and sharp end ones?

The DREAM analyses of the 60 accidents of the scenario 8 are summarized in Figure 50 and Figure 51, considering first the rider and their failures and then the driver and their failures also. Each DREAM analysis is separately described in order to underline the accident factors linked to each user.

Riders

From the rider point of view, the main phenotype refers to the timing for initiating an action. The first one is a problem of timing for initiating an action which was too late. For instance, the rider braked too late to avoid collision with a car turning across his path. The second main phenotype is also a problem of timing but this time, any manoeuvre to avoid the accident was initiated. For example, the rider crossed an intersection where he had a right of way status and did not perform any manoeuvre to avoid the collision.

The most frequent genotypes to these phenotypes are “misjudgement of situation” and “misjudgement of time gaps” (bad estimation of the time needed to perform a manoeuvre) and these ones are explained by the following antecedents:

- The rider expected a certain behaviour from the passenger car (i.e. he expected car to wait until he had passed before pulling out).
- The observation of some information was correct but late. It means that when the observation was made, there was insufficient time to act in an optimal way (i.e. the rider did not see the car starting to turn out of junction across his path until it is too late). Inattention is one the main genotypes which explains this problem. Indeed, driven or parked vehicles are also the reasons of this late observation. And finally, the passenger car driver failed to transmit information to the rider.
- Inattention also indicates why riders made a mistake when observing some information.
- The riders did not choose a safe riding strategy (i.e. the rider overtook traffic at junction when it was unsafe to do so).

Drivers

For drivers, phenotypes are also timing problems. Unlike riders, manoeuvres were initiated too early, before the required conditions were established (i.e. he entered the road before he could see that it was clear).

The most frequent genotypes to these phenotypes are also “misjudgement of situation” and “misjudgement of time gaps” (bad estimation of the time needed to perform a manoeuvre). These ones are explained by the lack of observation which is either late or missed.

The late observation is rather explained by a temporary obstruction of view (parked or moving vehicles) and inattention whereas missed observation is the consequence of temporary (passenger in the vehicle, dirty mirrors) or permanent sight obstruction (vehicle blind spot), (temporary obstruction of view and inattention are also antecedents of missed observations).

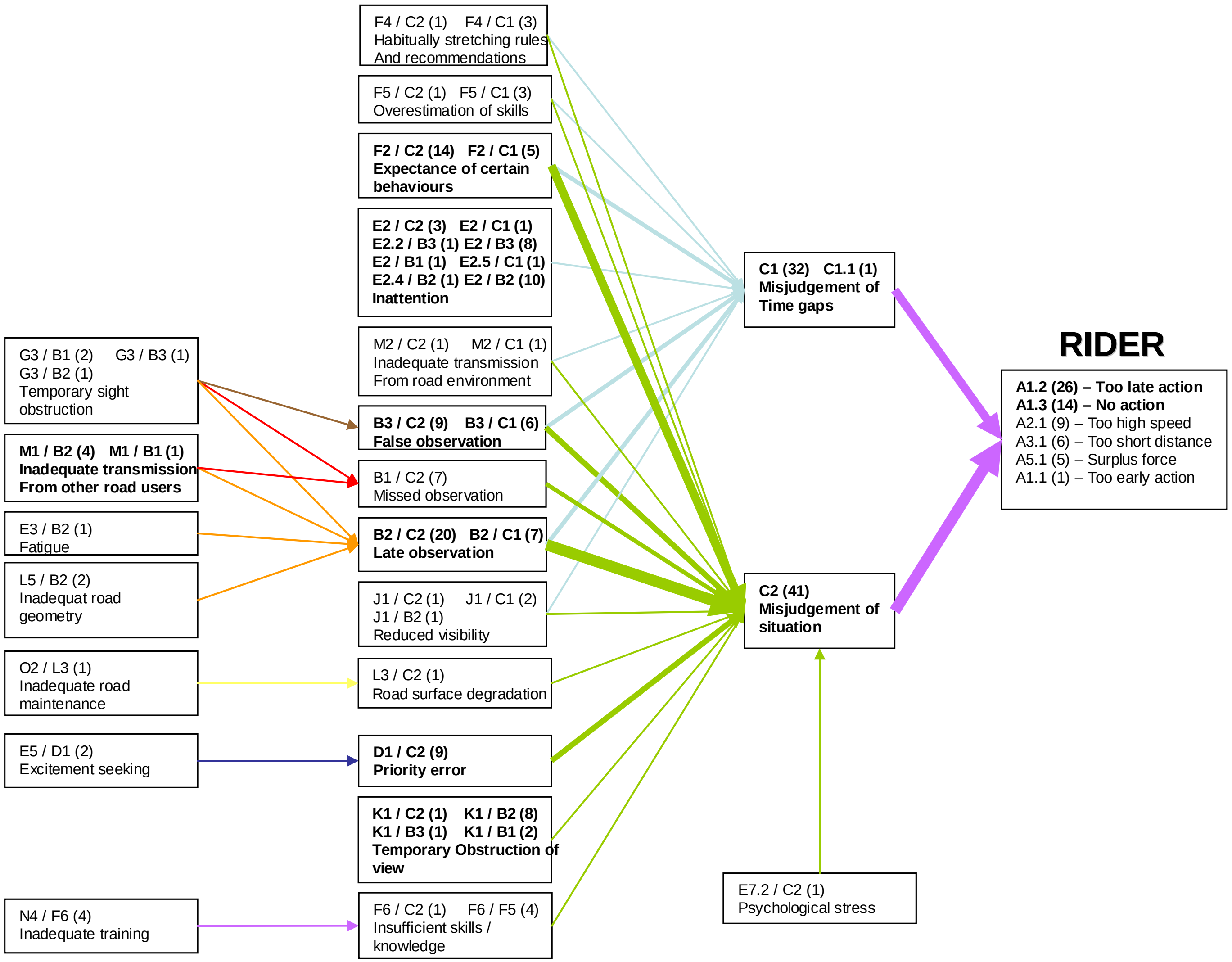

Figure 51: Scenario 8 - DREAM Analysis for the riders

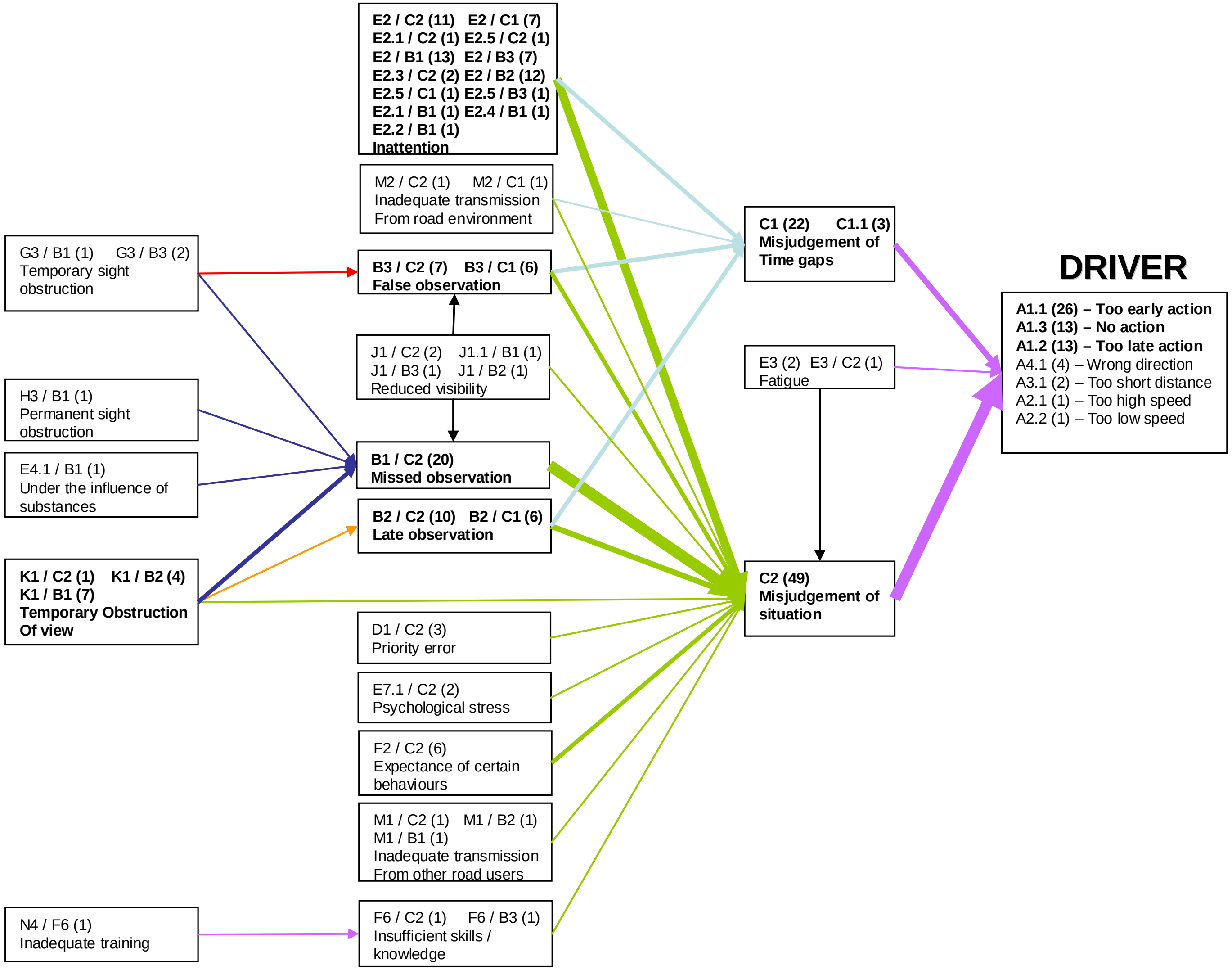

Figure 52: Scenario 8 - DREAM Analysis for the drivers

5.10. Scenario 9: Motorcycle / Passenger car accident – Outside urban area – Intersection

5.10.1. Who is involved in such accidents? Where and with which kind of vehicles?

The description of the three components of the system DVE comes from two kinds of information sources: from national databases and from in-depth ones. The reason is that this paragraph only states on descriptive data and national databases contain such information.

Information from national databases

Most fatal accidents occurred during good weather conditions (91% of accidents), on a dry surface (92% of accidents), on a straight road (84% of accidents) and during the day (70% of accidents).

11% of PTW riders involved in these accidents were under 25, 17% were over 50 and 72% were between 25 and 50 years old.

97% of motorcycle users were male.

The conditions in which the accident happened and the riders involved in these accidents were not so different between scenarios 8 and 9.

Information from in-depth databases

Most motorcycles in this sample were conventional street PTW (37%), sport (31%) and sport touring ones (20%). 56% of PTW were propelled by a motor of a capacity of 600cc or less and 82% by a motor of a capacity of 1,000cc or less. The most frequent PTW regarding to its capacity were 600cc (28%) motorcycles. The motorcycle average age was 4.9 years and 50% of them were 3 years old or less and 27% were new as they were less than 1 year. Their kilometre-age average was 35,500 kilometres and the kilometre-age of 51% of motorcycles was lower than 25,000 kilometres.

All of them were in good state and no defect on the vehicle has been found.

