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Accident causation and pre-accidental driving situations: Part 1. Overview and general statistics

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TRaffic Accident Causation in Europe

Information Society Technologies

Project No. 027763 – TRACE

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Accident causation and pre-accidental driving situations. Part 1. Overview and general statistics

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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 descriptive analysis with the identification of the most relevant scenario regarding the situation in which the driver is involved just prior the accident. The results are based on the literature review, general statistics and the analysis of the national databases available in TRACE via WP8. Because the information level differ from databases to another, the available scenario presented here for the 4 predefined types of situations are generics and some specific situations could not have be distinguished. For each situation some key indicators are given, such as prevalence, severity, KSI (killed x severely injured), etc. When it is possible, these indicators are estimated at the EU27 level.

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 based on national databases coming from Spain, UK, Germany, Italy and France.

STATS 19: National Accident Data for Great Britain are collected by police forces and collated by the UK Department for Transport. The data are made available to the Vehicle Safety Research Centre, Ergonomics and Safety Research Institute, 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.

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..

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.

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 is the first deliverable of the WP2 (Types of situation). It focuses on a statistical analysis of European data available in TRACE with the identification of the main scenarios experienced by the road users.

The results are based on the literature review and the analysis of the national databases available in TRACE via WP8. Because the information level differ from databases to another, the available scenario presented here for the 4 predefined types of situations are generics and some specific situations could not have be distinguished. For each situation some key indicators are given, such as prevalence, severity, KSI (killed x severely injured), etc. When it is possible, these indicators are estimated at the EU27 level.

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)

In the descriptive part, the following scenarios were identified:

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**

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)

In the descriptive part, the following scenarios were identified:

- **Situation 1:** a driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian.
- **Situation 2:** a driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident.
- **Situation 3:** a 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.
- **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.

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)

In the descriptive part, the following scenarios were identified:

rank	KSI	Scenario
1	21%	Scenario 1: **Overtaking**
2	17%	Scenario 2: **Turning left**
3	17%	Scenario 3: **U-turning**

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)

Typical degraded lighting accident scenario

- Single car accident (also car versus pedestrian accident in the Czech Republic and Australia),
- Involved either a car or a moped,
- The vehicle was going ahead (i.e. not turning, overtaking, starting, stopping…) (Great Britain, France, Spain only)
- Dual carriageway road (Greece, Czech Republic only)
- Driver gave positive alcohol breath test,
- Driver under the age of 25,
- Male driver.

Typical carriageway hazard accident scenario

- Single car accidents,
- Involved either a goods vehicle, bus or motorcycle,
- Not at an intersection,
- Rural road or motorway,
- High speed roads (90-113kph),
- A vehicle which left the carriageway after losing control (Greece only),

Typical degraded weather accident scenario

- Single car accidents,
- Not at an intersection,
- Not on an urban road,
- Involved either a passenger car, goods vehicle or minibus,
- The vehicle was going ahead (i.e. not making a manoeuvre; GB, France and Spain only),
- Male driver (Greece and Spain only),
- Driver under the age of 20 (Great Britain and Australia only),

Typical degraded road surface accident scenario

- Single car accident (apart from Greece),
- Not at an intersection,
- Rural road (apart from Spain and Australia),
- Single carriageway road (GB, Greece & Czech Republic),
- Road with a high speed limit (Great Britain only),
- Cars and/or goods vehicles,
- The vehicle was going ahead (i.e. no manoeuvre being undertaken – GB, France, Greece only),
- A vehicle which left the carriageway after losing control (Great Britain, France only),
- Driver gave negative alcohol breath test (all but Australia),
- Younger age groups (in Great Britain, France, Germany and Australia),
- Male driver (Greece, Spain only)

3 Introduction

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.
From major studies published by the World Health Organization, many publications have identified the growing importance of road crashes as a cause of death, particularly in developing and transitional countries. Murray (1996) showed that in 1990 road crashes as a cause of death or disability were by no means insignificant, lying in ninth (9th) place out of a total of over 100 separately identified causes. However, by the year 2020 forecasts suggest that as a cause of death, road crashes will move up to sixth (6th) place and in terms of years of life lost (YLL) and 'disability-adjusted life years' (DALYs) will be in second (2nd) and third (3rd) place respectively (Table 1).

1990		2020	
Rank	**Disease or injury**	**Rank**	**Disease or injury**
1	Lower respiratory infections	1	Ischaemic heart disease
2	Diarrhoal diseases	2	Unipolar major depression
3	Perinatal conditions	***3***	***Road traffic injuries***
4	Unipolar major depression	4	Cerebrovascular disease
5	Ischaemic heart disease	5	Chronic obstructive pulmonary disease
6	Cerebrovascular disease	6	Lower respiratory infections
7	Tuberculosis	7	Tuberculosis
8	Measles	8	War
9	***Road traffic injuries***	9	Diarrhoeal diseases
10	Congenital abnormalities	10	HIV

DALY: Disability-adjusted life year. A health-gap measure that combines information on the number of years lost from premature death with the loss of health from disability.

Table 1 : Change in rank order of DALYs for the 10 leading causes of the global burden disease.

These Projections show that, between 2000 and 2020, 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%.

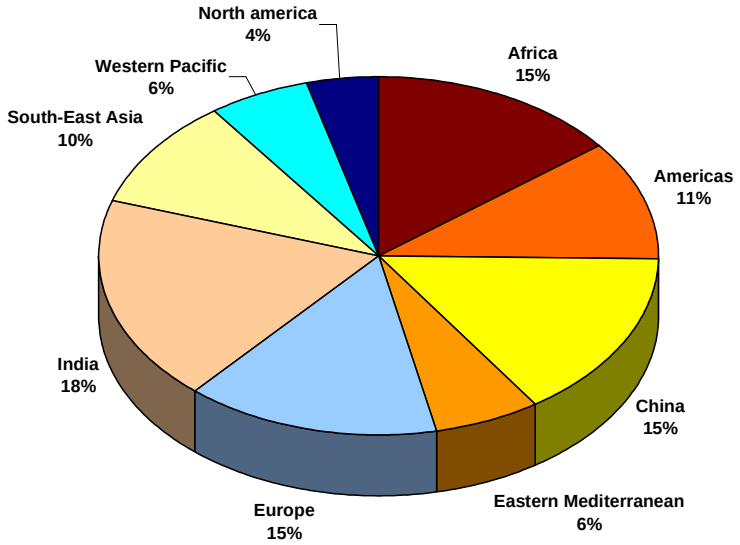


Figure 1: Worldwide road traffic fatalities – 1998 (source WHO 2002)

Because the reduction in 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. However, without a real safety target, a common commitment is not possible and the progress (in term of road safety) is difficult to evaluate. This is why, in 2001, the European Commission published its "White Paper" on transport policy (European Commission 2001), in which the main research axes to be improved and quantified targets are determined for road traffic safety.

The short-term strategic objective is to halve the number of fatalities by 2010 compared to 2001. The medium term objective is to cut the number of people killed or severely injured in road accidents by around 75% by 2025, while the long-term vision is to render road transport as safe as all other modes. It is hoped that supporting research addressing human, vehicle and infrastructure environment could achieve this last strategic target. Research should also combine measures and technologies for prevention, mitigation and investigation of road accidents paying special attention to high risk and vulnerable user groups, such as children, handicapped people and the elderly.

However, since 2001, the European Union has grown from 15 member states[1], to 25 members[2] in 2002 and 27 countries[3] in 2007, and unfortunately, the road safety target is not a criterion of eligibility for the integration of the new countries.
Figure 2 shows the difference between the real fatality curve and the predicted one considering the different composition of the Europe (EU15 in blue, EU25 in red and EU27 in green). From this graphic, we can see that only the results of EU15 are on the way to reach the 2010 target fixed by EC.

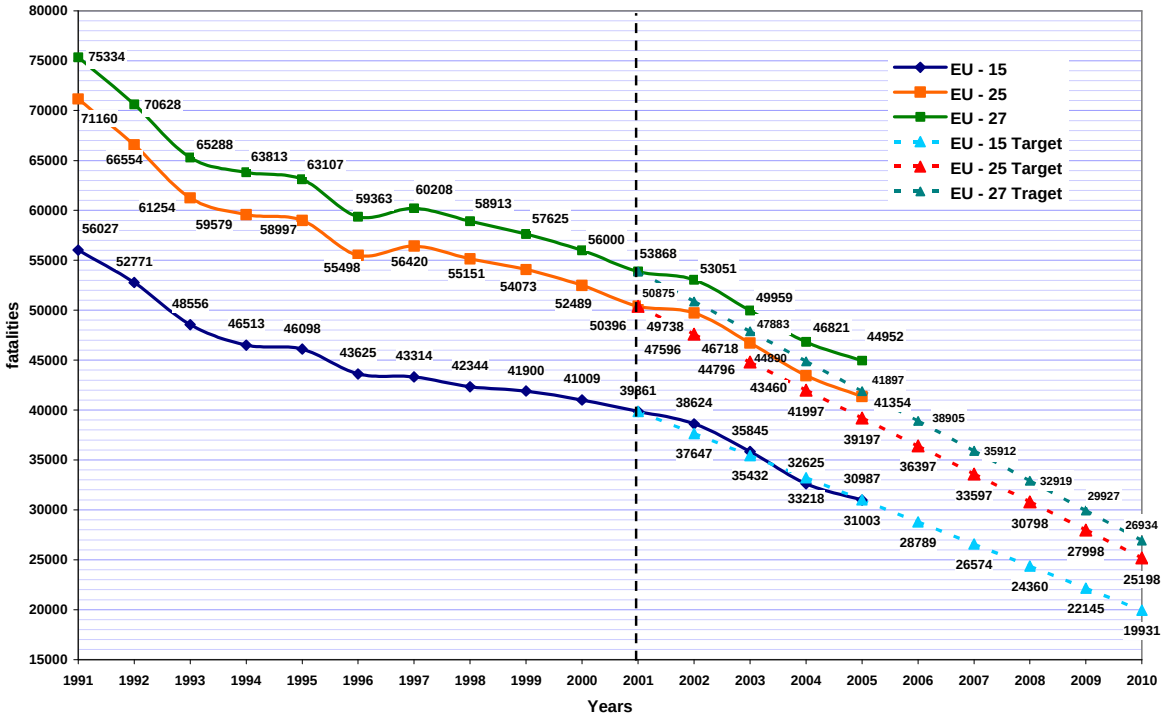


Figure 2: Road traffic fatalities in Europe from 1995 to 2005
(Source CARE, IRTAD, IRF, and National Databank statistics).

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[1] EU15 was composed by Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom.

[2] EU25 was composed by the EU15 associated to the 10 new members: Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Slovenia.

[3] EU27 is composed by the EU25 associated to Bulgaria and Romania.

