Project No. 027763 – TRACE

Deliverable D 2.2
Accident causation and pre-accidental driving situations. Part 2. In-depth accident causation analysis

Abstract:

WP2 of the European Project TRACE is concerned with "Types of Situations" to analyse the causation of road traffic accidents from the pre-accidental driving situation point of view. Four complementary situations were defined: stabilized situations, intersection, specific manoeuvre and degradation scenario. To reach this objective, the analysis is based on a common methodology composed on 3 steps: the "descriptive analysis" which from general statistics will allow to identify among the studied situations those them relevant and to give their characteristics, the "in-depth analysis" allowing to obtain accident causes from the generic description of the problems identified in the previous step and the risk analysis identifying the risk of being involved in an accident taking into account the results obtained from the 'in–depth' level. This report is dedicated to the identification of the accident causes analysed for the pre-accidental driving situation point of view, i.e. the circumstances in which the driver is involved just prior the accident. This analysis has been conducted from the scenarios identified for each type of situation during the descriptive analysis realized in a first part (Report D2.1: Accident causation and pre-accidental driving situations. Part 1. Overview and general statistics). These results are based on the study of disaggregated data (in-depth accidents collection databases) available via WP8 in TRACE. With the identification of the main causes and contributing factor, the aspect related to the human functional failure has been taken into account. This innovative concept studied in TRACE WP5, has been used here in order to have a more complete overview of the problems in working on each road users involved in the accident and not only on the whole accident.

Keyword list: pre-accidental driving situation, accident causation, intersection, specific manoeuvres, stabilized situations.

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1   Acknowledgments

The Trace Partners have access to national and in-depth accident databases. The results presented in this report are based on the work performed by the according organisations keeping the databases.

No guarantee can be given on the correctness of the interpretations of the results. The conclusions drawn might not reflect the views of the organisations and partners, respectively.

This report is mainly based on in-depth accidents databases coming from Spain, UK, Germany, Italy and France.

The analysis describes in this report would not have been possible without the kind permission of the organisations responsible for these databases and the authors would like to acknowledge their support. In particular, acknowledgement is given to those who provided information via the WP8 data supply process, including the following:

From UK:
National Accident Data for Great Britain (STATS19) is collected by police forces and collated by the UK Department for Transport. The data are made available to the Vehicle Safety Research Centre at Loughborough University by the UK Department for Transport. The Department for Transport and those who carried out the original collection of the data bear no responsibility for the further analysis or interpretation of it.

The UK OTS project is funded by the UK Department for Transport and the Highways Agency. The project would not be possible without help and ongoing support from many individuals, especially including the Chief Constables of Nottinghamshire and Thames Valley Police Forces and their officers. The views expressed in this work belong to the authors and are not necessarily those of the UK Department for Transport, Highways Agency, Nottinghamshire Police or Thames Valley Police.

Acknowledgement is also given to Martin Maguire at Loughborough University, who assisted with the analysis of UK OTS in this study.

From Spain:
Spanish Road Accidents database is carried out by a public organisation called DGT, dependent of the Ministry of the Interior. Information contained in DGT Spanish Road Accidents Database is collected by police forces, when an accident occurs. The data are made available for CIDAUT since 1993. The Department for Transport and those who carried out the original collection of the data bear no responsibility for the further analysis or interpretation of it.

'DIANA' database: CIDAUT counts with spanish accident investigation teams in the region of Valladolid (Spain) that travel immediately to the accident scene to perform an 'in-depth investigation', in close cooperation with police forces, medical services, forensic surgeons, garages and scrap yards. All information gathered is stored in an own ORACLE database (called DIANA) for further exploitation jointly with access to other accident databases, as for example the national one coming from the DGT (Dirección General de Tráfico) which provide information on every injury accident.

From France:
BAAC (Bulletin d'Analyse des Accidents Corporels) : National accident database for France collected by police, CRS and Gendarmerie forces and provided by ONISR (Observatoire National Interministériel de Sécurité Routière). The data are made available to the Laboratory of Accidentology, Biomechanics and human behaviour PSA Peugeot-Citroën, Renault.

2   Executive Summary

According to the World Health Organization and other sources, the total number of road deaths, while not completely accurate, is estimated at 1.2 million, with a further 50 million injured every year in traffic accidents. Two thirds of the casualties occur in developing countries. 70 % of casualties in these countries are vulnerable road users such as pedestrians, cyclists and motorcyclists.

The projections show that, between 2000 and 2020, road crashes as a cause of death or disability lying today in ninth place out of a total of over 100 separately identified causes, will move up to 3rd place. The road traffic deaths will decline by about 30% in high-income countries but increase substantially in low and middle-income countries.

In 1998, the "poor nations" (as referenced by WHO) represented 87% of worldwide road traffic fatalities, with high rates for India (18.5%), China (15.3%) and Africa (14.5%). The rate for Europe (only for the wealthy nations) represents 5.6%.

Because the reduction of road traffic injuries is a challenge for all of us, the European Community has been trying for many years to promote initiatives through the different Framework Programs in order to contribute to the safety effort. The Commission has expressed two kinds of interest as regards accident analysis:

- Research in consistent accident causation analysis to gain a detailed knowledge about the real backgrounds of European traffic accidents using existing data sources.

- Research to assess the potential impact and socio-economic cost/benefit, up to 2020, of stand-alone and co-operative intelligent vehicle safety systems in Europe".

TRACE addresses the first concern (accident causation) and the benefit part of the second (impact assessment of technologies). The main objectives are to improve road safety and to reduce or avoid road accidents in Europe by:

- contributing to the identification of the main causes of outstanding European accidents which still remain today,
- improving the evaluation methodology of safety devices.

To carry out these two ambitious objectives, TRACE is broken down into three series of Work packages:

- The operational work packages are dedicated to accident causation (WP1, WP2 and WP3) and the evaluation of the safety benefits of safety functions (WP4).

- The methodology work packages, cover the methodological aspects needed by the operational and evaluation groups and concerns statistical methods (WP7), human function failures (WP5) and safety functions (WP6).

- The data supply work package (WP8) provides data obtained from the sources available to the TRACE project.

To improve the knowledge on accident causation, the TRACE idea is to purpose to analyse this field through three complementary points of view: road users (WP1), the situation in which a road users can be involved (WP2) and the risk factors (WP3).

The expected results are identifying the main accident causes determined for each point of view.

To reach this target, a 3 steps methodology is applied:

- Descriptive statistical analysis: the goal of this level is to identify the main problems and their magnitude related to accident causation. The intention of the descriptive statistical analysis is to determine the situations (or scenarios) where the likelihood of having an accident is high.

- In-depth analysis: the main aim of this level is to obtain accident causes from the generic description of the problems identified in the previous level of the analysis.

- Risk analysis: this third level is dedicated to identifying the risk of being involved in an accident taking into account the results obtained from the 'in–depth' level, i.e. once accident causes have been identified.

Because the evaluation of the effectiveness of the safety devices can be made particularly by the identification of typical scenarios of accident for which the system can act, it was important to define first typical accident classes for each operational workpackages.

For WP2, we identified four specific groups of situations covering the majority of the real ones:

- *Stabilized Traffic Scenarios* concerning every normal driving situation that can become risky due to specific failures (e.g. guidance errors) or sudden conflict situations with other road users.

- *Intersection Scenarios* that concerns every situation occurring at or close to an intersection.

- *Specific Manoeuvre Scenarios* including accidents due to scenarios created by performing specific driving manoeuvres (e.g. overtaking, U-turning, car-following, joining a carriageway, etc.).

- *Degradation Scenarios* gathering accidents concerned with the presence of factors which degrade the road way, the environment (fog, heavy rain) and trigger accidents.

Of course, other choices would have been possible. The present choice is based on the following arguments:

- Most of the promising safety devices are relied on active safety, i.e. on events prior to the crash. It is important to take into account situations corresponding to the pre-accidental phase;

- The selected situations have to be as generic as possible and do not have to answer to a specific technology;

- Because accident process is sequential, all phases have to be taken into account, not only one;

- The complementarily of the selected situations. They are to cover the majority of the situations without any overlap. Regarding the estimation of the effectiveness of safety device, avoid overlaps, facilitates the selection of the corresponding accidents. This is the case for the 3 first types, but not for the "degradation situations". However, it is important to identify this type of situation because the accidental mechanisms occurring in these cases are different from those of 3 other groups (ex: visibility, perception, surface conditions, etc.).

This current report D2.2 is the second deliverable of the WP2 (Types of situation). Based on the analysis and the identification of the main causes (problems) occurring during the pre-accidental driving situation, it brings a real essential complement to the descriptive analysis realized in the first report (D2.1). This study is based on the analysis of the disaggregated accident data obtained from the in-depth accident data collection, the only data enough detailed allowing to work on the accidental mechanisms and the causes of accident.

Related to 'Operational Workpackage', 'Work Package 2: Type of situations' has been aimed to update **accident causation knowledge from the road user situation point of view** (stabilized situation, intersection situation, specific manoeuvre and degraded situation).

Firstly, TRACE has proposed a common methodology for the analysis of each type of situation maximizing the use of existing databases and their limitations. This integrated methodology can be summarized as follows:

1. What knowledge has already been obtained for each type of situation?
2. What are the most relevant accident configurations at European level?
3. Why accidents of those configurations take place?
4. Which factors increase the risk of each accident configuration?

Each task has followed the above method in order to study the different type of situations. The main achievements, apart from the specific results on each task, make reference to the following facts:

- Innovative statistical methods, developed by WP7, have been applied as much as possible in order to provide data at EU27 level related to the magnitude of the accident figures for each type of situation although this was an initial target of the project. When available, these figures have been combined with exposure data in order to provide general risks estimations.

- Relevant and specific accident configurations have been detected and describing for each type of situations at macroscopic level. This means that safety solutions addressing these configurations would benefit to larger groups of road users.

- Contributory factors have been identified through microscopic analysis in order to detect what aspects have contributed to the accident. This is what topics should new safety systems would be addressing. The WP5 methodology to identify Human Functional Failure has been applied in this step allowing the identification of the human decisions mechanisms that did not perform positively in each accident configuration.

- Last but not least, the different risk analyses performed allow deciding which new systems should be prioritized as they address factors that induce a higher level of risk for each road user.

TRACE differs from other accident research project both on the methodology used and the collating of almost all the relevant accident databases at European Level both at macroscopic and microscopic level.

Nevertheless, this does not mean that everything is achieved in accident causation. This project has also encountered some relevant difficulties that should help the research community to identify the next actions to be taken:

- There is not enough data to perform all the ideal risk analyses in accident causation. Sometimes there is a lack of data related to the detail of accident information and sometimes it is not possible to get the necessary exposure data to perform risk. For example, combining data from different in – depth accident databases has required a great effort in developing common concepts that could be analysed in each database, taking into account they are designed with different structures.

- The quantity and quality of information is not the same for all type of situation. Those less represented in the different vehicle circulating parks could be improved their level of safety by a higher level of detail in the information that accident data offers.

- If a common accident investigation methodology is applied in the future, this will allow performing a new updating of the accident causation knowledge under this approach.

- The last problem focused on the application of the innovative methodology emerging from WP5 – Analyzing "Human Functional Failure" in road accidents. Two difficulties appeared:
  - We need to well understand the new approach if we want to have relevant results and to have the same understanding of the approach between all the partners.

  - Once, the approach understood, we have to find in our database the appropriated information which could help us to apply the new approach on our sample.

All potential users of the results of this work package should not only consider the different percentages and specific conclusions of each type of situations but also the methodology followed to obtain each result. Both objectives of developing and applying the methodology for the updating and accident causation have been achieved within this work package from the point of view of the pre-crash driving situation in which the road users is involved.

From the in-depth analysis, the main results for each situation studied in WP2 are the following:

Intersection scenarios

The accidents in intersection represent:

- 43% of the total number of injury accidents in EU27.
- 21% of the overall fatalities (1% of the casualties in intersection)
- 34% of severely injured (11% of the casualties in intersection)

The main results regarding the identification of the causes are the following:

In-depth analysis	Drivers right of way	Drivers not the right of way
Key events	70% endogenous key events: Misinterpretation of the situation Excessive speed Incorrect driving manoeuvre Inappropriate reaction Failed to look	90% endogenous key events: Incorrect driving manoeuvre Poor evaluation of the situation Misinterpretation of the situation Failed to look
Human Functional Failures	Prognostic: Waiting for regulation or absence of other driver manoeuvre Perception: Focused attention/inattention/no visibility/no look/quick look	Perception: Quick look/focused attention/no look/no visibility/inattention
Emergency reaction	70% braked 2/3 stopping distance too short.	60% no reaction Sight distance/looked but didn't see / lost /mask /luminosity
Driver age	Younger drivers (<25) Traffic lights	Older drivers (65+) Yield/perception/misunderstanding /slow manoeuvre
Countermeasures	Understanding of the situation Reducing the braking distance	Reducing the approach speed (main road) Sight distance Improving the legibility of the road layout

Stabilized situations

These situations represent:

- 49% of the total number of situations in EU27.
- 33% of the total number of injury accidents in Europe (estimation relying on results coming from Spain, UK, France, Greece and Czech Republic)

The main results regarding the identification of the causes are the following:

In-depth analysis	Collision with a pedestrian	Lane departure/ run-off accident	Accident with more than one vehicle
Key events	Pedestrian has a recognition error, crossing or invading the road illegally. Also, the pedestrian made an error recognition and low level of attention	Speeding Decision error Alcohol impairment Low level of attention Environmental perturbation Complex or difficult site, narrow road	Opponent error: Speeding Opponent car decision error Stabilized car decision error Stabilized error: Not keeping safe distance Stabilized state: Low level of attention
Human Functional Failures	Detection: The passenger car driver was surprised by the pedestrian non visible	Diagnosis stage: The passenger car driver has an erroneous evaluation of the bend in a context of playing-driving and of an although known bend. Handling stage: Guidance interruption consequently to attention orientation towards a secondary task	Handling stage: The stabilized vehicle sudden encounter of an external disruption. Loss of psycho-physiological capacities consequently to a falling asleep or ill-health from the opponent vehicle. Detection: Late detection of the slowing down of the vehicle ahead
Risk factors (Increase)	Straight sections Pedestrian gender (male)	Driver gender: male Bad weather conditions Single carriageway road Sharp curve Night lightning	Slight curves Bad weather conditions Night lightning Double carriageway road

Specific manoeuvres

These situations represent:

- 7% of the total number of situations in EU27.
- 24% of the total number of injury accidents in Europe (estimation relying on results coming from Spain, UK, France, Greece and Czech Republic)

The main results regarding the identification of the causes are the following:
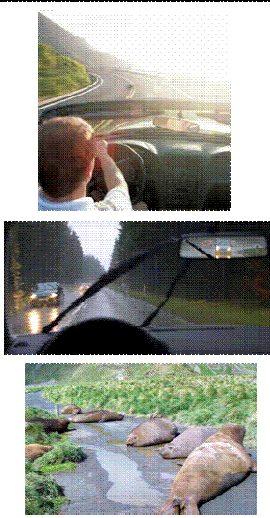
	Overtaking	Turning left	U-turning	Changing lane

Key events	1. **Internal conditions of the task:**
	  a. Incorrect driving manoeuvre
	  b. Poor evaluation / anticipation
	2. **Driver behaviour**
	  Looked but did not see			

Contributing factors	1. Inadapted speed 2. Careless, reckless or in a hurry 3. Risky driving 4. Excessive speed	1. Automatic driving 2. Global time constraint 3. Risky driving 4. Mobile mask	1. Risky driving 2. Global time constraint 3. Low level of attention 4. Careless, reckless or in a hurry	1. Restlessness 2. Risky driving 3. Alcohol / drugs 4. Inadapted speed
Human functional failures	1. Decision 2. Action 3. Diagnosis	1. Perception 2. Decision 3. Diagnosis	1. Perception 2. Decision 3. Diagnosis	Not available
Counter-measures	▪To adapt the speed to the situation and to the legal limit speed ▪Collision warning system ▪Collision avoidance system ▪Inter-vehicle communication system ▪Lane changing assistance ▪To respect laws ▪ESC/TCS	▪inter-vehicle communication system ▪To respect laws ▪To help the driver to see	▪Blind spot monitoring ▪Inter-vehicle communication system ▪To respect laws	▪inter-vehicle communication system ▪Alcohol and drug preventio ▪To adapt the speed to the situation and to the legal limit speed

Degradation situations

The accidents in degraded conditions (in dark and/or bad weather conditions only) represent:

- 35% of the total number of injury accidents in EU27.
- 46% of the overall fatalities (3% of the casualties in degraded situation)
- 39% of severely injured (14% of the casualties in degraded situation)

The main results regarding the identification of the causes are the following:

	Key events	Human fucntional failures
	❑ "Risk taking" was the most commonly identified factor group within degraded lighting, degraded weather and degraded road surface ❑ "Distraction" was also a commonly occurring factor group within carriageway hazards, along with "visibility impaired" ❑ "Psychological condition", "distraction", "road condition", "visibility impaired" were also prevalent.	❑ The presence of degradation in general mainly led to either failures in detection (i.e. the degraded situation restricted the road user's visibility) or failures when taking action (i.e. the degradation directly affected the road user's control of their vehicle, such as when manoeuvring around a bend). ❑ Accidents where degraded lighting was a cause mainly led to failures in detecting a conflict ahead, ❑ In accidents where degraded road surfaces were a cause, the road user experienced a failure when trying to keep control of their vehicle ("taking action") ❑ Both degraded weather and hazards were found to lead to a failure in two ways, either in detection (visibility restricted) or when taking action (keeping control of vehicle)

Introduction

1769 was marked by the arrival of the first self-propelled vehicle, the "fardier à vapeur" elaborated by Cugnot[2]. The vehicle, which weighed about 2.5 tonnes tare, had two wheels at the rear and one in the front where the horses would normally have been; this front wheel supported the steam boiler and driving mechanism. The power unit was articulated to the "trailer" and steered from there by means of a double handle arrangement. This prototype with military vocation was planned to tow artillery, could reach a speed 4 km/h and had an autonomy of 15 minutes. The first accident occured during a try in November, 1770: we do not succeed in slowing down the fardier which knocked down part of the Arsenal wall (the first known 'automobile' accident?).

Figure 1: The first vehicle ("fardier à vapeur" Cugnot 1770) and the first known vehicle accident

Since, vehicles did not stop evolving, at first in performance (motor, speed, autonomy), then technically (driving wheels -1876-, speed gear -1880-, disk brake – 1902-, etc.) in comfort and finally in safety.

At the end of the XIXe century the research and the evolution of the automobile is going to progress rapidly in West. It is also in this period that begin the difficulties for the car: while it remained an object of luxury reserved for the most fortunate, roads without cover nor road marking turned out very difficult to practice. The starting up of the engine was a "boring" event, the bad weather as the dust were dreaded and the occupants not being isolated in a closed space.

At this time, France is then in the leader of the production as showed by the figures at the beginning of the century: in 1903: France produces 30 204 cars (that is 48,77 % of the world production), the United States 11 235. The British (9 437), the Germans (6 904), the Belgians (2 839) and the Italians (1 308) are the other producing countries. Peugeot, Renault and the other Panhard already have selling points in the United States. France account 30 car manufacturers in 1900, 57 in 1910 and 155 in 1914. In the United States, in 1898, we counted 50 brands and 291 in 1908.

It is also in this period when appears the first automobile races. These races had consequence to annihilate the steam engine and to emphasize the flexibility and the stamina of the engine with explosion but they also demonstrated, thanks to Peugeot piloted by André Michelin, whom the car gains a lot "to run on the air".

From the models of races with their enormous engines, the car manufacturers try hard to develop much more accessible models as the Ford Model T then A by a research for the decrease of the production cost, notably by a breakdown into individual operations of the tasks in assembly lines.

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[2] **Nicolas-Joseph Cugnot** (26 February 1725 – 2 October 1804) was a French inventor. He is believed to have built the first self-propelled mechanical vehicle.

With the success of the automobile and its popularity growing years after years, the number of road accidents did not stop increasing over the years. Was it the price to pay?

However, road crashes, causing death, injury, and damage have always happened.

History tells of many notable historic personalities who were the victim of such incidents. Louis IV of France[3] died in 954 after falling from his horse, as did at least two kings of England: William I[4] (William the Conqueror) in 1087 and William III[5] in 1702. Handel[6] was seriously injured in a carriage crash in 1752. Mary Ward an Irish scientist died on 31st August 1869 when she fell out of her cousins' steam car and was run over. She has the distinction of being the first fatality in a car accident. She was thrown from the car on a bend in the road. She fell under its steel wheel and died almost instantly. When a doctor, who lived opposite the scene of the accident, arrived within moments, he found her cut, bruised and bleeding from the ears. The fatal injury was a broken neck. In 1898, the marquis of Montaignac was involved the first fatal accident in race (Périgueux, 01/05/1898, 146km). In 1903 Louis Renault loses dramatically his brother 31-year-old Marcel victim of a lane departure during the motor racing Paris-Madrid (see next pictures).
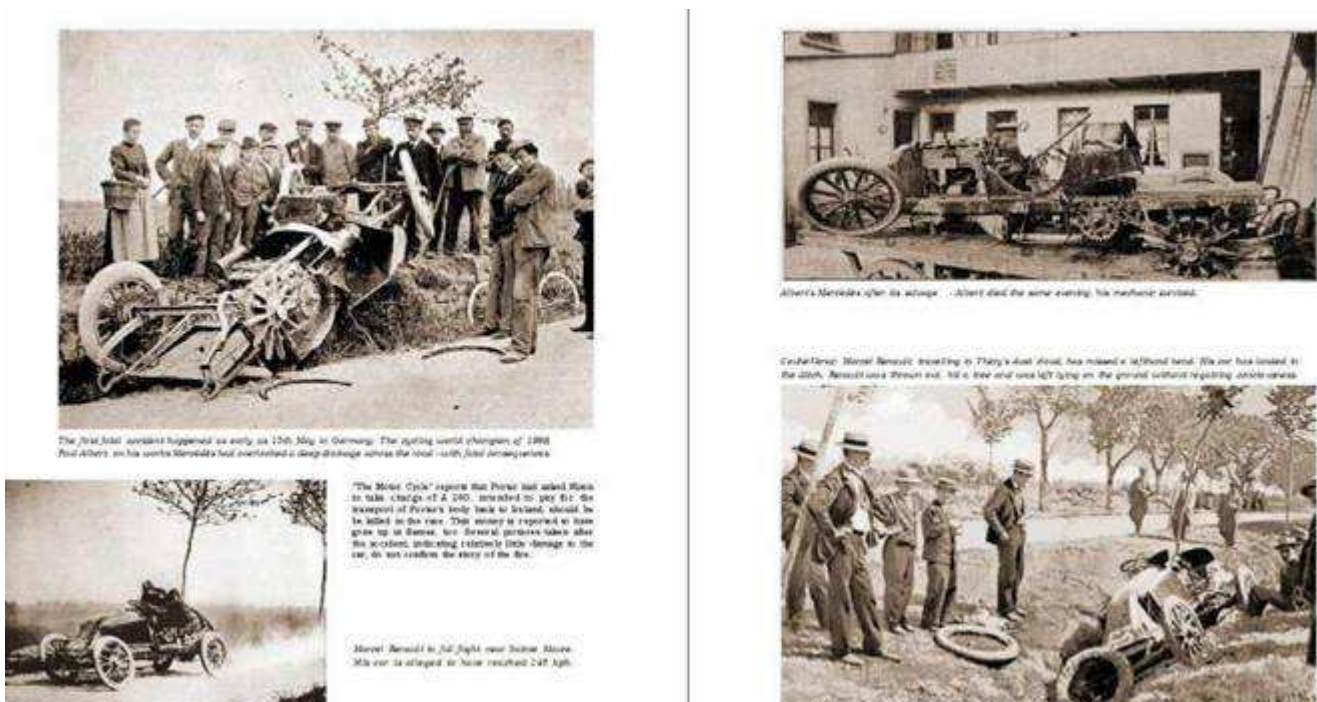
Figure 2: Fatal accident in the race Paris – Madrid in 1903

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[3] **Louis IV** (10 September 920 – 30 September 954), called *d'Outremer* or *Transmarinus* (both meaning "from overseas"), reigned as king of France from 936 to 954. He was a member of the Carolingian dynasty

[4] **William I of England** (1027 – 9 September 1087), also known as **William the Conqueror** (French: *Guillaume le Conquérant*), was Duke of Normandy from 1035 and King of England from 1066 to his death.

[5] **William III** (14 November 1650 – 8 March 1702) was the Prince of Orange from his birth, Stadtholder of the main provinces of the Dutch Republic from 28 June 1672, King of England and King of Ireland from 13 February 1689, and King of Scots (under the name **William II**) from 11 April 1689, in each case until his death.

[6] **George Frideric Handel** (Friday, 23 February 1685 – Saturday, 14 April 1759) was a German-born Baroque composer who is famous for his operas, oratorios and concerti grossi.

In 1969, J. J. Leeming[7], compared the statistics for fatality rates in Great Britain, for transport incidents both before and after the introduction of the motor vehicle, for journeys, including those by water, which would now be undertaken by motor vehicle: For the period 1863–1870 there were: **470** fatalities per million of population (76 on railways, 143 on roads, 251 on water); for the period 1891–1900 the corresponding figures were: **348** (63, 107, 178); for the period 1931–1938: **403** (22, 311, 70) and for the year 1963: **325** (10, 278, 37). Leeming concluded that the data showed that "*travel accidents may even have been more frequent a century ago than they are now, at least for men*" (Leeming 1969).

Today, we are indeed far from these figures: at every minute, two persons in the world die from a road accident! Every day, it is more than 3 000 deaths, 140 000 injured persons among whom 15 000 will remain handicapped in life! So much human suffering, so many families broken for ever. The message of the OMS addresses each of us, without exception: " the road accident is not a fate ".
The hour came to stop the bleeding. Because if nothing is made, the number of victims could increase by 60 % before 2020!
The weight of the plague is not the same according to continents. Even there, the geography is revealing of an unbearable disparity: on the 1,260 million deaths who arise every year, 9 on 10 live in a developing country! It is in Africa where the mortality rate is highest, with 28 deaths for 100 000 inhabitants! Four times more than in countries as Sweden, Great Britain and Norway (WHO, 2004).
Other major difference: in most of the developed countries the majority of the deaths concern the occupants of automobiles: drivers or passengers. In developing countries, the first victims of accidents are the pedestrians and the cyclists. On the other hand, in the North as in the South the road accidents strike especially the young people and the active persons (workers).

Because the reduction of road traffic injuries is a challenge for all of us, the European Community has been trying for many years to promote initiatives through the different Framework Programs in order to contribute to the safety effort. The Commission has expressed two kinds of interest as regards accident analysis:

- Research in consistent accident causation analysis to gain a detailed knowledge about the real backgrounds of European traffic accidents using existing data sources.
- Research to assess the potential impact and socio-economic cost/benefit, up to 2020, of stand-alone and co-operative intelligent vehicle safety systems in Europe".

TRACE addresses the first concern (accident causation) and the benefit part of the second (impact assessment of technologies). The main objectives are to improve road safety and to reduce or avoid road accidents in Europe by:

- contributing to the identification of the main causes of outstanding European accidents which still remain today,
- improving the evaluation methodology of safety devices.

To carry out these two ambitious objectives, TRACE is broken down into three series of Work packages:

- The **operational work packages** are dedicated to accident causation and the evaluation of the safety benefits of safety functions. Because accident causes depend on research objectives, the original aspect proposed in TRACE was to propose three different views of the accident: the road user (WP1), the situation (WP2) and the human factors (WP3). These three axes of research should normally cover the main aspects. The evaluation of the safety benefits of safety functions (WP4) lies on the estimation of the effectiveness of these safety systems in terms of expected (or observed) accidents avoided and lives saved

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[7] **John Joseph Leeming** was a British road engineer. He forwarded controversial ideas for the causes of, and remedies for, road crashes, including the notion that drivers should not always be assumed to be at fault.

- **The methodology work packages,** as suggested by their name, cover the methodological aspects needed by the operational and evaluation groups. Three work packages are concerned: WP7 (statistical methods) with the twin objective of improving statistical methodology in empirical traffic accident research and providing statistical services and methodological advice to other work packages, WP5 (Human Function Failure) looking at the role played by the human component in the traffic system, which is innovative and WP6 (Safety functions) which is to make a comprehensive overview of the safety functions available or under development.

- The **data supply work package** (WP8) provides data obtained from the sources available to the TRACE project to support data analysis activities in the other work packages (principally Work Packages 1, 2, 3 and 4) and the eIMPACT project. The objective is not to produce a common database, but to combine results coming from different countries in answer to the requests made by the operational work packages.
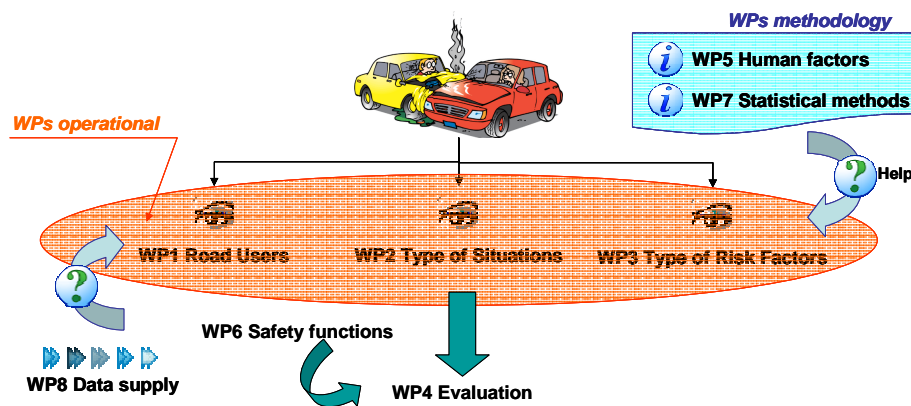
Figure 3: Organization of work packages in TRACE

From accident causation perspective, this purpose is very innovative:

- Accident causation is very complex and requires several angles of approach.

- Up to now, the accident causes were established from expertise opinion and focused on a specific target. In TRACE, different and complementary accident angles are covered: road users, situation and human factors.

- Most of time, safety devices born from engineer idea and are dedicated to a specific target without any argument to know if the solution fit to the main problems. In this situation, the role of accidentologist is only to try to estimate its effectiveness. The 3 angles of this research follow the opposite way: establish first the problems before to find a solution.

- The scenario fitting the accident reality, allow us to know what are the problems where countermeasures exist, what are the ones where some solutions have to be found.

- Covering most of the accident angles, this research can be used to establish common indicators at the European level (to evaluate the road safety performance) and for each country (to define their safety priorities).

Based on an accurate literature review and an expert analysis, for WP2, we identified four main situations covering all predictable situations:

"stabilized situations", "intersection situations", "situations with specific manoeuvres" and "degradation situations".

Of course, other choices would have been possible. The present choice is based on the following arguments:

- Most of the promising safety devices are relied on active safety, i.e. on events prior to the crash. It is important to take into account situations corresponding to the pre-accidental phase;

- The selected situations have to be as generic as possible and do not have to answer to a specific technology;

- Because accident process is sequential, all phases have to be taken into account, not only one;

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This current report D2.2 is the second deliverable of the WP2 (Types of situation). Based on the analysis and the identification of the main causes (problems) occurring during the pre-accidental driving situation, it brings a real essential complement to the descriptive analysis realized in the first report (D2.1). This study is based on the analysis of the disaggregated accident data obtained from the in-depth accident data collection, the only data enough detailed allowing to work on the accidental mechanisms and the causes of accident.

This report is organized into four main parts:

- A general description of the WP2 including objectives, organization and the proposed methodology for accident causation analysis. In particular, we will attach to describe how the objectives of WP2 contribute to the TRACE ones, its innovative aspects and what the WP2 connections with the whole TRACE project are.

- A introduction to the in-depth analysis presenting the targeted objective and giving the definition of the different concepts that we are going to used here.

- The 3rd part is based on the results of the in-depth accident causation analysis. For each task, we will recall the results obtained during the descriptive analysis (magnitude, stakes, relevant scenarios) and we will present the identification of the causes related to each relevant situation analysed.

- In the last part a conclusion will be given, underlining the striking results obtained. We will propose also to give a critical analysis on the work realized which will allow an experience feedback, to bring to light the key points and the difficulties met during the analysis, and to propose axes of improvement which can be used for the future ERSO.

3   WP2 in details

The WP2 is one of the three operational work packages. It aims to analyze accident causation factors by looking at the situation in which the driver is confronted.

A situation is defined as a pre-accidental driving situation to which the driver is confronted in normal driving conditions just before it turns into an accident situation[8] . It is assumed that there are specific accident causation factors related to these situations that deserve to be studied. The types of situation can include one or more accident scenarios, which contributed to the accident.

Four specific groups of situations, which either correspond to normal driving situations with no specific driver solicitation, or to driving manoeuvres where the driver is specifically solicited, have been identified:

- **Task 2.1.** *Stabilized Traffic Scenarios*: This task analyzes the causation of traffic accidents in situations that would not be considered as hazardous per se. Normal driving situations can become risky due to specific failures (e.g. guidance errors) or sudden conflict situations with other road users. For example, this scenario consists of driving normally on a straight road or entering a corner, etc.

- **Task 2.2.** *Intersection Scenarios*: This task analyzes the causation of traffic accidents at intersections. Statistical and in-depth analyzes provide the task with an overview of the conditions under which accidents at crossings and intersections occur. The magnitude of intersection accidents and the most relevant accident situations will be defined based on the pre-accidental manoeuvres. Distributions of the main pre-crash parameters will be established for each situation.

- **Task 2.3.** *Specific Manoeuvre Scenarios*: This task investigates accidents due to scenarios created by performing specific driving manoeuvres (e.g. overtaking, U-turning, changing lane, etc.). Some driving manoeuvres can increase accident risk in relationship with a particular highway characteristic. This task will address scenarios on all road types.

- **Task 2.4.** *Degradation Scenarios*: This task is concerned with the presence of factors which degrade the road way, the environment (fog, heavy rain) and trigger accidents. Among the factors which will be considered are night time, lighting issues and conspicuity; weather conditions which affect visibility and speed leading to loss of control; deteriorated highway conditions as result of obstruction, surface contamination; etc.

These four types of situations should be covering the majority of the real situations which may occur in road injury accidents. Certain atypical accidents or situations will never fit neatly into a fixed classification.

The first three WP2 tasks are mutually exclusive without overlap (see next figure).

The degradation scenarios are however a subset of the other scenarios. We can find so degraded situations at intersection.

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[8] A situation is linked to a vehicle. One accident whit two vehicles count two situations
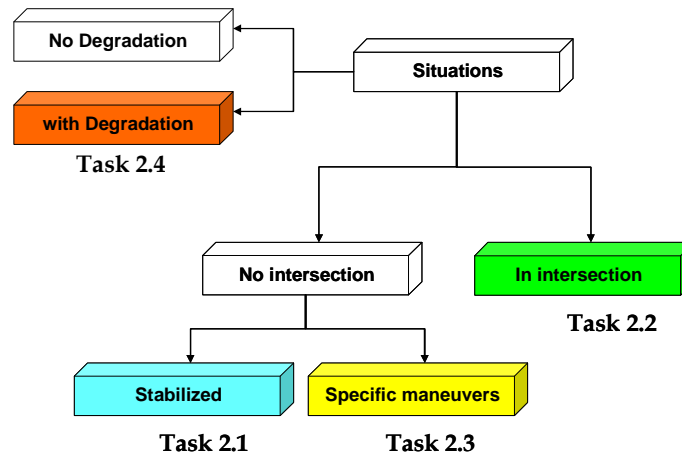
Figure 4 : Scope of each situation studied in WP2.

3.1   Objectives

The main objectives of WP2 "Types of situations" are to:

1.   Identify and quantify accident causation factors associated to particular types of driving and pre-accidental situations, at a statistical level, by analyzing various available databases in Europe.

2.   Obtain a focused understanding of accident causation issues related to these types of situations at an in-depth level by analyzing data from available in-depth databases.

3.   Identify the level of risk associated to these selected types of situation in causing accidents.

3.2   Description of the work

The work package focuses on these situation types, addressing road geometry and characteristics, user category and environmental factors. Although the tasks deal with different scenarios, any commonalty in the types of situation arising across the four tasks will also be highlighted.

Analysis in this work package will offer a better understanding of the accidents and suggest characteristics which can be targeted for remedial measures.

As in the other operational work packages, the analysis will be performed at three levels:
▪   Descriptive statistical analysis: the goal of this level is to identify the main problems and their magnitude related to accident causation. As this analysis will be performed separately for each type of situation, the specifications will be identified. The intention of the descriptive statistical analysis is to determine the situations where the likelihood of having an accident is high. The idea is to analyze the personal, technical and environmental conditions in which the accident happened in order to understand t the circumstances. It is hoped that a well-balanced description of the accident situation will be obtained among the different countries of the European Union, using several extensive accident databases. This picture is guaranteed by the link with WP8 "Data Supply".
▪   In-depth analysis: the main aim of this level is to obtain accident causes from the generic description of the problems identified in the previous level of the analysis. By looking at in-depth data, the nature of the problem can be understood. Then, if needed, the outcome can be projected back to the descriptive statistics by means of statistical methods (see WP7). As this WP is focused on types of situations, special attention will be paid to human behaviour analysis. The required methodology will be obtained from WP5 "Human factors". In-depth analysis should involve at least the following items (to be further developed in WP5):

    o Adoption of a general systemic approach: accident process considered as the result of interactions between the different elements (driver-vehicle-infrastructure).

    o Establishment of a list of all the relevant accident contributing factors, based on the earlier studies performed by the different participants, literature review, and WP3 'Types of factors'. This list should differentiate the factors from the human part of the system (e.g. psycho-physiological state, experience, etc.), the layout (visibility, complexity, etc.), traffic interaction (insertion into traffic flow, transgressions from others, etc.) and the vehicle.

- Risk analysis: the third level is dedicated to identifying the risk of being involved in an accident taking into account the results obtained from the 'in – depth' level, i.e. once accident causes have been identified. To perform these risk analysis for the different types of situations, it is necessary to use driver behaviour data. These data are by no means accident data and should be found, if available, in driver behaviour databases which will offer a quantification of the risk posed for a given type of scenario.

This report is dedicated to the in-depth and risk analysis. Its objectives are to give an update of the knowledge on the accident causation related to the situation point of view in order to identify and understand what are the problems met by the drivers just prior the accident. The innovative aspect brought in this analysis has been to integrate the analysis of the production of the driver functional failure in the situations covered in WP2.

The results providing by the descriptive analysis has been developed on a previous report (D2.1, 2007)

3.3 Expected final results

One of the most important expected results of WP2 is to define and give the distribution of "understandable/usable" scenarios related to the **<u>pre-accidental driving situation</u>** to which the driver/rider is confronted.

For each scenario we propose to:

- Describe the accident situation in real world and highlight the magnitude of the stakes through national databases.
- Identify the specific accident mechanisms and the main causes.
- Characterize each relevant situation by risk analysis indicator.

The overall outcomes will:

- Update diagnosis of road traffic safety in Europe
- Update knowledge of main accident causes
- Help for the evaluation of the effectiveness of existing safety devices
- Help for the determination of the most promising safety systems
- Help for the identification of the configurations not addressed by present technologies
- A base to create common indicators allowing to quantify the road safety performance and to identify the priorities at the European level but also individually per country.

Note : because the objective of WP8 (data supply) is not to produce a common database, but rather to gather available data coming from different countries answering the requests made by the operational work packages, the results will be a statistical estimation at the European level. Based on a methodology proposed by the WP7 (statistical methods), the confidence of these estimations depends on the representativeness of the available country data. Although the main indicators such as fatalities, casualties or injury accidents can be easily defined at EU-27 level, it is not the case for the relevant parameters describing the situations.

3.4   Main issues of the WP2

However, the analysis of the accident causes at the European level is not an easy task.

Firstly, analysis relies on the availability of different types of data: descriptive, in-depth and exposure.

The main issue is the access to common European data. Although some extensive databases exist (CARE, IRTAD, IRF, WHOSIS, etc.) the relevant information necessary for the WP2 analysis (from a situation perspective) is not available in the national databases but rather in the in-depth databases.

With regard to the use of the in-depth databases, even though they exist and include a large range of information from many different countries, they do not cover the whole European Union, may be oriented to a specific target (such EACS, MAIDS, ETAC, etc) and often have restricted access. This is why WP8 was set up, enabling the operational work packages to access data provided by TRACE partners.

Secondly, during data analysis, some statistical problems appear such as missing data, different levels of detail, harmonisation of the definitions, consistency and of course extension to the European level. TRACE WP7 (Statistical methods) covers this area and proposed a simple methodology to allow the extension to the EU-27.

Thirdly, an innovative idea proposed in TRACE is to focus the analysis, not only on accident causes, but also with the integration of a new concept developed in WP5, introducing human functional failure. One of the challenges of WP5 is to make this methodology comprehensive and usable by the operational work packages.

4   The in-depth accident causation analysis

The main objective of WP2 is to update knowledge on accident causation by considering the situation to which the driver/rider was confronted. Because there are many situations, four types was pre-determined: stabilized situations, intersection, specific manoeuvres and degradation scenarios.

To reach this target, the methodology proposed in TRACE and common to all operational work packages, is divided into three steps:

- ▪ The descriptive analysis. The objective is to use macro-accidentology (use of extensive databases) to characterise the different sample using general statistics. One of the findings is the identification of the main scenarios for each pre-defined situation types.

- ▪ The in-depth analysis. After the identification of the main scenarios, this analysis details them to provide information on:
  - o the accident mechanisms;
  - o the main causes, through relevant indicators, specific to the scenario (such as precipitating event, contributing factors, driver failures, etc.)

  This analysis requires the use of in-depth databases.

- ▪ The risk analysis. The objective is to identify the risk of being involved in an accident taking into account the results obtained from the 'in – depth' level.

The present report is based on the identification of the main causes related to the scenarios previously determined during the descriptive analysis for different pre-accidental driving situations.

This report is a complement of the first one. Only the main results providing by the general statistics are here recalled. For more details, we invite the reader to find them in report D2.1 (TRACE WP2 - D2.1, 2007)

4.1   The methodology

As seen before, the in-depth analysis is based on a micro-accidentology study, in other words on disaggregated accident data.

A lot is known about micro accidentology since researchers have been working in this area for several decades, both in the areas of accident causation and in passive safety. The basic method applied in micro accidentology is that the accident is studied in its chronology: The **driving phase**, which is, for the driver, a normal situation with no unexpected demands upon him. The **rupture phase**, that occurs when an unexpected event (or so-called precipitating event) turns the driving situation into an accident situation for which, suddenly, the demand to the driver exceeds his normal or acceptable ability to respond. The **emergency phase**, which covers the space and time between rupture and collision. And finally, the **crash phase** (e.g. impact, collision or roll over).

There are also many ways to analyze accidents and accident mechanisms. For example, LAB (F) developed its own accident analysis model in order to understand the production of the accidental situation. This model was inspired by previous work and especially those carried out by INRETS (F) at the beginning of the nineteen eighties in the south of France and identifies:
- The sequential description of the accident circumstances,
- The events that could have contributed to convert a driving situation into an accident situation,
- The nature of the driver functional failure (e.g. perception, comprehension, decision, action)and the mechanism of the human failure (e.g. driving errors, unavailability of information, under-activation to driving),
- An identification of manoeuvres carried out by the drivers and the trajectories of the vehicles.

- And finally the sequential correspondence between car kinematics parameters and human cognitive parameters, from the initial conflict situation to the impact. This is the final step of the accident analysis: its reconstruction.

The use of such a model has already produced interesting results. For example, INRETS has examined French in-depth accident data and has proposed to set a classification of accidents based on the production of human failure. The fundamental idea of this approach is to consider the human error not as a cause of the accident but rather as a consequence of malfunctions occurring in the interactions between the driver and his environment. Some causes of the error are considered to be internal to the driver whereas other causes are considered to be external. In this research, the error is exclusively studied, just before the accident situation, from the driver perspective. It could actually be argued that part of the cause of an accident could be nested within the organization of traffic, production of vehicles, individual proneness to be involved in accidents, economical context, urban management, or other complex multi-factorial factors.

We propose now to detail the different concepts that we will use in this analysis.

4.1.1   Accident sequences

A way of drawing up the accident scenario is to determine the sequence of events. These ones are divided into four phases, connected one to the others:

- **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 rupture phase***: the 'rupture' is an unexpected event that interrupts the driving situation by upsetting its balance and thus endangering the system.

- **The emergency phase***: it is the period during which the driver tries to return to the normal situation by carrying out an emergency manoeuvre.

- **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.
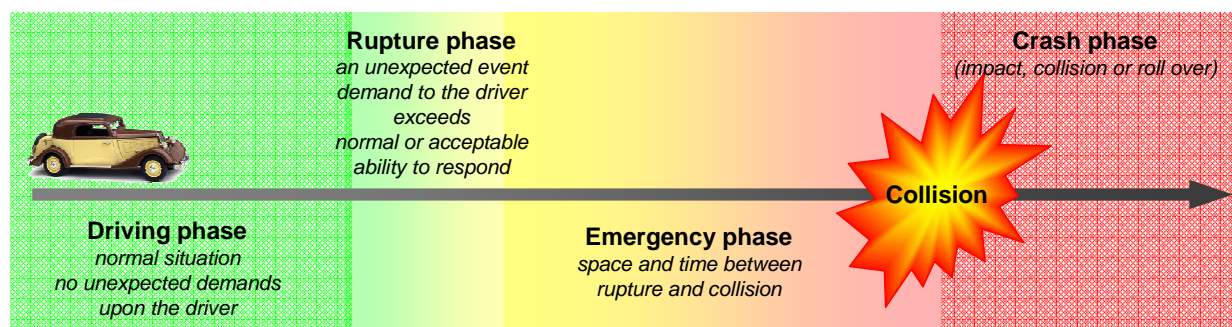
Figure 5: Accident view as a sequential event

Then, the in-depth analysis will focus on the rupture phase in which an event interrupted the driving situation. This event will be considered as the cause of the accident and it will be named "**Key event**". Moreover, we will consider too, all factors which contribute to convert a driving situation into an accident situation and which give any chance to the driver to convert an emergency situation into a driving situation. These factors will be named "**contributing factor**s".

The key event and the contributing factor are classified by categories and sub-categories and are the results of the literature review and the current data collection system (TRACE-WP5-D5.2, 2007).

The categories are defined as follow:
- Internal condition of the task: it is related to the task that the 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, the driver adopts a non adapted speed considering its driving situation).

- Driver behaviour: behaviour of the road user can affect the way they control their vehicle and respond to both their internal and external surroundings. This category refers to a problem of inattention, distraction or perception.

- Driver state: The 'state' of the user includes physical, physiological or psychological conditions, either pre-existing or brought on by substances taken, such as alcohol or drugs.

- Experience: The user's prior exposure to the task in hand or their surroundings will affect the way they process information. Experience can be related to the non experience of the situation or of the driving task or to the over experience of the driver.

- Road environment: it deals with factors linked to infrastructure such as a visibility limited by infrastructure or a road layout not adapted to the situation.

- Traffic condition: it refers to the conditions in which the user is driving. The flow, speed or density of the traffic on the road will potentially affect the road user's ability to undertake their journey

- Vehicle: This category involves the equipment or devices the user is interacting with in the task such as the maintenance of the vehicle, all mechanical or electro-mechanical problems or the load.

4.1.2   The driver functional failure

These failures are related to the functions that a driver must do in loops in order to ensure the driving task: perception, diagnostic, prognostic, decision, action. Of course, functions are not independent and can eventually be performed simultaneously.

Perception is related to the situation as a whole. There is a problem of perception whenever the driver did not perceive something that he should have perceived whatever the thing not perceived (opponent, road signs, information, danger, etc.). Actually, problem of perception does not exclusively mean lack of perception. It could also be a late perception or an incorrect perception. This last statement (late or incorrect) also holds for the other functional failures.

Diagnostic refers to the determination of values of parameters (distance to other vehicles, other vehicle speed, road width, curve radius…) that the driver needs to drive correctly and adapt his own trajectory and speed to its environment.

Prognostic refers to the comprehension process of the driving situation: once the situation is perceived and evaluated, is it correctly interpreted and anticipated? Here is an example of the articulation between evaluation and interpretation: let's say that a driver is driving up to a junction. He's got the right of way. He is looking at the secondary road as well and sees a vehicle on this road: he perceives the vehicle. He evaluates the speed of this vehicle. He feels like the vehicle is slowing down while coming to the stop sign. He interprets the situation as a normal situation: the other vehicle is slowing down. He could then make an interpretation failure by considering that the other driver is going to stop because he is slowing down whereas he is going to slide the stop without stopping.

Decision refers to a problem while perception, diagnostic and prognostic were correctly performed: once he has perceived, evaluated and interpreted, the driver can make a decision failure: he does not decide or decides incorrectly or decides too late what the situation requires from him. For example, he sees a bend, evaluate its radius and adherence, interprets it as risky but decides to slow down too late.

Action: needless to say: there is a problem in the action itself: for example, let us assume in the previous situation that he decides to slow down in time. He can brake hard instead of slowing down. This is an action failure.
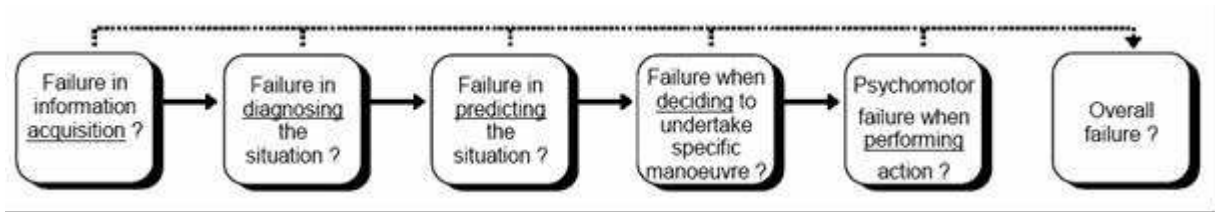
Figure 6: Human functional failure analysis

Human functional failures find explanation with "Explanatory elements" including endogenous elements related to the driver (state, behaviour, task) and exogenous elements related to the driver environment (traffic conditions, road, vehicle) as described below:
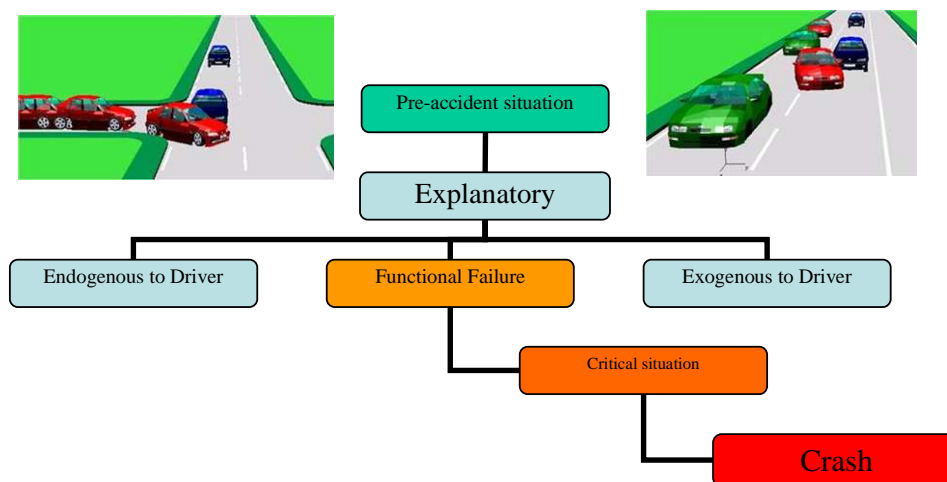
Figure 7: Human functional failure and explanatory elements

More details can be found in report TRACE-WP5-D5.1.

4.1.3   Degree of involvement of the driver

This analysis allows us to identify 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, this information tries 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.

- **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. 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. They are not considered as 'active' subjects because the information they had did not enable them to prevent the failure of others.

- ▪ **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.

This concept allows us to identify the Human Functional Failures and how we explain these failures with factors related to the driver or with factors related to his environment.

4.1.4   The scenarios

The last concept we widely used is the scenario concept. What is a scenario and why have we decided to base our survey on this concept?

This concept is based on the general idea to classify accidents into homogenous groups. Accidents are often classified according to a single criterion. For example, accidents can be distributed according to the collision type (head-on, rear-end, front-side, side-swipe, rollover), road geometry (crossing collisions at junctions, accidents on straight roads, loss of control in bends), vehicle configurations (single vehicle accidents, car-to-car collisions, collisions with obstacles, etc.) or even driving situations (overtaking, change of direction, loss of control, U-turn, left-turn, right-turn, parking accidents, etc.).

The accident scenario is determined upon a description and an analysis of the sequential process of the accident. The difficulty, in identifying prototypical accident scenarios, is to show the complexity of the event, the diversity of the circumstances and at the same time to achieve a certain level of generality.

According to the objectives of TRACE, we proposed to rely on a simple classification of accidents, based simultaneously

- on road profile (intersection / no intersection),
- type of manoeuvre
- and type of collision.

The main accident configurations are illustrated by so-called accident pictograms. Actually, we were interested in accidents but also in accidental situations.

The difference between the accident and an accidental situation is the following: the accidental situation is tied to a couple driver-vehicle. In a single vehicle accident, there is only one situation corresponding to the situation faced by the only involved driver. In a car-to-car collision, there are two accidental situations (Case vehicle situation CV and Opponent vehicle situation OV) because there are two opponents and the two opponents are confronted to different situations. For example in a crossing accident at a junction, the first situation corresponds to the user who is pulling out of the intersection after stopping at a stop sign (OV) and the second situation corresponds to the driver with right of way who has to cope with a sudden secant vehicle (CV). And of course safety functions corresponding to either one or the other involved road user might be completely different. Consequently, the classification aims at identifying or evaluating safety functions should separate the two situations. This is the reason why, apart from the traditional classification, we also choose to build a classification of accidental situations rather than a classification of accidents.

Despite the fact we have classified through the European data the accidents in scenario gathering the situation of the CV (always a passenger car) and the situation of the OV having or not the right of way, the in-depth analysis showed us that it is more relevant to compare the drivers having the right of way to the drivers having not the right of way. So, in the part devoted to the accident causes or factors, we will compare the causes, Human Functional Failures in this two user groups.

This concept allows us to cluster the accidents and so the problem into common scenarios with similar causes and similar events leading to the crash.

5   Stabilized situation

The objective of this section is to analyze configurations from traffic accidents in situations called '**stabilized situation**', in order to identify and quantify what are the main causes and human functional failures for each of them.

Instead considering the problem in its global nature, the idea is to split into relevant scenarios the majority of the stabilized situations at the macroscopic level, and then to identify the causes and the contributing factors with detailed information. With this approach, the difficulty is to classify the situations into clusters enough small to dread differences but big enough to avoid a too large variety of scenarios containing only a very weak number of individual. Each class is formed by situations presenting resemblances either in its genesis or in its progress.

The analysis of this type of configuration can help to understand why some accidents occur in these situations, and what kind of help (in term of safety device) could be useful for the driver in the stabilized situation either to avoid the accident or to mitigate the injuries. It is important to remark that accident studies through this view must be understood firstly, in the specific point that in one accident can coincide with different type of accident situations (one situation for each vehicle involved).

To achieve the target, it has been decided to set up a common methodology based on the following three steps:

- A **descriptive analysis** to detect what are the most relevant accident configurations related to the studied situation from aggregated databases.

- An **in-depth analysis** to have a better understanding on what happen in the main scenarios previously identified. This step allows identifying the main causes and human functional failures from detailed analysis of each configuration based on in-depth databases.

- A **risk analysis** to identify the main risk factors related to the studied situation.

This part shows the results of the second and third step of the methodology, based on the in-depth and risk analysis. It is composed of the following sections:

- Main results obtained from the first part of the methodology (showed in the 'Deliverable 2.1: Accident causation and pre-accidental driving situations. Part 1. Overview and general statistics').

  These results are based on the identification of the most important scenarios, and their characterization from descriptive parameters available in aggregated databases. After this recall to main configurations, new analyses will be done over accidents belonging to these configurations but using, in this new step, in-depth and exposure databases.

- Accident causation and risk factors analysis.

  For each one of the stabilized scenarios detected, analyses done over accident causation and risk factors will show the results regarding in-depth analysis (concerning causes, risk factors and human function failures).

- Conclusions

  After obtaining a better understanding of how the accidents happen, which the main causes are, which factors can increase the risk of being involved in an accident, the conclusions will be focus on knowing, for instance, how this information can be used, the main difficulties, the main strengths of this study,….

A **stabilized situation** can be defined as a normal driving situation in which a driver (from any kind of vehicle involved in injury accident) does not have any difficulty in the driving task, without any particular or abnormal solicitation. Accidents in intersection and situations in which the driver make a specific manoeuvre (such as turning, u-turning, overtaking, changing lane, etc.) are excluded. The subsequent accident situation may be due to either internal or external events. All driving actions

made by the driver to follow his way without any change in direction or in lane are included in the stabilized situation.

To avoid complexity, only passenger car being in stabilized situation (as define previously) are included in this study. Therefore, a stabilized situation could be defined by the following criteria:

- Location : out of intersection
- Vehicle : at least one passenger car in the accident
- Driver' manoeuvres : no specific (not overtaking, not turning, not u-turning, …)

5.1   Overview and general statistics

The next figure shows an overview of the stabilized situations:
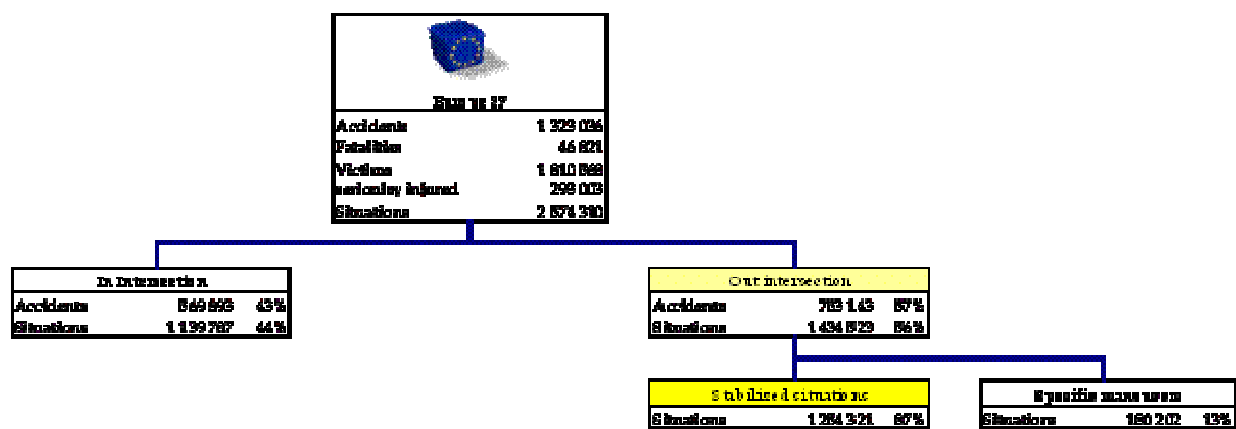
Figure 8: Distribution of stabilized situations in EU-27
(year 2004, Sources CARE, IRF, IRTAD, National Statistics Databanks)

Related to the severity associated to this kind of situations, a range between 50% and 60% of all the fatalities occurred in a stabilized situation (TRACE survey 2006-2007). In the stabilized accidents, the percentage of fatal stabilized accidents is close to 7%, while the percentage of serious and slight stabilized accidents is 28% and 65%, respectively.

The main results obtained in the report TRACE-WP2-D2.1 are related with the main configurations (scenarios) that are going to be analysed in different ways with the aim of gathering the purpose of this WP2. The 'final stabilized scenarios' are:

- **Situation 1:** A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian. For a better understanding of why these accidents happen, this scenario will be divided in the 3 following sub-scenarios:

Situation 1.a ('Pedestrian crossing from left'): A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a **pedestrian crossing from left**. The following figure shows this situation

Situation 1.b ('Pedestrian crossing from right'): A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a **pedestrian crossing from right**. This situation is shown in the following figure.

Situation 1.c ('Pedestrian moving along the road on right side'): A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a **pedestrian moving along the road on right side**.

- **Situation 2:** A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident. This configuration can be divided into 3 sub-scenarios:

Situation 2.a ('Lane departure'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a **lane departure** with an initial loss of control.
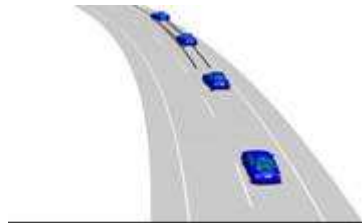
Situation 2.b ('Run-off accident to the left'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a **run-off accident to the left**.

Situation 2.c ('Run-off accident to the right'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a **run-off accident to the right**.

- **Situation 3:** A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. It can be divided into the 5 sub-scenarios:

Situation 3.a ('Reduction of driving space due to opponent overtaking'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver (blue car in the following figure) was performing a normal driving. The driver is confronted to a vehicle (called 'opponent vehicle') which is **reducing his driving space** (the **opponent vehicle is overtaking** in the following figure is the red car).
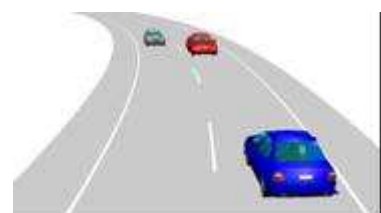
Situation 3.b ('Reduction of driving space due to opponent loss of control'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver (blue car in the following figure) was performing a normal driving. The driver is confronted to a vehicle (the 'opponent vehicle') which is **reducing his driving space** (the **opponent vehicle is under loss of control** in the following figure is the red car). As it can be seen in the following figure, this situation is very different to situation 3.a.
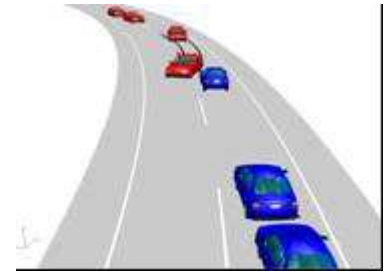
Situation 3.c ('Same lane but the opponent is stopped'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver (blue car in the following figure) was performing a normal driving. The driver confronted to a vehicle (this is the 'opponent vehicle' which is in grey colour in the figure) is in front of him, in the **same lane but the opponent vehicle is stopped**.

In this figure, two stabilized situation are shown. At a first place, stabilized situation 3.c can be shown if the focus is over blue and grey cars; but as it will be explained, another stabilized situation (3.e) is shown if the focus now is over red and blue car.
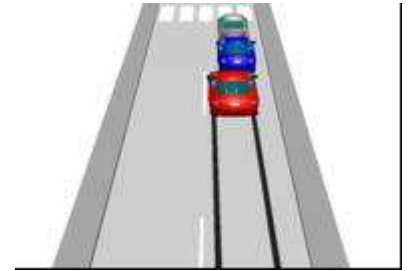
Situation 3.d ('Same lane but the opponent is with lower speed'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This stabilized driver (the blue car in the figure above) was performing a normal driving. The driver confronted to a vehicle (this is 'opponent vehicle', which is in red colour) which is in front of him, in the **same lane but the opponent vehicle was with a lower speed**. The following figure can explain better this situation.

Situation 3.e ('Same lane but the opponent is coming rear'): The stabilized driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver was performing a normal driving. The driver (blue car) confronted by **other vehicle coming rear** (red car). It can be established a comparison between situation 3.b, 3.c and 3.f, but as it can be seen the main difference is the position of the stabilized vehicle (the blue car).

- **Situation 4:** a driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver had to perform an emergency manoeuvre in order to avoid an obstacle or a vehicle.
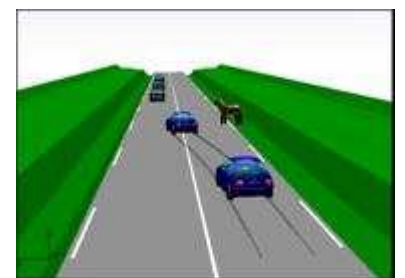
Although these four 'stabilized situations' are the main ones, the first three scenarios will be the final scenarios to be analysed in this report, covering near 80% of the fatalities occurred in stabilized situations and 70% of the casualties. The focus on only the three most common stabilized situations will not move away the gathering of the initial objectives because the majority of these accidents are covered (the three first scenarios were selected in order to assure data suppliers did not apply the difficult criteria related to this fourth scenario).

The achievement of these challenges has implied the obtaining of the expected output in this deliverable:

- Identify the specific accident mechanism and the main issues from each road user accidents. To obtain a pictogram or a figure of each road user allowing to understand these accident mechanisms.
- Understanding the main accident configurations from each road user point of view will help for:
    - The evaluation of the effectiveness of existing safety devices.
    - The determination of the most promising safety systems.
    - The identification of the configurations not addressed by present technologies.

5.2 Identification of the accident causes

In this chapter, as it has been mentioned, the causation of traffic stabilized accidents will be analyzed as well as risk factors associated to each scenario. The achievement of these challenges will imply the obtaining of the expected output in this deliverable:

- Identify the specific accident mechanism and the main issues from each road user accidents. To obtain a pictogram or a figure of each road user allowing to understand these accident mechanisms.
- Understanding the main accident configurations from each road user point of view will help for:
    - The evaluation of the effectiveness of existing safety devices.
    - The determination of the most promising safety systems.
    - The identification of the configurations not addressed by present technologies.

Although the general methodology has been explained in the general chapters of this report, it is suitable to provide some clarifications related to the way of obtaining the information.

The way of working during this task has been different to the majority of TRACE analysts. Instead of asking for 'aggregated' specific tables (queries) to all the 'in-depth suppliers' from Work Package 8 (Data Supply), Task 2.1 asked for '**disaggregated**' information from each accident. The main reason to ask for data in this way is due to assess what is the relative risk of specific factors. As there is not exposure data available, we cannot assess absolute risk once that we have defined specific scenarios or situations. Therefore, for stabilized situations analyses, a special request was sent to partners from WP8 with the aim of obtaining specific variables for each of the stabilized accidents they had in their own 'in-depth' databases. Finally, a complex matrix (variables in columns and accidents in rows, without any confidential data) was obtained from WP8 for the respective accident causation and risk analysis for each stabilized sub-scenario. Two out of the six partners that supplied in-depth information in this task were only able to give this information in an aggregated way, so also a special request was sent to these partners to obtain this information from their databases.

For stabilized situation the following 'in-depth' databases have been used: OTS (UK), EDA (FR), SISS (IT) and DIANA (SP).
Information asked in the respective requests was related to the following aspects:

- ✓ **Causation factors** from the stabilized vehicle and opponent point of view. It is important to mention that this division it was taken into account with the final aim of knowing the mechanism of the accident from each driver. If several vehicles were involved in the accident, the analyses have been focused on the stabilized and the opponent vehicle.
- ✓ Variables related to '**precipitating events**' before the accident, taking also into account if it is concerned the stabilized vehicle or the opponent.
- ✓ Variables related to '**Human Function Failure**' (based on the codification used in the 'Work Package 5').
- ✓ Other aspects (severity, type or road, weather, lighting, alignment, experience, gender …).

The first three issues ('Causation factors', 'Precipitating events' and 'Human Function Failures') were asked with the aim of a better understanding of accident causation. Of course, it is rather unusual being able to establish the only cause of an accident, because of an accident may be due to several concurrent factors. Nevertheless, it is important to mention that what the Work Package 2 is trying to analyse is the situation in which the driver was confronted and not the whole accident. Most of the study on accident causation analyse the accident and not the different causes (even there are not important) that could be relied to each participant. Therefore, the most important subject is to understand that through the analyses of these situations, WP2 will focus on the stabilized driver (task 2.1) for a better understanding of the problem and to have an idea of what and how WP2 can help him.

The 'other aspects' requested were asked with the objective of estimating the risk factors in stabilized accidents. The way of obtaining this information allows doing the risk analysis using statistical methods provided by the 'Work Package 7'. The results to be obtained after this risk analyses will let to know which variables (factors) are related to each accident causation detected in every one of the stabilized scenarios. The final conclusion about these analyses will be:

'In the case of a stabilized accident happened due to specific accident causation, the factors directly related with this accident causation would have been detected. Therefore, it could be affirmed that if one of these risk factors exist, the probability of that specific accident causation is the cause of the accident in this accident is higher'

5.2.1   General stabilized situations

The first analyses over information from 'in-depth' databases will be related to the three general stabilized situation described previously as the main three situations to be studied in a deeper way. Although the accident mechanism and causation will be the expected output in this chapter, it has been detected that it is very difficult to generalize the dynamic of the accident in each situation because of the differences between the sub-scenarios.

For each specific stabilized scenario detected in the descriptive analysis (TRACE-WP2-D2.1), the main and striking results are going to be detailed from the in-depth, risk and human failure analyses. As it can be seen, the idea during this workpackage (for all the tasks) has been to go deeply in the understanding of (mainly) why the accident happens (from each type of situation point of view) and what are the accident causes. Although three main stabilized scenarios had been selected, the information from them is very diverse to be considered in a whole way.

The way of showing the main results will be directly related to the objectives of the present deliverable, this means:

- For each sub-scenario, the main mechanisms of the accident will be given, as well as the main accident causation.

- Once the main accident causations have been detected, a risk analysis will offer which factors are the most frequent related to each accident cause. This means that, once an accident has happened and a specific cause has been involved, the factors related with this cause will be determined, so in case a new accident happen and these risk factors exist, it will be more likely the accident causation is the specific one for which these risk factors have been determined.

- Finally, analyses over possible 'Human Function Failures' have been done using the methodology explained in 'Work Package 5: Human Factor'('Deliverable D5.3-Typical human functional failure-generating scenarios: a way of aggregation'). Through this methodology, human behaviour (from its failure point of view) is going to be analysed to detect which possible failures were associated to each accident scenario. This is an added value because it is possible to know which kind of typical human failures are committed in the stabilized situations and therefore, help to define appropriate countermeasures.

- The possible options related to human failures are as follow in the following tables:

Typical human functional failure scenarios at the information detection stage		
P1 Failure - Non-detection in visibility constraints conditions		
	P1C	Road user surprised by a pedestrian or a two-wheeler non-visible when approaching
	P1D	Driver surprised by the manoeuvre of a non-visible approaching vehicle
P2 Failure - Information acquisition focused on a partial component of the situation		
	P2A	Focalisation on a directional problem
	P2B	Focalisation towards a source of information as a function of driver's layout representation
	P2C	Focalisation towards a source of information regarding the importance of the traffic flow
	P2D	Focalisation towards an identified source of danger
P3 Failure - Cursory or hurried information acquisition		
	P3A	Cursory search for information while turning on the left (on the right for left driving countries)
	P3B	Cursory search for information while crossing intersection
P4 Failure - Momentary interruption in information acquisition activity		
	P4A	Non-detection of the rapprochement from the vehicle ahead
P5 Failure - Neglecting the need to search for information		
	P5A	Late detection of the slowing down of the vehicle ahead
	P5B	Late detection of a non-priority road user starting manoeuvre in intersection

Typical human functional failure scenarios at the information diagnostic stage		
T1 Failure - Erroneous evaluation of a passing road difficulty		
	T1B	Under evaluation of the difficulty of an although known bend
	T1C	Erroneous evaluation of a bend difficulty in a context of playful-driving
T2 Failure - Erroneous evaluation of a gap size		
	T2B	Erroneous evaluation of a merging gap connected to the low attention paid to the manoeuvre
T3 Failure - Mistaken understanding of how a site functions		
	T3A	Mistaken understanding leading to a stopping failure in intersection
T4 Failure - Mistaken understanding of another user's manoeuvre		
	T4B	Mistaken understanding of the other's manoeuvre related to the polysemy of their signals
	T4C	Mistaken understanding of other's manoeuvre related to cursory processing of the interaction

Typical human functional failure scenarios at the prognostic stage		
T5 Failure - Expecting another user not to perform a manoeuvre		
	T5A	Expecting a non priority vehicle not to undertake a manoeuvre in intersection
T6 Failure - Actively expecting another user to take regulating action		
	T6B	Erroneous expectation of the stopping of a non priority vehicle approaching intersection
	T6C	Erroneous expectation of the stopping of a non priority vehicle coming on the trajectory
T7 Failure - Expecting no perturbation ahead		
	T7A	Expecting no vehicle ahead in a bend with no visibility

Typical human functional failure scenarios at the handling stage		
E1 Failure - Poor control of an external disruption		
	E1A	Sudden encounter of an external disruption
	E1B	Sudden encounter of an external disruption, more or less expectable
E2 Failure - Guidance problem		
	E2A	Guidance interruption consequently to attention orientation towards a secondary task
	E2B	Guidance interruption consequently to attention impairment

Typical overall human functional failure scenarios		
G1 Failure - Loss of psycho-physiological capacities		
	G1A	Loss of psycho-physiological capacities consequently to a falling asleep or ill-health
G2 Failure – Alteration of sensorimotor and cognitive capacities		
	G2A	Alteration of trajectory negotiation capacities
	G2B	Alteration of guidance capacities
G3 Failure - Overstretching cognitive capacities		
	G3A	Overstretching processing capacities in traffic interaction situation

Table 1.-Typical human functional failure scenarios at the information detection stage

It is important to say that it has been not possible to find exposure data related to stabilized situations, because too many hypotheses should be taken into account with the available data for TRACE project to be considered as stabilized exposure data (for instance, not all the vehicles belonging to the 'park' are in stabilized situations or not all the number of kilometres-vehicle could be considered as stabilized data).

For the analyses of accident causation and risk, 1,760 stabilized accidents were gathered from the in-depth databases available to this task (showed in the next figure). The distribution of these stabilized accidents is:
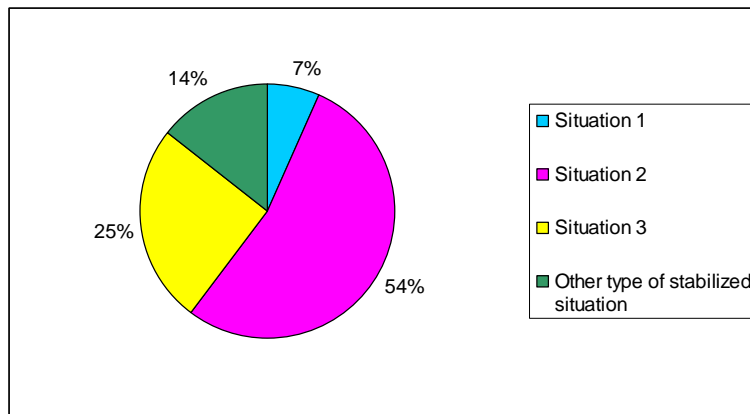
Figure 9: Distribution of accidents within the sample according to situations.

As it can be seen in the figure above, the study of the three situations selected covered 86% of all data sample accidents, being the situation 2 the most common of the stabilized situations (it accumulates more than 50% of the accidents).

5.2.2   Situation 1

A driver (red arrow), not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian.
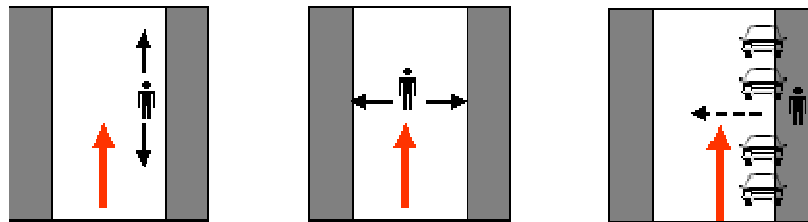
Figure 10: Type of configurations of the scenario related to 'Situation 1'.

The objective is not to analyse pedestrian accident configuration but the specific stabilized situations of the driver described here confronted to a pedestrian. For more details about pedestrian accidents, we invite the reader to refer to the report TRACE-WP1- D1.1 and TRACE-WP1-D1.2.

The number of accidents analysed related to this scenario was 117 cases (this means, 7% of all the stabilized situations), being almost 80% of them came from pedestrians crossing the road (situations 1a and 1b) as it can be showed in the figure below.
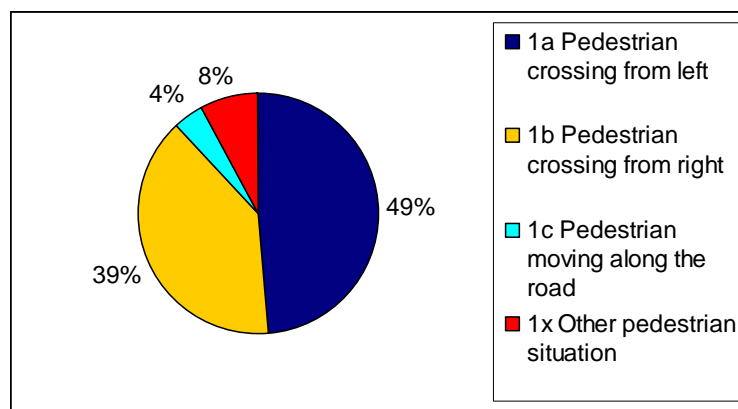
Figure 11: Distribution of stabilized accidents with pedestrian involved (Stabilized Situation 1).

The general analyses over these accidents can show us that these accidents happen in urban areas (65%), single carriageway roads (66%), in a straight section (69%) and during good weather (73%) and

daylight conditions (50%)[9]. Through the 'in-depth' analysis was possible to identified that the majority of these accidents were due to a pedestrian action, been 'to invade or cross the road illegally' the most common one.

It has to be considered that these accidents do no happen in intersections, so the scenario (as it has been said before) is a straight section. The mechanism of the accident could be as follows:

'A passenger car collides with a pedestrian (male in near 70%) who failed to look in the moment of crossing (low level of attention) and also crossed or invaded the road in an illegal way. This interpretation means that the pedestrian tried to cross the road in a place where there was not pedestrian cross, of course. At this moment, an experienced passenger driver collides with the pedestrian '.

This is the most common configuration for accidents belonging stabilized situation 1. Related to passenger car behaviour, it has been studied that in only 25% of accidents, it can be said that the driver was the guilty, specially due to the driver did not recognize the pedestrian (low level of attention of the driver) or even when the driver wanted to brake, it was too late because of the high speed of the driver'.

The real deep analysis over the mechanisms of the accident, the accident causation and the risk analyses were done over the following sub-scenarios.

5.2.2.*a*   Situation 1.a ('Pedestrian crossing from left')

This kind of accidents represents almost half of the pedestrian situation accidents. Some general characteristics are: The accidents happen in urban areas (61%), in single carriageway roads (67%), with good weather (72%) and good lighting conditions (daylight 51%) and curiously in a straight section road (65%). In most of the occasions the driver was a male with a high experience (more then 5 years driving).

The analyses performed over the in-depth databases available to this task shows that the main accident causation was a pedestrian error (61%), being 'recognition error' and 'to invade or cross the road illegally' the most common.

During the analysis of the Human Function Failures (HFF), the HFF analysis was applied over the accidents belonging to this situation. Confirming the mechanism of these accident, the most common failure found in these accidents was related to the perception, 'Non detection in visibility constraint detection' (P1), specifically, the passenger car driver was surprised by the pedestrian (P1C) non visible when the car is approaching.

Also, it has been found that the pedestrian crossed not obeying the rules, so the most possible configuration of accident could be a pedestrian, non visible by other vehicle, was knocked down whilst the pedestrian was crossing the road illegally (there was not pedestrian cross).

Two main causation factors have been identified as prevalent for this sub-scenario:
- The pedestrian is crossing the carriageway not obeying traffic rules.
- There is a recognition error made by the pedestrian.

Indeed, after analysing the correlation between both factors they show a relevant relationship ($r = 0.707$, p-value = 0.01). This can be explained by the fact that the pedestrian is crossing the carriageway illegally because he falls on a recognition error analysing the traffic situation. This error might be caused, under the knowledge of the authors, either by the road infrastructure, the misjudgement of oncoming vehicle speed or even because the pedestrian "did not look twice".

The logistic regression analysis has shown that this sub-situation is more likely to happen on straight section that on curves (Odds Ratio (OR) = 2.5; p – value = 0.05). This means, the probability of happening in a straight section is 2.5 than happening in curve sections (150% higher).

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[9] All these percentages are calculated including the category 'unknown'.

5.2.2.b   **Situation 1.b ('Pedestrian crossing from right')**

This situation gathers 46 cases. The characteristics of these accidents are quite similar to the previous situation ones: Male driver with more than 10 years of driving experience, driving along a straight stretch in an urban area under good weather conditions and daylight.

The Human function failures detected were 'P1C' (Passenger car driver surprised by a pedestrian non-visible when approaching' in 65% of the occasions and 'P2C' (Passenger car focalisation towards a source of information regarding the importance of the traffic flow) in 20%. This means that in these accidents, the passenger car driver was surprised by the pedestrian in visibility constraint conditions and also, the passenger car driver was focalising towards a source of information regarding the importance of traffic flow. Of course, there is a perception problem in this situation due, linked mainly to the surprising pedestrian way of crossing. According to the previous circumstances and the causation factors explained below, these accidents seem to happen when a pedestrian was trying to cross the road illegally (out of a pedestrian cross) made a recognition error due to low level of attention and got knock down by another vehicle which could not see the pedestrian on time due to visibility limitation (trees, road layout, parked cars…). As it can be understood, this is very important finding because here a possible detection device will not be able to help the driver, except if the device could detect the pedestrian after these visibility limitation. In this case, three causation factors have been found as relevant:

- PEDESTRIAN ERROR:
  - The pedestrian is crossing the carriageway not obeying traffic rules.
  - There is a recognition error made by the pedestrian.
- PEDESTRIAN STATE:
  - Low level of attention

In the case of pedestrian error, the situation is similar to 1.a, this means, the pedestrian is crossing the carriageway illegally because he falls on a recognition error analysing the traffic situation. In this case the correlation showed to be even stronger ($r = 0.901$, $p – value = 0.01$).

From the logistic regressions done, it was concluded that 'Pedestrian gender' can be considered as risk factor. In this way, in the cases the accident causation had been due to invade or cross the road illegally, it is more likely for male pedestrians ($OR = 3.6$; $p – value = 0.05$).

The pedestrian error also appeared to be more likely for male pedestrians ($OR = 2.8$; $p – value = 0.05$).

When the accident was mainly caused due to a low level of attention, it has been found that this causation factor is more likely to appear in curve sections than in straight roads ($OR = 2.3$; $p – value = 0.05$). Visibility obstructions caused either by the road infrastructure or other vehicles are deemed to be linked to this issue.

5.2.2.c   **Situation 1.c ('Pedestrian moving along the road on right side')**

Not many accidents of this type were registered on the in-depth database (only 5 cases, this 4% of situations type 1). For the few accidents found, the most common HFF found is that the passenger driver is G2A 'Alteration of trajectory negotiation capacities'. Due to the lack of this type of accidents, is difficult to describe the prototypical motions of the pedestrians and the other vehicles, as well as concerning risk analyses, there were not enough data available to do the analyses.