The average of motorcycle riding experience was 11 years but 56% of riders had less than three years of riding experience. Motorcycle riders rode 8,700 kilometres per year on average and for 70% of them it was less than 10,000 kilometres. 43% of riders used PTW to move (i.e. from home to work) and for leisure and 32% of them used it only for leisure. On average, they have had the accident 35 minutes after departure and for 51% of them, it was during the first 20 minutes.

Most riders (95%) were correctly using a helmet (the helmet was fastened and the size was adapted to the rider). All riders were using helmet. Only 24% of riders were well equipped. It means that they were wearing a jacket, a pair of trousers, gloves and boots. All of them were PTW specific clothes. The most popular PTW clothes were gloves (51% of riders) and jacket (56%).

On average, passenger car drivers were 42 years old and 55% of them were less than 40.

5.10.2. How the accident evolved from the driving phase to the crash?

Riders

The main pre-accident situations for the riders, in this scenario, are:

- They are going ahead at an intersection, especially when they are crossing an intersection where they have a right of way status. The conflict (the passenger car) is coming from a side road.
- They are on approach of the intersection and most of the time the rider has a right of way status. As for the previous pre-accident situation, main conflicts are coming from side roads. It means that the accident happened before the intersection and that the passenger car is coming from a private road on the side or it could mean that the rider has lost the control of its PTW when he was approaching the intersection and has crashed a vehicle coming from a side road.
- If the conflict is not coming from a side road, it is whether from the opposite lane (an oncoming vehicle) and the rider is confronted with a driver who turns into the lane of the motorcyclist or from ahead and the passenger car is stopped because of congestion or from a lateral lane in which a passenger car is travelling (in the same direction).
- Approaching the intersection or inside the intersection, riders are overtaking or splitting lanes and are in conflict with a vehicle from a lateral lane travelling in the same direction.

The precipitating event is the event which has disturbed the rider driving situation. And due to this event, the situation of the rider became critical. The main events are linked to the internal conditions of the driving task (it is the way “internally” they are realizing their manoeuvre or they are trying to follow a road). Here is the list of the main precipitating events:

- Misinterpreted the driving situation (21).
- Poor evaluation or anticipation of the evolution of the situation (5).
- Incorrect driving manoeuvre (risk taking, poor overtaking…), (5). This event reflects pre-accident situations where riders were realizing a manoeuvre. This one has causes a disturbance in their “normal” driving phase.

Following this event, 67% of riders were able to realize an emergency manoeuvre. And of course, the main one was the braking (39% of riders only braked). 14% turned then braked or braked then turned in order to avoid the collision with the passenger car. 33% were not able to perform an emergency manoeuvre.

If we compare this scenario and the previous one, it seems that in scenario 9, more riders were not able to react after the rupture of their driving phase. The accident or the disturbing event was probably more critical and unexpected. That is why they were not able to react by an emergency manoeuvre. Inside urban area (scenario 8), travelling speed is lower than outside urban area and they have more time to react (it is a hypothesis).

Before the impact against the passenger car, 100% of riders were still on their motorcycles (the rider is not ejected from the PTW or the rider and the motorcycle are not separately sliding on the road). For the riders, 69% of main impacts were frontal ones and 24% sides ones.

The impact velocity is described in Figure 52 only when the impact speed was known and when the rider was still linked to his motorcycle. 50% of them are lower than 45 Km/h and 80% lower than 65 Km/h (see Figure 52). Comparing these results with what we found in the previous scenario, impact speeds are higher and it could be explained by the fact that in this scenario, accidents happen outside urban area.

Scenarios 3 and 6, also, describe motorcycle accidents happening outside urban area and impact speeds are higher than those find in this scenario. It could be explained by the fact that both scenarios consider motorcycle accidents out of intersection whereas for scenario 9, it is at intersection or on approach.

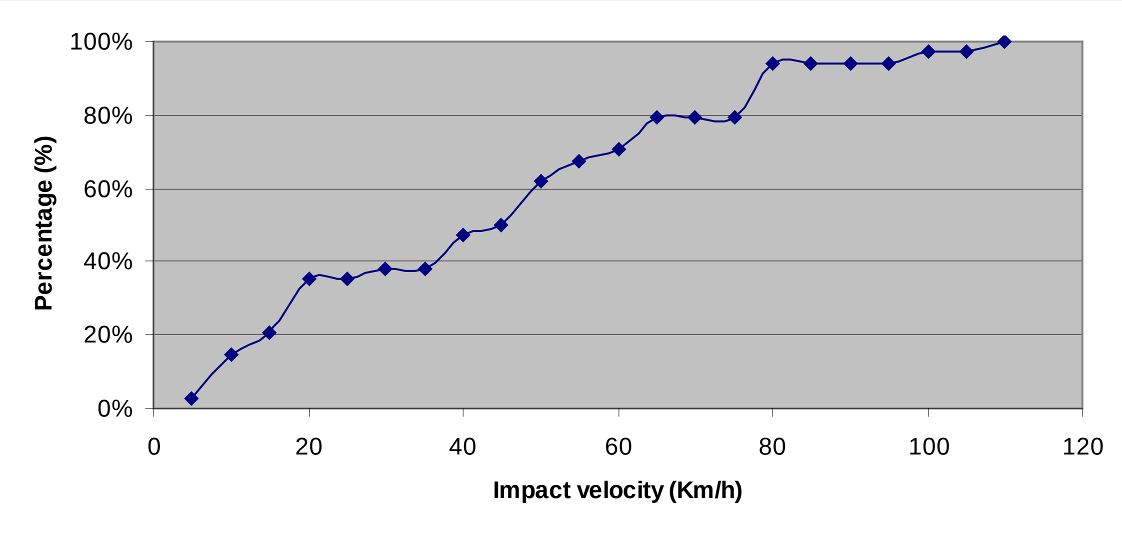

Figure 53: Scenario 9 - Cumulative frequency of impact velocity – Rider

Drivers

The main pre-accident situations, for the drivers, in this scenario are:

- Drivers are turning across traffic. The intersection is controlled by a "give way" sign, a "stop" sign or a traffic signal. Drivers are turning across traffic from main road into side road. In most cases, they are confronted with a motorcyclist who is coming from a side road. When the driver is turning across traffic at a "give way" intersection, most accidents arise. In this configuration, it is essential that riders and drivers understand the situation and see each other in order to regulate their driving. Assuming that there is lack of perception or understanding, the probability of accident is higher.
- Drivers are going ahead at the intersection. But pre-accident situations analysed in details show that in most accident they are crossing intersection where the passenger car has right of way. Riders are situated on a side road.
- Some accidents happen when the passenger car driver is realizing a manoeuvre when approaching the intersection and the conflict is from a lateral lane in which is travelling the rider.

The precipitating event is the event which has disturbed the driver driving situation. And due to this event, the situation of the rider became critical. The main events are linked to the behaviour of the driver. Here is the list of the main precipitating events:

- Failed to look, looked but did not see (26).
- Low level of attention because of internal or external distraction (4).
- Inattention, concentrated on another driving related task (4).

All precipitating events related to the driver illustrate a problem of perception of the situation and/or the rider involved in these accidents. That is why there are so many drivers who did not react after the rupture of the driving phase (80%). 12% of them only braked.

68% of impacts were side ones for the passenger car and the main obstacle was the motorcycle. Then 20% of impacts were frontal ones.

Impact speeds (when the passenger is crashed by the motorcycle) are very low. 45% are lower than 15 km/h and 80% lower than 35 km/h (see Figure 53). We have determined that during the pre-accident situation, many drivers were stopped at an intersection controlled by a "give way" sign. They were looking for a gap to realize their manoeuvre. So that is why impact speeds are so low.

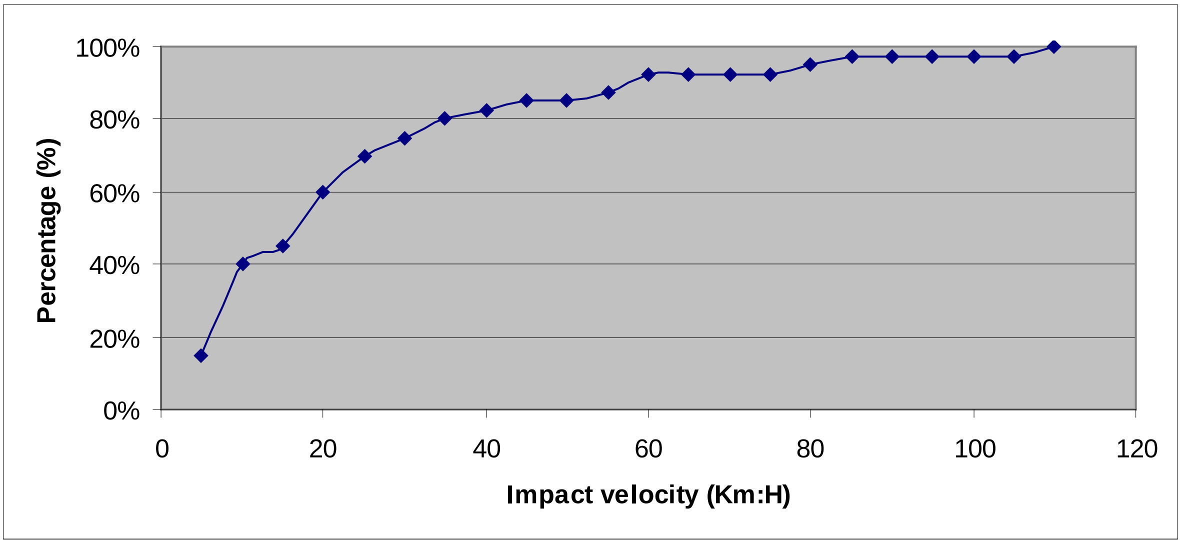

Figure 54: Scenario 9 - Cumulative frequency of impact velocity – Driver

5.10.3. When did the rider or the driver fail?

Riders

Riders were not active in the genesis of the accident. The disturbance or the origin of the accident was rather linked to the opponent. Indeed, 35% of riders were primary active users, 18% secondary active, 41% non active and 6% completely passive. On one hand, we need to find counter measures for riders which could avoid a critical situation and an accident. On the other hand, the avoidance of the accident would have been possible in theory if information had been supplied to them in time.

The main human functional failures identified for these scenario, when considering the rider are prognosis and detection failures. Whether the rider has difficulties to anticipate the potential changes in the currently encountered situation or he does not see any critical information about the situation (which could have been useful in order to avoid the collision). So, in details, the main human functional failures are (see Figure 54):

- T5 failure: Expecting another user not to perform a manoeuvre.
- P5 failure: Neglecting the need to search for information.
- P1 failure: Non detection in visibility constraints.
- P2 failure: Information acquisition focused on a partial component of the situation.
- D2 failure: Deliberate violation of a safety rule.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	3	T1	1	T5	26	D1	0	E1	0	G1	0
P2	2	T2	1	T6	1	D2	4	E2	0	G2	0
P3	1	T3	0	T7	0	D3	1			G3	0
P4	1	T4	3								
P5	4										
Tot.	**11**	**Tot.**	**5**	**Tot.**	**27**	**Tot.**	**5**	**Tot.**	**0**	**Tot.**	**0**

No Human Functional Failure 3

Figure 55: Scenario 9 - Rider human functional failure

These failures are explained by the following explanatory elements:

- Rigid attachment to the right of way status (24).
- Atypical manoeuvre from other road user (16).
- Other road user: absence of clues to manoeuvre (12).
- Heavy traffic (8).
- Non adapted speed for the driving situation (not over the legal limit) (7).
- Identification of potential risk about only part of the situation (6).
- In a hurry (5).
- Visibility impaired because of heavy traffic (5).
- Risk taking – ignored road markings (4).
- New rider (3).