The same results for EU25 show that the total mount of fatalities are 6% above the estimation (the curve is decreasing but insufficiently), and they are worse if we consider EU27 (+7%).

	EU15			EU25 - EU15			EU27 - EU25			EU27		
	Fatality	Target	Deviation	Fatality	Traget	Deviation	Fatality	Target	Deviation	Fatality	Target	Deviation
2001	39861	39861	0,0%	10535	10535	0,0%	3472	3472	0,0%	53868	53868	0,0%
2002	38624	37647	2,6%	11114	9950	11,7%	3313	3279	1,0%	53051	50875	4,3%
2003	35845	35432	1,2%	10873	9364	16,1%	3241	3086	5,0%	49959	47883	4,3%
2004	32625	33218	-1,8%	10835	8779	23,4%	3361	2893	16,2%	46821	44890	4,3%
2005	30987	31003	-0,1%	10367	8194	26,5%	3598	2700	33,2%	44952	41897	7,3%
2006		28789			7609			2508			38905	
2007		26574			7023			2315			35912	
2008		24360			6438			2122			32919	
2009		22145			5853			1929			29927	
2010		19931			5268			1736			26934	

Table 2: Road traffic fatalities follow up from 2001 to 2005 for Europe Union (Source CARE, IRF, IRTAD, National Statistics Databank).

Why are these results different between European regions?

Several answers can be advanced:

- The development of the new European states is not the same as the old European ones. Effectively, most of these eastern countries either were under the control of the Soviet Union or directly attached to the USSR (such as Estonia, Latvia and Lithuania). With the fall of the iron curtain and the dissolution of the Warsaw Pact in 1991, most of these countries, have been started to open and to develop, but the ditch with the Western countries was so big that they were not able to be filled up to now. As example, the new economic development implies that the consumption increase and the automotive market is in full expansion as you can see on the following figure.

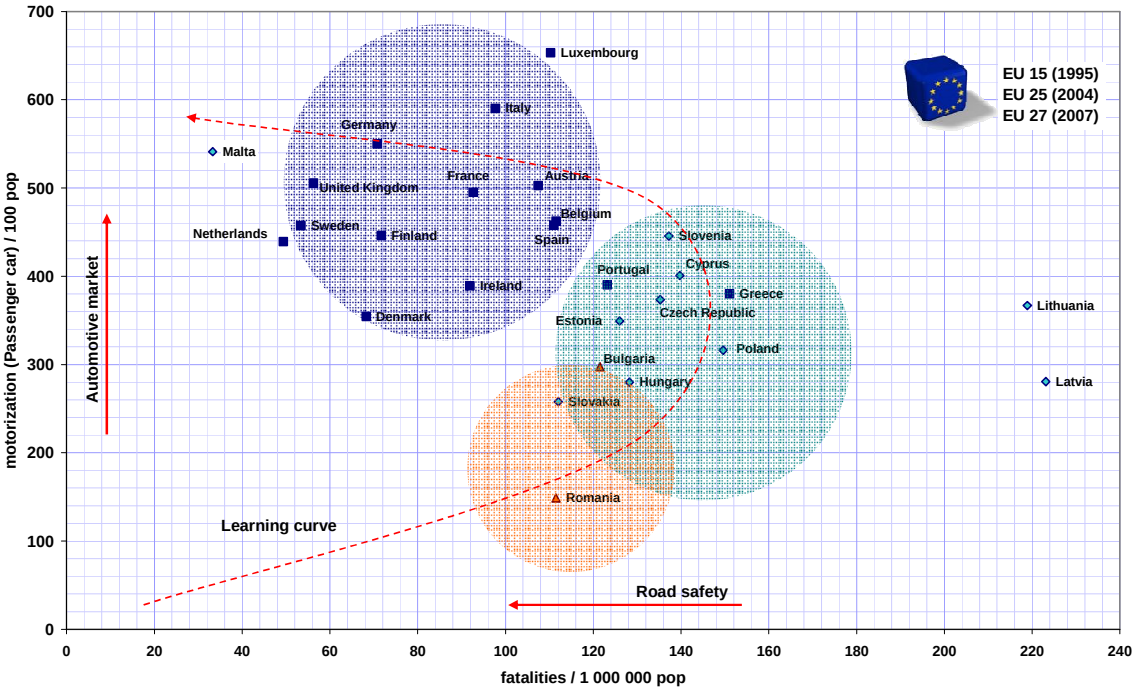


Figure 3: Distribution of the European countries following the rate of fatalities and the rate of motorization compared to the population in 2004 (Source CARE, IRF, IRTAD, National Statistics Databank)

- The road safety culture. In the Western Europe, since many decades, with the help of the European commission, the public authority, road makers and the automotive industry, the road safety is now one of the important concerns for the European citizens. This is not really the case for the new states where their economic priorities are somewhere else. This point can also be illustrated by the previous figure showing. the different position in the "road safety learning" between EU15, EU25-15 and EU27-25.
- Is the road safety target fixed by European commission appropriated with the new Europe? In 2001, this target was based on EU15 safety results years before. Maybe that a specific target should have be given with the arrival of the new states and take into account the "bad" effects on the road safety caused by the recent opening of these countries to the capitalism, the new market economy and the globalization.
- The cultural and social aspects are different following countries. Even if we are all European citizens, we have different sensibilities, values, social organizations, established norms, etc. making our wealth, and sometimes avoiding ourselves to go on. Most of the effective solutions are well known, "easy" to set up but "politically" difficult to implement: for example, most fatal accidents could be avoided if all drivers respected the Highway Code, especially the speed limit. This was well demonstrated in France when, in 2000, road traffic safety was declared by the French government as a "main national cause" accompanied with a (no popular) law enforcement and the number of fatalities was decreased by 35% from 2001.
- The efforts required differ between countries. Decreasing the number of fatalities does not claim the same effort or the same measure between countries. For example, decrease of 4000 in France or 3500 in Germany the fatalities is not the same as reducing to 8 deaths in Malta or 35 in Luxembourg. These different situations require different solutions.
- The road safety policies and measures seems more adapted in EU15 than in the others countries. Several hypothesis can be advanced: a weakness road safety information system (some countries do not have all the necessary tools to set up a good road safety diagnosis, to analyse and to identify the problems. This fact has been pointed out in SafetyNet project and during the descriptive analysis carry out in TRACE, regarding the data), an organisation in charge of the road safety that are inadequate, missing or fragmented, a more or less implication of all road safety actors (such as road makers, local administration, victims association, etc.).
- The accident causes evolve over time and have to be updated. Nevertheless, this update is not sufficient. If we want to compare results, several tools have to be set up such as relevant indicators (allowing judging the road safety performance) and common methodology to assume that the accident causation sheets are made on the same way.
- The accident causation differs between countries. If the "common" tool have to be established at the European level, dissemination and accompanying have to be set up to help each country to make is own diagnosis and to define their own priorities.

The European Commission is therefore very keen to acquire an understanding of accident and injury causes, and research activities aimed at developing and assessing support tools such as accident causation research and impact assessment analysis.

This action is also in line with the European Commission's demand for:

- Integrating technologies for driving, piloting and manoeuvring assistance to improve safety and maximize the effective capacity of the infrastructure, including the secure transportation of hazardous goods.
- Developing integrated safety systems, which are reliable, and fault tolerant (i.e. preventive, active and passive) taking into account human-machine interface concepts focusing on system implementation.

- Designing user-friendly driver interfaces based on human-centered design philosophies taking into consideration biomechanics, ergonomics and human factors, injury reduction measures, environment perception and effective lay-out of signalling and piloting information for improved road safety.
- Developing and demonstrating Co-operative systems for road transport that can make transport more efficient and effective, safer and more environmentally friendly. Cooperative Systems (as an extension to autonomous or stand-alone systems), in which the vehicles communicate with each other and the infrastructure, have the potential to greatly increase the quality and reliability of information available about the vehicles, their location and the road environment, enabling improved and new services for the road users. Such systems will enhance the support available to drivers and other road users and will provide for:
    - Greater transport efficiency by making better use of the capacity of the available infrastructure and by managing varying demands;
    - Increased safety by improving the quality and reliability of information used by advanced driver assistance systems and allowing the implementation of advanced safety applications.

It appears that the Commission has expressed two kinds of interest as regards accident analysis (cf. Strategic Objectives 2005-2006: 2.4.12: eSsafety – Co-operative systems for road Transport):
"In support of the eSafety initiative, and as a pre requisite for diagnosis and evaluation of the most promising active safety technologies:

- *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 of the TRACE project 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
- **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.

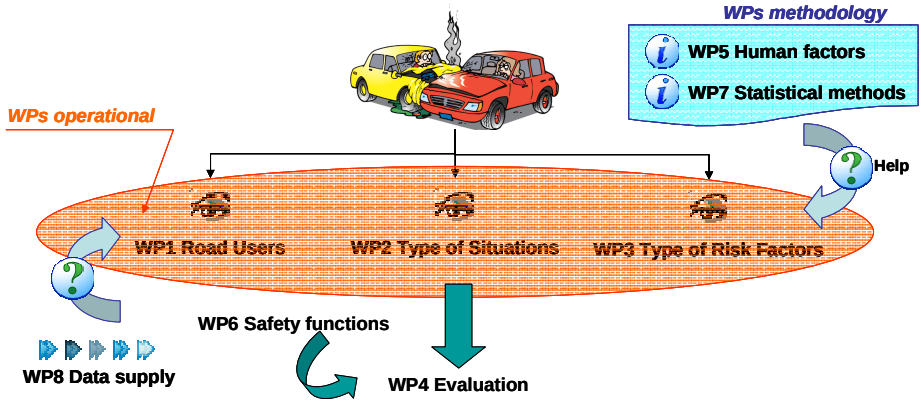


Figure 4: Organization of work packages in TRACE

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;
- The complementarily of the selected situations. They 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 D2.1 is the first deliverable of the WP2 (Types of situation). It focuses on a statistical analysis of European data available in TRACE with the identification of the main scenarios experienced by the road users trough the European network.

A literature review that summarizes the previous surveys on the subject and highlights the unexplored fields to take into account in the TRACE project is also included in this report. These fields need further investigation either through the statistics analysis or through the in-depth analysis. A descriptive analysis of the national and European data leads to define common scenarios and to describe with a few relevant parameters the prevalence of the different situations at a European level. These results (coming from the descriptive analysis) will enable the subsequent in-depth analysis of the main scenarios, defining and quantifying the main causes and the most frequent human functional failures. The overall results will be given in the deliverable D2.2.

Regarding the results, the magnitude of the accidents and the relevant accident situations are defined upon the pre-accident manoeuvres (whether the manoeuvre is performed or not, accidents involving at least one passenger car) and the road layout (at intersection or out off intersection).