A comparison between the results from in-depth and risk analysis in stabilized situations in scenario '2' and the results from the literature review in D2.1 shows:

- ✓ Literature review showed that, for urban scenarios, young as well as the elderly people are more likely to be involved in fatal pedestrians, but no information about this has been obtained from the in-depth analyses.
- ✓ Literature review showed that pedestrians were probably struck while crossing a roadway either not in a crosswalk or where no crosswalk existed. This conclusion was the same as analysis over situation 1.a and 1.b, 'pedestrians were crossing the carriageway not obeying traffic rules'.
- ✓ Literature review showed that for rural scenarios, the pedestrians were attempting to cross two-lane highways that were controlled by neither stop signs nor traffic signals (it is supposed the vehicle was travelling without doing any manoeuvre, so these are stabilized situations). Variables that significantly influenced pedestrian injury severity were clear roadway width, pedestrian age 65 years and older and pedestrian alcohol involvement. This conclusion was also obtained in the

TRACE in-depth analyses, specially because he falls on a recognition error analysing the traffic situation.

Of course, new findings have been brought up from TRACE analyses that other studies (Literature review) does not give us, as it has been showed during the description of this scenario.

5.2.3   Situation 2

A driver (red narrow), not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident.
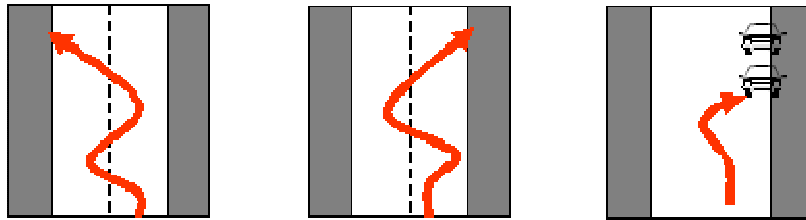
Figure 12: Type of configurations of the scenario related to 'Situation 2'.

This is the most common situation in the sample from the information requested to In-depth suppliers. 920 cases were gathered, which represents 54% of all the stabilized accidents analyzed.
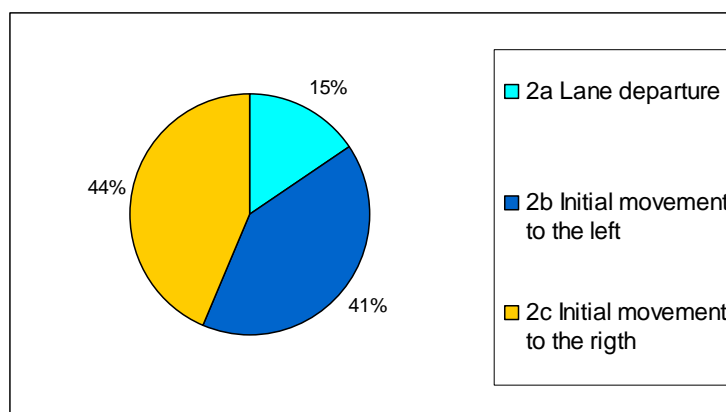
Figure 13: Distribution of stabilized lane departure or-run off accidents (Stabilized Situation 2).

The accidents belong this situation were in single carriageway roads (68%) and outside urban area (68%). Although the visibility was good (good weather and daylight conditions), the driver (male) is involved in a lane departure or run-off in straight sections (most of the occasions) or slight curves, impacting against a part of the road infrastructure. Through the 'in-depth' queries requested, it is possible to know the origin of the cause: infrastructure, human behaviour or environment.

In this kind of accidents where the only character is the passenger car, it could be easy to say that all the possible accident causations come from the driver, but the 'in-depth analyses' over data from WP8 can offer the following picture:

'In most of the accidents, the driver was travelling under high speed conditions (in the slight curves) and low level of attention (in the straight sections). Nevertheless when the focus is over accident causation, it can be saw that the traffic conditions can be selected also as causes in near 50% of the accidents'.

In these last mentioned situations in which the traffic conditions are considered as causation factors (these are the 50% of the accidents), the passenger car goes over the section road when suddenly it finds a problematic situation in which, mainly, the road surface in not too enough or the road design does not allow to suppose what the driver is going t o find (for example, the driver find a more narrow road).

Anyway, knowing that the most common cause in this type of accidents is the driver behaviour (of course from the only driver involved), especially 'excessive speed', 'decision error' and 'alcohol impairment' (the greater percentage of cases where alcohol was present are in scenario 2a and urban areas). Although the driver can find a bad road condition due to aspects like rain or drizzle weather especially in scenarios 2b and 2c, these situations could be lower influential if the speed was adequate to traffic and environmental circumstances. At the end, in 3 out 4 of these accidents, human behaviour was the reason of the collision, being the speed and way of driving the main causes. Related to behaviour, it is important to say that alcohol was present in more than 5% of accidents.

5.2.3.*a*   Situation 2.a ('Lane departure')

The majority of these accidents occurred under good weather conditions (71%) but there is a significant percentage of accidents which happened whilst it was drizzle (13%). Some common characteristics are that most of them were on a single carriageway road and with daylight.

Attending to the information displayed, these accidents could happen when a driver, sometimes under alcohol consumption, was driving speeding and confront a complex site as a bend with a small radius.

Other possible typical could be when the driver loses the control due to the slide surface even when it was expectable under drizzle weather.

In these accidents, what the passenger car driver did related his failure was T1C ('The passenger car driver has an erroneous evaluation of the bend in a context of playing-driving') in more than 50%. This means that this is a human failure directly related to the diagnostic stage when the passenger car driver did not evaluate correctly the passing road difficulty, specifically, at the moment of negotiating a bend in a context of playful-driving, curiously. Another aspect to be considered for the human behaviour was that in 10% of the occasions, the driver sudden encountered of an external disruption, although it was more or less expectable. This last consideration can agree with the fact that the driver find some external modifications of the road (curve radius, narrow road,…).

Four accident causation factors have been found relevant, not showing a correlation between them after performing the correlation analysis (p-value = 0.05):

- PASSENGER CAR ERROR:
  - Erratic action: speeding (16%). All accidents happened in single carriageway roads, being increased the probability for this causation factor in sharp curves (OR = 4.87 compared to soft curves and 11.36 compared to straight, p – value = 0.05).

  - Decision error (14%). For this causation factor not relevant results have been found in the logistic regression analysis. From a descriptive point of, view, most of the accidents happened urban area under good weather conditions. Taking into account 'cross-tables' in the statistical analyses, urban area is 4.24 time more than rural area and straight alignment is 4.84 times more than curve

- PASSENGER CAR STATE:
  - Alcohol impairment (14%). Urban area (OR = 2.26, p – value = 0.05) and male driver (OR = 4.18, p – value = 0.05) appeared as factors increasing the risk for being causation factor of being present.

- PASSENGER CAR TRAFFIC: In this case, the causation factor is related to the environment around the passenger car which runs off.
  - Environmental perturbation (loss of adherence such as ice, aquaplaning, oil, snow…, 22%). Factors that increase the probability of having this causation factor are a single carriageway road (OR = 2.87, p – value = 0.05 compared to double carriageway), sharp bend (OR = 4 compared to soft curves and 11.76 compared to straight, p – value = 0.05), male driver (OR = 2.32, p – value = 0.05) and bad conditions (OR= 4.07, p – value = 0.05 compared to good weather).

5.2.3.b   Situation 2.b ('Run-off accident to the left')

These accidents happen outside urban areas (68%), with good weather conditions (79%), half of them with daylight but also a high percentage (36%) at night.

A description of how these accidents occurred could be: male driving at night in with a low level of attention due to the road layout (accidents in double carriageway road 29%) or a secondary task when confront a sharp bend.

Other possible explanation of this type of accidents is a driver confronting a bend loses the control due a recognition error by excessive speed and/or bad weather conditions.

The most common human function found in the WP5 analyses over the accidents from this scenario show that there are two main HFF:

- The first one is related the low level of attention the driver had during the driving task, therefore, 'E2A' (Guidance interruption consequently to attention orientation towards a secondary task) has been chosen as the first function failure of the driver (20% of the accidents in this situation '2b'). This HFF shows as the driver had a guidance problem at the handling stage. To be more concrete, he had a guidance interruption consequently to attention orientation towards a secondary task (different to driving task, of course). This failure can be applied to run-offs in curve and straight sections.

- The second failure concerns only to bends. In these accidents, the driver evaluated in an erroneous way the passing road difficulty. 'T1B' ('Erroneous evaluation of a passing road difficulty, specifically, under evaluation of the evaluation of an although known bend') This failure at the information diagnostic stage gives the understanding of what happened, the driver knew the bend where he was travelling, but a bad evaluation of the bend was the driver failure (also, 20% of the accidents in this situation '2b').

Four accident causation factors have been found relevant:

- PASSENGER CAR ERROR:
  - Speeding (38%). This causation factor showed to be more likely when the following factors are present; single carriageway (OR = 2.68, p – value = 0.05), bad weather conditions (OR = 2.93, p – value = 0.05), sharp curves (OR = 4 compared to soft curves and 11.76 compared to straight, p – value = 0.05) and male driver (OR = 2.32, p – value = 0.05).

  - Decision error (22%). In this case, there are more probabilities to commit a decision error at night time (OR = 1.53 compared to twilight and 1.72 compared to daylight, p – value = 0.05) and sharp curve (OR = 1.60 compared to soft curve and 3.97 compared to straight sections, p – value = 0.05).

- PASSENGER CAR STATE:
  - Alcohol impairment (15%). Urban area (OR = 2.23, p – value = 0.05) has been shown as the only factor increasing significantly from the statistical point of view the probability for this causation factor of being present at the accident.

- PASSENGER CAR ENVIRONMENT:
  - Complex site, difficult site, narrow road (16%). This causation mechanism is more likely outside urban area (OR = 3, p – value = 0.05) and in sharp curves (OR = 5.74 compared to soft curves and 50 compared to straight sections, p – value = 0.05).

The variables speeding, decision error and complex site showed some correlation (r = 0,305 & 0,393, p – value = 0,01). This might be explained by some situations where the road infrastructure layout do not transmit the driver a transition from a long distance along a straight section to a sharp curve, causing this an error in the driver evaluating the speed at he is able to handle the bend.

5.2.3.c   Situation 2.c ('Run-off accident to the right')

This situation is practically equal to the previous one. Run off accidents which occurred outside urban areas (70%), with good weather conditions (79%) in a single carriageway (67%).

These accidents seem to happen when a male driving in a single carriageway road confront a slight or normal bend with a low level of attention or attending to a secondary task is surprised by the site because is more complex of what he thought.

As the previous situation, other possible explanation of this type of accidents is a driver confronting a sharp bend at night in a single carriageway loses the control due to inadequate speed and/or bad weather conditions.

In this case, the HFF chosen are the same as the previous scenario, but in different percentages:

- The most common HFF detected in this scenario was a human failure at the handling stage, specifically 'E2A' ('Guidance problem due to a guidance interruption consequently to attention orientation towards a secondary task') in 30% of the accidents in this situation '2b'. What means that the driver had a guidance interruption consequently to attention orientation towards a secondary task. As it can be supposed, this failure can be applied to run-offs in curve and straight sections.

- The second failure (although only present in 10% of the accidents) concerns only to bends. In these accidents, the driver knew the bend where he was travelling, but a bad evaluation of the bend was the driver failure ('T1B', this is a failure at the diagnostic stage, specifically called 'Erroneous evaluation of a passing road difficulty, specifically, under evaluation of the evaluation of an although known bend').

These kinds of accidents are due to similar accident causation than the previous situation (2b). Accidents are due to low level of attention associated to alcohol impairment or decision error.

From the risk analyses done over the four most relevant accident causation factors, it has been found:

- PASSENGER CAR ERROR:
  - Speeding (34%). This causation factor showed to be more likely when the following factors are present; single carriageway (OR = 2.53, p – value = 0.05 compared to double carriageway), during night lighting conditions (OR = 1.49, p – value = 0.05 compared to daylight conditions), curves (OR = 3.16 compared to straight sections, p – value = 0.05), specifically, slight or normal curve is 1.96 times more than sharp curve and 3.69 times more than straight, and, finally, male drivers (OR = 1.97, p – value = 0.05).

  - Decision error (16%). In this case, only the variable 'road' was selected as risk factor from the analyses. Single carriageway is 1.73 times more likely than double carriageway.

- PASSENGER CAR STATE:
  - Alcohol impairment (13%). Urban area (OR = 2.35, p – value = 0.05) has been shown as one of the factors increasing significantly from the statistical point of view the probability for this causation factor of being present at the accident, as well as single carriageway (OR = 2.39, p – value = 0.05). Nevertheless, the factor associated to this accident causation with higher index 'Odds Ratio' is 'night' (accidents during night are 3.29 times more than twilight and 8.55 times more than daylight).

  - Low level of attention (14%). Double carriageway roads (OR = 1.91, p – value = 0.05) has been shown as the only factor increasing significantly from the statistical point of view the probability for this causation factor of being present at the accident.

A comparison between the results from in-depth and risk analysis in stabilized situations in scenario '2' and the results from the literature review in D2.1 shows:

✓ In bends: Attention, speed, lane layout, perception, presence of signals and driver age has to be considered.

✓ Literature review shows that in single vehicle accidents, the main important risk factor is speed, which tends to increase risk factor. First of all, this conclusion should be done knowing if these accidents have been under stabilized situations. On the other way, analyses over TRACE in-depth database show that this factor increases the risk of being involved in specific characteristics for each sub-situation (for example, single carriageway, male driver, curves…).

Literature review does not offer more information about these specific stabilized situations because the considerations about accident mechanism and risk factors are very general to be considered only for stabilized situations '2'. Therefore, the analyses done over TRACE in-depth databases offer new important findings about the objective of WP2: Accident causation and risk analyses in these situations (2.a, 2.b and 2.c).

5.2.4   Situation 3

A driver (red narrow), not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle.
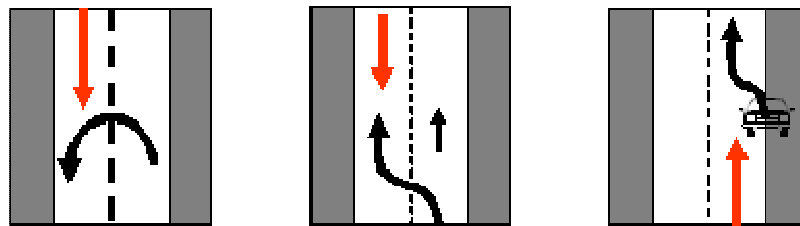
Figure 14: Type of configurations of the scenario related to 'Situation 3'.

The number of cases analysed from the In-depth suppliers was equal to 442 cases (25% of the total stabilized sample). Different sub-scenarios were detected:
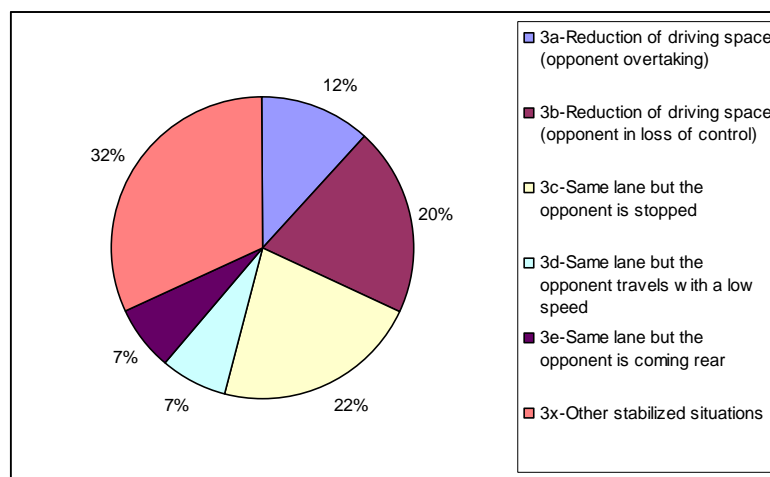
Figure 15: Distribution of stabilized lane departure or-run off accidents (Stabilized Situation 3).

Before giving the main explanations about general accident configurations and causations in this stabilized situation type, it is obvious to detail that division between information from the stabilized and the opponent vehicle should be considered. The aim of the analyses done over each sub-scenario will allow to define from stabilized vehicle point of view and from opponent ones. As it has been said, in this scenario (stabilized situation 3), only information from the first two vehicles involved (stabilized and opponent) will be studied.

The first look over these accidents can shows that they happen between two passenger cars (89%), after failing at the moment of perceiving the situation. If the analyses are over the whole typology of these situation accidents, this 'failure to look' can come from the stabilized and from the opponent in the same percentage (25%). It is clear that analyses of causes should be done taking into account the different sub-scenarios, because the mechanism of the accident is very different in each case. If we would like to offer some figures about accident causation, most of the causes are due to 'stabilized driver decisions' (the driver did not keep the safety distance, for example, in rear-end accidents or for example driving too fast); but a high bias is associated to this analysis, so the best option is go ahead for each sub-scenario and the respective causation and risk analyses.

5.2.4.a   Situation 3.a ('Reduction of driving space due to opponent overtaking')

The stereotype of this kind of accident is a head-on accident between two passenger cars, whose drivers are male with high driving experience (more than 10 years). These accidents happened outside urban area (81%), mostly, in straight sections (62%) of single carriageway roads (66%). Just mention that there were 53 accidents of this type within the database.

The accident happened due to the opponent vehicle behaviour at the moment of overtaking. The opponent vehicle decides to overtake, but he commits a decision error because it is not the best moment to overtake. The driver, who is doing an aggressive way of driving, failed at the moment of looking if another vehicle is coming (the stabilized vehicle). Therefore, the most common accident causation (40% of the accidents) is a decision error at the moment of the overtaking, being accompanied by a failure at the moment of recognition and therefore an inadequate speeding. This mechanism of the accident agree with the result of the Human Function Failure analysis, in which 'E1' ('Sudden encounter of an external disruption', this is a human failure at the handling stage) shows that the opponent vehicle had a poor control of the external disruption.

From the risk analyses done over the most relevant accident causation factors, it has been found:
- OPPONENT ERROR:
  - Decision (32%). This causation factor showed to be more likely when the following factors are present:
    - Curve (O.R. = 8.35, p – value = 0.05 compared to straight sections). To be more concrete, slight curves are 2.33 times more than sharp curves and 10.57 times more than straight.
    - Male drivers are 2.55 times more likely to suffer this kind of accidents than females.

As it can be saw, during the whole risk analyses done in this chapter, all the results have been showed from the point of view of 'Which categories can increase the risk of been involved in a stabilized accident?', therefore, if we desire to know which factors decrease the risk of being involved we would only have to study the situation (Odds Ratio) from the opposite point of view.

5.2.4.b   Situation 3.b ('Reduction of driving space due to opponent loss of control')

In this situation all the possible causes come from the opponent vehicle. These accidents represent 20% of the collisions within this situation. There are many possible configurations about this type of accidents, but the most common is the loss of control due to opponent error (25%), especially due to the speeding or decision error during the travelling task. Although this is the main accident causation, the environment contributed in more than 30% of cases. For example, the bad condition of surface or even the complexity of the road (narrow road) could be considered as cause in 10% of the accidents.

Going back to the accidents due to the driver of the opponent vehicle, obviously the state of the opponent driver has been considered as relevant. In 20% of the accidents, this has been considered as causation factor (taking into account in 10% of these, there was alcohol impairment, and in other 10% there was low level of attention).

Why did the opponent driver lose control? The analyses over the human function failure show us that the opponent vehicle loss control due to loss of psycho-physiological capacities consequently to a

failing asleep or ill-health (G1A from the opponent point of view) and what happen is that the stabilized vehicle does not detect the rapprochement of the vehicle ahead.

If we would desire to know the main characteristics about the character, it could be said that after the loss of control of the opponent vehicle, this vehicle (which is a passenger car) collides against the stabilized vehicle (which is another passenger car, of course) in a head-on way. The drivers are in both of the cases, males with a high driving experience). The location of this sub-scenario is outside urban area. The kind of road is, mostly, single carriageway roads, therefore the type of collision would be head-on or even front-side due to the last reaction of one of the driver before crashing and trying to avoid the accidents with a sudden swerve.

The risk analyses done over the most relevant accident causation factors shows:
- OPPONENT ERROR:
  - Speeding (16%). This causation factor showed to be more likely when the following factors are present; bad weather conditions (OR = 3.06, $p - value = 0.05$ compared to good weather conditions), during night lighting conditions (OR = 2.41, $p - value = 0.05$ compared to daylight conditions), curves (OR = 2.3 compared to straight sections, $p - value = 0.05$), and, finally, female drivers (OR = 1.74, $p - value = 0.05$).

5.2.4.c   Situation 3.c ('Same lane but the opponent is stopped')

The 96 accidents are located either in single carriageway (56%) or double carriageway (40%), between two passenger cars in a rear-end collision. These accidents are due to a failure (P5A: 'Late detection of the slowing down of the vehicle ahead) from the stabilized vehicle which is travelling and due to the low level of attention and a low safety distance, it collides against the vehicle ahead. In these accidents, there is no problem related to speed from the 'bull vehicle' (the stabilized in this case).

The risk analyses done over the three most relevant accident causation factors shows:

- STABILIZED ERROR:
  - Decision error (46%). This causation factor showed to be more likely when the following factors are present; double carriageway road (OR = 2.08 compared to single ones, $p - value = 0.05$), and, male drivers (OR = 1.84, $p - value = 0.05$). Near 96% of the accidents were in straight sections.

  - Not keeping safe distance (42%). During the logistic regressions, no significant variables were found to be significant. The only important aspect was the fact that 95% were in straight sections, and near all of them (except one accident) were rear-end accidents.

- STABILIZED STATE:
  - Low level of attention (46%). This causation factor showed to be more likely when double carriageway road is present (OR = 1.91 compared to single ones, $p - value = 0.05$). Also, 94% were in straight sections.

It has been found that, after looking at the respective correlation table between these three factors, the factor 'decision error' is related to the other two ones. The interpretation of this correlation could be that when a decision error appears, this can be due to the lack of attention from the driver or the lack of safety distance.

5.2.4.d   Situation 3.d ('Same lane but the opponent is with lower speed')

This type of accidents could be considered similar to 3.c, but now, the difference is in the targeted vehicle. Instead of being stopped, the targeted vehicle is with lower speed while the stabilized vehicle comes from rear and impact against this first vehicle. At a first view, it can be thought that the mechanism of the accident and the accident causation can be very similar to the main findings in the previous situation 3.c (in those accidents, the main accident causations came from the stabilized

vehicle) but the analyses over the in-depth information show that is the opponent vehicle (targeted vehicle) which is the cause of the accident. The data sample had 33 cases which belong to this scenario.

Firstly, it can be said that the location of the accident is outside urban area (72% of the accidents), and curiously the happen more frequent in dual carriage way (56%) than in single ones. Also, the light conditions match up with daylight conditions, although the quantity of the accidents during the night is higher than in scenario 3.c (25% instead of 16%). As in the previous scenario, this kind of accidents happen in straight sections (85%), but the biggest difference with the previous scenario is concerned with the type of collisions. Whereas in the previous scenario the kind of collision was rear-end in majority, in the present situation there are too much sideswipe collisions (17%).

For understanding what happens in this scenario, the analyses of accident causation and human function failure can help to detail the mechanism of the accident. While the HFF analysis tells that the stabilized vehicle had a late detection of the slowing down of the vehicle ahead ('P5A: Late detection of the slowing down of the vehicle ahead' belonging to failures at the detection stage), the analysis of the accident causation shows the striking result that, it is the opponent vehicle the one that the accident causation comes from. Recognition error and low level of attention from the opponent vehicle driver (this is the targeted vehicle) are the most common causes of the accidents, so, it could be said that the mechanism of the accident (once it is know when, where and who are the characters) consists on a passenger car which does not give enough attention to the driving task and make a sudden manoeuvre (with or without braking) that supposed that the stabilized vehicle (which is travelling with a higher speed).

The manoeuvre done by the opponent vehicle (due to a decision error and low level of attention), supposes a sideswipe collision in a double carriageway road or a rear-end collision, probably in a single carriage way road.

It is important to mention the importance of the in-depth analyses versus extensive database. In some of the countries, for example, Spain, the guilt in rear-end accidents is, in majority, the vehicle which collides against the vehicle ahead without taking into account what the vehicle ahead has done and considering the fact that if the stabilized vehicle would have kept the safety distance, these accidents would not have happened. Thorough the in-depth analyses, it has been showed that the real causation comes from the opponent vehicle and the sudden manoeuvre, independently it was ahead.

Although the passenger cars continue being the most common vehicles in this kind of accidents, trucks (as stabilized vehicle in 25% or opponent vehicle 18%) takes a higher percentage related the other scenarios.

Finally, due to the low quantity of these accidents, it has not been possible to do the respective risk analysis.

5.2.4.e   Situation 3.e ('Same lane but the opponent is coming rear')

The number of accidents from In-depth suppliers was equal to 32 cases, what it means 7% of the stabilized accidents. The accident mechanism associated to this scenario could include different situations already mentioned previously. In this case, the opponent vehicle comes from rear and impacts the stabilized vehicle. Although this general explanation does not detail what each vehicle was doing, from the opponent vehicle point of view, this vehicle could be in the following situations:
   ✓ The opponent vehicle could be also the stabilized vehicle belonging stabilized situation 3.c.
   ✓ The opponent vehicle could be also the stabilized vehicle belonging stabilized situation 3.d.
   ✓ The opponent vehicle could be doing a specific manoeuvre and collides against the stabilized vehicle which is ahead.

Therefore, a priori, the final configurations and results from the respective analyses should be different to ones from scenarios 3.c and 3.d.

A general description of these scenarios shows that the majority of the accidents happen outside urban area, in dual carriage way (74%) and in straight section (85%). Looking at these main characteristics could seem difficult to understand why these accidents happen in these locations. If we have a look at the visibility conditions, a high percentage of these accidents happen during the night (near 40%), this

means the visibility conditions are constraint. Also, it has been saw that other kind of 'degraded conditions' like bad weather conditions (fog, raining…).

Apart of these considerations, almost of these accidents are rear-end collisions, and the type of the opponent vehicles is a passenger car (58%) or, curiously, a truck (27%), whereas the stabilized vehicle (targeted vehicle) is a passenger car, of course (it was a criteria for stabilized situations).

It is clear that the cause of the accident comes from the opponent vehicle in a recognition error. The opponent vehicle was travelling in an 'easy road' (this could mean: straight section in double carriageway road), but due a failure at the moment of looking, the vehicle collides against the stabilized vehicle. As the in-depth information gives, it was not a problem of speed, but in many occasions there is a lack of visibility due, specially, to the following degraded situations (where the visibility is deteriorated):

- Weather degraded situation: fog, rain…
- Luminosity degraded situation (night).

During the following task 2.4 ('Degraded situations'), these situations will be studied from that point of view, although the conclusion will be showed in a different way.

Finally and it has happened in the previous scenario, due to the low quantity of these accidents, it has not been possible to do the respective risk analysis.

The results obtained from the literature review in D2.1 do not focus specifically on the stabilized situations '3'. The only aspects related to these scenarios (type 3) are the ones concerning the most common accidents (rear-end accidents, although it is not possible to extend these conclusions to all the rear-end belonging stabilized situations because there could be other type of rear-end collisions out of stabilized-situations), so special comparisons between results from literature review and from the 'in-depth' analyses can be done.

5.3 Conclusions

This task has analyzed the causation of traffic accidents in situations that would not be considered as hazardous by themselves. Normal driving situations, on occasions, can become risky situations due to specific failures (e.g. guidance errors) or sudden conflict situations with other road users that have to be addressed (for example, this scenario consists of driving normally on a straight road). Therefore, in this chapter, the named 'stabilized situations' have been studied to know how these accidents occur with the aim of determining specially the accident causation.

TRACE has proposed a common methodology for the analysis of each type of situation maximizing the use of existing databases and their limitations. This integrated methodology can be summarized as follows:

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

Once the main configurations were detected in the descriptive analyses done in the deliverable D2.1, information from TRACE in-depth databases was required to do specific accident causation and risk analyses. Concrete sub-situations were defined, although not always too many cases from each sub-scenario were gathered, which supposed not to realize the respective risk-analyses.

Although only stabilized situations have been studied, there are many accidents in this chapter that can belong to other specific situation of WP2. For example, there can be accidents in which two vehicles are involved and, although one of them is in a stabilized situation, the other one can be making a specific manoeuvre (task 2.3); or in the case that the accident has happened under constraint visibility due to night conditions or has happened under bad surface state (oil, rain,….) the accident

situation will belong also to the called 'degraded situation' (task 2.4). This supposes that accidents studied in this chapter could be dealt in other WP2 situations, but, of course the degree of deep will be less detailed as this chapter.

It is important to understand the strong relation of this task with other Work Package. The following actions have been gathered:

- Work Package 5 'Human Factors': Detection and codification of the Human Function Failures present in the accidents, through the methodology developed in this Work Package.

- Work Package 6 'Safety Functions': Feedback to this WP of the main findings and results obtained from the analyses of National, In-depth and Exposure databases.

- Work Package 7 'Statistical Methods': Use of statistical techniques explained and developed in this Work package for the analysis of accident information.

- Work Package 8 'Data Supply': Use of the most current information from National accident databases, In-depth and exposure databases.

Related the difficulties, the ones found during this chapter have been the risk analysis. Due to the lack of data related to these situations, it has been decided to ask for disaggregated data. Although, this kind of requests has implied more resources from Work Package 8, it has been the only way of estimating the relative risk of (in the cases of suffering an accident) which the factor are related each specific accident causation. Going on with these analyses, during the whole risk work done in this chapter, all the results have been showed from the point of view of 'Which categories can increase the risk of been involved in a stabilized accident?', therefore, if we desire to know which factors decrease the risk of being involved we would only have to study the situation (Odds Ratio) from the opposite point of view.

Another difficulty found is the related to exposure data. Although Work Package 8 'Data Supply' has been in charge of supplying all kind of exposure data for Operational Workpackages, related 'stabilized situations' there is no possibility of being sure that any kind of exposure data are only concerning 'stabilized situations'. To give an overview of these percentages at the EU 27 level, some specific data would be necessary. As it is not possible to obtain general data at this level for stabilized situation, what it can de done is to find some statistics related, in a closed way, to this situation. For instance, analyzing data from Europe (2007), it can be shown that all pedestrians (which part of them are represented by scenario 1), single vehicle accidents (which part of them are represented by scenario 2), rear-end collisions (which part of them are represented by scenario 3) and head-on collisions (which part of them are represented by scenario 4) are near 70% of the injured accident in EU27. This is the only approach data which can be used to give an overview at European level about Stabilized Situations means.

Finally, and considering that through the better understanding of what the accidents happen, improvement safety devices or countermeasures from these points of view could be recommended to avoid or minimize these accidents. Once the different accident mechanism, accident causation and the main risk analyses have been identified, it could be proposed the following considerations:

- ✓ Related to pedestrians accidents in stabilized situations 1: It has been showed that this kind of accidents usually happen when the pedestrian cross the carriageway without obeying traffic rules. To notify the driver that a pedestrian is inside the carriageway, a special recognition system for users crossing the lane lines would be able to notify this presence (for example, in case a pedestrian cross the lane lines, the road milestones would get in red). Also, this system would be helpful to notify the presence of possible animals.
  Of course, educational policies should be orientated to avoid this type of pedestrian behaviour.

✓ Related to run-off and lane departure accidents in stabilized situations 2: It has been showed that different accident causation and risk factors have been detected, therefore many devices or proposals could be taken into account to improve safety.

- First of all, speed has been detected as causation in many configurations. Special devices in the vehicle that compares the vehicle speed and the specific speed recommended, especially in curves to be negotiated, could help to improve safety. Also, this comparison should be done taking into account the specific speed needed for the conditions in that moment: bad surface (presence of oil, ice …), weather conditions (rain, snow…)…

- Other improvement could be related with the design of curves. It has been saw that most of these accidents are more likely to happen in curves (sharp curves), so improvement of these section could help to safety (design, restraint road system for minimizing the severity,…).

- Another causation factor detected in these accidents has been the lack of attention to the driving task. For this reason, special devices related for example with 'faces lab' devices would notify the lack of attention to this task and avoid the run-off.

- Of course, devices as lane-departure warning would notify the moment when the driver is leaving the lane.

- Finally, it has been found that bad surface appears as a consideration to be taken into account, therefore, notification of special surface conditions (oil, ice, wet surface…) will help to avoid these accidents.

✓ Lastly, related to stabilized accidents in situations 3, some devices that could :

- ADAS systems for helping to detect obstacles (vehicles) in the same lane (specially related to 3.a, 3.b, 3.c and 3.d), either travelling in the same direction for vehicle with lower speed or vehicles coming in the opposite direction.

- Improve the vision in degraded conditions (due to weather conditions as fog, rain.. or lighting conditions as night period) to avoid possible accidents concerning stabilized situations 3.d

6   Specific manoeuvres

The aim of TRACE is to improve knowledge on accident causations. To reach this goal, TRACE analyzes road accidents according to several points of view (road users, road user situation and accident factors). So the point of view examined in this report is the road user situation one and especially the specific manoeuvres situations.

The first step of the study focused on descriptive analysis (macro accidentology level) in order to determine the issues and the scenarios where we have to focus our analysis. Descriptive analysis or macro accidentology level relied on intensive accident databases such as census of accident data registered by the police forces and put into national files or CARE database. This macro accidentology study is rather poor in identifying accident causation factors because the complex process of a crash is not analyzed and recorded in such databases and because many of the recorded variables are mostly descriptive and not analytic. Nevertheless, they provided us reliable information which was used to identify the magnitude of the problems (e.g. 25 % of fatalities are young road users between 18 and 24 years old, 70 % of the fatalities occur in rural roads, 20 % of injury accidents occur on wet pavements, etc.).

So, this report is the logical continuation of the first step. Indeed, using the results of the first step and the in-depth databases (which contain, in addition to descriptive information, analytic information on the accidents) provided by TRACE partners, this report will focus on the causes of accidents when a driver is performing a specific manoeuvre according to the scenarios determined in the descriptive analysis.

A lot is known about micro accidentology since researchers have been working in this area for several decades, both in the areas of accident causation and in passive safety. And in addition to the well known and basic method analysis applied in micro accidentology - the accident is studied in its chronology – TRACE will apply an innovative methodology emerging from deliverable D 5.1 – Analyzing "Human Functional Failure" in road accidents. The fundamental idea of this approach is to consider the human error not as a cause of the accident but rather as a consequence of malfunctions occurring in the interactions between the driver and his environment. Some causes of the error are considered to be internal to the driver whereas other causes are considered to be external. In this research, the error is exclusively studied, just before the accident situation, from the driver perspective.

The report will be shared in two main parts. The first one will remind the main important issues from the deliverable D 2.1 (results from the literature review and from the descriptive analysis). The second one will present the accident causation issues related to the performance of a specific manoeuvre at an in-depth level by analyzing data from available in-depth databases. In this part, we will show the in-depth databases we used the definitions of accident causations and the causes of accidents according to the specific manoeuvres. The accident causations will be presented firstly, from a global point view (what are the accident causations when the driver is performing a specific manoeuvre?), secondly, from each found specific manoeuvre point of view (result of the descriptive analysis – For instance, what are the accident causations when the driver is performing an overtaking manoeuvre?) and finally, from factors point of view (revealed from the descriptive analysis – For instance, what are the accident causations for different drivers according to their age?) .

And of course, the last part will identify the relevant counter-measures existing or not associated to the causes of the accidents.

6.1 Overview and general statistics

This chapter reminds the main results from the descriptive analysis presented in the deliverable D 2.1. Our analysis is devoted to specific manoeuvres performed by passenger car drivers.

The intention of the descriptive statistical analysis was to obtain the situations/factors/parameters (targets) where likelihood of having an accident is high from the **point of view of specific manoeuvre**. The purpose was to analyze the personal, technical and environmental conditions in which the accident has happened to find an appropriate understanding of the circumstances the accident occurs under. Some of these conditions were: age, driving experience / training, professional occupation, cohabitation with other road users, gender, light, time / day / month, specific type of vehicle, speed…

The descriptive analysis has used two sources of information. The first one was available data from TRACE project and the second one is estimated data (for data not available).

So, this part of the report will present the stakes of specific manoeuvre accidents in Europe 27, the main results from the literature review and from the descriptive analysis. And this is from these conclusions that we have turned our in-depth analysis.

6.1.1 Scope and definition

For memory, specific manoeuvres cover the situations in which the driver has to realize a specific manoeuvre for which a higher than usual solicitation is required and without any environmental or human degradations. All specific manoeuvres performed at an intersection are excluded. It is characterized by sub situations that must be studied separately:

The main specific manoeuvres are illustrated by the pictures above and are:

- The overtaking manoeuvre: the accident takes place away from a proper intersection and the driver is performing an overtaking manoeuvre. He overtakes a moving or a static vehicle on the offside or a moving vehicle on the nearside.

- The turning left manoeuvre (or right, in countries where you drive on the left): the accident takes place away from a proper intersection and the driver is performing a turning left manoeuvre in order to join a private road or a parking for instance..

- The u-turning manoeuvre: the accident takes place away from a proper intersection and the driver turns in order to completely reverse his direction of travel.

- **The changing lane manoeuvre:** the accident takes place away from a proper intersection and the driver is performing a changing lane manoeuvre. This one applies to carriageways with at least 2 lanes in the direction of travel (i.e. where there is a legitimate opportunity to change lane). It differs from the overtaking manoeuvre because the vehicle has no vehicle to overtake and the aim of the manoeuvre is to change lane in order to change direction.

If the numbers of accidents or persons killed stay data relatively easy to find, the number of situations is much more difficult to dread because many databases have not the information at the level of every road users. The proportion of stabilized and "specific manoeuvre" situations out off intersection have been determined from the data available at the TRACE level, i.e. from Spain, UK, French and Czech Republic data.

The specific manoeuvre situations represent only 13% of the situation out off intersection, 7% of the total number of situations and 24% of the total number of injury accidents in Europe (estimation relaying on results coming from Spain, UK, France, Greece and Czech Republic).
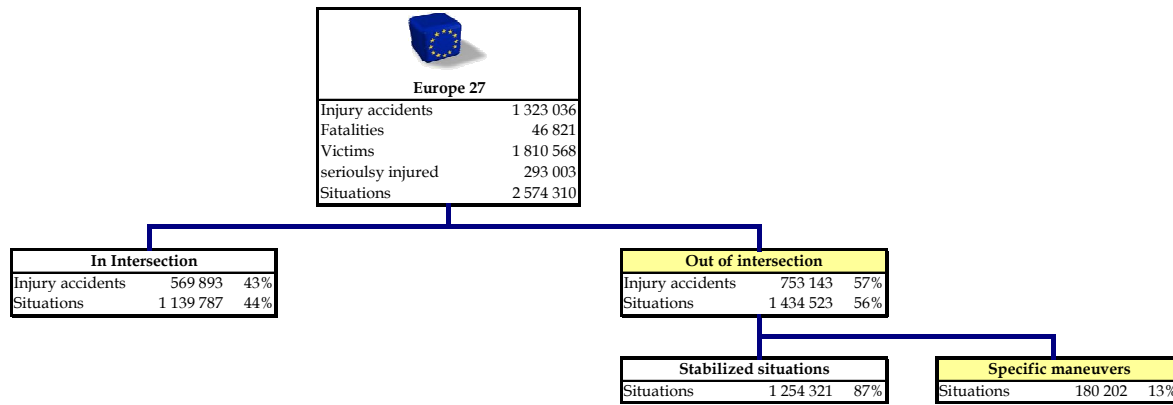
Figure 16: Distribution of the specific manoeuvres situations in EU27
(year 2004, Sources CARE, IRF, IRTAD, National Statistics Databanks).

6.1.2   Main results from the descriptive analysis

The descriptive analysis used the British, French and Spanish databases and CARE one when the information was available. National databases hold data recorded by the police on all road traffic accidents involving an injury to establish the main issues for specific manoeuvres. Accidents occurring in the year 2004 were considered for analysis. It should be noted that in Great Britain, vehicles drive on the left side of the road. This has implications when interpreting data on vehicle manoeuvres.

- Overtaking represents 18 to 38% of all accidents where at least one specific manoeuvre is performed, Changing lane 11 to 19% and Turning left 10 to 43% according to the country.

- Manoeuvres associated with a higher than average number of fatal and serious accidents were 'overtaking a vehicle on the offside' and turning left (away from an intersection).

- The majority of vehicles involved in accidents away from junctions, regardless of manoeuvre, are typically driving on the following roads:
  > On single carriageway, typically national roads and main secondary roads, turning left, U-turning and overtaking offside are the three major manoeuvres performed in high proportion.
  > On dual carriageway, typically motorways, changing lanes are predominant.

  On dual carriageway (within ways physically separated), the main situations are overtaking, turning left and changing lane manoeuvres (for GB and France).

  On single carriageway, such as national roads and main secondary roads, overtaking and turning left manoeuvres are the main performed manoeuvres.

The specific manoeuvres chosen for the in-depth analysis has been determined thanks to 2 indicators. The first one is the percentage of accidents with at least one passenger car performing a specific manoeuvre divided by the total number of accidents with specific manoeuvres. This indicator is a result of the deliverable D2.1 and the two main specific manoeuvres retained are overtaking (prevalence= 18% to 38%) and turning left (prevalence= 10% to 43%) manoeuvres.

The second indicator used is the rate of fatalities per 1,000 road injury accidents according to the specific manoeuvre performed. For instance, in France, there are 12,602 injury accidents involving at least one driver performing a specific manoeuvre. And these accidents generate 231 fatalities. It means that the rate is 56,5 fatalities for 1,000 injury accidents (involving at least one driver performing a specific manoeuvre). Moreover, in order to compare them to other situations, the next table present this rate for accidents at intersection.

The result is that overtaking and turning left manoeuvre, on top of their high prevalence, their rate of fatality per 1,000 road injury accidents are also important. Changing lane and u-turning manoeuvres have a less important prevalence but their rates of fatality per 1,000 road injury accidents are not insignificant. And finally, these four specific manoeuvres accidents have at least a rate as high as for the one for accidents at intersection. That is why, we chose to study the accident causations of the following specific manoeuvre: overtaking, turning left, changing lane and u-turning.

	Fatality / 1,000 accidents										
	AT	BE	DK	EL	ES	FR	IT	NL	PT	UK	**Total**
Overtaking	20,8	14,6	n.a.	58,0	54,0	56,5	16,1	22,5	34,6	18,4	**30,6**
Turning left	n.a.	6,3	14,4	56,8	11,9	70,9	n.a.	n.a.	3,1	3,3	**47,6**
Changing lane	n.a.	n.a.	54,8	16,9	n.a.	10,0	n.a.	n.a.	53,1	7,1	**18,4**
U-turning	n.a.	5,0	n.a.	53,7	17,7	17,1	n.a.	73,2	28,2	4,4	**14,0**
At intersection	9,4	14,4	39,0	33,9	23,7	35,4	15,5	15,8	17,6	9,3	**15,6**
n.a. : not available											

Table 2: Fatality for 1,000 accidents for specific manoeuvre accidents and accidents at intersection
(Year 2004, Sources CARE, IRF, IRTAD, TRACE, National Statistics Databanks)

6.2 Identification of the accident causes

This part is devoted to the identification of the accident causations for specific manoeuvre accidents. These causes will be determined for all the specific manoeuvres accidents and for each of them too. The reason is that we can suppose that each situation has its own causes.

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 TRACE for this accident causations identification is to harmonize the different accident causations approaches from all the databases available and to apply the innovative methodology emerging from deliverable D 5.1 – Analyzing "Human Functional Failure" in road accidents.

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.

6.2.1   The sample

In order to favour the quality versus the quantity, we decided to examine the data investigated on the scene – named in-depth accident analysis - by accident research teams and not the intensive databases. One disadvantage is that the data collected by each European team are not coded in the same way and has not the same approach of accident causation. Nevertheless, the advantages are that each accident is well known and analyzed by teams and is largely detailed. So this level of details will give the possibility to the teams to readjust its analysis according to the TRACE objectives and to apply the innovative methodology emerging from deliverable D 5.1 – Analyzing "Human Functional Failure" in road accidents. Indeed, even if the information is not clearly defined and available in the accident folder, the high level of information and knowledge about the accident allow the teams to identify the new accident causation approach.

Consequently, the in-depth databases used are from: LAB (France, 64 accidents), INRETS (France, 66 accidents), OTS (UK, 170 accidents) GIDAS (Germany, 35 accidents.)
The period of investigation for the in-depth accident databases presented above is from 1997 to now.
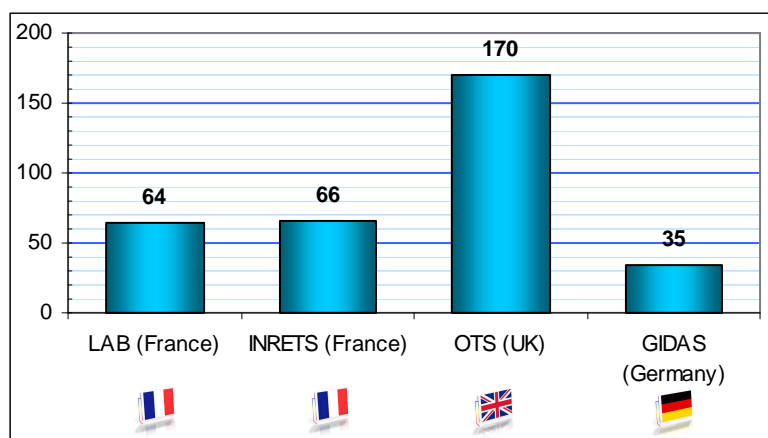
Figure 17: In-depth databases contribution for specific manoeuvres accidents

In the next figure, the contribution of each in-depth database according the specific manoeuvre is showed. Even if the overtaking manoeuvre is the one which gathers most of the accidents, the contribution of each country is very heterogeneous. Indeed, it depends on the accident data collection and the aim of the database. Indeed, in France (at LAB), the accidents with at least one injured occupants have priority. And as, u-turning and changing lane accidents are rather accidents with material damages, it could explain why LAB has only few cases. Moreover, we saw in the literature review that changing lane manoeuvre rather happened on motorways. And LAB does not study such accident on motorway for political and safety reasons.
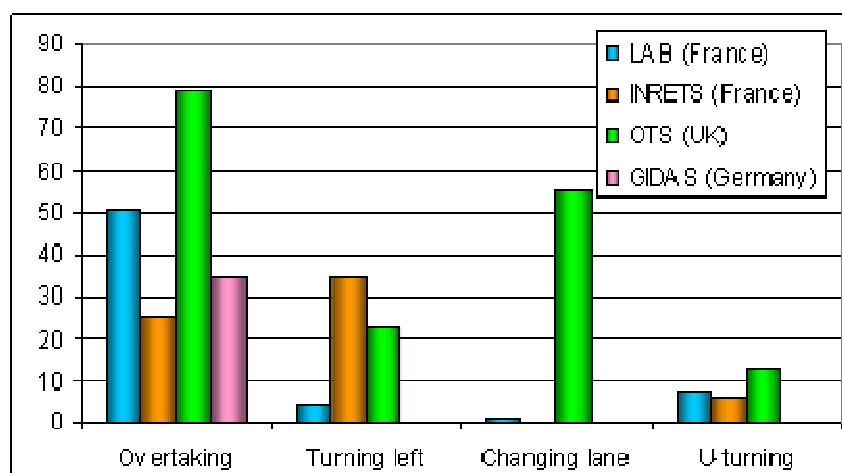
Figure 18: In-depth databases contribution according to specific manoeuvres

As presented in the previous chapter, we will determine the causes of accidents for passenger car drivers performing a specific manoeuvre.

Firstly, we will present the overall causes for all these accidents and secondly, the causes will be detailed and shown according to the specific manoeuvre studied. Indeed, it is assumed that the causes, the failures are different according to the specific manoeuvre.

The in-depth databases provided by TRACE partners have been used to determine the causes. The main difficulty to analyze accident causations with these in-depth databases was the homogenization of the results from the partners (remark: teams involved in the deliverable D3.1 have had the same problem). Indeed, each in-depth database has its own way of cause identification. Moreover, an innovative approach of accident causations has been applied on these in-depth databases. That is to say that a lot of works have been done by TRACE partners to homogenize the accident causations results. Indeed, each team has been trained by Workpackage 5 leader in order to well understand the new accident approach (Human Functional Failure). Then, each team has identified and analyzed in its own database which information was necessary to determine the causes of the new accident approach. And finally, it was necessary that each team codes into its database the results of the new approach analysis.

Consequently, the first part of this chapter – overall causes – won't be presented in details. The reason is that overtaking manoeuvres are over represented in our sample. So detail the overall causes for specific manoeuvres would be detail overtaking manoeuvre. On the other hand, each scenario will be well described and will define the relevant counter-measures associated to each of them.

A situation is defined as a pre-accidental situation to which the driver or the rider is confronted to in normal driving conditions just before it turns out into an accident situation. It is assumed that there are specific accident causation factors related to these situations that deserve to be studied. The types of situation can include one or more accident scenarios which contributed to the accident occurring.

Then, this report is focused on accidents in passenger cars performing a specific manoeuvre (such as an overtaking, a changing lane, a turning left or a u-turning). So in the report, we use two terms which are defined as follow:
-   **the case vehicle**: it is the vehicle which performs the specific manoeuvre
-   **the opponent:** it the road user which is involved in the accident and which have had a crash with the case vehicle.

The situation scenarios will be shared as follow:
-   passenger car driver performing an overtaking manoeuvre,
-   passenger car driver turning left (or right in UK) away from an intersection,
-   passenger car driver u-turning,
-   passenger car driver changing lane.

6.2.2   Specific manoeuvres: overall causes

6.2.2.a   Driver involvement status
The main information emerging from the Figure 19 is that case vehicles (driver realizing a specific manoeuvre) is a primary active driver. It means that he is at the origin of the accident. The next items will help us to determine at which level, we can help the driver. Nevertheless, the study of each scenario will show us that opponent vehicles are also active in the accident genesis. It means that in these accidents in which a driver is performing a specific manoeuvre, case vehicle and opponent vehicle need counter-measures. The next part of the study will detail which kind of counter-measure, the driver needs.

Remark: The situation of the opponent vehicle when he does not perform too a specific manoeuvre, is considered as a stabilized situation. And this situation is largely studied in the task 1 of the work package 2.
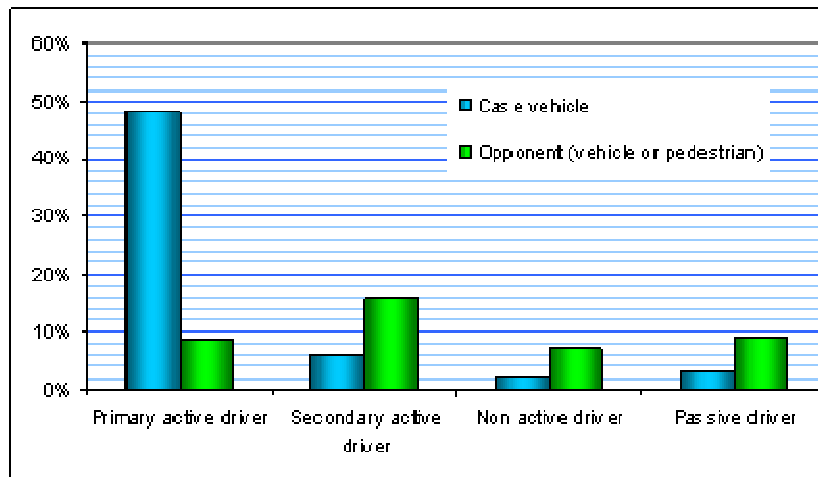
Figure 19: Degree of involvement in specific manoeuvre accidents

6.2.2.b   **Key Events**
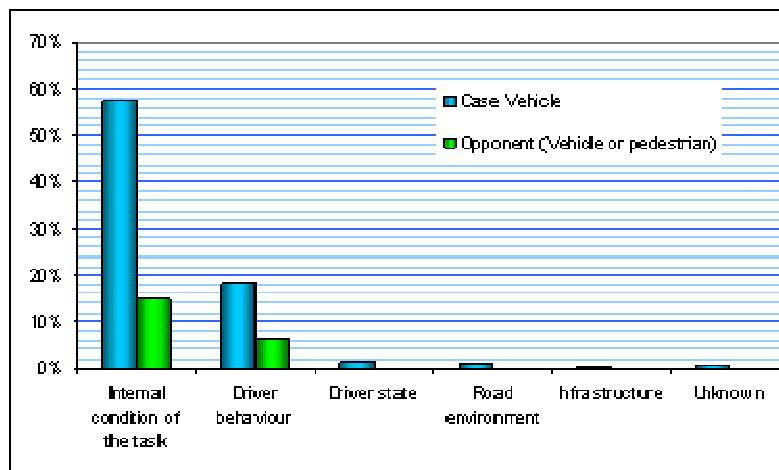
Figure 20: Distribution of the key event fields for specific manoeuvre accidents (n=175)

The key event has been defined as the event at the origin of the perturbation of the driver. As concluded in the previous paragraph, it is not surprising to see that the key event is rather linked to the case vehicle. Nevertheless, the key events are the same for case and opponent vehicles and are linked to the following key event category: the internal condition of the task realization (it is related to the task that the driver is performing, but refers more specifically to the 'conditioning' of the driver to the task, Figure 20) and to a lesser extent to the driver behaviour (behaviour of the road user can affect the way they control their vehicle and respond to both their internal and external surroundings, n=63, Figure 20). When looking at the key event in details (what is inside the categories), the three main key events for specific manoeuvre accidents are (Table 3):
-   Incorrect driving manoeuvre (poor overtaking, risk taking.., n=111): It means that the driving condition was not optimum to realize the manoeuvre (no visibility, no enough safety distance…). Although this lack of good conditions, the drivers has performed the manoeuvre all the same.
-   Poor evaluation / anticipation (other vehicle speed, n=58). The identification of hazards and the quantification of their potential for danger has been neglected or was difficult to identify by the driver. So he was not able to well anticipate the evolution of the situation.
-   Failed to look, looked but did not see (n=62). The driver failed to look, which means that he looked but did not see. It is an important point which is often studied in behavioural

experiments. Psychological bases on LBFTS[10] say that these errors can be attributed to individuals' attentional biases and to their imperfect visual scanning capabilities or practices. These are common human deficiencies, especially under load and time stress, therefore the LBFTS problem is inherently important in a visually demanding traffic system, although there will obviously be individual differences in the tendency to commit such errors. Understanding these individual differences and the road and traffic situations which predispose drivers to LBFTS are essential requirements if counter-measures against this error are to be designed and introduced effectively.

These three key events refer to a failure in the preparation of the manoeuvre and not in the manoeuvre realization. So, the counter-measure associated to these key events should help the driver to have a good overview of the driving situation. Nevertheless, these ones are probably different according to the manoeuvre and will be identified in the following chapters.

It can be noticed than most of the key events in our sample are rather linked to the driver. Road environment, infrastructure are at the origin of these specific manoeuvre accidents in only few cases in our sample.

In the next table, there are two key events which have not been detailed previously because of their low prevalence. The first one is the "excessive speed". It means that the road user was driving too fast considering the legal speed limit of the road. The second one is the "inappropriate reaction". It often brings up a problem of driver panic. This key event can be illustrated by a non reaction by the driver or a steering manoeuvre which was not appropriated to the situation.

Key event		
	Case vehicle	**Opponent vehicle**
Internal conditions of the task		
Incorrect driving manoeuvre (poor overtaking, risk taking…)	93	18
Poor evaluation / anticipation (other vehicle's speed…)	46	12
Excessive speed	6	0
Inappropriate reaction	0	7
Driver behaviour		
Failed to look, looked but did not see…	47	15
Inattention – concentrated on another driving related task	1	0
All	**193**	**52**

Table 3: Key events detailed for specific manoeuvre accidents

6.2.2.c   Contributing factors

The contributing factors are the other factors that are necessary, in addition to the key event, to produce the accident. Two important information emerge from the next figure and table:

1- Case and opponent vehicles have both contributing factors linked to each other. Indeed, 69% of all the contributing factors are linked to the case vehicle and 31% to the opponent (Figure 21). It means that counter-measures should be applied for both road users but not for the same objectives. The study of the key events in the previous paragraph showed that they were mainly linked to the case vehicle. But in this paragraph, contributing factors reveals that it is necessary too to focus our analysis on the opponent.

2- All the elements from the triptych vehicle-environment-driver play a role in the accident development. It means that even if the road environment, the vehicle was not at the origin of the accident, they contribute to the accident development. If the key events study showed that it is necessary to focus our analysis and our counter-measures on the driver, the contributing factors analysis underlines the fact that the road environment and the traffic conditions has to be improved in order to avoid accidents.

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[10] Looked But Failed To See
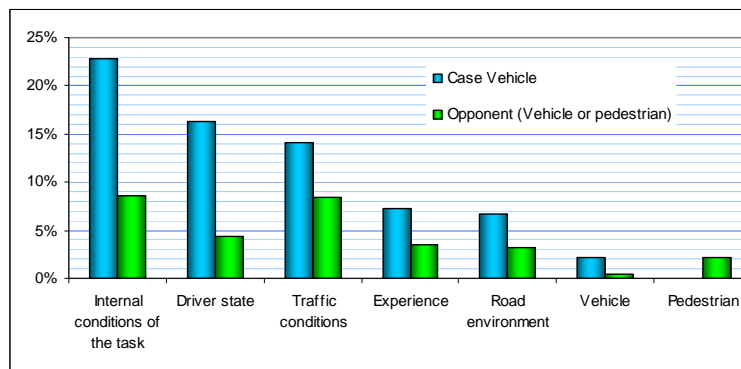
Figure 21: Contributing factor fields for specific manoeuvre accidents

For case vehicle and opponent one, the contributing factor analysis brings up problems not identified during the key event analysis (Table 4):

- The speed: the main problem of the speed is that it is not appropriated to the situation (n=55) and to a lesser extent it is above the speed limit (n=18).
- The driver is subjected to a global time constraint for his trip or his manoeuvre (n=30). This constraint has an influence on his way of driving and on his manoeuvre realisation.
- The last contributing factor could explain why the driver state has so much influence in the accident genesis. Indeed, "restlessness, careless, reckless or in a hurry" and the "lox level of attention" gather 113 contributing factors.
- The visibility of the situation is also a problem (n=72) which was not found in the key event analysis. This lack of visibility is due to mobile masks (road users driving on the road hide important elements of the situation), environment (visibility deteriorated by the night, the sun, the rain…) and the infrastructure (for instance, an overtaking manoeuvre performed before a curve or at the top of a hill).

Contributing factors

	Case vehicle	Opponent vehicle
Internal conditions of the task		
Risky driving (ludic, test of performance, transgression, deliberate accident-generating behaviour, trivialization of the situation (potentially dangerous but treated as 'pain-killer') Driving too close etc.)	47	13
Inadapted speed : Choose of a too high vehicle speed for the situation	37	18
Global time constraint (for the trip or the manoeuvre)	26	4
Speed above speed limit	14	4
Right of way feeling (Rigid attachment to the right of way status;Excessive confidence in the signs given to others)	12	14
Driver state		
Restlessness	32	10
Careless, reckless or in a hurry	30	5
Low level of attention (low vigilance, affectation of attentional resources to driving task, internal distraction such as thinking, external distraction such as discussing)	22	14
Alcohol impairment or other illegal or legal drugs	14	0
Traffic conditions		
Temporal inconvenience for visibility (mobile mask such as another vehicle)	21	12
Deterioration of visibility (night, rain, dazzling sun...)	18	0
Experience		
Automatic driving: low attention level due to high experience of the trip (or its monotony) or low attention level due to high experience of the manœuvre	16	14
Low experience of driving (e.g. novice driver or elderly drivers, weak experience of the situation...)	14	7
Road environment		
Visibility limited by infrastructure (road equipment, vegetation and buildings)	15	6
Complex site (e.g. intersection), Difficult site (low radius in bend, rupture), Narrow road	12	5
All	**330**	**126**

Table 4: Contributing factors detailed for specific manoeuvre accidents

6.2.2.d   **Human functional failure**
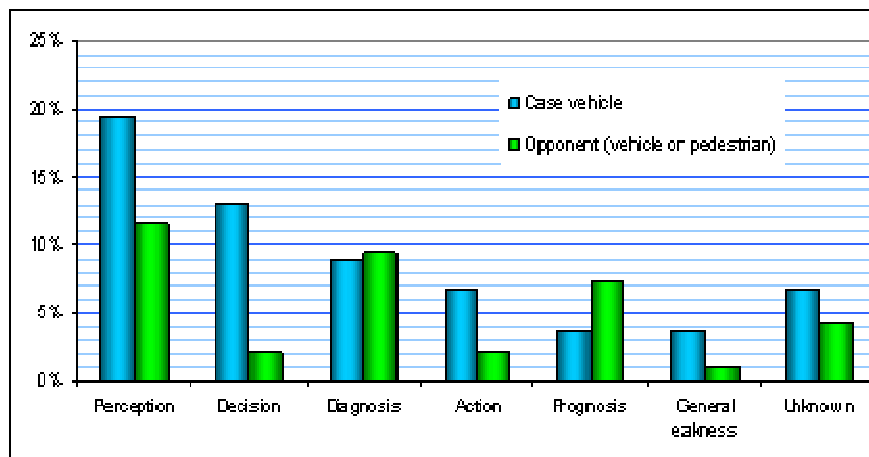
Figure 22: Human functional failure field for specific manoeuvre accidents

The human functional failure analysis shows different failures for case vehicles and for the opponent ones. Indeed, case vehicles have failure linked to the perception (19%, Figure 22, the driver has not detected certain essential parameters of the situation mainly because of hurry information acquisition or a bad information acquisition strategy), the decision (13%, Figure 22, the driver deliberately takes risk: he performed the manoeuvre although the lack of safety) and the diagnosis (9%, Figure 22, the driver has badly anticipate the difficulties of the situation) whereas for the opponent vehicles, the failures are rather linked to the perception (12%, Figure 22, the opponent was not able to anticipate the situation evolution due to a lack of visibility), the diagnosis (9%, Figure 22, the opponent was not aware of such manoeuvre from the case vehicle due to a lack of its lack of information given to the opponent) and the prognosis (the opponent was expecting the regulation of the situation by the case vehicle).

Human functional failure	Case vehicle	Opponent vehicle
Perception		
P3 failure – Cursory or hurried information acquisition	14	2
P2 failure – Information acquisition focused on a partial component	11	3
P1 failure – Non-detection in visibility constraints conditions	8	11
Decision		
D2 failure – Deliberate violation of a safety rule	16	2
D3 failure – Violation - error	7	0
Diagnosis		
T4 failure – Mistaken understanding of another user's manoeuvre	8	17
T1 failure – Erroneous evaluation of a passing road difficulty	4	1
T2 failure – Erroneous evaluation of the size of a gap	4	0
Action		
E2 failure – Guidance problem	6	1
E1 failure – Poor control of an external disruption	5	3
Prognosis		
T5 failure – Expecting another user not to perform a manoeuvre	3	5
T6 failure – Actively expecting another user to take regulating action	2	7
All	55	36

Table 5: Human functional failure detailed for specific manoeuvre accidents

The newt two chapters consider all the specific manoeuvre accidents according to two factors. These factors have been chosen because of their importance (emerging from the report TRACE-WP2-D2.1). The first one is the experience of driving of the road users involved in the accidents. What is the causes of specific manoeuvre accidents for novice and experienced drivers? The second one is the emergency reaction. How drivers in specific manoeuvre accidents react and where are the problems when there is no reaction?

6.2.2.*e* **Experience of driving and accident involvement**
This chapter focuses on the experience of driving for road users involved in an accident in which a specific manoeuvre is performed. The experience of driving is estimated considering the date of the accident and the date of driving licence obtaining (driving licence for the kind of vehicle used during the accident).

Our sample shows that experienced drivers are more involved in the accidents and especially male but what is interesting is to compare the failures between novice and experienced drivers.

Then, the in-depth analysis indicates that for experienced drivers, when these ones are performing a manoeuvre, the human functional failure is linked to the perception. There are two kinds of perception problems for these drivers:

1- The driver is surprised by another road user during his manoeuvre because he was not able to detect the other road user. The contributing factors which emerge from the analysis are the age of the driver (sight trouble and slow reaction) and the fact that these drivers travel occasionally.

2- The driver has a poor organisation of information acquisition strategy. He reduced to a minimum the time and attention they devote to the search for information. The contributing factors which emerge from the analysis are the low level of attention on the situation because of annex tasks, automatic driving behaviour or the driver followed the driver in front of him performing too an overtaking manoeuvre.
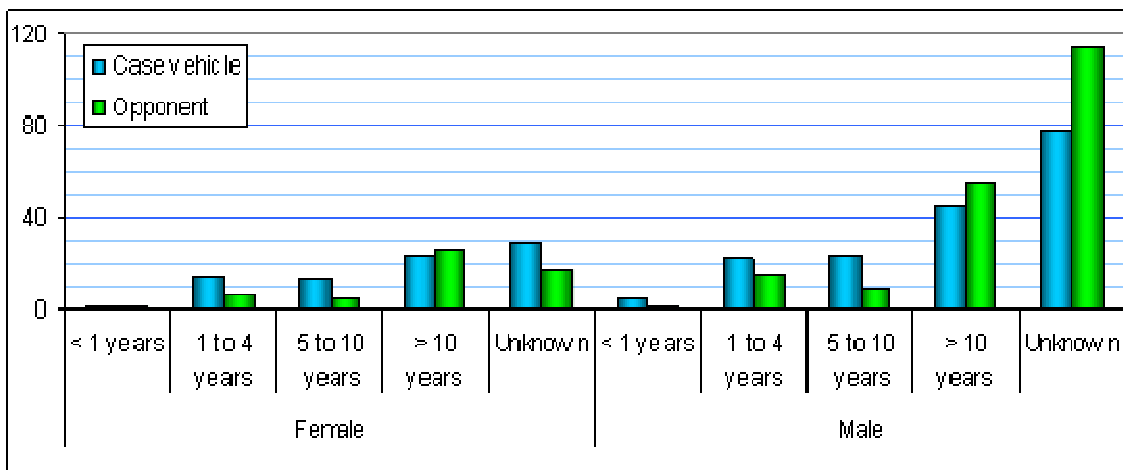
Figure 23: Experience of driving and gender for driver involved in specific manoeuvre accidents

For novice drivers, the human functional failures are rather linked to the diagnostic, the prognosis and the decision. It raises a problem to the experience of the driver who badly evaluates the situation information, who is not aware of the situation evolution and consequently, he does not take the good decision when performing a specific manoeuvre. Moreover, the contributing factors analysis shows that these drivers tended to cause accidents due to excess or non adapted speed, recklessness, alcohol and risky driving.

6.2.2.ƒ   Emergency reaction
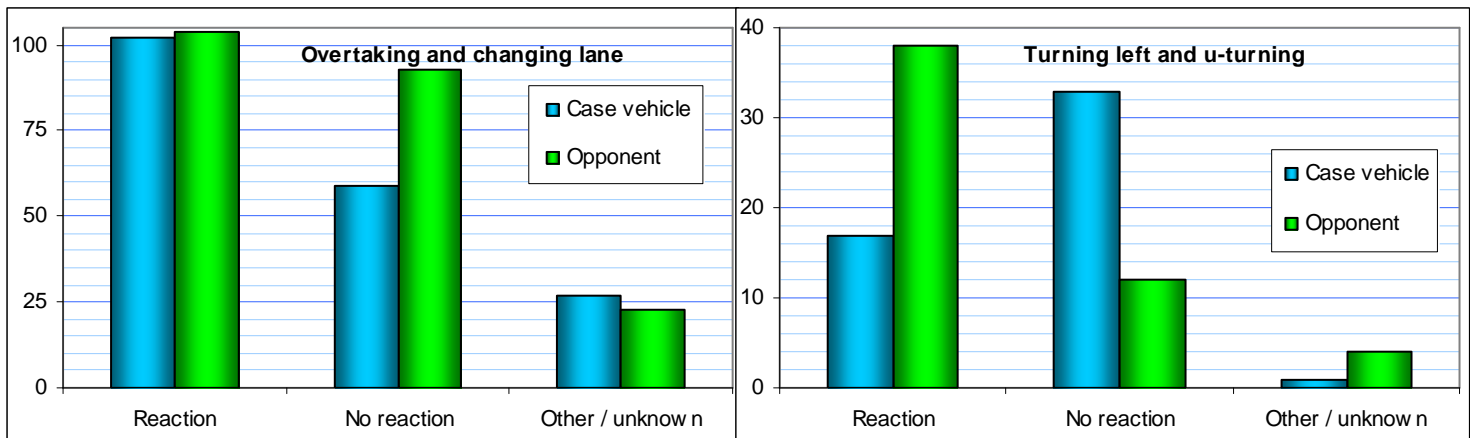
Figure 24: Emergency reaction for specific manoeuvre accidents

We analyze the way the drivers reacted just prior the crash. This manoeuvre is called "emergency manoeuvre". Reaction is a risk factor linked to a panel of factors such as driver age and experience, the road layout, the approach speed, the direction of the opponent vehicle.

To analyze, this factor, specific manoeuvres have been shared in two groups. The first one gathers accidents involving a passenger performing an overtaking or a changing lane and the second one gathers turning left and u-turning.

The reason of this sharing is that overtaking and changing lane have greater more similar accident conditions (such as road type, and initial speed) and turning left and u-turning are manoeuvres performing at lowliest initial speed.

For overtaking and changing lane manoeuvres, most of the case drivers had an emergency reaction (such as braking, turning…). Indeed, the human functional failure shows that the problem mainly comes from the realization of the manoeuvre. Due to the risky driving, the inadapted speed and the reckless behaviour, the driver often have a problem of guidance or loss of control. Perception is not the preponderant cause.

Nevertheless, for opponent vehicles, one driver out of two has no reaction. It is due to the fact that he was not able to anticipate such a manoeuvre from the case vehicle.

For turning left and u-turning manoeuvre, it is clear here that opponent vehicles reacted most of time with a braking manoeuvre while the case vehicle didn't react! The opponent drivers did not have perception failure. The problem is rather attached to a prognosis failure. Indeed, the in-depth analysis shows that opponents were not expecting perturbations ahead. So he is not prepared to meet such a situation (a passenger car u-turning or turning left). So at the last time, he perceives the danger, but it is too late in spite of an emergency reaction. Moreover, excessive speed is often linked to the opponent drivers. It means that his time to react is considerably reduced.

For the case vehicle, performing a u-turning or a turning left manoeuvre, the preponderant failure is the perception one. The driver is not able to detect the opponent vehicle because this one was masked during the manoeuvre performing or the case vehicle driver was focused on his manoeuvre and not on other components of the situations. For the first perception failure, visibility constraints (such as road layout and weather conditions) are the reasons of the non perception of the opponent vehicle. Whereas for the second perception failure, the in-depth analysis underlines the facts that case vehicle drivers have an automatic driving (performing their manoeuvres) and have difficulties to find a gap to realize their manoeuvres and so have situational time constraint.

6.2.2.g   Conclusion

Considering all the passenger car drivers performing a specific manoeuvre, these ones are mainly an active driver (54%, **Figure 19**). It means that he is mainly involved in the accident genesis. It means that counter-measures should focus on the driver who is performing a specific manoeuvre if we want to avoid the accident. When talking about counter-measures for the case vehicle, it can be measures to help the driver in the manoeuvre realization or to anticipate other road user's evolution or to improve the infrastructure of the case vehicle.

The main issues from this chapter are:
1- The manoeuvres are not performed in good conditions because of a problem of perception of the global situation:
   - The case vehicle driver has not enough information about the situation to perform his manoeuvre in a safe way; because he hurried his information acquisition or failed to look properly or he has a low level of attention.
   - There was a lack of visibility of the situation because of the mobile mask, infrastructure or weather conditions.
2- The case vehicle driver deliberately take risk when performing his manoeuvre:
   - The manoeuvre is not performed in a safe way because of an inappropriate speed (considering the infrastructure) or an excessive speed (considering the legal speed).
   - The case vehicle driver did not respect safety rules when performing his manoeuvre such as crossing a continuous lane.

<u>*Remark:*</u> we have to be careful with these results as in our sample, overtaking manoeuvres are over represented. That is why results will be more precise and detailed in the next chapters (which consider each manoeuvre separately). The scenario analysis will determine the failures linked to each manoeuvre and determine counter-measures for each of them. Indeed, problems of perception or diagnosis are not the same according to the scenario and the vehicle considered (the case or opponent one).

6.2.3   Accident causes related to scenario

The previous chapter has presented the causes of specific manoeuvre accidents from a global point of view. On disadvantage of this analysis was that overtaking manoeuvre was over represented in our sample and the accident causations tended to explain overtaking accidents. But it is assumed that these causes / failures could be different according to the specific manoeuvre. And in order to be more efficient and relevant, it is necessary to focus on each specific manoeuvre to determine the appropriate counter-measure. Thanks to the results of the deliverable 2.1, 4 scenarios will be studied:
1- The passenger car driver is performing an overtaking manoeuvre,
2- The passenger car driver is turning left (or right in UK) away from an intersection,
3- The passenger car driver u-turning,
4- The passenger car driver changing lane.

And finally, there are two final chapters which focus on two factors which emerged from the descriptive analysis:
   ✓ What is the experience of driving and the driver age contribution in specific manoeuvre accidents?
   ✓ What is the emergency reaction of drivers in specific manoeuvre accidents?

Each specific manoeuvre chosen for the analysis will be presented following the next layout:
   - An overview of the specific manoeuvre: definition, the prevalence in Europe, the in-depth databases used and the number of cases in the in-depth sample.
   - The driver involvement status in the accident for case vehicle drivers and opponent ones.
   - The key events associated to the specific manoeuvre accidents.
   - The contributing factors associated to the specific manoeuvre accidents.
   - The human functional failures associated to the specific manoeuvre accidents.

6.2.3.*a*   Scenario 1: Overtaking situation

Prevalence in Europe: 18% to 38%

Severity KSI[11]: 20% to 28%

In-depth databases used: LAB, INRETS, OTS and GIDAS

Sample: 190 accidents
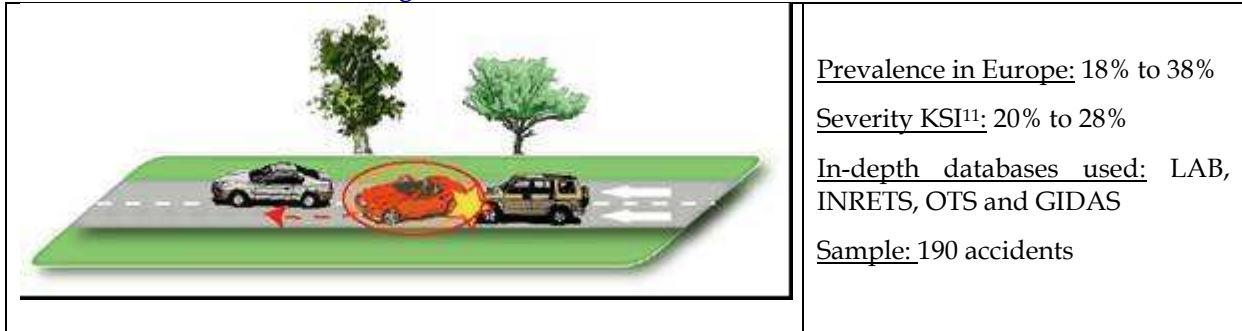
This sheet is dedicated to the identification of the accident causations when a passenger car is performing an overtaking manoeuvre. It means that the accident took place away from a proper intersection and the <u>passenger car</u> is performing an overtaking manoeuvre (a moving or static vehicle on the offside or a moving vehicle on the nearside).

The objective of such manoeuvre is to overtake a vehicle ahead driving slowly.

The pictogram above is just an example and do not cover all the accidents with an overtaking manoeuvre.

In the next parts, the passenger car performing an overtaking manoeuvre is considered as the case vehicle. The opponent vehicle or pedestrian is the other road user involved in the accident (it can be another passenger car or a truck…). It is not necessary the road user overtaken.

Driver involvement status
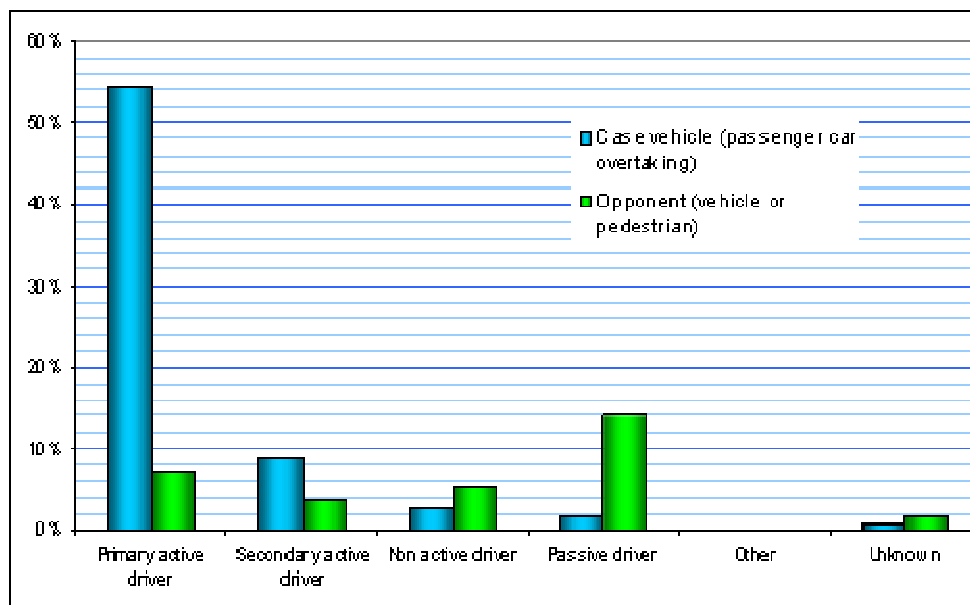
Figure 25: Driver involvement status for overtaking accidents

The study of the driver involvement status gives us several information:
-   **The passenger car overtaking** is most of the time **a primary active driver**. Indeed, 54% of the drivers involved in the specific manoeuvre accidents are case vehicle drivers and primary active ones (Figure 25). It means that the driver provokes for himself or for the other interfering users in the system, a critical situation in which the accident situation is going to take place.

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[11] Severity KSI: fatalities + severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

- **The opponent user** is first and foremost a passive driver. His only role consists in being present and he cannot be considered as an engaging part in the disturbance.
- There are twice less opponent users than case vehicles (Figure 25). It means that half of the accidents involving at least one passenger car realizing an overtaking manoeuvre are single vehicle accidents. So, the driver performing the overtaking manoeuvre does not crash any other road user.

To conclude, accidents involving at least one passenger car overtaking are often single vehicle accidents (considering as a loss of control situation or a problem of guidance). Moreover, supposing that another user is involved in the accident, this one is considered as a passive driver. He did not contribute in the accident creation and development.

So, we need to focus on passenger car overtaking in order to well understand the causes of accidents and to find the most appropriated safety measures which could prevent the accident or mitigate its violence.

Key Events
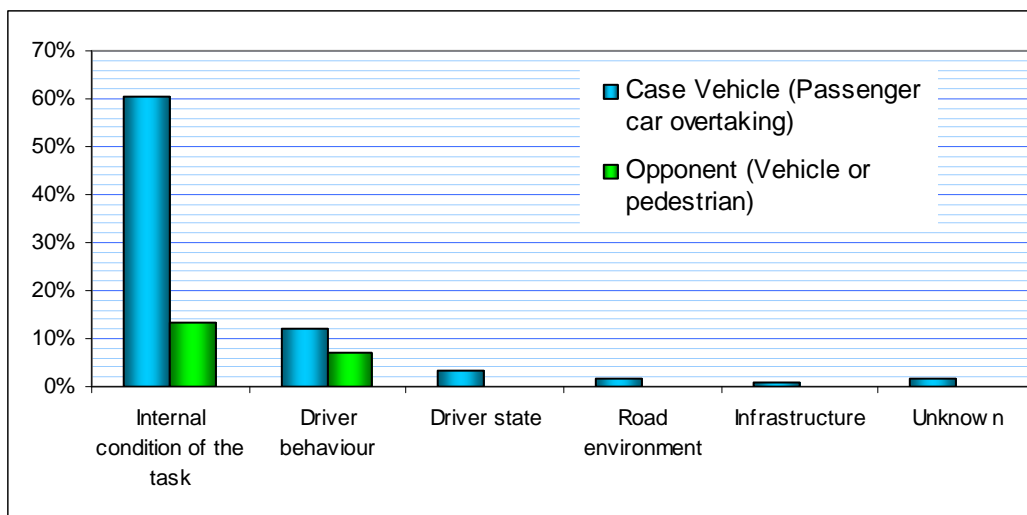
Figure 26: Key event fields for overtaking accidents

As predicted previously, the case vehicle driver (the driver overtaking) is the one on which we have to focus our analysis. Moreover, the key event analysis shows that 80% of the key events are linked to the driver performing an overtaking (Figure 26). It means that if we are able to prevent these key events, the accident could probably be avoided.

The key event, the event at the first beginning of the accident and which interrupts the driving situation is linked to internal conditions of the overtaking tasks (Figure 26). It means that there was a lack of preparation before the realization of the overtaking manoeuvre. The 'conditioning' of the driver to the task was not optimum. So, the main causes linked to this key event category are:

- Incorrect driving manoeuvre: poor overtaking, risky driving…. (n=48, Table 6). The overtaking manoeuvre was incorrectly prepared. It means that the conditions were not optimum to perform the manoeuvre. And in spite of everything, the driver has all the same tried to overtake another road user.

- A poor evaluation or anticipation of the situation (for instance other road user speed…), (n=19, Table 6). The identification of hazards and the quantification of their potential for danger have been neglected or were difficult to identify by the driver. So he was not able to well anticipate the evolution of the situation.

The other causes are linked to the driver behaviour category (Figure 26). Indeed, the driver overtaking failed to look, which means that he looked but did not see (n=14, Table 6). It is an important point

which is often studied in behavioural experiments. Psychological bases on LBFTS[12] say that these errors can be attributed to individuals' attentional biases and to their imperfect visual scanning capabilities or practices. These are common human deficiencies, especially under load and time stress, therefore the LBFTS problem is inherently important in a visually demanding traffic system, although there will obviously be individual differences in the tendency to commit such errors. Understanding these individual differences and the road and traffic situations which predispose drivers to LBFTS are essential requirements if counter-measures against this error are to be designed and introduced effectively.

If the key event shows what is the event at the origin of the accident, it does not explain why this event happened and what contributes to such event. That is why, the next chapter will try to identify the factors which contributed to such events.