Drivers

In many accidents, the driver was active in the disturbance of the situation. The critical situation was linked to him and he has provoked an accident. Indeed, 74% of drivers were primary active users, 6% secondary active, 12% non active and 8% completely passive. In theory, counter measures applied on the driver could prevent accidents.

The main human functional failure categories are linked to the detection and decision phases. Drivers are not able to well perceive all information about the situation and to choose the right driving strategy. In details, human functional failures are (see Figure 55):

- P3 failure: Cursory or hurried information acquisition.
- P5 failure: Neglecting the need to search for information.
- P2 failure: Information acquisition focused on a partial component of the situation.
- P1 failure: Non detection in visibility constraints.
- D2 failure: Deliberate violation of a safety rule.

Detection		Diagnosis		Prognosis		Decision		Action		Overall	
P1	5	T1	0	T5	3	D1	0	E1	0	G1	0
P2	6	T2	1	T6	1	D2	5	E2	0	G2	0
P3	13	T3	0	T7	1	D3	1			G3	0
P4	2	T4	1								
P5	6										
Tot.	**32**	**Tot.**	**2**	**Tot.**	**5**	**Tot.**	**6**	**Tot.**	**0**	**Tot.**	**0**

No Human Functional Failure	4
Unknown	2

Figure 56: Scenario 9 - Driver human functional failure

These failures are explained by the following explanatory elements:

- Atypical manoeuvre from other road user (11).
- Distraction within the vehicle (9, i.e. discussing with a passenger car occupant)
- Identification of potential risk about only part of the situation (9).
- Heavy traffic (6).
- Rigid attachment to the right of way status (5).
- Blind spot (5).

- Visibility impaired due to darkness (5).
- Visibility impaired: environment equipment (5, trees, signs, bollards…)
- Visibility masks (5): vehicle stopped due to congestion and parked.
- Excessive confidence in signs given to others (4).
- The user has a high experience of the route. His attention level is low (4).

5.10.4. What are the blunt end failures, the latent and sharp end ones?

The DREAM analyses of the 51 accidents of the scenario 9 are summarized in Figure 56 and Figure 57, considering first the rider and their failures and then the driver and their failures also. Each DREAM analysis is separately described in order to underline the accident factors linked to each user.

Riders

From the rider point of view, the main phenotype refers to the timing for initiating an action. The first one is a problem of timing for initiating an action which was too late. For instance, the rider braked too late to avoid impact with the car crossing his path. The second main phenotype is also a problem of timing but this time the rider did not initiate any manoeuvre to avoid the accident. For example, the rider has been taken by surprise when car he was overtaking moved to right

The most frequent genotype to these phenotypes is “misjudgement of situation” and this one is explained by the following antecedents:

- The rider expected a certain behaviour from the passenger car driver with whom he was crashed (i.e. he expected car to give way to priority traffic).
- The rider did not choose a safe riding strategy (i.e. the rider overtook illegally to avoid being held up by queue).
- The rider missed observation about the situation (i.e. he failed to see stationary car ahead in his lane before commencing overtake) because of whether temporary (i.e. view obscured by the vehicles he was overtaking) or permanent (i.e. trees covered the side road / path from which the car was coming) or inadequate transmission information from other road users (i.e. the passenger car driver did not signal clearly the manoeuvre he was realizing).
- The observation of some information was correct but late (i.e. he didn't see traffic slowing until it was too late) because of whether inattention or temporary or permanent obstruction of view or expectance no changes to the road environment on familiar roads.
- Inattention also contributes to explain previous genotypes.

Drivers

For drivers, phenotypes are also timing problems. Unlike riders, manoeuvres were initiated too early, before the required conditions were established (i.e. he entered road before he could see that it was clear). In other cases, no action was realized by the driver; probably because they did not see the conflict with the rider.

The most frequent genotype to these phenotypes is “misjudgement of situation” and this one is explained by the following antecedents:

- The driver missed observation about the situation (i.e. he failed to see motorcyclist behind in parallel lane) because of whether temporary (i.e. view obscured by temporary road works signs) or permanent (i.e. vision obscured by roadside bollard) or permanent sight obstruction (i.e. passenger car blind spot).
- The driver expected a certain behaviour from the rider with whom he was crashed (i.e. he did not expect anything to be illegally overtaking the queue).
- The visibility was reduced due to lighting conditions and / or weather conditions.
- Inattention also indicates why drivers made a mistake when observing some information.

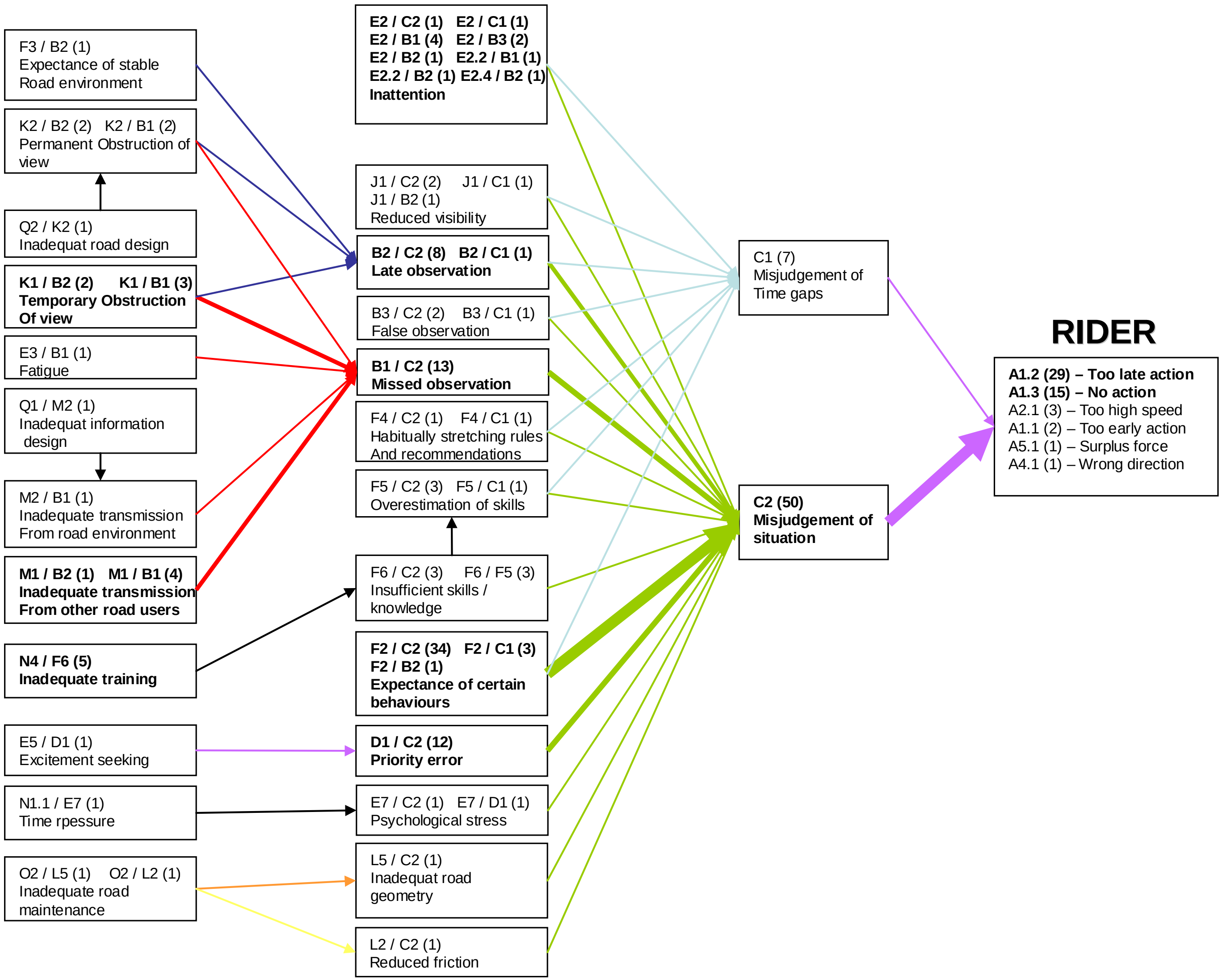

Figure 57: Scenario 9 - DREAM Analysis for the riders

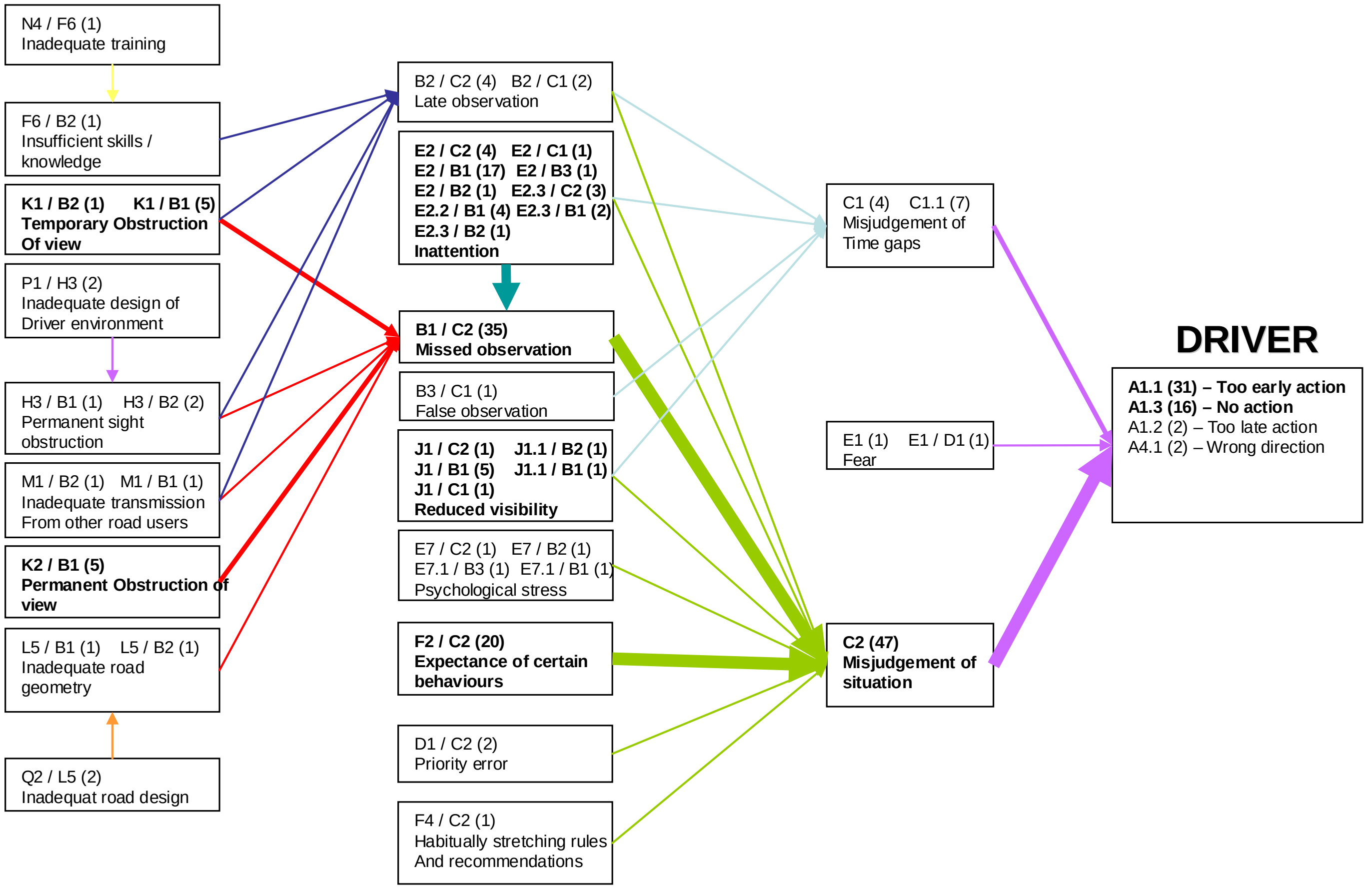

Figure 58: Scenario 9 - DREAM Analysis for the drivers

6. Conclusions

In 2008, the European Commission funded the 2BESAFE project (2-wheeler Behaviour and SAFEty).