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 part dedicated to the descriptive analysis methodology giving the research objectives and the common target applied across the four tasks developed in WP2.
- The 3rd part is based on the results of this first analysis. For each task, we will give some definitions allowing to define the scope, a literature review (trying to know the state of art and to highlight the unexplored fields), a general description of the stakes at the European level, and when it has been possible the specific scenarios, with for each of them, its prevalence in term of accident and injuries.
- A conclusion of the first step of the analysis, underlining the main results obtained from the descriptive analysis, introducing the next steps and the main issues observed during this step.

4 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 with which the driver is confronted.

A situation is defined as a pre-accidental situation to which the driver is confronted in normal driving conditions just before it turns into an accident situation[4] . 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[5], 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, car-following, joining a carriageway, 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.

4.1 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.

[4] A situation is linked to a vehicle. One accident whit two vehicles count two situations

[5] A scenario clusters several similar situations according to predefined criteria.

4.2 The partners

Five institutes are involved in WP2: BASC (UK), VSRC (UK), CIDAUT (Spain), IDIADA (Spain), CDV (Czech Republic) and LAB (France).

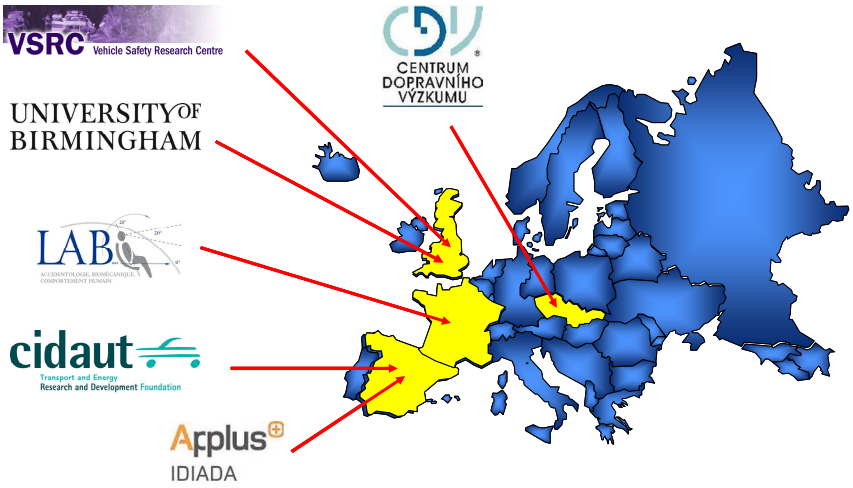


Figure 5: Institutes involve in WP2.

4.3 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 in a sequential order:

- 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):
    - Adoption of a general systemic approach: accident process considered as the result of interactions between the different elements (driver-vehicle-infrastructure).
    - 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 gives the preliminary results from the descriptive analysis.

4.4 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 **pre-accidental situation** 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 original and useful idea is the illustration of each relevant scenario with:

- A pictogram or picture of the scenarios (defined within the national databases) allowing to understand quickly the situation.
- A brief description of the scenario. This information will remain general and will be based on the common part of the included accidents (based on the in-depth analysis).
- Key indicators mainly based on relevant parameters available in descriptive databases and defined by the first step of the analysis at the European level (e.g. number of accidents, fatalities, severe injuries, etc.). These indicators allow to rank the scenarios but also to identify what are the main road safety problem.
- The main causes related to the scenario.

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.

4.5 Relationships between WP2 and the others WPs in TRACE.

Reminder that, the two main objectives of TRACE are:

- To contribute to the identification of the main causes of outstanding European accidents,
- To improve the methodology for the evaluation of safety devices.

WP2 is clearly identified as one of the operational work packages directly related to the first objective. It offers an original point of view on accidents and contributes, with WP1 (Road users) and WP3 (Human factors), to a comprehensive overview of the accident causes, including for the first time, human functional failure.

Another result is to allow WP4 (Evaluation) and WP6 (Safety functions) to identify the most appropriate safety systems corresponding to each accident scenario and defined in the operational databases. A typical example of the results is shown in the following table.

	%	Safety function 1			Safety function j			Total		
Scenario 1										
Scenario i	Ai	Bi1	Ci1	Di1	Bij	Cij	Dij			
……										
Total										

Ai: percentage of injury accidents corresponding to the scenario i
Bij: percentage of injury accidents corresponding to the scenario i for which the safety function j is relevant
Cij: percentage of injury accidents corresponding to the scenario i that could be avoided by the safety function j
Dij: percentage of injuries of the scenario i that could be avoided by the safety function j.

Table 3: Example of results available in TRACE.

If the results expected from the operational work packages is to update the knowledge on accident causation in Europe, the complexity of the task shows clearly that this work can not be carry out without the help of other multidisciplinary methodologies. They are considered as necessary to achieve this knowledge and especially methodologies for analysing the influence of human factors as well as the statistical methodologies used in risk and evaluation analysis. This objective is addressed in TRACE by the constitution of specific Work Packages devoted to methodologies which :

- provide the operational Work Packages with tools and instruments for accident causation analysis and the assessment of the safety benefits of technologies. One of these specific Work Packages is WP 7 (“Statistical Methods”). Its main objectives are to improve statistical methodology in empirical traffic accident research (Tasks 7.1 to 7.4) and to provide statistical services and methodological advice to other work packages (Task 7.5).
- identify and improve the scientific approaches in human factors analysis applied to accident causation and evaluation. This specific task is carried out by WP5 (“Human Functional Failures”). It main objective is to allow the analysis of the role of "human factors" in road accident production. In brief, WP5 is oriented toward the diagnosis of the difficulties met by road users which lead them to an accident, toward the identification of the contexts in which they take place, and toward the definition of the origins of these difficulties whether they are human in nature otherwise. One of the several challenges is to define and provide usable tools and methodological analysis to operational work packages.

Another challenge in TRACE is relied to the data. Results require European data delivered by WP8.

As already describe in this report, the objective of WP8 is not to create a new common European database, but to manage the requests made by operational WP to partners having available data.

These requests are based on statistical tables and not on data extraction. The tables are gathered on a Excel file following a specific format set up by WP8. Each operational WP built is own request regarding its field and send them to WP8. The WP leader have to check that the request is conform to the pre defined format, check that the tables are understandable, ask more information if necessary, fix a deadline for the answer in agreement with the requester and send the final request to the corresponding partners to be filled in. During the "filling time", WP8 lists the different questions exchanged between partners and requester in order to gather and disseminated all useful information. All contributions are received by WP8, checked, gathered in a unique file and finally sent to the requester.

We can see that the organisation proposed in TRACE is a mature reflexion and make this project is not a succession of methodologies but a set of knowledge that articulate between them.

4.6 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, 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.

5 The descriptive 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:
  - the accident mechanisms;
  - 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.

This report is based on the descriptive analysis and the determination of the main scenarios associated to each of pre-defined situations.

5.1 The methodology

As seen before, the descriptive analysis is based on a macro-accidentology study, in other words on extensive national accident data.

It is understood that macro accidentology is rather poor in identifying accident causation factors if it relies only on extensive accident databases (i.e. census of accident data registered by the police forces and put into national files), essentially 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. On the other hand, they can often provide reliable information that can be 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.) and to start risk analysis if they can be connected to exposure data (e.g. the risk of being involved in an accident whilst the pavement is wet is doubled compared to dry pavement if the 20 % of accidents on wet pavement is compared to the 10 % of kilometres driven whilst the pavement is wet)..
These 'Stake' and 'risk analysis' approaches are fundamental in accident causation and are frequently the catalyst of any kind of accident analysis as they consider the accident in its quantitative aspect. A large number of reports and papers use these approaches and it is impossible to report on all of them. Most of the outcomes include numerous simple statistics combining variables of a series of accident and exposure databases. These outcomes are generally descriptive data or risk indicators. They are highly useful to determine the prevalence of factors (e.g. in France, a driver under the influence of alcohol is recorded in 27 % of the road accidents), or, even more interesting, the relative risk and the attributable risk to be involved in an accident due to a risk factor or a combination of factors.

The advantage of the extensive databases is to offer a large and representative sample of injury accidents useful to define the magnitude of the problems in Europe. However, if the exhaustiveness of accidents is more or less guaranteed, the number of information is limited, especially as the number of participating countries increases.

Today, most of the European countries has its own data collection at a national level. If some variables are usual (such as fatalities, casualties, location, weather conditions, lighting condition, etc.) because they represent some key indicators enabling comparison of the contribution of each country, others are either missing or have a different definition. That is the case for example of the variable related to the road user manoeuvre before the accident, which is crucial information for the analysis. This variable exists in most extensive databases but is expressed in different way leading to a useful common data obtained by combining several parameters. These difficulties have been raised by the SafetyNet project.

In waiting the future ERSO and the CADAS[6] database, the challenge of the descriptive analysis is to find databases that allow us to:

- find some aggregated data related to the situation point of view. The needed information to determine the most relevant scenario for each task cover in WP2 has to be available at the vehicle and/or driver level. They rely essentially on the manoeuvres.
- give results covering the EU25 or EU27 as recommended by the EC.

To find a common base, European extensive databases such as CARE or IRTAD have to limit the information to relevant and existing data and have to adapt themselves to the expansion of the EU.
Instead of building a common European database, the TRACE project identified a specific work package (WP8) to provide the operational work packages with data. Of course, WP8 has access to the previously quoted European database but, through the partners involved, can also benefit from the large variety of data in the different national databases made available.

The functioning of the WP8 is based on request tables. Each operational work package defines a set of relevant tables that they need as shown below. The requests are based on the literature review firstly performed. This literature review highlighted recurrent problems and raised other problems not mentioned in the previous surveys. To avoid misunderstanding or wrong interpretation, each table is accompanied with a text clarifying the data required and remind the main definitions. All tables are gathered in an Excel file and sent to WP8 associated to a deadline for the answer. WP8 then identifies the partner who can answer (Three different sets exist: descriptive data, in-depth data and exposure data) sends the file to each selected TRACE partner, controls the time spent, then collects the information from the partners, and redirects it towards the requesting WP.

For further information on the request process, please refer to the WP8 deliverable.

Research Question: *Which intersection type is the most represented?*

3	Type of intersection													
	Pedestrian accidents							Without pedestrian						Total
	X	T	Y	round about	other	unknown		X	T	Y	round about	other	unknown	
Injury accidents														
Vehicles														
Fatalities														
Seriously injured														
Casualties														

Table 4: Example of a data request

In the WP2 case, the four task leaders submitted a proposal of request for the WP leader approval in order to respect all along the survey a common methodology.

[6] Future common European database included in ERSO (European Road Safety Observatory) based on CARE structure gathering all necessary aggregated information (following the SafetyNet recommendations) and available for the overall European countries.