Key event		
	Passenger car overtkaing	**Opponent vehicle**
Internal conditions of the task		
Incorrect driving manoeuvre (poor overtaking, risk taking…)	48	11
Poor evaluation / anticipation (other vehicle's speed…)	19	5
Excessive speed	6	0
Inappropriate speed (related to weather, road surface, infrastructure…)	1	0
Other	2	1
Driver behaviour		
Failed to look, looked but did not see…	14	9
Inattention – concentrated on another driving related task	1	0
All	**91**	**26**

Table 6: Key events detailed for overtaking accidents

Contributing factors
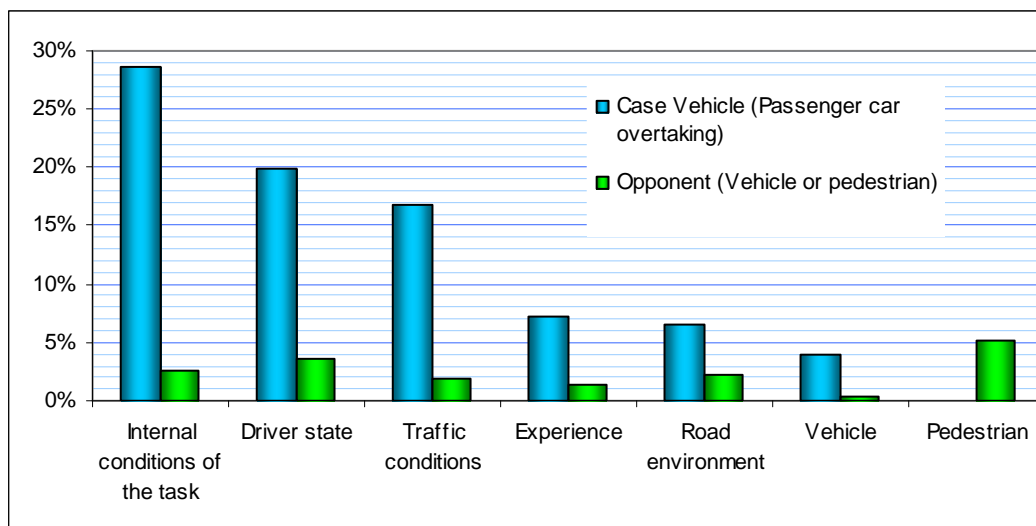
Figure 27: Contributing factor fields for overtaking accidents

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[12] Looked But Failed To See

Elements which could contribute to the failures of the manoeuvres presented above are named contributing factors. As explained above, the accident contributing factors will only focus on the case vehicle which is the passenger car performing an overtaking manoeuvre.

Obviously, they are mainly linked to the internal conditions of the tasks but other fields are concerned such as the driver state and the traffic conditions. The main results are:

- A problem of speed and especially an non adapted speed (n=43, Table 7). The speed is not necessary over the legal speed limit. The fact is that the driver chose a too high speed for the situation and was not able to well analyze the situation and to control his vehicle during the manoeuvre.

- A risky driving. The in-depth analysis shows that the driver disobeyed traffic control signs/signals/markings. The last point is the main important one. Indeed, case vehicle overtook in spite of a continuous lane (n=20, Table 7).

- The road user was affected by time constraints (n=7, Table 7). It could explain why he wanted to overtake another user and why he looked but failed to see. This factor has an influence in the internal conditions of the task realization and on the state of the driver. On the other hand, there is another time constraint which is linked to the situation. Indeed, if a vehicle is coming in front of him or the road becomes a one lane road (instead of two lane roads in the same direction), the case vehicle driver needs to rapidly finish his manoeuvre.

- Other contributing factors are linked to the driver state and illustrate this time constraint as the driver was careless, reckless, in a hurry or restlessness (n=33, Table 7).

- Traffic conditions contributed too to the failure of the driver performing an overtaking manoeuvre. Problem of visibility (deteriorated or mobile mask) emerges from this analysis (n=14, Table 7). The driver had not a good visibility of the situation due to the luminosity during the accident or another vehicle masked the essential points of the situation.

    Remark: the in-depth analysis shows that for more than 90% of the case vehicle the longitudinal visibility (related to the road layout) is over 300 meters. So the road layout did not contribute to the accident development but the visibility due to luminosity did.

- Other road users ahead have an inconvenient behaviour for the passenger car overtaking (n=8, Table 7). Indeed, during the cut in phase, the road user in front of the case vehicle suddenly braked. It reveals problems of distance between vehicles as the case vehicle was not able to anticipate the situation at the end of this manoeuvre.

(Table 7 is showed on the following page)

Human functional failure

The approach of the human functional failure confirmed the results found above. Indeed, the main human failures are linked to (only considering the case vehicle):

- **The decision** on the execution of the overtaking manoeuvre (16,5%, Figure 28). The malfunctions revealed in this type of process have more to do with the notion of 'violation' than the notion of 'error' in information processing terms Indeed the passenger car performing an overtaking manoeuvre has deliberately violated safety rules because he was in a hurry or he had a risky driving behaviour (n=13, Table 8).

- The psychomotor stage of taking **action** (16,5%, Figure 28). As WP5 exposed it on its report, this category only includes accidents in which a problem of vehicle control is the direct cause of the emergence of an accident situation (n=11, Table 8).

Contributing factor	Passenger car overtkaing	Opponent vehicle
Internal conditions of the task		
Inadapted speed : Choose of a too high vehicle speed for the situation	31	1
Risky driving (ludic, test of performance, transgression, deliberate accident-generating behaviour, trivialization of the situation (potentially dangerous but treated as 'pain-killer') Driving too close etc.)	20	1
Speed above speed limit	12	1
Global time constraint (for the trip or the manoeuvre)	7	0
Other	18	5
Driver state		
Careless, reckless or in a hurry	26	5
unknown but related to driver state	10	1
Low level of attention (low vigilance, affectation of attentional resources to driving task, internal distraction such as thinking, external distraction such as discussing)	7	3
Restlessness	7	2
Alcohol impairment or other illegal or legal drugs	6	0
Falling asleep	4	0
Other	1	0
Traffic conditions		
unknown but related to the traffic conditions	11	1
Deterioration of visibility (night, rain, dazzling sun...)	9	0
Inconvenient behaviour of a user ahead (low speed for example), atypical manoeuvres from other users (illegal manœuvre excessive speed…)	8	1
Environmental perturbation (loss of adherence such as ice, aquaplaning, oil, snow…)	7	1
Temporal inconvenience for visibility (mobile mask such as another vehicle)	5	0
Situational pressure inducing a precipitated manœuvre	4	0
other	4	1
Situational pressure inducing a precipitated manoeuvre	4	2
Experience		
unknown but related to driver experience	10	1
Low experience of driving (e.g. novice driver or elderly drivers, weak experience of the situation...)	6	1
Site not known	4	0
Automatic driving: low attention level due to high experience of the trip (or its monotony) or low attention level due to high experience of the manœuvre	1	1
Low experience of the vehicle handling	1	1
Road environment		
unknown but related to the road environment	11	1
Visibility limited by infrastructure (road equipment, vegetation and buildings)	4	3
Complex site (e.g. intersection), Difficult site (low radius in bend, rupture), Narrow road	4	1
Problems in equipment (atypical, not legible, not adapted to certain vehicles), Equipment inciting to speeding, Bad road surface maintenance	1	2
Vehicle		
unknown but related to the vehicle	11	1
Vehicle size	1	0
Pedestrian		
Pedestrian: crossing road masked by stationary or parked vehicle	0	5
Pedestrian: failed to look properly	0	5
Pedestrian: dangerous action in carriageway (e.g. playing)	0	1
Pedestrian: careless, reckless or in a hurry	0	5
All	**255**	**53**

Table 7: Contributing factors detailed for overtaking accidents
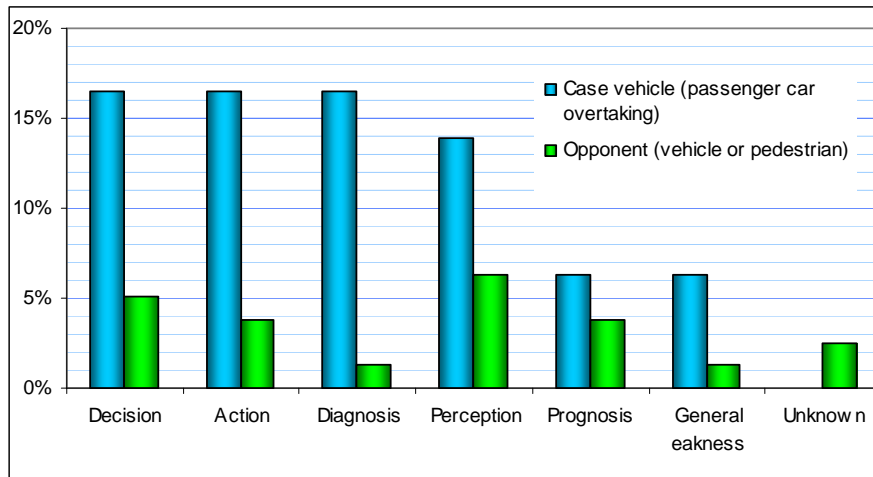
Figure 28: Human functional failure fields for overtaking accidents

It is not surprising to find this human failure as noticed in the paragraph "driver involvement status", accidents are often single vehicle accidents (synonymous with loss of control or guidance problem). Even if another road user is involved in an accident in which a passenger is performing an overtaking manoeuvre, the road user is a passive driver. These accidents can also be considered as a loss of control or a problem of guidance for the vehicle performing the specific manoeuvre.

The newt paragraph will focus on this failure in order to answer to the question: why the case vehicle driver has lost his vehicle control.

- **The diagnostic** of the situation (16,5%, Figure 28). Taking into consideration previous results, the driver made a cursory assessment of the interaction and went no further than identified an impediment to his progress (n=8, Table 8).

Human functional failure	Passenger car overtkaing	Opponent vehicle
Decision		
D2 failure - Deliberate violation of a safety rule	13	2
D1 failure - Violation directed by the characteristics of the situation	0	2
Action		
E2 failure - Guidance problem	6	0
E1 failure - Poor control of an external disruption	5	3
Other failure linked to the action	2	
Diagnosis		
T4 failure - Mistaken understanding of another user's manœuvre	8	0
T1 failure - Erroneous evaluation of a passing road difficulty	4	1
T3 failure - Mistaken understanding of how a site functions	1	0
Perception		
P1 failure - Non-detection in visibility constraints conditions	5	2
P2 failure - Information acquisition focused on a partial component	2	0
P3 failure - Cursory or hurried information acquisition	1	2
P4 failure - Momentary interruption in information acquisition acttiv	1	1
Prognosis		
T5 failure - Expecting another user not to perform a manœuvre	3	1
T6 failure - Actively expecting another user to take regulating actio	1	2
T7 failure - Expecting no perturbation ahead	1	0
General weakness		
G1 failure - Loss of psycho-physiological capacities	3	1
G2 failure - Alteration of sensorimotor and cognitive capacities	1	0
G3 failure - Overstretching cognitive capacities	1	0
All	58	17

Table 8: Human functional failures detailed for overtaking accidents

In which phase of the overtaking, the accident happened?

The loss of control is one of the most frequent accident situations during an overtaking manoeuvre. In order to better understand these accidents, we shared the overtaking manoeuvre in several phases and studied the causes of the accidents in each phase:

1- The first step is the changing lane in order to overtake the vehicle ahead,

2- The second step consists in being on the nearside of the vehicle overtaken,

3- The third step is the cutting in. So the vehicle is now in front of the vehicle overtaken.

For the three steps, we noticed that the causes of the accidents were clearly different and that the loss of control mainly began during the two last steps. Here are the main causes of the accidents according the different phases:

- Step 1 - changing lane:

    ▪ The case vehicle driver begins his overtaking manoeuvre and sees at the same time a vehicle in front of him or on his side (he is overtaken by another road user). This cause underlines the lack of control of the situation due to lack of visibility. This cause is clearly linked to a problem of perception. The driver has not checked his possibility to overtake or was not able to find relevant information to realise his manoeuvre.

- Step 2 – stabilized phase:

    ▪ During the stabilized phase, the vehicle swerved to the left shoulder of the road. It means that the driver has a problem in the manoeuvre realization and especially in the lateral distance between the case vehicle and the left shoulder.

    ▪ The vehicle overtaken swerves to the vehicle overtaking side. The vehicles overtaken are not often involved in the crash accident. That is why, the previous paragraphs did not detect such problems. Nevertheless, we could underline the fact that vehicle overtaken had a problem of situation control.

- Step 3 – cutting in:

    ▪ Situational constraint: the number of lanes in the direction of the vehicle is reduced or a vehicle is coming from the opposite direction. This situation has brought about a hurried cutting in.

    ▪ During the cutting in manoeuvre, the vehicle crossed the right shoulder. It means that the driver has a problem in the manoeuvre realization and especially in the lateral distance between the case vehicle and the right shoulder.

    ▪ The case vehicle cuts in between two vehicles and the vehicle in front of him is braking.

Conclusions for overtaking manoeuvre accidents

The passenger car overtaking is a *primary active driver* in the genesis of the accident. When another road user is involved in the accident, this one is a passive driver. His only role consists in being present and he cannot be considered as an engaging part in the disturbance. So, if we want to avoid the accident, we need to find appropriated safety measures linked to the passenger car overtaking.

The first main result is that we need to help the driver to diagnose the situation before realizing the overtaking manoeuvre. Here are the factors coming from the in-depth analysis explaining this lack of diagnosis and their safety systems associated:

- The speed is non adapted to the situation (and especially to the road layout). The safety system appropriated to this failure is an intelligent speed adaptation. The system adapts the speed to the speed limits and to the prevailing conditions (for instance, adverse road or weather conditions).

- The speed is over the legal speed limit. The speed alerting system or the speed limit system could warm the driver of the over-speed or could force the driver to not drive over the legal speed limit.

- Some factors linked to the state of the driver can explain why there is a poor diagnosis of the situation. Indeed, the analysis showed that the driver was careless, reckless, in a hurry or restlessness. If it is difficult to find a system which could change your mental state, we can all the same prevent or help him to diagnose the situation. The systems which could help the driver are a collision warning system, a collision avoidance system, an inter-vehicle communication system or a lane changing assistance. These systems could also help the driver when the visibility is deteriorated.

The second main result underlines the fact that we need to help the driver overtaking during his decision phase (for the overtaking realization). Indeed, the driver deliberately violates safety rules and takes risk. Indeed, passenger car overtakes in spite of a continuous lane and so already identified risky place. The first main counter-measure is to enforce laws thanks to road safety preventing campaigns and to repression. The other counter-measure could be a system which warms the driver when he is crossing a continuous lane.

The last result shows that there is a problem of loss of control during the realization of the overtaking. Indeed, the passenger car driver, during the stabilized phase and the cutting one, crossed respectively the left and right shoulder and this crossing are often at the origin of the loss of control. Naturally systems which could avoid a loss of control are the most appropriated such as ESC[13] or TCS[14]. Nevertheless, it is possible to associate counter-measures to the road. Indeed, we could think that a larger road would have avoided the crossing on the shoulders or warning painting on the road would have inform the driver that he is very close to the shoulder.

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[13] Electronic Stability Control

[14] Traction Control System

6.2.3.b   **Scenario 2: Turning left (turning right for UK) manoeuvre**

<u>Prevalence in Europe:</u> 10% to 43%

<u>Severity KSI[15]:</u> 16% to 22%

<u>In-depth databases used:</u> LAB, INRETS and OTS

<u>Sample:</u> 62 accidents
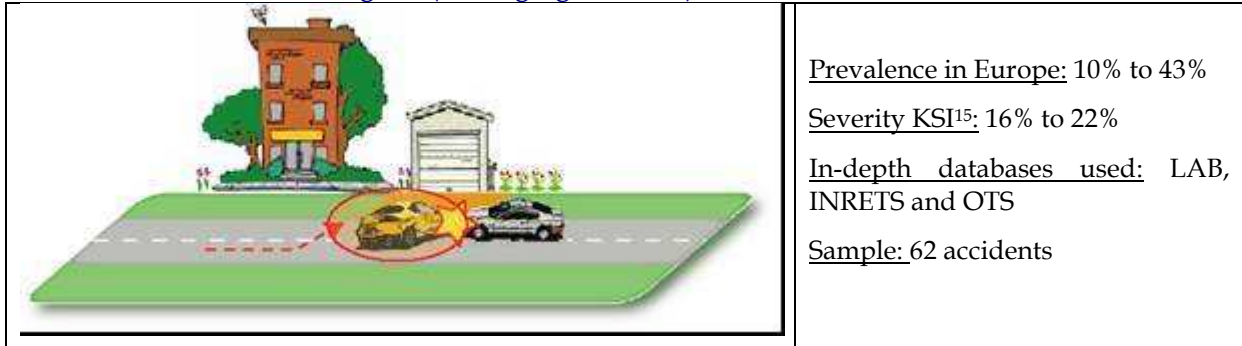
In this part, for convenient reasons, the expression "turning left manoeuvre" will cover too "turning right manoeuvre" (for countries driving on the left side of the road, i.e. United Kingdom).

The situation studied is the turning left manoeuvre. It means that the accident took place away from a proper intersection and the <u>passenger car</u> is performing a turning left (in order to join a private road, a parking). For instance, a passenger car driver turns on left in order to a join a petrol station. And at the same time, a power two-wheeler overtook him. The accident is unavoidable.

The pictogram above is just an example and do not cover all the accidents with a turning left manoeuvre.

In the next parts, the passenger car performing a turning left manoeuvre is considered as the case vehicle. The opponent vehicle or pedestrian is the other road user involved in the accident. It can be another passenger car or another road user.

Driver involvement status
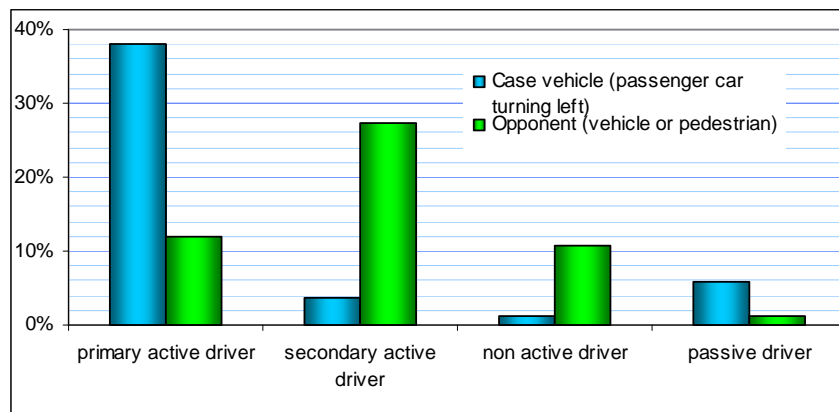
Figure 29: Driver involvement status for turning left accidents

This manoeuvre differs from the previous one. Indeed, case vehicle and opponent one both play a role in the genesis of the accident at different degree. The case vehicle is above all a primary active driver. He is at the origin of the destabilization of the situation. He involved himself and other road users in a critical situation whose outcome is the crash.

Whereas the opponent is a secondary active road user. He participates in the non-resolution of the problem by a wrong anticipation of the events evolution. During the pre-accident phase, 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.

So to determine causes of these accidents, it is necessary to focus on all road users involved, that is to say the passenger car performing a turning left manoeuvre and the other road users as they all participate to the accident development.

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[15] Severity KSI: fatalities + severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

Key Events

The key events of turning left manoeuvre have lots of similarities with overtaking manoeuvre. Indeed, the preponderant key events are linked to the internal conditions of the turning left manoeuvre and the driver behaviour and the driver performing the turning left is linked to the key event in 86% of the accidents (Table 9). Here are the main key events:

- Incorrect driving manoeuvre: poor turning left, risky driving…. (n=15). The turning left manoeuvre was incorrectly realized. It means that the conditions were not optimum to perform the manoeuvre. And in spite of everything, the driver has all the same tried to turn left.
- A poor evaluation or anticipation of the situation (for instance other road user speed…), (n=7). The identification of hazards and the quantification of their potential for danger have been neglected or were difficult to identify by the driver. So he was not able to well anticipate the evolution of the situation.
- Looked but failed to see (n=14)

The last key event refers to LBFTS paragraph in the previous chapter. The next parts of this chapter will focus on these keys events in order to better understand what contributed to these critical events. As for the previous sheet (overtaking manoeuvre), the key event only describe the event at the origin of the accident. And the next paragraph will try to determine what the factors which contribute to such events.

Key event		
	Passenger car turning left	**Opponent vehicle**
Internal conditions of the task		
Incorrect driving manoeuvre (poor overtaking, risk taking…)	15	1
Poor evaluation / anticipation (other vehicle's speed…)	7	1
Decision making error	1	0
Misinterpreted the driving situation	0	2
Driver behaviour		
Failed to look, looked but did not see…	14	2
All	37	6

Table 9: Key events detailed for turning left accidents

Contributing factors
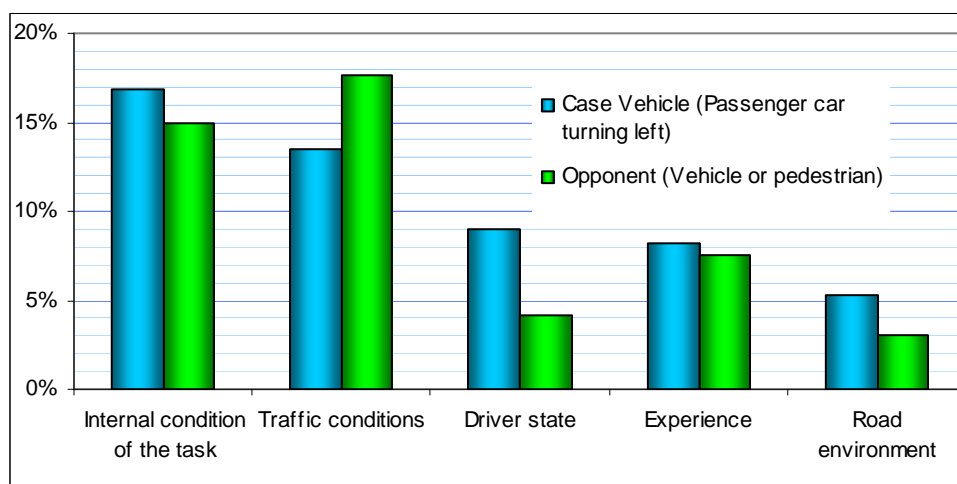
Figure 30: Contributing factor fields for turning left accidents

Several relevant contributing factors appear in the in-depth analysis for turning left manoeuvre and bring up different problems (Table 10):

1- The passenger car driver turning left has difficulties to find a gap to cross the opposite lane and is subject to a situational time constraint to realize his manoeuvre (vehicles behind him and traffic flow on the opposite lane), (n=21). The in-depth analysis did not show any difference between accidents with a vehicle coming from behind and accidents with a vehicle coming from the opposite lane.

2- Automatic driving and trivialization of the manoeuvre for the passenger car performing the turning left (n=26). It results to a low level of attention at the situation.

   Both problems are linked to other factors which could make matters worse. Indeed, the in-depth analysis shows that case vehicle and opponent one have both a right of way feeling due to the confidence in the signs given to each other or due to the right of way status (n=20). This lack of understanding increases the risk of accident between vehicles.

   Moreover, we can see in the in-depth analysis that there are often problems of bad visibility and legibility of the situation (due to weather condition, mobile mask or road layout), (n=30). Then, it could result in an non adapted speed from the opponent vehicle which is not prepared to the situation (n=11).

3- The passenger car turning left gives any or ambiguous clues indicating its manoeuvre. Then, the opponent is not able to prevent the manoeuvre and also the accident (n=11).

Contributing factors	Passenger car turning left	Opponent vehicle
Internal condition of the tasks		
Global time constraint (for the trip or the manoeuvre)	13	4
Risky driving (ludic, test of performance, transgression, deliberate accident-generating behaviour, trivialization of the situation (potentially dangerous but treated as 'pain-killer') Driving too close etc.)	12	9
Right of way feeling (Rigid attachment to the right of way status;Excessive confidence in the signs given to others)	9	11
Identification of a potential risk only about a part of the situation	7	2
Inadapted speed : Choose of a too high vehicle speed for the situation	1	11
Other	3	3
Traffic conditions		
Temporal inconvenience for visibility (mobile mask such as another vehicle)	12	11
Difficulty in finding a gap to cross or to insert (density or speed to the traffic)	8	0
Deterioration of visibility (night, rain, dazzling sun...)	7	0
Being dragged (by a passenger, a vehicle ahead is starting …)	6	0
Inconvenient behaviour of a user ahead (low speed for example), atypical manoeuvres from other users (illegal manœuvre excessive speed…)	1	23
Ambiguity or Absence of clues indicating a manoeuvre made by another user	0	11
Other	2	2
Driver state		
Low level of attention (low vigilance, affectation of attentional resources to driving task, internal distraction such as thinking, external distraction such as discussing)	11	7
Restlessness	8	2
Slow reaction	3	1
Falling asleep	2	1
Experience		
Automatic driving: low attention level due to high experience of the trip (or its monotony) or low attention level due to high experience of the manœuvre	14	12
Low experience of driving (e.g. novice driver or elderly drivers, weak experience of the situation...)	4	5
Site not known	3	3
Low experience of the vehicle handling	1	0
Road environment		
Visibility limited by infrastructure (road equipment, vegetation and buildings)	7	2
Complex site (e.g. intersection), Difficult site (low radius in bend, rupture), Narrow road	5	4
Problems in equipment (atypical, not legible, not adapted to certain vehicles), Equipment inciting to speeding, Bad road surface maintenance	2	2
All	141	126

Table 10: Contributing factors detailed for turning left accidents

Human functional failure

The human functional failure approach shows different errors for the case vehicles and their opponents. Indeed, the case vehicle is associated with perception failures (22%) whereas its opponent is rather linked to perception and diagnosis failures (18% and 16%).
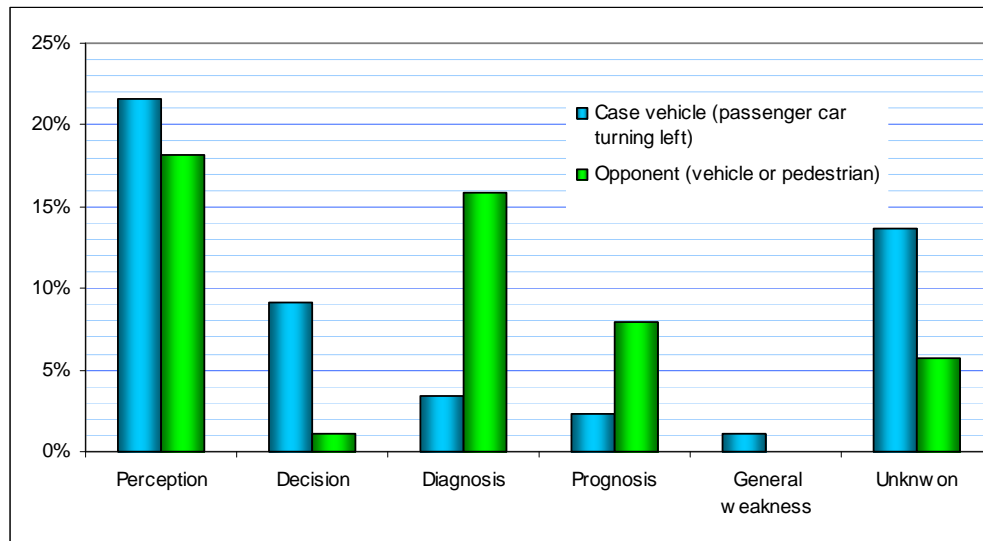
Figure 31: Human functional failure fields for turning left accidents

We will distinguish both vehicles and situation to detail the human functional failures.

The case vehicle turning left:

- Perception failures are the most important one for case vehicles (22%). The analysis indicates that the drivers reduced to a minimum the time and attention devoted to the search of information (n=12, Table 11).

This failure is explained the factors presented above. Indeed, this lack of perception can be due to the routine nature of the manoeuvre or because they experience a situational pressure (with time constraint, workload, incitation from a third part, etc.).

The opponent:

Human functional failures well illustrate the fact that opponent road users were not expecting such a situation. Indeed perception failures show that they were not able to detect the manoeuvre from the case vehicles due to the following reasons:

- Non detection in visibility constraints conditions (n=8, Table 11): Environmental constraints linked to the layout of the road, to the presence of other vehicles, or luminosity problems, made it difficult to detect an important element in the situation when the drivers would have needed it.

- Neglecting the need to search for information (n=5, Table 11). One more time, the opponent vehicle is induced by a feeling of right of way to the point of ignoring totally an opponent vehicle up to the moment when it becomes inevitable.

- The opponent vehicle was not able to diagnosis such a manoeuvre from the case vehicle (n=14, Table 11). This type of understanding failure is specifically devoted to the behaviour of the passenger car turning left. It can arise as a result of the user not properly signalling his manoeuvre, or his giving of ambiguous signals, or of the driver making a cursory assessment of the interaction and going no further than identifying an impediment to his progress.

Human functional failure		
	Passenger car turning left	Opponent vehicle
Perception		
P3 failure - Cursory or hurried information acquisition	12	0
P2 failure - information acquisition focused on a partial component of the situation	6	2
P1 failure - Non-detection in visibility constraints conditions	0	8
P4 failure - Momentary interruption in information acquisition activity	1	0
P5 failure - Neglecting the need to search for information	0	5
Decision		
D3 failure - Violation error	4	0
D2 failure - Deliberate violation of a safety rule	2	1
D1 failure - Violation directed by the characteristics of the situation	2	0
Diagnosis		
T4 failure - Mistaken understanding of another user's manœuvre	0	14
T2 failure - Erroneous evaluation of the size of a gap	3	0
Prognosis		
T6 failure - Actively expecting another user to take regualting action	1	5
T7 faiIure - Expecting no perturbation ahead	1	0
T5 failure - Expecting another user not to perform a manœuvre	0	2
General weakness		
G3 failure - Overstretching cognitive capacities	1	0
All	33	37

Table 11: Human functional failures detailed for turning left accidents

Conclusions for turning left manoeuvre accidents

The in-depth analysis of passenger car realizing a turning left manoeuvre shows that the main problem related to the manoeuvre is linked to the preparation of it. It means that it is not realized in good safety conditions.

The main problem for passenger car turning left is a problem of perception of all the elements of the driving situation. The information acquisition is neglected by the driver and he is not able to anticipate the evolution of the situation. The reasons of this lack of perception are due to the following causes:

-   The driver is subjected to situational constraint (road users waiting behind him) and he has some difficulties to find a gap to cross the opposite lane. The counter-measure associated to this cause is rather linked to the infrastructure and the to traffic management. Nevertheless, we can think that a system fitted on the vehicle such as an inter-vehicle communication system could inform the driver about his possibility to turn left considering the other road users approach.

-   The driver trivializes the manoeuvre and the situation. He has given signs to the other road user and he has a right of way feeling. Once again, the inter-vehicle communication system could prevent such accident by informing the driver of the impossibility of turning left.

-   There is also a problem of bad visibility of the situation. The driver is not aware of all the elements helping him to perform his manoeuvre. When the road layout is at the origin of the problem of visibility, it is necessary to work on the traffic regulation surrounding the turning left place. When the lack of visibility is linked to weather condition or mobile mask, a system helping the driver to see the other road user not visible should be efficient. Once again, the inter-vehicle communication system gives to the road users advanced knowledge of approaching vehicles outside their field of vision.

The second main problem for passenger car driver realizing a turning left is the decision to perform this manoeuvre. Indeed, the driver deliberately violated safety rules and was not allowed to turn left. As for the overtaking manoeuvre, one of the counter-measures could be and enforcement laws thanks to road safety preventing campaigns and to repression. To prevent the driver from turning left, it can be possible to separate the lanes by a fix barrier or to have a system warning the driver that he is not allowed to turn left.

6.2.3.c Scenario3: U-turning manoeuvre

Prevalence in Europe: 7% to 20%

Severity KSI[16]: 17% to 22%

In-depth databases used: LAB, INRETS and OTS

Sample: 27 accidents
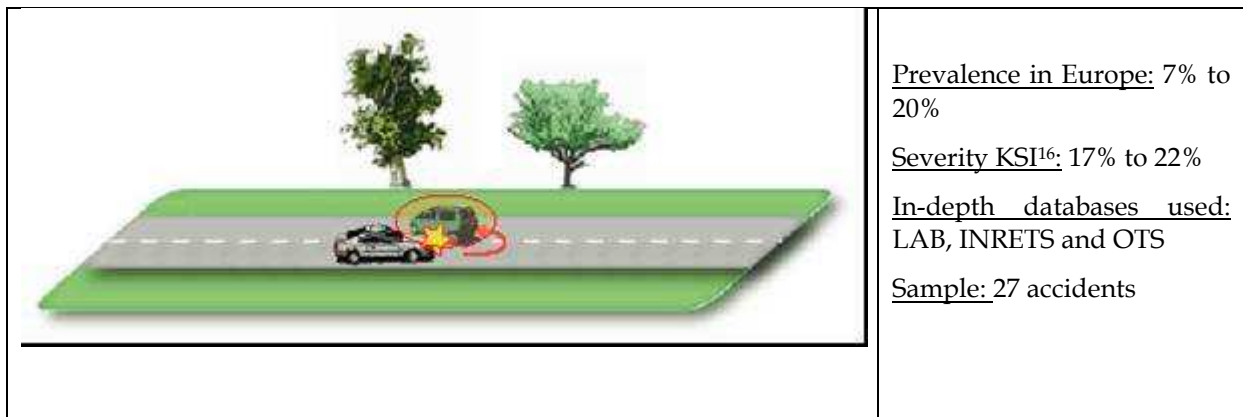
In this chapter, the situation studied is the u-turning manoeuvre. It means that the accident took place away from a proper intersection and the passenger car is performing a u-turning manoeuvre.
The pictogram above is just an example and do not cover all the accidents with a u-turning manoeuvre.
In the next parts, the passenger car performing a u-turning manoeuvre is considered as the case vehicle. The opponent vehicle or pedestrian is the other road user involved in the accident.
This manoeuvre seems to have similarities with the previous one, considering the realization sequence. The in-depth analysis will determine if the causes of accidents are the same too.

Remark: The in-depth analysis shows that in this accident configuration, the passenger car driver u-turning performed his manoeuvre from the road lane or from a parking place (there is no difference) and was involved in an accident with a vehicle coming from behind (and not from the opposite lane). So the pictogram above is a good overview of our in-depth accidents involving a passenger car performing a u-turning manoeuvre.

Driver involvement status
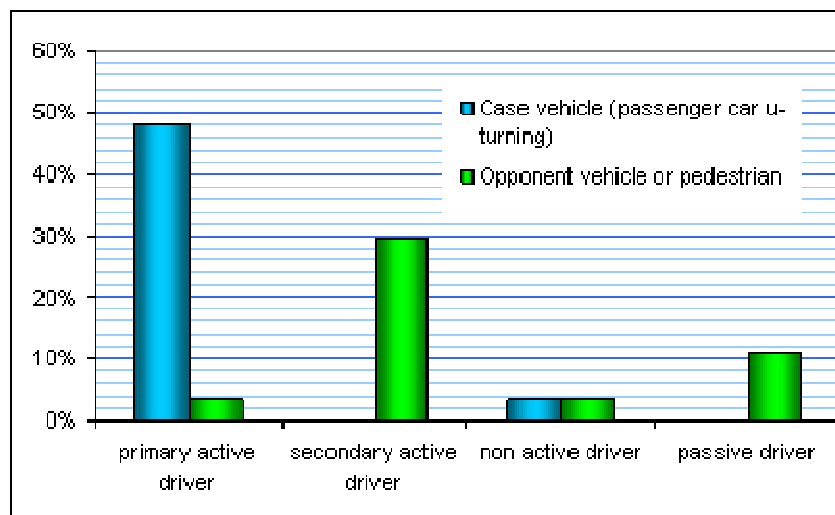
Figure 32: Driver involvement status for u-turning accidents

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[16] Severity KSI: fatalities + severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

This manoeuvre has similarities with the turning left manoeuvre. Indeed, the case vehicles and the opponent ones both play a role in the genesis of the accident at different degrees. The case vehicle is above all a primary active driver. He is at the origin of the destabilization of the situation. He involved himself and other road users in a critical situation whose outcome is the crash.

Whereas the opponent is a secondary active road user. He participates in the non-resolution of the problem by a wrong anticipation of the events evolution. In pre-accident situation, 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. So to determine the causes of these accidents, it is necessary to focus on all vehicles involved, that is to say the passenger car performing a u-turning manoeuvre and the other road users as they all participate to the accident development.

The next paragraphs will identify the main causes of this kind of accident and determine if u-turning and turning left manoeuvres have the same causes.

<u>Key event</u>

Key event		
	Passenger car u-turning	**Opponent vehicle**
Internal conditions of the task		
Decision making error	1	0
Incorrect driving manoeuvre (poor overtaking, risk taking…)	10	1
Poor evaluation / anticipation (other vehicle's speed…)	1	2
other	1	0
Driver behaviour		
Failed to look, looked but did not see…	6	0
All	19	3

Table 12: Key events detailed for u-turning accidents

The key events of u-turning manoeuvre have lots of similarities with overtaking and turning left manoeuvres. Indeed, the preponderant key events are linked to the internal conditions of the turning left manoeuvre and the driver behaviour. Here are the main key events:

- Incorrect driving manoeuvre: poor overtaking, risky driving…. The u-turning manoeuvre was incorrectly realized. It means that the conditions were not optimum to perform the manoeuvre. And in spite of everything, the driver has all the same tried to u-turn.

- A poor evaluation or anticipation of the situation (for instance other road user speed…). The identification of hazards and the quantification of their potential for danger have been neglected or were difficult to identify by the driver. So he was not able to well anticipate the evolution of the situation.

- Looked but failed to see.

The last key event refers to LBFTS paragraph in the previous chapter. The next parts of this chapter will focus on these keys events in order to better understand what contributed to these failures.

Contributing factors
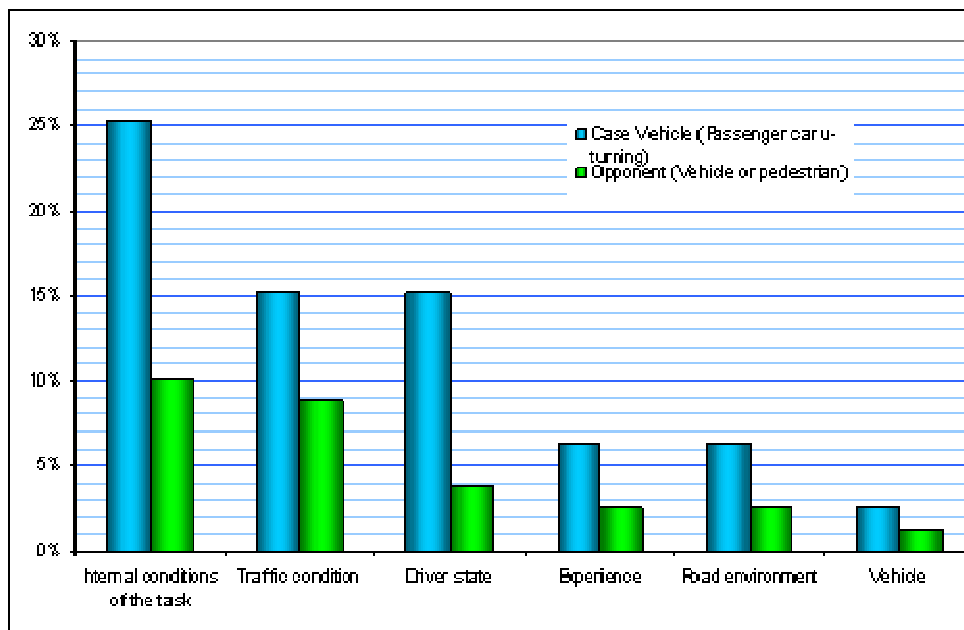
Figure 33: Contributing factor fields for u-turning accidents

First of all, it seems that this manoeuvre in our in-depth accidents databases are often linked to purposeful violation of traffic laws, regulations… It means that the passenger car driver performing the u-turning was not allowed to realize it (n=7, Table 13).

In addition to this factor, a lack of clues indicating the manoeuvre generates a bad and impossible anticipation for the opponent vehicle (n=3). Nevertheless, the in-depth accidents show that the factor "non adapted speed for the situation" (considering the infrastructure and its road layout) is mainly imputed to the opponent vehicle (n=4). So, the chance for this one to avoid the accident is reduced and that is why he is considered as a secondary active driver. He did not participate to the resolution of the problem.

Another factor prevents the driver from having a good anticipation of the situation evolution. This factor is the bad visibility due to mobile mask (n=3) and due to weather condition (n=2)

On the other hand, the analysis underlines a situational time constraint for the manoeuvre realization (n=6). Then, it could explain why the case vehicle has all the same realize the manoeuvre (and he was not allowed) and why he did not give clues to other road users.

Then, all these factors have an effect on the driver state. And that is why 15% of the contributing factors (Figure 33) are linked to driver state and increase the filling of time constraint.

Contributing factors

	Passenger car u-turning	Opponent vehicle
Internal conditions of the task		
Risky driving (ludic, test of performance, transgression, deliberate accident-generating behaviour, trivialization of the situation (potentially dangerous but treated as 'pain-killer') Driving too close etc.)	7	0
Global time constraint (for the trip or the manoeuvre)	6	0
Inadapted speed : Choose of a too high vehicle speed for the situation	1	4
Right of way feeling (Rigid attachment to the right of way status;Excessive confidence in the signs given to others)	1	2
Secondary task (that has nothing to do with driving)	1	1
Identification of a potential risk only about a part of the situation	1	1
Other	3	0
Traffic condition		
Temporal inconvenience for visibility (mobile mask such as another vehicle)	3	0
Ambiguity or Absence of clues indicating a manoeuvre made by another user	2	3
Situational pressure inducing a precipitated manoeuvre	2	0
Inconvenient behaviour of a user ahead (low speed for example), atypical manoeuvres from other users (illegal manœuvre excessive speed…)	0	3
Deterioration of visibility (night, rain, dazzling sun...)	2	0
Other	3	1
Driver state		
Low level of attention (low vigilance, affectation of attentional resources to driving task, internal distraction such as thinking, external distraction such as discussing)	4	3
Careless, reckless or in a hurry	4	0
Slow reaction	3	0
unknown but related to driver state	1	0
Experience		
Low experience of driving (e.g. novice driver or elderly drivers, weak experience of the situation...)	2	1
Automatic driving: low attention level due to high experience of the trip (or its monotony) or low attention level due to high experience of the manœuvre	1	1
Site not known	1	0
unknown but related to driver experience	1	0
Road environment		
Visibility limited by infrastructure (road equipment, vegetation and buildings)	1	1
Complex site (e.g. intersection), Difficult site (low radius in bend, rupture), Narrow road	1	0
Problem in lighting the site	1	0
unknown but related to the road environment	2	1
Vehicle		
unknown but related to the vehicle	2	1
All	56	23

Table 13: Contributing factors detailed for u-turning accidents

 Human functional failure
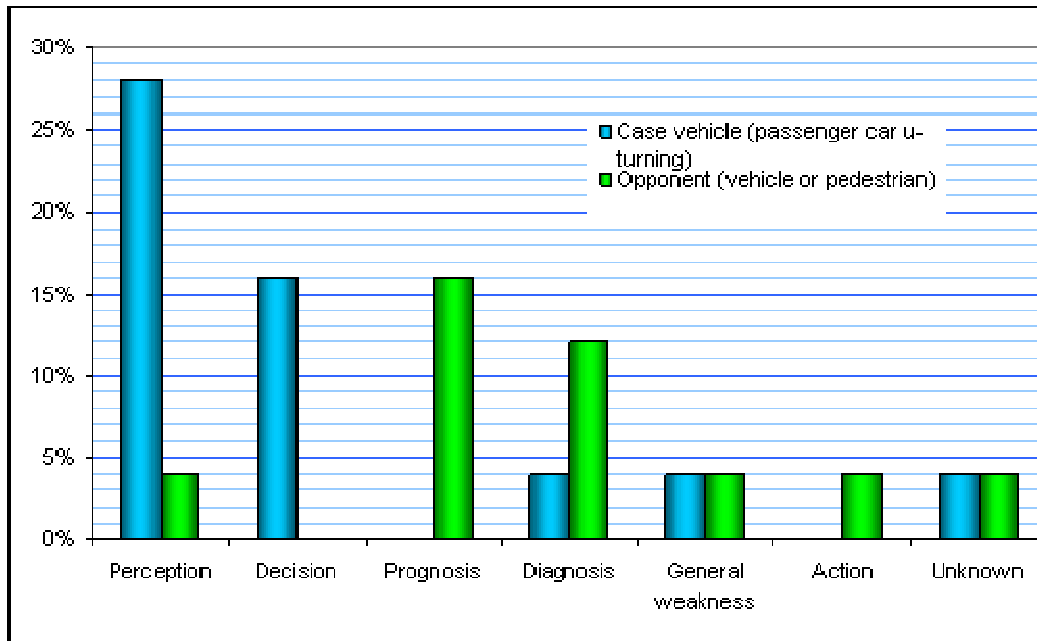
Figure 34: Human functional failure fields for u-turning accidents

Human functional failures are clearly different for the case vehicle and the opponent one. Indeed, the first one is linked to perception and decision failures whereas the second one is rather linked to prognosis and diagnosis failures.

We will distinguish both vehicles and situation to detail the human functional failure.

The case vehicle u-turning:

- One of the human failures is linked to the perception (28%, Figure 34). Indeed, there is a non detection of information due to visibility constraints conditions (n=3, Table 14). Vehicles coming from a parking place and performing a u-turning manoeuvre have problems to access to some potential useful items of information. It is mainly due to parked vehicles which reduced the visibility for case vehicles and opponent ones.

- The second detection problem refers to a question of information acquisition 'strategy' (n=3, Table 14). The driver has a low level of attention and did not detect crucial elements of the situations. The in-depth analysis shows that these drivers were disturbed by an external distraction or in spite of the checking of incoming vehicles, the drivers did not see them. This last problem refers to LBFTS problem explained in previous chapters.

- The third human failure is a decision failures and especially a "violation-error" (expression from WP5), (n=3, Table 14). The u-turning manoeuvre is the result of an impulsive release of an automatism. This occurs mostly in answer to a certain form of delegation to others of the processing of the situation (dragging effect) which is going to lead the driver.

The human functional failures attached to the opponent vehicles illustrate the fact that they were surprised by the case vehicle manoeuvre and were not able to anticipate the situation. Indeed, the failures are:

- As in the previous chapter, the opponent vehicle was not able to diagnosis such a manoeuvre from the case vehicle (n=3, Table 14). This type of understanding failure is specifically devoted to the behaviour of the passenger car u-turning. It can arise as a result of the user not

properly signalling his manoeuvre, or his giving of ambiguous signals, or of the driver making a cursory assessment of the interaction and going no further than identifying an impediment to his progress.

In our in-depth accidents, the opponent vehicle coming from behind the case vehicle has a right of way feeling and status and can't imagine that the case vehicle will realize a manoeuvre despite its coming. That is why prognosis failures are also combined with opponent vehicles.

Human functional failure		
	Passenger car u-turning	Opponent vehicle
Perception		
P1 failure - Non-detection in visibility constraints conditions	3	1
P2 failure - Information acquisition focused on a partial component of the situation	3	0
P3 failure - Cursory or hurried information acquisition	1	0
Decision		
D3 failure - Violation - error	3	0
D2 failure - Deliberate violation of a safety rule	1	0
Prognosis		
T5 failure - Expecting another user not to perform a manœuvre	0	2
T7 failure - Expecting no perturbation ahead	0	2
Diagnosis		
T4 failure - Mistaken understanding of another user's manœuvre	0	3
T2 failure - Erroneous evaluation of the size of a gap	1	0
General weakness		
G3 failure - Overstretching cognitive capacities	1	0
Action		
E2 failure - Guidance problem	0	1
All	13	9

Table 14: Human functional failures detailed for u-turning accidents

Conclusions for u-turning manoeuvre accidents

The main problem of u-turning manoeuvres is not the manoeuvre realization but is the preparation of the manoeuvre. It means that it is what has to be done before realizing the manoeuvre. Indeed, the human functional failure analysis shows that the main failure is a perception one.

Indeed, the in-depth analysis indicates that drivers coming from a parking place on the nearside of the side have problems of visibility. Due to other vehicles parked, they are not able to access to some potential useful items of information and the opponent road users have also problem to see case vehicles. So, one of the systems which could help the driver to prevent such accidents is the blind spot monitoring which warns the driver when a road user is travelling in the blind spot. The inter-vehicle communication system could help too the driver u-turning by informing him about road users outside his field of vision.

This last system could assist the driver too in another perception problem. Indeed, the in-depth analysis shows that the driver u-turning is subjected to time constraints and has a low level of attention. The consequence of this inattention is that the driver u-turning does not detect crucial elements of the situation.

The last failure underlined by the in-depth analysis is a problem of decision. This one is explained by the fact the driver u-turning has broken certain number of elementary safety rules and the infringement is not really deliberate (the driver is subjected to a situational pressure inducing a precipitated manoeuvre). To prevent the driver from u-turning, it can be possible to separate the lanes by a fix barrier or to have a system warning the driver that he is not allowed to u-turn.

6.2.3.d   Scenario 4: Changing lane manoeuvre

Prevalence in Europe: 11% to 19%

Severity KSI[17]: 12% to 17%

In-depth databases used: LAB and OTS

Sample: 56 accidents

In this chapter, the situation studied is the changing lane manoeuvre. It means that the accident took place away from a proper intersection and the <u>passenger car</u> is performing a changing lane manoeuvre. This one applies to carriageways with at least 2 lanes in the direction of travel (i.e. where there is a legitimate opportunity to change lane).

It differs from the overtaking manoeuvre because the vehicle has no vehicle to overtake and the aim of the manoeuvre is to change lane in order to change direction.

The pictogram above is just an example and do not cover all the accidents with a changing lane manoeuvre.

This chapter will focus only on the keys events and the contributing factors. Indeed, this situation happened but not very often. So, TRACE in-depth databases do not have lots of accidents for this situation. Moreover, in the in-depth databases used, the information focusing on the human functional failure is not available.

In the next parts, the passenger car performing a changing lane manoeuvre is considered as the case vehicle. The opponent vehicle or pedestrian is the other road user involved in the accident.

Key event
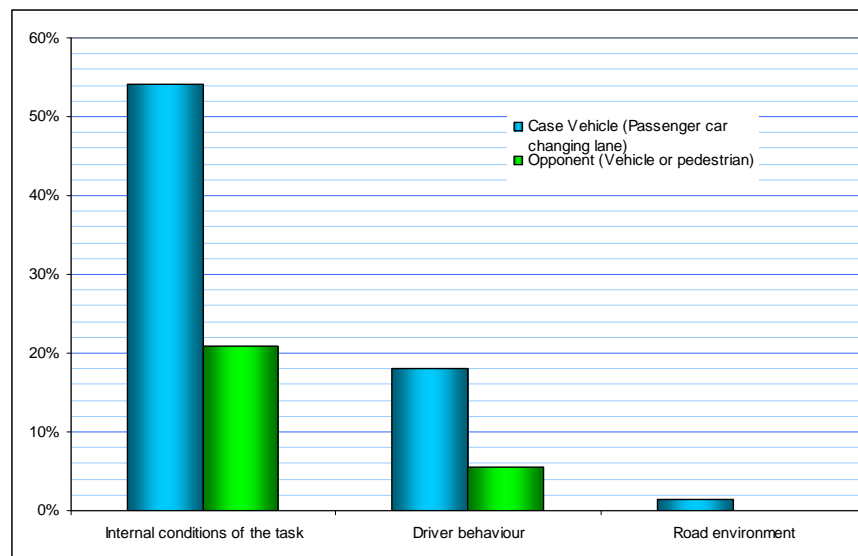
Figure 35: Key event fields for changing lane accidents

As for the three first situations studied above, the same key events emerge from the in-depth analysis. And, it appears that the case vehicle is mainly linked to the event at the first beginning of the accident

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[17] Severity KSI: fatalities + severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

and which interrupts the driving situation (74% of the key events are linked to the case vehicle, Figure 35). So the main causes of the accident for this situation are:

- Incorrect driving manoeuvre: poor overtaking, risky driving…. (n=20, Table 15). The changing lane manoeuvre was incorrectly realized. It means that the conditions were not optimum to perform the manoeuvre. And in spite of everything, the driver has all the same tried to change lane.
- A poor evaluation or anticipation of the situation (for instance other road user speed…), (n=19, Table 15). The identification of hazards and the quantification of their potential for danger have been neglected or were difficult to identify by the driver. So he was not able to well anticipate the evolution of the situation.
- Looked But Failed To See (n=13, Table 15).

The next parts of this chapter will focus on these keys events in order to better understand and to have more details on what contributed to these failures.

Key event	Passenger car changing lane	Opponent vehicle
Internal conditions of the task		
Incorrect driving manoeuvre (poor overtaking, risk taking…)	20	5
Poor evaluation / anticipation (other vehicle's speed…)	19	4
Inappropriate reaction (panic, exaggerated movements…)	0	6
Driver behaviour		
Failed to look, looked but did not see…	13	4
Road environment		
unknown but related to the road environment	1	0
All	53	19

Table 15: Key events detailed for changing lane accidents

Contributing factors
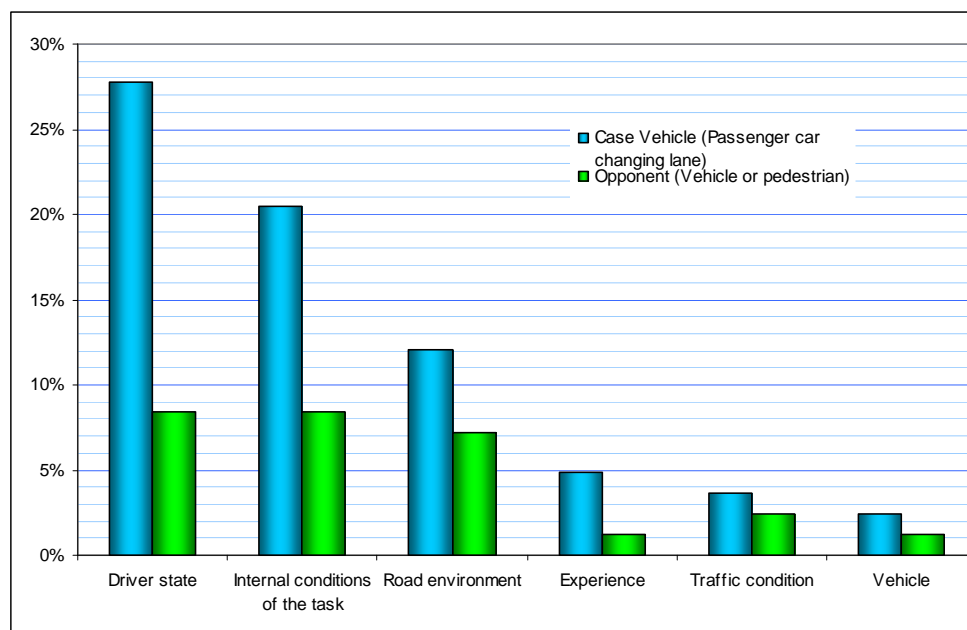
Figure 36: Contributing factor field for changing lane accidents

Looking at the contributing factors and the key events distribution regarding to the vehicles, it appears that the passenger car performing a changing lane seems to be more involved in the accident

genesis than opponent road users (71% of the contributing factors are linked to the case vehicle, Figure 36). It means that the case vehicle driver largely participates by his behaviour to the fact that the critical situation turned to the accident. So our analysis will concentrate on the factors linked to the case vehicle.

The main results are:

- The driver state is one of the most important factors which contribute to the accident development (28%, Figure 36). Indeed, the in-depth analysis shows that the restlessness of the driver (n=17, Table 16) is the most important factor. It could explain why the conditions in which the manoeuvre is realized are not optimum and why the conditioning of the task has been neglected (a poor evaluation of the situation and missing information to well analyze the situation, Table 15)

- The internal conditions of the manoeuvre realization are not optimum and the driver deliberately takes risk (n=8, Table 16).

- A problem of speed and especially an non adapted speed considering the road layout. The driver chooses a too high speed for the situation and was not able to well analyze the situation (n=6, Table 16).

Contributing factors	Passenger car Changing lane	Opponent vehicle
Driver state		
Restlessness	17	6
Alcohol impairment or other illegal or legal drugs	5	0
Unknown but related to driver state	1	0
Low level of attention (low vigilance, affectation of attentional resources to driving task, internal distraction such as thinking, external distraction such as discussing)	0	1
Internal conditions of the task		
Risky driving (ludic, test of performance, transgression, deliberate accident-generating behaviour, trivialization of the situation (potentially dangerous but treated as 'pain-killer') Driving too close etc.)	8	3
Inadapted speed : Choose of a too high vehicle speed for the situation	4	2
Speed above speed limit	2	1
Blind spot	2	1
Unknown but related to the internal conditions of the task	1	0
Road environment		
Problems in equipment (atypical, not legible, not adapted to certain vehicles), Equipment inciting to speeding, Bad road surface maintenance	4	6
Visibility limited by infrastructure (road equipment, vegetation and buildings)	3	0
Complex site (e.g. intersection), Difficult site (low radius in bend, rupture), Narrow road	2	0
unknown but related to the road environment	1	0
Experience		
Low experience of driving (e.g. novice driver or elderly drivers, weak experience of the situation...)	2	1
Low experience of the vehicle handling	1	0
unknown but related to driver experience	1	0
Traffic condition		
Temporal inconvenience for visibility (mobile mask such as another vehicle)	1	1
Environmental perturbation (loss of adherence such as ice, aquaplaning, oil, snow…)	1	1
Vehicle		
Tire problems (Problem in pressure, wear...)	1	0
unknown but related to the vehicle	1	0
other	0	1
All	58	24

Table 16: Contributing factors detailed for changing lane accidents

Even if, we don't have any information about human functional failure and degree of involvement of the roads users involved in this kind of accident, we can suggest the possibility that changing lane and overtaking manoeuvres have similar mechanisms. That is why, we suggest to remind conclusions from the overtaking chapter.

Overtaking human functional failure:

The approach of the human functional failure confirmed the results found above. Indeed, the main human failures are linked to:

- *The decision on the execution of the overtaking manoeuvre. The malfunctions revealed in this type of process have more to do with the notion of 'violation' than the notion of 'error' in information processing terms Indeed the passenger car performing an overtaking manoeuvre has deliberately violated safety rules because he was in a hurry for instance…*

- *The psychomotor stage of taking action. As WP5 exposed it on its report, this category only includes accidents in which a problem of vehicle control is the direct cause of the emergence of an accident situation.*

It is not surprising to find this human failure as noticed in the paragraph "driver involvement status", accidents are often single vehicle accidents (synonymous with loss of control or guidance problem). Even if another road user is involved in an accident in which a passenger is performing an overtaking manoeuvre, the road user is a passive driver. These accidents can also be considered as a loss of control or a problem of guidance for the vehicle performing the specific manoeuvre.

- *The diagnostic of the situation. Taking into consideration previous results, the driver made a cursory assessment of the interaction and went no further than identified an impediment to his progress.*

Conclusions for changing lane manoeuvre accidents

The in-depth analysis shows that the state of the driver has an important influence on the changing lane realization. Even if the human functional failure analysis is not available for this manoeuvre, we can think that perception failures are conditioned by the driver state. Indeed, we determined that most of the key events were a poor evaluation/anticipation of the situation. So the counter-measure should help the driver in warning him of the proximity of other road users. And the inter-vehicle communication well answers to the problem.

Two other factors are underlined in the in-depth analysis. The first one is the problem of alcohol impairment or other illegal or legal drugs. First of all, campaigns about the dangers of drinking and driving or drugging and driving should be enforced. Then, systems preventing the driver from driving because he is over the legal limit of alcohol exist and could be efficient to solve this problem. To detect drugs or medicines, no reliable system giving instantaneous results already exists. And the second one is the non-adapted speed to the situation. The safety system appropriated to this failure is an intelligent speed adaptation. The system adapts the speed to the speed limits and to the prevailing conditions (for instance, adverse road or weather conditions).

6.3 Conclusion

The in-depth analysis of specific manoeuvre accidents showed that passenger car drivers (performing a specific manoeuvre) are primary active drivers. It means that they are at the origin of the accident situation.

The main problem for these manoeuvres does not come from the realization of them but from the preparation of them (what we have to do before realizing the manoeuvre). Indeed, for all the case vehicle drivers (performing a specific manoeuvre), it appears that the conditions were not optimum to perform the manoeuvre. And in spite of everything, the driver has all the same tried to realize it.

Then, the case vehicle driver did not enough anticipate the evolution of the situation. It means that the identification of hazards and the quantification of their potential for danger have been neglected or were difficult to identify by the driver. And finally, the case vehicle driver is subjected to the Looked But Failed to See problem. It can be explained by the fact that most of the drivers was affected by time constraints.

The next paragraphs will summarize the causes of such problems according to specific manoeuvre.

And the main counter-measures identified focus on "how can we help the driver in performing his manoeuvre in good conditions?". And this is what is presented below according to specific manoeuvres.

6.3.1   What are the main important results to keep in mind?

On overtaking manoeuvre accidents

The passenger car overtaking is a *primary active driver* in the genesis of the accident. When another road user is involved in the accident, this one is a passive driver. His only role consists in being present and he cannot be considered as an engaging part in the disturbance. So, if we want to avoid the accident, we need to find appropriated safety measures linked to the passenger car overtaking.

The first main result is that we need to help the driver to diagnose the situation before realizing the overtaking manoeuvre. Here are the factors coming from the in-depth analysis explaining this lack of diagnosis and their safety systems associated:

-   The speed is non adapted to the situation (and especially to the road layout). The safety system appropriated to this failure is an intelligent speed adaptation. The system adapts the speed to the speed limits and to the prevailing conditions (for instance, adverse road or weather conditions).

-   The speed is over the legal speed limit. The speed alerting system or the speed limit system could warm the driver of the over-speed or could force the driver to not drive over the legal speed limit.

-   Some factors linked to the state of the driver can explain why there is a poor diagnosis of the situation. Indeed, the analysis showed that the driver was careless, reckless, in a hurry or restlessness. If it is difficult to find a system which could change your mental state, we can all the same prevent or help him to diagnose the situation. The systems which could help the driver are a collision warning system, a collision avoidance system, an inter-vehicle communication system or a lane changing assistance. These systems could also help the driver when the visibility is deteriorated.

The second main result underlines the fact that we need to help the driver overtaking during his decision phase (for the overtaking realization). Indeed, the driver deliberately violates safety rules and takes risk. Indeed, passenger car overtakes in spite of a continuous lane and so already identified risky place. The first main counter-measure is to enforce laws thanks to road safety preventing campaigns and to repression. The other counter-measure could be a system which warms the driver when he is crossing a continuous lane.

The last result shows that there is a problem of loss of control during the realization of the overtaking. Indeed, the passenger car driver, during the stabilized phase and the cutting one, crossed respectively the left and right shoulder and this crossing are often at the origin of the loss of control. Naturally systems which could avoid a loss of control are the most appropriated such as ESC[18] or TCS[19].

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[18] Electronic Stability Control

Nevertheless, it is possible to associate counter-measures to the road. Indeed, we could think that a larger road would have avoided the crossing on the shoulders or warning painting on the road would have inform the driver that he is very close to the shoulder.

On turning left manoeuvre accidents

The in-depth analysis of passenger car realizing a turning left manoeuvre shows that the main problem related to the manoeuvre is linked to the preparation of it. It means that it is not realized in good safety conditions.

The main problem for passenger car turning left is a problem of perception of all the elements of the driving situation. The information acquisition is neglected by the driver and he is not able to anticipate the evolution of the situation. The reasons of this lack of perception are due to the following causes:

- The driver is subjected to situational constraint (road users waiting behind him) and he has some difficulties to find a gap to cross the opposite lane. The counter-measure associated to this cause is rather linked to the infrastructure and the to traffic management. Nevertheless, we can think that a system fitted on the vehicle such as an inter-vehicle communication system could inform the driver about his possibility to turn left considering the other road users approach.

- The driver trivializes the manoeuvre and the situation. He has given signs to the other road user and he has a right of way feeling. Once again, the inter-vehicle communication system could prevent such accident by informing the driver of the impossibility of turning left.

- There is also a problem of bad visibility of the situation. The driver is not aware of all the elements helping him to perform his manoeuvre. When the road layout is at the origin of the problem of visibility, it is necessary to work on the traffic regulation surrounding the turning left place. When the lack of visibility is linked to weather condition or mobile mask, a system helping the driver to see the other road user not visible should be efficient. Once again, the inter-vehicle communication system gives to the road users advanced knowledge of approaching vehicles outside their field of vision.

The second main problem for passenger car driver realizing a turning left is the decision to perform this manoeuvre. Indeed, the driver deliberately violated safety rules and was not allowed to turn left. As for the overtaking manoeuvre, one of the counter-measures could be and enforcement laws thanks to road safety preventing campaigns and to repression. To prevent the driver from turning left, it can be possible to separate the lanes by a fix barrier or to have a system warning the driver that he is not allowed to turn left.

On u-turning manoeuvre accidents

The main problem of u-turning manoeuvres is not the manoeuvre realization but is the preparation of the manoeuvre. It means that it is what has to be done before realizing the manoeuvre. Indeed, the human functional failure analysis shows that the main failure is a perception one.

Indeed, the in-depth analysis indicates that drivers coming from a parking place on the nearside of the side have problems of visibility. Due to other vehicles parked, they are not able to access to some potential useful items of information and the opponent road users have also problem to see case vehicles. So, one of the systems which could help the driver to prevent such accidents is the blind spot monitoring which warns the driver when a road user is travelling in the blind spot. The inter-vehicle communication system could help too the driver u-turning by informing him about road users outside his field of vision.

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[19] Traction Control System

This last system could assist the driver too in another perception problem. Indeed, the in-depth analysis shows that the driver u-turning is subjected to time constraints and has a low level of attention. The consequence of this inattention is that the driver u-turning does not detect crucial elements of the situation.

The last failure underlined by the in-depth analysis is a problem of decision. This one is explained by the fact the driver u-turning has broken certain number of elementary safety rules and the infringement is not really deliberate (the driver is subjected to a situational pressure inducing a precipitated manoeuvre). To prevent the driver from u-turning, it can be possible to separate the lanes by a fix barrier or to have a system warning the driver that he is not allowed to u-turn.

On changing lane manoeuvre accidents

The in-depth analysis shows that the state of the driver has an important influence on the changing lane realization. Even if the human functional failure analysis is not available for this manoeuvre, we can think that perception failures are conditioned by the driver state. Indeed, we determined that most of the key events were a poor evaluation/anticipation of the situation. So the counter-measure should help the driver in warning him of the proximity of other road users. And the inter-vehicle communication well answers to the problem.

Two other factors are underlined in the in-depth analysis. The first one is the problem of alcohol impairment or other illegal or legal drugs. First of all, campaigns about the dangers of drinking and driving or drugging and driving should be enforced. Then, systems preventing the driver from driving because he is over the legal limit of alcohol exist and could be efficient to solve this problem. To detect drugs or medicines, no reliable system giving instantaneous results already exists.

6.3.2   What were the main issues?

The first main problem of the in-depth analysis is that the sample on which we are working is very small. The reason is that this kind of accident is not frequent. The disadvantage of the small sample is that it is difficult to obtain relevant information and representative results.

The second problem is the use of several in-depth databases because of the following reasons:

- It is necessary to well identify the manoeuvre we study in order that each team is able to select the accident according o the manoeuvre. The reason of such precaution is that each in-depth database has its own accident approach and coding.

- 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. It means that the task leader was dependant on the other partner progress. And, as the number of specific manoeuvre accidents is very low, it was necessary to wait for all the partner database results.

The last problem focused on the application of the innovative methodology emerging from WP5 – Analyzing "Human Functional Failure" in road accidents. Two difficulties appeared:

- We need to well understand the new approach if we want to have relevant results and to have the same understanding of the approach between all the partners.

- Once, the approach understood, we have to find in our database the appropriated information which could help us to apply the new approach on our sample.

7 Intersection situations

Task 2-2 is related to the intersection situations, one of the 4 accident situations identified and studied in the first part of the report. While the part I of the Task2 aimed to identify the issues, the stakes and the main accident scenarios, this part is devoted to explain why intersection accidents happened, which data can explain the occurrence of accidents (accident causation factors), what can we do to avoid intersection accidents.

We remind here the definition we commonly adopted at the beginning of the survey:

Intersection situations are all situations directly related to an intersection location. An intersection is an area formed by the connection of two or more roadways not classified as a driveway or alley access, but does not include entry or exit slip roads. This definition includes loss of control at intersections and situations involving all kinds of opponent road-users (included pedestrian).

After a brief remind of the main issues and scenarios identified in the previous step of the project (descriptive analysis, see report TRACE-WP2-D2.1), As explain above, in-depth database is useful to give a breakdown of the accident mechanisms. We used the scenario concept in order to cluster the issues and to perform an accurate analysis of accidents that present similarities. These scenarios were identified through the descriptive analysis of project participants and extrapolated to European level.
We expose the in-depth approach we used along this survey.
We present the sample on which we based our analysis.
Then, we summarize the causes related to the intersection scenario (overall causes).
We show, scenario by scenario, the variability and the specificities along the different scenarios. Each scenario is analyzed. Key events and Human Functional Failures are identified. Other factors such as initial speed, sight distance are examined too. When the analysis requires detailed information, not available in the TRACE sample, we used the in-depth LAB database within a case by case analysis.

At last we approach the relative risk factors related to the situation.

7.1 Overview and general statistics

In the EU27, the accidents at intersection represent (see Figure 37):
   ▪ 43% of road injury accidents;
   ▪ 45% of the total number of victims (death + injured)
   ▪ 21% of the fatalities
   ▪ **32% of fatalities and serious injuries.**

Europe 27	
Accidents	1 323 036
Fatalities	46 821
Victims	1 810 568
Serioulsy injured	293 003

At Intersection		
Accidents	569893	43%
Fatalities	9978	21%
Victims	805530	44%
Serioulsy injured	99009	34%

Out off intersection		
Accidents	753 143	57%
Fatalities	36 843	79%
Victims	1 005 038	56%
Serioulsy injured	193 994	66%

Figure 37: Distribution of road accidents following their location at or out off intersection in EU27 (year 2004, Source: CARE, IRF, IRTAD, TRACE, and National Statistics Databanks)

The accidents at intersection represent 43% of road injury accidents in EU27. This result is pull up by some countries such as UK, Czech Republic, Italy, Denmark and Netherlands with the rate varying between 47% and 59%. While these accidents count around for the half of the total number of accidents in EU27, they contribute only to 21% of fatalities and 32% of fatalities and serious injuries. Among EU27 countries, UK, Netherlands, Denmark and Sweden have the higher fatality rate (from 25% to 50%). However, these high rates can be explained with a different definition of the intersection accident such as UK who counts intersection accidents when accident occurred at intersection and 20 meters on either side.

7.1.1   From the literature

This literature review highlighted the different issues we identified being related to the intersection accidents. The following points were tackled:

- Previous European survey – INTERSAFE
- Literature review
    - The traffic flows, the different users
    - The infrastructure design layout
    - The visibility and legibility
    - The users and their functional failures
    - The vulnerable users

All details are available in the report D2.1, so we will only remind here the main information.

In the light of the literature review, we highlighted several issues we wanted to develop through the European descriptive analysis. Indeed, numerous surveys have described broadly the intersection problems. The favourite subjects were related to the infrastructure layout, traffic flow, and traffic regulation. But we were aware that there is little survey on the causation factors, on the driver functional failure. This lack was filled in first with the descriptive analysis by the identification of the main intersection scenarios in order to gather accidents that have similar genesis. The main scenarios according to the frequency and the severity of them were defined. In complement, in-depth analysis aim is the identification of the main causes related to the identified scenarios.

The subjects we tackled through the descriptive analysis were:

- European intersection accidents classification to allow evaluation of preventive systems.
- The distribution of the accident actors according to the age, gender, manoeuvres compare to the whole injury accidents database: identification of overrepresentation, identification of manoeuvre, identification of problems.
- The distribution of the vehicles involved to concentrate the effort on the most frequent.
- The influence of the environment (visibility, conspicuity) on the accident through the in-depth analysis.

In a second step, our target was to document these following issues:

- The identification of the factors that explain the accident. Endogenous factors linked to the driver, exogenous factors linked to the environment (infrastructure, the vehicle).
- The driving manoeuvres that conduct to the accident.
- The influence of the layout in the driver understanding of the situation, and decision-making.
- The driver functional weakness: causes or consequences?

Obviously, these last issues can't be extracted from the national or European accident databases. So, we will develop them within the in-depth analysis as explained later.

As a base of the intersection accident analysis performed along TRACE project, the PReVENT-INTERSAFE project carried out an intersection accident analysis in the United Kingdom, Germany, and in France by teams of accident experts using accident data available in these countries (Simon & al 2006).

A statistical analysis provided an overview of the magnitude and the conditions under which accidents at crossings and intersections occurred. The magnitude of intersection accidents and the

most relevant accident situations were defined according to pre-accident manoeuvres. This distribution was basically made upon the French National data.

The study ended up with a list of 50 accidental situations (The unit of the analysis was a vehicle involvement, not an accident). Out of these 50, about 20 concerned intersection accidents, out of which the top five was selected. Round about accidents were intentionally excluded from the analysis.

These most relevant situations are described below:

4 turn onto/cross scenarios:

- Scenario 1: Vehicle A is pulling out of a road with a road sign (mainly a STOP sign) whereas another vehicle B is coming from the right or from the left on the road with right of way.
- Scenario 2:Vehicle A is coming up to an intersection with right-of-way whereas another vehicle B is pulling out of the intersection from the right or from the left.
- Scenario 3: LTIP. Vehicle A is pulling out of a road with a road sign (usually a STOP sign) and turning left whereas another vehicle B is coming from the left on the perpendicular road.
- Scenario 4: LTIP. Vehicle A is coming up to an intersection with right-of-way whereas another vehicle B is pulling out of the intersection from the right and is turning left or right.

1 turn off scenario:

- Scenario 5: LTAP. Vehicle A is turning left whereas another vehicle B is coming from the opposite direction on the same road.

These 5 situations represented 60-70 % of intersection injury accidents depending on the country.

This classification was useful to launch the TRACE approach. We remind later the bases of the accident classification performed through the TRACE descriptive analysis.

Despite we based TRACE project intersection analysis along the thread of INTERSAFE project, and used the scenario concept which is useful to analyze accidents that are similar; we innovate here in using driver Human Functional Failure HFF and the relevant elements that can explain these functional failures, concept never used in European project. We also highlight here the fundamental role of the driving speed or initial speed and the sight distance, both parameters closely linked, in the occurrence of intersection accidents.

7.1.2   Main results from the descriptive analysis

In 2004, 25% to 59% of road injury accidents occurred at intersection in Europe, an average of 43% estimated in Eu-27. If the results for the EU15 can be considered as close of the reality, on the other hand those related to EU27 are only estimations and are strongly correlated to the EU15 ones.
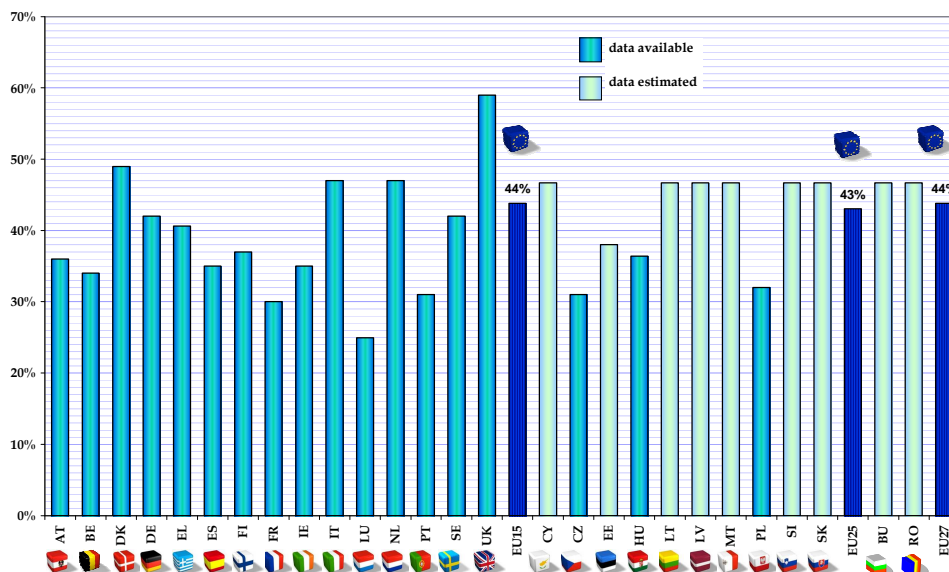
Figure 38: Distribution of the rate of accidents in intersection by EU27 countries (Year 2004, Sources CARE, IRF, IRTAD, TRACE, National Statistics Databanks)

In Great Britain, in 2004, the junction accidents represented more than a half of overall accidents whereas in France one third of overall accidents were concerned. This data show dispersion between countries that could be explained with the differences of network, urbanization, vehicle fleets and also with the differences of definition used in the national databases. It is the case the intersection definition in UK that takes into account the 20 meters before and after the intersection.

7.1.2.*a*   General statistics

Users: 85 to 90% of the intersection accidents involved at least one passenger car. 9% to 15% of intersection accidents are pedestrian accidents. Pedestrian accidents occurred rather inside urban area, at intersection with traffic regulation. Older pedestrian are well represented (12 to 41% of the pedestrians involved at intersection).

Gender: 65% to 76% of drivers involved in intersection accidents involving at least one passenger car are male.

Location: Inside or outside urban area? 64% to 73% of intersection accidents occurred inside urban area. Moreover 73% to 85% of intersection accidents with at least one passenger car occurred in urban area and 45% to 68% of intersection accidents occurred at intersection with regulation.

Luminosity: 65% to 74% of intersection accidents (with at least one car) occurred in the daylight.

Weather: 82% to 90 % of all intersection accidents occurred while the weather was normal. Moreover, 68% to 88 % of all intersection accidents occurred while the road surface was dry

> According to the above information, intersection accidents occurred rather inside urban area, during daylight, with good conditions of visibility and involved rather passenger car driven by male drivers.

7.1.2.*b*   Identification of the relevant scenarios

In order to identify the parameters linked to the intersection circumstances, the accidents occurring at intersection have been split into scenarios. These scenarios have been first identified on the base of the literature review. In fact the literature highlighted the prevalence of "cutting accidents" SCP (Straight Crossing Path), accidents occurring between two vehicles coming from two crossing directions, "the turning into the path" LTIP and RTIP (Left and Right turning Into Path) and at last "the turning across path" LTAP and RTAP (Left or Right Turning Across Path).

In order to identify these relevant scenarios we have based our selection onto the available parameters such as the pre-accidental manoeuvre, the relative speed direction, the right of way, the vehicle type.

Each scenario was characterized with the frequency (number of accidents in this scenario compared to all intersection accidents, either in national database or in European databases). The second criterion is the KSI or "Killed and Seriously Injured" rate (number of fatalities and serious injuries compared to all injuries in the related sample).

Obviously, we were confronted to the problem of data compatibility. Each European partner had to adapt the data in order to be in accordance with the scenario request. We decided to gather scenarios into six main common European scenarios. They represent 97% of all intersection accidents in Europe.

Scenario 1: All intersection except "rear end" and pedestrian crash scenarios

Characteristics: one driver turns left or right or crosses
while the opponent comes from left or right

70% of intersection accidents

KSI[20] : 68%
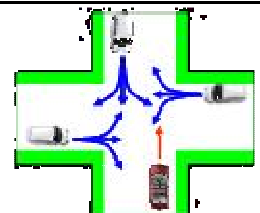
The scenario 1 where vehicles crossed the roads and/or the trajectory of the opponent vehicle (the drivers turned left or right or not) is more frequent and more severe than anyone else. 70% of all

---

[20] KSI: (Killed + Seriously Injured) /all casualties

intersection accidents and 68% of the fatalities and the serious injuries at intersection belong to the scenario 1.

This scenario is split into 3 accident types:
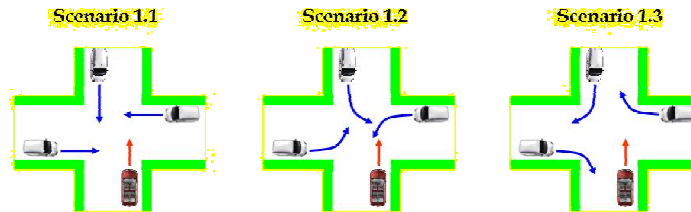
Regarding the descriptive analysis provided in the first part of the TRACE project, we can say that within the scenario 1, the scenarios 1.1 and 1.2 are predominant.

When the road users go straight, cross the intersection perform no manoeuvre and the 2 road users come from cross directions, we call this situation "cutting accidents".

When at least one of the drivers turns left or right on crossed roads, we call these situations either

- LTIP (Left Turn Into Path),
- LTAP (Left Turn Across Path),
- RTIP (Right Turn Into Path) or
- RTAP (Right Turn Across Path).

Scenario 1.1 SCP - Straight Crossing Path Crossing paths, No maneuvers, The OV vehicle comes from left or right	Scenario 1.2 LTIP and LTAP Crossing path or oncoming vehicle with one driver turns left (right in GB)

For obvious reasons related to the similarities of the situations, we gathered these two scenarios in the in-depth analysis.

Scenario 2: Rear-End crash vehicles scenario, with a turn manoeuvre of the hit vehicle

Characteristics: 2 vehicles on the same road same direction, 1 driver turns left or right

2% of intersection accidents

KSI: 2%
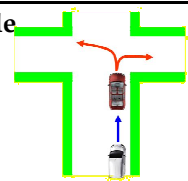
The scenario 2 where the two vehicles involved are on the same road, same direction, one of the two drivers is turning left or right represents 2% of the intersection accidents.

Scenario 3: Rear-End crash vehicles scenario, with no manoeuvre of the hit vehicle

Characteristics: 2 vehicles on the same road same direction, no manoeuvre except slowing down
5% of intersection accidents
KSI: 2%
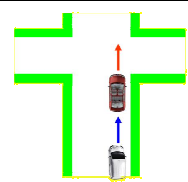
The scenario 3 where the two vehicles involved are on the same road, same direction, no manoeuvre is performed, represents 5% of the intersection accidents.

Scenario 4: "Incoming" scenarios (except pedestrian)

Characteristics: no manoeuvre, Head-on Collision, same road

2% of intersection accidents
KSI 4%
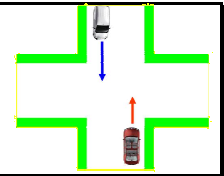
The scenario 4 where the two vehicles involved are on the same road, different directions, no manoeuvre is performed, represents 2% of the intersection accidents.

Scenario 5: Roundabout

Characteristics: concern all injury accident happening in roundabout.
11% of intersection accidents
KSI: 7%
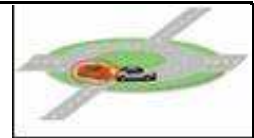
The scenario 5 where the two vehicles involved are in a round about, represents % of the intersection accidents.