The overall aim of this project, which involves almost 30 partners, across Europe, Israel and Australia, is to understand the behavioural and ergonomic factors that contribute to crashes and incidents involving motorcycle and scooter riders and, using this information, to formulate options for countermeasures to improve rider safety.

The project is divided into 8 work packages, one of which (Work Package 1) is concerned with understanding in detail the causal factors that contribute to powered two-wheeler accidents.

This report is placed within "Work Package 1 – Activity 1.1: Rider / Driver behaviours and road safety". The main objectives of this activity are to identify problems and the magnitude of problems for the riders to understand and identify the specific accident causes for the different road users considered, mainly by means of micro level analyses performed on in-depth accident databases (intensive databases). All problems and causes highlighted in this report are related to the understanding of behavioural and ergonomic factors that contribute to crashes and incidents involving motorcycle and moped riders.

Activity 1.2 and 1.3 and respectively Deliverables 2 and 3 cover accident causations related to weathers conditions and infrastructure.

2BESAFE has proposed a common methodology for the analysis of each work package 1 activity (1.1, 1.2 and 1.3). This integrated methodology can be summarized as follows:

1. What knowledge has already been obtained for each road user? → **LITERATURE REVIEW**
2. What are the most relevant accident configurations at European level?→ **DESCRIPTIVE ANALYSIS**
3. Why accidents of those configurations take place? → **IN-DEPTH ANALYSIS**

6.1. Literature review conclusions

The main results of the literature review performed on PTWs traffic accidents have been presented in this deliverable. Different papers and public reports have been reviewed with the aim of identifying which factors have already been analysed as possible PTWs accident risk factors and which methodologies have been used to conclude that.

PTW accidents present several complex interactions with the manner riders or drivers behave on the road system. These interactions are magnified in certain accident configurations, such as accidents at intersection and accidents during an overtaking manoeuvre, right of way violations (ROWVs) most frequently caused by a party other than the motorcyclist, loss of control, speeding, influencing greatly the severity of PTW injuries.

From the extensive analysis of the literature concerning the interactions of drive/rider behaviour with the PTW accidents several critical factors have emerged:

- Riding/Driving Attitudes and Patterns (such as sensation seeking, risk taking, speeding and so on).
- Age, Gender and experience.
- Licensing, Education and Training.
- Type of PTW (relate to the power engine, type of use, tampered PTW).
- Perception of drivers/riders and human errors (from the point of view of the PTW or the passenger car).
- Collision type (rural or urban, PTW single accident or more than one vehicle accidents, more than one, front side crash, side-side and so on).
- Conspicuity, perception of drivers for motorcycles.

- Alcohol and other impairments (medical prescriptions, drugs, fatigue and so on).
- Personal Protective Equipment (Helmet protection and other PTW apparel).

These factors form a conceptual basis for the following macroscopic analysis of PTW accident risk factors based on the National and European PTW accident databases.

6.2. Descriptive analysis conclusions

Once the available knowledge on PTWs accident situation was reviewed, the next step has been to detect which the main accident configurations were for PTW users. It has been obtained analysing the available national accident databases within the activity 1.1 consortium (Italy, Greece, Finland, The United Kingdom and France). The accident configurations have been mainly selected according to the other vehicles involved in the accident, the number of vehicles (including pedestrians) involved in the accident, location of the accident and road layout configuration.

So we saw that PTW accidents are issues for all countries and distinguishing mopeds and motorcycles, the first national statistics on the five 2BESAFE countries show several main results:

5. Fatal motorcycle accidents are issues in all countries: at least 68% of PTW fatalities are motorcyclists.
6. Fatal moped accidents are not issues in the United Kingdom[18].
7. Per 100 000 circulating PTW, the risk of a fatal motorcycle accident is higher than that for a fatal moped accident, for all 5 countries. Fatal motorcycle accident risk is at least 1.9 times higher than that for fatal moped accidents (from 1.9 times in Greece to 3.3 times in the United Kingdom). Fatal motorcycle accidents risk is at least 1,9 times higher than fatal moped accidents one (from 1,9 times in Greece to 3,3 times in the United Kingdom).
8. France is the country where this risk is the highest for both kinds of PTW and Finland is the country where the risk is the lowest.

The following table summarizes the different PTW accident scenarios chosen for each country according to the kind of PTW (either moped or motorcycle) and the number of vehicles involved in the accident.

% (1) is the percentage of PTW accident configuration per number of vehicles involved in the accidents. For instance, 80% of fatal single moped accidents in Finland are outside urban area and not at intersection.

%T (2) is the percentage of PTW accident configuration considering the kind of PTW. For instance, 16,7% of fatal moped accidents in Finland are outside urban area and not at intersection.

In total, there are 20 PTW accident configurations, common or not to the five countries involved in the activity 1.1, which need to be analysed in-depth.

[18] It could be due to UK law. Compulsory Basic Training (CBT) for all PTW users has been in effect since 2001; the earliest age for moped riding is 16 years, and mopeds are restricted to max design speed of 48kph.

PTW Accident configuration	Finland		France		Greece		Italy		The United Kingdom	
	% (1)	%T (2)	% (1)	%T (2)	% (1)	%T (2)	% (1)	%T (2)	% (1)	%T (2)
Single moped accident – Inside urban area – No intersection			65,6%	19,5%	46,4%	13,5%	59,5%	12,0%		
Single moped accident – Outside urban area – No intersection	80,0%	16,7%	28,2%	8,4%	39,3%	11,5%	31,3%	6,3%		
Total Single moped accident	80,0%		93,8%		85,7%		90,8%			
Moped / Passenger car accident – Outside urban area – No intersection			28,8%	18,4%	26,6%	17,7%	13,2%	9,8%		
Moped / Passenger car accident – Inside urban area – No intersection			17,4%	11,1%	15,6%	10,4%	19,3%	14,4%		
Moped / Passenger car accident – Inside urban area –Intersection	5,6%	4,2%	9,8%	6,2%	26,6%	17,7%	28,4%	21,2%		
Moped / Passenger car accident – Outside urban area –Intersection	27,8%	20,8%					11,1%	8,3%		
Moped / Truck accident – Outside urban area – No intersection	16,7%	12,5%	10,7%	6,8%						
Moped / Truck accident – Inside urban area – No intersection			8,1%	5,2%						
Total Moped / Another vehicle	50,0%		74,8%		68,8%		72,0%			
TOTAL MOPED ACCIDENTS		54,2%		75,6%		70,8%		72,0%		
Single motorcycle accident – Outside urban area – No intersection	81,8%	36,0%	55,1%	19,4%	43,3%	18,1%	53,2%	15,3%	53,1%	12,3%
Single motorcycle accident – Inside urban area – No intersection	18,2%	8,0%	37,0%	13,0%	47,4%	19,9%	35,1%	10,1%	17,2%	4,0%
Single motorcycle accident – Outside urban area –Intersection									14,8%	3,4%
Single motorcycle accident – Inside urban area – Intersection									14,8%	3,4%
Total Singe motorcycle accident	100,0%		92,0%		90,6%		88,3%		100,0%	
Motorcycle / Passenger car accident – Outside urban area – No intersection	33,3%	14,0%	37,5%	20,8%	17,7%	9,6%	16,4%	10,5%	22,2%	11,5%
Motorcycle / Passenger car accident – Inside urban area – No intersection			14,7%	8,1%	25,2%	13,6%	19,6%	12,5%	5,1%	2,6%
Motorcycle / Passenger car accident – Inside urban area – Intersection	19,0%	8,0%	12,5%	6,9%	21,5%	11,6%	26,5%	16,9%	13,7%	7,0%
Motorcycle / Truck accident – Outside urban area – No intersection	14,3%	6,0%	13,5%	7,5%			4,5%	2,9%		
Motorcycle / Passenger car accident – Outside urban area – Intersection	14,3%	6,0%					13,0%	8,3%	22,1%	11,4%
Motorcycle / Truck accident – Inside urban area – Intersection					5,4%	2,9%	4,3%	2,7%		
Motorcycle / Truck accident – Outside urban area – Intersection					2,3%	1,2%				
Total Motorcycle / Another vehicle	81,0%		78,2%		72,1%		84,4%		63,0%	
More than three vehicles									100,0%	25,4%
TOTAL MOTORCYCLE ACCIDENTS		78,0%		75,8%		77,0%		79,2%		81,0%

Finally, some relevant issues deserved to be mentioned regarding the above configurations:

- They are the ones which should be used for the next steps of this project as they constitute the most relevant accident problematic for PTWs accidents.
- They have been constructed so as to be easily recognisable when analysing in – depth accident databases.
- Due to the nature of the databases analysed for this analysis (macroscopic accident databases), that are mainly filled in by police questionnaires, no reliable information can be provided regarding accident causation as it is well recognised within the accident research community that those databases do not contain the necessary level of detail to offer such conclusions.

6.3. In-depth analysis conclusions

Finally, 9 scenarios have been selected. Indeed, some scenarios were issues only in one or two countries (i.e. motorcycle / truck accidents at intersection) or the number of in-depth accidents for the scenario was not sufficient (i.e. single moped accidents outside and inside urban area – No intersection are issues for most countries, but the in-depth sample is not large enough – 10 accidents - to have relevant results). Finally, they are defined as follow:

- Scenario 1: Moped / passenger car accident – Inside urban area – No intersection,
- Scenario 2: Moped / passenger car accident – Inside urban area – Intersection,
- Scenario 3: Single motorcycle accident – Outside urban area – No intersection,
- Scenario 4: Single motorcycle accident – Inside urban area – No intersection,
- Scenario 5: Single motorcycle accident – Inside urban area –Intersection,
- Scenario 6: Motorcycle / passenger car accident – Outside urban area – No intersection,
- Scenario 7: Motorcycle / passenger car accident – Inside urban area – No intersection,
- Scenario 8: Motorcycle / passenger car accident – Inside urban area – Intersection,
- Scenario 9: Motorcycle / passenger car accident – Outside urban area – Intersection.

In this Activity 1.1, four accident causation models were used to analyse and classify accident data derived from in-depth studies of PTW crashes previously conducted in the United Kingdom, Finland and France.

The first model, which we refer to as the Driver-Vehicle-Environment system description model, documents detailed factual information relating to the rider (eg. the rider's professional status, family status, age, gender, etc), to the other party involved in the crash, to the vehicles involved (eg. vehicle type, vehicle age, vehicle defects, etc) and to the environment (eg. type of road, road geometry, traffic density, etc).