However this process has some weaknesses:

- All the EU25/27 is not covered by the TRACE partnership: although the main western countries are represented, the eastern ones are less involved. It is therefore necessary to use statistical methods which will enable estimation at the European level based. But this estimation depends on the level of representativeness of the available data in other words on the number and proportion of west and east countries.
- National databases are all different regarding the type of parameters, the accuracy of the parameters, the database frame itself (data available for the vehicle and/or for the whole accident) that changes the sense of the analysis. We attached a great importance to acquire a good understanding of each database before thinking to a request proposal.
- Because this process is time consuming, the requests have been simplified and contain only tables necessary for the analysis. This is the challenge of each work package.

  To reach a common methodology and speed up the analysis, each partner or task leader carried out the main analysis, which requires multiple cross-tabulations, on its own available and well known data, before asking for more specific data on only the relevant variables to the different partners through the WP8.

The common methodology used in the different tasks for the descriptive analysis is relayed in the following steps:

1. Definition of the scope and the terms of the study
2. A literature review to establish existing knowledge and the missing subjects.
3. The task leaders identify relevant parameters in their own country's database
4. Using the relevant parameters, an analysis of the task leader's own country's data is undertaken,
5. The most interesting results from this analysis is used to create a data request which is forwarded to WP8 to request similar tables of aggregated data from other TRACE partners who have access to their national data,
6. Once the data tables from other countries were returned, a full analysis is carried out on all the data
7. Classification of the situations into scenarios. Each scenario includes road user situations with a similar process.
8. Complement of the analysis with other available databases. The objective is to define the relevant tables which will be submitted to WP8 to describe the classification.
9. Merge and extension to the EU-27. The objective of this step is to gather the different answers provided by each partner asked by WP8 and to extend these results to the EU level. The use of statistical tools is needed.
10. Selection of the most relevant scenarios. In-depth analysis will concern only the most important scenarios.

5.2 Definitions and scope

In order to control the use of common methodology, first of all we defined simple but not so simple terms we are going to use all along the survey.

Injury Road Accident is a sequence of events leading to a collision between a given road user and any other road user (motorized or not), any fixed or mobile obstacle (on or off the road) or any road and/or roadside surface resulting in the injury of at least one person (i.e.: excluding property damage only accidents).

A passenger car accident is defined as an accident involving at least one passenger car which contains an occupant who suffered at least 'slight' injuries.

Accident Situation is a description of the combination of elements which describe the pre-collision phase for a given road user. It involves the road user's specific manoeuvre, the road layout (intersection, curve, straight line, etc.), the traffic and the environmental conditions and potential opponent manoeuvres. In a given accident, each involved party has a specific pre-collision situation (see Table 5).

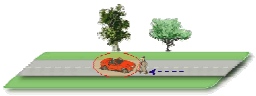
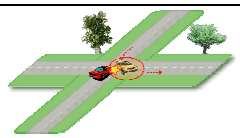
Accident	Configuration	Situations
	Accident with a car alone	1 situation
	Accident between a car and a pedestrian	2 situations situation #1 for the pedestrian Situation #2 for the car
	Accident in intersection between 2 cars	2 situations situation #1 for the red car situation #2 for the yellow car

Table 5: Examples of situations

Accident Scenario: a prototypical accident scenario can be defined as a prototype of an accident process corresponding to a series of accidents or situations, which present overall similarities regarding the chain of facts and causal relationships throughout the various accident stages. The accident scenario is determined upon a description and an analysis of the sequential process of the accident.

Note that injury accident classification techniques depend on the objectives of the classification and on the type and volume of information available in the databases. The objectives range from the determination of general characteristics of accidents to the analysis of accident mechanisms or evaluation of the safety policies.
Accidents are often classified according to a single criterion. For example, accidents can be distributed according to 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.).
In order to refine the survey we used the unit "situation" when it was possible. Of course safety functions corresponding to either one or the other involved road user might be completely different. Consequently, the classification aimed at identifying or evaluating safety functions should separate the two situations. We sometimes used the accident level to describe general parameters along with the accuracy of the extensive database. This is why we have chosen to build a **classification of accidental situations** rather than a classification of accidents (or accident scenarios).

Four types of situations have been defined in WP2: "Stabilized traffic situation" (task 2.1), "Intersections scenarios" (task 2.2), "Specific manoeuvres" (task 2.3) and "degraded situations" (task 2.4). These generic types should cover the vast majority of situations which may occur in road injury accidents (as defined above). Certain atypical accidents or situations will never fit neatly into a fixed classification.

The first three WP2 tasks are mutually exclusive without overlap (

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

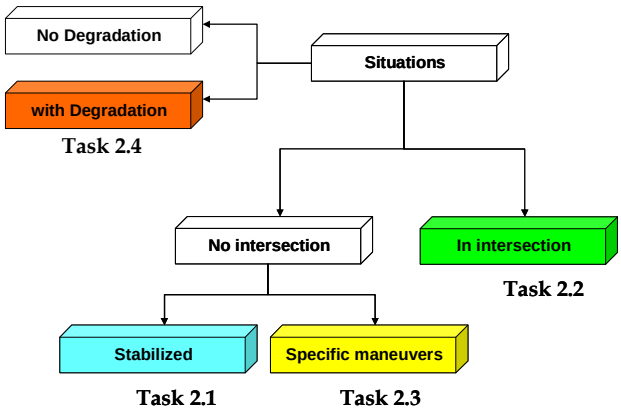


Figure 6 : Scope of each situation studied in WP2.

5.2.1 Definition of the injury severity

The analysis of the accident data considers fatalities, seriously and slightly injured persons. A general remark should be made regarding the accuracy of the casualty data in the report. The statistical collection revealed differences in quality of the data, e.g. the level of reporting injuries in the countries is not always the same.

France: **Killed:** all persons who died within 6 days as a result of the accident.
Seriously injured: Hospitalized for more than 6 days.
Slightly injured: All other injured persons.

Great Britain: **Fatality**: an accident in which at least one person sustained injuries causing death within 30 days of the accident. Confirmed suicides are excluded from this.
Seriously injured: an accident in which at least one person is seriously injured, but no person (other than a confirmed suicide) is killed. A serious injury is defined as 'an injury for which a person is detained in hospital as an "in-patient", or any of the following injuries whether or not they are detained in hospital: fractures, concussion, internal injuries, crushing, burns (excluding friction burns), severe cuts and lacerations, severe general shock requiring medical treatment and injuries causing death 30 or more days after the accident'.
Slightly injured: an accident in which one person is slightly injured, but no person is killed or seriously injured.

Greece: No information.

Czech Republic: **Fatality:** all persons who died within 30 days as a result of the accident.
Seriously injured: Opinion of the doctor.
Slightly injured: Opinion of the doctor.

Spain: **Fatality:** Victim that died within 24 hours as a result of the accident.
Seriously injured: Hospitalized for more than 24h.
Slightly injured: All other injured persons.

KSI:
Some of the data relates to 'killed or seriously injured' (KSI) rates. These rates are calculated from injury data only (i.e. fatal, serious and slight accident data, but does not include non-injury data), as shown in the equation below:
KSI rates (%) = 100 x ((fatal + serious) /fatal + serious + slight))

5.3 Overview of the problem

Before detailing the statistical analysis for each situation covered in wP2, we propose to give first a general overview of the stakes and the magnitude of each of them. These first results are based both on TRACE consortium and CARE data, and completed with other sources such as IRTAD, International Road Federation (IRF) and National Statistics Databanks.

The objective of this section is to give the general stakes for the 4 situations studied in WP2 at the European level. The prevalence of each type of situation is given in term of number of accidents, fatalities, victims, and seriously injured associated with the frequency compared with the overall numbers.

At EU27 level, these data regarding injury accidents can be easily available. However, as soon as we need details, the number of countries where data are available decreases. In case of missing values, we decided to estimate them by simple linear regression from the relevant parameters (such as the total number of accidents, fatalities, victims, etc.) and the requested information available on the other countries. This is the case for example for the number of fatalities in intersection accidents for Estonia, Cyprus, Latvia, Lithuania, Hungary, Slovenia, Bulgaria and Romania that have been estimated from this variable available in the other 19 countries and from the total number of fatalities in each country.

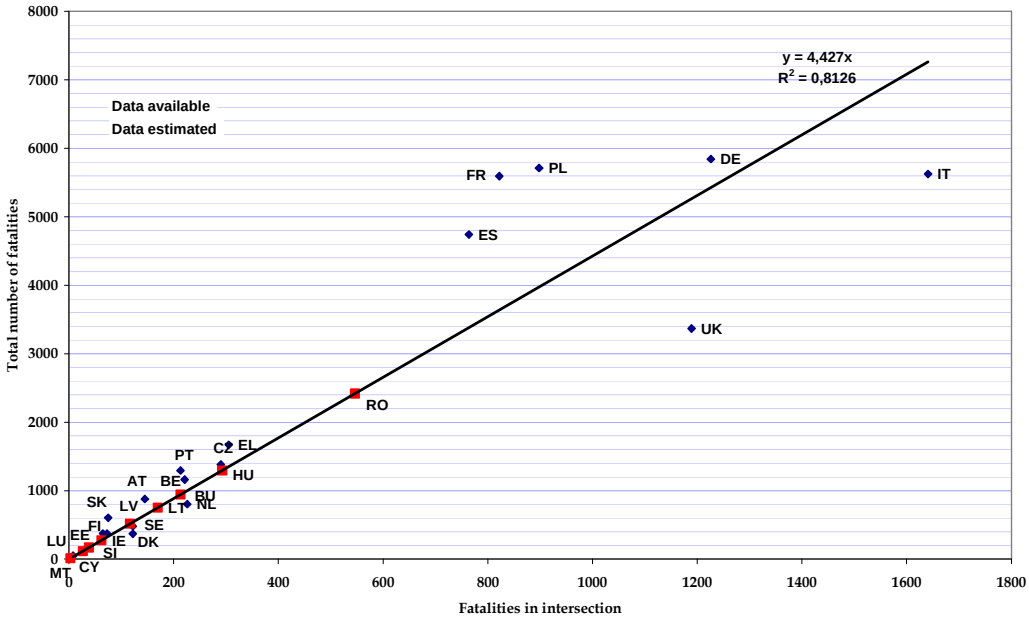


Figure 7: Estimation of the number of fatalities in intersection accidents in EU-27 (year 2004, Sources CARE, IRF, IRTAD and National Statistics Databank)

Even if the results don't give the strict reality, we can say that these estimations are good for the following reasons:

- The number of missing is low, in the worst case it is 9 on 27 countries;
- Some data are available in Eastern European countries such as Czech Republic, Poland, Latvia or Hungary which represent 62% of the overall fatalities among the Eastern Europe;
- The lower weight (in term of fatalities) that missing countries have. Most of the Eastern European countries where data are missing are small ones and their contribution in term of fatality remains small (Cyprus, Malta, Estonia).