Scenario 6: Other

9% to 15% of intersection accidents are pedestrian accidents.

The scenario 6 where at least one pedestrian and a passenger car are involved represents 9 to 15% of the intersection accidents (more details about pedestrian accident causation can be found in report TRACE-WP1-D1.2).

7.2   Identification of the accident causes

Remind that the descriptive analysis at the European level allowed us to identify the main scenarios involving two vehicles. Because 85 to 90% of intersection accidents involved at least one passenger car, we have focused the classification onto the accidents involving at least one passenger car.
The in-depth analysis will allow defining in detail the main causes and the accident mechanisms related to the occurrence of intersection accidents.
This part is devoted to the analysis of the accident in detail through the available European in-depth databases. Each partner was invited to initiate the analysis within his own data and complete the survey with the partner databases in order to support the trends they highlighted, within a more representative sample gathering accidents from different countries. These accidents show differences that result from differences such as social, economical, political context as well as the road network, vehicle fleets etc.

We split this chapter into three parts as following:
- First we describe the accident data sample (TRACE sample) on which we based our in-depth analysis.
- We dedicate a part to the overall causes related to the intersection scenarios in the whole. Results are global. More details are provided in the following part of the report.
- Then we describe the most relevant scenarios along the following thread with the parameters previously defined:

> Key events: which factors are determinant to switch the driving phase to the rupture phase?
> Driver involvement: is the driver mostly primary active when he has not the right of way?
> Driver Human Functional Failures: how drivers are involved? Are they active or passive?
> Explanatory elements related to the Human Functional Failures: why the drivers didn't see?

Note that, despite we have built the intersection scenarios onto the parameters such as the intersection layout, the direction of the vehicles and the respective manoeuvres, and distinguished the case vehicle CV (passenger car) from the opponent vehicle OV (all vehicle or pedestrian), in-depth analysis led us to consider the driver "Having the Right Of Way" HROW opposed to the drivers "Having Not the Right Of Way" HNROW.

In fact, the manoeuvre the drivers had to perform according to their right of way is completely different. Most of drivers "having not the right of way" HNROW had to perform a manoeuvre (crossing the road or turning into a main road) while they looked in both lateral directions and decided when and how they can perform safely their manoeuvre. The task is not easy obviously.

However, for the driver having the right of way, the driving task is obviously easier. So, the causes are different as well as the countermeasures.

In-depth analysis will tend to identify the accident causes according to the right of way.

7.2.1   The Sample

In-depth database gathers detailed information related to the accident. This database can be built on the base of different collection approaches:

- It could be an in-depth analysis based on police reports. In this case the data are collected by the police teams and analyzed by accident experts.
- Or experts investigate accidents on the site and collect data in detail. The data are related to the driver, the vehicle and the environment. Experts analyze the information and perform a reconstruction of the accident. Causes, Human Functional Failures, risk factors are identified.

However the manner data are collected, in-depth data will help us to identify more accurately the accident causes and in particular the human functional failure HFF, data not available in police reports neither in most of in-depth databases. As mentioned before, this concept is newly used within European project and will give to the survey a new dimension and a new vision of the causes of accidents.

The sample we used in this accurate analysis is composed of seven European in-depth database sources. We took into account accidents occurred from 1997 onwards in order to analyze recent vehicles and situations.
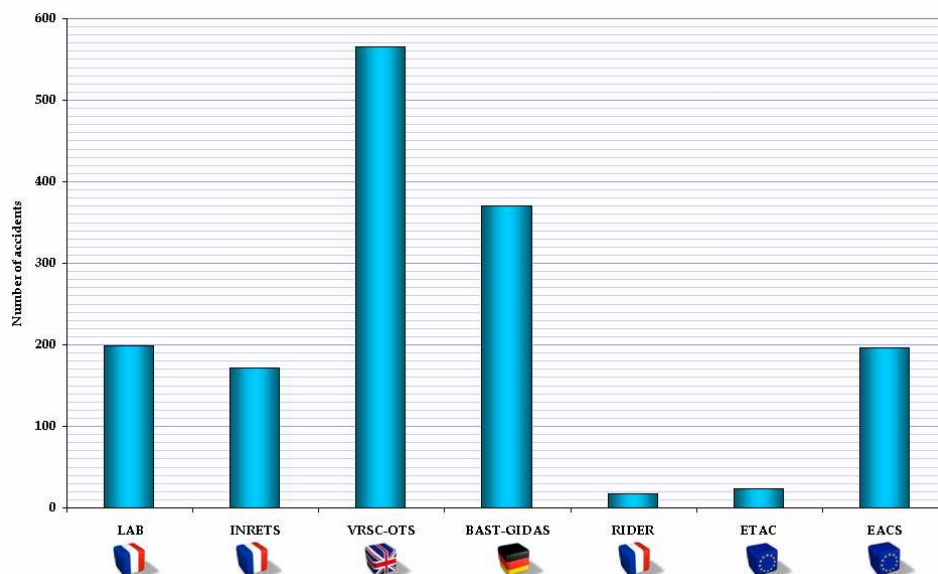
Figure 39: In-depth databases used for the accident causation analysis in intersection situations

Remind of the in-depth database (WP8 extract):

LAB-EDA database currently contains information on approximately 900 accidents, involving 1380 drivers. Data includes accident identification data, road and environmental parameters, vehicle active and passive safety information, participant descriptive and behavioural details, photographic and audio files and cinematic reconstruction data where available. More information is available in WP8 reports.

The In Depth Accident Study (EDA) is available from **INRETS-MA**. It provides in-depth data from the year 1996 onwards, with 50 cases per year around the area of Salon-de-Provence (South-East of France). The survey strategy is based on collecting as much information as possible on the accident sequence, at the scene of the accident itself. This data collection is three-fold: driver, vehicle and infrastructure. The aim is to collect the data required to identify the circumstances of the accident and reconstruct the cinematic scenario. The further objective is to open to questions and hypotheses to be investigated through different methods (statistical accident analysis, experimentations, and observations).

The On-The-Spot Accident Research Project (**VSRC-OTS**) is available from VSRC. This provides in-depth data from the year 2000 onwards, with 500 cases per year covering the Midlands & South-East regions of England. Data available covers the road user, the accident situation, participants (inc. cars, motorcycles, pedestrians/cyclists and trucks), accident cause, injury cause, human factors and vehicle technologies.

BAST-GIDAS database is a joint project between the German car industry FAT (Forschungsvereinigung Automobiltechnik or Automotive Industry Research Association) and the German government BASt (Bundesanstalt für Straßenwesen or the Federal Road Research Institute) on in-depth-investigation on scene. Two teams in the geographical areas of Hanover (Medical University Hannover) and Dresden (Technical University Dresden) are collecting data in one common database. This joint project started on July 1, 1999 with about 2000 cases per year.
In the two centers Hannover and Dresden, about 2000 accidents are investigated annually. The studies include such information as: Environmental conditions, Road design, Traffic control, Accident details and cause of the accident, Crash information e.g. driving and collision speed, Delta-v and EES, degree of deformation, Vehicle deformation, Impact contact points for passengers or pedestrians, Technical vehicle data, Information relating to the people involved, such as weight, height etc.

ETAC is a European project based on European Truck Accident Causation. The final objective of the project is providing a powerful database on truck accidents.
This database contains 624 truck accidents over all Europe. All kind of accidents can be included.
Main data is related to the state of the driver before the accident, the tasks he had been doing, the focussed attention and the actions done after the precipitating event, but changes in the infrastructure and performances of the vehicle are also taken into account.
Despite the database is built onto accidents involving at least one truck, 391 of these accidents involved a passenger car too (62%).

EACS (European Accident Causation Survey) was launched by the ACEA and the European Commission in 1997 after a 100 cases pilot study carried out by DEKRA (D).
The project was aimed at compiling an in-depth database on accident causation for accidents involving at least one passenger car using data recoded from existing files in contributing organisations. Data was provided by several European countries and was intended to be representative of the individual country's accident situation. Exact methodologies varied although data coding protocols were consistent across study. 1904 injury accidents have been collected.

RIDER is French survey for Powered Two Wheelers (PTWs) accidents based on the experience of MAIDS which is the most comprehensive in-depth data currently available for Powered Two Wheelers (PTWs) accidents in Europe. The investigation was conducted during 2 years on 200 accidents. The purpose of the study was the identification of the causation factors of motorcycle accidents and their interaction in order to identify and moreover to evaluate related counter-measures. On these 200 cases, 124 concern accidents between PTW and another vehicle whose 89 was a passenger car.
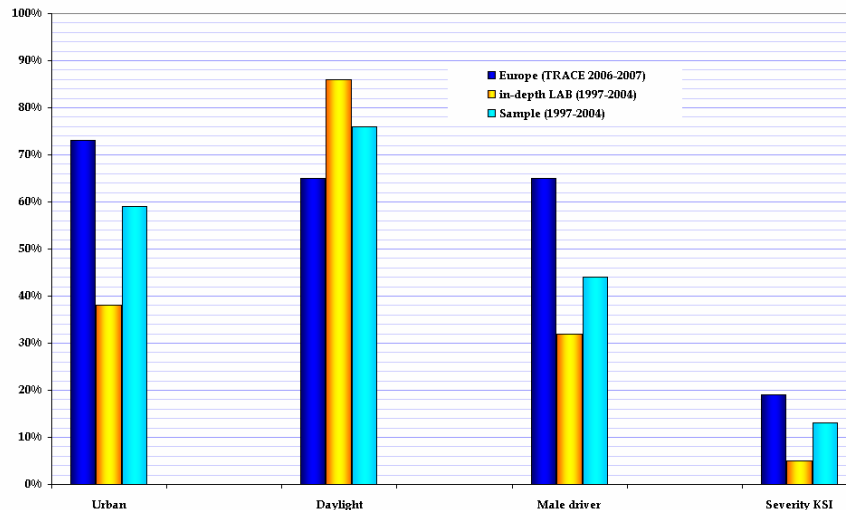
Figure 40: Main characteristics of the sample

The previous figure show clearly that the TRACE sample we used is very close to the European figures according to relevant parameters such as the split urban/rural, daylight/night, male/female, severity (KSI). So, even if the sample is not representative in the whole, the sample shows a closer distribution of the parameters to the European figures than the in-depth LAB database on its own.

The great challenge of this in-depth analysis was to reach compatibility between different sources of data collected in different countries. Data collection is performed with different approaches and purposes due to the differences in research targets, but also the economical, social and political context. Several data needed a specific codification according to the TRACE project requirement. This type of common analysis is quite new in Europe. While National data is gathered into a European database (CARE) still a long time, although not without difficulty, in-depth data is so specific that we needed to perform a common and new codification to reach the same level of accuracy. This work was performed by each partner in order to identify the main causes and the accident mechanisms of the related situations.

7.2.2   Intersection situations: Overall causes

Causes, as defined previously, are the added values to the first part of the survey focused on the stakes related to the intersection accidents. These in-depth factors will allow us to understand the accident mechanisms, to identify the driver needs and to suggest adapted countermeasures leading to avoid or at least to mitigate the accident.

We have organized the next part as following:
- We remind first the accident causes definition proposed by the WP3 of the project;
- Then we present the factors that are specific to the intersection accident in the whole:
    o key events
    o human functional failure HFF
    o explanatory elements
  ▪ At last the detailed factors according to the right of way.

7.2.2.a   Accident related factors – Definition

Accident-related factors are defined as all imaginable entities that contribute to the accident occurrence. These factors can be material things, but also circumstances, situations, events, manoeuvres, ideas, attitudes, states, and conditions. They contribute to an accident in the sense that if they had not been present, the accident would not have happened".
 "The cause for an accident is seen as a combination of co-occurring accident-related factors.

Accident causation models are often based on the idea that certain background circumstances provide the platform for certain interactions, where accidents can happen. Environmental, societal, economical, educational, political and other background conditions influence the roadway system, the traffic, and the traffic participant".

As described before, accident occurrence is the result of different related causes allocated to the system Driver/Vehicle/Environment. Remind that "Key events" are the events that shift the driving phase into the rupture phase in the sequential description of the accident occurrence.

7.2.2.b General characteristics of the sample

The TRACE sample includes 11% of older drivers (65+) and 23% of younger drivers (<25) at intersection.

42% of intersections are regulated with Yield, 40% with STOP or traffic lights.
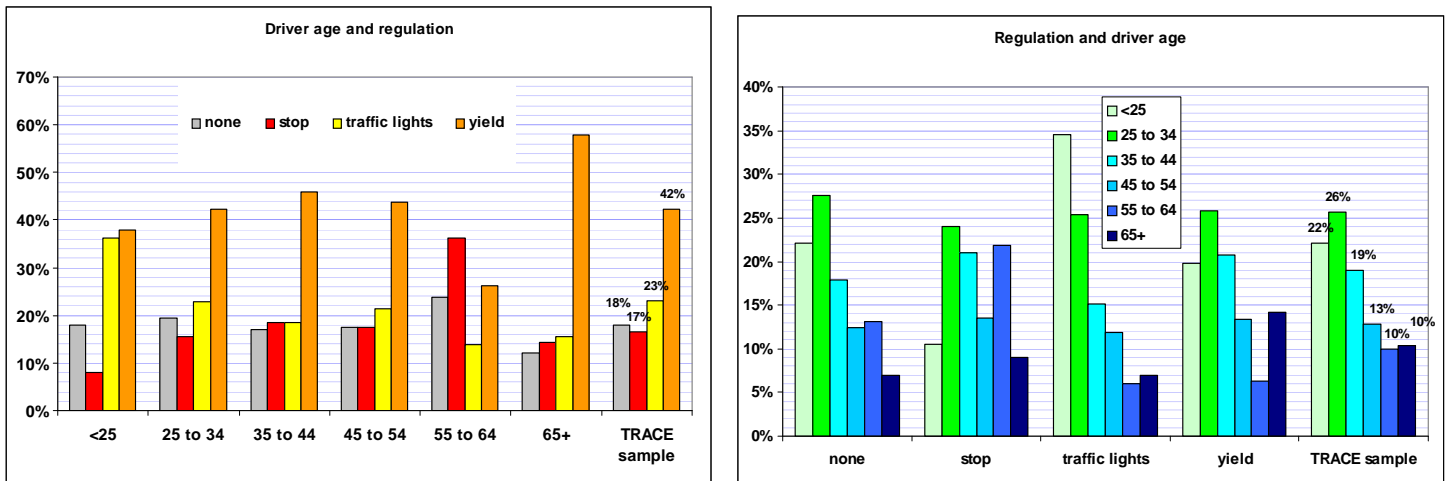
Figure 41: Driver age and regulation at intersection

Older drivers (65+) are more involved at Yield regulated intersection than other regulation. Younger drivers are involved at traffic lights regulation.

7.2.2.c The main causes – All drivers
Key events
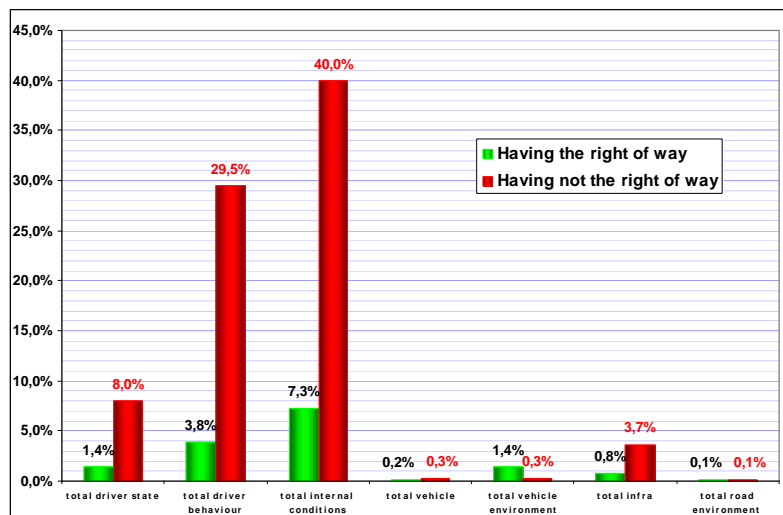
Figure 42: Distribution of the key events regarding the right of way of the driver
(Source TRACE sample – n=1171)

Considering all known key events (n=1171), 83% of them are attributed to the driver "Having Not the Right of Way" (HNROW). The main relevant key events related to the intersection are:

- the internal conditions of the task (85% of "internal conditions of the task" is attributed to the driver "HNROW).
- the driver behaviour 88% of "driver behaviour" is attributed to the driver "HNROW)
- the driver state (8%)

		HROW	NHROW	Total
Total driver state	Nb	16	94	110
	% lin.	15%	85%	100%
	% col.	8%	10%	9%
Total driver behaviour	Nb	45	345	390
	% lin.	12%	88%	100%
	% col.	22%	36%	33%
Total internal conditions	Nb	85	468	553
	% lin.	15%	85%	100%
	% col.	42%	48%	47%
Total vehicle problems	Nb	2	3	5
	% lin.	40%	60%	100%
	% col.	1%	0%	0%
Total vehicle environment	Nb	16	3	19
	% lin.	84%	16%	100%
	% col.	8%	0%	2%
Total road	Nb	9	43	52
	% lin.	17%	83%	100%
	% col.	4%	4%	4%
Total road environment	Nb	1	1	2
	% lin.	50%	50%	100%
	% col.	0%	0%	0%
Others	Nb	27	5	32
	% lin.	85%	15%	100%
	% col.	13%	1%	3%
Total	Nb	204	967	1 171
	% lin.	17%	83%	100%
	% col.	100%	100%	100%

Table 17: Distribution of the key events following the right of way of the driver involved in intersection accident (TRACE Sample, n=1711)

Human Functional Failures
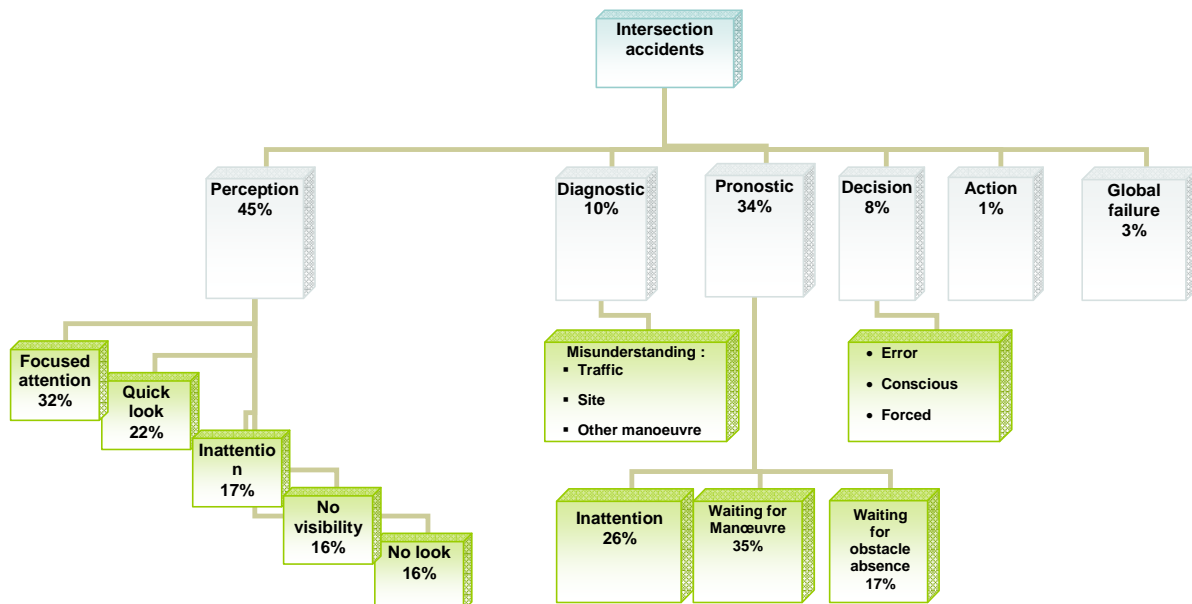
Figure 43: Identification of the functional failure of the drivers involved in intersection accidents (source: TRACE sample, n=801)

These figures show that at intersection, drivers sustained mainly:
- Perception failures
- And prognostic failures

We will see below that differences appear according to the right of way.

7.2.2.d   The main causes related to driver having not the right of way

Key events

83% of key events are attributed to the driver "Having Not the Right of Way" HNROW.
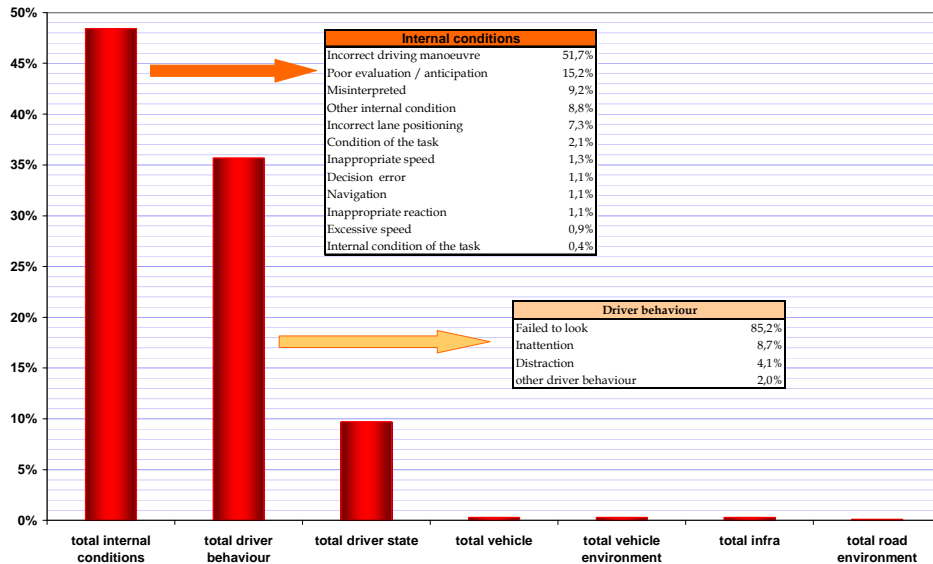
Figure 44: Distribution of the key events for drivers having not the right of way at intersection (source: TRACE sample, n=967)

Two key event groups are over-represented:

- 48% are related to the internal conditions of the task, such as incorrect driving manoeuvre (didn't stop at STOP), poor evaluation anticipation or misinterpreted.
- 35% are related to the driver behaviour, such as failed to look (absence of look or quick look or inappropriate look)

Human Functional Failures
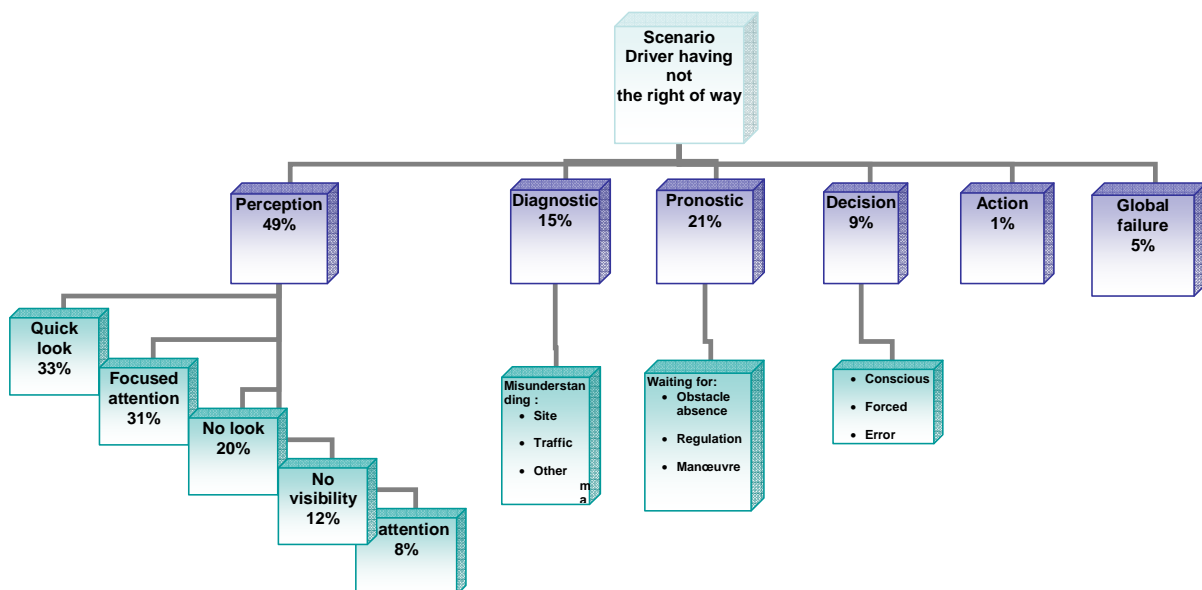
Figure 45: Identification of the functional failure of the drivers HNROW involved in intersection accidents (source: TRACE sample, n=)

While the two main HFF at intersection are Perception and Prognostic, the drivers HNROW present mainly Perception failures.

Perception failures are mainly related to the manner the driver looked at the traffic (quick, focused, no look) rather to the "impossibility of seeing (no visibility related to a mask for example).

We develop this acknowledgement through the detailed analysis of the scenarios.

Driver age
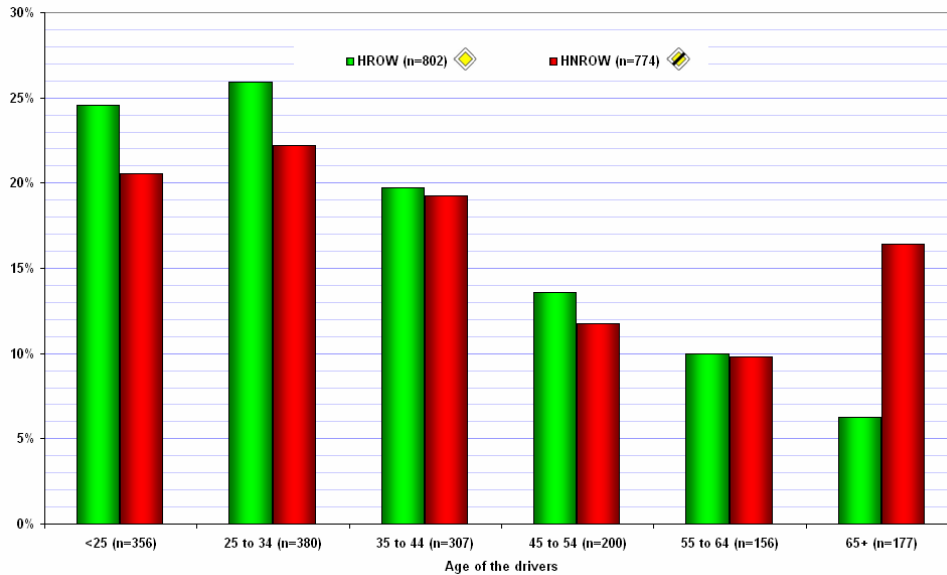
Figure 46: Distribution of the driver age regarding HROW and HNROW
(Source TRACE Sample, n=1576)

It is clear that older drivers (65+) are more represented in this group of drivers HNROW than in other groups. We will develop later through the detailed description of the scenarios how and why older drivers are involved at intersection.
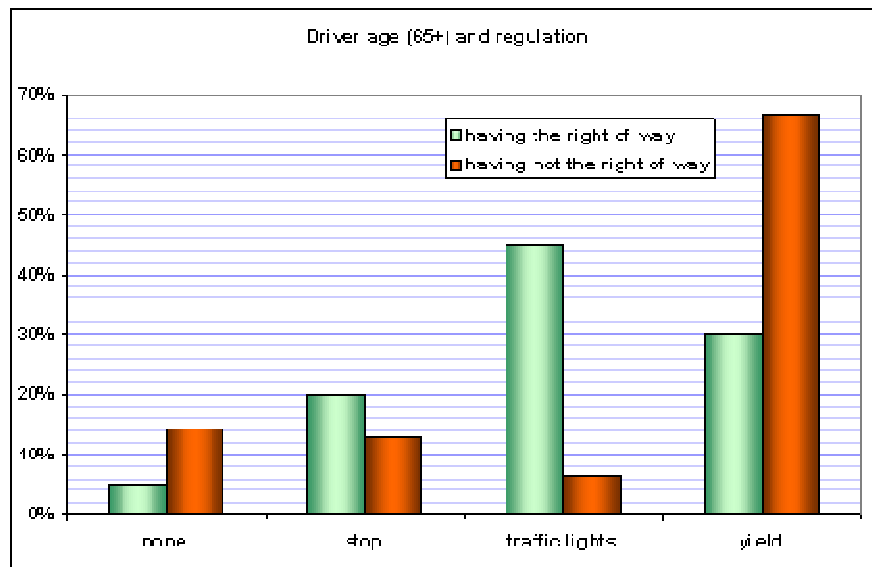
Figure 47: Distribution of the 65+ years old driver regarding intersection regulation
(Source: TRACE sample, n=801)

While older drivers (65+) are more involved at Yield, they are essentially involved when they have not the right of way (HNROW).

7.2.2.e   The main causes related to driver having the right of way

Key events

17% of key events are attributed to the driver "Having the Right of Way" HROW.

Internal conditions	
Incorrect driving manoeuvre	43,5%
Misinterpreted	23,5%
Excessive speed	11,8%
Inappropriate speed	9,4%
Inappropriate reaction	8,2%
Poor evaluation / anticipation	2,4%
Incorrect lane positioning	1,2%

Driver behaviour	
Failed to look	81,4%
Distraction	9,3%
Other driver behaviour cause	9,3%
Inattention	4,7%
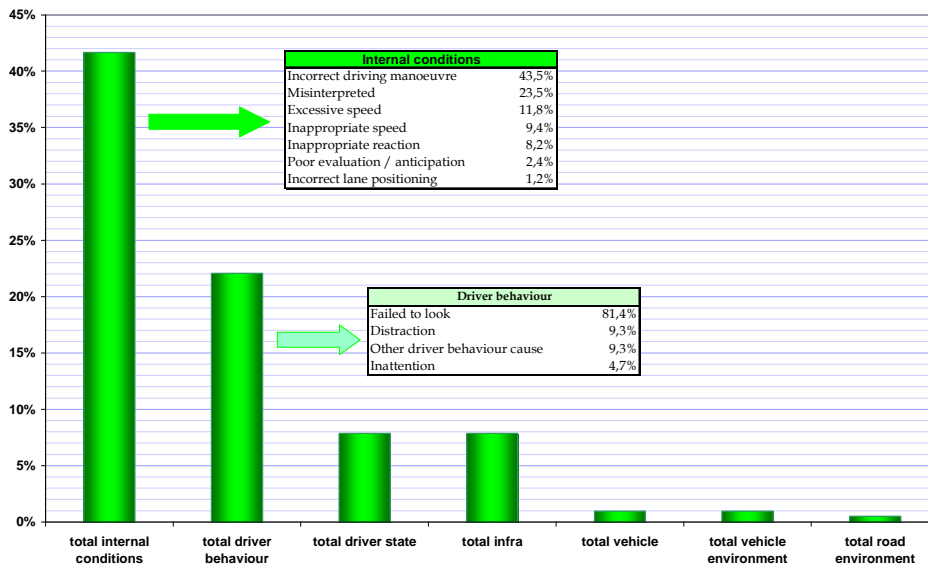
Figure 48: Distribution of the key events for drivers having the right of way at intersection (source: TRACE sample, n=204)

Two key event groups are over-represented:

- 42% are related to the internal conditions of the task, such as misinterpreted the situation such as misunderstanding the other driver manoeuvre or excessive speed (compared to the speed limits)
- 22% are related to the driver behaviour, such as failed to look (at traffic lights intersection, the lights are green and the driver HROW didn't attach importance to the traffic because of a strong feeling of right of way).

Human Functional Failures
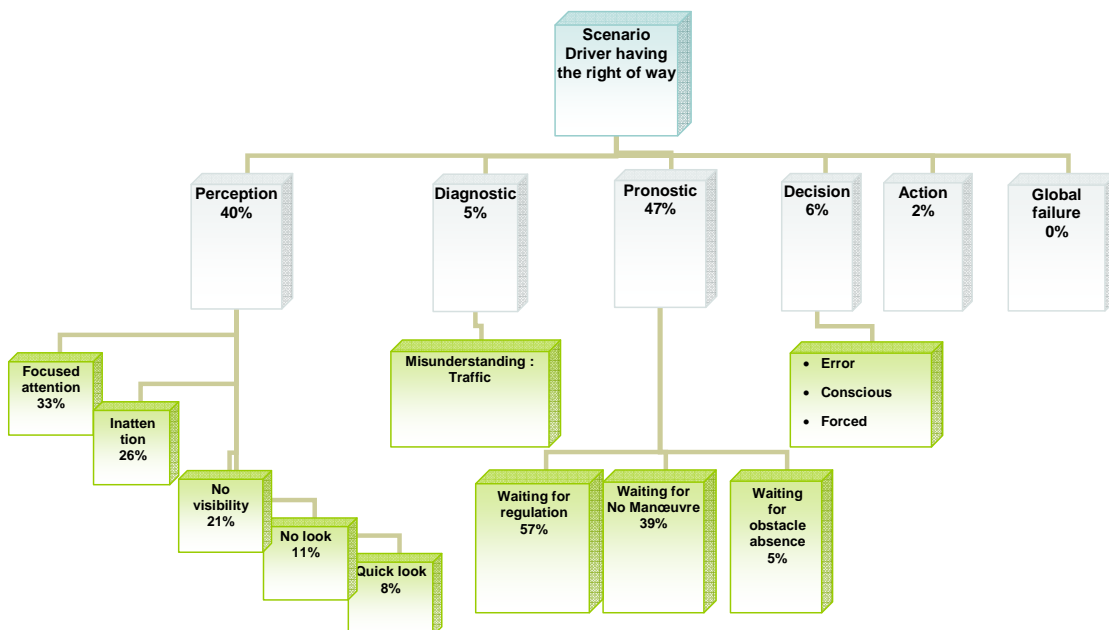
Figure 49: Identification of the functional failure of the drivers HROW involved in intersection accidents (source: TRACE sample)

While drivers HNROW presented rather Perception failures, drivers having the Right of Way sustained Perception as well as Prognostic failures.

Perception failures are rather due to the manner the driver looked at the traffic:

- Focused attention (right of way feeling at intersection with no regulation, focused look at the right side)
- Inattention (habitual trip, traffic lights green, no attention to the traffic)
- No look (non driving task)
- Quick look (when the intersection layout is difficult to understand the driver looks quickly but has to manage too much information or when the manoeuvre is habitual and doesn't require more attention).

However he was confronted to a problem of visibility (33% such as a moving vehicle masking the visibility).

Driver age

In this group, older drivers (65+) are less represented than in the group of drivers HNROW (see Figure 46). Younger drivers however are well represented (30%) compared to the whole sample (23%).

7.2.2.f   *Accident causes – Summary*

Older drivers (65+) are more involved at Yield regulated intersection than other regulation.

Younger drivers (<25) are more likely involved at traffic lights.

4/5 of the key events are related to the drivers having not the right of way. These key events are mainly endogenous events (related to the driver):

- internal conditions of the task
- driver behaviour
- driver state

Human Functional Failures are:

- Perception failures
- Prognostic failures

Regarding Drivers having not the right of way, the key events are mainly:

Endogenous (90%):

- Internal conditions of the task
- Driver behaviour
- Driver state

And exogenous (10%):

- Infrastructure

Drivers having not the right of way present mainly perception failures

Older drivers are more involved when they have not the right of way

Regarding drivers having the right of way, the key events are:

Endogenous (70%):

- Internal conditions of the task
- Driver behaviour
- Driver state

And exogenous (30%):

- Vehicle environment
- Infrastructure
- Vehicle

Drivers having the right of way present mainly

- perception failures
- and prognostic failures

Younger drivers (<25) are more involved than in the whole sample.

7.2.3   Intersection situations: causes related to the scenarios

In this paragraph we develop the main relevant parameters highlighted in the previous part devoted to the overall causes. We take into account the parameters such as:

- key events,
- Human Functional Failures,
- Explanatory elements
- and other specific parameters such as initial speed, sight distance and emergency reaction.

When it is possible we have based our analysis on TRACE sample. In order to provide an accurate analysis, we have completed it with a case by case analysis with the in-depth LAB database.

The analysis of the pre-accidental events through the different concepts or approaches exposed above, will allow identifying the accident mechanisms with:

- The key event that switch the driving phase onto the rupture phase. Remind that accident occurrence is the result of different related causes affected to the system Driver/Vehicle/Environment. Key events are the events that explain the rupture between the driving phase and the rupture phase. At last, key event is mainly attributed to the driver having not the right of way, sometimes to both drivers.
- The Human Functional Failures
- The accident causes:
    - o   Explanatory elements of the Human Functional Failures
    - o   Initial speed
    - o   Sight distance
    - o   Stopping distance
    - o   Emergency reaction

Through the literature review and our experience, we know that the road layout, the traffic flows, the speed and the sight distance have a great effect on the accident occurrence.

All accident research teams (LAB included) and institutes mention the speed is a crucial factor in the severity of a crash and obviously in the crash avoidance. Speed has different impact according to the related moment along the sequential phases of the occurrence of the accident.

- The driving speed is the speed during the driving phase or initial speed. The speed can be adapted or not-adapted to the circumstances (according to the difficulties of the situation such as road layout, weather conditions), excessive (higher than the speed limits) or not. At last this speed will allow the driver to perform or not an emergency manoeuvre, will allow the vehicle to help the driver to perform the manoeuvre.
- The speed at the beginning of the crash phase which conditions the crash violence.
- The speed at the end of the crash phase which conditions the post collision phase

Because the TRACE project aim is to define the main causes related to the intersection situations, we focused our analysis on the initial speed to show the effect of this parameter in the genesis of the accident.

So, we analyzed:

- The initial speed for both drivers according to the right of way and the respective directions.
- The sight distance which is determinant to cross the main road and depends on the vehicle speed on the main road.
- At last the emergency reaction for both drivers according to the location and to the right of way at intersection.

We are going to define

- The initial speed
- The sight distance for driver on the secondary road along the main road
- The stopping distance for the driver on the main road

7.2.3.a   The initial speed

The initial speed is the vehicle speed at the beginning of the reconstruction. It depends on the information you have collected on the site of the accident and consequently the time or the distance you are able to understand to the crash point. Usually the initial speed is the speed corresponding to the beginning of the marks left by the vehicle on the road surface or the point at the beginning of the reaction time or the point at the perception time. Initial speed is so a difficult parameter to use because of the related definitions of the point of reference (marks, reaction, perception). But this parameter is still useful to evaluate the conditions of the driving phase for both drivers.

Initial speed characterizes:
- The conditions of the driving phase (stopped, deceleration, acceleration, constant speed)
- Compared to the speed limits highlights the excessive speed
- Compared to the traffic conditions, highlights the non adapted speed.
- Reflects the driver behaviour

With the help of the accidents scene schema experts have drawn on the scene of the accident (including the vehicle rest positions, the marks on the road and the shoulders of the vehicle trajectories), the vehicle deformations and the driver interviews, experts are able to calculate as more accurately as possible, the driving speed. But when there are no marks on the road, the data collected to the driver are essential. So, driver interview helps us to situate the different phases in the environment. Vehicle deformations, trajectories and some scientific assumptions are so used to evaluate accurately the most probable events.

7.2.3.b   The sight distance

Roadway layout device conception is managed by different viewpoint. Sight distance is considered as one of the most important factor taking into account for the conception of new roads or the improvement of existing roads.

The driver adapts indeed his driving behaviour to his road perception and its environment such as:
- The traffic
- The geometric design feature
- The equipment of the road
- The road environment in urban, inter urban, rural context
- The specific sign post (posted speed)…

What is the sight distance?
The sight distance is the distance ahead or along an intersecting roadway that a driver can see from any location on the roadway system. Provision of adequate sight distance is fundamental to the design of roadways and intersections for safe operations.

Three types of sight distance are particularly critical to the safe operation of at-grade intersections:
- intersection sight distance,
- stopping sight distance,
- and sight distance to traffic control devices.

The sight distance is very pertinent at intersection. Out off intersection, the visibility parameter is rather called stopping sight distance (visibility up to the next bend for example). So intersection sight distance can't be compared to a population involved out off intersection. It is a sort of intrinsic risk.

Intersection sight distance is the visibility distance for the driver on the secondary road along the main road. This distance takes into account the geometric visibility. All drivers having not the right of way at intersection with crossing roads are concerned. The manoeuvre they wanted to perform was crossing the road or turning into the road. So, they need time to achieve safely the manoeuvre.

Sight distances of the secondary road depend on the crossing times. Sight distances are very important for the driver who stopped at the STOP sign for example and proceed across the intersection. The aim

is to give the driver "having not the right of way", necessary time to carry out his manoeuvre before being hitting by the opponent vehicle travelling on the main road.

It is recommended that the sight distance along the major road for a passenger car at a STOP-controlled intersection be based on a distance equal to 7.5 s to 8 s of travel time at the design speed (V85) of the major road (6s is a minimum). V85 is the speed 85% of the drivers are travelling. This value can be measured or estimated. Because we didn't know the V85 of the roads involved in our sample we used the speed limit which is a good assumption.

7.2.3.*c*   The stopping distance

The stopping distance is the theoretical distance required to stop the vehicle before the crash. To calculate this distance we need to evaluate:

- the reaction time,
- the time to move the foot from the accelerator to the brake pedal if relevant
- the time to the braking system to be efficient
- and finally the time to decelerate the vehicle to the speed zero.

The stopping distance is the sum of the distances covered during these successive times.

7.2.3.*d*   The emergency reaction

The emergency reaction is the reaction or action performed by the driver to avoid the crash. This action takes place during the emergency phase, the phase just before the crash.

The more frequent actions are: braking only, braking and swerving, swerving only, accelerating and no reaction.

7.2.3.*e*   The sample

The intersection scenarios were previously identified (descriptive analysis) on one hand according to the driver manoeuvre, the relative direction of the vehicles and the regulation and in the other hand according to the frequency and the severity KSI. In-depth analysis highlights how accidents occurred (accident mechanisms) and what are the main causes. The following analysis will show that among the relevant parameters, regulation (right of way or not) and direction of the opponent vehicle are the main parameters showing different and relevant causes. This analysis led us to split the results according to the right of way. Obviously, the related counter-measures we can propose will be adapted to the driver according to his driving tasks and his needs.
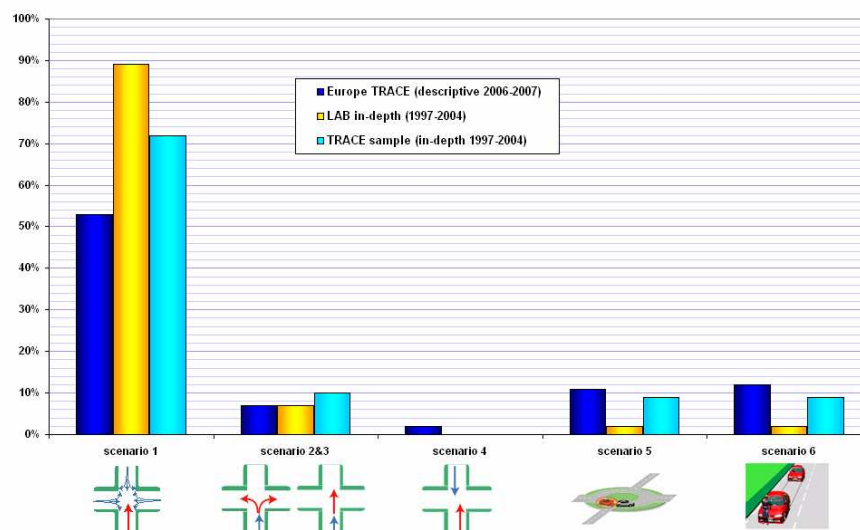
Figure 50: Comparison of the intersection scenarios distribution following the available sources in TRACE

The distribution of the main scenarios into the TRACE sample show that we will perform a more accurately analysis with a more representative sample. In fact, the scenario distribution is very close to the European situation (closer than in-depth LAB database on its own).

In order to propose an accurate analysis and to avoid sample size bias, we have focused the analysis on the 2 main scenarios that cover 79 to 85% of all intersection accidents:

- Scenario 1 covers 53% of all intersection accidents in Europe and 59% of the KSI. So we have focused our in-depth analysis onto this scenario.
- Scenario 6 (pedestrian scenario). Despite the lack of information concerning the pedestrian accidents in the in-depth databases, we intend to analyze the circumstances of such cases and highlight the requirements for a further investigation.

Because in Europe, 85 to 90% of intersection accidents involved at least one passenger car and the scenarios were defined on the base of the involvement of at least one passenger car, we have focused our analysis onto accidents involving at least one passenger car. The analysis showed that more than the respective directions (the opponent coming from the left or the right) or the vehicle type, the priority nature leads to relevant conclusions.

So we have gathered similar scenarios according to the priority point of view:
- Drivers having not the right of way HNROW.
- Drivers having the right of way HROW.
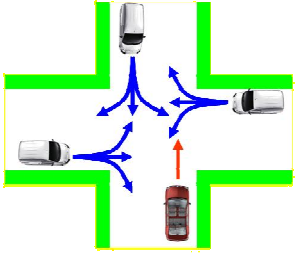
According to the priority point of view, we highlight the accident mechanisms through:
- The Key events that switch the driving phase to the rupture phase
- The Human Functional Failures that identify which driver function failed in the functional loops Perception-Diagnostic-prognostic-Decision-Action.
- The explanatory elements that explain the HFF.
- The cinematic parameters:
     Initial speed
     Sight distance
     Emergency reaction
- The driver age, parameters highlighted in the literature review as a determinant factor.

We are going now to study in details each relevant scenario and to identify for each of them their characteristics and their specific causes.

7.2.3.*f*   Scenario 1

	53% of European intersection accidents
	59% of fatalities and severely injuries
	70% TRACE sample

The scenario 1 is a set of several sub-scenarios in which the Opponent Vehicle comes from the left or the right. The Case Vehicle has the right of way or not and is going straight or turning.

We propose to deal with the scenario 1 into 2 main sub-scenarios (precisions in the table above), so called scenario 1A and scenario 1B that we develop further in the report.

Sub scenario	Pictograms	Right of way	Definition of the scenario	TRACE Sample	Frequency in TRACE sample
Sub scenario 1A		Having Right Of Way vs Having Not the Right Of Way	Straight Crossing Path SCP Crashes And Left Turning Into Path LTIP crashes	877	78%
Sub scenario 1B		Having the right of way (going straight) vs having not the right of way (turning)	Left Turning Across Path LTAP crashes	243	22%
Total scenario 1				1120	100%

Scenarios were gathered according to the similarities of the related situations for both vehicles involved.

7.2.3.g   Scenario 1.a

The driver having the right of way going straight confronted to the other vehicle coming left or right	**The driver having not the right of way turning left while the other vehicle is going straight**

57% intersection accidents in the TRACE sample
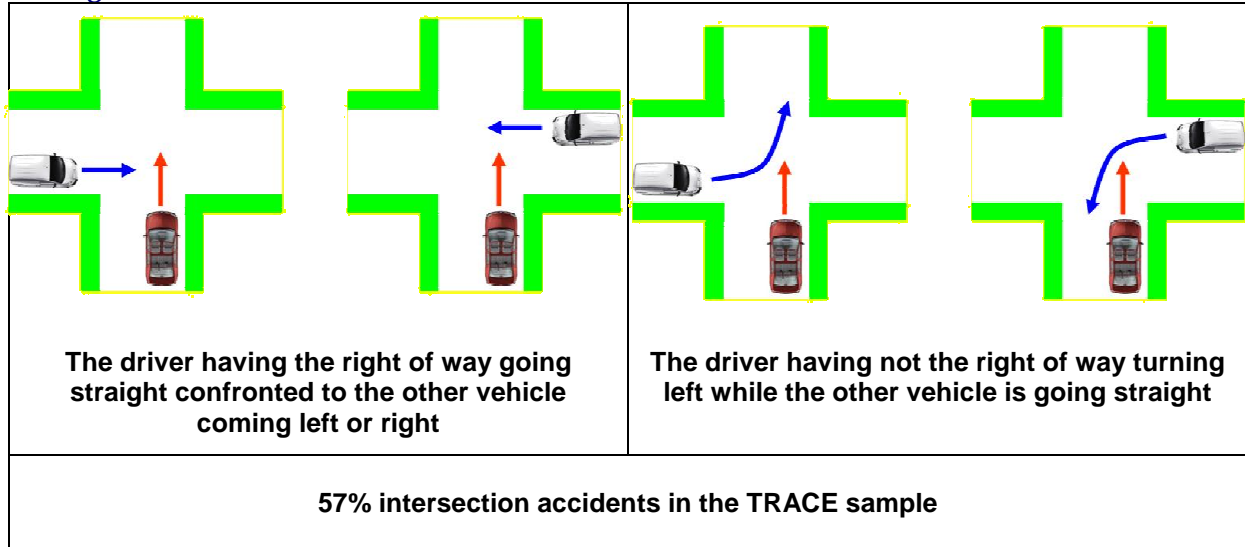
For the accident causation analysis we decided to split the study between the driver having not the right of way (HNROW) and the driver having the right of way (HROW). Effectively, the most of the accident causes are affected to the driver HNROW. It is the case here for the scenario 1a where 87% of the total key events are related to the driver HNROW.

A) The driver having not the right of way (HNROW)

The driver has to cross the main road or to turn into the main road. He has to manage his driving manoeuvre and the traffic along the main road.

Driver behaviour		
Failed to look	216	82%
Inattention	29	11%
Distraction	11	4%
Other driver behaviour	7	3%
Total	**263**	**100%**

Internal Condition		
Incorrect driving manoeuvre	156	47,1%
Poor evaluation / anticipation	42	12,7%
Incorrect lane positioning	34	10,3%
Other internal conditions	34	10,3%
Misinterpreted	31	9,4%
Condition of the task	10	3,0%
Inappropriate speed	6	1,8%
Inappropriate reaction	5	1,5%
Navigation	4	1,2%
Decision error	4	1,2%
Excessive speed	3	0,9%
Internal condition of the task	2	0,6%
Total	**331**	**100,0%**

Key event

> **Figure 51**: Distribution of the Key events regarding scenario 1a (Source: TRACE sample, n=699)

Key events that shift the driving phase into the rupture phase are mainly represented by the endogenous parameters (related to the driver) with:
- 47% are related to the "internal conditions of the task"
- 38% are related to the "driver behaviour" factors.

The "internal conditions of the task" means all factors related to the driving task such as the driving manoeuvre (turning, going straight) correctly performed or not, the speed. We understand that these factors are essential in the understanding of the accident mechanisms.

The drivers having not the right of way (HNROW) are more likely:
- concerned by incorrect driving manoeuvre or incorrect positioning (57%)
- present a poor evaluation of the situation or a problem of anticipation of the opponent manoeuvre (13%)
- followed by a misinterpretation of the situation (9%).

Case by case analysis (in-depth LAB database) shows that:
- "Incorrect driving manoeuvre" includes 2/3 of non-respect of regulation and 1/3 of incorrect decision to perform a manoeuvre according to the available information (visibility or the available time opposite the main road traffic).
- "Poor evaluation" means that drivers saw the other vehicle (on the main road) but all drivers estimated having time to cross.
- "Misinterpreted the driving situation" includes 1/3 of poor experience of the site, 1/3 of misleading infrastructure leading to legibility problems (the road is not like we think it is!) and 1/3 of several factors such as driver state or visibility (mask).

The "driver behaviour" means all factors directly linked to the driver awareness of the situation (attention, distraction for example). Most drivers having not the right of way and presenting "driver behaviour" key event, "failed to look".
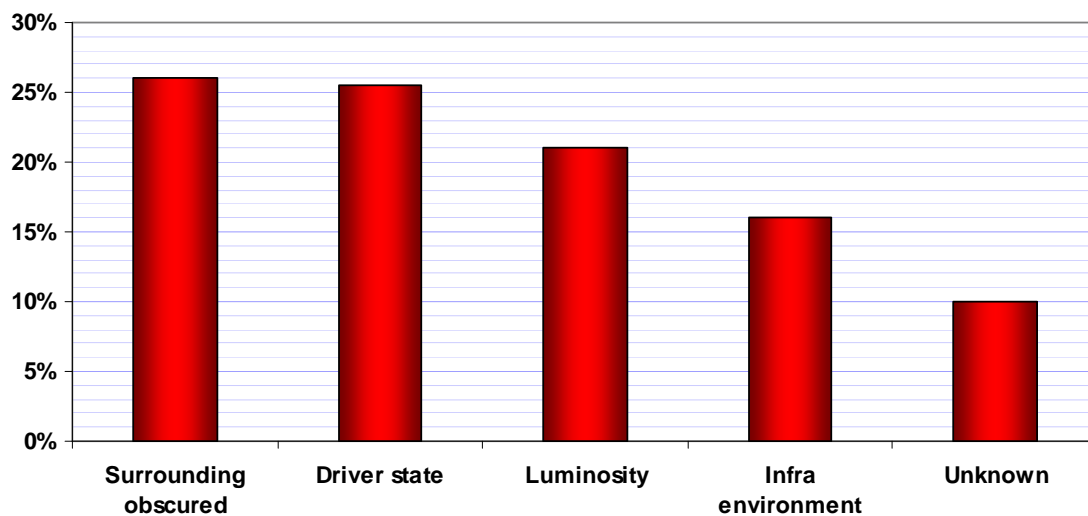
Figure 52: The contributory factors explaining why drivers failed to look
(Source: LAB sample)

Case by case analysis (in-depth LAB database) shows that:
- 2/3 of "failed to look" causes are exogenous and related to the infrastructure and the environment (road layout, mask, weather luminosity). Moreover, 1/3 of these drivers had to manage a problem of geometrical visibility (sight distance), directly linked to the road layout.
- 1/3 is endogenous and related to the driver state (age, mood, experience).

Moreover,
- 3/4 of the drivers HNROW who failed to look didn't react before the crash because:
  - 2/3 didn't perceived the other vehicle
  - 1/3 perceived but incorrectly or late
- while 1/4 braked or accelerated when they perceived and understood late the emergency.

Driver functional failures

Figure 53: Identification of the functional failure of the drivers HNROW involved
in scenario 1A (source: TRACE sample)

Half drivers having not the right of way HNROW experience rather "perception failure" than the other functional failures. The perception failure can be explained by:
- a quick look (rapid information search (quick look at the environment and the opponent)),
- focused attention (information search organisation (focus on a part of the situation at the expense of the opponent vehicle)),
- no look (break in information search (the driver stopped searching information (ex: he performed other task than the driving task)),
- no visibility (information detection strain (the information is not available or there is a geometric mask)).
- inattention (information search negligence (low driving task strain, inattention…)),

Case by case analysis (in-depth LAB database) shows that:
- ¾ of perception failures find explanation with endogenous explanatory elements.
  - ½ endogenous element are related to the "internal conditions of the task" such as misunderstanding, navigation, non adapted speed.
  - ½ are related to the driver behaviour (distraction, discussion) or his experience of the trip, automatic driving

Because, the driver didn't perceive correctly the opponent vehicle, he couldn't anticipate and avoid the crash. Only 1/3 drivers HROW, with perception failures, attempted to avoid the crash by braking or accelerating while 2/3 didn't react before the crash.

20% of these drivers (perception failures) drove at excessive speed reducing the chance to avoid the crash with a braking action.

Human Functional Failures, HFF, are explained with the explanatory elements that are classified according to the relation to the driver. In this way, there are endogenous and exogenous elements. Endogenous elements are related to the driver and his driving task while the exogenous elements are related to the vehicle, the road and the environment.

Explanatory elements - scenario 1A
drivers having not the right of way
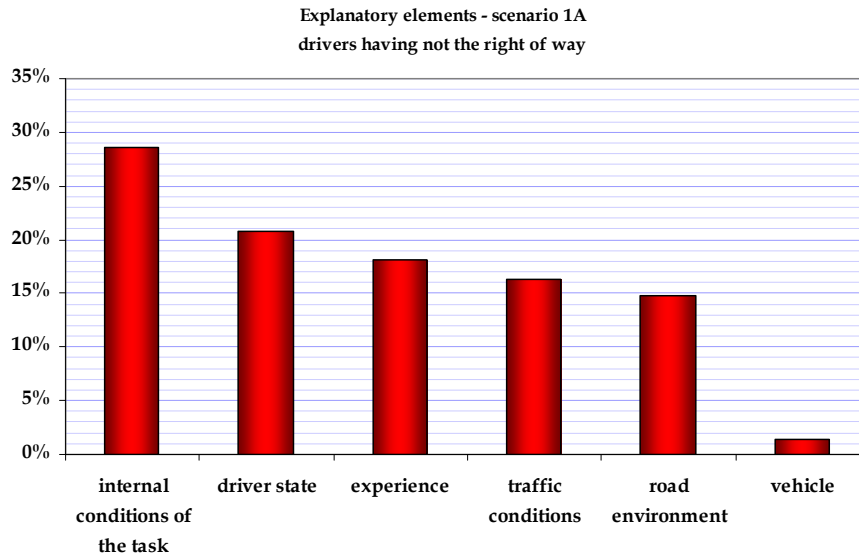
Figure 54: Explanatory elements of drivers having not the right of way (Source: TRACE sample)

Explanatory elements that explain the HFF of the drivers HNROW are:
- Endogenous with the
    - internal conditions of the task,
    - the drivers state and experience
- Exogenous with
    - the traffic conditions
    - and the road environment

Internal conditions of the task - scenario 1A
drivers having not the right of way
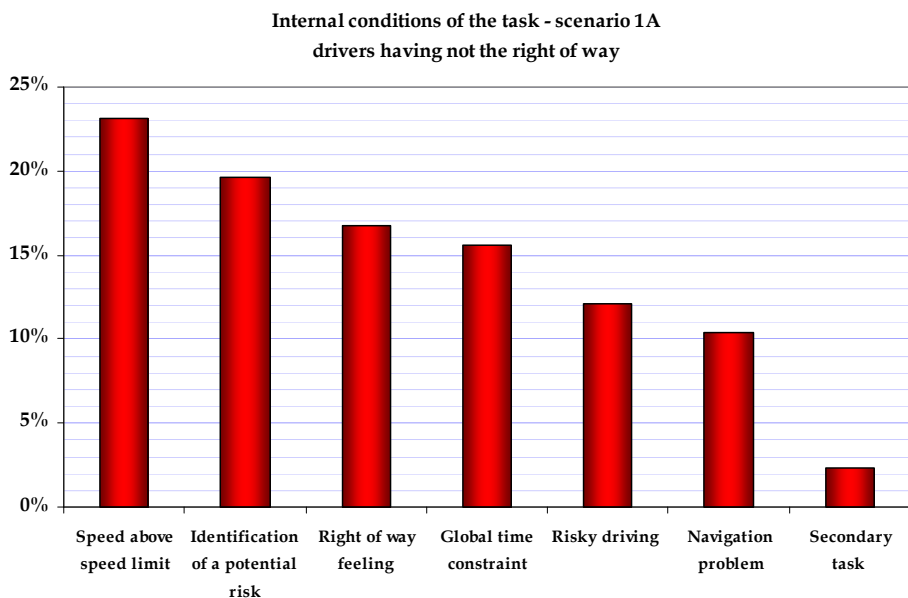
Figure 55: Explanatory elements – internal conditions of the task (Source: TRACE sample)

Most of explanatory elements are related to the internal conditions of the task such as
- the speed the driver has decided to drive,
- the available time to perform the trip,
- the risk related to the manoeuvre
- or the behaviour etc.

Driver state - scenario 1A
drivers having not the right of way
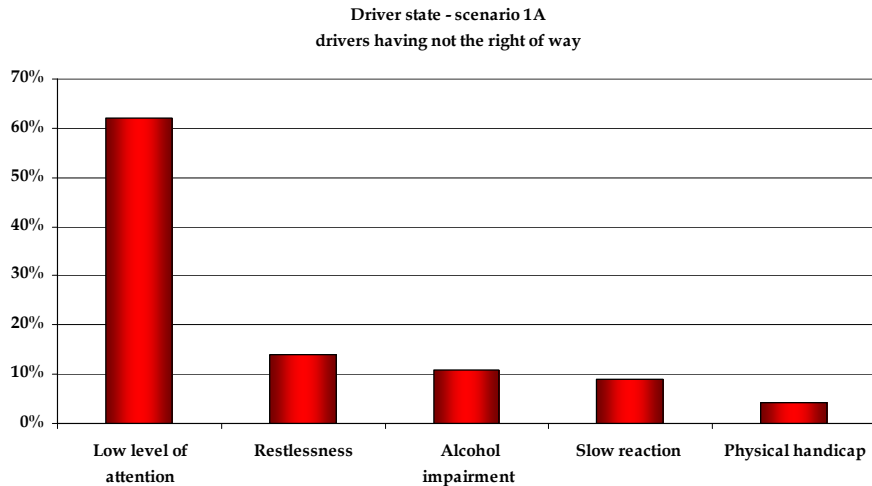
Figure 56: Explanatory elements related to the driver state (Scenario 1A driver HNROW)

Drivers having not the right of way showed a "low level of attention" such as:
- low vigilance,
- affectation of attention resources to driving task,
- internal distraction such as thinking,
- and external distraction such as discussing.

The emergency manoeuvre
In order to adapt countermeasures to the driver needs, let us analyze their emergency reaction.

Scenario 1A
drivers having not the right of way
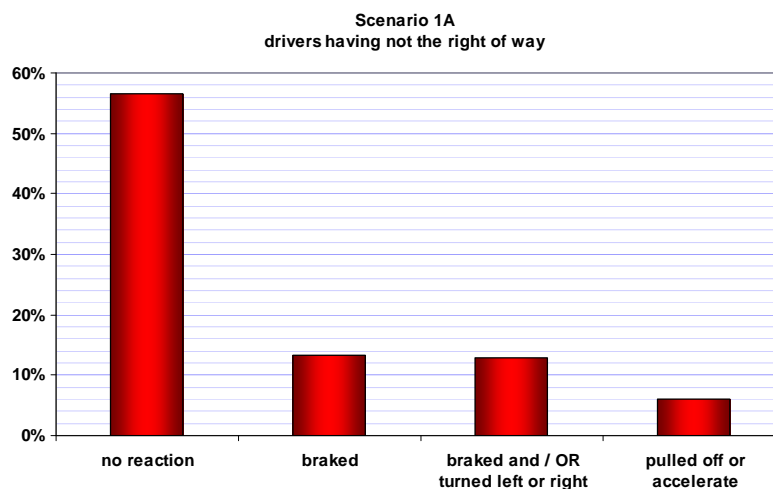
Figure 57: Emergency manoeuvre (Scenario 1A driver HNROW)

Most drivers having not the right of way didn't react before the crash.
Case by case analysis (in-depth LAB database) shows that:
- ½ drivers who didn't react "failed to look".
  - o 50% had problem of sight distance. The time required crossing the main road and then the distance of geometrical visibility required along the main road is inferior to the minimum required (reference to he sight distance definition).
  - o 50%were confronted to different problems:
    - ▪ Looked but didn't see. This problem is present in the literature especially reported by the Department of transport of United Kingdom. In fact the visibility is correct, the weather is normal, the driver looked but didn't see.

> ▪ Were confronted to a misleading infrastructure (for example: the main road is raised in comparison with the secondary road (platform) or the main road approach is a curve, leading for the driver having not the right of way to difficulties to see along the main road)
> ▪ Had difficulties to see because of a mask (vegetal or moving masking the traffic)
> ▪ Had difficulties to see because of the luminosity such as dazzling sun (temporarily masking the other vehicle)

- ½ drivers who didn't react were split in different classes explaining the lack of reaction:
  - o "driver state" is involved such as mood, stress (didn't react because was focused on other task than driving)
  - o "driver behaviour" is involved such as inattention (attention was focused on other task than driving)
  - o "internal conditions of the task" is involved such as navigation, incorrect driving manoeuvre (didn't stop at STOP for example).
  - o "infrastructure environment" is involved such as mask of visibility.

Another aspect of the problem can highlight the situation of these drivers. Indeed, drivers having not the right of way HNROW had to perform a driving manoeuvre. The driving task was either to cross the main road or to turn into or across the main road. When the driver HNROW decides to perform the manoeuvre he is not in the conditions to perform an emergency manoeuvre.
In fact during the driving phase, the driver evaluates the situation as "normal without risk", "risky but easy to achieve" or "risky but hard to achieve.

In this context, either he stopped (STOP or traffic lights) and pulled off or he drove at constant or decreased speed ready to accelerate. His foot is then on the accelerator pedal. The time required to move his foot from the accelerator pedal to the braking pedal is variable according to the driver state, age, experience and reflex. So, his foot is not at the right place to anticipate the situation and his mind is in accordance with his action.

Driver age
Literature review highlighted two driver categories over represented, the youngest and the eldest drivers.
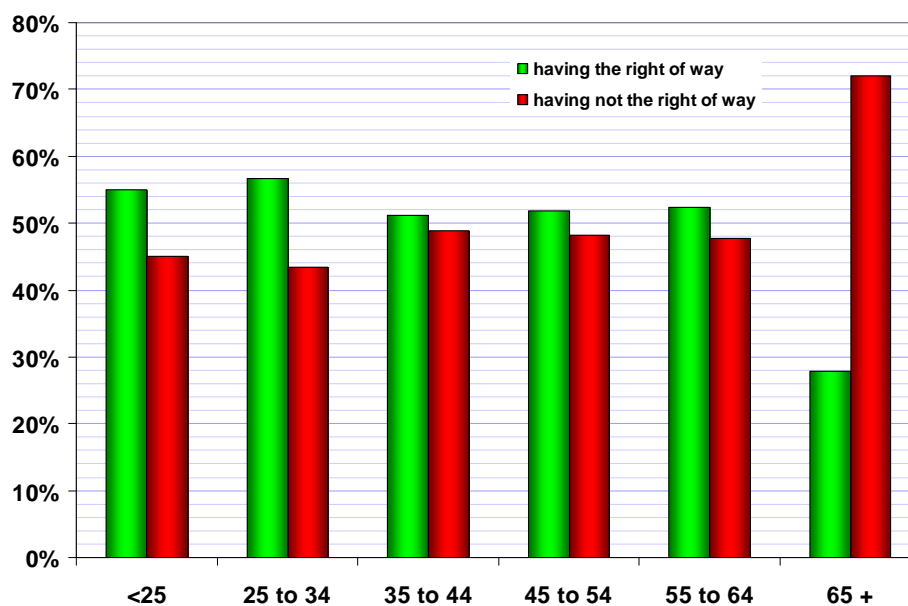
Figure 58: Distribution of the driver age in scenario 1A.

Despite the fact the proportion of older drivers (65+) in TRACE sample is low (11% of the drivers at intersection), they are more often involved as "driver having not the right of way" HNROW than the other categories. It means that older drivers have problem to manage the driving task at intersection and especially when they have not the right of way.

Case by case analysis (in-depth LAB database) shows that older drivers involved at intersection present as well perception, diagnostic as prognostic failures while the older drivers (65+) in the whole (all accident type) present rather perception failures.
Here are several situations characterizing the older involvement at intersection.
- o   Perception issues :
    - ▪ Failed to look (looked but didn't see or looked, didn't see anything decided to cross but didn't control)
    - ▪ Navigation (attention focused on the route search) or mood (irritated),
- o   Misinterpretation of the traffic lights in operation
- o   Hesitant manoeuvre or slow manoeuvre (after looking at the traffic, pulled out slowly).

So, older drivers (65+) HNROW had problem related to the perception of the other vehicle but also problems related to the understanding of the situation. Moreover, when they performed correctly the perception and the understanding their action was too slow.
In consequence of these failures, they pulled out at intersection or crossed the intersection and most of them didn't react. They couldn't avoid the crash.

Driver involvement
We have defined previously a "primary active driver" as a driver who causes the perturbation with himself and the other participants. The involvement is determinant in the accident genesis. The two drivers can be both primary active if they both contributed actively to the occurrence of the accident.

The figures below show that young drivers (<25) and older drivers (65+) are more likely primary active when they have not the right of way HNROW.
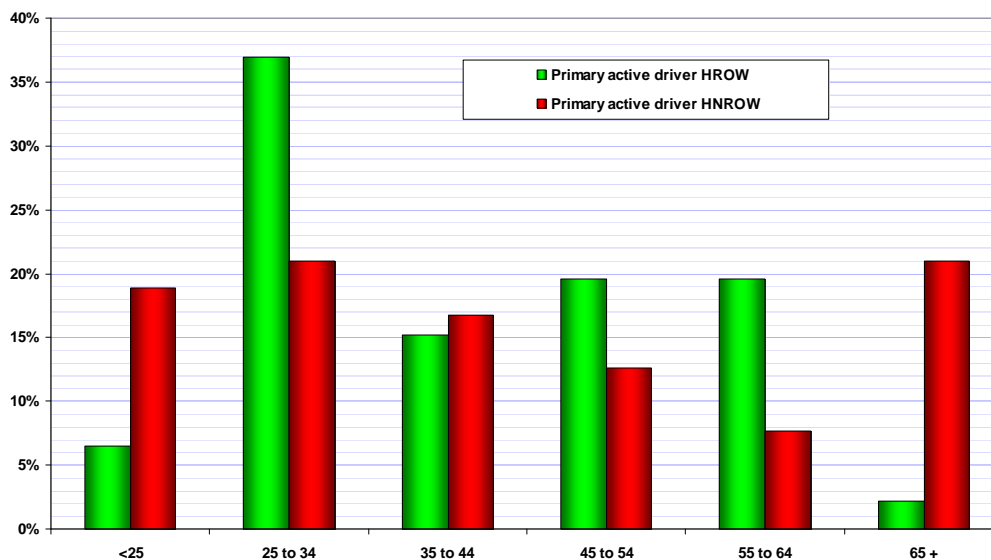
Figure 59: Driver involvement for driver HNROW in Scenario 1A.

The results show that if the older drivers are overrepresented when they have not the right of way as "primary active drivers", they are more likely involved when they come from the right.

The main results regarding the driver having not the right of way involved in Scenario 1A are the following:

Key events are endogenous

- Internal conditions of the task
    - o Incorrect driving manoeuvre
    - o Poor evaluation of the situation
    - o Misinterpretation of the situation
- Driver behaviour
    - o Failed to look

Human Functional Failures are

- Perception
    - o Quick look
    - o Focused attention
    - o No look
    - o No visibility
    - o Inattention

The main explanatory elements are:
- o Internal conditions of the task
    - ▪ misunderstanding,
    - ▪ navigation,
    - ▪ non adapted speed
- o driver behaviour
    - ▪ distraction,
    - ▪ discussion
- o driver experience

Emergency reaction

58% didn't react before the crash because they mainly failed to look because of
- o sight distance problems
- o looked but didn't see
- o lost in a misleading infrastructure
- o mask
- o luminosity

Driver age

Older drivers (65+) are overrepresented/the sample in the whole
- perception of the other vehicle
- misunderstanding of the situation
- slow manoeuvre

B) The driver having the right of way

The driving task of the drivers having the right of way
The driver having the right of way has to drive along the main road. He didn't perform any specific manoeuvre. He is confronted to a vehicle coming from the left or the right, stopping decelerating, accelerating or driving at constant speed.

Key events

Despite the key events are most of time related to the drivers having not the right of way, sometimes both drivers HROW and HNROW contributed to the switch of the driving phase to the rupture phase.

Internal Condition		
Incorrect driving manoeuvre	17	33%
Misinterpreted	11	22%
Inappropriate speed	8	16%
Inappropriate reaction	7	14%
Excessive speed	7	14%
Incorrect lane positioning	1	2%
Total	**51**	100%

Driver behaviour		
Failed to look	22	85%
Other driver behaviour	4	15%
Distraction	3	12%
Total	**26**	100%
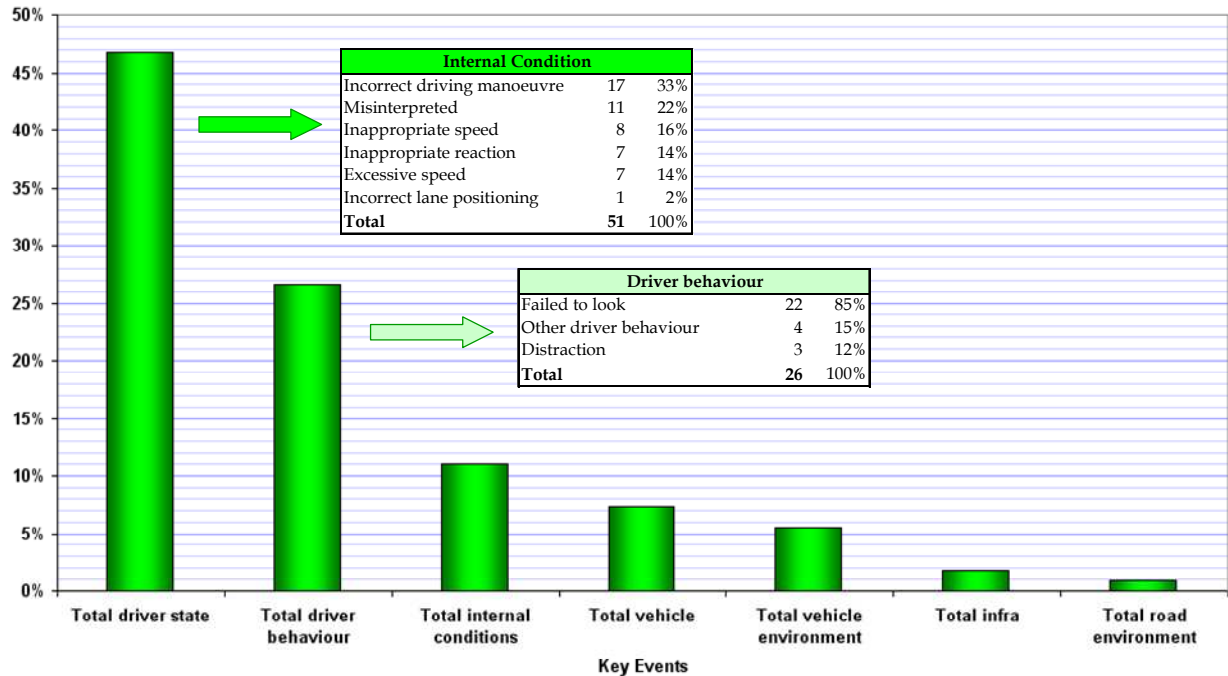
Figure 60: Key events related to the drivers having the right of way in scenario 1A
(Source: TRACE sample)

"Internal conditions of the task" and "driver behaviour" are the main relevant key events related to the drivers HROW.

Internal conditions of the task are:
- "Incorrect driving manoeuvre"
- "Misinterpreted the driving situation"
- "Inappropriate speed"
- "Inappropriate reaction"
- "Excessive speed"

Case by case analysis (in-depth LAB database) shows that:
- "Misinterpreted the driving situation" is related to the driver who misunderstands the intentions of the other driver. He anticipates and tries avoidance or thinks that danger is gone but he is wrong.

- "Excessive speed" is related to the speed limits (superior to the speed limits) while inappropriate speed is related to the driving conditions (weather, road surface, traffic…) even if the speed limit is not reached.
- "Incorrect driving manoeuvre" is related to the risk taking. The driver sees the other driver, understands the danger but doesn't anticipate.
- "Inappropriate reaction" is related to the driver who brakes to avoid the crash but locks the wheels (sample of accidents with passenger car not equipped with ABS). The vehicle slides on the road without any control. Moreover, the stopping distance is not long enough to perform a correct avoidance of the crash. The drivers HROW see the other driver (on the secondary road), but understands too late his intentions.
- "Driver behaviour" is mainly "failed to look".

Case by case analysis (in-depth LAB database) shows that "failed to look" is related to the driver HROW who looked at the traffic but didn't see the other vehicle because he didn't search the information (right of way feeling).
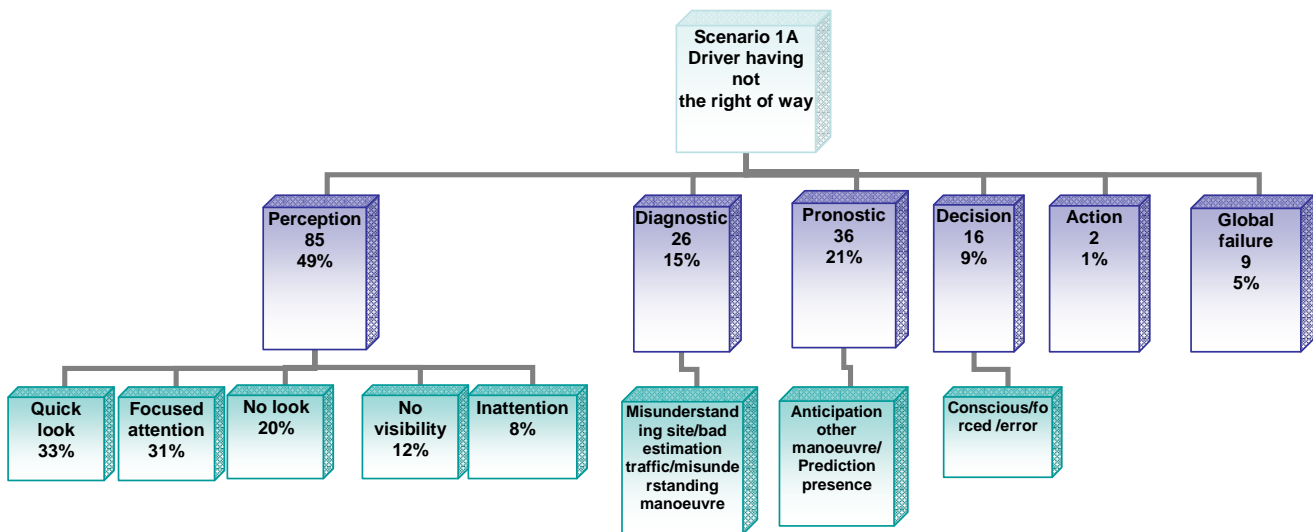
Driver functional failures
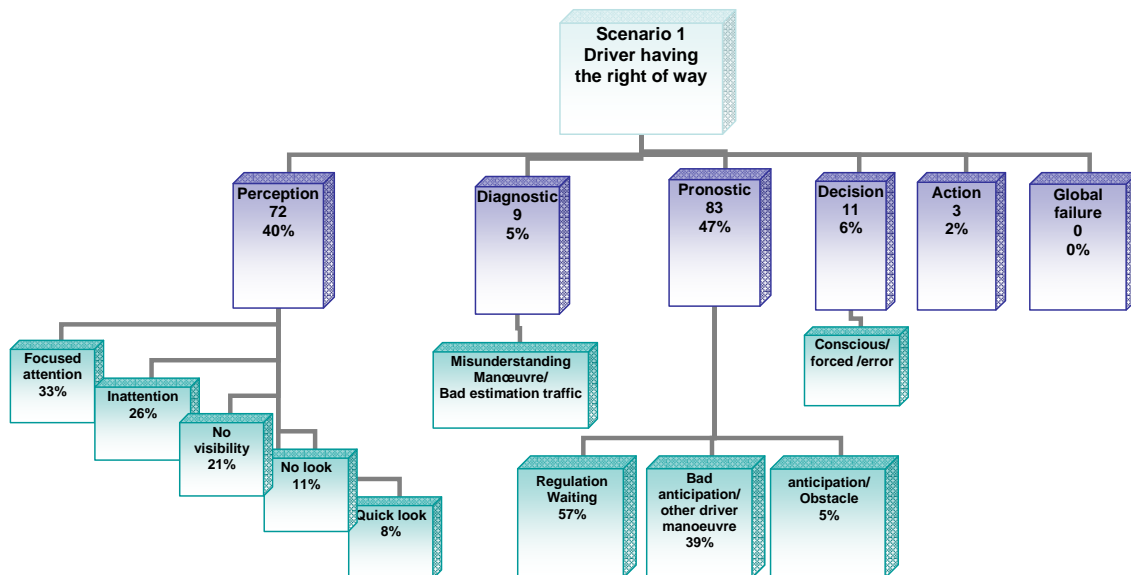
Figure 61: Identification of the functional failure of the drivers HROW involved in scenario 1A (source: TRACE sample)

Drivers having the right of way experience more
- "prognostic failures" such as anticipation of the opponent driver manoeuvre, prediction of opponent driver presence.
- and perception failures.

The "prognostic failures" can be explained with the fact the driver HROW is:
- Waiting for the regulation by the other driver (sees the other vehicle slowing down up to the intersection but thinks he is going to stop)
- Waiting for no other driver manoeuvre (sees the other vehicle stopped on the secondary road but doesn't anticipate his manoeuvre)
- Waiting for no obstacle (unusual manoeuvre performed by the other driver).

In almost nine cases on ten "prognostic failures", the drivers having the right of way braked before the crash.
Case by case analysis (in-depth LAB database) shows that:
- ¾ of "prognostic failures" find explanation with endogenous explanatory elements (related to the driver).
  - ¾ are related to the "internal conditions of the task"
    - ½ right of way feeling
    - 1/3 non adapted speed
    - 1/6 time constraint, risky driving, misunderstanding the situation

The "perception failures" can be explained by:
- focused attention (on the priority rules)
- inattention (lost in thought)
- no visibility (moving mask)
- no look (break in information search because of non driving task)
- a quick look (feeling of right of way)

Moreover, half of drivers having the right of way and sustaining perception failures braked before the crash. The last half didn't react.

One more point, "Focused attention" failures led to "no reaction" (as emergency reaction) performed by the driver HROW while the other classes (inattention, no look and quick look) led to a braking response.

Case by case analysis (in-depth LAB database) shows that:
- ¾ of perception failures find explanation with endogenous explanatory elements (related to the driver).
  - o 2/3 endogenous element are related to the "internal conditions of the task"
    - ½ right of way feeling
    - 1/3 non adapted speed
    - 1/6 non driving task or misunderstanding of the situation

Explanatory elements of drivers HROW failures in the whole

Human Functional Failures, HFF, are explained with the explanatory elements that are classified according to the relation to the driver. In this way, there are endogenous and exogenous elements. Endogenous elements are related to the driver and his driving task while the exogenous elements are related to the vehicle, the road and the environment.