The second model documents factual information relating to each phase in the evolution of the crash – the normal driving phase, the precipitating event, the emergency phase, the crash phase and the post-collision phase (Brenac, 1997; Fleury et al., 2001).

The third model, the human functional failure model (Van Elslande and Fouquet, 2007), classifies factors, characterizing the state of the system and their interactions, which explain human failures that contribute to crashes. This model considers that the driver, when driving, performs several sequential and inter-linked functions: detection, diagnosis, prognosis, decision and action. A rupture of one link in the chain can create an imbalance in the system; for example, a crash.

The final model, which is the focus of this paper, is the DREAM 3.0 model (Driving Reliability and Error Analysis Method; Warner et al., 2008). DREAM 3.0 provides a way to systematically classify and record accident causation information which has been gathered through in-depth crash investigations. It provides a structured way of sorting the accident causes into defined categories of contributing factors. Failures at the "sharp" end as well as at the "blunt" end are taken into consideration.

Each model has a different approach to the understanding and classification of the causal factors which contribute to crashes and incidents. All of the models, however, are complementary and, from each, it is possible to aggregate the classified data in order to provide an overall summary of causation factors.

Table 7, Table 8, Table 9 and Table 10 summarize the results found when realizing the in-depth analysis according to the four approaches and the nine scenarios. These tables underline the main facts and results in order to be able to compare them between scenarios and to understand PTW accident causations. Here are the main conclusions for the in-depth analysis:

- Moped riders are necessarily young users as most of them are under 18. When having their accidents, they had only less than one year of riding experience. They consider the moped as a mode of transport and they do not use it only for leisure. Their mopeds are in good state at the time of accident. The environmental conditions in which the accident happened (e.g. weather, lighting, etc) do not seem to be relevant factors. Nevertheless, night riding is riskier for these users. Moped users do not wear any PTW clothes (such as gloves, trousers, etc…), except a helmet (but it is not always well adapted to the user).
- If the moped rider is at the origin of the accident, he is often incorrectly positioned on the road or he voluntary takes risks. If the passenger car driver is at the origin of the accident, he fails to look, he looks but do not see. That is why, in the case of accidents between a moped and other vehicle, the most frequent human error is a failure in perceiving the moped by another vehicle driver (associated to the traffic environment, traffic scanning error, lack of other vehicle driver attention, faulty traffic strategy or low conspicuity of the moped).
- Single motorcycle accidents involve users who do not ride a lot each year compared to motorcyclists involved in accidents between a motorcycle and another vehicle. Single motorcycle accidents happen either during the day and in a curve, outside urban areas or during the night and on a straight road (when it is inside the urban area).
- Single motorcycle accidents, outside the urban area, happen later after departure than single motorcycle accidents inside the urban area. In the first configuration (single mortocycle accidents outside urban area), a conflict with another vehicle is possible and has caused the accident (even if there is no crash).

- The main human functional failures for single motorcycle accidents describe a loss of control when underlying a guidance problem or a poor control of an external disruption because of excessive or unadapted speeds, risk taking, etc.
- When the accident involved a motorcycle and a passenger car, at intersection, the motorcyclist is crossing the intersection, has a right of way and is confronted by a vehicle coming from a side road. The other vehicle is generally turning across traffic. Once again, such accidents underline the lack of perception (from the passenger car driver and of the motorcyclists) because they neglect the need to search for information or they cannot see the riders because of visibility masks. That is why motorcyclists misinterpret the driving situation. They are on a road where they have a right of way status, there is an absence of clues from the other road user, and they then do not understand the manoeuvre taken by the driver.
- When the accident involves a motorcycle and a passenger car, not at an intersection, the accident situations are more complex. Here the rider is realizing a manoeuvre legal or not (such as overtaking or splitting lanes) and is confronted by an oncoming vehicle or a vehicle in a lateral lane; or the rider does not perform any manoeuvre and is confronted by a passenger car driver realizing a manoeuvre (changing lane, overtaking, turning not at an intersection). In both cases, the drivers do not see the motorcyclist.

Accident configurations 1 and 2 dealt with accidents with a moped and a passenger car, inside the urban area. The first scenario revealed that inattention and late observation (because of reduced visibility) caused a large number of riders to miss seeing the opponent vehicle. In the second one, the rider had the right of way status and expected the passenger car driver to behave in a certain way. Alternatively, the rider did not have the right of way status and the main genotypes were late observation, inattention, priority error and reduced visibility. In both moped accident configurations, a lack of riding experience was identified.

Accident configurations 3, 4 and 5 dealt with accidents involving only one motorcycle. Inside the urban area (configurations 4 and 5), the force with which riders were realizing an action (braking, steering, accelerating) was highlighted. The main three factors explaining such accidents were reduced friction on the road, inattention and an overestimation of skills (which is in part a consequence of insufficient skill). In some cases, another vehicle could have been an unexpected event which generated the accident (without crashing with this vehicle). In Scenario 3, speed was revealed as the action which was the first observable effect on the accident. Several factors explain this phenotype: priority error because of excitement seeking, inadequate information transmission from the road environment because of an inadequate information design and an overestimation of skills.

Accident configurations 6 and 7 analyse accidents involving a motorcycle and a passenger, not at an intersection. In accidents, inside the urban area, the problems of observation (of the situation and of the opponent vehicle) were mainly linked to inattention and reduced visibility. Outside the urban area, riders missed observations because the other vehicle driver did not provide any information about the manoeuvre they were undertaking. In both situations, priority error was also a main factor.

In scenarios 8 and 9, accidents involved a motorcycle and a passenger, at intersections. In both situations, it seems that there were two ways in which to analyse the DREAM charts for riders. The first one is that riders had right of way status at the intersection. So, they were expecting a certain behaviour from the other road user (the passenger car driver). The possible second way shows that riders did not have a right of way status and did not drive in a safe way and missed some important information about the situation (because of a temporary obstruction of view).

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8	Scenario 9
RIDER	Rider	☐ Under 18 ☐ < 1 year riding experience ☐ 3,800 km per year ☐ Mode of transport ☐ 25% of riders - helmet not adapted ☐ No PTW clothes	☐ Under 18 and over 50 ☐ < 1 year riding experience ☐ 5,000 km per year ☐ Mode of transport ☐ 25% of riders - helmet not adapted ☐ No PTW clothes	☐ 25 - 50 years old ☐ 3 years of driving experience ☐ 50% of riders fully equipped	☐ 25 - 50 years old ☐ 3 years of driving experience ☐ 5,000 km per year ☐ Mode of transport ☐ 17% of riders fully equipped	☐ 18-25 years old ☐ 3 years of driving experience ☐ 5,000 km per year ☐ 26% of riders fully equipped	☐ 18-25 and over 50 years old ☐ 2 years of driving experience ☐ 15,000 km per year ☐ PTW used for transport and leisure ☐ 60% of riders fully equipped	☐ 25 - 50 years old ☐ 3 years of riding experience ☐ 10,000 km per year ☐ PTW used for transport and leisure ☐ 26% of riders fully equipped	☐ 18-25 years old ☐ 2 years of riding experience ☐ 10,000 km per year ☐ PTW used for transport ☐ 28% of riders fully equipped	☐ 25 - 50 years old ☐ 3 years of riding experience ☐ 10,000 km per year ☐ PTW used for transport ☐ 24% of riders fully equipped
	PTW	☐ Scooter - 50 cc ☐ Good state	☐ Scooter - 50 cc ☐ Step throught ☐ Good state	☐ Sport motorcycles ☐ 600 cc ☐ Good state	☐ Conventional street PTW ☐ 600 cc ☐ Good state	☐ Conventional street PTW ☐ Sport PTW ☐ 600 cc ☐ Good state	☐ Conventional street PTW ☐ Sport PTW ☐ 600 cc ☐ Good state	☐ Conventional street PTW ☐ Sport PTW ☐ 600 cc ☐ Good state	☐ Conventional street PTW ☐ Sport PTW ☐ 600 cc ☐ Good state	☐ Conventional street PTW ☐ Sport PTW ☐ 600 cc ☐ Good state
	Environment	☐ Good weather conditions ☐ Dry surface ☐ Straight road ☐ Day/Night	☐ Good weather conditions ☐ Dry surface ☐ Day/Night	☐ Good weather conditions ☐ Dry surface ☐ Day ☐ In a curve	☐ Good weather conditions ☐ Dry surface ☐ Night ☐ Straight road	☐ Good weather conditions ☐ Dry surface ☐ Night ☐ Straight road	☐ Good weather conditions ☐ Dry surface ☐ Day ☐ Straight road	☐ Good weather conditions ☐ Dry surface ☐ Day/Night ☐ Straight road	☐ Good weather conditions ☐ Dry surface ☐ Day/Night ☐ Straight road	☐ Good weather conditions ☐ Dry surface ☐ Day ☐ Straight road
DRIVER	Driver	Under 30	☐ Under 40				☐ Under 35	☐ Under 38	☐ Under 35	☐ Under 40

Table 9: Results of the DVE description for all the scenarios

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8	Scenario 9
RIDER	Time since departure Manœuvre	☐ <15 mn after departure ☐ Splitting lane or overtaking ☐ No specific manœuvre	☐ <10 mn after departure ☐ Crossing intersection where rider has right of way	☐ 49 mn after departure ☐ Going ahead on a bend ☐ Going ahead on a straight road	☐ 20 mn after departure ☐ Going ahead on a bend ☐ Going ahead on a straight road	☐ 15 mn after departure ☐ Crossing the intersection to go ahead ☐ Travelling on a roundabout	☐ 30 mn after departure ☐ Going ahead on a straight road ☐ Splitting lane	☐ 15 mn after departure ☐ Going ahead on a straight road	☐ 20 mn after departure ☐ Crossing the intersection to go ahead ☐ Approach of the intersection (has a right of way status)	☐ 20 mn after departure ☐ Crossing the intersection to go ahead ☐ Approach of the intersection (has a right of way status)
	Conflict	☐ Cars from lateral lanes	☐ Cars coming from the side road	☐ No conflict with other vehicles ☐ 25% of conflict with other users but no collision	☐ No conflict	☐ No conflict	☐ Oncoming vehicle in correct lane ☐ Vehicle in a lateral lane in the same direction	☐ A vehicle moving ahead ☐ A stationary vehicle ahead	☐ Passenger car coming from a side road	☐ Passenger car coming from a side road
	Precipitating event	☐ Misinterpretation of the situation ☐ Incorrectly positionned on the road	☐ Misinterpretation of the situation ☐ Voluntarily take risks	☐ Excessive speed ☐ Misinterpreted the driving situation ☐ Incorrect driving manœuvre	☐ Poor evaluation or anticipation ☐ Weather conditions ☐ Alcohol : Drugs	☐ Inappropriate reaction ☐ Incorrect driving manœuvre	☐ Incorrect driving manœuvre ☐ Misinterpreted the driving situation	☐ Incorrect driving manœuvre ☐ Misinterpreted the driving situation	☐ Misinterpreted the driving situation ☐ Poor evaluation or anticipation of the evolution of the situation	☐ Misinterpreted the driving situation ☐ Poor evaluation or anticipation of the evolution of the situation
	Emergency manœuvre	☐ Braking	☐ Braking ☐ No reaction	☐ Braking ☐ No reaction	☐ Braking ☐ No reaction	☐ Braking ☐ No reaction	☐ Braking ☐ No reaction	☐ Braking ☐ Try to control his PTW	☐ Braking ☐ Braking and turning	☐ Braking ☐ No reaction
	Crash	☐ Frontal ☐ Under 35 km/h	☐ Frontal ☐ Under35 km/h	☐ Under75 km/h	☐ Under45 km/h	☐ Under35 km/h	☐ Frontal ☐ Under55 km/h	☐ Frontal ☐ Under45 km/h	☐ Frontal ☐ Under35 km/h	☐ Frontal ☐ Under45 km/h
DRIVER	Time since departure Manœuvre	☐ <10 mn after departure ☐ Go ahead on a straight road	☐ <10 mn after departure ☐ Turn accros or away traffic				☐ Going ahead on a straight road or on a bend ☐ Changing lane	☐ Changing lane ☐ Overtaking ☐ Turning (not at an intersection)	☐ Turning accross traffic ☐ Turning away traffic ☐ Stooped at an intersection	☐ Turning accross traffic ☐ Going ahead at the intersection
	Conflict	☐ PTW from side road	☐ PTW from side road				☐ Oncoming PTW not in the correct lane ☐ PTW travelling in a lateral lane in the same direction	☐ PTW comig from a side road ☐ PTW travelling in a lateral lane in the same direction	☐ PTW comig from a side road	☐ PTW comig from a side road
	Precipitating event	☐ Failed to look ☐ Concentrated on another task	☐ Failed to look ☐ Concentrated on another task				☐ Failed to look, looked but did not see	☐ Failed to look, looked but did not see ☐ Incorrect driving manœuvre	☐ Failed to look, looked but did not see ☐ Inattention, concentrated on another driving related task	☐ Failed to look, looked but did not see ☐ Low level of attention because of internal or external distraction
	Emergency manœuvre	☐ Braking	☐ No reaction				☐ No reaction	☐ No reaction	☐ No reaction	☐ No reaction
	Crash	☐ Side ☐ Under20 km/h	☐ Side/front ☐ Under15 km/h				☐ Frontal ☐ Under35 km/h	☐ Side impact ☐ Under25 km/h	☐ Side impact ☐ Under15 km/h	☐ Side impact ☐ Under35 km/h