To have a better estimation of the missing values, we also could used more sophisticated tools as described in report D7.1 (Statistical methods for improving the usability of existing accident databases), but at this step, these tools were not yet available.

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 6 : Road injured accidents figures for EU27
(year 2004, Source IRDTAD, CARE, IRF and National Statistics Databank)

If some comparisons between countries can be made regarding fatalities, it is not really the case for the other variables where definitions can be different from one state to another one.

In order to evaluate the magnitude of the stakes according to each situations, we distinguished firstly the accident "at intersection" from those occurring "out off intersection".
Then, the accidents out off intersection were split in "stabilized situations" and "situations with a specific manoeuvre". The "degradation situations" has been evaluated independently.

The stakes for intersection and degradation situation are presented by accident, whilst those related to "stabilized situation" and "specific manoeuvres" are given by situation.

The numbers presented in the next figures are only estimations and don't represent the strict reality. They are based on figures given in Table 6. Only frequencies give a good idea of what the stakes are.

5.3.1 Accident in intersection

The accidents in 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%.
If these accidents count around for the half of the total number of accidents in EU27, they contribute only for 21% of the fatalities and 32% of fatalities and serious injuries.

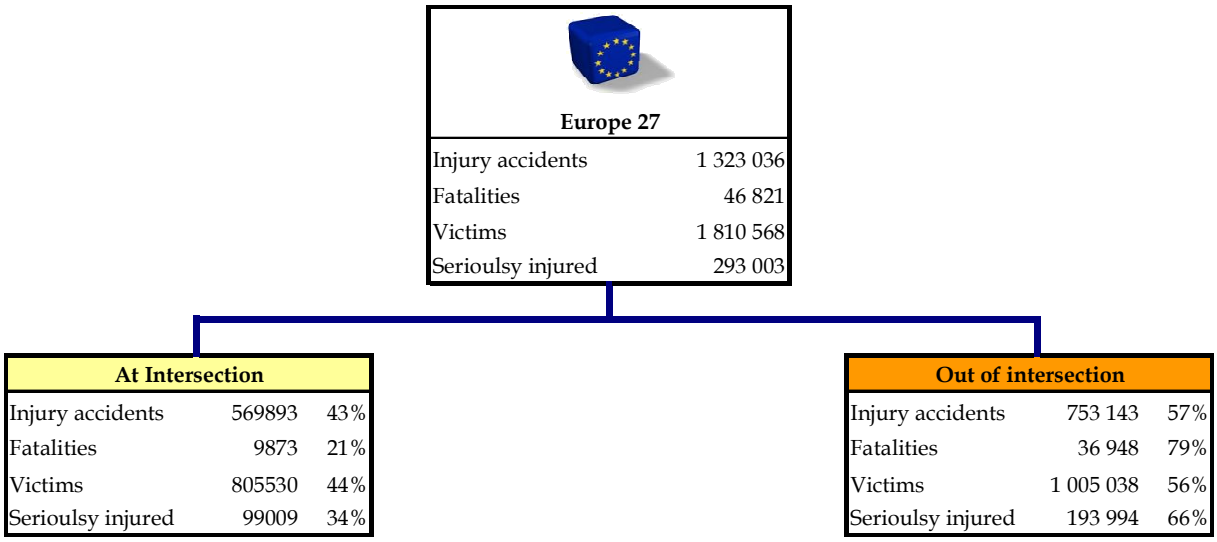


Figure 8: Distribution of road accidents following their location at or out of intersection in EU27 (year 2004, Source: CARE, IRF, IRTAD, TRACE and National Statistics Databanks)

Among the 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 what an accident in intersection is, like in UK where the neighbourhood of the intersection is also taken into account.

At European level, 43% of injury accidents occurred at intersection showing that this accident configuration represents an important axle of road safety improvement. If the number of injury accidents is high, the number of fatalities or severe injuries remains low. The fatality and severely injured represent respectively 1% and 11% of the casualties occurring at intersection.

These results argue the fact that this type of accidents has to be carefully investigated.

More detailed information can be found in chapter 8.

5.3.2 Accident occurring in degraded situations

The degraded situations represent 35% of the road injury accidents in EU27. Here the "degraded situations" correspond to accident occurred either at night (dark) or with bad weather condition. It does not take into account entirely the degradation problems. For example, bad surface conditions (except in bas weather conditions) are not included.

In other words, this result indicates that 65% of accidents occurred with good lighting and weather conditions. But this result is an over estimation.

However, we can see that this kind of accidents is in proportion more severe than the intersection ones (17 deaths at intersection against 47 in degraded situations for 1000 accidents). Their occurrences are less but the fatalities are higher.

In term of fatalities, the following countries are among the higher contributors: Belgium, Estonia, Greece, Ireland, Luxembourg, Malta and UK with proportion varying from 48% to 54%. The higher levels are for Luxembourg and Malta with respectively a rate of 68% and 82% but these results are relative with the low total number of fatalities in these countries (respectively 50 and 13 deaths).

Once again, these results show that more investigation have to be done in order to have a better understanding of the accident mechanisms, and identify what are their main characteristics. This is the objective of the chapter 9.

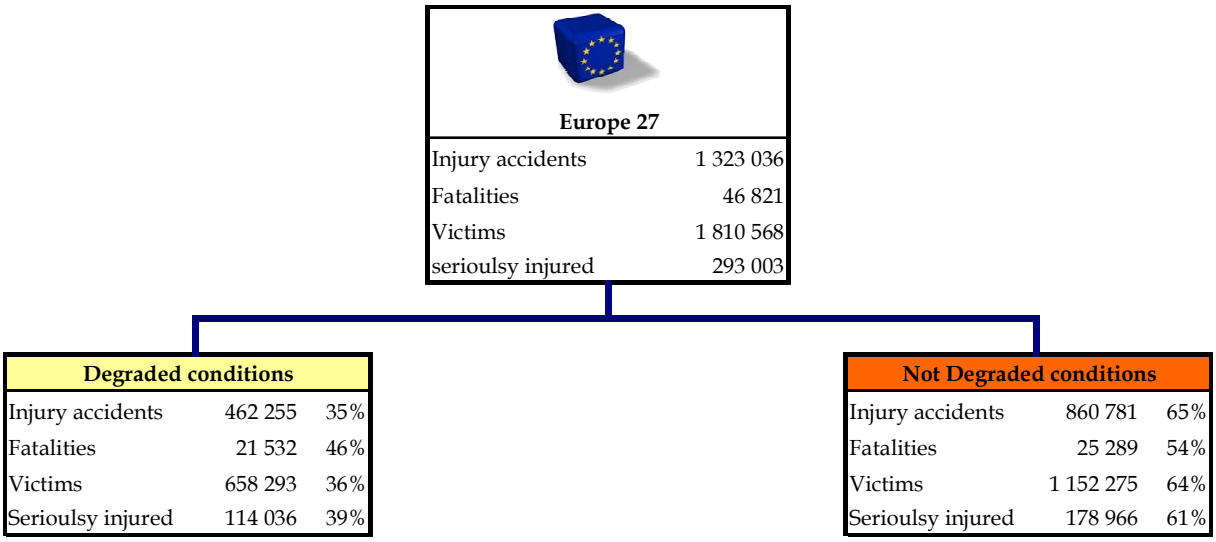


Figure 9: Distribution of road accidents following the degraded situation in EU27 (year 2004, sources: CARE, IRF, IRTAD and National Statistics Databanks).

5.3.3 Stabilized situations and specific manoeuvres

If the number of injury accidents stays common data relatively easy to find, the total number of situations in injury accidents is much more difficult to dread because many databases do not have the information at the level of every road users.

To have a rougth estimation of the number of situations out of intersection we have to estimate the overal number of sisutations by country and the number of situations in intersection.

For the 1st number, we used several databases taking the information about the nature of accident on the following items :accidents between vehicle and pedestrian, single vehicle accidents and accidents between vehicles. In multiplying the number of accidents by the number of road users involved in each configuration and adding these 3 results we can obtain a rougth estimation of the toal number of situation. However, the total number of vehicles involved in each configuration is not well-known. Estimating that most of vehicle/vehicle and vehicle/pedestrian accidents involves at least 2 road users, the calculated number is under-estimated. The final result gives 2 574 310 situations corresponding to the 1 323 036 injury accidents.

Once the total number of situations estimated for all the 27 countries, it does not more remain than to subtract the total number of situations in intersection. The total number of situations in intersection is estimated in multiplying the total number of accidents in intersection by 2 (at least 2 vehicles involved). The total number of situations out of intersection was estimated to 1 434 523 and represents 56% of the overall.

The next step consists in distinguishing the "stabilized situations" to "specific manoeuvre situations" among the situations out of intersection.

The proportion of stabilized and "specific manoeuvre" situations out of intersection have been estimated from the data available at the TRACE level, i.e. from Spain, UK, France, Greece and Czech Republic only.

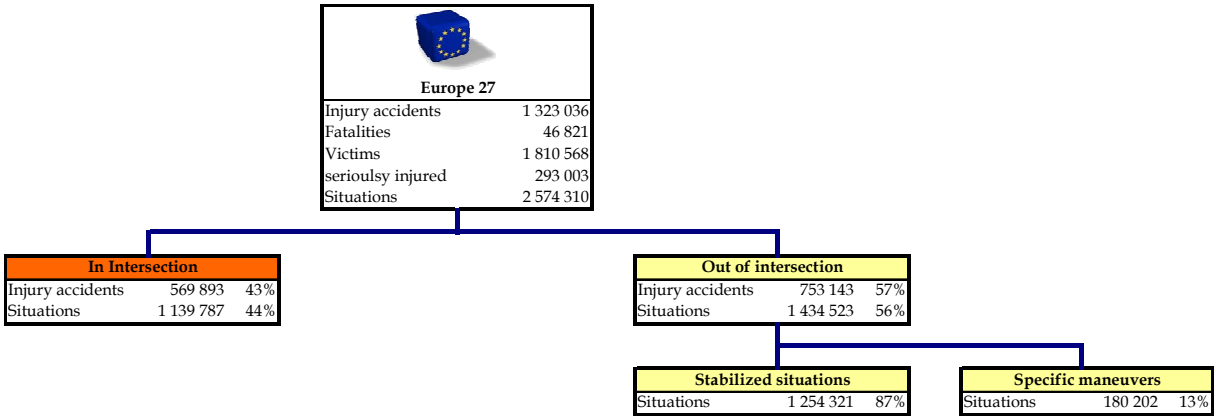


Figure 10: Distribution of stabilized and "specific manoeuvres" situations in EU27 (year 2004, Sources CARE, IRF, IRTAD, National Statistics Databanks).