Explanatory elements - scenario 1A
drivers having the right of way
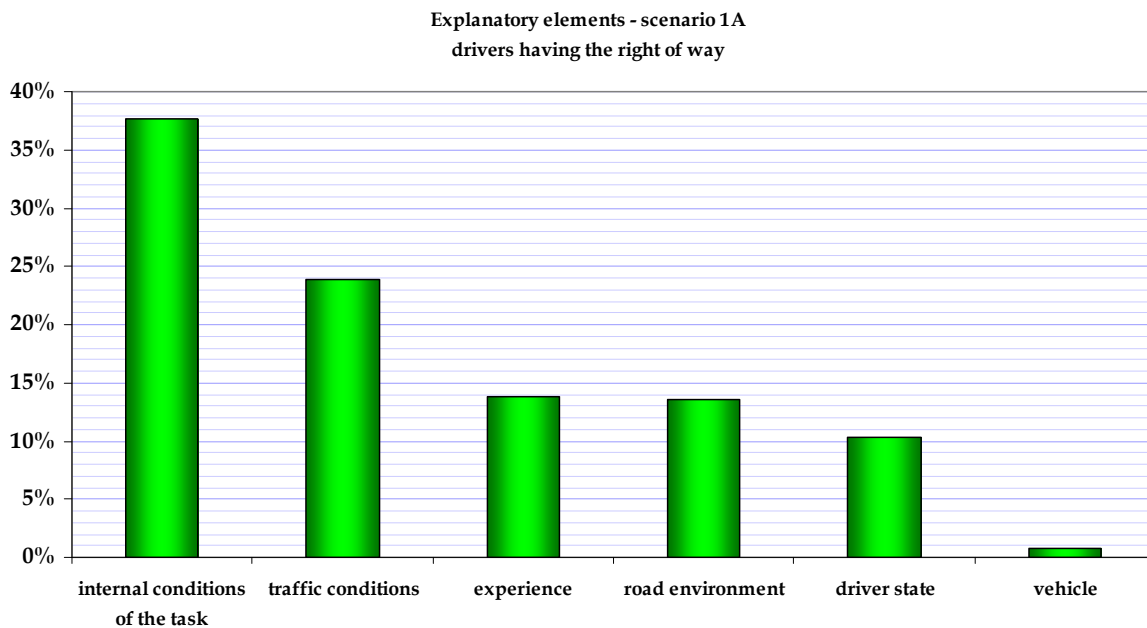
Figure 62: Explanatory elements according to the driver HROW in scenario 1A
(Source: TRACE sample)

The explanatory elements that explain the HFF in the whole are:
- Internal conditions of the task
- Traffic conditions
- Driver experience
- Road environment

Internal conditions of the task - scenario 1A
Drivers having the right of way
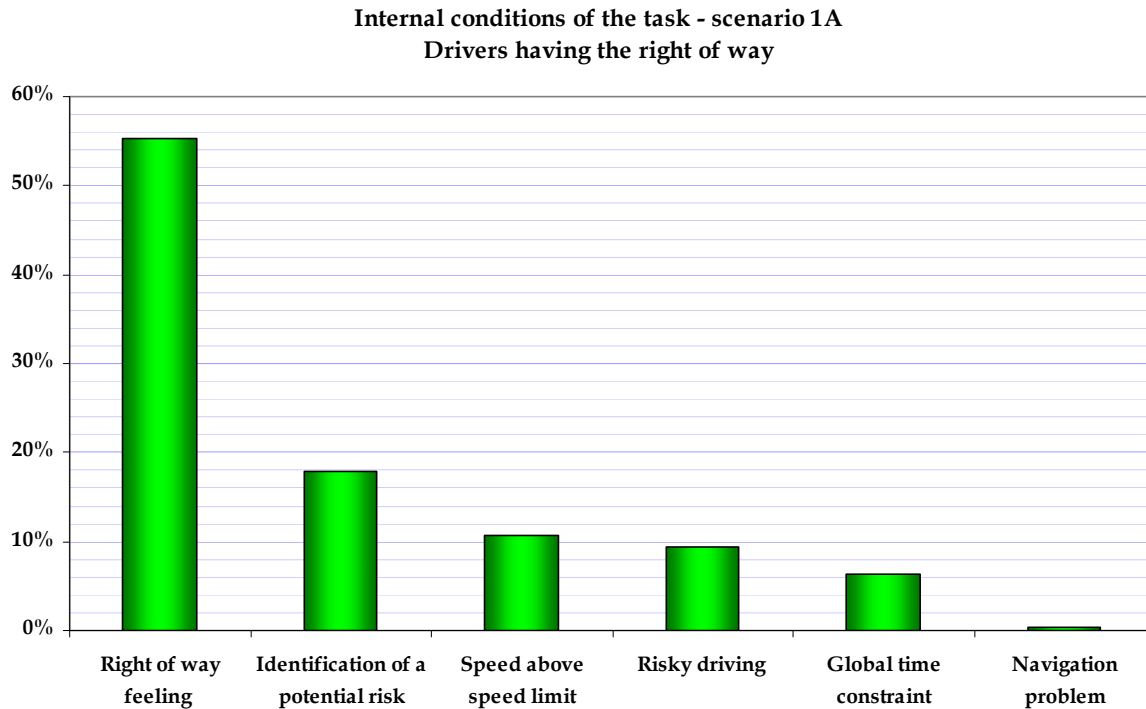
Figure 63: Explanatory elements – internal conditions of the task (Source: TRACE sample)

The internal conditions of the task that contributes to explain the HFF in the whole are mainly:

- Secondary task (the driver is doing something else than the driving task such as using or watching his mobile phone).
- Right of way feeling (the drivers do not change anything in their driving. They do not anticipate the eventual manoeuvre of the other driver).
- Risky driving (does not stop at traffic lights out of order).

Traffic conditions scenario 1A drivers having the right of way
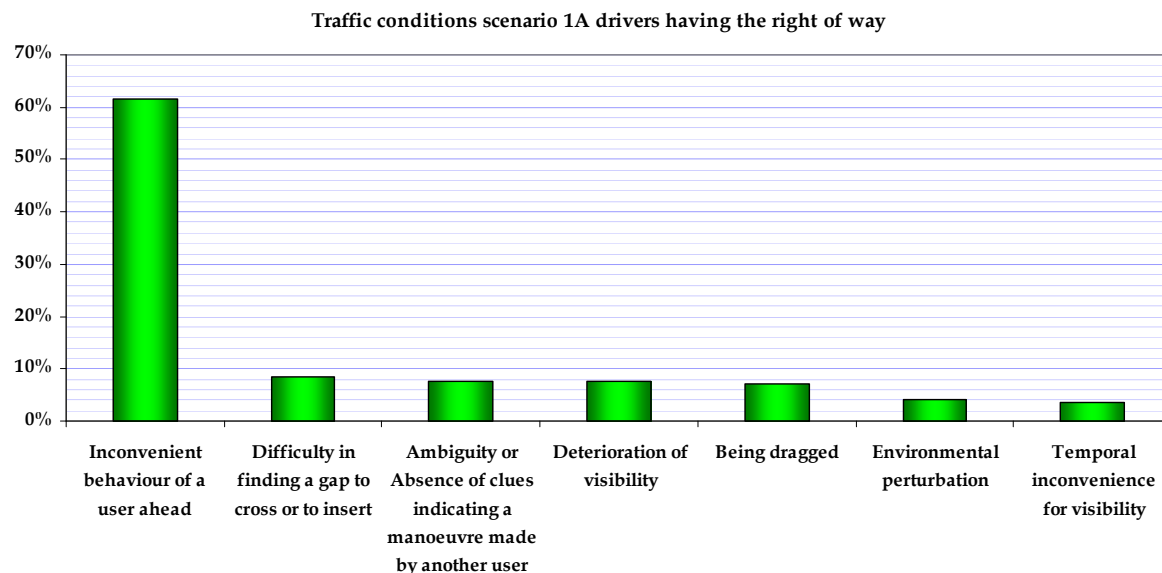
Figure 64: Explanatory elements – traffic conditions (Source: TRACE sample)

The Traffic conditions that contribute to explain the HFF in the whole are mainly the "inconvenient behaviour of a user ahead" (atypical or illegal manoeuvre performed by the other driver).

Driver experience scenario 1A drivers having the right of way

Figure 65: Explanatory elements – driver experience (Source: TRACE sample)

The driver experience that contributes to explain the HFF in the whole are:
- Experience of the manoeuvre, the trip leading to an automatic driving
- Low experience of driving
- Site not known

The emergency manoeuvre
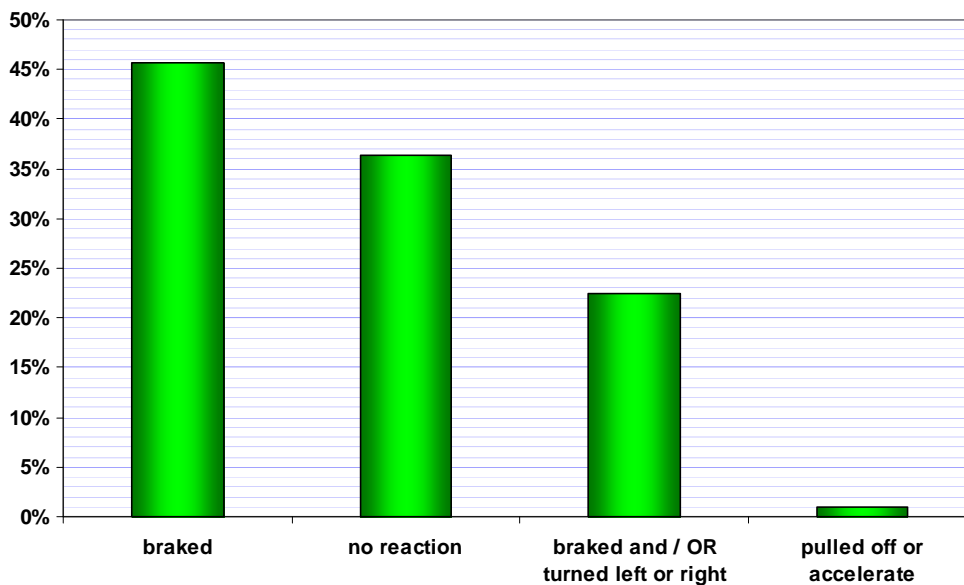
Figure 66: Emergency manoeuvre – drivers HROW (Source: TRACE sample)

Regarding the emergency manoeuvre we can see that:
- 70% of the drivers having the right of way performed an emergency manoeuvre to avoid the crash. Most of them (97%) braked.
- 30% did not react.

Braking reaction
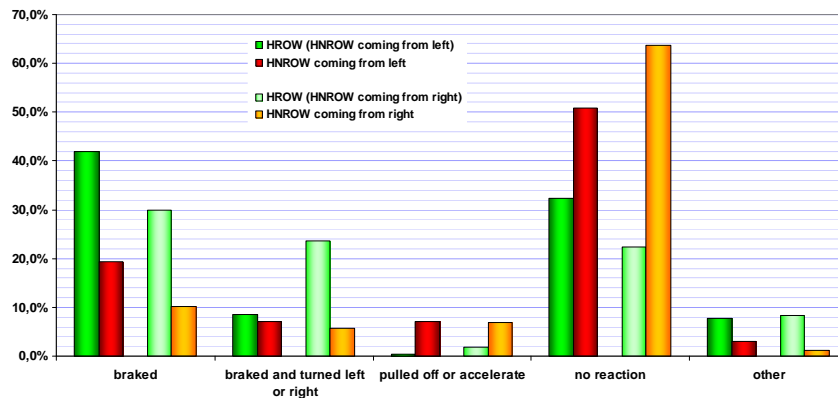
Figure 67: Emergency manoeuvre for driver HROW (Source: TRACE sample)

When the driver having the right of way is confronted with a vehicle coming from the left or the right, his emergency manoeuvre is slightly different.

- When the other vehicle comes from the left, the driver having the right of way reacts mainly with a braking reaction.
- While, when the other vehicle comes from the right, the driver having the right of way reacts with a braking response and/or a braking and a steering action. There are more avoidance manoeuvres when the OV comes from the right.

Experimentations performed with a driving simulator at intersection and in-depth accident analysis both show that:

o Despite the driver has performed a manoeuvre, he didn't avoid the crash. Experimentation showed indeed that the steering manoeuvre is mostly performed in the direction of the other vehicle speed vector. It means that if a vehicle comes from right, the driver having right of way will perform mostly a steering manoeuvre to the left.

o The driver having the right of way perception of the other vehicle depends of the visibility (mask), the luminosity and the azimuth of the other vehicle. Moreover, the more the driver having the right of way is close to the intersection, the later he perceives the other vehicle. These parameters are dependent on the relative speeds of the 2 vehicles.
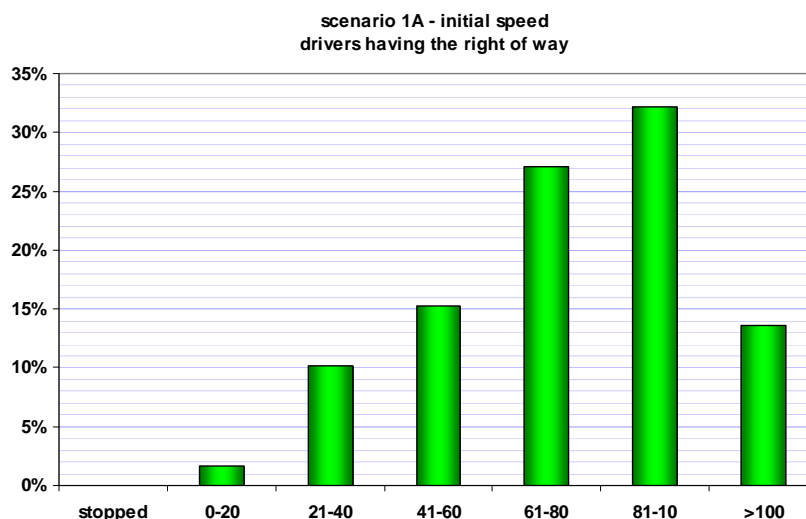
Figure 68: Initial speed – all drivers having the right of way (Source: LAB sample)
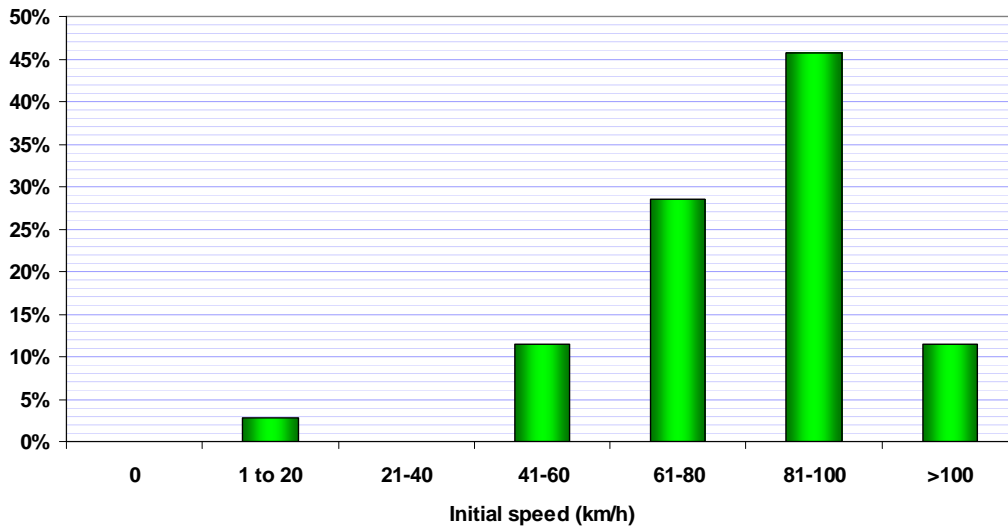
Figure 69: Distribution of the initial speed when the drivers brake (Source: LAB sample)

More than a half of the initial speeds, for drivers having the ROW and braking before the crash, was higher than 80 km/h. 1/4 of the calculated initial speed was excessive speed (according to the speed limits).

More than the initial speed or the driving speed, the stopping distance is relevant to establish the probability to avoid the crash.

We remind that to perform a manoeuvre the driver needs time that is the sum of
   o   the reaction time (including the time to understand, to move the foot; 1 to 1.5s)
   o   and the time to the braking system (0,3 to 0.5 s) to be operational.

Times between 1.3 to 2s (at 90km/h 32 to 50m) are required before the braking itself.

The stopping distance is then the distance required to stop the vehicle before the crash. It includes the distance during the reaction time and the braking distance.

Despite the drivers performed a braking manoeuvre to avoid the crash, the accident happened. If we compare the stopping distance to the available distance (distance to crash used in the reconstruction of the accident to evaluate the initial speed), 66% of the drivers had not the distance required to stop their vehicle and avoid the crash.
The idea here is to provide the drivers with the information allowing them to anticipate or to provide the vehicle with system that improves the efficiency of the braking action.
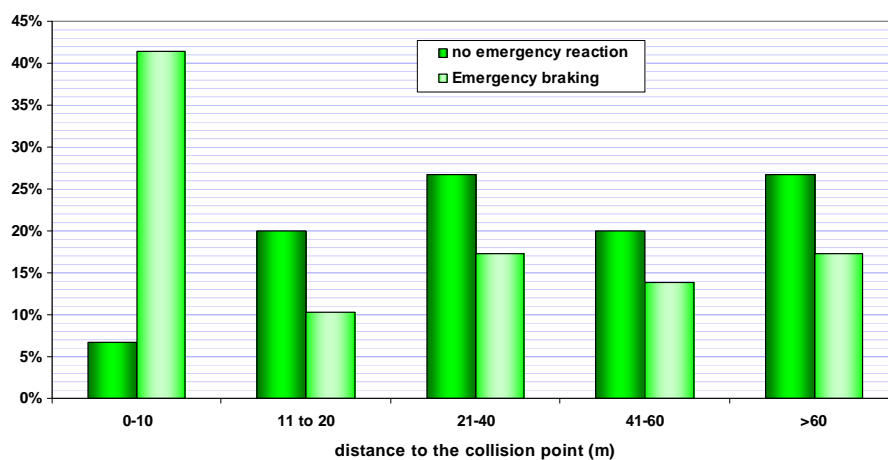
Figure 70: Distance to crash according to the reaction (Source: LAB sample)

Case by case analysis (in-depth LAB database) shows that the factors related to the drivers HROW braking before the crash are:
- Excessive speed (+10km/h compared to the speed limits), increases the stopping distances.
- Wet road surface, decreases the performance of the braking. A wet road surface lost 30% of grip compared to a dry road.
- Surrounding obscured (mask), the drivers couldn't anticipate because they couldn't see.

So, the drivers braking before the crash didn't avoid the accident because:
- They had not the time and the space to perform a manoeuvre
- They drove too fast (excessive speed)
- The road surface was wet, decreasing the efficiency of the braking
- They had not the visibility to see the other driver

No reaction

30% of drivers having the right of way didn't react before the crash.

"Case by case" analysis within in-depth LAB database shows that those drivers didn't react because they had no time to perform an emergency manoeuvre. It means that despite they have seen the other driver (on the secondary road) it was too late to react.

Because the other driver (on the secondary road) performed an atypical or illegal manoeuvre (didn't stop at STOP, pulled out while crossing traffic don't allow the manoeuvre), the driver having the right of way couldn't anticipate. The observation (below) of the initial speed and the distances required to stop the vehicle confirm this assumption.

If we compare the stopping distance required to the available distance to the crash, 67% of the drivers had not the distance required to stop their vehicle and to avoid the crash.

Here again, the idea here is to provide the drivers with the information allowing them to anticipate or to provide the vehicle with system that improve the efficiency of the braking action.

The driver age
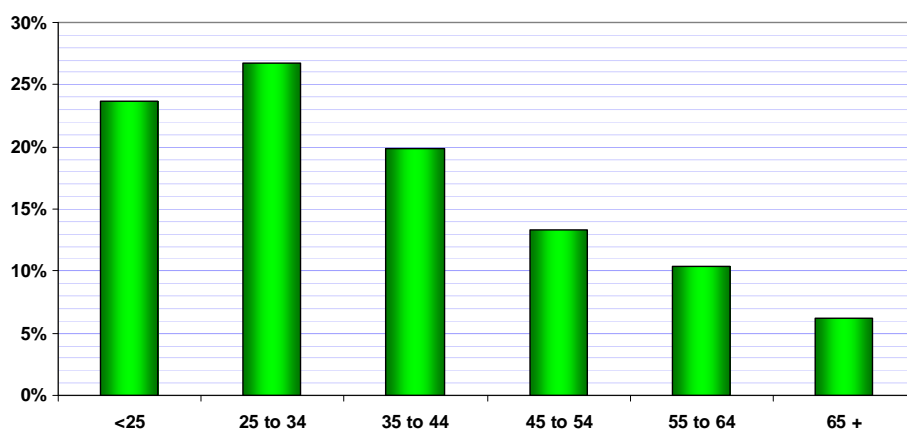
Figure 71: Driver age – drivers HROW in scenario 1A (Source: TRACE sample)

Younger drivers (<25 to 34) are over-represented compared to the sample in the whole.

Case by case analysis (in-depth LAB database) shows no particularity in this group related to the intersection regulation, nor to the other driver age.
In this group, 2/3 braked before the crash while 1/3 didn't react. This result is conforming to the observation related to the whole sample of drivers having the right of way.

Driver involvement

We have defined previously a "primary active driver" as a driver who causes the perturbation with himself and the other participants. The involvement is determinant in the accident genesis. The two drivers can be both primary active if they both contributed actively to the occurrence of the accident.
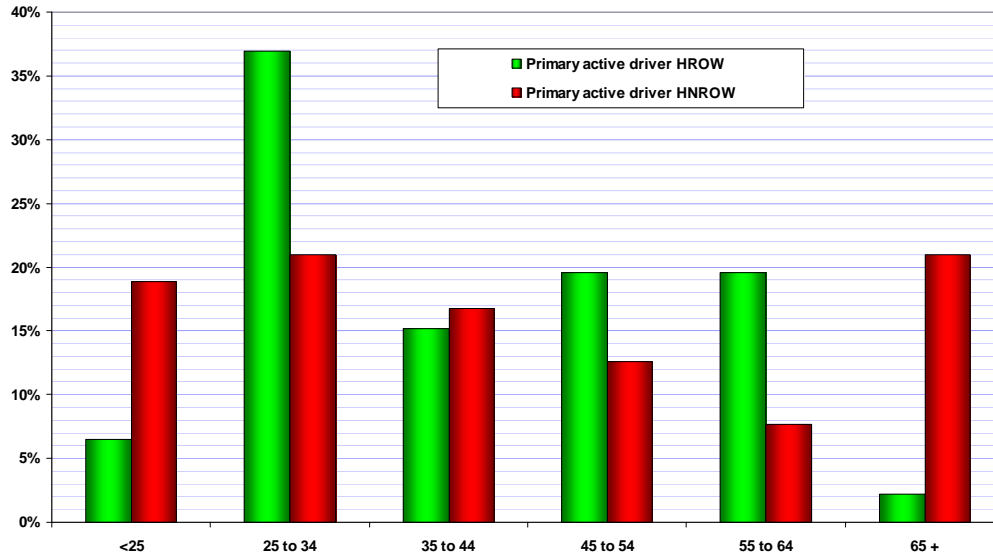
Figure 72: Driver involvement – distribution of the primary active drivers according to the driver age (Source: TRACE sample)

While we see above the difference in involvement whether the driver has the right of way or not, here drivers "25 to 34" are overrepresented as primary active drivers when they have the right of way.
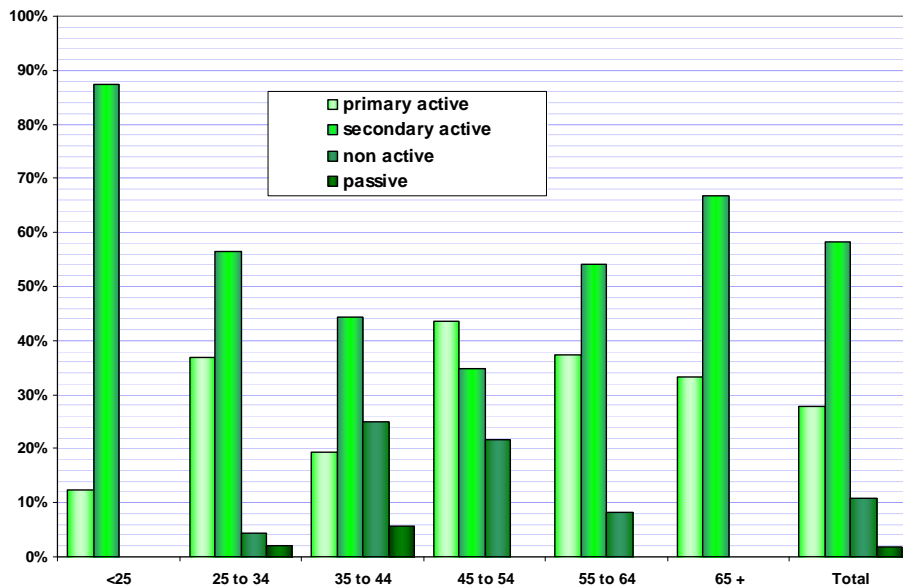
Figure 73: Driver involvement – distribution in a driver age group of the involvement level (Source: TRACE sample)

Two driver groups are more represented than the other (<25 and 65+) as secondary active drivers. They are not the cause of the accident but they participate to its occurrence.

The main results regarding the driver having the right of way (HROW) involved in Scenario 1A are the following:

Key events are endogenous
- Internal conditions of the task
    - Misinterpreted the situation
    - Excessive speed
    - Incorrect driving manoeuvre
    - Inappropriate reaction
- Driver behaviour
    - Failed to look

Human Functional Failures are
- Prognostic
    - Waiting for regulation by other driver
    - Waiting for no manoeuvre performed by the other driver
    - Waiting for no obstacle

Emergency reaction is braking

Explanatory elements:
    - Right of way feeling
    - Non adapted speed
    - Time constraint/risky driving/misunderstanding of the situation
- Perception
    - Focused attention
    - Inattention
    - No visibility
    - No look
    - Quick look

50% braked and 50% didn't react
Explanatory elements:
    - Right of way feeling
    - Non adapted speed
    - Non driving task or misunderstanding of the situation.

Emergency reaction
- 70% braked before the crash (associated with a steering action when the opponent driver comes from the right). 66% of them had not the distance required to perform a correct an avoidance of the crash.
- 30% didn't react: these drivers had no time to perform an emergency manoeuvre

Age of the driver
Younger drivers (<35) are overrepresented/the sample in the whole
- 2/3 braked before the crash
- 1/3 didn't react

SCENARIO 1A – MAIN CONCLUSIONS

Drivers having not the right of way

The problem related to the age of the driver is mainly present for the younger and older drivers having not the right of way. Most of them are primary active drivers. They are actively active in the genesis of the accident. This result is in accordance with the literature review that highlighted the overrepresentation of the two driver population at intersection.

Older drivers having not the right of way experienced problems to perceive the other vehicle and to understand the situation.

Most of drivers didn't react before the crash because they failed to look.

Drivers having not the right of way had more likely problem of perception mostly due to a low level of attention. They failed to look, performed an incorrect manoeuvre and misinterpreted the situation.

Drivers having the right of way

When drivers have the right of way, despite the fact they perceived correctly, they appreciated the situation in a wrong way. Most of them presented a prognostic failure such as a wrong anticipation of the other driver manoeuvre. Moreover they had a strong feeling of right of way.

7/10 drivers braked before the crash associated or not with a steering action.

When the other vehicle comes from the left most drivers having the right of way braked but didn't steer to avoid the crash. However when the other vehicle comes from the right most drivers braked and/or steered. But they didn't avoid the crash either.

GENERIC COUNTERMEASURES

Thinking about the best way to help the older drivers at intersection.
Drivers are getting older as the population and this problem is going to be predominant in the future. Today the best way to help them with the available ITS is the detection of obstacle.
But when older drivers perceived the other vehicle and performed a manoeuvre such as crossing the main road or turning left into the main road, they are confronted to a rapid traffic while they need more time to perform their manoeuvre. So, the best help is to reduce the approach speed limits on the main road to allow older drivers to perform the manoeuvre.

Helping the driver having not the right of way to perceive the other vehicle.
Control the geometric visibility (sight distance),
Helping the driver to look properly, detecting the other vehicle for him,
Helping the driver to be more attentive (more concentrated on his driving task).

Helping the driver having the right of way to anticipate the other driver manoeuvre.
These drivers have a strong feeling of right! They don't appreciate the situation as a risky one but rather as a security one. They see but don't anticipate or too late. They need to be informed of the risky situation with an up-to-date navigation tool that informs the driver of the risk to be confronted to a risky situation according to the geometric, visibility constraints, to the referenced black spots.
They also need to be help along their emergency manoeuvre. AFU can reduce the braking distances.

7.2.3.h **Scenario 1.B**

Accident occurring at intersection
Same road, different directions
One driver is turning left

13 % of TRACE sample
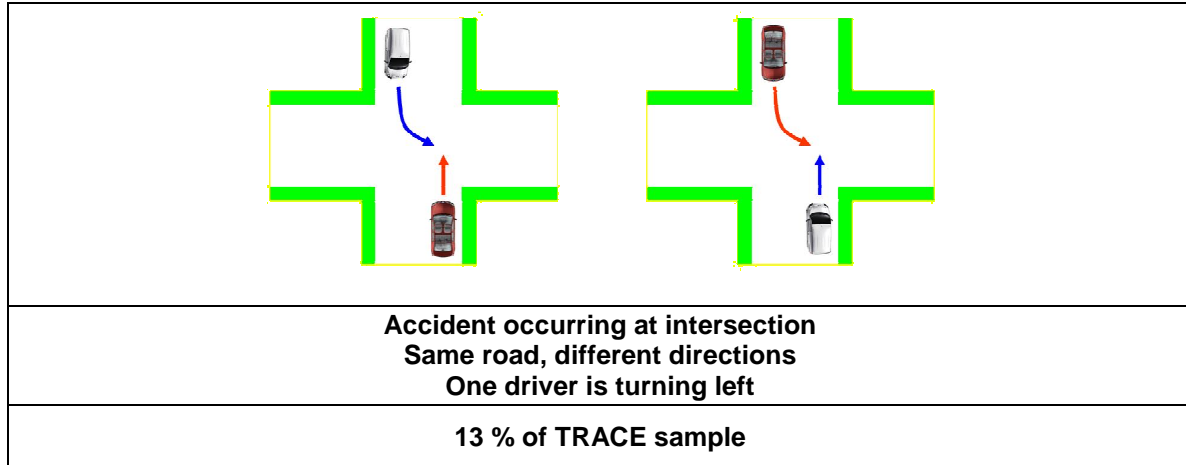
For the accident causation analysis we decided to split the study between the driver turning across the road (TAR) and the driver going straight (GS). Effectively, most of the accident causes are often affected to the driver TAR. It is the case here for the scenario 1a where 74% of the total key events are related to the driver TAR.

A) Drivers turning across the road (TAR)

Key events

Accident occurrence is the result of different related causes affected to the systemic model Driver/Vehicle/Environment. Key events are the events that explain the rupture between the driving phase and the emergency phase.
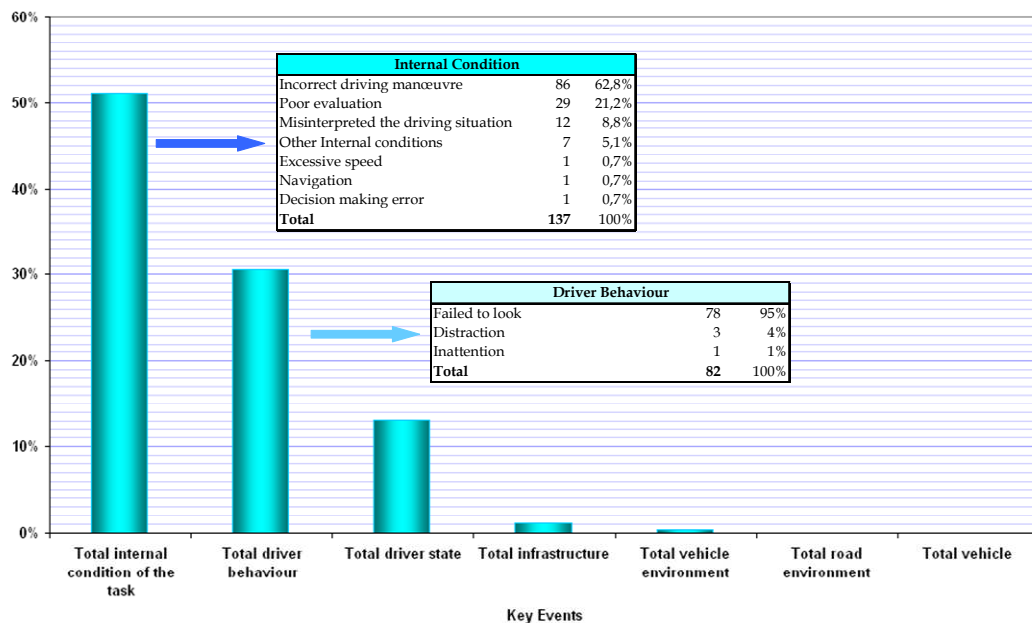
Figure 74: Distribution of the Key events related to drivers TAR in scenario 1B
(Source: TRACE sample, n=137)

Key events that shift the driving phase into the rupture phase are mainly represented by the endogenous parameters (related to the driver) with:
- Internal conditions of the task (more than half of the sample) (51%)
- Driver behaviour and state (31% and 13%)

The internal conditions of the task means all factors related to the driving task such as the driving manoeuvre (turning, going straight) correctly performed or not, the speed.

The drivers turning left across the road are more likely concerned by
- Incorrect driving manoeuvre (example: overtook and turned left at intersection).
- Poor evaluation (example: misjudges the time required to perform the manoeuvre).
- Misinterpretation of the driving situation (example: pulled off at traffic lights and performed the manoeuvre without any control).

The driver behaviour means all factors directly linked to the driver awareness of the situation (attention, distraction for example).

Most drivers turning left across the road and presenting "driver behaviour" key event, "failed to look".

Case by case analysis shows that the drivers turning left across the road failed to look because:
- Excessive speed of the other vehicle inside urban area that reduced the time to perform the manoeuvre.
- Moving mask while they performed the manoeuvre.
- Luminosity such as dazzling sun masking the oncoming traffic.
- Looked towards the wished direction but didn't control again the oncoming traffic.

8/9 drivers who failed to look didn't perceive at all and didn't react before the crash.

Driver functional failures
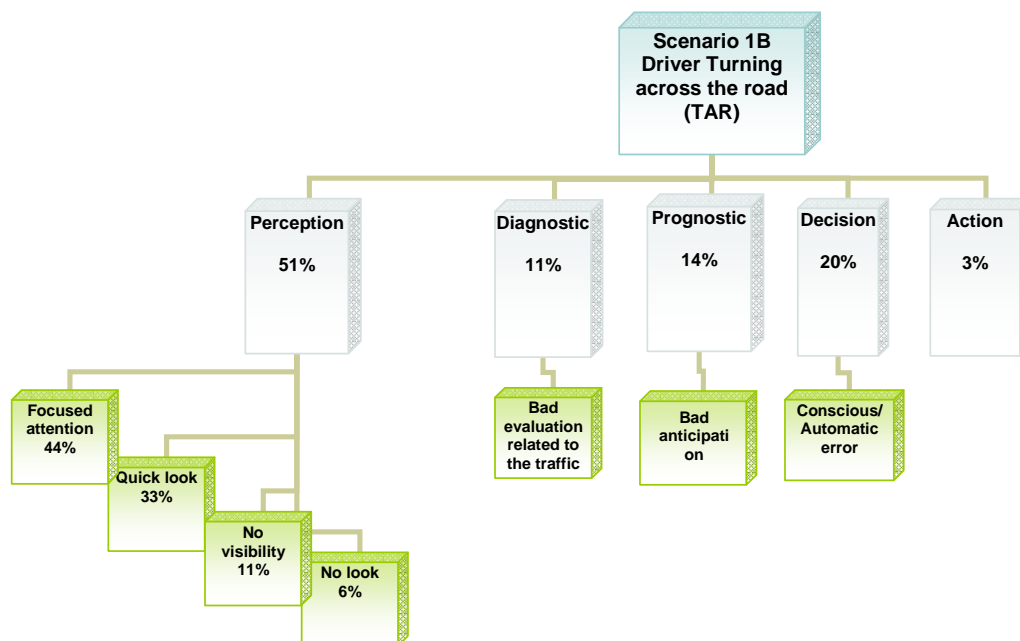
Figure 75: Identification of the functional failure of the drivers TAR involved in scenario 1B (source: TRACE sample)

Drivers who are turning left experience rather (51% of human functional failures in this scenario) a "perception failure". The perception failures can be explained by:
- focused attention (example : looked at the wished direction but not at oncoming traffic)
- quick look (example: turned left, rapid look at the traffic leading to a bad evaluation of the distances)
- no visibility (example : turned left while another vehicle masked the visibility)
- no look (example: stopped on a left-turn lane at traffic lights, pulled off without any control)

Case by case analysis shows that associated with perception failures is the emergency reaction:
- 3/5 didn't react
- 2/5 braked or accelerated

20% of HFF are related to the "decision". For example, a driver wanting to turn left decided to overtake a vehicle and to turn left at the same time.

Case by case analysis shows that these drivers didn't react before the crash.

Explanatory elements explaining the HFF

Human Functional Failures, HFF, are explained with the explanatory elements that are classified according to the relation to the driver. In this way, there are endogenous and exogenous elements. Endogenous elements are related to the driver and his driving task while the exogenous elements are related to the vehicle, the road and the environment.

70% of explanatory elements are endogenous, it means they are related to the driver.
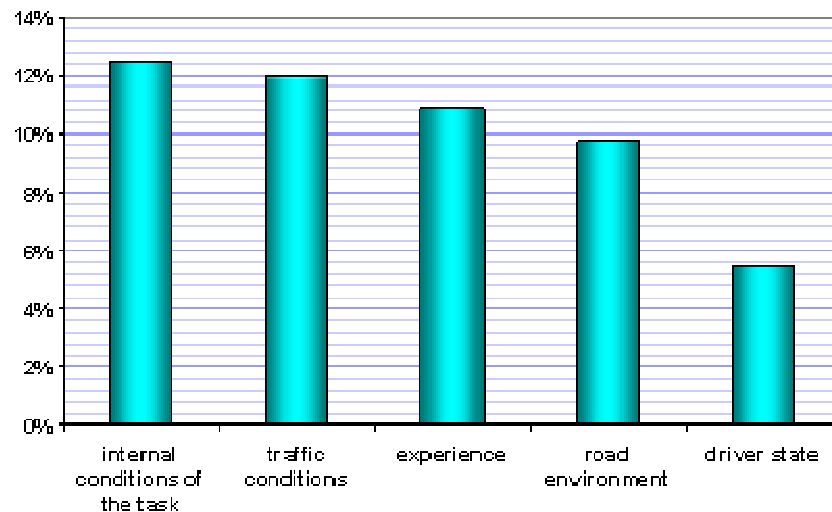
Figure 76: Explanatory elements according to the driver TAR in scenario 1B (Source: TRACE sample)

Endogenous explanatory elements that explain the HFF in this scenario are:
- Internal conditions of the task (examples: excessive speed, navigation, risk identification but wrong evaluation).
- Experience (example: bad estimation of the traffic lights regulation)
- Driver state (example : driver age (70+), alcohol)

Exogenous explanatory elements that explain the HFF in this scenario are mainly related to the traffic conditions (example: turned left while a vehicle is masking the visibility).

Endogenous and exogenous explanatory elements are detailed in the figures below.

Internal conditions		
Right of way feeling	11	26,8%
Identification of a potential risk	10	24,4%
Risky driving	9	22,0%
Navigation problem and lane position	5	12,2%
Global time constraint	2	4,9%
Inadapted speed	2	4,9%
Others internal conditions	2	4,9%
Total	**41**	100%

Table 18: Explanatory elements related to internal conditions of the task - drivers TAR in scenario 1B (Source: TRACE sample, n=41)

Regarding problems linked to the internal condition, the drivers who are turning across the road (TAR) present mainly:
- Right of way feeling (didn't search the information because of the right of way)

- Identification of a potential risk on the base of wrong information (misinterpretation of the situation)
- Risky driving
- Navigation (attention focused on the navigation)

Experience		
Automatic driving	12	63,2%
Low experience of driving	3	15,8%
Site not known	2	10,5%
Experience of a site in its previous confi	1	5,3%
Low experience of the vehicle handling	1	5,3%
Total	**19**	100,0%

Table 19: Explanatory elements related to the driver experience – drivers TAR in scenario 1B
(Source: TRACE sample, n=19)

Considering experience problems, the drivers who are turning across the road (TAR) present:
- "automatic driving" : too much experience of the trip, didn't pay attention to the oncoming traffic.
- low experience of driving or of the site or of the vehicle

Traffic conditions		
Temporal inconvenience for visibility	13	72,2%
Situational pressure	2	11,1%
Difficulty in finding a gap	1	5,6%
Ambiguity or Absence of clues	1	5,6%
Being dragged	1	5,6%
Total	**18**	100,0%

Table 20: Explanatory elements related to the traffic conditions – drivers TAR in scenario 1B
(Source: TRACE sample, n=18)

Regarding problems related to the traffic conditions, the drivers who are turning across the road (TAR) present mainly a temporal inconvenience for visibility (moving vehicle masking the oncoming traffic)

The emergency reaction
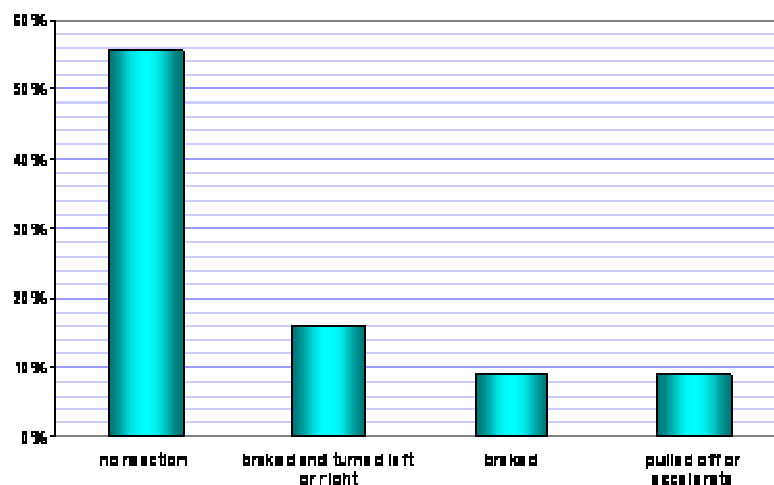
In order to adapt countermeasures to the driver needs, let us analyze their emergency reaction.

Figure 77: Distribution of the "Emergency reaction" related to the drivers TAR in scenario 1B
(Source: TRACE sample, n=157)

The results show that 3/5 of drivers turning left did not react before the crash.

For these drivers (no reaction), the case by case analysis (in-depth LAB database) shows that:
- ½ failed to look because of:
  - Excessive speed of the other vehicle, no time to react.
  - Illegal manoeuvre of the other vehicle, astonished, no time to react.
- ½ performed a poor evaluation or had focused their attention on navigation such as:
  - Dazzling sun, the driver didn't see the traffic lights, risk taking.
  - Navigation, attention focused on the mistake.

The results shows also, that 2/5 of the drivers TAR braked and swerved (¾ braked and ¼ braked and swerved). The case by case analysis (in-depth LAB database) shows that the main causes for the drivers who braked before the crash are:
- failed to look
- were inattentive
- misinterpreted the situation
- performed a poor evaluation
- performed a non driving task

In fact, they react but late. Their attention is focused on the driving task (turning left). When they see the oncoming driver, the reaction is too close to the eventual crash point. These drivers needs information before performing their manoeuvre.

The initial speed
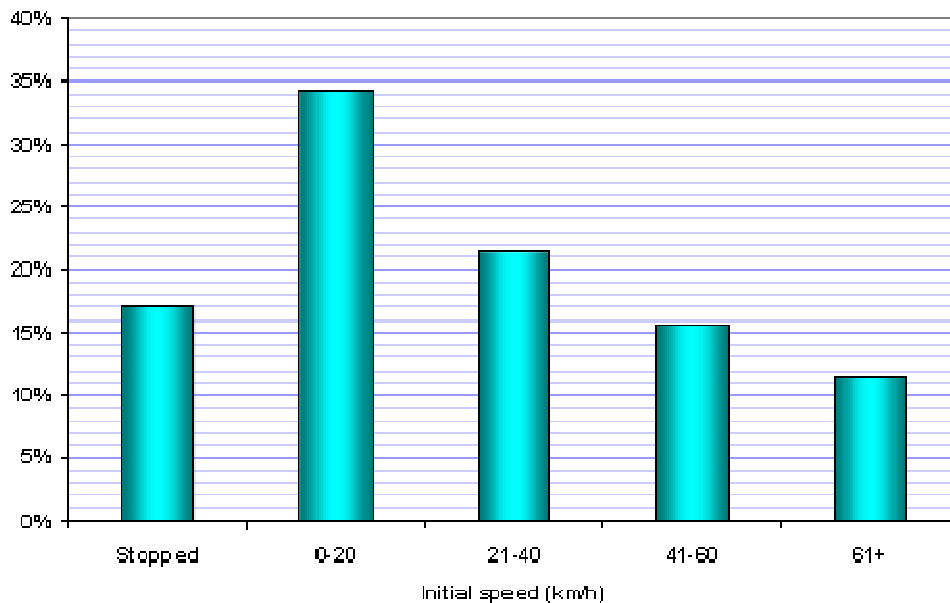
Figure 78: Distribution of the Initial speed estimated for the drivers TAR in scenario 1B
(Source: TRACE sample, n=70)

Most of the drivers turning across the road (TAR) did not stop before turning (8/10) because of:
- intersection regulation (yield, green traffic lights or no sign) encouraging them to take the information prior to the intersection and continue without stopping.
- visibility mask – risk taking. Drivers did not see or notice vehicles but estimated that they having time to perform their manoeuvre.

Case by case analysis (in-depth LAB database) shows that:
- Drivers who were stopped before they turned left across the road didn't react before the crash. They realized their manoeuvre being confident to make it safely.
- Among the drivers who didn't stop before performing their manoeuvre, ¾ of them braked and ¼ didn't react because they didn't see the danger.

The driver age
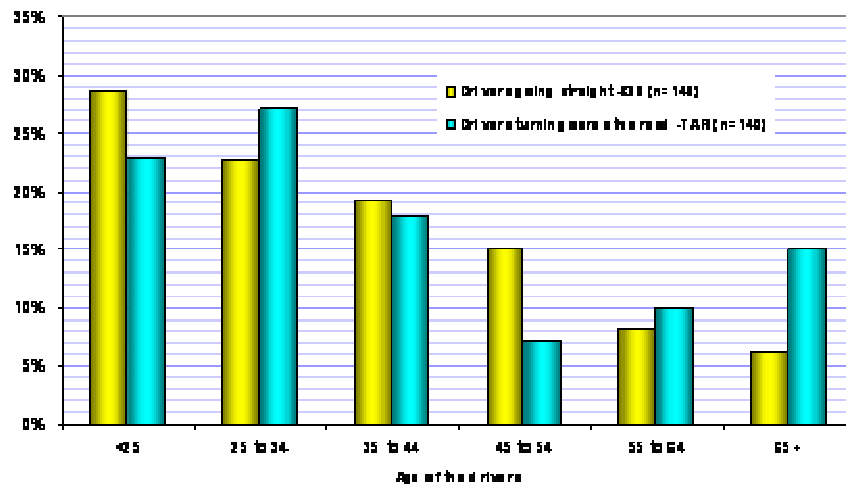
Figure 79: Distribution of the driver age according to the realized manoeuvre in scenario 1B
(Source: TRACE sample, n=286)

The literature review recalled that older drivers are more likely involved in turning manoeuvre. We see above that older drivers (65+) involved in the scenario 1B are rather those who are turning left onto the road. The case by case analysis (in-depth LAB database) shows that drivers 65+ (most of them are rather 70+ up to 92!) who are turning left sustained visibility problems (dazzling sun) leading to a poor evaluation of the distances or the relative speeds, or focused attention at traffic but not at the oncoming traffic, or navigation problems (lost). The feeling of the situations involving older drivers (and even drivers 70+ up to 92 years in LAB sample) is the confusion in the achievement of the driving task.

The main results regarding the driver turning across the road (TAR) involved in Scenario 1B are the following:

Key events are mainly endogenous events (related to the driver):
- Related to the "internal conditions of the task". The main factors are related to the incorrect driving manoeuvre, poor evaluation, or misinterpretation of the driving situation.
- Related to the "driver behaviour". The main factor is "failed to look" because of excessive speed of the other vehicle/Moving mask/Luminosity/Focused attention. Drivers who failed to look didn't react before the crash.

The HFF are mainly perception failures such as focused attention, quick look, no visibility or no look. Associated with perception failures is the emergency reaction, 3/5 of the drivers didn't react and 2/5 braked or accelerated.

Explanatory elements in the whole are mainly
- endogenous elements (related to the driver). The main factors are internal conditions of the task (such as "right of way" feeling, misinterpretation of the situation, risky driving or navigation), or the driving experience (such as automatic driving or low experience) or linked to the driver state.
- And exogenous elements. The main factor is linked to the traffic conditions and especially visibility problems. 3/5 of drivers turning left across the road didn't react because of failed to look, or made a poor evaluation, or they had focused attention or they had some navigation problem.

Regarding the emergency reaction, 3/5 of the drivers didn't react before the crash and 2/5 braked and swerved to avoid the crash.

Regarding the driver age. Among older drivers (65+) those who are turning left are well represented because they had visibility problems, focused attention, or some navigation problems.

B) Drivers going straight (GS)

The driving task of the drivers going straight

The driver going straight is driving in "normal conditions" that is to say he has not to perform a driving manoeuvre. He is confronted to an oncoming driver who is crossing his velocity direction.

Key events

Accident occurrence is the result of different related causes affected to the systemic model Driver/Vehicle/Environment. Key events are the events that explain the rupture between the driving phase and the emergency phase.

Internal conditions

Incorrect driving manoeuvre	20	58.8%
Misinterpreted the driving situation	9	26.5%
Excessive need	3	8.8%
Poor evaluation	2	5.9%
Total	34	100.0%

Driver behaviour

Failed to look	13	81.3%
Inattention	2	12.5%
Distraction	1	6.3%
Total	16	100.0%
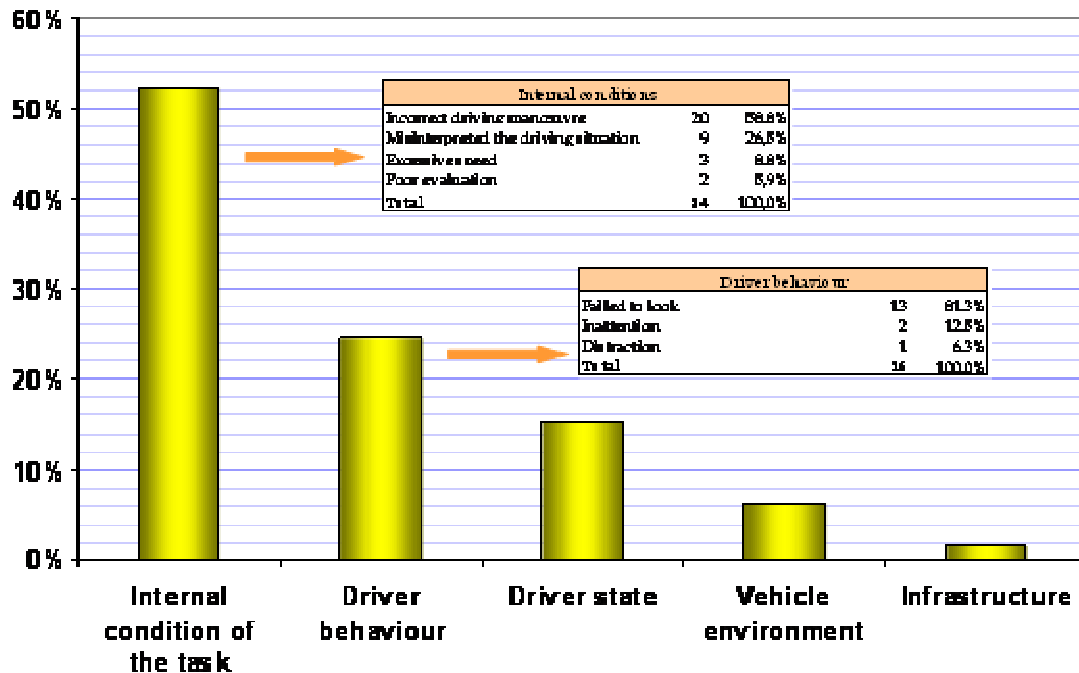
Figure 80: Distribution of the Key events related to the drivers going straight (GS) in scenario 1B (Source: TRACE sample, n=65)

Most key events related to the driver going straight are endogenous (related to the driver):
- Internal conditions of the task (excessive speed, poor experience)
- Driver behaviour (failed to look because of a strong feeling of right of way or didn't look while the dazzling sun masked the traffic lights colour)
- Driver state (illness, fatigue)

Human Functional failures

Half drivers going straight experience rather:
- perception failures
  - no visibility (dazzling sun masking the opponent vehicle or the intersection regulation)
  - focused attention
  - quick look (right of way feeling)
  - no look (no look at the intersection regulation)
- and prognostic failures
  - waiting for regulation by the opponent driver.
  - waiting for no manoeuvre performed by the opponent driver.
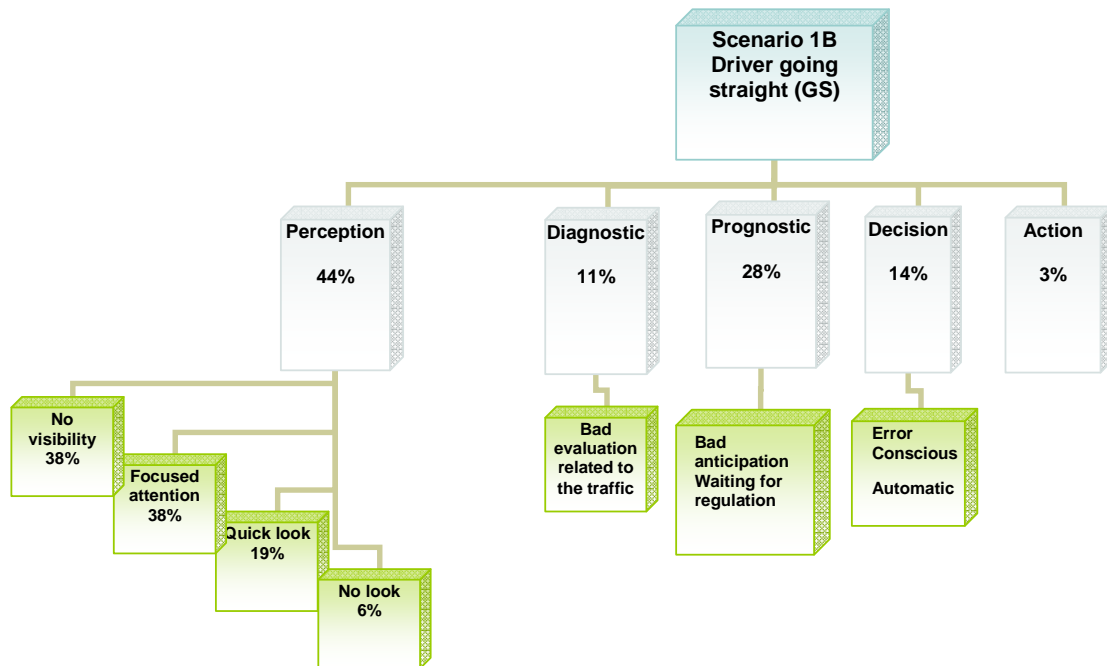
Figure 81: Identification of the functional failure of the drivers GS involved in scenario 1B (source: TRACE sample)

Emergency reaction
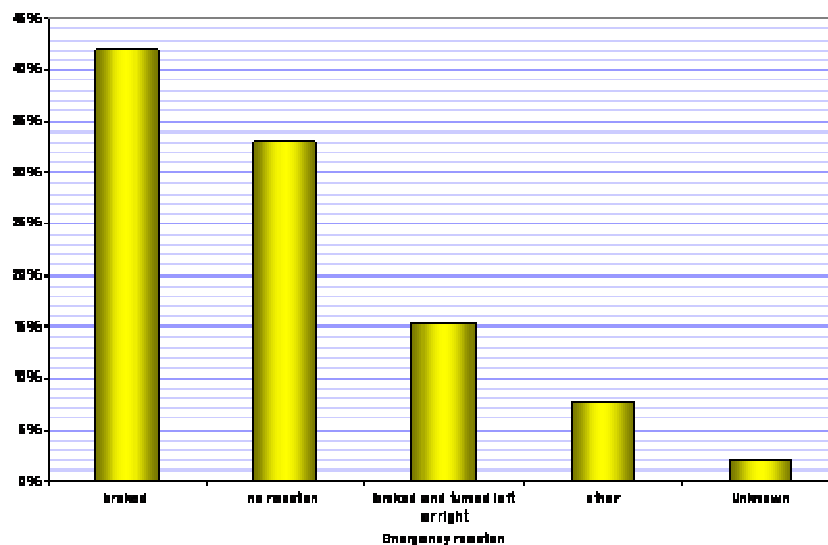
Figure 82: Distribution of the emergency reaction realized by the drivers going straight (GS) in scenario 1B (Source: TRACE sample, n=157)

3/5 of drivers going straight confronted to a vehicle turning left across the road, braked before the crash. Case by case analysis (in-depth LAB sample) shows that most of them (9/10) perceived but sustained problems to perform:

- the diagnostic (saw the other driver but misinterpreted his manoeuvre)
- and the prognostic of the situation (saw a vehicle stopped and supposed the other driver saw him).

2/5 of drivers going straight confronted to a vehicle turning left across the road didn't react because they had the "feeling of right of way", or due to an atypical manoeuvre performed by the other driver.

The main results regarding the driver going straight (GS) involved in Scenario 1B are the following:
The key events are mainly endogenous (related to driver) and concern mainly factors linked to the internal conditions of the task, or to the driver behaviour, or to the driver state.

The most important HFF are perception failures and prognostic failures (they thought that the opponent vehicle didn't cross in front of them).

Regarding the emergency reaction, 3/5 of these drivers braked before the crash, and 2/5 didn't react because of a strong feeling of right of way and an atypical manoeuvre performed by the other driver.

<u>SCENARIO 1B – MAIN CONCLUSIONS</u>

Despite most of key events are related to the driver turning left, both driver situations, turning left or going straight, are characterized by endogenous key events (related to the driver).
Drivers turning left endogenous events reflect
- the misunderstanding of the driver
- and the problem of perception of the other vehicle.

Drivers going straight endogenous events are related to:
- the excessive speed
- the poor experience
- the fact they failed to look

Human Functional Failures depends on the driving manoeuvre performed:
- Drivers who are turning left presented rather perception failures
- while the drivers who are going straight presented perception and prognostic failures.

Emergency reaction depends on the driving manoeuvre performed:
- Drivers turning left didn't react
- while the drivers going straight braked.

The problem related to the age of the driver is mainly present for older drivers having turning left.

<u>GENERIC COUNTERMEASURES</u>

Thinking about the best way to help the older drivers at intersection. Older drivers do need a regular training to learn the best way to perform manoeuvres especially at intersection. Other solution is to think about the environmental planning and the road layout to improve the legibility of the road.

Helping the driver having the right of way to anticipate the other driver manoeuvre.
These drivers need to be informed of the intentions of the other driver in order to be able to anticipate the situation even if they have the right of way.

7.2.3.*i*   Pedestrian scenario

Accident occurring at intersection
Involving a passenger car and a pedestrian

9% to 15% of intersection accident in Europe

10% to 25% of fatalities and serious injuries

For the accident causation analysis we decided to split the study be Remind that in Europe, 14% of the road fatalities were pedestrians in 2004, 11%in France, and 21% in UK. 67% of pedestrian fatalities occurred inside urban areas, 34% of pedestrian fatalities are aged 65+ and 45% are aged 0 to 24 (CARE 2006).

Driver age
Among passenger car drivers involved at intersection with a pedestrian, no age class is
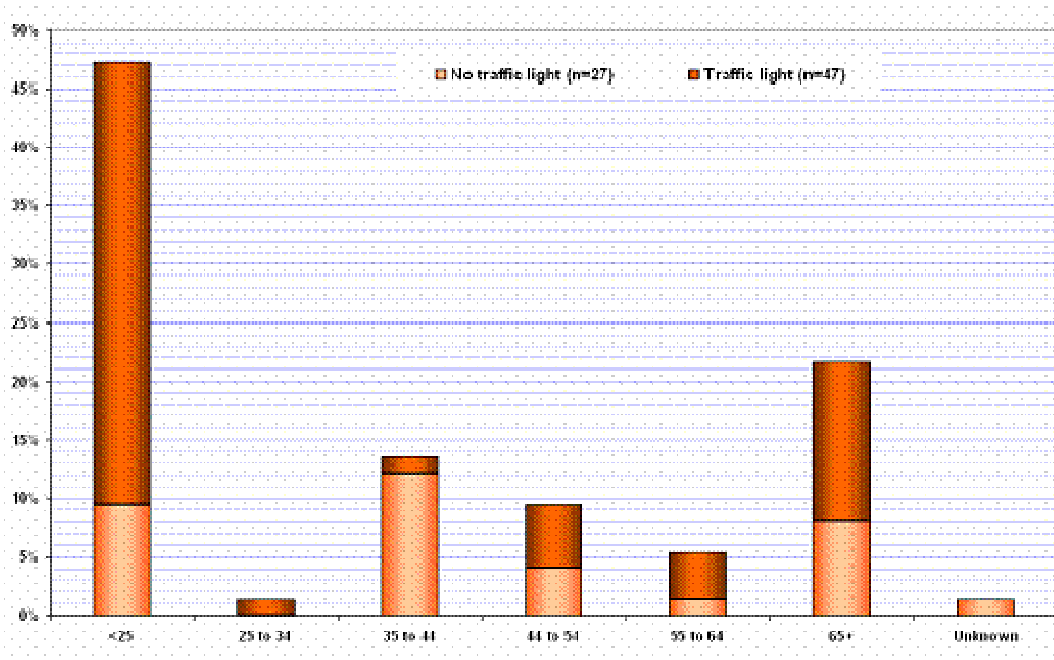
overrepresented.

Figure 83: Distribution of the pedestrian age following the intersection regulation
(Source: TRACE sample, n=74)

However, pedestrian are mostly involved at intersection with no regulation or traffic lights. In this configuration, youngest and eldest are overrepresented. Moreover, half of youngest are less 10 while half of eldest are 70+.

Key events

Distribution of the key events according to the passenger car or to the pedestrian. The chart contains the following embedded tables:

Related to the pedestrian		
Pedestrian: failed to look properly	45	37,2%
Pedestrian: careless, reckless or in a hurry	30	24,8%
Pedestrian: crossing road masked by stationary or parked vehicle	13	10,7%
Pedestrian: failed to judge vehicle's path or speed	10	8,3%
Pedestrian: wrong use of pedestrian crossing facility	10	8,3%
Pedestrian: impaired by alcohol	6	5,0%
Pedestrian: dangerous action in carriageway (e.g. playing)	4	3,3%
Pedestrian: wore dark clothing at night	3	2,5%
Total	**121**	**100%**

Internal conditions		
Failed to look	6	27,3%
Inconvenient behaviour of a user ahead	3	13,6%
Incorrect driving manoeuvre	2	9,1%
Automatic driving	2	9,1%
Excessive speed	2	9,1%
Identification of a potential risk	2	9,1%
Inappropriate speed	1	4,5%
Secondary task	1	4,5%
Difficulty in finding a gap	1	4,5%
Incorrect lane positioning	1	4,5%
Right of way feeling	1	4,5%
Total	**22**	**100%**

Legend: Pedestrian (n=138); Passenger car (n=44). X-axis categories: Related to the pedestrian; internal condition of the task; road environment; driver state; experience; driver behaviour.

Figure 84: Distribution of the key events according to the passenger car or to the pedestrian (Source: TRACE sample, n=182)

Most of time (9/10), the key event of the accident is related to the pedestrian. In second position behind the pedestrian causes, is "the internal conditions of the task" related to the passenger car.

In second position behind the pedestrian causes, is "the internal conditions of the task" related to the passenger car.

For both pedestrian and passenger car "failed to look properly" is the first causation factor. In fact the visibility problem related to this scenario is particular. The visibility is linked to the manner the pedestrian cross the road.

Half of the pedestrians are crossing at intersection with no regulation. But the half of them is crossing at traffic lights intersection! The literature review answered the question "Why do pedestrians tend to choose marked pedestrian crossings?" "Why are they less careful when they do so?" The studies that have been done indicate that pedestrians look before crossing at both marked and unmarked pedestrian crossings, except at signalized intersections. We do have to investigate more to understand the crossing strategy and the related causes.

Half of intersection accidents involving pedestrian in our sample occurred during the night and most of them inside urban area.

We suppose that in daylight the problem can be linked to the different traffic flows, the urban environment, and the "visual pollution". The literature review highlighted that when volumes are higher than 12 000 ADT, marked pedestrian crossings on multi-lane roads were more prone to crashes than unmarked locations, and the risk goes up as the volume rises.

During the night, the problem is different. We know that factors such as contrast related to the vehicle colour and lights and to the pedestrian clothes appear to have an effect on the conspicuity of both users.

Emergency reaction
In spite of the fact that 60% of passenger car drivers braked before the crash, 40% of them didn't react! In fact 9 pedestrian accidents out of 10 engaged the pedestrian fault and could explain the lack of reaction. The survey sample doesn't allow us to know how the passenger car driver braked and when he started his emergency manoeuvre. We need to know accurately this information in order to appreciate if the problem is related to the perception or the manoeuvre itself. The counter-measures are obviously different. A further in-depth investigation on the scene is necessary.

Figure 85: Distribution of the emergency reaction of the driver confronted to a pedestrian at intersection (Source: TRACE sample)

Initial speed

All intersection accidents involving a pedestrian occurred when the initial speed of the passenger car was lower than 60 km/h. For half of them, the initial speed was lower than 40 km/h.

Passive safety survey (ref LAB) performed on pedestrian accidents shows that when the impact speed is raised from 45 km/h to 55 km/h that is to say "only" 10 km/h, the fatal risk (the risk to sustained fatal injuries) is raised as well from 30% to 50%!
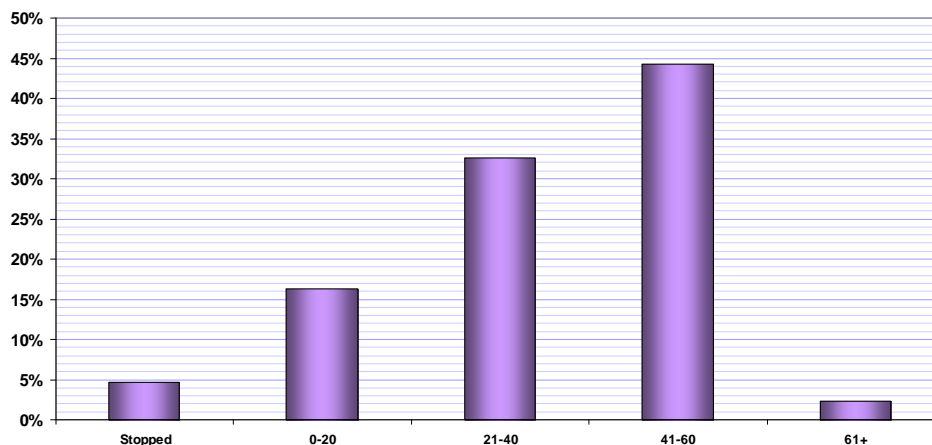
Figure 86: Distribution of the initial speed in injury accident at intersection with pedestrian (Source: TRACE sample, n=43)

PEDESTRIAN SCENARIO – MAIN CONCLUSIONS

Despite the lack of information, we know that:
- Pedestrian are mostly involved at intersection with no regulation or traffic lights.
- In this configuration, youngest and eldest are overrepresented.
- Most of time (9/10), the causation factor of the accident is related to the pedestrian.
- For both pedestrian and passenger car "failed to look properly" is the first causation factor.

GENERIC COUNTERMEASURES

Helping the passenger car driver to perform his emergency manoeuvre. The driver braked most of time (60%) but didn't avoid the crash. AFU can be useful and help the driver.

Helping the passenger car to prognostic the presence of a pedestrian, to see the pedestrian and to anticipate the avoidance.
Obstacle detection is required when the pedestrian is on the road but when pedestrian is previously masked the detection is more difficult. Navigation tools can be useful to inform the driver about a potential risk zone (pedestrian presence likelihood).

7.2.4   Risk factors

In road traffic, according to WHO World Health Organization, risk is a function of four elements:
- The exposure which reflects the amount of movement or travel by different users or a given population density
- The underlying probability of a crash
- The probability of injury, given a crash
- The outcome of injury

The factors influencing the crash involvement arises as rthe result of various factors:
- Endogenous (or related to the driver) such as the speed, the alcohol, the fatigue, the gender
- Or exogenous (related to the environment) such as the vehicle state, the road design, the visibility, the road surface.

7.2.4.a   **Definition**

Risk factors are defined as all imaginable things that increase the chance for an accident to occur. They are found by statistical analysis on a sample level by estimating risk measures describing the increase in risk for an accident. A causal contribution to accidents is not necessarily given.

Risk estimates for traffic accidents can refer to individual participants, to certain sub-populations of traffic participants, as well as to more specified accident types, and are published most often as relative risks.

In epidemiological survey, risk factors can be:
- Prevalence factors which refer to a population of users involved in accident vs the whole population of drivers or the whole population in a country.
- Incidence rate that is related to the evaluation of the data during a period defined.
- Relative risk that is useful to compare small population of users involved in accident (intersection) with a witness population (out off intersection).

In this part of the project we focused the risk analysis onto the risk related to the situation on the base of the in-depth data such as the key events (previously defined):
- We remind first the definition of the relative risk factor
- Then we compare the relative fatal risk at intersection vs out off intersection
- At last we compare the over-speeding population at intersection vs out off intersection.

Relative risk is used here because the outcome of interest has relatively low probability (ref WP7 advice).
Relative risk is defined as the ratio of the probability of the event occurring in the exposed group (intersection situations) versus the control (non-exposed) group (out off intersection).

This risk analysis was based on the in-depth LAB database.

Risk arises largely as a result of various factors such as factors related to the driver, the environment, the conditions of the traffic, the conditions of the road.

Among all these factors in-depth analysis highlighted factors that have a great impact on the occurrence of accident

- Road layout (at intersection/out off intersection)
- Speed (excessive speed)
- Visibility (longitudinal geometric visibility)
- Emergency reaction
- Human Functional Failures (perception)

We are going to evaluate the relative risk of these factors at intersection.

7.2.4.b   At intersection vs out off intersection

The aim of this chapter is to define if it is more dangerous to be involved at intersection rather out off intersection. In other words, when a user is involved at intersection, the collision type frontal-lateral (mainly represented in crossing path crashes) leads to severe injuries in the vehicle collided in lateral because of intrusion in the vehicle cabin. In the other hand, the more severe crash type out off intersection is the run off crash (the vehicle left the roadway) leading to crash to fixed obstacle and/or with rollover.

We are going to compare with the relative risk R_r, the risk to be killed at intersection R_i to the risk to be killed out off intersection R_{oi}:

Risk factor (risk to be killed) related to the intersection accidents (drivers having the right of way) is R_i = 0.06, while the risk factor related to the accidents out off intersection is R_{oi} = 0.046.

The relative risk R_r associated with the intersection is $R_r = R_i/R_{oi}$ = 1.304

The calculated Relative Risk shows that the probability to be killed when the user is involved in accident at intersection is higher than the probability to be killed when the user is involved out off intersection. Although this result is conform to the knowledge about the subject, this result is based on the LAB-in-depth database (France) and the sample is not big enough to conclude. More investigation and bigger database is required to be more accurate.

7.2.4.c   Excessive speed

According to WHO report on Road traffic injury Prevention, the speed of motor vehicles is at the core of the road injury problem. Speed influences both crash risk and crash consequence.

Excess speed is defined as a vehicle exceeding the relevant speed limits.

Inappropriate speed refers to a vehicle travelling at a speed unsuitable for the prevailing road and traffic conditions.

The National French accident observatory (ONISR) publishes every year a report gathering all information concerning accident data. In addition, is a speed observatory that records all type road user speeds along different type of roads. In 2004, the year we focused on through the descriptive analysis, 20% of the passenger cars were observed with an over-speed (+10km/h compared to the speed limit) and 1.5% with +30km/k.

ONISR France	2004	2005
+10km/h	20%	16%
+30km/h	1.5%	0.6%

Table 21: Over speed of the passenger car in 2004 and 2005 in France (Source: ONISR 2004)

Over-speed observed in France in 2004 and 2005 by ONISR shows an important decrease. This trend is generally observed since 2000 in France.

However, these average data were observed along the different type of roads.

Road type	Network	Speed limits	Overspeed
Motorway	20%	130 km/h	13 to 28%
Main roads	17%	90 to 110 km/h	20%
Urban area	28%	30 to 50 km/h	14 to 27%

Table 22: Over speed of the passenger car in 2004 according to the road type (Source: ONISR 2004)

So, on motorways (19.5% of the network observed; speed limits 130 km/h), the over-speeding represents 13 to 28%. On main roads and secondary roads (17.4% of the network observed; speed limits 90 to 110 km/h), the excess is 20% and in urban area (28.2% of the network observed; speed limits 30 to 50 km/h), 14 to 27%.

Over-speed is a causation factor directly related to the severity of the accidents. In 2006, ONISR evaluated the effect of the respect for the speed limits on the safety and predicted a positive effect with a decrease of 5km/h and 20% of fatalities.

In LAB-EDA database we have compared the calculated initial speed of the population of drivers having the right of way at intersection (most of them going straight on the main road) with the speed limit of the road. The same approach was performed for drivers involved out off intersection. Over speed +10km/h and +30km/h were observed.

LAB-EDA France 1997-2004	Intersection-driver having the right of way	Out off intersection
+10km/h	22%	28%
+30km/h	5%	9%

Table 23: Over speed of the passenger car (Source: LAB-in-depth database, France 1997-2004)

Over-speeding is rather observed out off intersection (all drivers) than at intersection (drivers having the right of way).

If we compare the risk to be killed or MAIS3+ in these two populations, the risk to be killed or MAIS3+at intersection is R_i= 0.23, while R_{io}, the risk to be killed or MAIS3+ out off intersection is R_{io} = 0.16.

The relative risk to be killed or MAIS3+ when the speed of the vehicle having the right of way is excessive at intersection is R_i/R_{io} = 1.44.

When users driving with excessive speed are involved at intersection accident, the risk to be killed or MAIS3+ is 1.44 higher than for users driving fast (excessive speed) out off intersection accidents.

Remind that excessive speed has several effects on the occurrence of the accident. On the driver "having the right of way" point of view, the excessive speed associated with a poor perception or a poor understanding of the situation leads to difficulties to perform a relevant emergency manoeuvre.

On the driver having not the right of way point of view, the excessive speed of the other driver reduces the available crossing time and reduces the chances to cross safely.

Reducing approach speed along the main road should help both drivers to look properly, understand the situation and let older drivers the opportunity to perform more safely their manoeuvre.

7.2.4.*d*   Longitudinal visibility

We compare here the probability to be involved at intersection vs the probability to be involved out off intersection when the geometrical visibility is reduced.

Available geometrical visibility at intersection gives the available stopping distance for the user driving on the main road (having the right of way). Remind that the stopping distance is the distance required to stop before the crash. It includes the distance covered during the reaction time, the time to move the foot, the time to the braking system to be operational and the time to stop. At 50km/h the driver needs 35 m to stop his vehicle (reaction time 1s and braking efficiency 0.5s). At 90km/h the driver needs 82 m to stop his vehicle.

Ri is the risk to be involved at intersection when the longitudinal visibility is reduced. Ri=0.017

Out off intersection, longitudinal visibility is defined according to the masks, the road layout (straight roads or bends). The risk to be involved out off intersection when the longitudinal visibility is reduced is Roi=0.79.

The relative risk to be involved at intersection vs out off intersection when the longitudinal visibility is reduced is given by Rr = Ri/Roi = 0.215

The relative risk to be involved at intersection vs out off intersection when the longitudinal visibility is reduced is 0.215. So, it is more likely probable (4 times) to be involved out off intersection when the geometrical visibility is reduced than at intersection.

7.2.4.*e*   Emergency reaction

We compare here the probability to perform an emergency manoeuvre at intersection vs out off intersection.

Emergency reaction is the manoeuvre performed by the driver before the crash. The assumption here is to say that if the driver has performed the manoeuvre, either the manoeuvre itself was wrong or the time (or the distance) required were not enough to avoid the crash. Comparing the probability to perform an emergency manoeuvre at intersection vs out off intersection let us evaluate the efficiency of manoeuvre assistance or braking assistance in avoiding the accident according to the accident type.

The risk to perform an emergency manoeuvre at intersection is Ri = 0.717.

The risk to perform an emergency manoeuvre out off intersection is Roi = 0.778

The relative risk to perform a manoeuvre at intersection is then given by : Rr = Ri/Roi = 0.92

So, the risk to perform an emergency manoeuvre is slightly higher out off intersection. This result is in accordance to the in-depth analysis that shows that a big proportion of drivers having or not the right of way didn't react before the crash.

7.2.4.*f*   Functional failures

In-depth analysis shows that the common human functional failure to the drivers having or not the right of way is the Perception. We focus this risk analysis on perception failures.

Perception can be quick, disturbed with mask, not performed at all, or focused.

We compare the probability to have a perception problem at intersection for drivers having the right of way vs out off intersection for all drivers.

The risk to have a perception failure when involved at intersection is Ri = 0.367

The risk to have a perception failure when involved out off intersection is Roi = 0.263.

The relative risk to have a perception failure when involved at intersection is then given by Rr = Ri/Roi = 1.395.

So, the risk to have a problem of perception at intersection is 1.4 higher than out off intersection.

In-depth analysis shows that perception failures related to the driver having the right of way find explanation mainly with endogenous parameters (related to the driver) that are essentially a right of way feeling, an inappropriate speed, a non driving task and a misunderstanding of the situation.

7.2.4.*g*   Main relative risk factors

The probability to be killed when the user is involved in accident at intersection is higher than the probability to be killed when the user is involved out off intersection (1.3).

When users driving with excessive speed are involved at intersection accident, the risk to be killed or MAIS3+ is 1.44 higher than for users driving fast (excessive speed) out off intersection accidents.

It is more likely probable (4 times) to be involved out off intersection when the geometrical visibility is reduced than at intersection.

The risk to perform an emergency manoeuvre is slightly higher out off intersection.

The risk to have a problem of perception at intersection is 1.4 higher than out off intersection.

7.3 Conclusions

The main objectives of TRACE project were to:
- Identify and quantify accident causation factors associated to particular types of driving and pre-accidental situations, at a statistical level, by analyzing various available databases in Europe.
- Obtain a focus understanding of accident causation issues related to these types of situations at an in-depth level by analyzing data from available in-depth databases.
- Identify the level of risk associated to these selected types of situation in generating accidents.

The task 2.2 (related to intersection situations) analyzed the causation of traffic accidents at intersections. A statistical and an in-depth analysis provided the task with an overview of the conditions under which accidents at crossings and intersections occur.

The main issues of the intersection accidents are:

In-depth analysis of the intersection accident scenarios highlighted that we have to consider the scenario as a combination of two situations related to the driver "having the right of way" confronted to the driver "having not the right of way". This point of view is very important to infer the best countermeasure related to each requirement.

Endogenous factors, related to the driver are well present. They are either related directly to the driver behaviour with the driving speed or related to the conditions of the task with a poor evaluation or a poor understanding of the situation.

Perception failures are common in both groups. This functional failure finds explanation with endogenous factors such as "right of way feeling" for the driver "having the right of way" but also in the case of the driver "having not the right of way" with the "sight distance", it is to say the available lateral geometrical distance along the main road. This last result leads to question the intersection design of future roads.

Drivers having the right of way performed more often an emergency reaction to avoid the crash. That is to say that the countermeasures recommended to these drivers could be helping the driver to perform earlier the emergency manoeuvre and helping the vehicle to be more efficient.

As regards to the risk factors, the probability to be killed when the user is involved in accident at intersection is higher than the probability to be killed when the user is involved out off intersection (1.3). Moreover, when users driving with excessive speed are involved at intersection accident, the risk to be killed or MAIS3+ is 1.44 higher than for users driving fast (excessive speed) out off intersection accidents.

Perspectives

In term of analysis, we need to identify the countermeasures able to help the driver to avoid the accident or at least to mitigate it and to identify the accident mechanisms related to the vulnerable users at intersection.

And finally, all along the survey we were confronted to problems related to the compatibility of the data. Obviously each data owner, whatever sources National data or in-depth data, has got his own objectives and his own constraints. Data are so collected in different way and with different aims. Moreover, data definitions are different between countries and between research teams. One challenge is to reach a common methodology and common data collection in Europe.

8   Degradation situations

One of the main objectives of TRACE is to identify factors that contribute to the occurrence of road accidents across Europe. Some of these factors such as speed, inattention, and alcohol consumption are endogenous to the driver. Others are exogenous, relating either to the vehicle (for example tyres or brakes), or to the road and the environment.

TRACE Work Package 2 investigates situations experienced by drivers immediately prior to a collision taking place. These situations have been classed as "stabilized traffic", "intersection", "specific manoeuvres" and "degradation". In Task 2.4, 'degraded' accident situations were defined as being those which occur during sudden or temporary unfavourable conditions, leading to poor visibility of the road ahead, or poor control of the vehicle (either through physical obstructions or poor surface conditions). Degradation scenarios are the subject of work package 2, task 4, and are described in detail within this report.

As defined in TRACE Deliverable 2.1 (Types of Situations: Preliminary Report), factors that degrade the road or the environment, giving rise to accident occurrence include:
- Night time and lighting issues;
- Weather conditions affecting visibility and speed leading to a potential for loss of control (e.g. fog, heavy rain, strong wind)
- Road surface conditions (e.g. wet road, ice, contaminants on surface, defective surfaces)
- Physical obstructions or hazards in the road (e.g. vehicle loads, stray animals) or temporary/sudden obstructions to visibility in the road/roadside (e.g. parked vehicles. overhanging trees)

It is the first objective of this report to provide an overview of the descriptive analysis to identify the prevalence of these different altered situations in accidents and their typical characteristics. In order to do this, this study will present an overview of relevant literature and also general statistics (national and European) about injury and fatal accidents corresponding to these situations. The results of both of the literature review and statistical overview have already been described in greater detail in the TRACE D2.1 Preliminary Report: Types of Situations'. Using the findings of this descriptive analysis, a more detailed analysis to identify typical accident scenarios when degradation is present is presented, also with a view to identifying and quantifying significant accident causation factors. This has been undertaken using in-depth accident data from available European countries which contain more detailed information about accident causation than the descriptive data. Risk factors associated to the degradation scenarios using relevant European exposure data related to degradation and other accident characteristics are also to be examined and compared with the previously analysed data where possible.

This part dedicated to the degradation situations is composed of 4 sections:

 The first one contains summaries of a general literature review for degradation scenarios (including published statistics), and an analysis of national descriptive data from seven European countries. The full report on these findings, including full definitions of the types of degradation included in this part of the study, can be found in the TRACE Deliverable 2.1 Preliminary Report: Types of Situations.