Table 10: Results of the description of the DVE evolution for all the scenarios

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8	Scenario 9
RIDER	HFF	☐ Neglecting the need to search for information ☐ Actively expecting another user to take regulation ☐ Erroneous evaluation of a passing road difficulty	☐ Mistaken understanding of another user's manœuvre ☐ Deliberate violation of a safety rule	☐ Guidance problem ☐ Poor control of an external disruption	☐ Guidance problem ☐ Poor control of an external disruption	☐ Poor control of an external disruption ☐ Erroneous evaluation of a passing road difficulty	☐ Expecting another user not to perform a manœuvre ☐ Neglecting the need to search for information	☐ Neglecting the need to search for information. ☐ Incorrect understanding of manoeuvre undertaken by another road user.	☐ Expecting another user not to perform a manoeuvre. ☐ Incorrect understanding of manoeuvre undertaken by another road user.	☐ Expecting another user not to perform a manoeuvre.
	Explanatory elements	☐ Narrow road ☐ Excessive speed ☐ Rigid attachment of the right of way status	☐ Non adapted speed ☐ Rigid attachment to the right of way status ☐ High experience of the road	☐ Excessive speed ☐ Intentional risk taking ☐ New PTW ☐ New rider	☐ Inadapted speed ☐ High experience of the road ☐ Bad road surface ☐ New driver	☐ Excessive speed ☐ In a hurry ☐ Inadapted speed	☐ Risk taking - lateral positioning ☐ Identification of potential risk about only part of the situation ☐ Atypical manœuvre from other road user	☐ Excessive speed or speed over the legal limit ☐ Non adapted speed for the driving situation (not over the legal limit) ☐ Other road user: absence of clues to manoeuvre	Rigid attachment to the right of way status ☐ Atypical manoeuvre from other road user ☐ Other road user: absence of clues to manoeuvre ☐ The rider has a high experience of the route. His attention level is low	☐ Rigid attachment to the right of way status ☐ Atypical manoeuvre from other road user ☐ Other road user: absence of clues to manoeuvre
DRIVER	HFF	☐ Neglecting the need to search for information ☐ Non detection in visibility constraints conditions	☐ Neglecting the need to search for information ☐ Information acquisition focused on a partial component of the situation ☐ Deliberate violation of a safety rule				☐ Cursory or hurried information acquisition ☐ Non detection in visibility constraints	☐ Neglecting the need to search for information. ☐ Deliberate violation of a safety rule.	☐ Neglecting the need to search for information. ☐ Non detection in visibility constraints.	☐ Cursory or hurried information acquisition. ☐ Neglecting the need to search for information.
	Explanatory elements	☐ Visibility impaired narrow road ☐ Searching for directional information	☐ Atypical manœuvre of other road users ☐ High experience of the road ☐ Rigid attachment to the right of way status				☐ Atypical manœuvre from other road user ☐ High density of the traffic ☐ Identification of potential risk about only part of the situation	☐ The user has a high experience of the route. His attention level is low ☐ Heavy traffic ☐ Atypical manoeuvre from other road user	☐ The driver has a high experience of the manoeuvre he is realizing. His attention level is low ☐ Heavy traffic ☐ Atypical manoeuvre from other road user	☐ Atypical manoeuvre from other road user ☐ Distraction within the vehicle ☐ Identification of potential risk about only part of the situation

Table 11: Results of the HFF analysis for all the scenarios

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8	Scenario 9
RIDER	Phenotype	☐ Too late action	☐ Too late action	☐ Too high speed ☐ No action	☐ Surplus force ☐ Too late action	☐ Surplus force ☐ Too late action	☐ Too late action ☐ Surplus force	☐ Too late action ☐ Too fast	☐ Too late action ☐ No action	☐ Too late action ☐ No action
	Genotypes	☐ Late or false observation ☐ Inattention ☐ Reduced visibility ☐ Insufficient skills / Knowledge	☐ Priority error ☐ Expectance of certain behaviours ☐ Late observation ☐ Insufficient skills / Knowledge	☐ Lack of practical skills or theoretical knowledge ☐ Late observation ☐ Expectance of certain behaviours ☐ Inattention ☐ Inadequate road maintenance	☐ Reduced friction ☐ Late or false observation ☐ Priority error ☐ Overestimation of riders' skills	☐ Reduced friction ☐ Priority error ☐ Expectance of certain behaviours ☐ Late observation ☐ Overestimation of riders' skills	☐ Expectance of certain behaviours ☐ Missed information ☐ False information ☐ Inattention ☐ Priority error	☐ Late observation Inattention ☐ Priority error ☐ Overestimation of riders' skills ☐ Expectance of certain behaviours	☐ Expectance of certain behaviours ☐ Late observation ☐ Inattention ☐ Visibility mask ☐ Priority error	☐ Expectance of certain behaviours ☐ Priority error ☐ Missed observation ☐ Late observation
DRIVER	Phenotype	☐ Too late action ☐ Too early action	☐ No action ☐ Too early action				☐ Too early action ☐ No action	☐ Too early action ☐ No action	☐ Too early action	☐ Too early aaction ☐ No action
	Genotypes	☐ Late or false observation ☐ Drugs/Alcohol	☐ Missed observation ☐ Priority error ☐ Expectance of certain behaviours				☐ Expectance of certain behaviours ☐ Missed information ☐ False information ☐ Inattention ☐ Priority error	☐ False observation ☐ Inattention ☐ Priority error ☐ Late observation ☐ Expectance of certain behaviours	☐ Late observation ☐ Obstruction of view Inattention	☐ Missed observation ☐ Expectance of certain behaviours ☐ Reduced visibility

Table 12: Results of the DREAM analysis for all the scenarios

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APPENDIX 1: The accident evolution analysis – The driving phase

The manoeuvre and location

A1. Stabilised Situation – Going ahead – Going ahead on a straight road

A2. Stabilised Situation – Going ahead – Going ahead on a left bend

A3. Stabilised Situation – Going ahead – Going ahead on a right bend

B1. Intersection – On approach – Approaching a 'give way' intersection

B2. Intersection – On approach – Approaching a 'stop' intersection

B3. Intersection – On approach – Approaching a 'traffic signal' intersection

B4. Intersection – On approach – Approaching intersection where road user has right of way

B5. Intersection – Stopped – Stopped at a 'give way' intersection

B6. Intersection – Stopped – Stopped at a 'stop' intersection

B7. Intersection – Stopped – Stopped at a 'traffic signal' intersection

B8. Intersection – Stopped – Stopped in road/ turning lane waiting to turn

B9. Intersection – Going ahead – Going straight on at a 'give-way' intersection

B10. Intersection – Going ahead – Going straight on at a 'stop' intersection

B11. Intersection – Going ahead – Going straight on at a 'traffic signal' intersection

B12. Intersection – Going ahead – Crossing intersection where road user has right of way

B13. Intersection – Going ahead – Travelling on roundabout (not turning on/off)

B14. Intersection – Going ahead – Travelling on slip-road (not turning on/off)

B15. Intersection – Turning – Turning across traffic at a 'give-way' intersection

B16. Intersection – Turning – Turning across traffic at a 'stop' intersection

B17. Intersection – Turning – Turning across traffic at a 'traffic signal' intersection

B18. Intersection – Turning – Turning across traffic from main road into side road

B19. Intersection – Turning – Turning away from traffic at a 'give-way' intersection

B20. Intersection – Turning – Turning away from traffic at a 'stop' intersection

B21. Intersection – Turning – Turning away from traffic at a 'traffic signal' intersection

B22. Intersection – Turning – Turning away from traffic from main road into side road

C1. Manoeuvre – Overtaking – Overtaking stationary vehicle on left

C2. Manoeuvre – Overtaking – Overtaking stationary vehicle on right

C3. Manoeuvre – Overtaking – Overtaking moving vehicle on left

C4. Manoeuvre – Overtaking – Overtaking moving vehicle on right

C5. Manoeuvre – Changing lane – Moved into lane on left (NOT overtaking)

C6. Manoeuvre – Changing lane – Moved into lane on right (NOT overtaking)

C7. Manoeuvre – Slowing – Stopping (not at junction)

C8. Manoeuvre – Slowing – Parking (roadside)

C9. Manoeuvre – Starting – Starting (not at junction)

C10. Manoeuvre – Starting – Leaving parking space (roadside)

C11. Manoeuvre – Turning (not at intersection) – Turning across traffic from main road into private drive

C12. Manoeuvre – Turning (not at intersection) – Turning away from traffic from main road into private drive

C13. Manoeuvre – Turning (not at intersection) – Turning across traffic out of private drive

C14. Manoeuvre – Turning (not at intersection) – Turning away from traffic out of private drive

C15. Manoeuvre – Reversing – Reversing

C16. Manoeuvre – U-turn – U-turn

C17. Manoeuvre – In wrong direction – Driving in wrong direction (e.g. down a one-way road)

C18. Manoeuvre – Lane splitting – Lane splitting

D1. Other – Parked – Parked

D2. Other – Stopped in traffic queue – Stopped in traffic queue

D3. Other – Pedestrian crossing – Approaching pedestrian crossing

D4. Other – Pedestrian crossing – Stopped at pedestrian crossing

D5. Other – Railway crossing – Approaching railway crossing

D6. Other – Railway crossing – Stopped at railway crossing

The conflict

A1. None – None

B1. Oncoming vehicle(s) – Oncoming vehicle(s) in correct lane

B2. Oncoming vehicle(s) – Oncoming vehicle(s) in wrong lane

C1. Vehicle ahead (moving in same direction or stationary) – Moving vehicle(s) ahead