The stabilized situations represent 87% of the situations occurring out of intersection that is 49% of the overall situations.

This kind of situations includes not only the vehicle/vehicle accidents but also all the accidents with a single vehicle in cause which represent 23% of the overall accidents in EU27.

The specific manoeuvre situations represent only 13% of the situation out of intersection and 7% of the total number of situations.

We are going to develop each situation type with a literature review on the subject and a descriptive analysis. In spite of we highlight differences, we are going to identify common scenarios in order to allow European actions whatever is the country.

6 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.

To achieve the target, we decided to set up a common methodology based on three steps:

- A descriptive analysis allowing to identify what are the most relevant accident configurations related to the studied situation from aggregated databases.
- An in-depth analysis allowing to have a better understanding on what happen in the relevant scenarios previously identified. This step allows to identify the main causes and human functional failures from detailed analysis of each configuration based on in-depth databases.
- A risk analysis allowing to identify the main risk factors related to the studied situation.

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 present part presents the results of the first step of the methodology based on the descriptive analysis, i.e on the characterization of the magnitude of the problem and on the classification.
It is composed of 4 sub-parts:

- Some definitions used here to state the scope of the covered situations
- A literature review presenting the main articles on the subject and identifying the missing aspects
- The results obtained from the descriptive analysis itself. These results are based on the identification of the main relevant scenarios, and their characterization from descriptive parameters available in aggregated databases.
- And a conclusion summarizing the work done during this first step and presenting the next ones.

6.1 Definition

The **stabilized situation** is related to 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. This is the case for example of negotiating a bend, stopping at red light or at stop sign, etc. In this case, we will use the term of "normal driving 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
- Car Driver' manoeuvres : no specific (not overtaking, not turning, not u-turning, …)

This type of situation gathering the following accidents:

- Lane departure
- Driver confronted to a vehicle reducing his driving space
- Driver confronted to a vehicle ahead
- Driver confronted to an obstacle ahead on the road
- Initial loss of control
- Pedestrian crossing ahead or moving along the lane

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 understand what a 'stabilized situation' is, in the following figure three situations from the same accident are shown: vehicle B (in blue) overtakes a truck (vehicle C in red) and impacts against a vehicle A (in grey) which was driving in the opposite direction.
In this case, only the vehicle A is included in "stabilized situation".
The situation for the vehicle B (overtaking the truck) depends on "specific manoeuvre" situation and studied in chapter 7.

The case for vehicle C should be in the stabilized situation only if it is included in the accident (not only present), but because we focus only on passenger car, this vehicle is not included here.

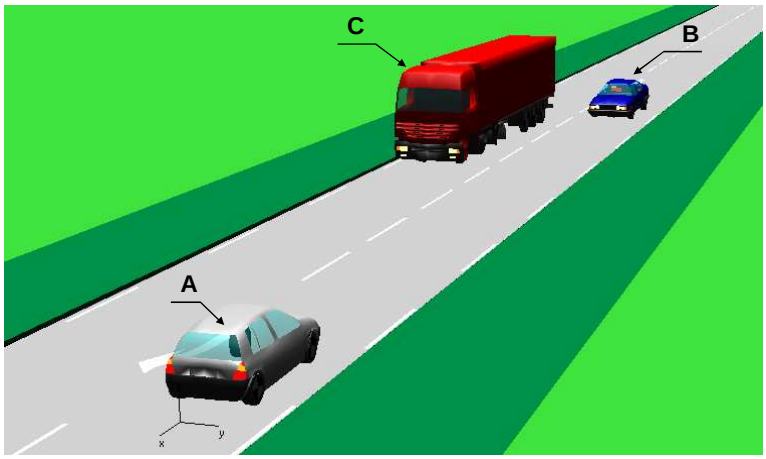


Figure 11: Example of 'Stabilized situation'.

Without specific manoeuvres does not tell that the driver did not make any urgent manoeuvre. The situation that we study is located in the pre-accidental phase, i.e. in time before the emergency phase if not before the crash.

In the following chapters, this situation is going to be dealt to know the main problems and their magnitude related to accident causation. The results are presented under the identification of the most relevant scenario regarding the situation in which the driver is involved.
In this section dedicated to stabilized situation, the reader will find:

- a literature review that summarizes the previous surveys on the subject, highlights the unexplored fields to take into account in the TRACE project and initiate the risk factor analysis,
- a descriptive analysis of the national and European data that lead to define common scenarios and to describe with a few relevant parameters the prevalence of the different situations at a European level.

These results will be in the next step (in-depth analysis) completed with the identification of the main causes and the most frequent human functional failures. The overall results will be given in the deliverable D2.2.

6.2 Literature review

This part is focused on obtaining a better understanding and the main characteristics of 'stabilized situations' from previous research studies. This characterization will address the roadway geometry, user category and the environmental factors among other relevant aspects of accident causation.

It is important to be aware of the fact that 'Stabilized situation' is not a recognized term in literature, so few research documents are really focused on the area of stabilized situations.

The different aspects obtained in the review are the following:

- Rear-end collisions
- Negotiating a bend
- Single vehicles accident
- Pedestrian

6.2.1 Rear-end collisions

This is a stabilized situation from the point of view of target vehicle, which is collided. Some important characteristics are:

- Rear-end accidents are a serious problem particularly in queuing traffic (Uppsala, N., 2000) and they are one of the most common type of accident on motorways (Golob, T.F., 2004). In a study on young drivers, the most problematic age young group is the 23-25 age group, even more problematic than for the younger 17–19 or 20-22 year-olds (Clarke, D, 2005).
- In this kind of accidents, one important aspect is the size of gaps between cars in queues (Uppsala, N., 2000)
  - ✓ Gaps were generally underestimated with the front gap being even more underestimated than the rear gap.
  - ✓ Perceived critical time gap was 1.0 second rearwards and 1.5 seconds forwards.
  - ✓ Recommended gaps are 2 seconds in the UK and France and 3 seconds in Sweden but these are difficult to implement in practice.
- If driver performance is studied in this kind of accidents, it could be comprised of four successive states (Golob, T.F. 2004; Horne J.A.; Hughes, P.K. 1986; Manser, M.P. 2006; Maycock, G. 1997; Neyens, D. 2006): Low risk, conflict, near crash and crash imminent.
- In an American study (Neyens, D. 2006) carried out over any kind of rear-end collisions of teenage drivers (16 – 19 years old), one of the most common distraction found (out of cognitive, in-vehicle and passenger-related distractions) was cell phone use.

6.2.2 Negotiating a bend

As reported in the definition part, this normal driving action is included in stabilized situation.
Literature shows (Charlton, S.D. 2006) that failures during these bends are due to driver attention, bad perception of speed and curvature, and bad position in the lane.
Negotiating curves requires that drivers anticipate the curve by adjusting their speed and lane position to accommodate the severity of the curve.
Concerning road infrastructure, the following variables are considered as contributing factors in these accidents:

- Increasing degrees of curvature causes more accidents (Haywood, J.C., 1980).
- Visibility distance during the bend. This is the threshold associated to the bend.
- A rating of the relative importance of various curve characteristics four factors were found to be most important: sight distance through the curve (curvature), road cross sections (lane and number of lanes), curve warning signs and separation of opposing traffic.
- Lack of perception of the warning bends.

Those bends where it is necessary an important speed reduction (Johnson, 1982) and the driver is approaching in normal way of driving, are overrepresented in the accidents. In these situations where an important reduction is done, there are some important issues observed:

- A higher level of available friction than at straight sections is necessary as the vehicle has to face longitudinal and transverse dynamic requirements.
- An increase of the lane and shoulder width, supposes a higher average speed during the bend.
- The low effect of the warning signals in bends can be due to overuse, especially in cases with low quantity of risk. Even, there are not studies showing the possible good effect of advisable speed signals in bends.
- Finally, it has been proved that chevron sight boards have good effect in the reduction of accidents when a driver is negotiating a bend and doing other secondary tasks inside the car.

Straight sections of road demand approximately 23% of a drivers' attentional resources at speeds ranging from 64 to 129 km/h. In contrast, drivers' attentional demands on curves are reliably higher (26% at 32 km/h on a 17º curve) and increase as vehicle speeds increase (42% at 64 km/h on a 17º curve).
Decrease in driver attention result in a decreased ability to negotiate curves which is exacerbated by higher speeds. It has been suggested (Drory, A. 1982; Hughes, P.K. 1986)) that in normal way of driving in a bend, a sizeable proportion of warning signs are needed only under conditions of poor visibility; with good visibility, some warning signs are not noticed because they convey information that is redundant with other sources.



In an indoor simulator test made in New Zealand (Charlton, S.G. 2002)), some drivers were studied while they were travelling under stabilized situations during three kinds of bends (45 km/h, 65 km/h and 85 km/h) and speaking on the phone. The three bends could be marked with three types of warnings: diamond, chevron and road marking (see figure).
It has been shown:

- In 45 km/h curves, all of the three warnings worked well reasonably.
- In 65 and 85 km/h curves, the diamond signs were ineffective in slowing. In contrast, the chevron and road marking warnings were accompanied by lower 65 km/h curve speeds. For the 85 km/h, the chevrons were the most effective and the road marking warning failed to slow participants.

Another study performed in New Zealand (Diew, Y. 1991) tried to know the driver behaviour at horizontal curves after modifying the curve layout (a horizontal curve is a usual bend, this means that only there are not changes on the vertical curvature (changes of longitudinal slope)). This study has revealed considerable variations between drivers, with respect to speed, path radius, and side friction demand. Realignment of the curves (i.e. modification of the bend layout mainly by decreasing the curvature radius) has led to substantial changes in speed, path radius and side friction demand. Despite a marked increased in vehicle speeds since realignment, the side friction demand has nevertheless diminished at all the realigned curves. It has been argued that an objective measure on the margin of safety is the available side friction minus the required side friction, and that an increase in this margin indicates a reduced risk of drivers' losing of traction and control of their vehicles

In other studies, way of negotiating bends was analyzed in young drivers:

- Young male drivers tend to have twice the proportion of accidents negotiating a bend than older drivers do.
- Young women drivers also have a higher proportion of accidents on bends than older women drivers.

Loss of control on bends was found to be a particular problem for the youngest drivers (age 17-19) more than for the 20 – 25 year-olds in a study on novice drivers.

6.2.3 Single vehicle accidents

A classification of non-voluntary lane departures (stabilized run-offs) could be based on the following criteria (Bar, F.):

- The event precipitating a normal driving situation into an accident situation.
- The origin of the swerve or drift in or out of the lane.
- Whether or not the vehicle is controllable at the moment of lane departure.
- An eventual driver reaction and its chronology (before or after lane departure).
- The possible return of the vehicle to the roadway after departure.