Section 2 starts by describing the approach to the comparative accident causation analysis of degradation data obtained from in-depth accident databases. Following on from this is a description of the results of the analysis, which aims to identify typical causes of accidents which occur during degraded conditions. Also included is a supplementary detailed case-by-case overview of specific degradation cases in the UK OTS database identified through the work, with the aim of investigating further the causes attributed to these accidents, using both traditional analysis methods and also, for a selection of cases, using the TRACE Work Package 5 methodology.

Section 3 contains a description of work carried out in an attempt to qualify the findings of previous sections to the real world by comparing degradation collision data with "exposure data" to try and identify high situations related to degradation.

Section 4 draws conclusions from TRACE Task 2.4.

8.1   Overview of Findings of Descriptive Analysis

8.1.1   Aims and Overview of Methodology

The aim of the descriptive analysis of accidents with degraded situations was to try and obtain, from available data, a general overview of the problem of degradation in accidents across Europe. To help undertake this, an initial literature review of relevant studies and published accident data was undertaken to identify previously well-researched 'problems' in degradation accidents, and also to identify relevant areas which have not previously been researched and could potentially be investigated further in this study.

Once this had been undertaken, an analysis of available descriptive accident data where degradation situations were present was undertaken. This analysis was initially undertaken using data available from the analyst's own country (STATS19 data from Great Britain) and then from this, similar data was requested from available TRACE databases across the rest of Europe. In total, 7 countries' data was analysed. Data regarding four main types of degradation were available for analysis, these being degraded lighting conditions, degraded weather conditions, degraded road surface conditions and hazards present on the road. Typical characteristics of accidents involving these four main types of degradation were identified from the data (e.g. characteristics of road users, vehicle type, accident type/location, type of manoeuvres) to try and determine typical accident situations when degradation is present.

The findings from this initial stage, which are summarised in this section of this report, form the basis of the detailed analysis which follows in later sections of this report. The full details of this descriptive analysis are reported in the TRACE Deliverables D2.1 'Preliminary Report: Degradation Scenarios'.

8.1.2   Literature Review

An extensive literature review was undertaken, of which a general overview of the results is given here (see TRACE D2.1 for full version). This revealed considerable published research regarding the effects of weather and lighting conditions on driver behaviour and accident risk, regarding both driver visibility and control. There was less work covering degraded road layout, maintenance or the presence of carriageway hazards, although investigation of UK OTS cases studies demonstrates that these issues are factors in some collisions.

The findings indicate that drivers slow down in bad weather (but not enough), that 25-30% of collisions take place in bad weather, and that accident risk on a wet road is 2.5 times that on a dry road A.D.Vos (1992). Simulation models show risk from cross winds is exacerbated in wet weather, and that wet roads, ice and snow have an impact of driver behaviour (Pauwelussen & Vos, 1991). Although exposure to fog is low, the risk of an accident proportionally is high, in particular because it was found that drivers do not slow down enough to compensate for the fog (Hawkins, 1988). Whilst these findings may be somewhat intuitive, it is important that research is found that backs up commonly held views.

In addition to studies found in the literature review, a number of studies were identified which gave an overview of accident data for both Great Britain and across Europe as a whole. Included in these studies was data regarding degraded road situations.

For example, the following conclusions were drawn from an analysis of published Great Britain national statistics (Road Casualties Great Britain 2004):

- Accidents in daylight are more likely to occur on dry roads, in hours of darkness there is increased likelihood of accidents on wet roads;

- Wet roads are the most common form of degraded road surface scenario;

- Accidents in daylight are more likely to involve fine weather, in hours of darkness there is increased likelihood of accidents involving fog, rain and snow;

- This implies that a combination of darkness with degraded road or weather conditions increases accident risk;

- Skidding accidents are more likely to occur during dry road conditions compared to wet road conditions (this may be because it is easier see skid marks in the dry but not in the wet), rather than it being because the risk is higher on dry roads than wet.
- Two wheeled vehicles and buses are more likely to skid during dry conditions than cars (this may be because large vehicles are more likely to leave skid marks).

Furthermore, Europe-wide studies looking at degradation accidents have found that 18% of accidents take place in poor weather, with 30% in hours of darkness (SafetyNet 2007).

In Great Britain, police "contributory factor" analysis reveals that road environment contributes to 15% of reported collisions. A slippery road was contributory in 10% cases, and going too fast for the conditions was contributory in 12% cases (Mosedale et al, 2004, Hickford & Hall, 2004, Robinson and Campbell, 2006).

It was decided from the results of the literature that it would be useful to not only further study those degradation types which were most commonly found to increase the risk of accidents (e.g. poor weather, lighting and surface conditions), but also to further investigate degradation types where no evidence was found of previous research (e.g. road maintenance, carriageway hazards), as from the brief overview of the OTS database undertaken, accidents involving these types of degradation do occur and often result in injuries to those involved.

8.1.3   Descriptive Data Analysis using European Data

As mentioned previously, the main aim of this descriptive analysis was to identify the scope of the problem of 'degradation' accidents and to indentify the typical characteristics of accidents involving degraded situations. Analysis was initially undertaken using data available from the analyst's own country (STATS19 data from Great Britain). This database contains the following variables relating to "degraded" situations:
- Weather conditions;
- Lighting conditions;
- Road surface conditions (inc defective road surface);
- Carriageway hazards (inc road works present)

Data was obtained from the year 2004 for car accidents involving at least one injured occupant, and the initial findings of this analysis was used as a basis to establish common factors relating to degraded accident scenarios. The sample of accidents from this year

Following on from this, similar data was requested from available TRACE databases from other countries in and beyond Europe. Data was obtained from the Czech Republic, France, Germany, Greece, Spain, and also from Australia. Data sample from the 7 countries ranged from just under 5,300 to 170,000 (car accidents involving at least one injured occupant). The data analysis involved taking the four previously defined degraded accident situations, and then comparing other explanatory variables associated with these situations in order to determine the typical characteristics of the degradation accidents. These "explanatory variables" included:
- Whether or not the vehicle was at a junction;
- The type of road, carriageway and speed limit each vehicle was on;
- The vehicle types;
- The vehicle manoeuvres;
- Whether or not the vehicle left the carriageway;
- Driver breath test results;
- Driver age and gender

The information from all seven countries was then collated and a series of "typical accident scenarios" were identified for each degradation type from the overall analysis. In addition GB KSI[21] data was analysed and compared with the international findings. Unfortunately it was not possible to make

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[21] KSI = Killed and Seriously Injured (i.e. the number or proportion of accidents where at least one occupant was killed or seriously injured compared with the number of all accidents 'injury' accidents (fatal, serious and slight).

estimates for the whole of EU27 using the data from the 7 countries analysed, because in order to be able to use correction factors techniques made available by WP7 to estimate figures for EU27, certain additional exposure data would be required to make these estimations. A search for this additional data was made, but the relevant information was not found.

8.1.3.a   Degradation in general

Degraded situations were found in at least 40% of the car accidents (involving at least one injury) analysed from 6 of the 7 countries. In the German data, overall degradation numbers were not available. However, at least 35% of their cases from 2004 were found to occur on degraded road surfaces (and 28% during degraded lighting), so it could be said that at least 35% of Germany's accidents occurred during degraded conditions.
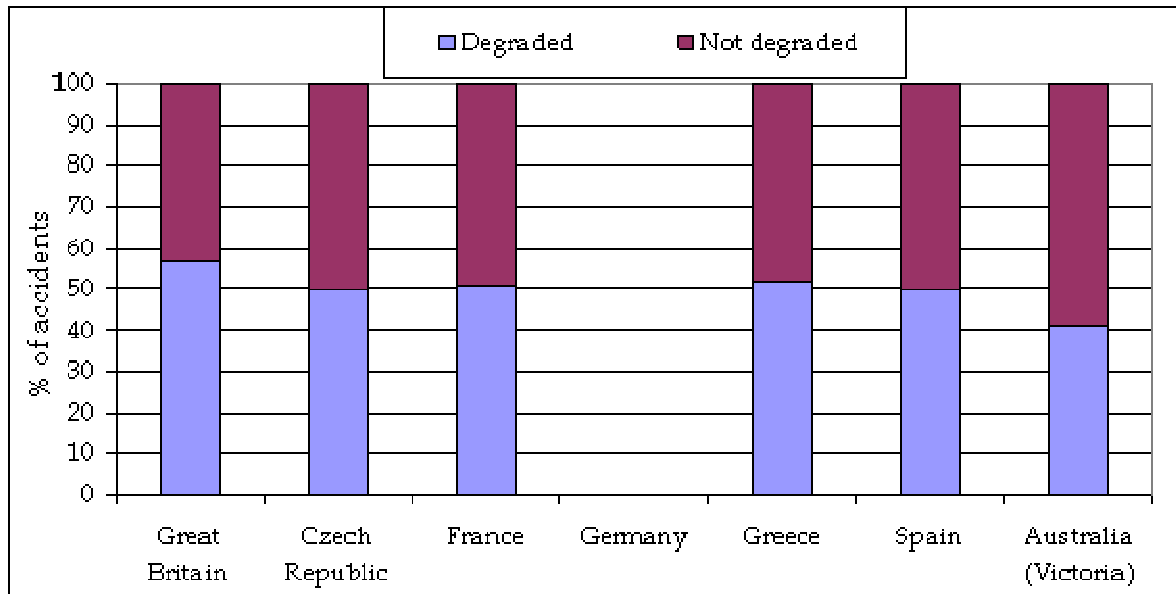
Figure 87: Prevalence of at least one type of degraded situation in accidents across Europe and Australia

8.1.3.b   Degraded lighting accident scenarios

For the 7 countries involved in the analysis, the proportion of accidents occurring in degraded lighting ranged from 27% to 41% of all injury accidents involving cars.

From the analysis undertaken, typical degraded scenarios for accidents in degraded lighting were found to involve:

- Single car collisions
- Car or mopeds
- Positive breath test
- Drivers under age of 25
- Male drivers

From the additional analysis of KSI data involving Great Britain data only, it was shown that the risk of KSI collisions is greatest when the degraded lighting condition was unlit at night, and when the following characteristics were present: car versus pedestrian collisions, collisions away from junctions, collisions on single carriageways, collisions on roads with high speed limits, collisions involving powered two-wheelers, collisions involving U-turns, collisions involving loss of control and leaving the carriageway, collisions with a positive breath test, collisions involving young drivers under 20 or older drivers over 70, and collisions involving male drivers.

8.1.3.c Degraded weather accident scenarios

For the 6 countries involved in the analysis (no data available for Germany), the proportion of accidents occurring in degraded weather ranged from 16% to 22% of all injury accidents involving cars. From the analysis undertaken, typical degraded scenarios for accidents in degraded weather were found to involve:

- Single car collisions
- Away from junctions
- Non-urban roads
- Passenger cars, goods vehicles or minibuses

From the additional analysis of KSI data involving Great Britain data only, it was shown that the risk of KSI collisions is greatest when the degraded weather was fog or mist, or high winds (with snow), and when the following characteristics were present: car versus pedestrian collisions, collisions away from junctions, collisions on single carriageways, collisions on roads with speed limits over 40mph, collisions involving powered two-wheelers, collisions involving U-turns or reversing, collisions involving loss of control and leaving the carriageway, collisions with a positive breath test, collisions involving young drivers under 25 or older drivers over 70, and collisions involving male drivers.

8.1.3.d Degraded road surface accident scenarios

For the 7 countries involved in the analysis, the proportion of accidents occurring on degraded road surfaces ranged from 16% to 40% of all injury accidents involving cars.

From the analysis undertaken, typical degraded scenarios for accidents on degraded road surfaces were found to involve:

- Single car collisions (except Greece)
- Away from junctions
- Cars and goods vehicles
- Negative breath test (except Australia)
- Wet/damp most frequent degraded scenario

From the additional analysis of KSI data involving Great Britain data only, it was shown that the risk of KSI collisions is greatest when the degraded road surface was oil or diesel, or "defective" road surface, and when the following characteristics were present: car versus pedestrian collisions, collisions away from junctions, collisions on rural roads and motorways, collisions on roads with speed limits at least 60mph, collisions involving powered two-wheelers and goods vehicles, collisions involving loss of control and leaving the carriageway, collisions with a positive breath test, collisions involving older drivers over 70, and collisions involving male drivers.

8.1.3.e Carriageway hazard accident scenarios

(Data available for GB, Greece, Spain, Australia)

For the 4 countries involved in the analysis, the proportion of accidents occurring when carriageway hazards were present ranged from 1% to 4% of all injury accidents involving cars, although most databases only had information about some, not all types of carriageway hazards.

From the analysis undertaken, typical degraded scenarios for accidents when carriageway hazards were present were found to involve:

- Single car accidents
- Away from junctions
- Rural roads or motorways
- High speed roads over 90kph speed limit

From the additional analysis of KSI data involving Great Britain data only, it was shown that the risk of KSI collisions is greatest when the hazard was an animal, previous accident, or "other" object, and when the following characteristics were present: car versus pedestrian/ motor cycle/ pedal cycle collisions, collisions away from junctions, collisions on single carriageways, collisions on roads with speed limits over 60mph, collisions involving powered two-wheelers, collisions involving loss of control and leaving the carriageway, collisions with a positive breath test, collisions involving young drivers under 20, and collisions involving male drivers.

8.1.4   Summary of Analysis

The literature review highlighted the degraded road conditions that not only occur in road accidents, but also appear to increase the risk of accidents occurring. Degraded weather and lighting were important factors in terms of driver visibility and control. Wet roads were significant, but fog, wind and wet weather spray, although occurring less frequently, were also seen to increase risk.

Although not identified in the literature search, visual obstructions, road surface defects, and obstacle hazards in the carriageway were identified as risk factors from cases studies within the UK OTS database.

Published studies that analysed accident data revealed accident risk with degraded road surface or weather was exacerbated in hours of darkness.

A series of independent national accident databases were then compared, although consistent comparison is difficult due to variations in reporting levels, definitions of accident severity etc. From these studies, degradation was found to be present in at least 50% of all car crashes in six of the seven countries studied. Degraded lighting (particularly darkness) and degraded road surface conditions (particularly wet road) were most frequent. The most frequent carriageway hazard varied across counties studied.

Higher killed and serious injury (KSI) rates were associated with unlit darkness, fog and high winds.

Following the analysis, the following potential characteristics of typical degradation scenarios were identified:

- A typical degraded lighting accident scenario occurs during unlit darkness and includes an emphasis on single car or moped accidents, non-manoeuvres, positive breath tests, young drivers and male drivers. Severity risk increases under unlit darkness;

- A typical degraded weather accident scenario occurs during rain and includes an emphasis on single car or good vehicle accidents, non-manoeuvres, non-junctions, and non urban roads. Severity risk increases under fog/mist or high winds;

- A typical degraded road surface accident scenario occurs during wet/damp conditions and includes an emphasis on single car or goods vehicle accidents, negative breath tests, non-junctions, and non urban roads;

- A typical "carriageway hazard" accident scenario includes an emphasis on large vehicles, minibuses or motor-cycles, non-junctions, non urban roads, and negative breath tests.

The detailed investigations in the following sections of this report will focus on these more 'typical' characteristics of the degraded scenarios. With that in mind, Table 24 below shows the typical accident characteristics for each of the 4 main types of degradation which were identified in the descriptive analysis and were investigated in more detail in the in-depth analysis to try and identify why these specific types of characteristics appear to have a stronger link with degraded accident situations than others.

Accident characteristic	Degradation type (as a contributory factor)			
	Lighting	Weather	Road surface	Carriageway hazard present
Single car accident	Y	Y	Y	Y
Non-intersection		Y	Y	Y
Non-urban roads		Y	Y	Y
Cars	Y	Y	Y	
Good vehicles		Y	Y	
Mopeds	Y			
Non-manoeuvre	Y	Y		
Driver – positive alcohol test	Y			
Driver – negative alcohol test			Y	
Driver <25 years old	Y			
Male drivers	Y			

Table 24: Accident characteristics identified in the descriptive analysis which are to be investigated further in in-depth analysis of degradation accidents

This table lists the main accident characteristics in the left hand column, and the four degradation scenarios in the top row. A "Y" in the body of the table demonstrates an emphasis on that characteristic for a particular degradation scenario, as described from the analysis carried out from the descriptive data. It was decided that, similar to other analyses being undertaken in TRACE, the following in-depth analysis would focus on passenger cars. Therefore specific analysis involving mopeds and goods vehicles would not be included.

8.2 In-depth Analysis (Accident Causation)

The objective of this part of the study is to look for strong evidence for accident causation in the typical degraded scenarios of lighting, weather conditions, road surface characteristics and presence of carriageway hazards. These causes may be human factors, environmental factors or vehicle factors.

Thus far descriptive data has been used to establish the most common characteristics of degradation accidents, and to establish the presence of accident characteristics prevalent in common degraded scenarios.

The next stage of this study concentrated on further investigation of those accidents where degraded conditions were present and identify the main causes. Detailed accident causation databases were selected as the best source of data, as in each case, more detailed accident causation information is collected than for accidents within the descriptive databases.

The approach taken to start with was to determine whether by using the detailed accident database that was already available to the analyst (the UK OTS database), it was possible to determine in more detail the main causes of degradation accidents when the characteristics described in Table 24 were also present. Once it was established that this was possible, a data request was developed and distributed via TRACE Work Package 8 to partners who had available to them their country's in-depth accident databases to determine whether their databases could deliver similar data.

Comparisons between the data were made, in order to draw any pan-European inferences. In the main, this data displays the presence of certain accident characteristics within the degraded accident scenarios.

Finally, a further in-depth study was made of a number of UK OTS accident cases displaying degraded scenarios and the 'typical' accident characteristics outlined in Table 24. In this data the research would attempt to establish in these 'typical' circumstance the other causes of accidents when degradation was a cause. The objective of this part of the work will be to confirm previous findings and establish any new issues.

A sample of these UK in-depth accident cases was also selected to undertake an analysis of Human Functional Failures and Typical Failure Generating Scenarios as part of the TRACE Work Package 5 analysis, in order to try and gain some insight into why accidents involving degraded conditions occur and where in the 'system' do the failures occur?

8.2.1   Methodology

As a result of the descriptive analysis, Table 24 (see section 8.1) was produced to show the cross-tabulations between degraded scenarios and the related typical accident characteristics.

The UK OTS database was initially used to determine whether accidents could be extracted based on the criteria shown on the table in section 8.1 of this report. Once the feasibility for this was established, a data request was developed in order to request data in a similar format from a number of European partners. In contrast to the descriptive analysis, this time all severities, including non-injury data was requested, the reason being that in this in-depth analysis, the main aim is to investigate accident causation, and the causes of accidents involving no injuries can often provide a useful view of the picture of potential more serious accidents that could happen.

8.2.1.a   **European data sources**
Requests for data were made from the following TRACE partners:

United Kingdom - The On-The-Spot Accident Research Project (**OTS**) is available from VSRC. This provides in-depth data from the year 2000 onwards, with 500 cases per year from the Midlands & South-East regions of England.   Data available covers the road user, the accident situation, participants (inc. cars, motorcycles, pedestrians/cyclists and trucks), accident cause, injury cause, human factors and vehicle technologies.   Data for this analysis was made available from the years 2000-2004.

France - LAB-EDA database currently contains information on approximately 900 accidents, involving 1380 drivers. Data includes accident identification data, road and environmental parameters, vehicle active and passive safety information, participant descriptive and behavioural details, photographic and audio files and cinematic reconstruction data where available. Data for this analysis was made available from the years 1997-2004.

France - The In Depth Accident Study (**EDA**) is available from **INRETS-MA**. It provides in-depth data from the year 1996 onwards, with 50 cases per year around the area of Salon-de-Provence (South-East of France). The survey strategy is based on collecting as much information as possible on the accident sequence, at the scene of the accident itself. This data collection is three-fold: driver, vehicle and infrastructure. The aim is to collect the data required to identify the circumstances of the accident and reconstruct the cinematic scenario. The further objective is to be open to questions and hypotheses to be investigated through different methods (statistical accident analysis, experimentations, and observations). Data for this analysis was made available from the years 2000-2007.

Germany - The **GIDAS** database is a joint project between the German car industry FAT (Forschungsvereinigung Automobiltechnik or Automotive Industry Research Association) and the German government **BASt** (Bundesanstalt für Straßenwesen or the Federal Road Research Institute) on in-depth-investigation on scene. Two teams in the geographical areas of Hanover (Medical University Hannover, **MUH**) and Dresden (Technical University Dresden) are collecting data in one common database. This joint project started on July 1, 1999 with about 2000 cases per year. In the two centres Hannover and Dresden, about 2000 accidents are investigated annually. The studies include such information as: Environmental conditions, Road design, Traffic control, Accident details and cause of the accident, Crash information e.g. driving and collision speed, Delta-v and EES, degree of deformation, Vehicle deformation, Impact contact points for passengers or pedestrians, Technical

vehicle data, Information relating to the people involved, such as weight, height etc. Data for this analysis was made available from the years 1999-2006.

Italy - The **SISS** Database (Sistema Integrato Sicurezza Stradale), provided by **ELASIS,** contains accident data coming from some Italian departments, across the North and the South of the Italy (Milan and Mantova provinces; Naples, Sorrento and Salerno municipalities). In the SISS database about 30,000 accidents are collected per year. Data covers different items: road users, accident situations, participants (including cars, motorcycles, pedestrians/cyclists and trucks), accident causes, injury causes, human factors and vehicle technologies. Data for this analysis was made available from the years 2000-2007.

Germany - The Kraft Informations Statistik System (**KISS**) is available from **Allianz**. This provides in-depth data from the year 2002 – 2004 onwards, including approximately 2,500 cases of the year 2004 for the passenger car database (in 2002-2003, only truck database available). This passenger car database comprises accidents with material damage (approx. 2,000 cases) and personal damage (approx. 500 cases). As well as general details about the accident, it includes information about the type of accident, kind of accident and causes of the accident. The type of accident describes the conflict situation which resulted in the accident, i.e. a phase in the traffic situation where the further course of events could no longer be controlled because of improper action or some other cause. The kind of accident describes the entire course of events in an accident, the direction into which the vehicles involved were heading, when they first collided on the carriageway or, if there was no collision, the first mechanical impact on a vehicle. Data for this analysis was made available from the year 2004.

Spain - The 'Proyecto De Investigación y ANálisis de Accidentes' database (**DIANA**) is available from **CIDAUT**. This provides in-depth data from the year 2003 onwards (2002 was the beginning year but there were very few cases from that year), with 40-60 cases per year covering the region of Valladolid with an extension of 8.202 km^2 (urban and rural areas), located in the middle part of Spain. More than one thousand different variables are defined in this database (this quantity increases when there is more than one vehicle, occupant or pedestrian involved). All these variables are classified into three modules: Accident, Vehicle and Occupant/Pedestrian. In addition to these general accident variables, variables directly associated with accident causation are included, along with active safety systems and a classification of accident type and manoeuvre. Data for this analysis was made available from the years 2000-2007.

8.2.1.b   **Definitions of 'degradation'**
The objective of the request for data was to provide information derived from detailed accident databases in each country for further accident causation analysis of degraded situations. For this analysis, the same definitions of each type of degradation was used. However, due to the increased detail of information available in the in-depth databases compared to the descriptive databases, this enabled the definition of degradation (specifically in terms of accident causation) to be expanded further. For example, in the descriptive analysis, degraded lighting was defined as any night-time or twilight conditions, with or without street lighting, mainly because this was all the information available in the descriptive databases. However, in the in-depth databases, degraded lighting as a causation factor can include any type of lighting experienced by the road user which contributed to the accident occurring, including too much lighting or poor contrast (e.g. dazzled by sun or headlights, pedestrian/cyclists wearing dark clothing) in addition to conditions where there is not enough lighting.

Also, 'hazards present' in the in-depth analysis does not only include physical obstacles on the carriageway as it did in the descriptive analysis, it also includes any temporary or sudden 'objects' on the road or roadside which obstruct the view ahead (e.g. parked or stationary vehicles, overhanging vegetation). This type of information was not available in the descriptive databases, but is more likely to be available in the in-depth data sources. The definitions of weather and road surface degradation generally remained unchanged. The types of degradation-related variables included in each of the 7 databases included in the analysis can be found in the Annex.

8.2.1.c   Data request – research aims

The information request from each data provider was grouped under seven headings, so that tabular data could be compared for each contributor and the individual findings could be collated to produce a summary of overall results. The seven headings all aimed to determine the most frequent type of accident causation factors in degradation accidents, including accidents where the most typical 'accident characteristics identified in the descriptive analysis were found The seven types of data requested were:

1. **The number of accidents where degradation was present, and the number of accidents where the degradation was a causation factor** – this data would enabled an overall picture to be produced of the prevalence of degradation in each set of accident data, plus compare how often this degradation was a cause of the accident.

2. **The number of accidents involving specific degradation-related causation factors** – this data would enable an identification, where possible, of the specific types of degradation-related causation factors in each set of accident data.

3. **In general, the most common type of causation factors in accidents where each type of degradation was present** – this data would enable an identification of the most frequent groups of causation factors from each set of accident data.

4. **The most common type of causation factors in degraded lighting accidents when associated accident characteristics are present** – this data would enable the identification of the main type of causes of accidents when accident characteristics found to be most prevalent in degraded lighting accidents in the descriptive analysis are present.

5. **The most common type of causation factors in degraded weather accidents when associated accident characteristics are present** – this data would enable the identification of the main type of causes of accidents when accident characteristics found to be most prevalent in degraded weather accidents in the descriptive analysis are present.

6. **The most common type of causation factors in accidents on degraded road surfaces when associated accident characteristics are present** – this data would enable the identification of the main type of causes of accidents when accident characteristics found to be most prevalent in accidents on degraded road surfaces in the descriptive analysis are present.

7. **The most common type of causation factors in accidents with hazards on the road/roadside when associated accident characteristics are present** – this data would enable the identification of the main type of causes of accidents when accident characteristics found to be most prevalent in 'hazard' accidents in the descriptive analysis are present.

8.2.1.d   Analysis of accident causation factor groups

For points 3 to 7 outlined above, each contributor was asked to determine the 5 most frequent causation factor groups contributing when each type of degradation and certain other accident characteristics were also present. The reason for using factor groups rather than requesting data about specific causation factors used in each country's database was that from work previously undertaken in WP3 of TRACE (Deliverable 3.1), there was found to be much variation in the types of causation factors included in the various data sources. Therefore, it was decided that by using causation factor groups, this would enable a harmonised dataset of the 7 European data sources to be created which would allow for a more comprehensive analysis to be undertaken.

In each case, the causation factor groups could be either human, environmental, or vehicle, as listed in the following table. The causation factor groups were based on the categories used in the grid of factors developed as part of the WP5 methodology. See TRACE Deliverable D5.2 for further details of this part of the methodology.

Code	Causation Factor Groups	Examples of Causation Factors included in this group
H1	Human - Physical/Physiological condition	Medical condition, pre-existing impairments
H2	Human - Substances taken	Alcohol, drugs, medication
H3	Human - Psychological condition	Emotional (upset, angry, anxious, happy…), in a hurry, fatigue, internal conditioning of the driving task (e.g. right of way status)
H4	Human - Experience	Little/no/over-experience of driving/route/vehicle/driving environment
H5	Human - Behaviour (Distraction)	Distraction within vehicle, outside vehicle, within user (e.g. lost in thought)
H6	Human - Behaviour (Risk taking)	Speeding (illegal or inappropriate), driving too close to vehicle in front, purposely disobeying signs/signals/markings, thrill-seeking…
E1	Environment - Road condition	Surface contaminants (wet, flood, snow, ice, frost, oil diesel, sand, gravel), surface defects, surface type)
E2	Environment - Road geometry	Bends, slopes, camber, traffic calming, confusing layout, speed-inciting
E3	Environment - Traffic condition	Traffic flow, traffic density, confusing/lack of information from other road user(s)
E4	Environment - Visibility impaired	Road lighting, vehicle lighting, day/night conditions, sun glare, weather, smoke, terrain profile (bends etc..), other vehicles, roadside objects
E5	Environment - Traffic guidance	Traffic signs, signals or road markings which are insufficient, poorly maintained, inappropriate or unexpected.
E6	Environment - High winds	High winds
E7	Environment - Hazards	Obstacles/hazards in road (animal, debris from previous accident, discarded load) or in roadside (e.g. car on fire), roadworks, level crossings...
V1	Vehicle - Electro-mechanical	Defects in steering, braking, engine, suspension, electrical/electronic systems.
V2	Vehicle - Maintenance	Windscreen chipped, broken, cracked, misted, dirty. Tyres (tread depth, air pressure, blow-out, incorrect type). Exterior/interior lights not working, broken, incorrect.
V3	Vehicle - Design	Blocking visibility (e.g. a-pillars, steering wheel, mirrors), Auditory warnings confusing, display and controls confusing/too small/incorrectly placed.
V4	Vehicle - Load	Heavy or uneven load. Visibility obstructed by a load on or within the vehicle.

Table 25: Causation factor groups used within this task

Once the data from the partners had been received, it was assembled for comparative 'pattern' analysis to identify typical causation factor groups in degradation accidents. This analysis is described in Sections 9.2.2 and 9.2.3.

8.2.1.e   Analysis of accidents where degradation was a cause

Following on from this analysis of grouped data, an additional analysis involved extracting a series of 80 detailed cases from the UK OTS database (approximately 20 of each type of degradation). These cases all contained at least one of the 'typical' accident characteristics outlined previously in Table 24. In each case, degradation had also been determined by the on-scene accident investigator as one of the causes of the accident. It was hoped that by undertaking a case by case review of these accidents, further insight into the specific causes of degradation accidents found in the initial comparative analysis could be obtained, and also to see whether similar causes are found when the degradation itself is also a cause. The analysis of these cases is described in section 9.2.4.

8.2.1.f   TRACE Work Package 5 Methodology

To analyse even further the type of accidents where degradation was a contributory factor and as a comparison to the more conventional case by case review undertaken in section 9.2.4, in particular the type of human functional failures that occur in these accidents, an in-depth analysis of a sample of cases where degradation was a cause was undertaken using the in-depth methodologies newly developed in TRACE Work Package 5. These methodologies were the classification model of human functional failures, the grid of factors and pre-accident driving situations and 'typical failure generating scenarios'. Also, distinctions were made between the road users in the accident who were 'primary active' in each accident, and those who were 'secondary active', 'non-active' and 'passive'. In the majority of accidents, there will be one road user who was at the centre of the 'destabilisation of the process', and either intentionally or unintentionally initiated the rupture phase (the point at which things start to go wrong). See Deliverable D5.1 for further definitions. It is only the primary active road users that are included in this analysis.

Also, closely related to the pre-accident driving situation is the 'conflict', which was also identified for each road user in each accident analysed. This can be defined as the initial conflict that the road user was faced with prior to an accident (i.e. another road user or object in the road way). The road user's resulting impact may or may not involve the 'conflicting' road user or object, but the conflict is an integral part of the accident process. It is also possible for a road user to have no conflict. See Deliverable D5.2 for further details.

To utilise the newly developed TRACE Work Package 5 methodology on UK OTS cases, detailed recoding of cases and in-depth analysis of each individual case was necessary to try and identify the main 'failures' in each accident and the factors (as defined in WP5) which led to these failures occurring. The aim was to try and identify some typical failure generating scenarios from each sample and identify whether these are 'typical' scenarios already identified in TRACE D5.3 or whether new scenarios can be identified.

The selection of these cases was initially based on the degraded situation being causative and it was ensured that the sample contained a selection of all 4 types of degradation being a causation factor. In addition, selection was also based on there being at least one (where possibly, two) of the 'typical' accident characteristics previously identified in the descriptive analysis was present. So for example, for cases where degraded lighting was causative, the cases were selected from those which contained as many of the following characteristics as possible: single car accident, no manoeuvre, alcohol impairment, young (<25 years old) driver and or/male driver. Using this selection criteria, approximately 20 cases were selected where degradation was cause and this would be large enough to reveal some interesting results. The results are given in section 9.2.5

8.2.2   Overview of 'Degradation' Accident Data

The following table shows a summary of the number of accidents where degraded situations were present and where the degradation was one of the causes of the accidents in the individual databases.

Country of data source (provided years of data)	Number of all accidents	Number of accidents where degradation was present	Number of accidents where degradation was causative
UK	3216	2273	496
France[A]	594	475	237
Italy	121286	35181	Not known
Spain	150	48	18
Germany[A]	610	237	28
France[B]	227	87	27
Germany[B]	11608	7549	697

Table 26: Number of accidents where degradation was present and where degradation was causative

As shown in the table above there is a wide spread in the number of accidents in each database and because of this spread it was felt that, even with some form of weighting, that aggregating the accidents into a single data source would not be valid as it would be dominated by the data sources with the greatest number of accidents. Similarly for a number of different reasons not all the individual partners were able to provide all of the requested accident causation information (i.e. the Italian data was not able to record the number of accidents in which a degraded situation in general was an accident causation factor (also see Table 28).

8.2.2.a   The proportion of accidents where degradation was present

As mentioned previously, the aim of this analysis was to enable an overall picture to be produced of the prevalence of degradation in each set of accident data, plus compare how often this degradation was a cause of the accident. As can also be seen in the following table, the proportion of all accidents in each dataset in which a degradation condition was present varied between 29% and 80%.

Accident type	% of degradation accidents from sample of all available car accidents							
	UK	France[A]	Italy	Germany[B]	Germany[A]	France[B]	Spain	Overall Range
Any 'degraded' situation present	71%	80%	29%	65%	39%	38%	32%	29-80%
Degraded lighting conditions present	20%	34%	2%	37%	22%	20%	20%	2-37%
Degraded weather conditions present	21%	18%	18%	25%	0.2%	18%	13%	0.2-25%
Degraded road surface conditions present	46%	61%	1%	32%	16%	16%	2%	1-46%
Hazards present	10%	12%	10%	15%	0.2%	1%	1%	0.2-15%

Table 27: The proportion of car accidents where a degraded condition was present

It can be seen from the overall ranges in the percentages that for all categories of degradation, there is large variation in the proportion of accidents where degradation is present. The large variations could be due to the way that degradation is recorded. For example, in the German[A] data, degraded weather is only recorded if it was known to contribute to the accidents occurring, which is due to the nature of the database (i.e. it is a database of insurance data and therefore certain aspects of the accident, such as weather, are only ever recorded if it was thought to be contributory to the accident). Also, variations in the environmental conditions of each country will also vary. For example, it would be expected that accidents during poor weather or road surface conditions would be less frequent in drier countries such as Spain and the proportions to be much greater in wetter countries such as Great Britain.

8.2.2.b   The proportion of accidents where degradation was a causation factor

The following table outlines the proportion of accidents in which degradation was a causation factor (i.e. contributed to the accident occurring) for each accident data source.   This tables shows that the proportion of all accidents in which at least one type of degradation contributed to accident occurring varied between 5% (Germany[A]) and 40% (France[A]).

A detailed examination of accidents where degradation was one of the causes of an accident is included in section 9.2.4 of this report. While the ranges are not as great as found in the previous Table 27, the table below shows that this general pattern of variation between data sources is continued in the information on accidents where degradation is one of the attributed causes of an accident. However, for degraded lighting and weather the range is much narrower, suggesting that there is a degree of consistency across the various databases where this information has been collected.

Accident type	% of all car accidents in available sample							
	UK	France[A]	Italy	Germany[B]	Germany[A]	France[B]	Spain	Range
Degradation in general was causation factor	15%	40%	0%	6%	5%	12%	15%	5-40%
Degraded lighting was causation factor	3%	4%	0%	1%	1%	8%	1%	1-8%
Degraded weather was causation factor	1%	3%	0%	1%	0.2%	2%	9%	0.2-3%
Degraded road surface was causation factor	6%	22%	0%	5%	3%	2%	1%	1-22%
Hazards were causation factor	7%	11%	0%	0.3%	0.2%	1%	1%	0.2-11%

Table 28: The proportion of car accidents where a degraded condition was contributory

There are many possible reasons for these wide inconsistencies in the proportions in which degraded situations contribute to accidents, such as the way the individual on-scene accident investigators attribute the causes of accident and how this information is recorded or how the database is structured (e.g. the choice of factors that can be recorded in a database), or the state of the road surface and the different levels of risk drivers in the partner's countries are exposed to. Section 9.3 of this report examines the exposure to risk drivers are exposed to the various country covered by the partner's data

8.2.2.c   The proportion of accidents where degradation was a cause in degradation accidents

The following table combines the information displayed in tables Table 27 and Table 28 by showing the frequent accidents where degradation was a cause in the sample of accidents where degradation was just present. For example, in all the accidents in the sample of UK accidents where degraded lighting was present, the degraded lighting was found to also be causative in 7% of the cases.

Degradation type	% of 'degradation' accidents where the degraded condition was also a cause							
	UK	France[A]	SISS	Germany[B]	Germany[A]	France[B]	Spain	Range
Any degradation	22%	50%	0	9%	12%	31%	38%	9-50%
Degraded lighting	7%	11%	0	2%	6%	40%	3%	2-40%
Degraded weather	3%	19%	0	2%	100%	12%	65%	2-100%
Degraded road surface	13%	36%	0	14%	18%	14%	67%	13-36%
Hazards present	69%	89%	0	2%	100%	100%	100%	2-100%

Table 29: The proportion of 'degradation' accidents in which the degraded condition was also a cause

Therefore, it could be said that the greater the proportion of 'degradation' in the degraded cases, the greater the risk that when a specific type of degradation is present, it will also be a cause. However, it could also be due to other reasons, such as variation in the way that 'degraded conditions present' and 'degraded conditions causative' are recorded in a database. Some databases may only generally code

certain types of degradation when it is known to have been causative and not necessarily when it is simply present, which will lead to greater percentages in the table above.

One clear example in the table above is related to 'hazards present'. For 3 of the data sources, the results imply that when hazards are present, they are always a cause. One explanation for this is that in these databases, a 'hazard' is only recorded by the accident investigator if it was a cause, (which is understandable because an object would generally not be known to an accident investigator unless it had been a hazard in the accident they are investigating). For these data sources, this highlights an important difference between results for degraded conditions of lighting, weather and road surface compared with the presence of hazards and possibly shows that this type of degradation should be considered separately in accident analysis.

8.2.2.*d*   Specific degradation-related causation factors

In addition to the data already discussed in this section, data was also collected regarding frequencies of specific degradation-related causation factors included in 5 of the 7 data sources. This information is displayed in Table 30 below.

From viewing this table, the most frequent type of degradation-related causation factors can be highlighted.

- When degraded lighting is a cause, it is more likely to be due to darkness (i.e. poor or no street lights lit) or due to glare from sun.

- When degraded weather is a cause, it is more likely due to be a result of the driver's visibility being affected by the weather (rain, spray..).

- When degraded road surface conditions were a cause, it is most likely to be due to a slippery surface rather than a damaged surface.

- When the presence of a hazard is a cause, it is more likely to be a result of either visibility being obstructed by a stationary vehicle or an obstruction by an animal or object or the roadway.

As can be seen from these results, there was found to be a great deal of variation in the data across the available European sources, which was mainly due to the variation in the type of degradation-related causation factors recorded in each database, which makes it more difficult to give good representation of the 'degradation' situation across Europe as a whole. For example, 'glare from headlights' and 'vision affected by vegetation' are only represented in the UK data, and there are another 8 factors where only 2 countries are represented.

By contrast there are a small number of accident characteristics with good representation, with at least 4 counties represented. These are 'lighting – glare from sun', 'weather - vision affected by rain, sleet, snow or fog', 'road surface – poor or defective surface' and 'hazard – animal/object in carriageway', although this representation is single case numbers in some instances.

As a result of these general findings the study is cautious about the results of any comparisons between the countries' data. There is variation in the number of cases, the severity index, and the proportion of cases in which a contributory factor is seen as contributing (as opposed to merely being present) make comparisons between countries difficult. If the data were grouped together, the inconsistencies would mean some results from individual contributions would be overwhelmed by much higher numbers from other contributions. Therefore, initially, a qualitative comparative analysis has been carried out, whereby patterns have been identified within the data. In particular this part of the research concentrates on repeat occurrences of causation factor groups across the various data sources and the results are described in the following sections.

Specific degradation factor	% of accidents				
	UK	France[A]	Germany[A]	France[B]	Spain
Degraded Lighting causation factors	*n =83*	*n =22*	*n =95*	*n = 18*	*n =1*
Lighting - Poor or no street lights lit	22%	55%	0%	67%	0%
Lighting - Glare from sun	43%	27%	75%	39%	100%
Lighting - Glare from headlights	8%	0%	0%	0%	0%
Lighting – Inconspicuous cyclist/pedestrian at night	30%	0%	0%	0%	0%
Lighting – Daytime contrast issues	0%	18%	0%	0%	0%
Lighting – Not further specified	0%	0%	≥25%	0%	0%
Degraded weather causation factors	*n =19*	*n =20*	*n =1*	*n =5*	*n =13*
Weather - Vision affected by rain, sleet, snow or fog or spray from other vehicles	84%	60%	100%	100%	92%
Weather - High winds	16%	30%	0%	0%	0%
Weather – Aquaplaning	0%	10%	0%	0%	0%
Weather – Not further specified	0%	0%	0%	0%	8%
Degraded road surface causation factors	*n =200*	*n =131*	*n =18*	*n =5*	*n =2*
Road surface - Slippery road (due to weather) or deposit on road (e.g. oil, mud chippings)	92%	85%	100%	100%	100%
Road surface - Poor or defective road surface	15%	24%	0%	20%	50%
Hazard causation factors	*n =215*	*n =64*	*n =1*	*n =3*	*n =2*
Hazard - Surroundings obscured by stationary/parked vehicle	53%	13%	0%	0%	0%
Hazard - Surroundings obscured by moving vehicle	12%	23%	0%	0%	0%
Hazard - Vision affected by vegetation	8%	48%	0%	0%	0%
Hazard - Road works/temporary road layout at site	7%	2%	0%	0%	0%
Hazard - Earlier accident	9%	3%	0%	0%	50%
Hazard - Animal or object in carriageway	20%	22%	100%	100%	50%

Table 30: Percentage of 'degraded lighting, weather, road surface or hazard' accidents where each degradation causation factor was present

8.2.3   Analysis of Main Causes of 'Degradation' Accidents

8.2.3.*a*   Overview of the Main Causes of Accidents Where Each Type of Degradation is Present

From the descriptive analysis, summarised in Section 9.1 of this report, it was found that there were four main types of degradation, these being degraded weather, lighting, road surface and where hazards were present in the road or on the roadside. The in-depth analysis followed on from this analysis by identifying that the causation factors involved in the chain of events resulting in the individual accidents fell into the three main categories traditionally identified in accident analysis, these being human, environmental and vehicle factors and that these categories can be further sub-divided into groups of accident causation factors. The categories of factors used in this study are outlined in Table 25 of this report and for ease these causation factor groups will be referred to by their code references (e.g. E1, H1 or V1)

Table I-3 in Annex I shows for accidents where degradation scenarios are present, the most common 5 groups of causation factors for each data source (see Table 25 for a list of the factors groups). Accidents are made up of a series of contributing events rather than a single cause, so in many of the rows in Tables I-3 to I-7, the contributing percentages add up to more than 100%. As mentioned previously, from the 6 data sources where data was available, the number of accident cases available for analysis varied greatly from 48 to 35,181.

A 'pattern' analysis was undertaken to identify both the most common two causation factor groups for each type of degradation and also the less common (but still occurring) factor groups. Whilst the

pattern analysis does represent each of the partners' contributions care has to be taken not to draw too many conclusions from partner's data which only includes a limited number of cases.

The "pattern" analysis carried out initially aimed to identify the most common two causation factor groups. So, for example, in table I - 3, the UK data recorded H6 (risk taking) as the most commonly occurring factor group occurring in 57% of the accidents. This was followed by H3 (psychological condition, 41%), H5 (distraction, 34%), E4 (visibility impaired, 12%) and E2 (road geometry, 9%). Although there were 7 data sources contributing to the study, the German[B] database was unable to produce data of this type, and in some degradation situations other data sources were unable to produce data. This meant a maximum of 6 centres contributing two factor groups each – providing a maximum 12 opportunities to list a specific factor group. Common (repeat) factor groups were identified as follows:

Degradation in general
- H6 (risk taking) 3/12;
- H5 (distraction) 2/12;
- H3 (psychological condition) 2/12;
- Overall human factors 9/12; Overall environmental factors 3/12

Degraded lighting
- H6 (risk taking) 5/12;
- H5 (distraction) 2/12;
- H3 (psychological condition) 2/12;
- Overall human factors 11/12; Overall environmental factors 1/12

Degraded weather
- H6 (risk taking) 4/11 [out of 11 as only one factor available from GermanyA];
- H5 (distraction) 2/11;
- H3 (psychological condition) 2/11;
- Overall human factors 9/11; Overall environmental factors 2/11

Degraded road surface
- H6 (risk taking) 3/12;
- H5 (distraction) 2/12;
- H3 (psychological condition) 2/12;
- E1 (road condition) 3/12;
- Overall human factors 8/12; Overall environmental factors 4/12

Hazards present
- H5 (distraction) 3/11 [out of 11 as only one factor available from GermanyA];
- E4 (visibility impaired) 3/11;
- H6 (risk taking) 2/11;
- Overall human factors 7/11; Overall environmental factors 4/11

The most common category of accident causation factor was found to be "risk taking" (H6) which is the most common causation factor group for 'degradation in general' accidents, and also the most popular in degraded lighting, weather and road surface accidents, whilst being the second most common in road/roadside hazard accidents. The most common accident causation categories in road and roadside hazard accidents are "distraction" (H5) (which is the second most common category in the 'degradation in general' accidents and the lighting, weather and road surface accidents) and "visibility impaired" (E4).

The "pattern" analysis carried out subsequently aimed to identify the slightly less common (4th and 5th) causation factor groups. With data from Germany[B] not available, this provided a maximum 12 opportunities to list factor groups. Common (repeat) factor groups were then identified as follows:

Degradation in general
- E4 (visibility impaired) 5/12;
- H2 (substances taken) 2/12;
- H5 (distraction) 2/12;
- Overall environmental factors 7/12; Overall human factors 5/12

Degraded lighting
- H2 (substances taken) 3/11 (out of 11 as only one factor available from GermanyA);
- V2 (vehicle maintenance) 2/11;
- Overall human factors 4/11;
- Overall environmental factors 4/11; Overall vehicle factors 2/11

Degraded weather
- E4 (visibility impaired) 5/11 (no data German sources, 3 factors from FranceA);
- H3 (psychological condition) 2/11;
- Overall environmental factors 7/11; Overall human factors 4/11

Degraded road surface
- E4 (visibility impaired) 2/10 (only one factor supplied from Germany & Italy);
- E2 (road geometry) 2/10;
- Overall environmental factors 7/10; Overall human factors 2/10

Hazards present
- H5 (distraction) 2/7 (no data from GermanyA & Spain, one factor from FranceB);
- E7 (environment – hazards) 2/7;
- Overall human factors 3/7; Overall environmental factors 4/7

Finally, the "pattern" analysis looked at all top 5 contributory factor groups for each data source, across each of the degradation situations listed in table I-3 (Annex I):
- Human factors were most prevalent within the degraded lighting situation;
- Environmental factors were most prevalent within the degraded weather and degraded road conditions situations;
- Only one single vehicle factors was prevalent, within the degraded lighting and carriageway hazards situations (although for carriageway hazards only 2 accidents for the country the vehicle factor appeared were available).

The general situation established by the pattern analysis in accidents where degraded lighting, weather or surface conditions was present, was the way in which the vehicle was being driven. This was shown by the 'risk taking' factor group being the most common category and was equally as important in the chain of events leading up to the catastrophic event in degraded lighting, weather and road surface accidents. The frequency with which drivers are adjudged by the accident investigators to be distracted in some way, shown by the frequency with which the H5 'distraction' causation category appears, would also suggest that not only are drivers taking risks with their vehicle they are also not fully aware of their surroundings. Although not as frequent, factors which impair the visibility of the road user were found to be present regularly in 'overall degradation' accidents and where more specifically degraded weather, road surface conditions and carriageway hazards, but interestingly not when degraded lighting is present.

There is a high frequency of "risk taking" causation factors associated with these accidents, there is also a common assumption that young male drivers are associated with this type of driving appears, which appears to be supported by the relatively high proportion of this group of drivers involved in the accidents particularly degraded weather and lighting (also see descriptive analysis in section 9.1).

8.2.3.b **The most common group of causation factors in accidents with degraded lighting present**

Table I - 4 in Annex I describes the most common accident causes where degraded lighting is present, where the causation factors are cross-referenced to the most prevalent accident characteristics in degraded lighting accidents, previously identified in the descriptive analysis (summarised in section 8.1). The following table summarises the number of accidents in each of the partners' databases for each of these accident scenarios.

Number of accidents	UK	France[A]	Italy	Spain	Germany[A]	France[B]	Germany[B]
Single car accidents	493	125	1622	0	5	22	13
Non-manoeuvre Accidents	809	183	599	0	0	37	26
Alcohol impairment accidents	151	58	26	0	2	10	2
Accidents with drivers <25 years old	151	58	26	0	2	10	2
Male driver accidents	926	163	2502	0	76	37	26

Table 31: The number of degraded lighting accidents where each degradation causation factor was present

The observations in this section of the report were made from an analysis of Table I – 4 in the Annex I. No data was available from Germany[A] and a limited number of accident cases in both the German[B] and Spanish data sources mean that there are no accidents in a number of the scenarios.

Typical Accident Scenario – Single Vehicle Accidents

Overall, the most commonly occurring factor groups in single vehicle accidents involving degraded lighting conditions were as follows:

- H6 (risk taking);
- H3 (psychological conditions);
- H2 (substances taken)

The factor groups H2 (substances taken) and H5 (distraction) were also present but less commonly occurring.

From the information shown on Table I – 4a in Annex I, the most commonly occurring causation factors involved drivers taking some form of risk, (60% and 37% in UK and French[A] data respectively) in the recorded cases of SVNP (Single Vehicle No Pedestrian) accidents where the lighting conditions are degraded. However, while the Italian information shows that risk taking featured in 10% of the cases held on their database, accidents where failures in the guidance given to drivers, such as signs or carriageway markings, were marginally more frequent (11%). Risk taking was far the most common type of causation factor to feature in the Spanish data, appearing as a type of factor in 23% of the accident records it holds. Risk taking also appeared in 41% of the cases in the French[B] database.

Psychological conditions were a type of causation factor in 46% of the UK cases, 41% of the French[B] records and 62% of the Spanish cases. This type of causation factor only featured in 12% of the cases in the French[A] database. The "psychological conditions" factor group includes causation factors such as "in a hurry" and "careless, reckless or thoughtless" which can also be linked or associated with the risk taking causation factors discussed above which would account for the relatively large proportion of accidents where these causation factors are present. In addition to these accident causation factors, "psychological conditions" also includes accidents where there has been impairment due to fatigue. This can be linked to the fact that these accidents are occurring in degraded lighting situations, which obviously includes night-time, when tiredness can occur, hence the presence of accidents where "impairment due to fatigue" is a contributory factor.

The most common causation factor group (41%) in the French[B] data was where substances had been taken. While this wasn't the most common factor group in the UK and French[A] data it did feature in 20% and 34% respectively of the cases, as well as in 20% of the German[A] cases and 8% of the Spanish cases. As discussed previously, the connection between degraded lighting and accidents where

substances have been taken is due largely to the times in which the substances are usually taken, namely in the evening or during the night.

Environmental causation factors are one of the five most common causation factor groups in each of the available data sources, but each database features different environmental causation factors.

Typical Accident Scenario – Non-manoeuvre accidents

Overall, the most commonly occurring factor groups in non-manoeuvre accidents involving degraded lighting conditions were as follows:
- H6 (risk taking);
- H3 (psychological conditions)

The factor groups H2 (substances taken) and E2 (road geometry) were also present but less commonly occurring.
Table I – 4b in Appendix I shows that as with SVNP accidents, for accidents involving vehicles not undertaking a manoeuvre (i.e. going ahead), the most common causation factor groups in the recorded accidents within the various databases were "human" related. The causation factors for 'going ahead' accidents in the UK database were the same as those for SVNP accidents. Over 50% of the collision records in the UK database which feature 'going ahead' accidents included causation factors where drivers had been involved in some form of risk taking behaviour, and over 40% of these accidents also included "psychological conditions".
As with SVNP accidents, the most common causation factor groups in the Italian data involved environmental factors, where the most common factor group was 'traffic conditions'.

Typical Accident Scenario –alcohol impairment accidents

Overall, the most commonly occurring factor groups in alcohol impairment accidents involving degraded lighting conditions were as follows:
- H2 (substances taken);
- H6 (risk taking)

The factor groups E2 (road geometry), H3 (psychological conditions) and H5 (distraction) were also present but less commonly occurring.

As expected, the most common causation factor group in all databases for accidents on Table I – 4c in Annex I where at least one driver was under the influence of alcohol was "substance taken". After the "substance taken" factor group, the most common causation factor group in four of the databases, and the third most common in a fifth, was "risk taking". There is a clear link between drivers consuming alcohol and subsequent risk taking behaviour.
While environmental causation factor groups were not the most common, they did feature in a smaller proportion of the accidents in most of the databases, particularly those related to the road geometry, conditions and guidance given to drivers about these situations. This suggests that the alcohol affects the drivers by diminishing their comprehension of the situation they are driving in and any guidance or advice they are given.

Typical Accident Scenario – Accidents with drivers younger than 25 years old

Overall, the most commonly occurring factor groups in accidents with young drivers involving degraded lighting conditions were as follows:
- H6 (risk taking);
- H5 (distraction);
- H3 (psychological conditions)

The factor groups H4 (human experience) and E3 (traffic conditions) were also present but less commonly occurring.

The most common causation factor groups in the majority of the databases in Table I – 4d are those factors that are usually anecdotally associated with young drivers. These factors are the most common: human "risk taking", "distraction", "experience" factors and the environment causation factor "traffic conditions". Less commonly occurring were factor groups such as "geometry", "traffic guidance" and "road condition". All these causation factors suggest a lack of driving experience that would be expected from a driver under 25 years old, either through bravado or through the lack of experience of anticipating situations, especially at night.

A common accident factor in all the other types of accident is "Substances taken" (H2). However, in accidents where drivers were under 25 years old the H2 factors were not as common, not appearing the UK data at all. The one exception was from the French[A] data where it appeared in 26% of the accident cases.

Typical Accident Scenario – Male driver accidents

Overall, the most commonly occurring factor groups in accidents with male drivers involving degraded lighting conditions were as follows:
- H6 (risk taking);
- H5 (distraction);
- H3 (psychological conditions)

The factor groups H2 (substances taken) and H4 (human experience) were also present but less commonly occurring.

The main causation factor groups for accidents involving male drivers shown on Table I – 4e only had minor differences from the causation factor groups in accidents where at least one of the drivers was less than 25 years old. These causation factors, as before, suggest that there is an element of bravado involved in male driving which can lead to either the misreading of the situations or the highway, or that the vehicle is being driven at excessive speed.

There also appeared to be a strong link between male drivers and accidents where substances have been taken. Of the six databases which provided information on accidents in this category only one did not feature "substances taken" as one it's top five most common causation factor groups. This causation group was included in over 30% of the accidents in this category in both French databases and in 15% of the UK cases.

Summary of Accident Causation Factors involved in Typical Degraded Lighting Accident Scenarios

The evidence from the accident causation categories shows that the most common causation group in four of the five accident scenarios was "risk taking", which includes factors such as driving at illegal or inappropriate speeds. "Distraction" and "psychological conditions" also appears as some of the most common accident causation categories, particularly in accidents involving under 25 year old drivers and also male drivers. Examples of causation factors in these categories include 'distraction within the vehicle', 'inattention', 'in a hurry' and 'careless thoughtless or reckless' which suggests that the driver's attitude makes a major contribution to the cause of these accidents.

While "substances taken", such as alcohol and drugs, was obviously the main accident causation category in alcohol-related accidents during degraded lighting conditions, it was also one of the main causes of single vehicle (no pedestrian) accidents and regularly occurred in non-manoeuvre and male driver accidents. This would suggest that drivers who have consumed alcohol or taken any form of drugs are susceptible to accidents in degraded lighting condition.

8.2.3.c   The most common group of causation factors in accidents with degraded weather present

The table below summarises the number of accidents in each of the partner's databases, listed on Table I – 5 in the Annex I to this report, where degraded weather was present in the four specific accident scenarios previously identified in the descriptive analysis (See section 9.1).

Number of accidents	UK	France[A]	Italy	Spain	Germany[A]	France[B]	Germany[B]
Single car accidents	186	58	9768	0	50	12	6
Non-intersection accidents	270	66	2287	0	0	30	10
Non-urban accidents	351	70	9365	0	1	25	18
Non-manoeuvre accidents	450	99	11194	0	1	25	16

Table 32: The number of 'degraded weather accidents where each degradation causation factor was present

Table I - 5 describes the most common accident causes where degraded weather is present. In table I - 5 the causation factors are cross-referenced to the accident characteristics that were identified from the descriptive analysis as being more prevalent when degraded weather conditions were present. The following observations were made from an analysis of table I - 5. In this part of the analysis only the most relevant information was used from the partner's data sources.

Typical Accident Scenario – Single vehicle accidents

Overall, the most commonly occurring factor groups in single vehicle accidents involving degraded weather conditions were as follows:
- H6 (risk taking);
- H5 (distraction)

The factor groups H3 (psychological condition) and V2 (maintenance) were also present but less commonly occurring.
Table I – 5a in Annex I shows that the most common accident causation factor group for SVNP accidents where degraded weather is present is "risk taking" (H6). It is the most common factor group, or it appears in at least 50% of the accidents from all but one of the databases, where the information has been provided. Environmental factors "road condition" (E1) and "road geometry" (E2) are also regularly featured as a causation factor in the majority of the databases which would suggest that there may be a link between risk taking by drivers and the road on which they are driving.

Typical Accident Scenario – Non-intersection accidents

Overall, the most commonly occurring factor groups in non-intersection accidents involving degraded weather conditions were as follows:
- H6 (risk taking);
- H5 (distraction);
- H3 (psychological condition)

The factor groups E4 (visibility impaired) and E2 (road geometry) were also present but less commonly occurring. The most common causation factor groups in non-intersection accidents shown on Table I – 5b (Annex I) do not differ significantly from those of SVNP accidents with "risk taking" (H6) featuring in the majority of these types of accidents in all but one of the databases that supplied information. However, environmental factors feature more commonly than with SVNP accidents, particularly "road condition" (E1) and "road geometry" (E2).

Typical Accident Scenario – Non-urban accidents

Overall, the most commonly occurring factor groups in non-urban accidents involving degraded weather conditions were as follows:
- H6 (risk taking);
- H3 (psychological condition);
- E4 (visibility impaired)

The factor group E1 (road conditions) was also present but less commonly occurring.

From the information on Table I – 5c in Annex I, "risk taking" (H6) was the most common factor in the majority of the databases. The one database where H6 was not the most common factor was the French database where "experience" (H4) was the most common factor.

As with non-intersection accidents environmental causations commonly feature in non-urban road accidents. "road condition" (E1) and "road geometry" (E2) are, as with non-intersection accidents, commonly featured but "visibility impaired" (E4) was the environmental factor which featured most commonly in the majority of databases.

Typical Accident Scenario – Non-manoeuvre accidents

Overall, the most commonly occurring factor groups in non-manoeuvre accidents involving degraded weather conditions were as follows:
- H6 (risk taking);
- H5 (distraction);
- H3 (psychological condition)

The factor groups E1 (road conditions), E2 (road geometry) and E4 (visibility impaired) were also present but less commonly occurring.

Human causation factor groups "distraction" (H5) and "risk taking" (H6) feature as common factors in most databases according to the information on Table I – 5d in Annex I along with environmental factors "road condition" (E1), "road geometry" (E2), and "visibility impaired" (E4). However, unlike the other types of accidents there is no common distribution of accident causation factors.

Summary of Accident Causation Factors involved in Typical Degraded Weather Accident Scenarios

As with degraded lighting conditions, the evidence from the accident causation categories for degraded weather shows that the most common causation group in all of the accident scenarios was 'risk taking', which includes causation factors such as 'driving at illegal or inappropriate speeds' or 'driving too close to the vehicle in front'. 'Distraction' and 'psychological conditions' also appears as some of the most common accident causation categories. These categories include the causation factors 'distraction within the vehicle', 'inattention', 'in a hurry' and 'careless thoughtless or reckless', which suggests that the driver's attitude makes a major contribution to the cause of these accidents.

'Impaired visibility' (e.g. due to weather, glare from sun/road/other vehicle, poor/no lighting, obstructions) is a regular accident causation category in non-urban accidents, and linking this with a more minor causation factor of 'road geometry' (e.g. bends, slopes) implies that when driving on non-urban roads, drivers are more susceptible to adverse conditions such as rainfall and are unable to control their vehicle as well when negotiating bends or other geometrical features of the road. This could be a failure directly related to the driver, but could also be a failure in the road design (i.e. non-urban roads are not as 'self-explanatory as urban roads).

8.2.3.d **The most common group of causation factors in accidents with degraded road surface conditions present**

Table I - 6 in Annex I describes the most common accident causes where degraded road surface conditions are present. In table I - 6 the causation factors are cross-referenced to the accident characteristics that were identified from the descriptive analysis as being more prevalent when degraded road surface conditions were present. The following observations have been made from an analysis of table I - 6.

In this part of the analysis, little or no data was available from the German[A] data source and limited data was available from France[A] and Spain.

Number of accidents	UK	France[A]	Italy	Spain	Germany[A]	France[B]	Germany[B]
Single car accidents	498	229	598	0	7	14	3
Non-intersection accidents	614	191	84	0	46	33	2
Non-urban accidents	759	219	706	0	28	22	3
Non-alcohol accidents	1420	283	1849	0	100	0	0

Table 33: The number of 'degraded road surface accidents where each degradation causation factor was present

Typical Accident Scenario – Single vehicle accidents

Overall, the most commonly occurring factor groups in single vehicle accidents involving degraded road surface conditions were as follows:
- H6 (risk taking);
- H3 (psychological conditions)

The factor groups E2 (road geometry) and H5 (distraction) were also present but less commonly occurring.

There is a mixed picture of the common accident causation factors from the European databases shown on Table I – 6a in Annex I for accidents involving single vehicle non-pedestrian accidents (SVNP) where degraded road surface conditions are present. Of the five databases where information was provided for these types of accident all of them feature "risk taking" (H6) and "distraction" (H5) amongst the most common factor groups. While the frequency with which these factors appeared in the various databases differed, the H6 factor group featured more often than the H5. The examination of the individual accident cases in the UK OTS database shows that these "risk taking" causation categories include "excessive speed", which includes 'travelling too fast for conditions' while the "distraction" was shown to be "inattention".

Every database, with the exception of the French[B] database, featured environmental factors in their five most common causation factor groups. However there is little consistency between these databases.

The degraded carriageway surface does not appear to be a common causation factor for SVNP accidents where the degraded surface is present. Only the UK and German[A] databases featured "road condition" (E1) causation factors amongst the five most frequent causation factors for this type of accident. This would suggest that these types of accidents, under this type of degraded situation, are most commonly attributed to the way the vehicle is being driven in the degraded surface conditions, because of the presence of the H6 and H5 causation factors and the lack of E1 factor in the assessment of the accidents.

The "experience" (H4) causation factor was the most common causation factor group in the French[B] database but this factor only appeared in one other database for this type of accident.

Typical Accident Scenario – Non- intersection accidents

Overall, the most commonly occurring factor groups in non-intersection accidents involving degraded road surface conditions were as follows:
- H6 (risk taking);
- H5 (distraction);
- H3 (psychological conditions);
- E1 (road condition)

The factor groups E2 (road geometry) and E3 (traffic condition) were also present but less commonly occurring.

The data in Table I – 6b (Annex I) indicates that, as with SVNP accidents, the various European databases for non-intersection accidents where degraded surface conditions were present also showed little consistency across these databases. "risk taking" (H6) and "distraction" (H5) were also the most common causation factor groups along with "road condition" (E1) in all but one of the databases.

Unlike SVNP accidents the degraded surface appeared to play a bigger part in the causation of non-intersection accidents, where degraded surface conditions were present. The way the vehicles were being driven in this degraded situation was the most common causation for these accidents. The state of the carriageway was a factor more often than in the SVNP accidents.

Typical Accident Scenario – Non-urban accidents

Overall, the most commonly occurring factor groups in non-urban accidents involving degraded road surface conditions were as follows:
- H6 (risk taking);
- E1 (road condition);

The factor groups E4 (visibility impaired) and E2 (road geometry) were also present but less commonly occurring.

The most common causation factor groups for non-urban accidents where degraded carriageway surface conditions shown on Table I – 6c in Annex I were present were similar to those for non-junction accidents, and the proportion of accidents these causation factors appear in is also similar. "risk taking" (H6) "distraction" (H5) and "road condition" (E1) were also the most common causation factor groups.

As with non-junction accidents, the cause of non-urban accidents where the surface was degraded appears to be a combination of the degraded road surface and the way vehicles are being driven in this degraded situation.

Typical Accident Scenario – Non-alcohol impairment accidents

Overall, the most commonly occurring factor groups in non-alcohol impairment accidents involving degraded road surface conditions were as follows:
- H6 (risk taking);
- E1 (road condition);

The factor group E4 (visibility impaired) was also present but less commonly occurring.

According to the data on Table I – 6d the picture is even more scattered for causation factors for accidents where car drivers are not under the influence of alcohol. While only four of the databases were able to provide information for this type of accident under this type of degraded situation, only the "risk taking" (H6) and "distraction" (H5) factor groups were common to all databases.

Each of the four databases where information is available feature environmental causation factors, but there is only a limited consistency between the databases. Whilst "road condition" (E1) and "visibility impaired" (E4) causation factor groups appeared in most but not all the four databases, they appear with varying frequency.

<u>**Summary of Accident Causation Factors involved in Typical Degraded Road Surface Accident Scenarios**</u>

As with degraded weather and lighting accidents, the most common causation factor group in all of the accident scenarios was 'risk taking', which includes causation factors such as 'driving at illegal or inappropriate speeds'. The factor group 'distraction', which includes causation factors such as 'inattention' and 'distraction within/outside vehicle' was also prevalent, as well as 'psychological conditions', which included causation factors such as 'in a hurry'. As with the two previous types of degraded accident situations, this evidence suggests that it is the drivers and their attitude to driving which plays a significant part of these accidents.

8.2.3.e **The most common group of causation factors in accidents with hazards on the road and roadside present**

Table I - 7 describes the most common accident causes where hazards were present. In this table the causation factors are cross-referenced to the accident characteristics that were identified from the descriptive analysis (see section 9.1) as being more prevalent when hazards were present.

Number of accidents	UK	France[A]	Italy	Spain	Germany[A]	France[B]	Germany[B]
Single car accidents	44	27	5716	0	1	1	1
Non-intersection accidents	132	23	375	0	1	3	2
Non-urban accidents	125	36	1753	0	0	2	2

Table 34: The number of accidents with hazards on the road/roadside

<u>**Typical Accident Scenario - Single vehicle accidents**</u>

Overall, the most commonly occurring factor groups in single vehicle accidents involving hazards were as follows:

- H5 (distraction);
- H6 (risk taking);
- E7 (hazards);
- E4 (visibility impaired)

The factor groups H3 (psychological conditions) and E5 (traffic guidance) were also present but less commonly occurring.

While six databases provided information for SVNP accidents where a hazard is present, as can be seen on Table I – 7a of Annex I, three of these databases only had one case which met the accident conditions (Germany[A], French[B] and Spain) and these three accidents are not included in this discussion. Therefore, only data from UK, France[A] and Italy are included.

There is a mixed picture regarding the most common accident causation factors for the three accident databases with the appropriate information. Not only is there little consistency over the causation factors between the databases there is also wide variation in the frequency with which these five most common factor groups appear in the accident cases.

Of the three remaining databases the two most common causation factor groups were the same for two of these databases (UK and Italy). The factors were "distraction" (H5) and "risk taking" (H6). The two most common causation factor groups from the third database (France[A]), were environmental factors - "hazards" (E7) and "visibility impaired" (E4). However, the H6 causation factor group is the fourth most common factor in the French[A] database, and it appears in a similar proportion of the accident records as the UK OTS database where it is the second most common causation factor group.

What this suggests is that the presence of a hazard does not have a consistent effect on drivers in the lead up to and causation of an accident. This may be due to the fact that, for this report, "hazard" includes a wider range of 'factors' than the other types of degraded situations.

<u>**Typical Accident Scenario - Non-intersection accidents**</u>

Overall, the most commonly occurring factor groups in non-intersection accidents involving hazards were as follows:
- H5 (distraction);
- H6 (risk taking);
- E4 (visibility impaired)

The factor group E7 (hazards) was also present but less commonly occurring than the 3 above, although first in the French[A] database.

While the general distribution of accident causation factors shown on Table I – 7b, for non-intersection accidents where a hazard was present, was as scattered as those for SVNP accidents, the "distraction" (H5) and "risk taking" (H6) causation factors were the most common factors. The "visibility impaired" (E4) factor group was also present as a common causation factor (third most common in French[A] and Italy and 4th in the UK).

One effect the presence of a "hazard" had on non-intersection accidents was that environmental causation factors became more common. However, there was found to be less of a pattern within those environmental factors that the degraded situations affects.

Typical Accident Scenario - Non-urban accidents

Overall, the most commonly occurring factor groups in non-urban accidents involving hazards were as follows:
- H6 (risk taking);
- H5 (distraction);
- E4 (visibility impaired)

The factor groups E2 (road geometry) and E7 (hazards) were also present but less commonly occurring.

As with both SVNP and non-junction accidents, the data on Table I – 7c in Annex I shows that there was a mix of common causation factors across the databases. The "risk taking" (H6) causation factor was again present in all the relevant databases but the frequency it appeared varied between 18% in the Italian database and 44% of the cases in the French[A] database.

Summary of accidents with hazards on the road/ roadside present

Differing slightly from the three previous types of degraded accident situations, for road and roadside hazard accidents, the most common form of accident causation category was found to be 'distraction', which suggests that drivers were not prepared to react to any sudden or emergency situation. 'Risk taking' (e.g. speeding or travelling too close to the vehicle in front) is a common accident causation category, but not the most common, which supports the suggestion that drivers were unprepared for the emergency situations and were not able to react to it. However, the accident causation category 'visibility impaired', which includes factors such as 'glare from the sun', 'obscured by weather, parked vehicles or buildings, vegetation' commonly occurs in single car (no pedestrian) accidents and non-urban accidents, which also suggests that as well as drivers attitudes, their ability, or in this case inability, to be able to see hazards and take appropriate avoiding action is clearly a major cause of these forms of accidents.

8.2.3.f **Summary**
The following table summarises the pattern analysis described above. The table represents a count of the overall human, environment and vehicle factor groups identified within the first two columns and then the last two columns in Tables I-4 to I-7 in Annex I. So, for example, for the principle causes (columns 1 & 2) for degraded lighting accidents, human factors were recorded on 91% of the available options, and environment factors on only 9%. However, when looking at the less common causes (columns 4 & 5) human factors were recorded on 48% occasions, environment on 46%, and vehicle factors on 6% occasions.

	Degraded lighting	Degraded weather	Degraded road surface	Road/Roadside hazard
Proportion of human factors in main 2 causes	91%	82%	75%	66%
Proportion of environment factors in main 2 causes	9%	18%	25%	34%
Proportion of human factors in last 2 causes	*48%*	*55%*	*25%*	*11%*
Proportion of environment factors in last 2 causes	*46%* *6% vehicle factors*	*40%* *5% vehicle factors*	*75%*	*89%*

Table 35: Summary of pattern analysis of accident causation categories where degradation was present

The table reveals that causation factor groups that relate to human factors tend to feature more frequently in accidents with degraded situations present than environmental factor groups do. This implies that whilst environmental factors are of course present in the accidents being studied, in fact it is the human causation factors that are recorded more often. This could be because, in an individual case, possibly just one environmental factor is recorded, whilst human factors are more numerous. For example, a young driver under the influence of alcohol on a poor road surface may have substances taken, experience and risk taking (thrill seeking and speed) recorded against him, but the environmental factor could just be road condition. It could also be that whilst environmental factors are present the investigators feel that in the majority of cases these factors themselves are not the principle cause of the accident, it is the human failure that is the real catalyst for the accident.

However, the concentration on human factors within principal causes does diminish across the table, with 91% human factors for degraded lighting reducing to 66% for carriageway hazards. The proportion of environmental factors increases accordingly across the degraded scenarios.

If the information presented by the partners is representative of the accident records in their countries of origin, as summarised in **Erreur ! Source du renvoi introuvable.** and**Erreur ! Source du renvoi introuvable.** earlier in this section of the report, then there is much variation in the prevalence of the four main types of degradation in the accidents across Europe.

The general picture is similar when the proportion of accidents where the degradation was in part causative in the various databases is compared, with the range of these accidents being between 5% and 40%. However, when the proportions for the specific types of degradation were compared, it was found that the proportion of accidents where degraded weather and lighting was present was similar in the various data sources.

The most frequent causation factor groups for all 4 types of degradation accidents were found to be 'risk taking', (e.g. speeding, travelling too close), 'distraction' (e.g. inside/outside vehicle, within user), and 'psychological conditions' (e.g. in a hurry, fatigue, emotional, internal conditioning of driving task). Additional factor groups were identified in accidents with degraded road surface conditions ('road condition') and accidents with hazards present ('visibility impaired').

When investigating degradation accidents specifically involving typical characteristics identified from the descriptive analysis, risk taking was again found to be one of the most prevalent factor groups in all the degradation scenarios investigated. Other human-related factors were also found to be frequent in these accidents, with environmental-related factor groups such as 'road condition' and 'visibility impaired' also being prevalent.

The following section aims to try and further explain, using in-depth cases from the UK OTS database, within these factor groups, the specific type of causation factors involved in accidents where degraded conditions were not only a cause, but also contributed to these accident occurring.

8.2.4 Analysis of Accidents Where Degradation Was a Causation Factor – Case by Case Review

In addition to the analysis of the main causes of accidents where degradation was present using the 7 European data sources outlined in the previous section, an additional analysis was undertaken to try and identify typical accident scenarios when each type of degradation was causative. Due to the nature of the analysis undertaken, which involved undertaking a case by case review of these accidents, this analysis was undertaken using data available to the Task 2.4 Leader, this being UK OTS data.

This additional analysis allowed for better application of what a "degraded situation accident" was and helped to put into context how the accident characteristics and causation groups identified in the pattern analysis in previous sections of this report contributed to the accidents being investigated by TRACE.

From the in-depth UK OTS database, 80 cases where degradation was causative were investigated. For each of the 4 degraded scenarios, 20 cases were analysed in detail using a case by case analysis, and the accident characteristics compared with previous (descriptive and in-depth) analyses. Where possible, cases were selected which included the most prevalent accident characteristics identified in the descriptive analysis (see Table 24) and used in the information provided in Tables I - 4 to I – 7 in Annex I. Therefore, although these cases may not be a 'representative' sample of cases from the main sample, they all include many of the characteristics of degradation accidents that were identified in the descriptive analysis.

The aim of this case-by-case analysis would be to go one step further than the previous analysis in section 8.2.3, where the most frequent causation factor groups were identified, and, using the sample cases, try to identify specific examples of contributory factors within these groups. This information provides the link between the information on accidents where degraded situations are present provided by the European partners and the specific cases from the UK OTS database.

8.2.4.a Degraded lighting conditions

A review of twenty UK OTS accident cases, where degraded lighting conditions were one of the causation factors for the accident was undertaken.

Of these 20 accidents, 55% of them resulted in no personal injuries, 35% in a slight injury and 10% in serious injuries, which gives a KSI rate of 10%.

Of the primary active (see section 8.2.1 and TRACE D5.1 for a further definition) drivers in these accidents 80% were male, with 25% of the accidents being caused by young male drivers, aged between 16 and 24 years old, 25% of the accidents caused by male drivers aged between 25 and 59 and a further 25% caused by male drivers aged 60 or over. The age for the remaining male driver was not recorded.

As degraded lighting is one of the causation factors for these accidents this would obviously bias the proportion of these accidents which occurred in the dark, which is why 70% of these cases occurred in the dark. As mentioned in the methodology section (Section 8.2.1) of this report degraded lighting also includes drivers being dazzled as well as just "darkness". Similarly, this would also account for the reason why 75% of the cases occurred between 16:00 and 23:59 hours.

Examining the individual accident reports, nine of the 20 accidents were partially due to drivers being dazzled by low sun or by headlights of other vehicles. Drivers were adjudged to have lost control of their vehicles in ten of these cases, six of them on bends. Four cases involved rear end shunts and a further four resulted in vehicles striking objects in or adjacent to the carriageway.

It was possible to identity 12 different causation factor groups from the 20 cases and the five most common factors and the proportion of the sample accident cases they appeared in is shown in the following table.

Causation Factor Group	E4	H5	H3	H6	E1
Number of Accidents	20	13	9	8	5

Table 36: Most common accident causation factors and the frequency they occur in the sample of 20 UK cases where degraded lighting was a cause

The difference between the main factors for accidents where degraded lighting conditions were present and where they were a cause of the accidents is the domination of "E4 - Environmental – Visibility Impaired" as the major causation factor. As these accidents are partially caused by degraded lighting and the E4 factor includes driver's visibility impaired by road lighting, vehicle lighting, day/night conditions, sun glare and weather, this would account for its high occurrence.

The dominant causation factor for accidents where degraded lighting was present is "H6 – Risk Taking", which is featured in over 60% of the accidents in all categories except accidents where at least one car driver was not undertaking a manoeuvre, where it appeared in 56% of the accidents.

The most common individual accident causations were glare from either the sun or headlights (E4) and inattention (H5) which appeared in 10 of the cases. The accident investigators felt that excessive speed (H6) was one of the causes in seven of the cases. Carelessness, recklessness or thoughtlessness (H3) and slippery road surfaces (E1) were one of the causes in five cases each.

From the evidence presented in the overview of the accidents from the partners to the more detailed individual accident information from the UK OTS information it would appear that both improved street lighting and driver education and awareness would be a benefit in reducing accidents which both occur when degraded light is present and also when it is one of the causes. Improved lighting would help drivers see their surrounding better and help them appreciate and react to any approaching dangers and hazards in a more controlled way. Driver education and awareness would help drivers appreciate the risks they are taking with their vehicles and the potential consequences of these actions.

Problems due to drivers being dazzled by the sun could be minimised, although not eradicated by an appreciation of the problem in the highway design stage so that the combination of geometric highway design and natural geometry required to put drivers in the position for the sun to have an adverse effect can be avoided as much as possible. The adoption of safety auditing procedures, together with trained experienced safety auditors would also help in identifying these potential problems at early stages of the design.

Vehicle manufacturers could also examine the possibility of anti-dazzle front and rear windscreens to also help minimise the effects of dazzle by the sun.

8.2.4.b   Degraded weather conditions

Nineteen UK OTS cases where degraded weather was a cause of the accidents have been reviewed. None of these accidents resulted in a fatality, 5% resulted in a serious injury, 32% with slight injury and the remaining 63% were non-injury accidents. As a result of this the KSI rate was 5%.

While 42% of these accidents occurred in the winter months of December, January and February, when the weather is expected to be most likely to contribute to road accidents, 32% of the accidents also occurred in May, June and July. Over 60% of these accidents occurred in daylight, with 32% of them occurring in the three hours between 14:00 and 16:59.

The degraded weather situations seemed to have a greater effect on younger male drivers as 74% of the drivers were male, and a number of these male drivers (43%) were aged between 16 and 24 years old. While the number of female drivers was smaller the majority of these females were aged between 25 and 60 years old. This would suggest that degraded weather has a more significant effect on male drivers, particularly younger male drivers, but of the female drivers it is those drivers aged between 25 and 59 that are affected the most.

The most common description of the accidents is that the drivers lost control of their vehicles, which happened in 70% of these sample cases, and 42% of these loss of control accidents occurred on a bend. Three of the sample cases also involved drivers failing to conform to automatic traffic signals.

Examining the causation factors that lead up to these accidents occurring reveals that the most frequently occurring factor is the environment-related factor group 'visibility impaired' (E4) in 68% of the sample accidents (in all cases, it was the weather that caused the visibility impairment). Interestingly, in approximately a quarter of the accident cases examined, a degraded "Road Condition" (E1) is adjudged to have been a causation factor. This suggests that accidents in degraded weather conditions are also due to the way vehicles are driven and not just the environment they are being driven in. As well as the road user's visibility being impaired due to the weather conditions, in the majority of the remaining cases, the weather-related causation factor was found to be 'high winds' (E6).

Another frequently occurring causation factor group was "Psychological Condition" (H3), more often being the factors "Carelessness, recklessness or thoughtlessness" and "In a hurry". Two other "Human" causation factor groups also feature in over 50% of the accidents, "Distraction" (H5) and "Risk Taking" (H6). The fact that the most common H5 causation factor was "inattention" and H6 accident causation "Excessive speed", featuring nine and ten cases respectively. This also supports the suggestion that degraded weather actually has just as great a bearing on the way drivers drive, and react to the conditions, as it does detrimentally affecting the environment they are driving in.

Causation Factor Group	E4	H3	H5	H6	E1
Number of Accidents	13	12	10	10	5

Table 37: Most common accident causation factors and the frequency they occur in the sample of 20 UK cases where degraded weather was a cause

The general picture of the accident causation factors in both accidents where degraded weather is <u>present</u> and where it is one of the <u>causes</u> is very similar to those involved in degraded lighting accidents. However, the specific accident cases in the UK OTS show that "excessive speed" is adjudged by the accident investigators to have played a significant part in an equally significant number of these degraded lighting accident cases. This reinforces the message that it is the way the vehicles are being driven by the drivers, taking risks, driving at excessive speed for the degraded situation whilst also being distracted from the act of driving though inattention that has led up to, and been one of, the causes of the accident.

From the evidence presented in the overview of the accidents from the partners to the more detailed individual accident information from the UK OTS information it would appear that better driver education and awareness would be a benefit in reducing accidents which both occur when degraded weather is present and also when it is one of the causes. A better awareness of how the degraded conditions affect the way their vehicle performs in relation to the road surface and other vehicles would help them appreciate and react to any approaching dangers and hazards in a more controlled way. Driver education and awareness would help drivers appreciate the risks they are taking with their vehicles and the potential consequences of these actions.

Additionally driver information systems would also inform drivers of any degradation due to weather so that when they are better educated they can take in this information and amend their driving in advance of any problems occurring.

8.2.4.c Degraded road surface conditions

Twenty one cases from the UK OTS database where degraded road surface conditions were one of the causation factors were reviewed. The KSI index for accidents where degraded surface was a causation factor was 14%, with 14% of the accidents resulting in a serious injury, 29% a slight injury and 57% of these accidents did not result in an injury.