C2. Vehicle ahead (moving in same direction or stationary) – Stationary vehicle(s) ahead (congestion or accident)

C3. Vehicle ahead (moving in same direction or stationary) – Stationary vehicle(s) ahead (parked)

C4. Vehicle ahead (moving in same direction or stationary) – Car door open on stationary vehicle

D1. Following vehicle(s) – Following vehicle(s)

E1. Vehicle from side – Vehicle(s) from side road/path

E2. Vehicle from side – Vehicle in lateral lane travelling in same direction

F1. Obstacle(s) ahead (non-vehicle) – Moving obstacle(s) ahead

F2. Obstacle(s) ahead (non-vehicle) – Stationary obstacle(s) ahead

G1. Pedestrian in road ahead – Pedestrian crossing over

G2. Pedestrian in road ahead – Pedestrian walking along road

G3. Pedestrian in road ahead – Pedestrian playing/ running on road

Manœuvre and location	Conflict							
	B1	B2	C1	C2	C3	E1	E2	Total
A1	2		1	1				4
A3	1			1				2
C2		1			1			2
C4				1				1
C6		1						1
C18						2	2	4
D1							1	1
Total	3	2	1	3	1	2	3	15

Table 13: Scenario 1 - Manoeuvre and location / conflict - Rider

Manœuvre and location	Conflict						
	B1	C1	C3	D1	E1	E2	Total
A1	3		1			1	5
A2	1						1
C6						2	2
C7				1			1
C10						1	1
C13		1			1		2
C14					2		2
D2				1			1
Total	4	1	1	2	3	4	15

Table 14: Scenario 1 - Manoeuvre and location / conflict – Driver

Manœuvre and location	Conflict								
	B1	B2	C1	C2	C4	D1	E1	E2	Total
B3	1								1
B4	1		1		1		2	2	7
B5						1			1
B9							1		1
B11	1								1
B12	3		2				9		14
B13						1			1
B16		1					1		2
B17	1						1		2
B19							1		1
B22	1								1
C1	1								1
C3			2				2	1	6
C4				2					2
C17		1					1		2
C18			1	1			4	1	7
Total	9	2	6	3	1	2	22	4	49

Table 15: Scenario 2 - Manoeuvre and location / conflict – Rider

Manœuvre and location		Conflict								
		B1	B2	C1	C2	C3	D1	E1	E2	Total
	B1		1							1
	B3	1								1
	B4							1		1
	B5				1			1		2
	B8							1		1
	B10		1					1		2
	B12	3						4		7
	B13			1						1
	B15	2					1	6		9
	B16							1		1
	B17	1						1	1	3
	B18	1					1			2
	B19							4		4
	B20							2		2
	B22	1								1
	C12							1		1
	C13							2	1	3
	C16					1		1	2	4
	D1						1			1
	D2			2						2
	Total	9	2	3	1	1	3	26	4	49

Table 16: Scenario 2 - Manoeuvre and location / conflict – Driver

Manœuvre and location		Conflict						
		A1	B1	C1	F1	F2	G3	Total
	A1	8		3	1			12
	A2	11	1		1			13
	A3	11		1	1		1	14
	C3	7				2		9
	C6	1						1
	C12	1						1
	C18					1		1
	Total	39	1	4	3	3	1	51

Table 17: Scenario 3 - Manoeuvre and location / conflict – Rider

Manœuvre and location		Conflict					
		A1	B2	C1	F2	G1	Total
	A1	24	1	2	1		28
	A2	6					6
	A3	7				1	8
	C13	1					1
	C18	3					3
	Total	41	1	2	1	1	46

Table 18: Scenario 4 - Manoeuvre and location / conflict – Rider

		Conflict								
		A1	B1	B2	C2	E1	E2	F2	unknown	Total
Manœuvre and location	B1					1				1
	B2	1								1
	B3				1					1
	B4	4		1						5
	B9	1								1
	B11	2								2
	B12		1			1				2
	B13	5	1						1	7
	B14	2								2
	B15	1								1
	B17	1								1
	B19	1								1
	B21	1								1
	B22	2				1				3
	C3						1			1
	C5	1								1
	C14	1								1
	C18		1			1		1		3
	Unknwon	1								1
	Total	24	3	1	1	4	1	1	1	36

Table 19: Scenario 5 - Manoeuvre and location / conflict – Rider

		Conflict							
		B1	B2	C1	C2	D1	E1	E2	Total
Manœuvre and location	A1	2		2	1		2		7
	A2	3			1				4
	A3	2	1	2					5
	B4	1		1			1	1	4
	C18			1	1		2	8	12
	C3	2	1				1	3	7
	C4			1		1		1	3
	Total	10	2	7	3	1	6	13	42

Table 20 : Scenario 6 - Manoeuvre and location / conflict – Rider

		Conflict								
		A1	B1	B2	C1	C2	D1	E1	E2	Total
Manœuvre and location	A1			1	1	1	2			5
	A2		3	1						4
	A3			6						6
	B18		2				1			3
	B4	1								1
	C3		1							1
	C5							1	3	4
	C6								6	6
	C7				1					1
	C10		1							1
	C11								1	1
	C13		1					3		4
	C16						1	1	2	4
	D1								1	1
	Total	1	8	8	2	1	4	5	13	42

Table 21: Scenario 6 - Manoeuvre and location / conflict – Driver

		Conflict								
		A1	B1	B2	C1	C2	C4	E1	E2	Total
Manœuvre and location	A1	1	4	1	14	5	1	1	4	31
	A3			1						1
	C1					1				1
	C4								1	1
	C6				1					1
	C11				1			1		2
	C18				1				3	4
	Total	1	4	2	17	6	1	2	8	41

Table 22: Scenario 7 - Manoeuvre and location / conflict – Rider

		Conflict								
		B1	C1	C2	C4	D1	E1	E2	unknown	Total
Manœuvre and location	A1	4	1			4	1	1		11
	C3	1								1
	C5		1				1	2		4
	C6					1	1	3		5
	C9					1				1
	C10						1			1
	C11	1				1				2
	C12						1			1
	C13	2					2			4
	C16			1			2			3
	C18							1		1
	D1	1								1
	D2				1	3				4
	D4					1				1
	unknown								1	1
	Total	9	2	1	1	11	9	7	1	41

Table 23: Scenario 7 - Manoeuvre and location / conflict – Driver

		Conflict								
		B1	B2	C1	C2	C4	D1	E1	E2	Total
Manœuvre and location	B1							1		1
	B3			2						2
	B4	2			1			7	1	11
	B5						1			1
	B7						1			1
	B11	1		1	1			2		5
	B12	3	1	2		1		8		15
	B13		1					1	2	4
	B14								1	1
	B16							1		1
	B17	1						1		2
	B19								1	1
	C17							1		1
	C18			2	1		1		1	5
	C3			1				2	5	8
	C4								1	1
	Total	7	2	8	3	1	3	24	12	60

Table 24: Scenario 8 - Manoeuvre and location / conflict – Rider

Manœuvre and location		Conflict							
		B1	B2	C1	C2	D1	E1	E2	Total
	B3				1				1
	B4						2		2
	B5				1				1
	B6						1		1
	B7					1	1		2
	B8	1			1	2			4
	B11	1					2		3
	B12							1	1
	B13						1	1	2
	B14							1	1
	B15		1				7		8
	B16			1			2		3
	B17			1			2	1	4
	B18	2		1			1	2	6
	B19		2				4	1	7
	B21			1					1
	B22							2	2
	C10	1					1		2
	C12							1	1
	C13						2		2
	C14						1		1
	C16			1				2	3
	C8					1			1
	D2						1		1
	Total	5	3	5	3	4	28	12	60

Table 25: Scenario 8 - Manoeuvre and location / conflict – Driver

Manœuvre and location		Conflict						
		B1	C1	C2	D1	E1	E2	Total
	B1			1				1
	B3						1	1
	B4	2		1		6	1	10
	B5				1			1
	B10					2		2
	B12	3		2		10	2	17
	B13					2		2
	B14		1					1
	B15					1		1
	B16					2		2
	B19					1		1
	C18	1	1			1	2	5
	C3			1		1	5	7
	Total	6	2	5	1	26	11	51

Table 26: Scenario 9 - Manoeuvre and location / conflict – Rider

		Conflict						
		B1	B2	C2	D1	E1	E2	Total
Manœuvre and location	B2					1		1
	B4						1	1
	B5			1	1			2
	B8				2	1		3
	B10					1		1
	B12					4		4
	B13					1		1
	B14				1			1
	B15	1				14		15
	B16				2	1		3
	B17		1					1
	B18	3				1	2	6
	B19					1		1
	C5				1		2	3
	C6				1		2	3
	C11						1	1
	C16						3	3
	D2				1			1
	Total	4	1	1	9	25	11	51

Table 27: Scenario 9 - Manoeuvre and location / conflict – Driver

APPENDIX 2: The accident evolution analysis – The rupture phase

STATE OF THE USER	1. Falling asleep
	2. Faintness
	3. Physical handicap (Visual handicap, auditive handicap,,,)
	4. Slow reaction
	5. Alcohol impairment or other illegal or legal drugs
	6. Low level of attention (low vigilance, affectation of attentional resources to driving task, internal distraction such as thinking, external distraction such as discussing, external distraction)
	7. Restlessness
	8. Aggressive driving
	9. Mood (stress, preoccupation, anger…)
	10. Fatigue
	11. Illness – sudden attack
	12. Impairment through drugs – medical
	13. Suicide
	14. other (to be detailed)
	15. unknown but related to the driver state
BEHAVIOUR	16. Failed to look, looked but did not see…
	17. Inattention – concentrated on another driving related task
	18. Distraction – non driving task
	19. other (to be detailed)
	20. unknown but related to the behaviour
INTERNAL CONDITION OF THE TASK	21. Misinterpreted the driving situation
	22. Decision making error
	23. Incorrect headway
	24. Incorrect trajectory
	25. Incorrect lane positioning
	26. Incorrect driving manoeuvre (poor overtaking, risk taking…)
	27. Poor evaluation / anticipation (other vehicle's speed…)
	28. Navigation
	29. Inappropriate reaction (panic, exaggerated movements…)
	30. Excessive speed
	31. Inappropriate speed (related to weather, road surface, infrastructure…)
	32. other (to be detailed)
	33. unknown but related to the internal condition of the task
DRIVER ENVIRONMENT	34. Animal in vehicle
	35. Passenger action
	36. other (to be detailed)
	37. unknown but related to the driver environment
VEHICLE	38. Mechanical defect
	39. Tyre blow out
	40. other (to be detailed)
	41. unknown but related to the vehicle
VEHICLE	42. Animal outside vehicle

ENVIRONMENT	43. Contrast (other vehicle, pedestrian…)
	44. Avoidance manoeuvre due to other vehicle
	45. Obstacle on the carriageway
	46. other (to be detailed)
	47. unknown but related to the vehicle environment
INFRASTRUCTURE	48. Narrow road
	49. Traffic light synchronisation problem
	50. Misleading infrastructure
	51. Surroundings obscured by infrastructure or roadside element
	52. Poor road surface
	53. other (to be detailed)
	54. unknown but related to the infrastructure
ROAD ENVIRONMENT	55. Fog
	56. Wet road surface
	57. Road surface pollution
	58. Heavy rain
	59. Wind
	60. Black ice
	61. other (to be detailed)
	62. unknown but related to the road environment