Three main actions have been detailed to prevent lane departures:

- Strictly preventive countermeasures that warn the driver about his state or about the state of the environment. The countermeasures deal with the origin of the driver failure that induces the lane departure. This is for instance the case of hypo-vigilance detection.
- Corrective actions, which adjust the drift or the lane departure. The countermeasures deal with the immediate consequence of driver failure. This would for example be the case of a system that could detect drift angle compared to the roadway trajectory.
- Recovery actions that could replace confused or over-amplified driver steering wheel and brake pedal actions (or even throttle off).

A population-based-case-control study was conducted in Hong Kong (Yau, K. 2003) to examine factors affecting the severity of single vehicle accidents (only concerning 'passenger cars':

- District, driver's age and gender are highly associated with injury severity, i.e.: male drivers have a higher risk of being involved in accidents with fatal and serious-injury.
- The age of the vehicle is another important factor, older vehicles being involved with a higher proportion of fatal and serious-injury.
- Day of the week and time of accident are important factors affecting injury severity, slight injuries usually occur during working days and daytime.
- The other two environmental factors, street light and rain conditions are both important factors affecting injury severity.
- Slight injuries occur more often in poor lighting.
- Traffic congestion is also found to be an important factor determining injury severity; moderate levels of traffic congestion generate a lower proportion of fatal and serious-injury.

If the review is focused on run-off accidents, we can find an American study (Gary,A. 2006) demonstrating there is not U-shaped relationship between speed and crash risk, although risk tended to increase as a function of speed. Applying Bayesian methods to compute the probability that a fatal outcome would have been avoided as a function of counterfactual initial speed, it has found that strict adherence to posted speed limits would have prevented about 50% crashes investigated in this study.

Another study (Dysannake, S.) carried out in USA shows young drivers (16 to 25 years old) experience higher percentage of single vehicle accidents. In this study, influential factors in making an injury severity were studied in *run-off* accidents with young driver in passenger cars. Factors such as influence of alcohol or drugs, ejection in the crash, point of impact, rural crash locations, existence of curve or grade, and speed of the vehicle were significantly important towards increasing the probability of having a more severe run-off crash. Some variables such as weather condition, residence location, and physical condition were not important at all.

The last study found related to stabilized situation (Manser M.P. 2006)) was focused on drivers who were driving, in normal situation, through a simulated transportation tunnel environment. Drivers gradually decreased speed when exposed to the decreasing width visual pattern and increased speed with the increasing width visual pattern. The presence of texture served to attenuate overall driving speed.

6.2.4 Pedestrian accidents

Pedestrian accidents included here are studied under the angle of the accident circumstances in a large view. A detailed and specific analysis of pedestrian accidents can be found in deliverables of WP1 dedicated to road users.

Characteristics of this kind of accidents have to be classified depending on rural or urban scenarios:

- For urban scenarios, one Arabian study Al Ghamdi, A. 2001) indicates young as well as the elderly people are more likely to be involved in fatal pedestrians (including all kind of vehicles, not only passenger cars). It has been found that 77% of pedestrians were probably struck while crossing a roadway either not in a crosswalk or where no crosswalk existed. The results of this study suggest that women should wear a reflective strip on their clothing so that they can be distinguished by drivers when the light is weak.
- For rural scenarios, one American study (Zajac, S. 2002) carried out and limited to crashes (with all kind of vehicles) in which 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

6.2.5 Risk factors

The risk factors have been studied mainly in lane departure and loss of control accidents in order to identify the counter measures. The main factors identified are speed, fatigue, drowsiness, and distraction.

SPEED: Speed-related causes are often noted to occur at curves where drivers underestimate their approach speeds and enter the curve at speeds far in excess of that which is safe. High speeds remains in some studies increasing crash risk, meaning by high speeds in most of the cases the difference between the design speed in the bend (not always equal to the bend legal speed) and the drivers' actual approach speed. (Gary, A. 2006).

FATIGUE: Driver fatigue is often cited as a cause of road accidents, however, fatigue is a condition which is not particularly well defined and which may involve a variety of physiological and psychological states

On one hand, it was found (Horne J.A.) that sleepiness was likely to be a contributory factor in between 16% and 23% of all accidents (included 'stabilized situations'). On the other hand, in one survey taken in the UK (Maycock, G; 1997), different car drivers were asked if there were any occasions they had felt close to falling asleep while driving in normal saturations; 29% of the drivers reported that there were. The following table shows driving conditions suggested by these car drivers as those which induce sleepiness while driving:

Driving condition	Percentage of drivers
Long working day/physical or mental exertion	21
Motorway driving for long distances	19
Late night/early morning	15
Driving for long hours	9
Heater on/too warm	9
After working night shift	6
Lack of sleep	6
Other (driving in the dark, poor visibility, boring journey)	15

Table 7: Driving conditions when sleepiness appears.

Although in this last study it is not clear if it is not possible to assure that the source came from 'stabilized accidents', the list of driving conditions showed in the previous table can help in the future 'in-depth' investigations belong to this WP

6.2.6 Literature review – summary

Although it has found literature related specifically to stabilized situations, there are not two much studies focused on these situations (situations studied included different situations together, so it is very complicated to divide the conclusions only for stabilized situations). In-depth investigations would give more information about accidents belonging to this type.

Nevertheless, it has been found some possible correlations to be considered in stabilized situations:

- For rear-end accidents:
  - ✓ It is important to consider the size of the gaps in queues.
  - ✓ 23-25 years old drivers is the specific group (from the young groups) who more accidents suffer.
  - ✓ In the specific group of 16-19 years old drivers, the use of cell phone was the main distraction factor.
- In bends: Attention, speed, lane layout, perception, presence of signals and driver age has to be considered.
- Single vehicle accidents: The main important risk factor is speed, which tends to increase risk factor.
- In pedestrian accidents: Width of the lane, presence of crosswalk and pedestrian age should be considered as important factors.
- Another factors as fatigue, can be relevant in some type of stabilized situations.

6.3 Descriptive analysis

The objective of this analysis is to identify the main problems and their magnitude related to accident causation for stabilized situations only.

The results are presented under the identification of the most relevant scenario regarding the situation in which the driver is involved.

This part not concerns directly the identification of the accident causes in stabilized situation, but it allows to build the basis of the study by determining the most important scenarios for which the detailed analysis (causes, contributing factors and risk) will be made.

We highlight here once again the difficulty to identify stabilized situations through the extensive databases and moreover through the common databases such as CARE. Note that these databases are built to aggregate all common data in order to assess the overall stakes and to identify the domain of future investigations. So, the main information will come from the request asked to the different partners in charge of looking at their own database the best way to answer accurately. These data will be extrapolated to the EU-27 with the help of the WP7 statistical tools.

6.3.1 Available data

Period of data

The data used in this work is restricted to a 4 year period, from 2001 to 2004 as an average. When analyzing the data of the different countries, it was always possible to get full information for the entire period of 4 years. In some cases, certain countries could not be taken into consideration as the lack of information could not be solved properly. Therefore missing countries in some tables throughout the report are just attributed to missing data.

Accidents considered in the study

This item will cover all the accidents where, at least, one of the road users was a passenger car user in a stabilized situation. The study contains data about accidents with personal damage, which is distinguished after fatalities, seriously and slightly injured persons.

Vehicles considered in the study
As it has been detailed, in stabilized situations there must be, at least, one passenger car involved, although this does not mean that passenger cars are always considered in the study. Once the situation comply with stabilized criteria, any kind of vehicle can be considered in the study, taking into account the vehicle is going to be studied is mainly the one which is driving in a stabilized situation.

Involved countries and covered geographical area
The information used in this section comes from different databases:

- European databases: Several databases have been used to show the problem due to traffic accidents (IRTAD, CARE and ERF databases). The only disadvantage of this kind of general database is the fact that it is not possible to obtain too much data related to stabilized situations. Nevertheless, some data related to these situations will be shown after using statistical methodologies explained in TRACE Work Package 7 'Statistical Methods' (European level extension once data from some countries are available).
- Extensive data from some countries: The main figures shown in this section have been obtained after analyzing detailed data from the following countries: France, Great Britain, Greece, Italy and Czech Republic. Although several extensive databases were accessible to the project, only some databases were suitable for the queries required, therefore, only the following databases were used:

Country	Database	Data Provider	Covered area
France	BAAC	LAB	Whole France
UK	STATS19	VSRC	The whole o UK (England, Wales, Scotland but not Northern Ireland)
Greece	Greek Nat. Stat.	HIT	Whole Greece
Czech Republic	CDV	CDV	Whole Czech Republic
Spain	DGT	CIDAUT	Whole Spain

Table 8: Main characteristics of databases used in the descriptive analysis.

Through the descriptive analysis done in this task, the main scenarios are going to be detailed where this kind of situations (it is more correct to refer to 'situations' than 'accidents') happened.
It is important to say that other non European data such as Australian data have been used to compare with European distribution.
Finally, for some very specific scenarios (called 'sub-scenarios'), data were only available in Spain extensive database, so tables or figures will be related to Spanish data.

6.3.2 Analysis and methodologies

At first, the general accident situation of each country is shown with the help of an overview.
The level of these describing data will go gradually deeper and deeper and indicate to the most important configurations. Afterwards, the most important accident scenarios are investigated more exactly.
The first step in this analysis is to select these stabilized situations in extensive accident databases. For that reason, some queries criteria should be implemented over these databases.
Another important aspect to be considered during the queries is not to overlap them with other situations from this work package.
At the end, these final criteria were, simultaneously:

- The vehicle studied was not performing any specific manoeuvre and not committing any infraction (for not to overlap with other tasks of this work package). To implement these criteria is necessary to know which manoeuvre has been done by the driver. In some cases, it

is impossible to implement them, so information from some databases available for TRACE cannot be used.

- At least one of the vehicles involved in the accident was a passenger car, so the variable 'Type of vehicle' correspondence to:
  - ✓ Motor vehicle with three or more wheels;
  - ✓ Used to transport only or mainly people;
  - ✓ Seating for no more than 8 passengers;
  - ✓ Type BE driving license required.
- Accidents, whose situation belongs to, must have happened out of intersection.
- The most decisive criterion is related to the driver manoeuvre. Only the following options were considered for the studied vehicle:
  - ✓ Performing normal driving.
  - ✓ Sudden/emergency manoeuvre to avoid obstacle or vehicle.
  - ✓ Sudden/emergency manoeuvre to avoid single or grouped pedestrians.
  - ✓ Sudden/emergency speed reduction.
  - ✓ Parked vehicle (without starting a moving manoeuvre).

6.3.3 TRACE Countries General Overview

During the period studied, the stabilized accidents meant around the 33% of the injury accidents and 49% of the overall situations in EU27.