The majority of the drivers responsible for these accidents (57%) were male (38% were female, although the sex of the driver in one case examined was not recorded). The male/female split for this type of degraded situation was the least biased towards male drivers of the four types of degradation. While some of the other forms of degradation had a disproportionate effect on younger drivers, in this case over 50% of the drivers, where an age was given, were aged 25 and 59.

As would be expected two-thirds of these accidents occurred in the five months between October and February, when poor weather conditions are more likely to have an effect on the carriageway surface. However, approximately 20% of the accidents also occurred in July and August when weather would

normally be expected to have less of an effect on the carriageway surface. While this phenomena would appear to be at odds with the common conception that weather adversely affects the road surface during the winter time it can be explained by the fact that road surface does not tend to be "washed" as efficiently during the summer months which allows a layer of fats and other detritus to build up on the surface. So when there is any rain it is not intense enough to clean the road surface and it creates a layer with a lower surface fiction than normal.

If these accidents were to be described in broad terms it could be said that 90% of these sample accidents could be described as loss of control accidents, with the remaining 10% overtaking accidents. Of the loss of control accidents, over 60% of them occurred on bends. However, given that the common factor with these sample accidents is a degraded surface condition, it should come as no surprise that the majority of these accidents occurred in locations where the forces exerted by vehicles are greatest, and by degrading the surface it increases the occurrence of accidents.

There did not appear to be a strong link between degraded lighting conditions and degraded road surface accidents as less than 30% of the degraded road surface accidents occurred in the dark.

Examining recurring factors associated with accidents where degraded surface conditions were present, and also those situations where degraded surface conditions are causative it would appear that causation factors do not appear as commonly in these accidents as they have done with degraded weather and lighting.

In terms of accident causation, as expected, "Road Conditions" (E1) was found to be contributory in all accidents in the sample, and in all of these cases, this was recorded as "Slippery road surface at site". However, it was found not just to be the weather that degraded the carriageway surfaces in these sample cases, "Deposits on the road" and "Poor or defective road surface" also were found to be causes. "Risk Taking" (H6) featured in over 62% of the accidents where degraded surface was also a cause. Risk taking in these sample cases was adjudged by the accident investigators to be vehicles being driven with "Excessive speed", which includes 'travelling too fast for conditions'. "Psychological conditions" (H3), which includes the causation factors "In a hurry" and "carelessness, recklessness and thoughtlessness", featured in 43% of the accidents, which suggests that there is a connection between drivers taking risks and degraded road surface conditions in the lead up to catastrophic situations.

Causation Factor Group	E4	H3	H5	H6	E1
Number of Accidents	13	12	10	10	5

Table 38: Most common accident causation factors and the frequency they occur in the sample of 20 UK cases where a degraded road surface was a cause

The conclusion that could be drawn from this relatively high frequency is that when the surface conditions are degraded, usually by the weather, it is drivers not adapting to these degraded conditions that cause the accidents rather than the degraded situation itself.

Again the evidence presented in the overview of the accidents from the partners to the more detailed individual accident information from the UK OTS information it would appear that better driver education and awareness would be a benefit in reducing accidents which both occur when degraded road surface conditions are present and also when they are one of the causes. A better awareness of how the degraded conditions affect the way their vehicle performs in relation to the road surface and other vehicles would help them appreciate and react to any approaching dangers and hazards in a more controlled way. Driver education and awareness would help drivers appreciate the risks they are taking with their vehicles and the potential consequences of these actions.

Improved maintenance and cleaning procedure by the appropriate Highway Authorities could also reduce the occurrence of surface contaminants and reduce the adverse effects on passing vehicles.

8.2.4.d   Road and roadside hazards

Twenty cases in the UK OTS database where a hazard was one of the causation factors have been examined. Two of these cases included a serious injury, six a slight injury and the remaining twelve were damage only accidents. This means that the KSI index for these types of accidents is 10%.

Of these twenty accidents, 50% of them occurred in the month period covering April, May and June, and 60% of the accidents occurring between 19:00 hours and midnight, and over half of them (55%) occurred in the dark. This would suggest that accidents of this type are most likely to occur in the evening of late spring/early summer time when the weather is not necessarily at its worst but still in degraded lighting conditions.

The drivers involved in these types of accidents tend to be males as they account for 70% of the drivers involved, but the 16 to 24 years age group were the most susceptible age group as 50% of drivers fell within this age group. However, it is female drivers that were over represented in this age group. There are a total of 10 drivers in this age group and 5 of them (50%) are women. However, there are only 6 women drivers in total, so they are over-represented within this age group.

The main type of accident, deemed by the on-scene accident investigator, in this sample of twenty accidents is "loss of control", which describes 70% of the accidents. Unlike the other degraded situations only a small proportion (14%) of these "loss of control" accidents occurred on bends. However, losing control of a vehicle in the process of an accident is usually as a consequence of another action or causation factor so the fact that drivers took avoiding action in 60% of the sample accidents, and the objects or hazards involved in these accidents were struck in only 25% of the cases, would suggest that it was the avoiding action or the reaction to the need for avoiding action which caused this "loss of control". This alone would suggest that the accidents where there is a hazard present were caused by the avoiding action taken by a driver rather than the hazard being struck.

The causation factor groups of these twenty sample UK OTS cases, broadly followed the pattern for all these accidents in the database, with "Hazards" (E7) and "Distraction" (H5) being the most common.

Causation Factor Group	E7	H5	H6	H3	H4
Number of Accidents	20	12	5	4	4

Table 39: Most common accident causation factor groups and the frequency they occur in the sample of 20 UK cases where the presence of a hazard was a cause

The individual accident causations included in the "E7" category describe the hazards drivers were faced with. The main cause was "Animals out of control on the road". However, the most common "H5" causation factor recorded in these cases is "Panic behaviour" which appeared in 67% of the accidents were a "H5" accident causation was used. This would support the indication given by the type of accidents in this sample that it was not necessarily the hazard that caused the accident but the way the driver dealt with the situation that was a significant factor in the accident.

It is interesting to note that vehicles being driven at "Excessive speed" were only thought to be a causation factor in 25% of the accident cases.

As the indications are that these accidents were as a result of drivers not being able to control their vehicles as a result of their actions and reactions when presented with a sudden and unexpected hazard, such as an uncontrolled animal in or near the carriageway, driver training in emergency situations would be beneficial. While this sort of training would be advantageous to all drivers, the information gathered from the UK OTS sample would suggest that this training should be aimed towards female drivers.

In addition to driver training, intelligent braking and traction systems in vehicles would also limit the ways in which drivers lose control of their vehicles.

8.2.5 Analysis of Degradation Accidents Using TRACE Work Package 5 Methodologies

As a comparison with the more conventional analyses undertaken and reported in the previous sections (9.2.2, 8.2.3, 8.2.4), an analysis of a selection of the 80 cases analysed in section 8.2.4 was undertaken using the human factors methodologies developed in Work Package 5.   These methodologies were the classification model of human functional failures, the grid of factors and pre-accident driving situations and 'typical failure generating scenarios', all of which are described in detail in the TRACE Deliverables D5.1, D5.2 and D5.3.

The aim was to try and identify some typical failure generating scenarios from each sample and identify whether these are 'typical' scenarios already identified in TRACE Deliverable 5.3 ('Typical Failure Generating Scenarios) or whether new scenarios can be identified. A typical failure generating scenario identifies the following for a specific road user:

- **The pre-accident driving situation the road user was in when they encountered a potential conflict.**
- **The type of human functional failure a road user experienced while in this situation, which subsequently led to the accident occurring**
  - A failure in detecting a potentially conflicting situation ahead
  - A failure to diagnose a situation correctly
  - A failure in prognosis (due to the road user's pre-expectations of the situation)
  - A failure in deciding how to proceed in the situation
  - Failure to handle a sudden deterioration in the situation when undertaking an action
  - An overall failure which means the road user is not fully in control of their vehicle (e.g. alcohol impairment, drowsiness, sudden illness, loss of driving skill)
- **The factors which lead to the failure occurring – Human, Vehicle and Environmental-related factors (e.g. poor visibility at an intersection led to the road user being unable to detect a vehicle approaching the intersection**.

Typical failure generating scenarios were only identified for the primary active road user in each accident, as there were only two non primary active road users (one was passive and one was non-active). As well as identifying overall typical failure generating scenarios for degradation accidents in general, the findings were also split by degradation type (lighting, weather, road surface, hazards), to try and identify whether typical scenarios were different for each type of degradation.

Using the selection criteria outlined in the methodology section (8.2.1), 20 cases were selected for analysis. In these 20 accidents, degraded lighting was causative in 6 cases, degraded weather was causative in 7 cases, degraded road surface conditions were causative in 6 cases and hazards were causative in 2 cases (in one case, both degraded road surface conditions and hazards were causative).

8.2.5.*a*   Pre-accident driving situations and conflicts

The results revealed that the majority of the primary active road users were going ahead, the remaining were approaching (but not at) an intersection (following table). Therefore, none involved a manoeuvre being undertaken.

Situation	Number of cases				
	Lighting	**Weather**	**Surface**	**Hazard**	**Total**
Going ahead on straight road	2	3	2*	2*	8
Going ahead on left bend	1	1	3	0	5
Going ahead on right bend	1	2	1	0	4
Approaching a 'give way' intersection	1	0	0	0	1
Approaching a 'traffic signal' intersection	1	1	0	0	2

Table 40: Pre-accident driving situations for the sample of 20 UK cases

*in one case the degraded road surface and a hazard were causative.

In 17 of the 20 cases, there was no conflict (i.e. it was a single vehicle accident). In the remaining 3 cases, the road user encountered an oncoming vehicle in the correct lane (degraded weather accident), encountered a vehicle from a side road or path or encountered a stationary obstacle ahead (both degraded lighting accidents).

8.2.5.b   Human Functional Failures

The majority of cases involved either a failure in detection or a failure when taking action.
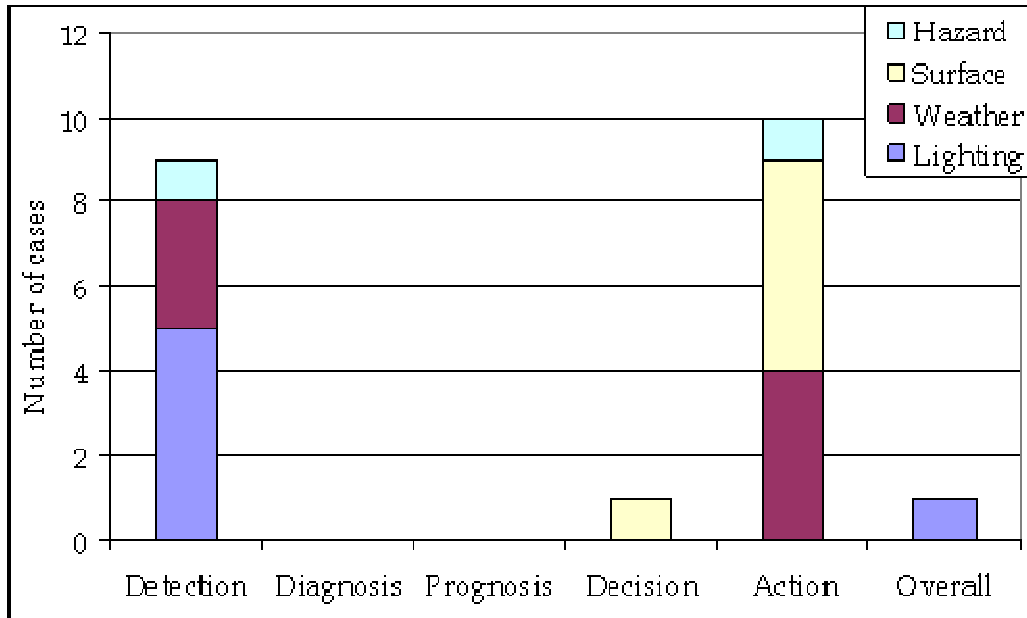
Figure 88: The type of human functional failures experienced by the primary active road users in the sample of 20 UK accidents where degradation was a cause*

*in one case the degraded road surface and a hazard were causative.

This chart also shows in more detail the human functional failures experienced by primary road users in accidents when each type of degradation was causative. For accidents where degraded lighting was a cause, it appears to be detection-related failures. When a degraded road surface was a cause, it appears to be taking action-related failures. When degraded weather or a hazard was a cause, it appears to be both detection and taking action-related failures.

It is interesting to note that diagnosis failures, which have been found more prevalent in other studies (e.g. see TRACE Work Package 3 reports D3.3 and D3.4), do not occur in any of the 20 sample cases. This could be just by chance (i.e. if another 20 cases had been selected, diagnosis failures may have been more prevalent). However, it could also be due to the effect of degraded conditions on the road user in the accident. They may actually more likely lead to more failures in detection and taking action and not affect as much the 'thinking' stages (i.e. diagnosis, prognosis and decision-making) of the human function. This implies that in situations where the conditions suddenly degrade, the degradation either stops the road user from detecting any potential conflict in the first place until it is too late to avoid, or the degradation is a complete surprise to the road user and they only become aware of it once they try to undertake their manoeuvre, which leads to a loss of control that the road user can't avoid.

The following table shows the specific human functional failures experienced by the primary road users in the 20 accidents where degradation was a cause.

	Human Functional Failure	Number of cases
Detection	P1 - Non-detection in visibility constraint conditions	8
	P2 - Information acquisition focussed on part of situation	1
Decision	D2 - Deliberate violation of safety rule	1
Action	E1 - Poor control of an external disruption	9
Overall	G2 - Alteration of sensor motor and cognitive capacities	1

Table 41: Types of human functional failures in sample of 20 UK cases where degradation was a cause

When looking at the specific type of failures involved, it was found that the majority were either P1 failures (non-detection in visibility constraint conditions) or E1 failures (Poor control of an external disruption).

Non-detection in visibility constraint conditions refers to situations where the road user is unable to detect a potential conflict due to restricted visibility at the site of the potential conflict (e.g. overgrown vegetation, weather conditions, glare from sun/headlights).

Poor control of an external disruption refers to when a road user experiences a sudden deterioration of the external conditions which results in the road user not being able to keep control of their vehicle. The external disruption is external to the road user, but not necessarily external to the vehicle, and can include road poor road surface conditions or a sudden breakdown in the vehicle mechanics (including tyre blowout).

Degraded lighting as a cause

In the 6 accidents where degraded lighting was causative, the most frequent type of failure was the detection-related failure P1 failure.

	Human Functional Failure	Number of cases
Detection	P1 - Non-detection in visibility constraint conditions	5
Overall	G2 - Alteration of sensor motor and cognitive capacities	1

Table 42: Types of human functional failures in the sample of 6 UK cases
where degraded lighting was a cause

In 3 cases where P1 was a failure, the road user was dazzled by the sun, which led them to either not see an object which they impacted or not be able to make out the roadway ahead. In the remaining 2 cases, the road user was either dazzled by an oncoming vehicle's headlights or disorientated by the street lights which suddenly ended on approach to a bend, not giving the road user enough time to adapt to the darkness, which led them to drive off the road at the bend.

Degraded weather as a cause

In the 7 accidents where degraded weather was contributory, two types of failure were found. In 4 cases, there was a 'taking action'-related E1 failure and in 3 cases, there was a detection-related P1 failure.

	Human Functional Failure	Number of cases
Detection	P1 - Non-detection in visibility constraint conditions	3
Action	E1 - Poor control of an external disruption	4

Table 43: Types of human functional failures in the sample of 7 UK cases
where degraded weather was a cause

In the 4 cases where there was an 'E1' failure, 2 involved a car & caravan losing control due to high winds, 1 involved the driver's visibility being impaired by falling snow and 1 involved the driver's visibility being impaired by spray from another vehicle.

In the 3 cases where there was a 'P1' failure, 2 involved a road user not seeing a bend ahead until too late because of fog and 1 involved the road user not seeing the traffic lights ahead until too late, also because of fog.

Degraded road surface conditions as a cause

In the 6 cases where degraded road surface conditions were contributory, 5 involved the road user experiencing a failure when taking action (E1). In 4 cases, this involved poor road surface contaminants and in 1 case, it involved a defective road surface.

Human Functional Failure		Number of cases
Decision	D2 - Deliberate violation of safety rule	1
Action	E1 - Poor control of an external disruption	5

Table 44: Types of human functional failures in the sample of 6 UK cases where degraded road surface conditions were a cause

In 1 of the 6 'degraded road surface' cases, the road user experienced a decision-making error, specifically related to a 'deliberate violation of a safety rule' (D2), in this case, the driver was risk taking by driving too fast around a bend with an uneven road surface.

Hazards as a cause

In the 2 cases where the presence of hazards was found to be contributory, 1 involved a failure while taking action, specifically related to a 'poor control of an external disruption' (E1) and 1 involved a failure in perception, related to 'information acquisition focused on a partial component of the situation' (P2).

Human Functional Failure		Number of cases
Detection	P2 - Information acquisition focussed on part of situation	1
Action	E1 - Poor control of an external disruption	1

Table 45: Types of human functional failures in the sample of 2 UK cases where hazards present were a cause

8.2.5.c Factors which led to the failures
Overall

The most frequent types of factors which led to the above failures occurring were related to the user's behaviour (17 cases), the geometry of the road (13 cases) or the road user's visibility being impaired (18 cases).
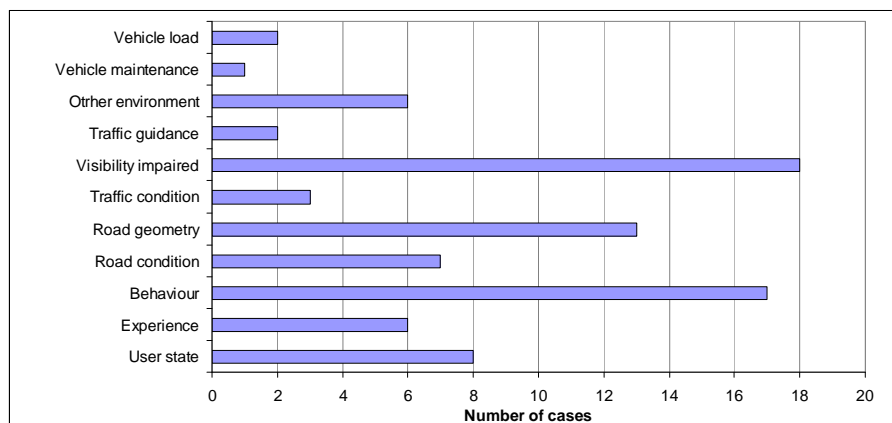
Figure 89: Factors which led to the failures in the 20 UK cases where degradation was a cause

More specifically, 'risk taking: speed' was the most frequent factor (12 cases), with 'bend', 'visibility impaired: weather', 'visibility impaired: road lighting' and 'alcohol impaired' also being contributory in at least 4 of the 20 cases.

Lighting

Of the 6 cases where degraded lighting was contributory, the road user's visibility was impaired in all cases, which was to be expected. In 3 of these cases, visibility was impaired by sun glare. Road lighting and darkness were the other two sources of the driver's visibility being impaired. The 'behaviour' of the road user was contributory in 4 cases, of which 'lost in thought' was the factor in 2 cases and 'risk taking-speed' was the factor in the remaining 2 cases.

Weather

Of the 7 cases where degraded weather conditions were contributory, the road user's visibility was impaired in 5 cases. In all 5 of these cases, it was the weather conditions that caused the impairment. The road user's ''behaviour' was also contributory in 5 cases, in all cases, this was found to be 'risk taking-speed'. The factors 'alcohol impairment', 'wet/flood/snow on road', 'bend', 'high wind' and 'heavy load' were also found to be contributory in degraded weather cases, all in 2 cases each.

Road surface conditions

Of the 6 cases where degraded road surface conditions were contributory, the specific type of surface condition was found to vary, including ice/frost, oil/diesel, wet and surface defects.

In addition to the degraded surface conditions, the road geometry was also found to be contributory in 5 cases. In 4 of these 5 cases, the factor was a bend in the road. The behaviour of the road user was also a cause in 4 cases, more specifically 'risk taking-speed'.

Hazards

Of the 2 cases where a hazard was the contributory degraded condition, the hazard was found to either be road works or a broken down car in the carriageway. In addition to the hazard itself, 'risk taking: speed' was also found to be contributory in both cases.

8.2.5.d   Factor/Failure links
When comparing the link between factors and failures, the factors 'alcohol impaired', 'lost in thought', 'risk taking: speed', 'visibility impaired: sun glare' and 'visibility impaired: weather' were the most frequent factors (at least 3 cases) when a P1 failure occurred ('non-detection in visibility constraint conditions').

The factors 'risk taking: speed', 'road condition: wet/flood/snow' and 'road geometry: bends' were the most frequent factors when an E1 failure occurred ('poor control of an external disruption').

When looking at the degraded lighting accidents only, the factors 'lost in thought', 'visibility impaired: night', and 'visibility impaired: sun glare' were most frequent when a P1 failure occurred (at least 2 of the 5 cases).

For degraded weather accidents only, the factors 'alcohol impaired', 'risk taking: speed' and 'visibility impaired: weather' were most frequent when a P1 failure occurred (at least 2 of the 4 cases).

When an E1 failure occurred, the most frequent factors were 'risk taking: speed', 'road condition: wet/flood/snow', 'visibility impaired: weather', 'high winds' and 'heavy load' (at least 2 of the 3 cases).

For degraded road surface accidents only, the factors 'risk taking: speed', 'road condition: ice/frost' and 'road geometry: bend' were the most frequent factors when an E1 failure occurred (at least 2 of the 5 cases).

8.2.5.e   Failure generating scenarios
Overall

Of the 20 cases in the sample, 11 could be related to a pre-defined failure generating scenario outlined in TRACE D5.3. The most frequent pre-defined scenario was E1B, which is described in D5.3 as being a 'sudden encounter of an external disruption, more or less expectable' (6 cases). The following pre-defined scenarios were also found in the sample:

- E1A: 'Sudden encounter of an external disruption' – 3 cases

- P2D: 'Focalisation towards an identified source of danger' – 1 case

- G2B: 'Alteration of guidance capacities' – 1 case

Of the remaining 9 cases which could not be related to a pre-defined D5.3 scenario, 8 involved a P1 failure and 1 involved a D2 failure. The following table outlines what happened in the 8 accidents where a P1 failure occurred.

Case	Cause of visibility impairment	Outcome
1	Disorientated by street lights ending	Didn't see bend until too late
2	Dazzled by car lights	Hit kerb at road works
3	Dazzled by sun glare	Hit skip on road ahead
4	Dazzled by sun glare	Didn't see junction until too late
5	Dazzled by sun glare	Confused by road layout & drove onto slip road & hits bollard & car
6	Visibility impaired by fog	Didn't see bend until too late
7	Visibility impaired by fog	Didn't see junction until too late
8	Visibility impaired by fog	Didn't see bend until too late

Table 46: The cause and outcome of the 8 sample UK cases where a P1 failure occurred

What can be seen is that there are 3 main types of causes of the road user's visibility being impaired, either being dazzled by a bright light, delayed dark adaptation or the presence of fog. This resulted in either the road user not seeing an object ahead (the skip), not seeing the road layout ahead (bend, approaching junction or a kerb at road works) or the lack of visibility caused confusion in perceiving the road layout.

Another non-defined scenario involved a D2 failure (deliberate violation of a safety rule). In this scenario, the driver was taking a risk by speeding around a bend which had an uneven surface and subsequently lost control of their vehicle. It is thought the driver in this accident had little experience of this road, so might not have known about the uneven surface when making a decision to travel at speed around this bend.

When analysing the 4 types of degradation accidents separately, the following was found.

Lighting

When degraded lighting was a cause, only one pre-defined D5.3 failure generating scenario was identified, which was G2B: 'alteration of guidance capacities'. In this case, an alcohol impaired road user who was travelling at an inappropriate speed lost control of their vehicle on approach to a bend with poor signage in poor lighting conditions (unlit darkness). In addition to these factors, the road layout of the road was considered to encourage inappropriate speeding. In this case, it was the alcohol impairment itself which was considered to be the overriding factor which led to the failure occurring.

In the remaining 5 of the 6 degraded lighting accidents where a pre-defined scenario could not be defined, all involved a failure in detection (P1) (cases 1 to 5 in Table 46 above).

Weather

When degraded weather was a cause, one pre-defined D5.3 failure generating scenario was identified for 3 cases, which was E1A: 'sudden encounter of an external disruption'. Two of these cases involved a car and caravan combination losing control in high winds, while the third case involved a vehicle aquaplaning on surface water during heavy rainfall (including spray from other vehicles). Another pre-defined scenario was identified for a case which involved another E1 failure, which was E1B: 'sudden encounter of an external disruption, more or less expectable'. In this accident, the road user who travelled this route often, lost control on a bend in snow. Probably due to the experience of the bend in dry conditions, the road user was thought to be probably travelling at an inappropriate speed for the conditions, but no faster than they normally drive it, and therefore did not expect to lose control, even though it should have been expected.

In the final 3 of the 7 degraded weather accidents, a pre-defined scenario could not be identified. All 3 involved a failure in detection (P1) and all involved the driver's visibility being impaired by fog (cases 6 to 8 in Table 46).

Road surface conditions

A pre-defined typical failure generating scenario could be defined for 5 of the 6 cases where degraded road surface conditions were causative. In all 5 cases, the scenario was E1B: 'sudden encounter of an external disruption, more or less expectable'. Three involved a loss of control on a bend (on ice, on oil/diesel, on a flooded road and on an uneven surface). Interestingly, in the case involving a loss of control on a patch of oil/diesel, this was the second of two concurrent accidents to occur at this location. The fifth case involved a loss of control on a straight icy road, possibly involving a break in the driver's concentration when they were distracted by a roadside event.

The final (6th) case involving degraded road surface as a case, where a pre-defined scenario could not be identified, involved a decision-making failure (D2). In this case, the vehicle lost control on a bend which had an uneven road surface.

Hazards

For the two accidents where a hazard contributed to the accident occurring, two pre-defined typical failure generating scenarios were defined. These were E1B: 'sudden encounter of an external disruption, more or less expectable' and P2D: 'focalisation towards an identified source of danger'. The external disruption suddenly encountered in the E1B scenario was an uneven road surface and involved a road user losing control on a hump-back bridge at a set of road-works where the surface was being replaced. This was a route taken regularly by the road user, so because the road works were new, the road user approached the bridge the way they normally did, but this was not appropriate for the conditions. As this case involved road-works (defined as a hazard in this analysis) and also an uneven surface, it was also included in the degraded road surface case analysis.

In the P2D scenario, the road user noticed signs on the motorway warning motorists of a stationary vehicle ahead (the hazard in this case). The road user than drove past a stranded vehicle on the hard shoulder, and was busy concentrating on this vehicle (assuming this was the stationary vehicle in question), that they didn't notice the actual stationary vehicle ahead in the carriageway. The road user lost control of their vehicle and came to rest in the central reservation.

8.2.5.f **Overview of findings of Work Package 5 analysis**

Overall

Failures in detection and when taking action were found to be the most prevalent in the sample of 20 cases where degradation was a cause. These failures occurred mainly when the road user was going ahead on a bend or straight and most didn't involve any other road users (single vehicle accidents).

The detection failure mainly involved visibility constraint conditions (including sun glare and weather conditions) and other factors which contributed to these failures included alcohol, being lost in thought and speed.

The failures when taking action mainly involved a poor control of an external disruption (i.e. wet/oil/diesel/flood/ice/snow/defective surface) and other contributory factors apart from the road conditions which contributed to these failures included speed and a bend in the road.

It was interesting to note that failures during the 'thinking' phases did not appear at all in the sample of cases, which could either be a sample issue or this could indicate that degradation mainly affects road users in one of two ways, either by stopping them from detecting a potential conflict or by suddenly appearing when the road users attempts to undertake a manoeuvre (e.g. negotiate a bend).

Lighting

Accidents where degraded lighting was a cause mainly involved a detection failure involving the degraded lighting itself (e.g. sun glare, poor street lighting, darkness) and additional contributory factors included speed and the road user being lost in thought.

Weather

Accidents where degraded weather was a cause mainly involved failures in either detection or taking action. The detection failures involved the road user's visibility of the road being restricted by weather conditions (i.e. fog), while the taking action failures involved the road user losing control because of 'an external disruption' (e.g. high winds, snowing, raining). Speed and alcohol were additional factors identified in these degraded weather accidents.

Road surface conditions

Accidents where a degraded road surface was a cause mainly involved failures in taking action, again losing control because of an external disruption which should have been expected by the road user, but because over their over-familiarity with the road, did not adjust their driving for the conditions. This time, the external disruption was found to be ice/oil/flood/defective surface and additional factors included speed.

Hazards

In the two accidents where a hazard was contributory, one involved a failure in detection related to their focussing on only part of the situation (and therefore not detecting the actual hazard) and one involved a failure in taking action related to encountering a sudden disruption (in this case, road works beyond a hump-back bridge). Again, speed was found to be an addition contributory factor.

In conclusion, degradation scenarios appear to be particularly hazardous to a road user, either by stopping the road user from detecting a potential conflicting situation ahead or by being the direct cause of that conflicting situation, suddenly appearing when the road user is not always expecting it or prepared. The additional risk taking actions of the road user can only increase the likelihood of an accident occurring if they suddenly encounter either one of these situations.

Possible solutions to reduce the likelihood of failure occurring when a road user encounters a degraded situation would include systems which would assist the road user in detecting potential conflicts in these degraded situations. For example, hazard detection systems and also in-vehicle satellite navigation systems which display the layout of the road ahead, which would assist if forward visibility was poor. Improved road design would also help, by ensuring roads are more self-explaining, so to as avoid confusion when visibility is restricted. To assist drivers avoiding losing control when suddenly encountering a degraded situation (e.g. poor surface conditions, high winds), anti-skid devices could be installed or other devices which help the road user in keeping control of their vehicle. Also, intelligent in-vehicle information systems which inform the road user of the impending poor conditions ahead would give drivers time to make an informed decision of the speed they should approach, thereby also avoiding accidents involving inappropriate speeding.

8.2.6 Main Findings and Conclusions

8.2.6.a Summary of method used

A descriptive analysis of accidents in a number of countries has enabled a comparison to be made between degraded accident scenarios and specific accident characteristics.

These relationships were tested on an in-depth database (UK OTS) to determine whether data could be extracted according to the scenarios and characteristics identified.

Having established that this was possible, requests were then made to four counties (France, Germany, Italy and Spain), and six organisations, for data to supplement that obtained through OTS for the UK.

Each country was asked to submit causation data for degraded scenarios in general, and for the four main scenarios of lighting, weather, road surface and carriageway hazards. In each case the causation data was requested for human, environmental and vehicle factors.

Most of the analysis of this data referred to situations in which degraded scenarios **were present** in accidents.

Finally a set of 80 OTS cases where degradation was **causative** in accidents was examined. The 80 cases were divided approximately equally between the four main degraded accident scenarios. The purpose of this part of the investigation was to examine any differences between the four scenarios, differences between situations where degradation is **present** and those where it is **causative**, and to enable the opportunity to use a detailed database to determine whether additional causation factors would be revealed from that detail.

8.2.6.b Data issues found

There were large variations in the total number of accidents supplied from each source (150 cases to 120,000+ cases).

There were differences between sources in their recording of presence of accident severity.

For injury cases the KSI rate varied from 17-56% suggesting either differing priorities in data collection, or maybe varying availability on minor injury data.

The level of recording whether degradation was **present** varied between 29-80%, and the level of recording whether degradation was **causative** between 5-28%. One source did not record where degradation was causative.

Some individual degraded scenario causation factors, for example glare from headlights, are only represented from one source. A small number of causation factors are represented in all four countries.

The variations within the data make an overall analysis difficult, particularly from a point of view of attempting to provide results at an overall European perspective. Caution should be expressed regarding any comparisons between the countries' data. The lack of consistency in the number of cases, the severity index, and the proportion of cases in which a contributory factor is seen as contributing (as opposed to merely being present) make comparisons between countries difficult. If the data were grouped together, the inconsistencies would mean some individual contributions would be swamped by much higher numbers from others. However, it is hoped that even with these limitations, the results give a useful and unique overview of the accident causation issues involving degradation accidents.

8.2.6.*c* Findings from the analysis of accidents where the degraded accident scenarios were present

Variation was found in the way the four main types of degradation were presented in the accident records from the various partner's databases from across Europe. In order to minimise any inconsistencies, a "pattern" analysis was carried out to investigate the most common two causation factor groups within the accident records recorded by each source.

Human factors dominate the causation factors for degradation scenarios in general, and for the four individual scenarios. "Risk taking" (e.g. speed, driving too close) was the most commonly identified factor group within degraded lighting, degraded weather and degraded road surface. "Distraction" (e.g. within/outside vehicle/with user) was the most commonly identified factor group within carriageway hazards. Although "Visibility impaired' was as frequent as 'Distraction' for carriageway hazards it was not as frequent when considered against the selected accident scenarios.

Overall, 91% of the two most commonly recorded causation factors for degraded lighting were human factors, and 9% were environmental. Very few vehicle factors were recorded at all - at least not as commonly occurring issues.

Overall, 82% of the two most commonly recorded causation factors for degraded weather were human factors, and 18% were environmental. Very few vehicle factors were recorded at all - at least not as commonly occurring issues.

Overall, 75% of the two most commonly recorded causation factors for degraded road surface were human factors, and 25% were environmental. Very few vehicle factors were recorded at all - at least not as commonly occurring issues.

Overall, 66% of the two most commonly recorded causation factors for carriageway hazards were human factors, and 34% were environmental. Very few vehicle factors were recorded at all - at least not as commonly occurring issues.

Whilst environmental factors are of course present in the accidents being studied, in fact it is the human causation factors that are recorded more often. This could be because, in an individual case, possibly just one environmental factor is recorded, whilst human factors are more numerous. It could also be that whilst environmental factors are present the investigators feel that in the majority of cases these factors themselves are not the principle cause of the accident, it is the human failure that is the real catalyst for the accident. Certainly some accidents at night might be considered in this way.

Environmental factors contribute most in those scenarios of degraded road surface and in particular carriageway hazards, although human factor groups are still more frequent. This is because of the more unexpected element (than lighting and weather) of road surface degradation and certainly hazards.

8.2.6.*d* Findings from the analysis of typical characteristics of degradation accidents

For each of the four situations where a degraded condition was present, accidents were identified which included the most typical accident characteristics found in the descriptive analysis. For each 'typical situation', the most commonly reported causation factor groups were recorded as shown below.

The findings show that, with the exception of carriageway hazards where distraction is the most common factor group, risk taking dominates as the main causation factor in these accidents. Risk taking is recorded on 13 occasions, distraction 3 and psychological and substances taken once each as the most frequent factor groups.

With respect to the accident characteristics found in the descriptive analysis, single car accidents occur in all four scenarios. Non-junction accidents occur in three out of four, non-urban accidents occur on three out of four, and non-manoeuvre accidents occur on two out of four.

This enables a picture to be built of the "typical degraded scenario accident". It is a single vehicle crash, away from a junction, on a rural road and the driver is taking risks (e.g. speeding, travelling too close, disobeying signs/signals).

Degraded scenario	Accident characteristic	Most common causation factor groups
Lighting	single car	risk taking & psychological condition
	non-manoeuvre	risk taking
	alcohol	substances taken
	young driver under 25	risk taking
	male driver	risk taking
Weather	single car	risk taking
	non-junction	risk taking
	non-urban	risk taking
	non-manoeuvre	risk taking
Road surface	single car	risk taking
	non-junction	risk taking
	non-urban	risk taking
	non-alcohol	risk taking
Hazard	single car	distraction
	non-junction	distraction
	non-urban	distraction and risk taking

Table 47: The most common causation factor groups for each type of degradation scenario

8.2.6.e Findings from the analysis of accidents where the degraded accident scenarios were causative

The overall impression from the information gathered on accidents where degraded lighting, weather or road surface was causative was that the way the vehicle was being driven was equally as important in the chain of events leading up to the catastrophic event. The most common causation factors attributed to these accidents have tended to be associated with drivers knowingly, or unknowingly, taking risks with their vehicles or psychological conditions which have affected the way drivers are driving their vehicles.

There is a high frequency of "risk taking" causation factors associated with these accidents, there is also a common assumption that young male drivers are associated with this type of driving, which appears to be supported by the relatively high proportion of this group of drivers involved in the accidents, particularly degraded weather and lighting.

The different degraded situations appear to have little effect on the severity of the accidents which were attributed to these adverse conditions. The proportion of injury accidents to non-injury accidents in the sample from UK OTS database differs little between the different degraded conditions. Similarly there are only small differences in the proportion of killed and seriously injury accidents to minor injury accidents within each of the four degradation categories with the proportion of the serious injuries being marginally higher in degraded road surface conditions.

When road or roadside hazards were the degraded situation, and causative, the other common factor appearing in the accident records is panic behaviour. The obvious explanation for this difference in comparison with the other forms of degradation is that road or roadside hazards are sudden events, and it is the way drivers deal with these sudden events that causes the accidents rather than just the hazard.

While the largest proportion of drivers involved in these accidents in the sample were male, a large proportion of the female drivers involved were aged between 17 and 24 years old.
A large proportion of these forms of accidents in the UK OTS database also occurred in darkness which would suggest that there is a link between the two degraded situations.

8.2.6.f   Analysis using WP5 methodology

Failures in detection and when taking action were found to be most prevalent in the sample of accident cases analysed where degradation was a causation factor and involved no failures in the 'thinking' phases of the human function. The road users experienced these failures most often in situations where they were going ahead, either on a straight or a bend and very few involved any other road users.

Degraded **lighting** was mainly found to affect road users by preventing them from detecting a conflict ahead until it was too late to avoid.

Degraded **road surfaces** were mainly found to affect road users by unexpectedly making it difficult or impossible for them to control their actions (e.g. negotiating a bend), even on roads very familiar to the road user.

Degraded **weather** and the presence of **hazards** were mainly found to affect road users by either preventing them from detecting a conflict or unexpectedly making it difficult to control their actions.

It was concluded that degradation scenarios can be hazardous, either by restricting the view of possible danger or by being the main cause of the conflicting situation, suddenly appearing when the road user is not always expecting it or prepared. If the road user is risk taking, in particular speeding, as was often found in this analysis, this will only make it more inevitable for an impact to occur in either one of these situations.

8.2.6.g   Potential solutions

From the 3 main types of analysis undertaken on the in-depth data in this study, a number of solutions were suggested which could help to reduce accidents involving degradation. These include information systems which would assist the road user in detecting potential conflicts in degraded lighting or weather (visibility) conditions, plus those which would assist the driver in controlling their vehicle when faced with sudden degraded road or weather conditions or hazards (e.g. braking systems, traction control). The importance of highway design and maintenance was also highlighted, in particular street lighting and maintenance of road surfaces. Finally, improving driver awareness through education of the dangers of driving in degraded situations was also suggested.

8.3   Risk Analysis

8.3.1   Introduction

The objective of the risk analysis is to compliment the causation analysis. Where an accident problem is identified with a high occurrence, it is important to determine whether it really is a real risk. For example, if 10% of drivers have an accident at night, but only 2% of the traffic occurs at night, the risk for those drivers of driving at night is higher than for other drivers travelling at other times of the day.

8.3.1.a   Background to analysis of exposure data

Accident occurrence is related to risk factors, as described, and to exposure to risk. The risk factors describe the probability that an accident will occur, given a certain exposure to risk. So a high number of accidents can arise when an average level of risk happens often, or when a high level of risk happens for an average amount of time.

It is not surprising that the descriptive analysis discovered that degraded lighting and road surface conditions were most prevalent. Poor light conditions (darkness) occur every day, and degraded road surfaces continue for some time following degraded weather conditions (e.g. a wet road lasts longer than the period of rainfall).

Many of the reasons why certain accident characteristics are prevalent in specific degraded scenarios relate to exposure to risk. For example, young and/or male drivers are probably more likely to drive at night than older and/or female drivers. Alcohol consumption is greater at night when it is dark. Single vehicle loss of control collisions are more likely to be associated with hours of darkness, poor

weather, poor road surface and carriageway hazards, so it is not surprising that this type of accident is emphasised in degraded scenarios compared to, say, multi-vehicle collisions.

Driver fatigue could be more likely in non-manoeuvre than manoeuvre situations, fatigue is more likely at night, when it is dark. Younger drivers have relatively less experience of driving in degraded situations than their older counterparts.

A less intuitive exposure based association was the emphasis on negative breath tests on degraded road surface conditions.

This section of the report derives exposure to risk information, in order to make generalised comparisons between degraded scenarios, accident characteristics, and exposure to risk.

8.3.1.b   **Methodology**

National exposure data was researched in order to make a comparison with information gathered through the previous accident causation analyses. The nations selected were the United Kingdom, Germany, France, Italy and Spain.

For each of these countries the following information was requested. These data were considered to be possible to obtain without extensive further research costs, from internet sources. The data cover some of the degraded accident situations and some of the main accident characteristics. The data sought was considered to be that most easily applied to comparisons with the accident analysis:-

- proportion of hours in a year that are dark
- proportion of driving done at night by age and sex
- proportion of hours in a year that it rains and rainfall figures
- how long it takes for roads to dry - or proportion of time the roads are wet
- proportion of male drivers in driving population
- proportion of under 25s in driving population
- proportion of male under 25s in driving population
- proportion of road network that is rural (non motorway network)
- proportion of driving carried out on rural roads

Research was solely internet based and predominantly found on both national and European statistic type websites. The document provided by TRACE titled *Exposure Data Sources from Work Package 8* was extremely useful in guiding the search. A list of websites used can be found in the references.

8.3.2   **Results & Analysis**

Not all the information sought could be found. A summary of the useful information can be found below.

8.3.2.a   **Information Found**

Proportion of hours in a year that are dark

Based on the time of sun-rise and sun-set in 2007 the following information was calculated. The UK had the least hours of darkness while Spain had the most.

2007				Proportion	
Area	**Hours/yr**	**Light**	**Darkness**	**Light**	**Dark**
UK	8784	4826	3958	54.95%	45.05%
Germany	8784	4491	4293	51.13%	48.87%
France	8784	4508	4268	51.32%	48.59%
Italy	8784	4458	4317	50.75%	49.14%
Spain	8784	4455	4320	50.72%	49.18%

Table 48: Hours of light and darkness across 5 European countries

Proportion of driving done at night by age and sex

This information was unattainable, from the sources investigated. The information would have been useful to compare with the apparent over-representation of darkness accidents involving younger male drivers. If the exposure data shows that young male drivers drive more at night compared to say, female drivers, or older male drivers, then the accident causation results would be explained to some extent by exposure to risk.

Proportion of hours in a year that it rains

The number of hours of rain was unattainable however the number of days when it rained was found for a key city in each country. Ideally the number of hours of rainfall would provide a more accurate description of how long it was raining, compared to just the number of days on which rain fell, although neither measure says anything about intensity of rain, which could be a factor in degraded situations. The number of hours of rainfall would be a better approximation of the time that the road surface was wet – which is a crucial factor in a degraded road surface scenario.

City	Days of Rain (2007)
Paris	198 (54%)
Bremen	241 (66%)
London	256 (70%)
Rome	97 (27%)
Madrid	93 (25%)

Table 49: Days of rainfall across 5 European countries

Proportion of time the roads are wet

Information on the proportion of time roads are wet was unavailable in a precise form. The nearest consistent data was the amount of days rain fell and the amount of rain that fell (mm). As stated above, information regarding number of hours of rainfall would provide a better approximation of the amount of time that the road surface was degraded in this way. Unfortunately this data was not available, and the number of days of rainfall has been taken forward.

How long it takes for roads to dry

The amount of time it takes a road to dry could be used in conjunction with the hours (or days) of rainfall to provide an estimate of the amount of time the roads are wet.
The length of time it takes for a carriageway surface to dry is dependant on many variables. It is therefore difficult to estimate a length of time that it takes a road to dry. Weather variables for drying time include temperature, rainfall, (both intensity and continuity of rainfall), air humidity, and wind speed. Physical variables include type and quality of carriageway surface, quality of drainage and camber and cross fall of the carriageway.

Driving Population

Information on the specific number of drivers for each area was unattainable. The only relevant information that was found was the number of registered vehicles for each country, and the number of license holders (for the UK only). This data refers to the existing vehicle fleet, and the existing number of users, rather than new users. The data could be used as a proxy for the number of drivers in each country, and for the UK at least this can be broken down by age group to provide an estimate of younger drivers, older drivers, and so on. A compilation of the demography of the driving population would be very useful as exposure data. The example quoted at the start of this chapter regarding driving at night serves to illustrate this point. In order to ascertain whether the over-representation of young male drivers in night time accidents is a real risk factor, it would be important to know the proportion of young male drivers in the driving population, and the number of hours driving they do at night compared to other age groups.

UK License Holders by age (2006)	All %	Male %
17-20	34	
21-29	67	71
30-39	82	86
40-49	84	89
50-59	82	91
60-69	76	90
70+	50	76
All	72	81

Table 50: Percentage of licence holders in the UK in 2006

Country	Mode of Transport	Vehicles at end of year				
		2000	2001	2002	2003	2004
France	A = Mopeds.	1,442,000	1,421,000	1,387,000	1,357,000	1,331,000
	B = Motorcycles	968,000	1,019,000	1,054,000	1,091,000	1,131,000
	C = Passenger cars, including taxis	28,060,000	28,700,000	29,160,000	29,560,000	29,900,000
	D = Buses, coaches and trolleybuses	85,749	86,954	85,876	87,101	88,417
	E = Lorries	5,194,817	5,306,067	5,354,321	5,362,600	5,382,259
	F = Road tractors.	197,688	201,961	208,511	218,921	229,440
Germany	A = Mopeds.	...	...	...	...	...
	B = Motorcycles	3,410,000	3,557,000	3,567,000	3,745,000	3,828,000
	C = Passenger cars, including taxis	43,772,300	44,383,000	44,657,300	45,022,900	45,376,000
	D = Buses, coaches and trolleybuses	86,656	86,461	85,880	86,480	85,508
	E = Lorries	2,610,885	2,649,097	2,619,267	2,586,329	2,572,142
	F = Road tractors.	171,124	177,884	178,114	179,219	185,364
Italy	A = Mopeds.	4,451,124	4,495,813	4,540,906	...	...
	B = Motorcycles	3,376,000	3,732,000	4,050,000	4,375,947	...
	C = Passenger cars, including taxis	32,583,815	33,239,029	33,706,153	34,310,446	...
	D = Buses, coaches and trolleybuses	87,956	89,838	91,716	92,701	...
	E = Lorries	3,377,573	3,541,545	3,751,699	3,933,930	...
	F = Road tractors.	115,958	124,149	132,622	139,402	...
Spain	A = Mopeds.	...	...	...	...	...
	B = Motorcycles	1,446,000	1,483,000	1,517,208	1,513,526	1,514,000
	C = Passenger cars, including taxis	17,449,000	18,151,000	18,732,632	18,688,320	18,688,000
	D = Buses, coaches and trolleybuses	54,732	56,146	56,953	55,993	55,993
	E = Lorries	3,780,221	3,949,001	4,091,875	4,188,910	...
	F = Road tractors.	142,955	155,957	167,014	174,507	...
UK	A = Mopeds.	120,000	126,000	126,000	133,000	134,020
	B = Motorcycles	968,000	1,026,000	1,112,000	1,181,000	1,109,148
	C = Passenger cars, including taxis	25,067,000	25,783,000	26,460,000	26,953,000	27,765,100
	D = Buses, coaches and trolleybuses	177,793	176,968	177,994	179,691	182,659
	E = Lorries	2,861,463	2,960,542	3,052,688	3,072,742	3,339,765
	F = Road tractors.	301,240	286,149	286,011	299,418	319,505

Table 51: Number of registered vehicles per country and per year

Proportion of young male drivers in driving population

Data on gender split within the driving population was unattainable. More general figures for the proportion of young males aged 17-25 within the population was collected. This information could be used in conjunction with the number of drivers to estimate the number of young male drivers in each country.

Country	Total	Total Female Population	Total Male Population	% of Males	Population of 17 – 25 year olds			
					Female	Male		
					17-25	17-25	% of Total Population	% of 17-25 males
Germany	82314906	42013740	40301166	49.0%	4308479	4465940	5.43%	50.90%
Spain	44474631	22531907	21942724	49.3%	2387007	2512288	5.65%	51.28%
France	63392140	32587979	30804161	48.6%	3637777	3723967	5.87%	50.59%
Italy	59131287	30412846	28718441	48.6%	2722362	2838084	4.80%	51.04%
UK	60852828	31015208	29837620	49.0%	3603859	3765274	6.19%	51.10%

Table 52: Proportion of males and females in the population of 5 European countries

Combining the previous data (from "Driving Population" and "Proportion of young male drivers in driving population"), the following estimates have been made for the total number of vehicles used by young male drivers (aged 17-25 years old);

- France: 1,755,130
- Germany: 2,463,917
- Italy: 1,646,901
- Spain: 1,055,872
- UK: 1,718,560

In addition to this information, it would be important to know how much travelling is carried out, and at what times of the day people travelled. This information was not available. However, based on the figures quoted above, it would appear that Germany has the highest exposure to risk in terms of the numbers of young male drivers available for driving, and Spain has the lowest exposure to risk.

Proportion of road network that is rural (non motorway network)

Rural road network information could only be found for the UK for 2006 and can be seen in the following table. This provides an indication of the type of road, and hence proportion of travelling that may be carried out on each type of road. However traffic flows would be important in determining factor in terms of true exposure to risk, and further analysis of type and age of driver travelling within those traffic flows would be even better. Again, this data does not appear to be available.

Road Classification	Kilometres of road
Rural A Roads	35,612
Rural B Roads	23,950
Rural C Roads	72,985
Unclassified Rural Roads	113,826
All Rural Roads	246,373

Table 53: Rural roads in the UK

Information on the rest of the Europe was defined as motorway or non motorway.

	Home Population	Total Network Length of all Public Roads	Network Length of all Motorways	Area of State	Number of Motor Vehicles	Number of Motorized Two-Wheelers	Number of Passenger Cars and Station Wagons
France	61 538	1 000 960	10 843	551 208	37 476	2 482	30 100
Germany	82 438	644 480	12 363	357 039	54 910	5 704	46 090
UK	58 846	398 350	3 555	229 898	33 275	1 224	27 890
Italy	57 888[b]	-	6 487[c]	301 328	43 141[b]	9 782[b]	33 973[b]
Spain	43 984	666 204[a]	-	504 750	28 531	4 385	20 637

Table 54: Road type and vehicle numbers in 5 European countries in 2006 (numbers in 1000's)
(a = 2005, b = 2004, c = 2003)

Other information was found for Italy's road network. However it is hard to determine which of these classifications is the equivalent of 'rural roads'.

Road Network	National Roads	Regional Roads	Provincial Roads
172,178	21,872	23,824	119,644

Table 55: Road network length in Italy (km/1000)

8.3.2.b **Proportion of driving carried out on rural roads**
Information related to the proportion of driving carried out on rural roads was unattainable.

8.3.2.c **Analysis**
The data obtained permits some very general comparisons with the accident data obtained from the descriptive analysis.

For example, the next table compares two degraded situations (darkness and rain) with exposure data. The data for darkness days and rain days is derived from Table 48 and Table 49 respectively.

Country	% accidents in darkness from descriptive analysis	% darkness days in a year	% accidents in rain from descriptive analysis	% rain days in a year
Great Britain	30	45	17	70
France	36	49	15	54
Germany	26	49	n/k	66
Spain	35	49	13	25

Table 56: General comparison of degraded conditions 'darkness' and 'rain' from Task 2.4 descriptive analysis with sourced exposure data

8.3.3 Main Findings & Conclusions

The prevalence of a particular accident type, or causation factor, will be related in part to the "exposure to risk" for that factor or road user involved. So, for example, the finding that young rural drivers lose control of vehicles at night on wet roads and then go on to strike objects off carriageway will be affected by:

- The proportion of young drivers in the population;
- The proportion of young drivers who drive at night;
- The proportion of night time hours available for driving;
- The proportion of nights when the road is wet;
- The type of roads driven on and the positioning of objects close to the edge of the carriageway on such roads.

Exposure data was sought from published sources to compare with the accident analyses carried out. Information was derived for:

- The proportion of hours that are dark (sources for all 5 countries);
- The proportion of time that it rains (sources for all 5 countries);
- Data on the driving population (UK only);
- The proportion of males in the population (sources for all 5 countries);
- The road classification (UK only);
- The vehicle fleet (sources for all 5 countries).

Most of this information did not appear to be directly comparable to the accident analyses carried out. A comparison was made between some of the descriptive accident data for dark accidents and wet accidents, and the proportion of darkness hours and time that it rains respectively. Descriptive data was not available for Italy in either category or for Germany with respect to the proportion of accidents in wet road conditions.

The analysis revealed no general correlation between darkness accidents and the proportion of hours of darkness for each country. A relationship appeared to be made between accidents on a wet road and days of rain for the UK, France and Spain. In this case the country with the least rain (Spain) also has the least accidents on a wet road surface, and the country with the most rain (UK) has the most accidents on a wet road. However the proportion of wet road accidents varies only slightly between the three countries, whilst there is a big range in the proportion of days on which it rains. Therefore, although it rains the least in Spain, it appears that when it does rain, the risk is much greater, as the proportion of rain accidents was much closer related to the proportion of rainfall in general than in other countries. Whereas the biggest difference was in the UK, which implies that the risk during rainfall is not as great as in other countries, which may be due to drivers in the UK being more used to adapting to driving in these conditions.

When comparing proportions of darkness accidents and the proportion of darkness in general compared with the same for rainfall, in general, the tables appear to show that there is a slightly greater risk of an accident when travelling at night than when it was raining, as the difference between the proportion of accidents in darkness compared to the proportion of general darkness is generally less than those related to rainfall. It would also be interesting to compare these results with exposure information for proportion of darkness days when it is also raining. This information would really help to highlight in which of these two degraded conditions the greatest risk lies. However, this data could not be located.

In order to carry out a true exposure to risk analysis for this type of study, it would be necessary to collect data specific to the study. This would include:

- The number of hours in a year in which a road surface was wet;

- The amount of driving carried out by different age/gender groups at different times of day.

8.4   Overall Conclusions

TRACE Work Package 2 has investigated situations experienced by drivers immediately prior to a collision taking place. This report has outlined the work undertaken in Task 2.4, which has investigated degraded accidents situations, which were defined as being those which occur during sudden or temporary unfavourable conditions, leading to poor visibility of the road ahead, or poor control of the vehicle (either through physical obstructions or poor surface conditions).

8.4.1   Descriptive Analysis

After undertaking an initial review of literature to identify the main issues of degradation in terms of accident causation and risk, a descriptive analysis of data from 7 data sources across Europe and Australia was undertaken. Degraded conditions were found in at least of 40% of accidents across the data sources, with degraded road surface conditions and degraded lighting conditions being the most frequent. This analysis also identified the following typical degradation scenarios:

- A typical degraded lighting accident scenario occurs during unlit darkness and includes an emphasis on single car or moped accidents, non-manoeuvres, positive breath tests, young drivers and male drivers. Severity risk increases under unlit darkness;

- A typical degraded weather accident scenario occurs during rain and includes an emphasis on single car or goods vehicle accidents, non-manoeuvres, non-junctions, and non urban roads. Severity risk increases under fog/mist or high winds;

- A typical degraded road surface accident scenario occurs during wet/damp conditions and includes an emphasis on single car or goods vehicle accidents, negative breath tests, non-junctions, and non urban roads;

- A typical "carriageway hazard" accident scenario includes an emphasis on large vehicles, minibuses or motor-cycles, non-junctions, non urban roads, and negative breath tests.

8.4.2   In-depth Analysis

Following on from this analysis, further analysis was undertaken using in-depth accident causation data from data sources provided by 7 TRACE partners in 5 European countries, with the aim of identifying the main causes of accidents where degraded conditions contributed to the accident occurring.

The numbers of degraded accidents, and the proportion of the total accidents held in the partners' databases varied widely. The implication of this is that the occurrence of degraded accidents and the recording of these accidents are inconsistent across the areas covered by the partners and by implication Europe. However, in an attempt to find a consistent way that these forms of accident could be examined, accident causation factors groups were examined. While it was still not possible for some of the partners to provide all of this information (e.g. because it is not included in the database), the information that was available provided a suitable and consistent method to look at accidents from across the data sources.

8.4.2.a   Accidents where degradation was present

From the pattern analysis undertaken of the accident causation factors groups for accidents where degraded **lighting, weather, road surface** or **hazards** were present, it was clear that the underlying characteristics between degraded lighting, weather and road surface were similar. In all three of these situations, drivers were adjudged to have been taking some form of risk (e.g. speeding) prior to the accident. In addition to this risk taking, there is also a common thread that drivers were subject to some form of distraction or inattention. The obvious implication of this is that drivers were not taking account of the degraded situation they were driving in, in their driving either because they were unaware of the degrading effect of these conditions or through choice, and that the drivers were not mentally prepared to be able to anticipate or observe a potential problem and react accordingly in time to prevent a collision occurring.

The pattern analysis also showed that the characteristics behind accidents where a hazard was present differs slightly from the other three types of degradation. While risk taking accident causation factors

do commonly occur in these accidents, it is the distraction or inattention which is most commonly attributed as the cause of these types of accidents, in that drivers were not able to react in time to the "surprise" of the road or roadside hazard. Visibility impaired was a common factor group for hazard present accidents overall, but when the selected accident scenarios were examined it was not as frequent.

8.4.2.*b*   Accidents where degradation was a cause

These general indications were confirmed when accidents involving the most common accident characteristics for each of the four types of degradation (previously identified in the descriptive analysis) were examined. While some characteristics associated with specific accident scenarios dominated the accident causations, such as degraded lighting accidents where the driver had consumed alcohol, the background picture remained that of risk taking and distracted drivers being involved in accidents where degraded lighting, weather and road surface were present and distracted drivers unable to react to sudden hazards in accidents where a road and roadside hazard was present. Confirmation of these findings was made with accidents where these types of degradation were adjudged to have been one of the causes for accidents.

8.4.2.*c*   TRACE Work Package 5 Methodology

Using the TRACE Work Package 5 Methodology to recode a sample of the above cases (from the UK OTS database), the results revealed that the presence of degradation in general mainly led to either failures in detection (i.e. the degraded situation restricted the road user's visibility) or failures when taking action (i.e. the degradation directly affected the road user's control of their vehicle, such as when manoeuvring around a bend).

- Degraded **lighting** was mainly found to affect road users by preventing them from detecting a conflict ahead until it was too late to avoid.
- Degraded **road surfaces** were mainly found to affect road users by unexpectedly making it difficult or impossible for them to control their actions (e.g. negotiating a bend), even on roads very familiar to the road user.
- Degraded **weather** and the presence of **hazards** were mainly found to affect road users by either preventing them from detecting a conflict or unexpectedly making it difficult to control their actions.

It was concluded that degradation scenarios can be hazardous, either by restricting the view of possible danger or by being the main cause of the conflicting situation, suddenly appearing when the road user is not always expecting it or prepared. If the road user is risk taking, in particular speeding, as was often found in this analysis, this will only make it more inevitable that an impact will occur in either one of these situations.

8.4.3   Risk Analysis

Although the results of the risk analysis were limited, mainly due to the limited availability of useful exposure data that could be compared with the results of the previous analyses, a brief comparison was possible between the proportion of accidents in degraded lighting (darkness) across 4 European countries and the proportion of darkness days in one year, and the same for accidents in rain. Overall, it appeared that the risk of accidents in darkness was slightly greater than during rainfall, with this risk increasing further in countries where rainfall is less. In order to carry out a true exposure to risk analysis for this type of study, it would be necessary for more data which was relevant to this study to be available. This was unfortunately not found.

Therefore recommendations for future risk analysis would be for easily accessible data sources of detailed exposure, relevant to this sort of study, to be made available. A collective bank for many sources of exposure data was developed by TRACE Work Package 8 (Task 8.4) and was found to be useful for this work, even though the sources themselves could unfortunately not be used for this analysis. However, this method for a collective exposure data resource could be something to be developed for the future, although the relevant individual data sources also need to be available in the first place.

8.4.4   Potential Solutions

Measures to reduce the possibility of accidents involving degraded conditions occurring in the future would need to be based around driver education and awareness. If drivers were more aware of the how each of the degraded situations affect their surrounding and the way in which their vehicle interacts with these surroundings then they would have a greater appreciation of the risks they are taking, the potential problems these risks present and the consequences of these risks.

Fully educated and aware drivers may be able to appreciate the degraded situation and the effects on their vehicle but they also need to be warned that these degraded situations exist. Driver information systems will also need to be available so that drivers are full aware of the problems ahead of them, so that they can apply this knowledge and experience they have gained.

Even if drivers are not distracted in their vehicles and paying their full attention the nature of road and roadside hazards, which tend to be rare random events, mean that it is not always possible to forewarn drivers. In these cases intelligent braking and vehicle traction systems would be a possible aid to drivers. This would help reduce the possibility of them losing control of their vehicle in an emergency situation.

8.4.5   Outlook and Recommendations

In summary, the evidence from the partners' information is that while degraded situations may play a part in an accident, it is the way vehicles are being driven and the driver's attitude which are the most significant factor in the chain of events which lead up to the catastrophic event that is a collision.

Although similarities were found between the characteristics of accidents which occur when each of the four main types of degradation are present (e.g. all were more likely to be single car accidents and most involved high speed rural roads where the road user was found to be risk taking, in particular speeding), distinct differences were also found, in particular with regards to the presence of hazards. This is probably due to the fact it is much more difficult to define a hazard than it is to define poor weather lighting or road surface conditions. Therefore, one future recommendation in accident data collection would be to develop a clearer definition of what a hazard is and what the different types are (as they were found to vary greatly across the databases in this study).

Also, analysis of hazard-related accidents should be kept separate to those of lighting, weather and road surface conditions. This is because lighting, weather and road surface conditions can all be recorded as present as well as contributory, but hazards are often only recorded as being present in an accident if they are contributory (i.e. the fact that an object is a hazard makes it contributory to an accident). Further analysis on hazards alone may be able to identify how often each type is found in the road environment (e.g. surveys at specific road locations), which may also help to identify the risk of these 'objects' becoming hazards.

Difficulties were found in attempting to harmonise the data across the available data sources and countries. This highlights the importance of using harmonised data not just in analysis of descriptive data, but also in the analysis of in-depth accident causation data. Research such as the type being carried out by other European projects (e.g. SafetyNet) are valuable in trying to overcome the data harmonisation issues that were found in this study.

Although data issues were identified in the analysis, this report has been able to highlight some interesting issues related to accidents which occur in different types of degraded situations, which were found to be common across a number of countries in Europe. Issues were highlighted, such as 'typical' characteristics and why drivers fail to successfully overcome the difficulties that these degraded situations bring.

9   General conclusion and discussion

9.1   Main results

9.1.1   Intersection situations

This situation concern all road users involved in injury accident occurring at intersection/junction.

From the literature review, the thematic on the intersections is one of subjects most often approached.

Indeed, besides their tremendous number and the fact that the intersections are a place of exchange or interconnection between various roads where different road users meet together in the same place facilitating conflicts, they amplify from their intrinsic characteristics certain problems such as visibility, legibility, speed, traffic regulation, traffic flow, distraction, inattention, risk taken, etc.

Most of the study related on accident causation regarding intersections are American and based either on traffic regulation or on crash configuration (mainly for perpendicular impacts) or dedicated to the conflict between vehicle and pedestrians.

The most interesting study of a point of view diagnosis of road safety on the accidents in intersection is the one realized within the framework of the European project Intersafe. Indeed, the accident analysis developed allows on one hand to characterize what are the main problems and on the other hand, to be able to identify the most adapted safety systems. Its weakness is that this analysis is mainly based on French data.

From the general statistical approach, the main results are the following:

Europe 27	
Injury accidents	1 323 036
Fatalities	46 821
Victims	1 810 568
Serioulsy injured	293 003

At Intersection		
Injury accidents	569893	43%
Fatalities	9873	21%
Victims	805530	44%
Serioulsy injured	99009	34%

Out of intersection		
Injury accidents	753 143	57%
Fatalities	36 948	79%
Victims	1 005 038	56%
Serioulsy injured	193 994	66%

In the EU27, the accidents in intersection represent:
- 43% of the total number of injury accidents.
- 21% of the overall fatalities (1% of the casualties in intersection)
- 34% of severely injured (11% of the casualties in intersection)

The different intersection situations can be classified under 5 main scenarios. Using KSI as criteria to rank them, the result is the following:

rank	KSI	Scenario
1	59%	Scenario 1: **All intersection except "rear end" and pedestrian crash scenarios**
2	7%	Scenario 5: **Roundabout**
3	4%	Scenario 3: **Rear-End crash vehicles scenario, with no maneuver of the hit vehicle**
4	2%	Scenario 4: **"Incoming" scenarios (except pedestrian)**
5	2%	Scenario 2: **Rear-End crash vehicles scenario, with a turn maneuver of the hit vehicle**

From the descriptive analysis, the accident in intersection can be characterised by the following findings:

- Most of intersection accidents occurred during the daylight, in urban area, the weather is normal and the road is dry.
- Most of accidents occurred with one of the road users turning left.
- Most of intersection accidents occurred at intersection with regulation.
- Most of drivers involved at intersection are male.
- Most intersection accidents involved at least one passenger car.
- Most of drivers involved in intersection accidents are skilled drivers.
- Most of intersection accidents belong to the scenario 1 (53%). The scenario 1.1 (see next figure) is f)ewer in number than the scenarios 1.2 and 1.3 but the scenario 1.1 is more severe (frontal to lateral collision).
- The scenario 4 account for a few percentages of intersection accidents but the severity is high (frontal to frontal collision).
- The scenario 5 accounts for 5 % of the intersection accidents. Most of accidents occurred while no manoeuvre was performed.

The identification of the accident causes related to situations in intersection, only scenarios 1 and 4 has been studied. Unfortunately, it was not possible to study scenarios 5 (roundabout accidents) and 3 (rear-end accidents at intersection) due to the low number of cases.

Because scenario 1 covers the majority of the accidents in intersection (53% of European intersection accidents and 59% of fatalities and severely injuries), it has been divided into the two main sub-scenarios 1A (the driver having the right of way going straight is confronted to the other vehicle coming left or right) and 1B (the vehicles move on the same road in opposite direction, and one driver is turning left). The main problems identified for scenarios 1A, 1B and 4 are the following.

9.1.1.a Scenario 1A

The driver having the right of way going straight is confronted to the other vehicle coming left or right

A) Driver having the right of way (HROW)

The driver having the right of way has to drive along the main road. He didn't perform any specific manoeuvre. He is confronted to a vehicle coming from the left or the right, stopping decelerating, accelerating or driving at constant speed.

For the drivers having the right of way, the key events are also mainly endogenous (related to the driver) but closely linked to the fact they have the right of way, drove on the main road and didn't expect the situation.

We distinguish first the factors linked to the "internal conditions of the task" with the "Incorrect driving manoeuvre "(related to the risk taking; the driver sees the other driver, understands the danger but doesn't anticipate), the "Misinterpretation of the driving situation" (related to the driver who misunderstands the intentions of the other driver; he anticipates and tries an avoidance or thinks that danger is gone but he is wrong), the "Excessive speed" related to the speed limits (superior to the speed limits) while inappropriate speed is related to the driving conditions (weather, road surface, traffic…) even if the speed limit is not reached and last the "Inappropriate reaction" related to the driver who brakes to avoid the crash but locks the wheels (sample of accidents with passenger car not equipped with ABS). The vehicle slides on the road without any control. Moreover, the stopping distances are not long enough to perform a correct avoidance of the crash. The drivers HROW see the other driver (on the secondary road), but understands too late his intentions.

Then, as endogenous key events, are factors related to the "driver behaviour" mainly represented by the drivers who "failed to look". The driver looked at the traffic but didn't see the other vehicle because he didn't search the information (right of way feeling).

Driver having the right of way presents mainly Prognostic Failures. This driver is waiting for the regulation performed by the other driver (sees the other vehicle slowing down up to the intersection

but thinks he is going to stop) or waiting for no maneuver performed by the other driver (sees the other vehicle stopped on the secondary road but doesn't anticipate his maneuver) or last waiting for no obstacle on the carriageway (unusual maneuver performed by the other driver). The ¾ of "prognostic failures" find explanation with endogenous explanatory elements (related to the driver) such as the right of way feeling, the inappropriate speed and last the time constraint, risky driving and misunderstanding of the situation. In almost nine cases on ten "Prognostic Failures", the drivers having the right of way braked before the crash. Despite these drivers has performed a braking manoeuvre to avoid the crash, the accident happened.

Then driver having the right of way presented "Perception Failures". These failures can be explained by a focused attention (on the priority rules) or inattention (lost in thought), no visibility (moving mask), no look (break in information search because of non driving task) and last a quick look (feeling of right of way). Half of these drivers braked before the crash. The last half didn't react.

Whatever is the human functional failure (perception or prognostic), most of drivers having the right of way performed an emergency action to avoid the crash. If we compare the stopping distance (distance required to stop) to the available distance (distance to crash from the perception or the understanding of the situation), 66% of the drivers had not the distance required to stop their vehicle and avoid the crash. The drivers braking before the crash didn't avoid the accident because they had not the time and the space to perform a manoeuvre, they drove too fast (excessive speed), the road surface was wet, decreasing the efficiency of the braking and last they had not the visibility to see the other driver.

The other drivers didn't react before the crash because they had no time to perform an emergency manoeuvre. It means that despite they have seen the other driver (on the secondary road) it was too late to react. Because the other driver (on the secondary road) performed an atypical or illegal manoeuvre (didn't stop at STOP, pulled out while crossing traffic don't allow the manoeuvre), the driver having the right of way couldn't anticipate.

B) Driver having not the right of way (HNROW)

The driver has to cross the main road or to turn into the main road. He has to manage his driving maneuver and the traffic along the main road.

For the drivers having not the right of way, the issues are different from the drivers having the right of way. It is important to highlight the differences in order to adapt accurate counter-measures.

In this case, the key events are mainly Endogenous (related to the driver) with:

- The factors linked to the "internal conditions of the task" (factors related to the driving task such as the driving manoeuvre (turning, going straight) correctly performed or not). These drivers are more likely concerned by "incorrect driving manoeuvre" such as "non respect of regulation" and "incorrect decision" to perform a manoeuvre according to the available information (visibility or the available time opposite the main road traffic). Then a "poor evaluation" of the situation or of the opponent manoeuvre (means that drivers saw the other vehicle (on the main road) but all the drivers estimated having time to cross) and last a "misinterpretation of the situation" (includes poor experience of the site, misleading infrastructure leading to legibility problems (the road is not like we think it is!) and several factors such as driver state or visibility (mask)).

- The factors linked to the "driver behaviour" (factors directly linked to the driver awareness of the situation (attention, distraction for example)). In this case, most drivers "failed to look" because of exogenous factors related to the infrastructure and the environment (road layout, mask, weather luminosity) and to problem of geometrical visibility (sight distance), directly linked to the road layout.

Drivers having not the right of way present mainly "Perception Failures". The "Perception Failures" can be explained by a quick look (rapid information search such as a quick look at the environment and the opponent), a focused attention (failure in the information search organisation such as a focus

on a part of the situation at the expense of the opponent vehicle), no look (break in information search such as the driver stopped searching information (ex: he performed other task than the driving task)), no visibility (information detection strain such as the information is not available or there is a geometric mask)) and last inattention (information search negligence such as low driving task strain, inattention…).

Because, the driver didn't perceive correctly the opponent vehicle, he couldn't anticipate and avoid the crash. Only 1/3 drivers HROW, with Perception Failures, attempted to avoid the crash by braking or accelerating while 2/3 didn't react before the crash. Moreover, 20% of these drivers drove at excessive speed reducing the chance to avoid the crash with a braking action.

We also highlighted that despite the fact the proportion of older drivers (65+) in the TRACE sample is low (11% of the drivers at intersection), they are more often involved as "driver Having Not the Right Of Way" than the other age classes. It means that older drivers have problem to manage the driving task at intersection and especially when they have not the right of way. These drivers (65+) are also more involved turning at "Yield" regulated intersection than other regulation while younger drivers (<25) are more likely involved at traffic lights. It means that when older drivers have not the right of way and have to manage with Yield regulation, they fail to perform their manoeuvre.

Generic counter-measures proposition

The main generic counter-measures related to the scenario 1A drivers as a whole involved at intersection are first closely linked to the older drivers then the driver perception in the whole and last the driver emergency manoeuvre.

In this way we need to think about the best way to help the older drivers at intersection. Drivers are getting older as the population and this problem is going to be predominant in the future. Today the best way to help them with the available ITS is the detection of obstacle. But when older drivers perceived the other vehicle and performed a manoeuvre such as crossing the main road or turning left into the main road, they are confronted to a rapid traffic while they need more time to perform their manoeuvre. So, the best help is to reduce the approach speed limits on the main road to allow older drivers to perform the manoeuvre.

Then drivers having not the right of way need to be helped to perceive the other vehicle to look properly and to detect the other vehicle. It is necessary to control the available geometric visibility (sight distance) and improve the visibility in case of problems, to develop new road layout with appropriate sight distances.

Last, the drivers having the right of way need to be helped first to be more attentive (more concentrated on his driving task) and last to anticipate the other driver manoeuvre. These drivers have a strong feeling of right. They don't appreciate the situation as a risky one but rather as a security one. They see but don't anticipate or too late. They need to be informed of the risky situation with an up-to-date navigation tool that informs the driver of the risk to be confronted to a risky situation according to the geometric, visibility constraints, to the referenced black spots. They also need to be help along their emergency manoeuvre. AFU can reduce the braking distances.

9.1.1.b Scenario 1B
The vehicles move on the same road in opposite direction, and one driver is turning left

Despite most of key events are related to the driver turning left, both driver situations, turning left or going straight, are characterized by endogenous key events (related to the driver).

Drivers turning left endogenous events reflect the misunderstanding of the driver and the problem of perception of the other vehicle.

Drivers going straight endogenous events are related to the excessive speed, the poor experience and the fact they failed to look.

Human Functional Failures depends on the driving manoeuvre performed. Drivers who are turning left presented rather perception failures while the drivers who are going straight presented perception and prognostic failures.

Emergency reaction depends on the driving manoeuvre performed. Drivers turning left didn't react while the drivers going straight braked.
The problem related to the age of the driver is mainly present for older drivers having turning left.

Generic counter-measures proposition

The main generic counter-measures related to the scenario 1B drivers as a whole involved at intersection are closely linked to the older drivers performing the manoeuvre and to the drivers having the right of way.

In this way we have to think about the best way to help the older drivers at intersection. Older drivers do need a regular training to learn the best way to perform manoeuvres especially at intersection. Other solution is to think about the environmental planning and the road layout to improve the legibility of the road.

The drivers having the right of way need to be helped to anticipate the other driver manoeuvre. These drivers need to be informed of the intentions of the other driver in order to be able to anticipate the situation even if they have the right of way.

9.1.1.c   Pedestrian scenario
Despite the lack of information we know that pedestrian are mostly involved at intersection with no regulation or traffic lights. In this configuration, youngest and eldest are overrepresented.

Most of time the accident causation factors are first related to the "pedestrian" and then to the "internal conditions of the passenger car driver task".

For both pedestrian and passenger car, "failed to look properly" is the first causation factor. In fact the visibility problem related to this scenario is particular. The visibility is linked to the manner the pedestrian cross the road. Half of intersection accidents involving pedestrian in our sample occurred during the night and most of them inside urban area. We suppose that in daylight the problem can be linked to the different traffic flows, the urban environment, and the "visual pollution". The literature review highlighted that when volumes are higher than 12 000 vehicles/day, marked pedestrian crossings on multi-lane roads were more prone to crashes than unmarked locations, and the risk goes up as the volume rises. During the night the problem is different. We know that factors such as contrast related to the vehicle colour and lights and to the pedestrian clothes appear to have an effect on the conspicuity of both users.

However, pedestrian are mostly involved at intersection with no regulation or traffic lights. In this configuration, youngest and eldest are overrepresented. Moreover, half of youngest are less 10 while half of eldest are 70+.
Half of the pedestrians are crossing at intersection with no regulation. But the half of them is crossing at traffic lights intersection! The studies that have been done indicate that pedestrians look before crossing at both marked and unmarked pedestrian crossings, except at signalized intersections.

In spite of the fact that 60% of passenger car drivers braked before the crash, 40% of them didn't react! In fact 9 pedestrian accidents out of 10 engaged the pedestrian fault and could explain the lack of reaction. Moreover, all intersection accidents involving a pedestrian occurred when the initial speed of the passenger car was lower than 60 km/h. For half of them, the initial speed was lower than 40 km/h. Passive safety survey (ref LAB) performed on pedestrian accidents shows that when the impact speed is raised from 45 km/h to 55 km/h that is to say "only" 10 km/h, the fatal risk (the risk to sustained fatal injuries) is raised as well from 30% to 50%!

Generic counter-measures proposition

Generic counter-measures linked to the pedestrian intersection accidents are related to the vehicle (passenger car) driver.

In this way, the passenger car driver needs to be helped to perform his emergency manoeuvre. The driver braked most of time (60%) but didn't avoid the crash. AFU can be useful and help the driver.

They also need to be helped to prognostic the presence of a pedestrian, to see the pedestrian and to anticipate the avoidance. Obstacle detection is required when the pedestrian is on the road but when pedestrian is previously masked the detection is more difficult. Navigation tools can be useful to inform the driver about a potential risk zone (pedestrian presence likelihood).

9.1.1.d   Main risk factors

Risk analysis led us to confirm that the probability to be killed when the user is involved in accident at intersection is higher (1.3) than the probability to be killed when the user is involved out off intersection.

Excessive speed is also a risk factor that increases the risk to be killed at intersection. So, when users driving with excessive speed are involved at intersection accident, the risk to be killed or MAIS3+ is 1.44 higher than for users driving fast (excessive speed) out off intersection accidents.

Sight distance was also highlighted as a fundamental risk factor. Geometrical visibility increases the risk to be involved at intersection accidents. It is more likely probable (4 times) to be involved out off intersection when the geometrical visibility is reduced than at intersection.

Drivers having the right of way performed more likely an emergency manoeuvre when they had the right of way. The conditions at intersection allow to perform slightly less emergency manoeuvre than out off intersection.

Human functional failures are fundamental too to explain the way the drivers failed. In fact, it was highlighted that the risk to have a problem of perception is 1.4 higher at intersection than out off intersection.

9.1.2   Stabilized situations

A stabilized situation is defined as the driving situation just prior the accident that can be considered as "normal", i.e. a situation in which a driver/rider does not have any difficulty in the driving task, and without any particular or abnormal solicitation. All stabilized situation occurred in intersection are here excluded.

From the general statistical approach, the main results are the following:

In EU27, the stabilized situations represent:

Europe 27	
Accidents	1 323 036
Fatalities	46 821
Victims	1 810 568
serioulsy injured	293 003
Situations	2 574 310

In Intersection		
Accidents	569 893	43%
Situations	1 139 787	44%

Out intersection		
Accidents	753 143	57%
Situations	1 434 523	56%

Stabilized situations		
Situations	1 254 321	87%

Specific maneuvers		
Situations	180 202	13%
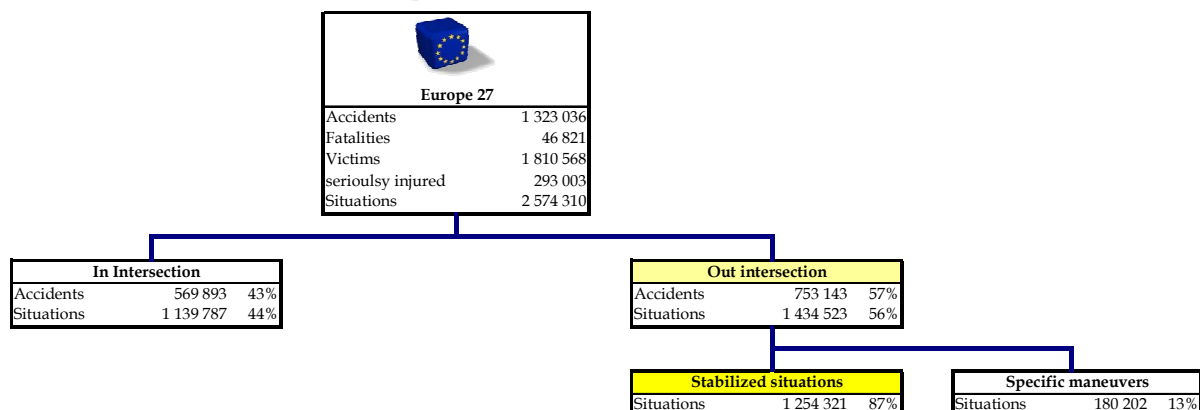
- 49% of the total number of situations.
- 33% of the total number of injury accidents in Europe (estimation relying on results coming from Spain, UK, France, Greece and Czech Republic)

Despite the lack of information in aggregated databases regarding this situation, 4 main scenarios has been determined from the descriptive analysis and confirmed by the in-depth analysis. The identification of the accident causes was conducted for each scenario. The most important results regarding the accident causation for stabilized situations are the following:

9.1.2.a   Situation 1: Pedestrian accidents

Characteristic of this scenario: a driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian.

This scenario has been divided into 3 sub-scenarios: scenario 1a (pedestrian crossing from left), scenario 1b (pedestrian crossing from right) and scenario 1c (pedestrian moving along the roadside).

The number of accidents analysed related to this scenario (scenario 1) was 117 cases (this means, 7% of all the stabilized situations), being almost 80% of them came from pedestrians crossing the road (situations 1a and 1b).

The main causes identified for these 3 sub-scenarios are the following:

Situation 1.a ('Pedestrian crossing from left')

This kind of accidents represents almost half of the pedestrian situation accidents. Some general characteristics are: The accidents happen in urban areas (61%), in single carriageway roads (67%), with good weather (72%) and good lighting conditions (daylight 51%) and curiously in a straight section road (65%). In most of the occasions the driver was a male with a high experience (more then 5 years driving).

The analyses performed over the in-depth databases available to this task shows that the main accident causation was a pedestrian error (61%), being 'recognition error' and 'to invade or cross the road illegally' the most common.

During the analysis of the Human Function Failures (HFF), the HFF analysis was applied over the accidents belonging to this situation. Confirming the mechanism of these accident, the most common failure found in these accidents was related to the perception, 'Non detection in visibility constraint detection' (P1), specifically, the passenger car driver was surprised by the pedestrian (P1C) non visible when the car is approaching.

Also, it has been found that the pedestrian crossed not obeying the rules, so the most possible configuration of accident could be a pedestrian, non visible by other vehicle, was knocked down whilst the pedestrian was crossing the road illegally (there was not pedestrian cross).

Two main causation factors have been identified as prevalent for this sub-scenario:
- The pedestrian is crossing the carriageway not obeying traffic rules.
- There is a recognition error made by the pedestrian.