APPENDIX 3: Single moped accidents

Single moped accidents

	Accidents	Fatalities
Finland	5	5
France	195	199
Greece	28	28
Italy	131	131
The United Kingdom	11	11
Total	**370**	**374**

Outside urban area - no intersection

	Accidents	Fatalities
Finland	4 (80%)	4 (80%)
France	55 (28.2%)	55 (27.6%)
Greece	11 (39.3%)	11 (39.3%)
Italy	41 (31.3%)	41 (31.3%)
The United Kingdom	6 (54.5%)	6 (54.5%)
Total	**117 (31.6%)**	**117 (31.3%)**

Outside urban area - intersection

	Accidents	Fatalities
Finland	0 (0%)	0 (0%)
France	0 (0%)	0 (0%)
Greece	0 (0%)	0 (0%)
Italy	1 (0.8%)	1 (0.8%)
The United Kingdom	0 (0%)	0 (0%)
Total	**1 (0.3%)**	**1 (0.3%)**

Inside urban area - no intersection

	Accidents	Fatalities
Finland	1 (20%)	1 (20%)
France	128 (65.6%)	131 (65.8%)
Greece	13 (46.4%)	13 (46.4%)
Italy	78 (59.5%)	81 (61.8%)
The United Kingdom	1 (9.1%)	1 (9.1%)
Total	**221 (59.7%)**	**227 (60.7%)**

Inside urban area - intersection

	Accidents	Fatalities
Finland	0 (0%)	0 (0%)
France	12 (6.2%)	13 (6.5%)
Greece	4 (14.3%)	4 (14.3%)
Italy	11 (8.4%)	11 (8.4%)
The United Kingdom	4 (36.4%)	5 (45.5%)
Total	**31 (8.4%)**	**33 (8.8%)**

APPENDIX 4: Two vehicles accidents and at least one moped

2 vehicles accidents (including a pedestrian)

	Accidents	Fatalities
Finland	18	18
France	420	425
Greece	64	69
Italy	486	507
The United Kingdom	27	27
Total	**1015**	**1046**

Outside urban area - no intersection - Passenger car

	Accidents	Fatalities
Finland	1 (5.6%)	1 (5.6%)
France	121 (28.8%)	122 (28.7%)
Greece	17 (26.6%)	17 (24.6%)
Italy	64 (13.2%)	70 (13.8%)
The United Kingdom	2 (7.4%)	2 (7.4%)
Total	**205 (20.2%)**	**212 (20.3%)**

Inside urban area - no intersection - Passenger car

	Accidents	Fatalities
Finland	0 (0%)	0 (0%)
France	73 (17.4%)	75 (17.6%)
Greece	10 (15.6%)	12 (17.4%)
Italy	94 (19.3%)	95 (18.7%)
The United Kingdom	2 (7.4%)	2 (7.4%)
Total	**179 (17.6%)**	**184 (17.6%)**

Outside urban area - intersection - Passenger car

	Accidents	Fatalities
Finland	5 (27.8%)	5 (27.8%)
France	29 (6.9%)	29 (6.8%)
Greece	6 (9.4%)	8 (11.6%)
Italy	54 (11.1%)	57 (11.2%)
The United Kingdom	6 (22.2%)	6 (22.2%)
Total	**100 (9.9%)**	**105 (10%)**

Inside urban area - intersection - Passenger car

	Accidents	Fatalities
Finland	1 (5.6%)	1 (5.6%)
France	41 (9.8%)	41 (9.6%)
Greece	17 (26.6%)	17 (24.6%)
Italy	138 (28.4%)	141 (27.8%)
The United Kingdom	7 (25.9%)	7 (25.9%)
Total	**204 (20.1%)**	**207 (19.8%)**

Outside urban area - no intersection - Truck

	Accidents	Fatalities
Finland	3 (16.7%)	3 (16.7%)
France	45 (10.7%)	46 (10.8%)
Greece	1 (1.6%)	1 (1.4%)
Italy	14 (2.9%)	14 (2.8%)
The United Kingdom	3 (11.1%)	3 (11.1%)
Total	**66 (6.5%)**	**67 (6.4%)**

Inside urban area - no intersection - Truck

	Accidents	Fatalities
Finland	0 (0%)	0 (0%)
France	34 (8.1%)	34 (8%)
Greece	3 (4.7%)	3 (4.3%)
Italy	22 (4.5%)	23 (4.5%)
The United Kingdom	1 (3.7%)	1 (3.7%)
Total	**60 (5.9%)**	**61 (5.8%)**

Outside urban area - intersection - Truck

	Accidents	Fatalities
Finland	2 (11.1%)	2 (11.1%)
France	11 (2.6%)	11 (2.6%)
Greece	1 (1.6%)	1 (1.4%)
Italy	15 (3.1%)	16 (3.2%)
The United Kingdom	2 (7.4%)	2 (7.4%)
Total	**31 (3.1%)**	**32 (3.1%)**

Inside urban area - intersection - Truck

	Accidents	Fatalities
Finland	1 (5.6%)	1 (5.6%)
France	15 (3.6%)	16 (3.8%)
Greece	2 (3.1%)	2 (2.9%)
Italy	30 (6.2%)	30 (5.9%)
The United Kingdom	0 (0%)	0 (0%)
Total	**48 (4.7%)**	**49 (4.7%)**

Other

	Accidents	Fatalities
Finland	5 (27.8%)	5 (27.8%)
France	51 (12.1%)	51 (12%)
Greece	7 (10.9%)	8 (11.6%)
Italy	55 (11.3%)	61 (12%)
The United Kingdom	4 (14.8%)	4 (14.8%)
Total	122 (12%)	129 (12.3%)

APPENDIX 5: Single motorcycle accidents

Single motorcycle accidents

	Accidents	Fatalities
Finland	22	22
France	552	564
Greece	342	351
Italy	607	621
The United Kingdom	256	262
Total	**1779**	**1820**

Outside urban area - no intersection

	Accidents	Fatalities
Finland	18 (81,8%)	18 (81,8%)
France	304 (55,1%)	309 (54,8%)
Greece	148 (43,3%)	151 (43%)
Italy	323 (53,2%)	332 (53,5%)
The United Kingdom	136 (53,1%)	137 (52,3%)
Total	**929 (52,2%)**	**947 (52%)**

Outside urban area - intersection

	Accidents	Fatalities
Finland	0 (0%)	0 (0%)
France	23 (4,2%)	24 (4,3%)
Greece	6 (1,8%)	6 (1,7%)
Italy	20 (3,3%)	22 (3,5%)
The United Kingdom	38 (14,8%)	38 (14,5%)
Total	**87 (4,9%)**	**90 (4,9%)**

Inside urban area - no intersection

	Accidents	Fatalities
Finland	4 (18,2%)	4 (18,2%)
France	204 (37%)	209 (37,1%)
Greece	162 (47,4%)	166 (47,3%)
Italy	213 (35,1%)	215 (34,6%)
The United Kingdom	44 (17,2%)	49 (18,7%)
Total	**627 (35,2%)**	**643 (35,3%)**

Inside urban area - intersection

	Accidents	Fatalities
Finland	0 (0%)	0 (0%)
France	21 (3,8%)	22 (3,9%)
Greece	26 (7,6%)	28 (8%)
Italy	51 (8,4%)	52 (8,4%)
The United Kingdom	38 (14,8%)	38 (14,5%)
Total	**136 (7,6%)**	**140 (7,7%)**

APPENDIX 6: Two vehicles accidents and at least one motorcycle

2 vehicles accidents (including a pedestrian)

	Accidents	Fatalities
Finland	21	22
France	866	905
Greece	441	466
Italy	1351	1418
The United Kingdom	571	584
Total	**3250**	**3395**

Outside urban area - no intersection - Passenger car

	Accidents	Fatalities
Finland	7 (33.3%)	7 (31.8%)
France	325 (37.5%)	336 (37.1%)
Greece	78 (17.7%)	85 (18.2%)
Italy	222 (16.4%)	235 (16.6%)
The United Kingdom	127 (22.2%)	133 (22.8%)
Total	**759 (23.4%)**	**796 (23.4%)**

Inside urban area - no intersection - Passenger car

	Accidents	Fatalities
Finland	1 (4.8%)	1 (4.5%)
France	127 (14.7%)	131 (14.5%)
Greece	111 (25.2%)	118 (25.3%)
Italy	265 (19.6%)	277 (19.5%)
The United Kingdom	29 (5.1%)	30 (5.1%)
Total	**533 (16.4%)**	**557 (16.4%)**

Outside urban area - intersection - Passenger car

	Accidents	Fatalities
Finland	3 (14.3%)	3 (13.6%)
France	57 (6.6%)	64 (7.1%)
Greece	18 (4.1%)	23 (4.9%)
Italy	176 (13%)	188 (13.3%)
The United Kingdom	126 (22.1%)	129 (22.1%)
Total	**380 (11.7%)**	**407 (12%)**

Inside urban area - intersection - Passenger car

	Accidents	Fatalities
Finland	4 (19%)	5 (22.7%)
France	108 (12.5%)	112 (12.4%)
Greece	95 (21.5%)	97 (20.8%)
Italy	358 (26.5%)	364 (25.7%)
The United Kingdom	78 (13.7%)	78 (13.4%)
Total	**643 (19.8%)**	**656 (19.3%)**

Outside urban area - no intersection - Truck

	Accidents	Fatalities
Finland	3 (14.3%)	3 (13.6%)
France	117 (13.5%)	122 (13.5%)
Greece	24 (5.4%)	23 (4.9%)
Italy	61 (4.5%)	64 (4.5%)
The United Kingdom	20 (3.5%)	20 (3.4%)
Total	**225 (6.9%)**	**232 (6.8%)**

Inside urban area - no intersection - Truck

	Accidents	Fatalities
Finland	0 (0%)	0 (0%)
France	42 (4.8%)	43 (4.8%)
Greece	32 (7.3%)	32 (6.9%)
Italy	46 (3.4%)	46 (3.2%)
The United Kingdom	4 (0.7%)	4 (0.7%)
Total	**124 (3.8%)**	**125 (3.7%)**

Outside urban area - intersection - Truck

	Accidents	Fatalities
Finland	0 (0%)	0 (0%)
France	25 (2.9%)	26 (2.9%)
Greece	10 (2.3%)	10 (2.1%)
Italy	45 (3.3%)	48 (3.4%)
The United Kingdom	18 (3.2%)	18 (3.1%)
Total	**98 (3%)**	**102 (3%)**

Inside urban area - intersection - Truck

	Accidents	Fatalities
Finland	1 (4.8%)	1 (4.5%)
France	13 (1.5%)	13 (1.4%)
Greece	24 (5.4%)	25 (5.4%)
Italy	58 (4.3%)	59 (4.2%)
The United Kingdom	4 (0.7%)	4 (0.7%)
Total	**100 (3.1%)**	**102 (3%)**

Other

	Accidents	Fatalities
Finland	2 (9.5%)	2 (9.1%)
France	52 (6%)	58 (6.4%)
Greece	49 (11.1%)	53 (11.4%)
Italy	120 (8.9%)	137 (9.7%)
The United Kingdom	165 (28.9%)	168 (28.8%)
Total	388 (11.9%)	418 (12.3%)