Indeed, after analysing the correlation between both factors they show a relevant relationship (r = 0.707, p-value = 0.01). This can be explained by the fact that the pedestrian is crossing the carriageway illegally because he falls on a recognition error analysing the traffic situation. This error might be caused, under the knowledge of the authors, either by the road infrastructure, the misjudgement of oncoming vehicle speed or even because the pedestrian "did not look twice".

The logistic regression analysis has shown that this sub-situation is more likely to happen on straight section that on curves (Odds Ratio (OR) = 2.5; p – value = 0.05). This means, the probability of happening in a straight section is 2.5 than happening in curve sections (150% higher).

Situation 1.b ('Pedestrian crossing from right')

This situation gathers 46 cases. The characteristics of these accidents are quite similar to the previous situation ones: Male driver with more than 10 years of driving experience, driving along a straight stretch in an urban area under good weather conditions and daylight.

The Human function failures detected were 'P1C' (Passenger car driver surprised by a pedestrian non-visible when approaching' in 65% of the occasions and 'P2C' (Passenger car focalisation towards a source of information regarding the importance of the traffic flow) in 20%. This means that in these accidents, the passenger car driver was surprised by the pedestrian in visibility constraint conditions and also, the passenger car driver was focalising towards a source of information regarding the importance of traffic flow. Of course, there is a perception problem in this situation due, linked mainly to the surprising pedestrian way of crossing.

According to the previous circumstances and the causation factors explained below, these accidents seem to happen when a pedestrian was trying to cross the road illegally (out of a pedestrian cross) made a recognition error due to low level of attention and got knock down by another vehicle which could not see the pedestrian on time due to visibility limitation (trees, road layout, parked cars…). As it can be understood, this is very important finding because here a possible detection device will not be able to help the driver, except if the device could detect the pedestrian after these visibility limitation.

In this case three causation factors have been found as relevant:

- PEDESTRIAN ERROR:
    - The pedestrian is crossing the carriageway not obeying traffic rules.
    - There is a recognition error made by the pedestrian.
- PEDESTRIAN STATE:
    - Low level of attention

In the case of pedestrian error, the situation is similar to 1.a, this means, the pedestrian is crossing the carriageway illegally because he falls on a recognition error analysing the traffic situation. In this case the correlation showed to be even stronger ($r = 0.901$, p – value = 0.01).

From the logistic regressions done, it was concluded that 'Pedestrian gender' can be considered as risk factor. In this way, in the cases the accident causation had been due to invade or cross the road illegally, it is more likely for male pedestrians (OR = 3.6; p – value = 0.05).

When the accident was mainly caused due to a low level of attention, it has been found that this causation factor is more likely to appear in curve sections than in straight roads (OR = 2.3; p – value = 0.05). Visibility obstructions caused either by the road infrastructure or other vehicles are deemed to be linked to this issue.

Situation 1.c ('Pedestrian moving along the road on right side')

Not many accidents of this type were registered on the in-depth database (only 5 cases, this 4% of situations type 1). For the few accidents found, the most common HFF found is that the passenger driver is G2A 'Alteration of trajectory negotiation capacities'. Due to the lack of this type of accidents, is difficult to describe the prototypical motions of the pedestrians and the other vehicles, as well as concerning risk analyses, there were not enough data available to do the analyses.

9.1.2.b   **Situation 2: Lane departure**
Characteristic of this situation: A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident.
This is the most common situation in the sample from the information requested to In-depth suppliers. 920 cases were gathered, which represents 54% of all the stabilized accidents analyzed.
This scenario has been divided into 3 sub-scenarios : scenario 2a (lane departure) scenario 2b (run off accident to the left) and scenario 2c (run off accident to the right).
Situation 2.a ('Lane departure')

The majority of these accidents occurred under good weather conditions (71%) but there is a significant percentage of accidents which happened whilst it was drizzle (13%). Some common characteristics are that most of them were on a single carriageway road and with daylight.

Attending to the information displayed, these accidents could happen when a driver, sometimes under alcohol consumption, was driving speeding and confront a complex site as a bend with a small radius.

Other possible typical could be when the driver loses the control due to the slide surface even when it was expectable under drizzle weather.

In these accidents, what the passenger car driver did related his failure was T1C ('The passenger car driver has an erroneous evaluation of the bend in a context of playing-driving') in more than 50%. This means that this is a human failure directly related to the diagnostic stage when the passenger car driver did not evaluate correctly the passing road difficulty, specifically, at the moment of negotiating a bend in a context of playful-driving, curiously. Another aspect to be considered for the human behaviour was that in 10% of the occasions, the driver sudden encountered of an external disruption, although it was more or less expectable. This last consideration can agree with the fact that the driver find some external modifications of the road (curve radius, narrow road,…).

Four accident causation factors have been found relevant, not showing a correlation between them after performing the correlation analysis (p-value = 0.05):

- PASSENGER CAR ERROR:
  - Erratic action: speeding (16%). All accidents happened in single carriageway roads, being increased the probability for this causation factor in sharp curves (OR = 4.87 compared to soft curves and 11.36 compared to straight, p – value = 0.05).
  - Decision error (14%). For this causation factor not relevant results have been found in the logistic regression analysis. From a descriptive point of, view, most of the accidents happened urban area under good weather conditions. Taking into account 'cross-tables' in the statistical analyses, urban area is 4.24 time more than rural area and straight alignment is 4.84 times more than curve
- PASSENGER CAR STATE:
  - Alcohol impairment (14%). Urban area (OR = 2.26, p – value = 0.05) and male driver (OR = 4.18, p – value = 0.05) appeared as factors increasing the risk for being causation factor of being present.
- PASSENGER CAR TRAFFIC: In this case, the causation factor is related to the environment around the passenger car which runs off.
  - Environmental perturbation (loss of adherence such as ice, aquaplaning, oil, snow…, 22%). Factors that increase the probability of having this causation factor are a single carriageway road (OR = 2.87, p – value = 0.05 compared to double carriageway), sharp bend (OR = 4 compared to soft curves and 11.76 compared to straight, p – value = 0.05), male driver (OR = 2.32, p – value = 0.05) and bad conditions (OR= 4.07, p – value = 0.05 compared to good weather).

Situation 2.b ('Run-off accident to the left')

These accidents happen outside urban areas (68%), with good weather conditions (79%), half of them with daylight but also a high percentage (36%) at night.

A description of how these accidents occurred could be: male driving at night in with a low level of attention due to the road layout (accidents in double carriageway road 29%) or a secondary task when confront a sharp bend.

Other possible explanation of this type of accidents is a driver confronting a bend loses the control due a recognition error by excessive speed and/or bad weather conditions.

The most common human function found in the WP5 analyses over the accidents from this scenario show that there are two main HFF:

- The first one is related the low level of attention the driver had during the driving task, therefore, 'E2A' (Guidance interruption consequently to attention orientation towards a secondary task) has been chosen as the first function failure of the driver (20% of the accidents

in this situation '2b'). This HFF shows as the driver had a guidance problem at the handling stage. To be more concrete, he had a guidance interruption consequently to attention orientation towards a secondary task (different to driving task, of course). This failure can be applied to run-offs in curve and straight sections.

- The second failure concerns only to bends. In these accidents, the driver evaluated in an erroneous way the passing road difficulty. 'T1B' ('Erroneous evaluation of a passing road difficulty, specifically, under evaluation of the evaluation of an although known bend') This failure at the information diagnostic stage gives the understanding of what happened, the driver knew the bend where he was travelling, but a bad evaluation of the bend was the driver failure (also, 20% of the accidents in this situation '2b').

Four accident causation factors have been found relevant:

- PASSENGER CAR ERROR:
    - Speeding (38%). This causation factor showed to be more likely when the following factors are present; single carriageway (OR = 2.68, p – value = 0.05), bad weather conditions (OR = 2.93, p – value = 0.05), sharp curves (OR = 4 compared to soft curves and 11.76 compared to straight, p – value = 0.05) and male driver (OR = 2.32, p – value = 0.05).
    - Decision error (22%). In this case, there are more probabilities to commit a decision error at night time (OR = 1.53 compared to twilight and 1.72 compared to daylight, p – value = 0.05) and sharp curve (OR = 1.60 compared to soft curve and 3.97 compared to straight sections, p – value = 0.05).
- PASSENGER CAR STATE:
    - Alcohol impairment (15%). Urban area (OR = 2.23, p – value = 0.05) has been shown as the only factor increasing significantly from the statistical point of view the probability for this causation factor of being present at the accident.
- PASSENGER CAR ENVIRONMENT:
    - Complex site, difficult site, narrow road (16%). This causation mechanism is more likely outside urban area (OR = 3, p – value = 0.05) and in sharp curves (OR = 5.74 compared to soft curves and 50 compared to straight sections, p – value = 0.05).

The variables speeding, decision error and complex site showed some correlation (r = 0,305 & 0,393, p – value = 0,01). This might be explained by some situations where the road infrastructure layout do not transmit the driver a transition from a long distance along a straight section to a sharp curve, causing this an error in the driver evaluating the speed at he is able to handle the bend.

Situation 2.c ('Run-off accident to the right')

This situation is practically equal to the previous one. Run off accidents which occurred outside urban areas (70%), with good weather conditions (79%) in a single carriageway (67%).

These accidents seem to happen when a male driving in a single carriageway road confront a slight or normal bend with a low level of attention or attending to a secondary task is surprised by the site because is more complex of what he thought.

As the previous situation, other possible explanation of this type of accidents is a driver confronting a sharp bend at night in a single carriageway loses the control due to inadequate speed and/or bad weather conditions.

In this case, the HFF chosen are the same as the previous scenario, but in different percentages:

- The most common HFF detected in this scenario was a human failure at the handling stage, specifically 'E2A' ('Guidance problem due to a guidance interruption consequently to attention orientation towards a secondary task') in 30% of the accidents in this situation '2b'. What means that the driver had a guidance interruption consequently to attention orientation towards a secondary task. As it can be supposed, this failure can be applied to run-offs in curve and straight sections.

- The second failure (although only present in 10% of the accidents) concerns only to bends. In these accidents, the driver knew the bend where he was travelling, but a bad evaluation of the bend was the driver failure ('T1B', this is a failure at the diagnostic stage, specifically called 'Erroneous evaluation of a passing road difficulty, specifically, under evaluation of the evaluation of an although known bend').

These kinds of accidents are due to similar accident causation than the previous situation (2b). Accidents are due to low level of attention associated to alcohol impairment or decision error.

From the risk analyses done over the four most relevant accident causation factors, it has been found:

- PASSENGER CAR ERROR:
  - Speeding (34%). This causation factor showed to be more likely when the following factors are present; single carriageway (OR = 2.53, p – value = 0.05 compared to double carriageway), during night lighting conditions (OR = 1.49, p – value = 0.05 compared to daylight conditions), curves (OR = 3.16 compared to straight sections, p – value = 0.05), specifically, slight or normal curve is 1.96 times more than sharp curve and 3.69 times more than straight, and, finally, male drivers (OR = 1.97, p – value = 0.05).
  - Decision error (16%). In this case, only the variable 'road' was selected as risk factor from the analyses. Single carriageway is 1.73 times more likely than double carriageway.
- PASSENGER CAR STATE:
  - Alcohol impairment (13%). Urban area (OR = 2.35, p – value = 0.05) has been shown as one of the factors increasing significantly from the statistical point of view the probability for this causation factor of being present at the accident, as well as single carriageway (OR = 2.39, p – value = 0.05). Nevertheless, the factor associated to this accident causation with higher index 'Odds Ratio' is 'night' (accidents during night are 3.29 times more than twilight and 8.55 times more than daylight).
  - Low level of attention (14%). Double carriageway roads (OR = 1.91, p – value = 0.05) has been shown as the only factor increasing significantly from the statistical point of view the probability for this causation factor of being present at the accident.

A comparison between the results from in-depth and risk analysis in stabilized situations in scenario '2' and the results from the literature review in D2.1 shows:

✓ In bends: Attention, speed, lane layout, perception, presence of signals and driver age has to be considered.

✓ Literature review shows that in single vehicle accidents, the main important risk factor is speed, which tends to increase risk factor. First of all, this conclusion should be done knowing if these accidents have been under stabilized situations. On the other way, analyses over TRACE in-depth database show that this factor increases the risk of being involved in specific characteristics for each sub-situation (for example, single carriageway, male driver, curves…).

9.1.2.c Situation 3: Vehicle confronted to another vehicle.

Characteristic of this situation: a driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle.

The number of cases analysed from the In-depth suppliers was equal to 442 cases (25% of the total stabilized sample). 3 sub-scenarios were detected: scenario 3a (Reduction of driving space due to opponent overtaking), scenario 3b (Reduction of driving space due to opponent loss of control), scenario 3c (Same lane but the opponent is stopped), scenario 3d (Same lane but the opponent is with lower speed) and scenario 3e (Same lane but the opponent is coming rear). The main results for each sub-scenarios are the following:

Situation 3.a ('Reduction of driving space due to opponent overtaking')

The stereotype of this kind of accident is a head-on accident between two passenger cars, whose drivers are male with high driving experience (more than 10 years). These accidents happened outside

urban area (81%), mostly, in straight sections (62%) of single carriageway roads (66%). Just mention that there were 53 accidents of this type within the database.

The accident happened due to the opponent vehicle behaviour at the moment of overtaking. The opponent vehicle decides to overtake, but he commits a decision error because it is not the best moment to overtake. The driver, who is doing an aggressive way of driving, failed at the moment of looking if another vehicle is coming (the stabilized vehicle). Therefore, the most common accident causation (40% of the accidents) is a decision error at the moment of the overtaking, being accompanied by a failure at the moment of recognition and therefore an inadequate speeding. This mechanism of the accident agree with the result of the Human Function Failure analysis, in which 'E1' ('Sudden encounter of an external disruption', this is a human failure at the handling stage) shows that the opponent vehicle had a poor control of the external disruption.

From the risk analyses done over the most relevant accident causation factors, it has been found:
- OPPONENT ERROR:
  - Decision (32%). This causation factor showed to be more likely when the following factors are present:
    - Curve (O.R. = 8.35, p – value = 0.05 compared to straight sections). To be more concrete, slight curves are 2.33 times more than sharp curves and 10.57 times more than straight.
    - Male drivers are 2.55 times more likely to suffer this kind of accidents than females.

As it can be saw, during the whole risk analyses done in this chapter, all the results have been showed from the point of view of 'Which categories can increase the risk of been involved in a stabilized accident?', therefore, if we desire to know which factors decrease the risk of being involved we would only have to study the situation (Odds Ratio) from the opposite point of view.

Situation 3.b ('Reduction of driving space due to opponent loss of control')

In this situation all the possible causes come from the opponent vehicle. These accidents represent 20% of the collisions within this situation. There are many possible configurations about this type of accidents, but the most common is the loss of control due to opponent error (25%), especially due to the speeding or decision error during the travelling task. Although this is the main accident causation, the environment contributed in more than 30% of cases. For example, the bad condition of surface or even the complexity of the road (narrow road) could be considered as cause in 10% of the accidents.

Going back to the accidents due to the driver of the opponent vehicle, obviously the state of the opponent driver has been considered as relevant. In 20% of the accidents, this has been considered as causation factor (taking into account in 10% of these, there was alcohol impairment, and in other 10% there was low level of attention).

Why did the opponent driver lose control? The analyses over the human function failure show us that the opponent vehicle loss control due to loss of psycho-physiological capacities consequently to a failing asleep or ill-health (G1A from the opponent point of view) and what happen is that the stabilized vehicle does not detect the rapprochement of the vehicle ahead.

If we would desire to know the main characteristics about the character, it could be said that after the loss of control of the opponent vehicle, this vehicle (which is a passenger car) collides against the stabilized vehicle (which is another passenger car, of course) in a head-on way. The drivers are in both of the cases, males with a high driving experience). The location of this sub-scenario is outside urban area. The kind of road is, mostly, single carriageway roads, therefore the type of collision would be head-on or even front-side due to the last reaction of one of the driver before crashing and trying to avoid the accidents with a sudden swerve.

The risk analyses done over the most relevant accident causation factors shows:
- OPPONENT ERROR:
  - Speeding (16%). This causation factor showed to be more likely when the following factors are present; bad weather conditions (OR = 3.06, p – value = 0.05 compared to

good weather conditions), during night lighting conditions (OR = 2.41, p – value = 0.05 compared to daylight conditions), curves (OR = 2.3 compared to straight sections, p – value = 0.05), and, finally, female drivers (OR = 1.74, p – value = 0.05).

Situation 3.c ('Same lane but the opponent is stopped')

The 96 accidents are located either in single carriageway (56%) or double carriageway (40%), between two passenger cars in a rear-end collision. These accidents are due to a failure (P5A: 'Late detection of the slowing down of the vehicle ahead') from the stabilized vehicle which is travelling and due to the low level of attention and a low safety distance, it collides against the vehicle ahead. In these accidents, there is no problem related to speed from the 'bull vehicle' (the stabilized in this case).

The risk analyses done over the three most relevant accident causation factors shows:

- STABILIZED ERROR:
    - Decision error (46%). This causation factor showed to be more likely when the following factors are present; double carriageway road (OR = 2.08 compared to single ones, p – value = 0.05), and, male drivers (OR = 1.84, p – value = 0.05). Near 96% of the accidents were in straight sections.
    - Not keeping safe distance (42%). During the logistic regressions, no significant variables were found to be significant. The only important aspect was the fact that 95% were in straight sections, and near all of them (except one accident) were rear-end accidents.
- STABILIZED STATE:
    - Low level of attention (46%). This causation factor showed to be more likely when double carriageway road is present (OR = 1.91 compared to single ones, p – value = 0.05). Also, 94% were in straight sections.

It has been found that, after looking at the respective correlation table between these three factors, the factor 'decision error' is related to the other two ones. The interpretation of this correlation could be that when a decision error appears, this can be due to the lack of attention from the driver or the lack of safety distance.

Situation 3.d ('Same lane but the opponent is with lower speed')

This type of accidents could be considered similar to 3.c, but now, the difference is in the targeted vehicle. Instead of being stopped, the targeted vehicle is with lower speed while the stabilized vehicle comes from rear and impact against this first vehicle. At a first view, it can be thought that the mechanism of the accident and the accident causation can be very similar to the main findings in the previous situation 3.c (in those accidents, the main accident causations came from the stabilized vehicle) but the analyses over the in-depth information show that is the opponent vehicle (targeted vehicle) which is the cause of the accident. The data sample had 33 cases which belong to this scenario.

Firstly, it can be said that the location of the accident is outside urban area (72% of the accidents), and curiously the happen more frequent in dual carriage way (56%) than in single ones. Also, the light conditions match up with daylight conditions, although the quantity of the accidents during the night is higher than in scenario 3.c (25% instead of 16%). As in the previous scenario, this kind of accidents happen in straight sections (85%), but the biggest difference with the previous scenario is concerned with the type of collisions. Whereas in the previous scenario the kind of collision was rear-end in majority, in the present situation there are too much sideswipe collisions (17%).

For understanding what happens in this scenario, the analyses of accident causation and human function failure can help to detail the mechanism of the accident. While the HFF analysis tells that the stabilized vehicle had a late detection of the slowing down of the vehicle ahead ('P5A: Late detection of the slowing down of the vehicle ahead' belonging to failures at the detection stage), the analysis of the accident causation shows the striking result that, it is the opponent vehicle the one that the accident causation comes from. Recognition error and low level of attention from the opponent vehicle

driver (this is the targeted vehicle) are the most common causes of the accidents, so, it could be said that the mechanism of the accident (once it is know when, where and who are the characters) consists on a passenger car which does not give enough attention to the driving task and make a sudden manoeuvre (with or without braking) that supposed that the stabilized vehicle (which is travelling with a higher speed).

The manoeuvre done by the opponent vehicle (due to a decision error and low level of attention), supposes a sideswipe collision in a double carriageway road or a rear-end collision, probably in a single carriage way road.

It is important to mention the importance of the in-depth analyses versus extensive database. In some of the countries, for example, Spain, the guilt in rear-end accidents is, in majority, the vehicle which collides against the vehicle ahead without taking into account what the vehicle ahead has done and considering the fact that if the stabilized vehicle would have kept the safety distance, these accidents would not have happened. Thorough the in-depth analyses, it has been showed that the real causation comes from the opponent vehicle and the sudden manoeuvre, independently it was ahead.

Although the passenger cars continue being the most common vehicles in this kind of accidents, trucks (as stabilized vehicle in 25% or opponent vehicle 18%) takes a higher percentage related the other scenarios.

Finally, due to the low quantity of these accidents, it has not been possible to do the respective risk analysis.

Situation 3.e ('Same lane but the opponent is coming rear')

The number of accidents from In-depth suppliers was equal to 32 cases, what it means 7% of the stabilized accidents. The accident mechanism associated to this scenario could include different situations already mentioned previously. In this case, the opponent vehicle comes from rear and impacts the stabilized vehicle. Although this general explanation does not detail what each vehicle was doing, from the opponent vehicle point of view, this vehicle could be in the following situations:
  ✓ The opponent vehicle could be also the stabilized vehicle belonging stabilized situation 3.c.
  ✓ The opponent vehicle could be also the stabilized vehicle belonging stabilized situation 3.d.
  ✓ The opponent vehicle could be doing a specific manoeuvre and collides against the stabilized vehicle which is ahead.

Therefore, a priori, the final configurations and results from the respective analyses should be different to ones from scenarios 3.c and 3.d.

A general description of these scenarios shows that the majority of the accidents happen outside urban area, in dual carriage way (74%) and in straight section (85%). Looking at these main characteristics could seem difficult to understand why these accidents happen in these locations. If we have a look at the visibility conditions, a high percentage of these accidents happen during the night (near 40%), this means the visibility conditions are constraint. Also, it has been saw that other kind of 'degradated conditions' like bad weather conditions (fog, raining…).

Apart of these considerations, almost of these accidents are rear-end collisions, and the type of the opponent vehicles is a passenger car (58%) or, curiously, a truck (27%), whereas the stabilized vehicle (targeted vehicle) is a passenger car, of course (it was a criteria for stabilized situations).

It is clear that the cause of the accident comes from the opponent vehicle in a recognition error. The opponent vehicle was travelling in an 'easy road' (this could mean: straight section in double carriageway road), but due a failure at the moment of looking, the vehicle collides against the stabilized vehicle. As the in-depth information gives, it was not a problem of speed, but in many occasions there is a lack of visibility due, specially, to the following degradated situations (where the visibility is deteriorated):
  - Weather degraded situation: fog, rain…
  - Luminosity degraded situation (night).

During the following task 2.4 ('Degradated situations'), these situations will be studied from that point of view, although the conclusion will be showed in a different way.

Finally and it has happened in the previous scenario, due to the low quantity of these accidents, it has not been possible to do the respective risk analysis.

The results obtained from the literature review in D2.1 do not focus specifically on the stabilized situations '3'. The only aspects related to these scenarios (type 3) are the ones concerning the most common accidents (rear-end accidents, although it is not possible to extend these conclusions to all the rear-end belonging stabilized situations because there could be other type of rear-end collisions out of stabilized-situations), so special comparisons between results from literature review and from the 'in-depth' analyses can be done.

9.1.3   Specific manoeuvres situations:

A specific manoeuvres situation has been defined as a situation in which the drivers has to realize a specific manoeuvre (overtaking, changing lane, turning, reversing, etc.) for which a higher than usual solicitation (normal driving) is required.
All specific manoeuvres performed at an intersection are excluded.
The specific manoeuvre receiving most of the attention in the literature is overtaking which is addressed in turn of driver age, gender, experience, skill and attitude. This manoeuvre was also closely linked to a situation known as 'tail-gating' or 'close-following' – which will be considered under the 'stabilized situations'.

Changing lane was addressed in terms of driver age and experience and also with reference to infrastructure. Turning was studied almost always in the context of intersections but these observations were deemed relevant to non-intersection turning. U-turns and reversing were briefly mentioned.

From the general statistical approach, the main results are the following:
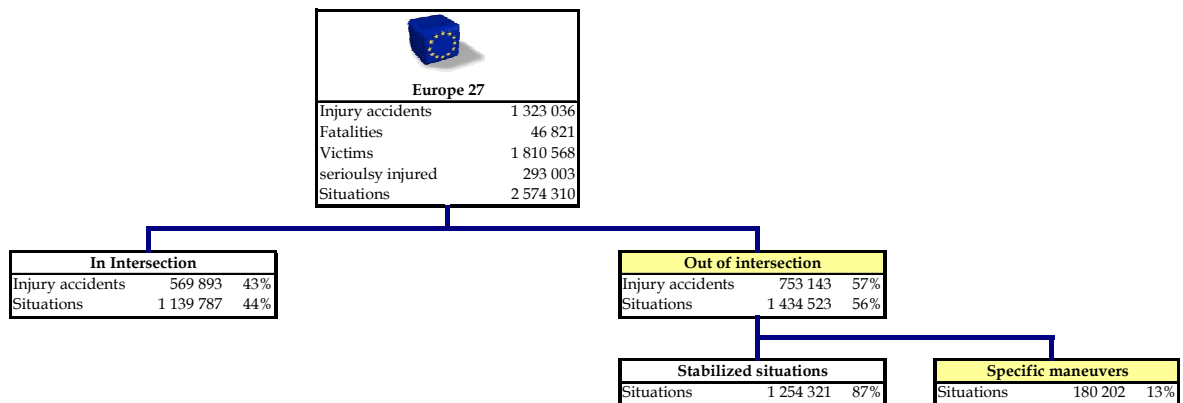
In EU27, the specific manoeuvre situations represent:
- 7% of the total number of situations
- 24% of the total number of injury accidents in Europe (estimation relying on results coming from Spain, UK, France, Greece and Czech Republic)

The main characteristics are the following:

- 5 to 11% of all situations or vehicles occurred when at least one specific manoeuvre was performed.
- When the reference is the number of situations out of intersection, the rate raises to 11 to 16%.
- Overtaking represents 18 to 38% of all accidents where at least one specific manoeuvre is performed, Changing lane 11 to 19% and Turning left 10 to 43% according to the country.

- Manoeuvres associated with a higher than average number of fatal and serious accidents were 'overtaking a vehicle on the offside' and turning left (away from an intersection).

The in-depth analysis of specific manoeuvre accidents showed that passenger car drivers (performing a specific manoeuvre) are primary active drivers. It means that they are at the origin of the accident situation.

The main problem for these manoeuvres does not come from the realization of them but from the preparation of them (what we have to do before realizing the manoeuvre). Indeed, for all the case vehicle drivers (performing a specific manoeuvre), it appears that the conditions were not optimum to perform the manoeuvre. And in spite of everything, the driver has all the same tried to realize it.

Then, the case vehicle driver did not enough anticipate the evolution of the situation. It means that the identification of hazards and the quantification of their potential for danger have been neglected or were difficult to identify by the driver. And finally, the case vehicle driver is subjected to the Looked But Failed to See problem. It can be explained by the fact that most of the drivers was affected by time constraints.

9.1.3.a   Overtaking manoeuvre accidents
✓ Prevalence in Europe: 18% to 38%
✓ Severity KSI[21]: 20% to 28%

The passenger car overtaking is a *primary active driver* in the genesis of the accident. When another road user is involved in the accident, this one is a passive driver. His only role consists in being present and he cannot be considered as an engaging part in the disturbance. So, if we want to avoid the accident, we need to find appropriated safety measures linked to the passenger car overtaking.

The first main result is that we need to help the driver to diagnose the situation before realizing the overtaking manoeuvre. Here are the factors coming from the in-depth analysis explaining this lack of diagnosis and their safety systems associated:
- The speed is non adapted to the situation (and especially to the road layout). The safety system appropriated to this failure is an intelligent speed adaptation. The system adapts the speed to the speed limits and to the prevailing conditions (for instance, adverse road or weather conditions).
- The speed is over the legal speed limit. The speed alerting system or the speed limit system could warm the driver of the over-speed or could force the driver to not drive over the legal speed limit.
- Some factors linked to the state of the driver can explain why there is a poor diagnosis of the situation. Indeed, the analysis showed that the driver was careless, reckless, in a hurry or restlessness. If it is difficult to find a system which could change your mental state, we can all the same prevent or help him to diagnose the situation. The systems which could help the driver are a collision warning system, a collision avoidance system, an inter-vehicle communication system or a lane changing assistance. These systems could also help the driver when the visibility is deteriorated.

The second main result underlines the fact that we need to help the driver overtaking during his decision phase (for the overtaking realization). Indeed, the driver deliberately violates safety rules and takes risk. Indeed, passenger car overtakes in spite of a continuous lane and so already identified risky place. The first main counter-measure is to enforce laws thanks to road safety preventing campaigns and to repression. The other counter-measure could be a system which warms the driver when he is crossing a continuous lane.

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[21] Severity KSI: fatalities + severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

The last result shows that there is a problem of loss of control during the realization of the overtaking. Indeed, the passenger car driver, during the stabilized phase and the cutting one, crossed respectively the left and right shoulder and this crossing are often at the origin of the loss of control. Naturally systems which could avoid a loss of control are the most appropriated such as ESC[22] or TCS[23]. Nevertheless, it is possible to associate counter-measures to the road. Indeed, we could think that a larger road would have avoided the crossing on the shoulders or warning painting on the road would have inform the driver that he is very close to the shoulder.

9.1.3.b   Turning left manoeuvre accidents
✓   Prevalence in Europe: 10% to 43%
✓   Severity KSI[24]: 16% to 22%

The in-depth analysis of passenger car realizing a turning left manoeuvre shows that the main problem related to the manoeuvre is linked to the preparation of it. It means that it is not realized in good safety conditions.

The main problem for passenger car turning left is a problem of perception of all the elements of the driving situation. The information acquisition is neglected by the driver and he is not able to anticipate the evolution of the situation. The reasons of this lack of perception are due to the following causes:
-   The driver is subjected to situational constraint (road users waiting behind him) and he has some difficulties to find a gap to cross the opposite lane. The counter-measure associated to this cause is rather linked to the infrastructure and the to traffic management. Nevertheless, we can think that a system fitted on the vehicle such as an inter-vehicle communication system could inform the driver about his possibility to turn left considering the other road users approach.
-   The driver trivializes the manoeuvre and the situation. He has given signs to the other road user and he has a right of way feeling. Once again, the inter-vehicle communication system could prevent such accident by informing the driver of the impossibility of turning left.
-   There is also a problem of bad visibility of the situation. The driver is not aware of all the elements helping him to perform his manoeuvre. When the road layout is at the origin of the problem of visibility, it is necessary to work on the traffic regulation surrounding the turning left place. When the lack of visibility is linked to weather condition or mobile mask, a system helping the driver to see the other road user not visible should be efficient. Once again, the inter-vehicle communication system gives to the road users advanced knowledge of approaching vehicles outside their field of vision.

The second main problem for passenger car driver realizing a turning left is the decision to perform this manoeuvre. Indeed, the driver deliberately violated safety rules and was not allowed to turn left. As for the overtaking manoeuvre, one of the counter-measures could be and enforcement laws thanks to road safety preventing campaigns and to repression. To prevent the driver from turning left, it can be possible to separate the lanes by a fix barrier or to have a system warning the driver that he is not allowed to turn left.

9.1.3.c   U-turning manoeuvre accidents
✓   Prevalence in Europe: 7% to 20%
✓   Severity KSI[25]: 17% to 22%

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[22] Electronic Stability Control

[23] Traction Control System

[24] Severity KSI: fatalities + severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

[25] Severity KSI: fatalities + severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

The main problem of u-turning manoeuvres is not the manoeuvre realization but is the preparation of the manoeuvre. It means that it is what has to be done before realizing the manoeuvre. Indeed, the human functional failure analysis shows that the main failure is a perception one.

Indeed, the in-depth analysis indicates that drivers coming from a parking place on the nearside of the side have problems of visibility. Due to other vehicles parked, they are not able to access to some potential useful items of information and the opponent road users have also problem to see case vehicles. So, one of the systems which could help the driver to prevent such accidents is the blind spot monitoring which warns the driver when a road user is travelling in the blind spot. The inter-vehicle communication system could help too the driver u-turning by informing him about road users outside his field of vision.

This last system could assist the driver too in another perception problem. Indeed, the in-depth analysis shows that the driver u-turning is subjected to time constraints and has a low level of attention. The consequence of this inattention is that the driver u-turning does not detect crucial elements of the situation.

The last failure underlined by the in-depth analysis is a problem of decision. This one is explained by the fact the driver u-turning has broken certain number of elementary safety rules and the infringement is not really deliberate (the driver is subjected to a situational pressure inducing a precipitated manoeuvre). To prevent the driver from u-turning, it can be possible to separate the lanes by a fix barrier or to have a system warning the driver that he is not allowed to u-turn.

9.1.3.d   Changing lane manoeuvre accidents
  ✓ Prevalence in Europe: 11% to 19%
  ✓ Severity KSI[26]: 12% to 17%

The in-depth analysis shows that the state of the driver has an important influence on the changing lane realization. Even if the human functional failure analysis is not available for this manoeuvre, we can think that perception failures are conditioned by the driver state. Indeed, we determined that most of the key events were a poor evaluation/anticipation of the situation. So the counter-measure should help the driver in warning him of the proximity of other road users. And the inter-vehicle communication well answers to the problem.

Two other factors are underlined in the in-depth analysis. The first one is the problem of alcohol impairment or other illegal or legal drugs. First of all, campaigns about the dangers of drinking and driving or drugging and driving should be enforced. Then, systems preventing the driver from driving because he is over the legal limit of alcohol exist and could be efficient to solve this problem. To detect drugs or medicines, no reliable system giving instantaneous results already exists. And the second one is the non-adapted speed to the situation. The safety system appropriated to this failure is an intelligent speed adaptation. The system adapts the speed to the speed limits and to the prevailing conditions (for instance, adverse road or weather conditions).

9.1.4   Degradation situations

A degradation situation has been defined as a situation where an accident arises out of the degradation of the exogenous environment in terms of:

(a) The driver's visibility of the road ahead (with obstruction to the view ahead due to the weather, time of days, street lighting, poorly maintained roadside features);

(b) The driver's control of the vehicle (e.g. strong wind, road surface contamination, road surface condition, physical obstruction in road such as a fallen load from an HGV or a previous accident).

From the general statistical approach, the main results are the following:

Europe 27	
Injury accidents	1 323 036
Fatalities	46 821
Victims	1 810 568
serioulsy injured	293 003

Degraded conditions		
Injury accidents	462 255	35%
Fatalities	21 532	46%
Victims	658 293	36%
Serioulsy injured	114 036	39%

Not Degraded conditions		
Injury accidents	860 781	65%
Fatalities	25 289	54%
Victims	1 152 275	64%
Serioulsy injured	178 966	61%

In EU27, the accidents in degraded conditions (in dark and/or bad weather conditions only) represent:

- 35% of the total number of injury accidents.
- 46% of the overall fatalities (3% of the casualties in degraded situation)
- 39% of severely injured (14% of the casualties in degraded situation)

A descriptive analysis of accidents in a number of countries has enabled a comparison to be made between degraded accident scenarios and specific accident characteristics.

These relationships were tested on an in-depth database (UK OTS) to determine whether data could be extracted according to the scenarios and characteristics identified.

Having established that this was possible, requests were then made to four counties (France, Germany, Italy and Spain), and six organisations, for data to supplement that obtained through OTS for the UK.

Each country was asked to submit causation data for degraded scenarios in general, and for the four main scenarios of lighting, weather, road surface and carriageway hazards. In each case the causation data was requested for human, environmental and vehicle factors.

Most of the analysis of this data referred to situations in which degraded scenarios **were present** in accidents.

Finally a set of 80 OTS cases where degradation was **causative** in accidents was examined. The 80 cases were divided approximately equally between the four main degraded accident scenarios. The purpose of this part of the investigation was to examine any differences between the four scenarios, differences between situations where degradation is **present** and those where it is **causative**, and to enable the opportunity to use a detailed database to determine whether additional causation factors would be revealed from that detail.

There were large variations in the total number of accidents supplied from each source (150 cases to 120,000+ cases).

There were differences between sources in their recording of presence of accident severity.

For injury cases the KSI rate varied from 17-56% suggesting either differing priorities in data collection, or maybe varying availability on minor injury data.

The level of recording whether degradation was **present** varied between 29-80%, and the level of recording whether degradation was **causative** between 5-28%. One source did not record where degradation was causative.

Some individual degraded scenario causation factors, for example glare from headlights, are only represented from one source. A small number of causation factors are represented in all four countries.

The variations within the data make an overall analysis difficult, particularly from a point of view of attempting to provide results at an overall European perspective. Caution should be expressed regarding any comparisons between the countries' data. The lack of consistency in the number of cases, the severity index, and the proportion of cases in which a contributory factor is seen as contributing (as opposed to merely being present) make comparisons between countries difficult. If the data were grouped together, the inconsistencies would mean some individual contributions would be swamped by much higher numbers from others. However, it is hoped that even with these limitations, the results give a useful and unique overview of the accident causation issues involving degradation accidents.

9.1.4.a   **Findings from the analysis of accidents where the degraded accident scenarios were present**

Variation was found in the way the four main types of degradation were presented in the accident records from the various partner's databases from across Europe. In order to minimise any inconsistencies, a "pattern" analysis was carried out to investigate the most common two causation factor groups within the accident records recorded by each source.

Human factors dominate the causation factors for degradation scenarios in general, and for the four individual scenarios. "Risk taking" (e.g. speed, driving too close) was the most commonly identified factor group within degraded lighting, degraded weather and degraded road surface. "Distraction" (e.g. within/outside vehicle/with user) was the most commonly identified factor group within carriageway hazards. Although "Visibility impaired' was as frequent as 'Distraction' for carriageway hazards it was not as frequent when considered against the selected accident scenarios.

Overall, 91% of the two most commonly recorded causation factors for degraded lighting were human factors, and 9% were environmental. Very few vehicle factors were recorded at all - at least not as commonly occurring issues.

Overall, 82% of the two most commonly recorded causation factors for degraded weather were human factors, and 18% were environmental. Very few vehicle factors were recorded at all - at least not as commonly occurring issues.

Overall, 75% of the two most commonly recorded causation factors for degraded road surface were human factors, and 25% were environmental. Very few vehicle factors were recorded at all - at least not as commonly occurring issues.

Overall, 66% of the two most commonly recorded causation factors for carriageway hazards were human factors, and 34% were environmental. Very few vehicle factors were recorded at all - at least not as commonly occurring issues.

Whilst environmental factors are of course present in the accidents being studied, in fact it is the human causation factors that are recorded more often. This could be because, in an individual case, possibly just one environmental factor is recorded, whilst human factors are more numerous. It could also be that whilst environmental factors are present the investigators feel that in the majority of cases

these factors themselves are not the principle cause of the accident, it is the human failure that is the real catalyst for the accident. Certainly some accidents at night might be considered in this way.

Environmental factors contribute most in those scenarios of degraded road surface and in particular carriageway hazards, although human factor groups are still more frequent. This is because of the more unexpected element (than lighting and weather) of road surface degradation and certainly hazards.

9.1.4.b   Findings from the analysis of typical characteristics of degradation accidents

For each of the four situations where a degraded condition was present, accidents were identified which included the most typical accident characteristics found in the descriptive analysis. For each 'typical situation', the most commonly reported causation factor groups were recorded as shown below.

The findings show that, with the exception of carriageway hazards where distraction is the most common factor group, risk taking dominates as the main causation factor in these accidents. Risk taking is recorded on 13 occasions, distraction 3 and psychological and substances taken once each as the most frequent factor groups.

With respect to the accident characteristics found in the descriptive analysis, single car accidents occur in all four scenarios. Non-junction accidents occur in three out of four, non-urban accidents occur on three out of four, and non-manoeuvre accidents occur on two out of four.

This enables a picture to be built of the "typical degraded scenario accident". It is a single vehicle crash, away from a junction, on a rural road and the driver is taking risks (e.g. speeding, travelling too close, disobeying signs/signals).

Degraded scenario	Accident characteristic	Most common causation factor groups
Lighting	single car	risk taking & psychological condition
	non-manoeuvre	risk taking
	alcohol	substances taken
	young driver under 25	risk taking
	male driver	risk taking
Weather	single car	risk taking
	non-junction	risk taking
	non-urban	risk taking
	non-manoeuvre	risk taking
Road surface	single car	risk taking
	non-junction	risk taking
	non-urban	risk taking
	non-alcohol	risk taking
Hazard	single car	distraction
	non-junction	distraction
	non-urban	distraction and risk taking

Table 57: The most common causation factor groups for each type of degradation scenario

9.1.4.c   Findings from the analysis of accidents where the degraded accident scenarios were causative

The overall impression from the information gathered on accidents where degraded lighting, weather or road surface was causative was that the way the vehicle was being driven was equally as important

in the chain of events leading up to the catastrophic event. The most common causation factors attributed to these accidents have tended to be associated with drivers knowingly, or unknowingly, taking risks with their vehicles or psychological conditions which have affected the way drivers are driving their vehicles.

There is a high frequency of "risk taking" causation factors associated with these accidents, there is also a common assumption that young male drivers are associated with this type of driving, which appears to be supported by the relatively high proportion of this group of drivers involved in the accidents, particularly degraded weather and lighting.

The different degraded situations appear to have little effect on the severity of the accidents which were attributed to these adverse conditions. The proportion of injury accidents to non-injury accidents in the sample from UK OTS database differs little between the different degraded conditions. Similarly there are only small differences in the proportion of killed and seriously injury accidents to minor injury accidents within each of the four degradation categories with the proportion of the serious injuries being marginally higher in degraded road surface conditions.

When road or roadside hazards were the degraded situation, and causative, the other common factor appearing in the accident records is panic behaviour. The obvious explanation for this difference in comparison with the other forms of degradation is that road or roadside hazards are sudden events, and it is the way drivers deal with these sudden events that causes the accidents rather than just the hazard.

While the largest proportion of drivers involved in these accidents in the sample were male, a large proportion of the female drivers involved were aged between 17 and 24 years old.
A large proportion of these forms of accidents in the UK OTS database also occurred in darkness which would suggest that there is a link between the two degraded situations.

9.1.4.d **TRACE Work Package 5 Methodology**

Using the TRACE Work Package 5 Methodology to recode a sample of the above cases (from the UK OTS database), the results revealed that the presence of degradation in general mainly led to either failures in detection (i.e. the degraded situation restricted the road user's visibility) or failures when taking action (i.e. the degradation directly affected the road user's control of their vehicle, such as when manoeuvring around a bend).

–   Degraded **lighting** was mainly found to affect road users by preventing them from detecting a conflict ahead until it was too late to avoid.

–   Degraded **road surfaces** were mainly found to affect road users by unexpectedly making it difficult or impossible for them to control their actions (e.g. negotiating a bend), even on roads very familiar to the road user.

–   Degraded **weather** and the presence of **hazards** were mainly found to affect road users by either preventing them from detecting a conflict or unexpectedly making it difficult to control their actions.

It was concluded that degradation scenarios can be hazardous, either by restricting the view of possible danger or by being the main cause of the conflicting situation, suddenly appearing when the road user is not always expecting it or prepared. If the road user is risk taking, in particular speeding, as was often found in this analysis, this will only make it more inevitable that an impact will occur in either one of these situations.

9.2 Discussion

The general objective of the TRACE project is to provide the scientific community, the stakeholders, the suppliers, the vehicle industry and other Integrated Safety program participants with an overview of the **road accident causation** issues in Europe, and possibly overseas, based on the analysis of any current available databases which include accident, injury, insurance, medical and exposure data

(including driver behaviour in normal driving conditions). In accordance with these objectives, TRACE has been divided into 3 series of technical Workpackages:

- ✓ The Operational Workpackages (WP1 Road Users – WP2 Types of driving situations and types of accident situations – WP3 Types of risk factors – WP4 Evaluation of the effectiveness of safety functions in terms of expected (or observed) accidents avoided and lives saved).

- ✓ The Methodologies Workpackages (WP5 Analysis of Human factors – WP7 Statistical Methods – WP6 Determination of Safety Functions).

- ✓ The Data Supply Workpackage (WP8).

Related to 'Operational Workpackage', 'Work Package 2: Type of situations' has been aimed to update **accident causation knowledge from the road user situation point of view** (stabilized situation, intersection situation, specific manoeuvre and degraded situation).

Firstly, TRACE has proposed a common methodology for the analysis of each type of situation maximizing the use of existing databases and their limitations. This integrated methodology can be summarized as follows:

5. What knowledge has already been obtained for each road user? → **LITERATURE REVIEW**

6. What are the most relevant accident configurations at European level? → **DESCRIPTIVE ANALYSIS**

7. Why accidents of those configurations take place? → **IN-DEPTH ANALYSIS**

8. Which factors increase the risk of each accident configuration? → **RISK ANALYSIS**

Each task has followed the above method in order to study the different type of situations. The main achievements, apart from the specific results on each task, make reference to the following facts:

- Innovative statistical methods, developed by WP7, have been applied as much as possible in order to provide data at EU27 level related to the magnitude of the accident figures for each type of situation although this was an initial target of the project. When available, these figures have been combined with exposure data in order to provide general risks estimations.

- Relevant & specific accident configurations have been detected and describing for each type of situations at macroscopic level. This means that safety solutions addressing these configurations would benefit to larger groups of road users.

- Contributory factors have been identified through microscopic analysis in order to detect what aspects have contributed to the accident. This is what topics should new safety systems would be addressing. The WP5 methodology to identify Human Functional Failure has been applied in this step allowing the identification of the human decisions mechanisms that did not perform positively in each accident configuration.

- Last but not least, the different risk analyses performed allow deciding which new systems should be prioritized as they address factors that induce a higher level of risk for each road user.

TRACE differs from other accident research project both on the methodology used and the collating of almost all the relevant accident databases at European Level both at macroscopic and microscopic level.

Nevertheless, this does not mean that everything is achieved in accident causation. This project has also encountered some relevant difficulties that should help the research community to identify the next actions to be taken:

- There is not enough data to perform all the ideal risk analyses in accident causation. Sometimes there is a lack of data related to the detail of accident information and sometimes it is not possible to get the necessary exposure data to perform risk. For example, combining data from different in – depth accident databases has required a great effort in developing common concepts that could be analysed in each database, taking into account they are designed with different structures.

- The quantity and quality of information is not the same for all type of situation. Those less represented in the different vehicle circulating parks could be improved their level of safety by a higher level of detail in the information that accident data offers.

- If a common accident investigation methodology is applied in the future, this will allow performing a new updating of the accident causation knowledge under this approach.

- The last problem focused on the application of the innovative methodology emerging from WP5 – Analyzing "Human Functional Failure" in road accidents. Two difficulties appeared:
  - ➢ We need to well understand the new approach if we want to have relevant results and to have the same understanding of the approach between all the partners.

  - ➢ Once, the approach understood, we have to find in our database the appropriated information which could help us to apply the new approach on our sample.

All potential users of the results of this work package should not only consider the different percentages and specific conclusions of each type of situations but also the methodology followed to obtain each result. Both objectives of developing and applying the methodology for the updating and accident causation have been achieved within this work package from the point of view of road users.

10 References

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TRACE DeliverabbeD3.3. "Trip Related Factors". 2008.

TRACE Deliverable D3.4. "Driving Task Related Factors". 2008.

TRACE Deliverable D8.1. "Final Work Package Co-ordinators Report". 2008.

WHO (2004) World Health Organisation "*World report on road traffic injury prevention*, IBSN 92-4-159131-5,

Sourced Exposure References

All Weather

http://www.weatheronline.co.uk/cgi-
bin/klisuframe?LANG=en&MOD=TAB&TMX=??&TMN=??&SON=??&PRE=??&MONAT=01

Rainfall

Madrid

http://www.weatheronline.co.uk//cgi-
bin/regframe?3&PRG=cityklima&LANG=en&WMO=08221&INFO=1

Rome

http://www.weatheronline.co.uk//cgi-
bin/regframe?3&PRG=cityklima&LANG=en&WMO=16242&INFO=1

London

http://www.weatheronline.co.uk//cgi-
bin/regframe?3&PRG=cityklima&LANG=en&WMO=03772&INFO=1

Bremen

http://www.weatheronline.co.uk//cgi-
bin/regframe?3&PRG=cityklima&LANG=en&WMO=10224&INFO=1

Paris

http://www.weatheronline.co.uk//cgi-
bin/regframe?3&PRG=cityklima&LANG=en&WMO=07149&INFO=1

Sunrise & Sunset Times

Paris

http://www.timeanddate.com/worldclock/astronomy.html?n=195&month=12&year=2008&obj=sun
&afl=-11&day=1

Berlin

http://www.timeanddate.com/worldclock/astronomy.html?month=12&year=2008&obj=sun&afl=-
11&day=1&n=37

London

http://www.timeanddate.com/worldclock/astronomy.html?month=12&year=2008&obj=sun&afl=-
11&day=1&n=136

Madrid

http://www.timeanddate.com/worldclock/astronomy.html?month=12&year=2008&obj=sun&afl=-
11&day=1&n=141

Rome

http://www.timeanddate.com/worldclock/astronomy.html?month=12&year=2008&obj=sun&afl=-
11&day=1&n=215

UK Rural Road Network

Transport Statistics Great Britain

http://www.dft.gov.uk/pgr/statistics/datatablespublications/tsgb/2007edition/sectionsevenroadsa
ndtraffic.pdf

Euro Road Network

IRTAD Database

http://cemt.org/IRTAD/IRTADPUBLIC/weng1.html

Vehicles Registered

STATISTICS OF ROAD TRAFFIC ACCIDENTS

http://www.unece.org/trans/main/wp6/pdfdocs/RAS_2007.pdf

Driving Population

Population by sex and age

http://epp.eurostat.ec.europa.eu

Annex I   Tables 1-7

Table I - 1 Degraded Accidents

Summary of Table I - 1		Fatal	Serious	Slight	Non-Injury	Not Known	Total (row)	Fatal	Serious	Slight	Non-Injury	Not Known	Fatal	Serious	Slight	Non-Injury	Not Known	Total (row)
Total number of accidents with at least one car	UK	69	341	1407	1334	65	3216	2%	11%	44%	41%	2%	-	-	-	-	-	-
	France[A]	18	20	169	51	10	268	7%	7%	63%	19%	4%	-	-	-	-	-	-
	Italy	1007	1470	11870	19484	0	121286	1%	1%	10%	16%	0%	-	-	-	-	-	-
	Germany[B]	332	3275	7976	4	21	11608	3%	28%	69%	0%	0%	-	-	-	-	-	-
	Germany[A]	1	0	0	0	609	610	0%	0%	0%	0%	100%	-	-	-	-	-	-
	France[B]	16	25	148	36	2	227	7%	11%	65%	16%	1%	-	-	-	-	-	-
	Spain	20	59	63	8	0	150	13%	39%	42%	5%	0%	-	-	-	-	-	-
Accidents with any 'degraded' situation present	UK	50	257	960	948	58	2273	2%	11%	42%	42%	3%	2%	8%	30%	29%	2%	71%
	France[A]	13	19	138	33	6	209	6%	9%	66%	16%	3%	5%	7%	51%	12%	2%	78%
	Italy	269	497	4412	7138	0	35181	1%	1%	13%	20%	0%	0%	0%	4%	6%	0%	29%
	Germany[B]	235	2241	5052	2	19	7549	3%	30%	67%	0%	0%	2%	19%	44%	0%	0%	65%
	Germany[A]	0	0	0	0	237	237	0%	0%	0%	0%	100%	0%	0%	0%	0%	39%	39%
	France[B]	5	9	53	18	2	87	6%	10%	61%	21%	2%	2%	4%	23%	8%	1%	38%
	Spain	5	18	22	3	0	48	10%	38%	46%	6%	0%	3%	12%	15%	2%	0%	32%
Accidents where the degraded situation was a causation factor	UK	9	55	220	209	3	496	2%	11%	44%	42%	1%	0%	2%	7%	6%	0%	15%
	France[A]	4	5	51	11	5	76	5%	7%	67%	14%	7%	1%	2%	19%	4%	2%	28%
	Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Germany[B]	18	187	491	0	1	697	3%	27%	70%	0%	0%	0%	2%	4%	0%	0%	6%
	Germany[A]	0	0	0	0	28	28	0%	0%	0%	0%	100%	0%	0%	0%	0%	5%	5%
	France[B]	2	1	15	8	1	27	7%	4%	56%	30%	4%	1%	0%	7%	4%	0%	12%
	Spain	1	8	8	1	0	18	6%	44%	44%	6%	0%	1%	5%	5%	1%	0%	12%
Accidents with degraded lighting conditions present	UK	38	144	493	514	46	1235	3%	12%	40%	42%	4%	1%	4%	15%	16%	1%	38%
	France[A]	4	4	49	10	7	74	5%	5%	66%	14%	9%	1%	1%	18%	4%	3%	28%
	Italy	12	79	618	742	0	2602	0%	3%	24%	29%	0%	0%	0%	1%	1%	0%	2%
	Germany[B]	177	1375	2679	0	14	4245	4%	32%	63%	0%	0%	2%	12%	23%	0%	0%	37%
	Germany[A]	0	0	0	0	137	137	0%	0%	0%	0%	100%	0%	0%	0%	0%	22%	22%
	France[B]	4	5	24	10	2	45	9%	11%	53%	22%	4%	2%	2%	11%	4%	1%	20%
	Spain	3	12	13	2	0	30	10%	40%	43%	7%	0%	2%	8%	9%	1%	0%	20%
Accidents where the degraded lighting was a causation factor	UK	3	7	43	29	1	83	4%	8%	52%	35%	1%	0%	0%	1%	1%	0%	3%
	France[A]	0	1	7	0	0	8	0%	13%	88%	0%	0%	0%	0%	3%	0%	0%	3%
	Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Germany[B]	2	15	78	0	0	95	2%	16%	82%	0%	0%	0%	0%	1%	0%	0%	1%
	Germany[A]	0	0	0	0	8	8	0%	0%	0%	0%	100%	0%	0%	0%	0%	1%	1%
	France[B]	2	1	8	6	1	18	11%	6%	44%	33%	6%	1%	0%	4%	3%	0%	8%
	Spain	0	0	1	0	0	1	0%	0%	100%	0%	0%	0%	0%	1%	0%	0%	1%

Summary of Table I - 1 (Continued)		Fatal	Serious	Slight	Non-Injury	Not Known	Total (row)	Fatal	Serious	Slight	Non-Injury	Not Known	Fatal	Serious	Slight	Non-Injury	Not Known	Total (row)
Accidents with degraded weather conditions present	UK	11	75	304	270	15	675	2%	11%	45%	40%	2%	0%	2%	9%	8%	0%	21%
	France^A	3	3	32	11	1	50	6%	6%	64%	22%	2%	1%	1%	12%	4%	0%	19%
	Italy	194	354	3119	5127	0	22414	1%	2%	14%	23%	0%	0%	0%	3%	4%	0%	18%
	Germany	73	818	2003	1	5	2900	3%	28%	69%	0%	0%	1%	7%	17%	0%	0%	25%
	Germany	0	0	0	0	1	1	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
	France^B	1	4	25	10	1	41	2%	10%	61%	24%	2%	0%	2%	11%	4%	0%	18%
	Spain	2	6	11	1	0	20	10%	30%	55%	5%	0%	1%	4%	7%	1%	0%	13%
Accidents where the degraded weather was a causation factor	UK	0	1	6	12	0	19	0%	5%	32%	63%	0%	0%	0%	0%	0%	0%	1%
	France^A	1	2	6	0	0	9	11%	22%	67%	0%	0%	0%	1%	2%	0%	0%	3%
	Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Germany	2	17	51	0	0	70	3%	24%	73%	0%	0%	0%	0%	0%	0%	0%	1%
	Germany	0	0	0	0	1	1	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
	France^B	0	0	3	1	1	5	0%	0%	60%	20%	20%	0%	0%	1%	0%	0%	2%
	Spain	1	5	6	1	0	13	8%	38%	46%	8%	0%	1%	3%	4%	1%	0%	9%
Accidents with degraded road surface conditions present	UK	26	163	620	649	31	1489	2%	11%	42%	44%	2%	1%	5%	19%	20%	1%	46%
	France^A	0	0	114	25	3	142	0%	0%	80%	18%	2%	0%	0%	43%	9%	1%	53%
	Italy	24	11	126	265	0	1170	2%	1%	11%	23%	0%	0%	0%	0%	0%	0%	1%
	Germany	105	1075	2488	0	9	3677	3%	29%	68%	0%	0%	1%	9%	21%	0%	0%	32%
	Germany	0	0	0	0	100	100	0%	0%	0%	0%	100%	0%	0%	0%	0%	16%	16%
	France^B	1	2	24	9	1	37	3%	5%	65%	24%	3%	0%	1%	11%	4%	0%	16%
	Spain	0	2	1	0	0	3	0%	67%	33%	0%	0%	0%	1%	1%	0%	0%	2%
Accidents where the degraded road surface was a causation factor	UK	4	21	68	105	2	200	2%	11%	34%	53%	1%	0%	1%	2%	3%	0%	6%
	France^A	3	2	38	11	5	59	5%	3%	64%	19%	8%	1%	1%	14%	4%	2%	22%
	Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Germany	14	157	353	0	1	525	3%	30%	67%	0%	0%	0%	1%	3%	0%	0%	5%
	Germany	0	0	0	0	18	18	0%	0%	0%	0%	100%	0%	0%	0%	0%	3%	3%
	France^B	0	0	4	1	0	5	0%	0%	80%	20%	0%	0%	0%	2%	0%	0%	2%
	Spain	0	1	1	0	0	2	0%	50%	50%	0%	0%	0%	1%	1%	0%	0%	1%
Accidents with hazards present	UK	7	46	158	100	0	311	2%	15%	51%	32%	0%	0%	1%	5%	3%	0%	10%
	France^A	0	3	19	6	0	28	0%	11%	68%	21%	0%	0%	1%	7%	2%	0%	10%
	Italy	63	109	1090	1862	0	12094	1%	1%	9%	15%	0%	0%	0%	1%	2%	0%	10%
	Germany	39	513	1154	2	4	1712	2%	30%	67%	0%	0%	0%	4%	10%	0%	0%	15%
	Germany	0	0	0	0	1	1	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
	France^B	0	0	3	0	0	3	0%	0%	100%	0%	0%	0%	0%	1%	0%	0%	1%
	Spain	0	2	0	0	0	2	0%	100%	0%	0%	0%	0%	1%	0%	0%	0%	1%
Accidents where the hazard was a causation factor	UK	2	26	113	74	0	215	1%	12%	53%	34%	0%	0%	1%	4%	2%	0%	7%
	France^A	0	3	17	6	0	26	0%	12%	65%	23%	0%	0%	1%	6%	2%	0%	10%
	Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Germany	1	8	29	0	0	38	3%	21%	76%	0%	0%	0%	0%	0%	0%	0%	0%
	Germany	0	0	0	0	1	1	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
	France^B	0	0	3	0	0	3	0%	0%	100%	0%	0%	0%	0%	1%	0%	0%	1%

Table I – 2a: The number of accidents involving specific degradation-related causation factors, split by accident severity

	Table I - 2a: Causation factors		Number of car accidents (split by accident severity)						Percentage of car accidents				
			Fatal	Serious	Slight	Non-injury	Not Known	Total	Fatal	Serious	Slight	Non-injury	Not Known
Causation factors affecting visibility	Lighting - Poor or no street lights lit	UK	0	1	7	9	1	18	0%	6%	39%	50%	6%
		France[A]	1	4	7	0	0	12	8%	33%	58%	0%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	1	5	5	1	12	0%	8%	42%	42%	8%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%
	Lighting - Glare from sun	UK	1	2	18	15	0	36	3%	6%	50%	42%	0%
		France[A]	0	2	4	0	0	6	0%	33%	67%	0%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	6	6	0%	0%	0%	0%	100%
		France[B]	2	0	4	1	0	7	29%	0%	57%	14%	0%
		Spain	0	0	1	0	0	1	0%	0%	100%	0%	0%
	Lighting - Glare from headlights	UK	0	0	3	4	0	7	0%	0%	43%	57%	0%
		France[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%
	Weather - Vision affected by rain, sleet, snow or fog	UK	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[A]	2	3	7	0	0	12	17%	25%	58%	0%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	1	1	0%	0%	0%	0%	100%
		France[B]	0	0	3	1	1	5	0%	0%	60%	20%	20%
		Spain	1	5	6	0	0	12	8%	42%	50%	0%	0%
	Weather - Vision affected by spray from other vehicles	UK	0	1	6	9	0	16	0%	6%	38%	56%	0%
		France[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%

Table I - 2a: Causation factors (Continued)			Number of car accidents (split by accident severity)						Percentage of car accidents				
			Fatal	Serious	Slight	Non-injury	Not Known	Total	Fatal	Serious	Slight	Non-injury	Not Known
Causation factors affecting visibility	Hazard - Surroundings obscured by stationary/parked vehicle	UK	1	20	76	18	0	115	1%	17%	66%	16%	0%
		France[A]	1	1	1	5	0	8	13%	13%	13%	63%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%
	Hazard - Surroundings obscured by moving vehicle	UK	0	0	19	7	0	26	0%	0%	73%	27%	0%
		France[A]	1	2	10	2	0	15	7%	13%	67%	13%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%
	Hazard - Vision affected by vegetation	UK	1	2	8	6	0	17	6%	12%	47%	35%	0%
		France[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%

Table I – 2b: The number of accidents involving specific degradation-related causation factors, split by accident severity

Table I - 2b: Causation factors			Number of car accidents (split by accident severity)						Percentage of car accidents				
			Fatal	Serious	Slight	Non-injury	Not Known	Total	Fatal	Serious	Slight	Non-injury	Not Known
Causation factors affecting control	Weather - High winds	UK	0	0	0	3	0	3	0%	0%	0%	100%	0%
		France[A]	1	1	1	3	0	6	17%	17%	17%	50%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%
	Road surface - slippery road (due to weather)	UK	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[A]	2	8	70	14	3	97	2%	8%	72%	14%	3%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	20	20	0%	0%	0%	0%	100%
		France[B]	0	0	4	1	0	5	0%	0%	80%	20%	0%
		Spain	0	1	1	0	0	2	0%	50%	50%	0%	0%
	Road surface - Poor or defective road surface	UK	3	1	9	17	0	30	10%	3%	30%	57%	0%
		France[A]	2	0	26	3	0	31	6%	0%	84%	10%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	1	0	0	1	0%	0%	100%	0%	0%
		Spain	0	0	0	1	0	1	0%	0%	0%	100%	0%
	Road surface - Deposit on road (e.g. oil, mud chippings)	UK	2	20	64	96	2	184	1%	11%	35%	52%	1%
		France[A]	0	1	10	3	0	14	0%	7%	71%	21%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%
	Hazard - Road works/temporary road layout at site	UK	0	1	6	7	0	14	0%	7%	43%	50%	0%
		France[A]	0	0	0	1	0	1	0%	0%	0%	100%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%
	Hazard - Earlier accident	UK	0	0	5	14	0	19	0%	0%	26%	74%	0%
		France[A]	0	0	2	0	0	2	0%	0%	100%	0%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%

Table I - 2b: Causation factors (Continued)			Number of car accidents (split by accident severity)						Percentage of car accidents				
			Fatal	Serious	Slight	Non-injury	Not Known	Total	Fatal	Serious	Slight	Non-injury	Not Known
Causation factors affecting control		France[A]	0	1	9	1	0	11	0%	9%	82%	9%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	1	1	0%	0%	0%	0%	100%
		France[B]	0	0	2	0	0	2	0%	0%	100%	0%	0%
		Spain	0	0	0	0	0	0	0%	0%	0%	0%	0%
	Hazard - Object in carriageway	UK	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[A]	0	1	2	0	0	3	0%	33%	67%	0%	0%
		Italy	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[B]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		Germany[A]	0	0	0	0	0	0	0%	0%	0%	0%	0%
		France[B]	0	0	1	0	0	1	0%	0%	100%	0%	0%
		Spain	0	1	0	0	0	1	0%	100%	0%	0%	0%

Table II – 3: The most common type of causation factors in accidents with degradation present

Table I - 3a: Degredation in General	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	2273	H6	57%	H3	41%	H5	34%	E4	12%	E2	9%
France[A]	687	H6	29%	H7	24%	E1	19%	E4	16%	H2	11%
Italy	35181	E4	65%	E7	34%	H6	28%	H5	17%	E5	11%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	237	H5	33%	E1	11%	H6	10%	E4	3%	H2	1%
France[B]	87	H3	61%	H4	60%	E3	44%	E4	41%	H5	34%
Spain	48	H5	63%	H6	56%	E1	17%	E4	15%	H3	19%

Table I - 3b: Degraded Lighting	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	1235	H6	58%	H3	42%	H5	31%	H2	14%	E2	12%
France[A]	204	H6	39%	H7	32%	H2	27%	E4	21%	E1	16%
Italy	2602	H6	17%	E3	12%	E5	11%	H5	9%	E7	5%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	137	H5	36%	H6	7%	E1	5%	E4	5%	X	0%
France[B]	45	H3	56%	H4	56%	E4	49%	E3	36%	H6	31%
Spain	30	H5	70%	H6	50%	H3	27%	H2	7%	V2	7%

Table I - 3c: Degraded Weather	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	675	H6	59%	H3	38%	H5	34%	E1	12%	E4	11%
France[A]	108	H6	44%	E1	43%	H7	30%	E4	25%	H4/E2	15%
Italy	22,414	H6	27%	H5	14%	E5	9%	E7	9%	E3	6%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	1	E4	100%	X	0%	X	0%	X	0%	X	0%
France[B]	41	H3	68%	H4	68%	E3	61%	H5	39%	E4	37%
Spain	20	H6	65%	H5	35%	E1	30%	H3	5%	E4	5%

Table I - 3d: Degraded Road Surface Conditions	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	1,489	H6	58%	H3	40%	H5	34%	E1	13%	E2	12%
France[A]	363	H6	43%	E1	36%	H7	36%	E2	31%	E4	18%
Italy	1170	E4	37%	H6	28%	H5	16%	E5	16%	E7	11%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	100	H5	27%	E1	18%	H6	14%	E4	1%	X	0%
France[B]	37	H4	73%	H3	57%	H5	46%	E3	46%	H6	38%
Spain	3	E1	133%	H5	100%	H6	67%	E4	33%	X	0%

Table I - 3e: Hazards	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	311	H6	52%	E4	41%	H3	36%	H5	34%	E7	13%
France[A]	71	E4	79%	H7	46%	H6	41%	E7	18%	H4/H8	13%
Italy	12094	H6	32%	H5	25%	E4	18%	E5	15%	E3	4%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	1	H5	100%	X	0%	X	0%	X	0%	X	0%
France[B]	3	E7	100%	E4	67%	H4	33%	H5	33%	X	0%
Spain	2	H5	100%	H3	50%	V1	50%	X	0%	X	0%

Table I – 4: The most common type of causation factors in accidents with degraded lighting present

Table I - 4a: Single car accidents (no pedestrian involvement)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	493	H6	60%	H3	46%	H5	26%	H2	20%	E2	20%
France[A]	125	H6	37%	H2	34%	H7	30%	E1	21%	H3	12%
Italy	1622	E5	11%	H6	10%	H5	10%	E3	9%	E7	4%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	5	E1	60%	H2	20%	H5	20%	X	0%	X	0%
France[B]	22	H2	41%	H3	41%	H6	41%	H4	36%	E4	32%
Spain	13	H5	85%	H3	62%	H6	23%	H2	8%	V2	8%

Table I - 4b: Accidents where at least one car driver was not undertaking a manouvre (going ahead)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	809	H6	56%	H3	43%	H5	32%	H2	15%	E2	14%
France[A]	183	H6	33%	H7	28%	H2	26%	E4	16%	E1	15%
Italy	599	E3	17%	H6	14%	E5	11%	H5	5%	E2	4%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	0	X	0%	X	0%	X	0%	X	0%	X	0%
France[B]	37	H4	51%	H3	51%	E4	41%	H2	32%	H6	32%
Spain	26	H5	69%	H6	50%	H3	31%	V2	8%	H2	4%

Table I - 4c: Accidents where at least one car driver was under influence of alcohol (over limit)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	151	H2	92%	H6	60%	H3	46%	H5	25%	E2	17%
France[A]	58	H2	76%	H6	71%	H7	29%	H3	14%	E1	9%
Italy	26	H2	96%	H6	38%	H5	23%	E7	23%	E5	19%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	2	H2	100%	X	0%	X	0%	X	0%	X	0%
France[B]	10	H2	100%	H3	50%	H6	40%	E2	30%	H1	20%
Spain	2	H2	100%	H5	50%	H6	50%	X	0%	X	0%

Table I - 4d: Accidents where at least one car driver was <25 years old	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	334	H6	65%	H3	50%	H5	28%	H4	18%	E2	13%
France[A]	76	H6	46%	H7	29%	H2	26%	H4	25%	E4	18%
Italy	526	H6	20%	E5	11%	E3	11%	H5	9%	E7	6%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	31	H5	29%	H6	10%	E1	6%	H2	3%	X	0%
France[B]	17	H3	59%	H4	59%	E4	53%	E3	41%	E2	35%
Spain	23	H5	70%	H6	61%	H3	22%	H2	9%	V2	4%

Table I - 4e: Accidents where at least one car driver was male	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	926	H6	60%	H3	44%	H5	32%	H2	15%	E2	12%
France[A]	163	H6	42%	H7	1%	H2	31%	E4	19%	H4	13%
Italy	2502	H6	15%	E5	10%	E3	9%	H5	8%	E7	4%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	76	H5	36%	H6	5%	E1	5%	H2	4%	X	0%
France[B]	37	H3	57%	H4	54%	E4	46%	E3	38%	H2	32%
Spain	26	H5	69%	H6	54%	H3	27%	H4	8%	H2	0%

Table I – 5: The most common type of causation factors in accidents with degraded weather present

Table I - 5a: Single car accidents (no pedestrian involvement)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	186	H6	63%	H3	39%	E1	22%	H5	22%	E2	18%
France[A]	58	H6	36%	E1	48%	H7	33%	H4/E2	16%	H2/H3	12%
Italy	9768	H6	23%	H5	16%	E5	10%	E7	9%	E3	6%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	50	H2	60%	E2	50%	H3	30%	V2	10%	H5	8%
France[B]	12	H4	67%	H6	58%	H3	42%	E2	33%	V2	25%
Spain	6	H5	67%	H6	50%	E1	50%	H3	17%	E4	17%

Table I - 5b: Accidents which did not occur at an intersection with private drives and without roundabouts	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	270	H6	56%	H3	36%	H5	32%	E1	18%	E2	13%
France[A]	66	H6	58%	E1	45%	H7	29%	E4	21%	E2	20%
Italy	2287	H6	25%	H5	9%	E5	8%	E3	6%	E7	1%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	0	X	0%	X	0%	X	0%	X	0%	X	0%
France[B]	30	H4	67%	H3	60%	E3	50%	E4	33%	H6	33%
Spain	10	H6	60%	H5	60%	E1	40%	H4	10%	E4	10%

Table I - 5c: Accidents which did not occur on an urban road (include rural roads and motorways only)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	351	H6	59%	H3	33%	H5	32%	E1	19%	E2	16%
France[A]	70	H6	49%	E1	39%	H7	33%	E4	27%	E2	20%
Italy	9,365	H6	24%	H5	10%	E5	4%	E3	3%	E7	3%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	1	E4	100%	X	0%	X	0%	X	0%	X	0%
France[B]	25	H4	72%	H3	56%	E3	44%	H6	40%	E4	36%
Spain	18	H6	72%	E4	39%	H5	33%	E1	28%	HA	11%

Table I - 5d: Accidents where at least one car driver was not undertaking a manouvre (just going ahead)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	450	H6	57%	H3	37%	H5	33%	E1	15%	E2	13%
France[A]	99	E1	40%	H6	39%	H7	25%	E4	18%	E2	14%
Italy	11194	H6	23%	H5	8%	E5	7%	E3	6%	E1	1%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	1	E4	100%	X	0%	X	0%	X	0%	X	0%
France[B]	25	H4	72%	H3	60%	E3	44%	H6	40%	E4	32%
Spain	16	H6	56%	H5	38%	E4	31%	H4	13%	H3	6%

Table I – 6: The most common type of causation factors in accidents with degraded road surface conditions present

Table I - 6a: Single car accidents (no pedestrian involvement)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	498	H6	61%	H3	44%	H5	28%	E1	24%	E2	21%
France[A]	229	H6	41%	H7	29%	H2	17%	H5	10%	H3/H4	10%
Italy	598	E4	36%	H6	23%	H5	17%	E5	17%	E7	10%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	7	E1	57%	H6	29%	H5	14%	X	0%	X	0%
France[B]	14	H4	79%	H6	71%	H3	43%	H5	36%	E2	29%
Spain	3	H5	100%	E1	100%	H6	33%	X	0%	X	0%

Table I - 6b: Accidents which did not occur at an intersection	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	614	H6	54%	H3	39%	H5	34%	E1	16%	E2	16%
France[A]	191	H6	46%	E1	46%	H7	32%	H2	16%	E2	14%
Italy	84	E4	23%	H6	20%	H5	10%	E3	8%	E5	7%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	46	H5	33%	H6	24%	E1	22%	E4	2%	X	0%
France[B]	33	H4	73%	H3	52%	H5	42%	H6	42%	E3	39%
Spain	2	H5	100%	E1	100%	H6	50%	X	0%	X	0%

Table I - 6c: Accidents which did not occur on an urban road (rural roads and motorways only)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	759	H6	58%	H3	38%	H5	32%	E1	18%	E2	16%
France[A]	219	H6	43%	E1	40%	H7	36%	E2	17%	E4/H5	15%
Italy	706	E4	32%	H6	19%	H5	10%	E5	6%	E7	4%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	28	H5	36%	E1	29%	H6	14%	E4	4%	X	0%
France[B]	22	H4	82%	H6	55%	H3	50%	H5	36%	E4	32%
Spain	3	H1	100%	H6	67%	H5	67%	E4	33%	X	0%

Table I - 6d: Accidents where at least one car driver was NOT under influence of alcohol (under limit)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	1,420	H6	58%	H3	40%	H5	34%	E1	13%	E4	12%
France[A]	283	H6	43%	E1	40%	H7	31%	E4	20%	H5	16%
Italy	1849	E4	23%	H6	18%	H5	10%	E5	10%	E7	7%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	100	H5	27%	E1	18%	H6	14%	E4	1%	X	0%
France[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Spain	0	X	0%	X	0%	X	0%	X	0%	X	0%

Table I – 7: The most common type of causation factors in accidents where hazards on the road/roadside were present

Table I - 7a: Single car accidents (no pedestrian involvement)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	44	H5	43%	H6	39%	H3	36%	E7	34%	E2	25%
France[A]	27	E7	48%	E4	44%	H7	37%	H6	37%	X	0%
Italy	5716	H5	23%	H6	19%	E5	17%	E4	15%	E3	2%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	1	H5	100%	UK	0%	X	0%	X	0%	X	0%
France[B]	1	E4	100%	E7	100%	X	0%	X	0%	X	0%
Spain	1	H5	100%	H3	100%	X	0%	X	0%	X	0%

Table I - 7b: Accidents which did not occur at an intersection	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	132	H6	45%	H5	42%	H3	35%	E4	27%	E7	17%
France[A]	23	E7	52%	H6	48%	E4	48%	E1	17%	E2/V2	13%
Italy	375	H6	15%	H5	11%	E4	9%	E5	7%	E3	4%
Spain	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	1	H5	100%	UK	0%	X	0%	X	0%	X	0%
France[B]	3	E7	100%	E4	67%	H4	33%	H5	33%	X	0%
Germany[B]	2	H5	100%	H3	50%	V1	50%	X	0%	X	0%

Table I - 7c: Accidents which did not occur on an urban road (rural roads and motorways only)	Total number of accidents	Factor Group 1 code	No. of accidents	Factor Group 2 code	No. of accidents	Factor Group 3 code	No. of accidents	Factor Group 4 code	No. of accidents	Factor Group 5 code	No. of accidents
UK	125	H6	51%	H5	43%	H3	30%	E7	23%	E2	20%
France[A]	36	E4	58%	H7	50%	H6	44%	E7	31%	E2	17%
Italy	1,753	H6	18%	E4	15%	H5	11%	E3	7%	E5	3%
Germany[B]	0	X	0%	X	0%	X	0%	X	0%	X	0%
Germany[A]	0	X	0%	X	0%	X	0%	X	0%	X	0%
France[B]	2	E7	100%	E4	50%	X	0%	X	0%	X	0%
Spain	2	H5	100%	H3	50%	V1	50%	X	0%	X	0%

Annex II Degradation-related causation factors included in each available data source used in the in-depth analysis

Information regarding specific degradation-related causation factors in German GIDAS (Germany[B]) and Italian SISS data was not available.

Degradation type	Specific type of causation factor
Degraded lighting	• Poor or no street lights lit • Glare from sun • Glare from headlights • Cyclist not displaying lights or cyclist/pedestrian wearing dark or inconspicuous clothing
Degraded weather	• Vision affected by rain, sleet, snow or fog or spray from other vehicles • High winds
Degraded road surface	• Slippery road (due to weather) • Poor or defective road surface • Slippery road due to weather or deposit on road (e.g. oil, mud chippings)
Hazards present	• Surroundings obscured by stationary/parked vehicle • Surroundings obscured by moving vehicle • Vision affected by vegetation • Road works/temporary road layout at site • Earlier accident • Animal in carriageway or object in carriageway

Table II – 1 Causation factors in UK OTS database

Degradation type	Specific type of causation factor
Degraded lighting	• Dazzle by sun light
Degraded weather	• Heavy rain • Fog • Drizzle • Snow
Degraded road surface	• Wet • With gravel
Hazards present	• Hazard: Collision with a tyre in a lane from other crash passenger car • Hazard: Collision with a passenger car stopped in a lane

Table II – 2 Causation factors in Spanish DIANA database

Degradation type	Specific type of causation factor
Degraded lighting	• Lighting - Poor or no street lights lit inside urban area + darkness with street lights lit but obscurity having a role in the accident • Lighting - Glare from sun • Lighting - Glare from headlights • darkness outside urban area • daytime, contrast vehicle vs environment
Degraded weather	• Weather - Vision affected by rain, sleet, snow or fog • Weather - Vision affected by spray from other vehicles • Weather - High winds • Weather - Aquaplaning
Degraded road surface	• Road surface - Slippery road (due to weather) • Road surface - Poor or defective road surface • Road surface - Deposit on road (e.g. oil, mud chippings)
Hazards present	• Hazard - Road works/temporary road layout at site • Hazard - Earlier accident • Hazard - Animal in carriageway • Hazard - Object in carriageway • Hazard - Surroundings obscured by stationary/parked vehicle • Hazard - Surroundings obscured by moving vehicle • Hazard - Vision affected by vegetation (overgrown vegetation)

Table II – 3   Causation factors in French EDA database (France[A])

Degradation type	Specific type of causation factor
Degraded lighting	• Poor or no street lights lit • Glare from sun • Glare from headlights
Degraded weather	• Vision affected by rain, sleet, snow or fog • Vision affected by spray from other vehicles • High winds
Degraded road surface	• Slippery road (due to weather) • Poor or defective road surface • Deposit on road (e.g. oil, mud chippings)
Hazards present	• Surroundings obscured by stationary/parked vehicle • Surroundings obscured by moving vehicle • Vision affected by vegetation • Road works/temporary road layout at site • Earlier accident • Animal in carriageway • Object in carriageway

Table II – 4   Causation factors in French INRETS database (France[B]) and German Allianz database (Germany[A])

Annex III   European basic figures

In 2004 Europe-27 was affected by 1 323 036 road injury accidents, 46 821 fatalities and 1 810 568 victims (injured + dead).

		Injured Accidents	Serious injured	Fatalities	Slight injured	Victims	Vehicles
AT		42 657	14 152	878	41 705	56 735	75 384
BE		43 861	6 231	1 162	50 570	57 963	78 180
BU		7 612	1 361	943	7 004	9 308	13 956
CY		3 284	517	117	2 659	3 293	6 021
CZ		26 516	4 737	1 382	29 517	35 636	42 457
DE		339 310	80 801	5 842	359 325	445 968	620 784
DK		6 207	3 559	369	3 985	7 913	10 937
EE		2 244	633	170	2 241	3 044	3 345
EL		15 751	2 348	1 670	18 324	22 342	27 146
ES		94 009	21 805	4 741	116 578	143 124	164 580
FI		6 767	1 407	375	7 384	9 166	11 271
FR		85 390	17 114	5 593	91 252	113 959	146 281
HU		20 957	8 523	1 296	19 531	29 350	34 769
IE		5 984	1 109	374	7 284	8 767	10 102
IT		224 553	50 661	5 625	265 969	322 255	427 752
LT		6 357	1 157	752	5 953	7 862	11 655
LU		769	350	50	750	1 162	1 286
LV		5 081	1 222	516	5 194	6 932	6 509
MT		1 281	264	13	903	1 180	2 349
NL		31 635	10 596	804	27 604	39 004	59 516
PL		51 069	17 399	5 712	47 262	70 373	79 937
PT		41 495	4 602	1 294	50 718	56 614	68 124
RO		6 860	910	2 418	4 684	8 012	12 577
SE		18 029	4 022	480	22 560	27 062	30 392
SI		12 721	3 046	274	15 677	18 997	23 323
SK		8 443	1 821	603	9 369	11 793	15 479
UK		214 194	32 656	3 368	256 730	292 754	392 711
EU27		1 323 036	293 003	46 821	1 470 732	1 810 568	2 376 822

Table 58 : Road injured accidents figures for EU27
(year 2004, Source IRDTAD, CARE, IRF and National Statistics Databank)

Annex IV   Available sources for the in-depth accident analysis

In-Depth Data

CHILD – EU: IDIADA (Tarragona, SPA)
ROLLOVER – EU: IDIADA (Tarragona, SPA)
ETAC – EU: IDIADA (Tarragona, SPA)
PENDANT - EU: VSRC (Loughborough, UK)
RISER – EU: TNO (Delft, NL)
EACS – EU: LAB (Nanterre, FRA)
MAIDS – EU: TNO (Delft, NL)

OTS: VSRC (Loughborough, UK)
CCIS : BASC (Birmingham, UK)

Trohognomon: HIT (Thessaloniki, GRC)

LAB: LAB (Nanterre, FRA)
PVM: LAB (Nanterre, FRA)
EDA: INRETS (Lyon, FRA)

BUS-SP: IDIADA (Tarragona, SPA)
PED-BCN: IDIADA (Tarragona, SPA)
Singular Cases: IDIADA (Tarragona, SPA)
SCT : IDIADA (Tarragona, SPA)
BIA: IDIADA (Tarragona, SPA)
DIANA: CIDAUT (Valladolid, SPA)

SISS: ELASIS (Naples, ITA)

LMU FARS: LMU (Munich, GER)
KISS: Allianz (Ismaning, GER)
GIDAS: VW (Wolsfburg, GER) &
          BASt (Bergisch Gladbach, GER)
VW In-House: VW (Wolsfburg, GER)
Saxony Fatals: MUH (Hannover, GER)

SUV: TNO (Delft, NL)
Trucks: TNO (Delft, NL)
Trams:TNO (Delft, NL)