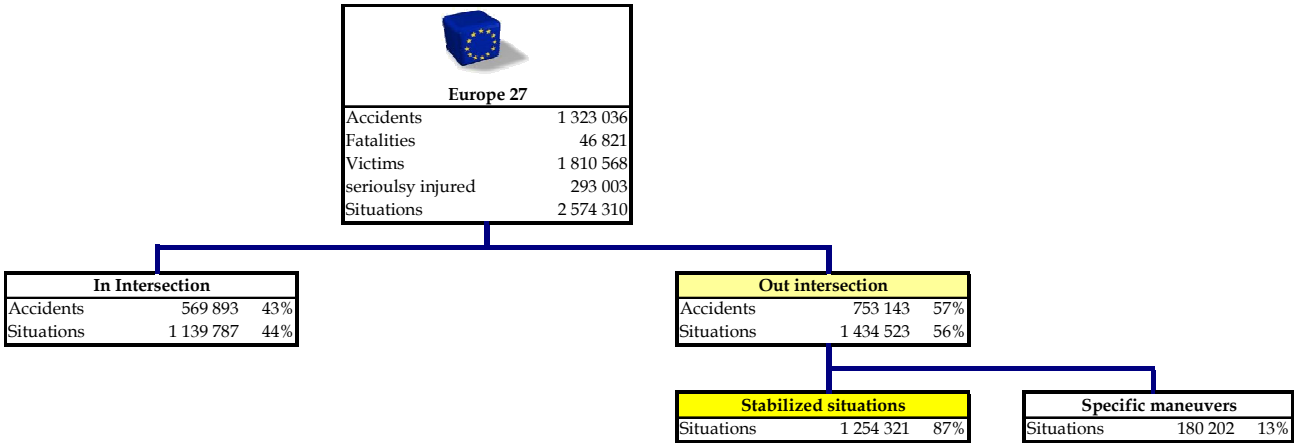


Figure 12: Distribution of stabilized situations in EU27
(year 2004, Sources CARE, IRF, IRTAD, National Statistics Databanks).

The results given above are only a rough estimation. Effectively in order to have a more accurate estimation, the information regarding the manoeuvre has to be available at the vehicle level. Besides the well known problems (country not contributing to CARE or IRTAD databases, missing information), this criterion is only stressing the difficulties. In order to make consistent our results, we choose to base the following analysis only on the information available in the TRACE consortium.

Country	Stabilized accidents (percentage of total injury accidents in each country)
France (only 2004)	23,870 (28%)
Great Britain (only 2004)	64,993 (31%)
Greece (only 2004)	6,411 (41%)
Czech Republic (only 2004)	11,848 (57%)
Spain (2001 – 2004)	128,971 (33%)

Table 9: Distribution of accidents where a stabilized situation appears (TRACE survey).

The stabilized situation represents approximatively about 33% of the total number of injury accidents, and around 54% of all fatalities (average made on 5 countries).

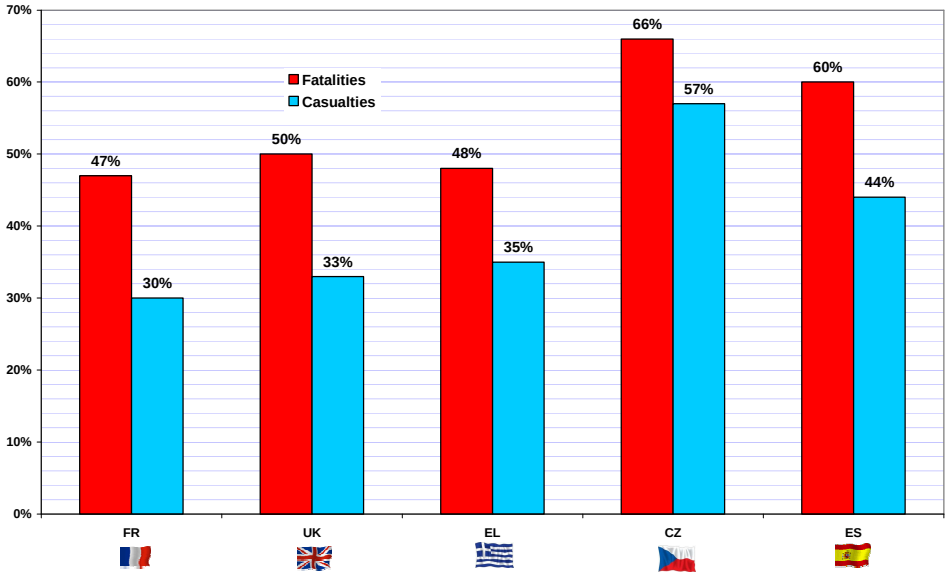


Figure 13: Fatalities and casualties distribution (TRACE survey).

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 (see figure below).

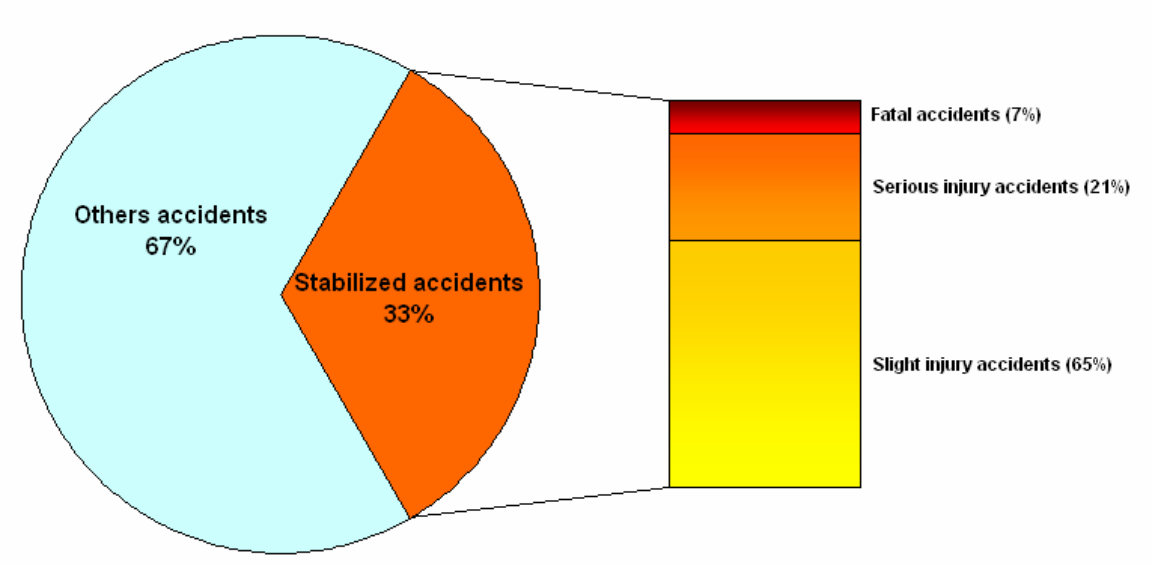


Figure 14: Fatalities and casualties distribution (TRACE survey 2006-2007).

6.3.4 Identification of the stabilized situations

The identification of the scenario is based on the analysis at the aggregated level using the Spanish national Accident database, on the literature review and on the knowledge of the experts. Once scenarios determined, the next step is to question the available databases in TRACE to allow on one hand to select the relevant scenarios and the others hand to characterize them. The requests are composed by several simple tables or cross tables allowing to know the occurrence on a selection of relevant parameters for each predefined scenario.
For the stabilized situation, the following scenarios have been established:

- **Situation A:** a driver not performing any specific manoeuvre and not crossing an intersection, who collides with a pedestrian.
  The criteria applied over the data were, simultaneously:
  - The accident did not take in an intersection.
  - At least one passenger car driver not performing any specific manoeuvre.
  - The accident was a pedestrian accident.

- **Situation B:** a driver not performing any specific manoeuvre and not crossing an intersection is involved in a lane departure/run-off accident. Only one vehicle is involved in the accident. For this situation, it was decided to choose accidents with only one vehicle involved because in case of being more than one vehicle involved in a run-off, it could be possible not to know actually which was the vehicle suffered the run-off.
  The criteria applied over the data were, simultaneously:
  - The accident did not take in an intersection.
  - Only one vehicle involved (a passenger car).
  - The passenger car driver was not performing any specific manoeuvre.
  - The accident was a run-off accident.

- **Situation C:** a driver not performing any specific manoeuvre and not crossing an intersection is involved in an accident with more than one vehicle. This driver is performing a normal driving action. The criteria applied over the data were, simultaneously:
  - The accident did not take in an intersection.
  - More than one vehicle involved (at least one passenger car).
  - The passenger car driver was not performing any specific manoeuvre, only performing a normal driving action.

- **Situation D:** a 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 but suddenly has to perform an emergency manoeuvre in order to avoid an obstacle (it is not possible to distinguish the type of object).
  The criteria applied over the data were, simultaneously:
  - The accident did not take in an intersection.
  - More than one vehicle involved (at least one passenger car).
  - The passenger car driver made an emergency manoeuvre to avoid the obstacle.

- **Situation E:** a driver not performing any specific manoeuvre and not crossing an intersection is involved in an accident with more than one vehicle. This driver has to perform an emergency important reduction of speed and finally is involved in the accident.
  The criteria applied over the data were, simultaneously:
  - The accident did not take in an intersection.
  - More than one vehicle involved (at least one passenger car).
  - The passenger car driver made an emergency reduction of speed.

- **Situation F:** a driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle which is parked.
  The criteria applied over the data were, simultaneously:
  - The accident did not take in an intersection.
  - More than one vehicle involved (at least one passenger car).
  - One of the vehicles involved was parked.

Finally, although the six initial stabilized situations have been defined, two situations have been removed for the final consideration because of their low relevance in the national situations.
The 'final stabilized scenarios' are:

- **Situation 1:** a driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian. This situation can be drawn in the following figures which shown this situation (red arrow):

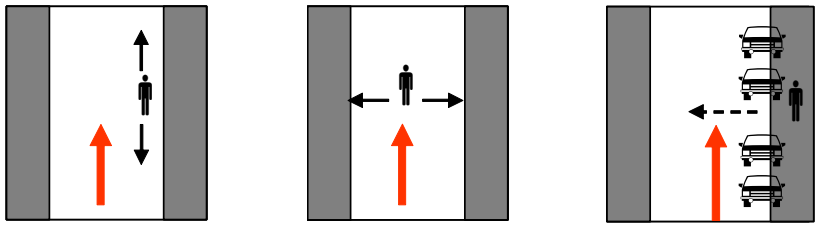


Figure 15: Type of configurations of the scenario related to 'Situation 1'.

- **Situation 2:** a driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident. This situation is shown in the following figures (red arrow):

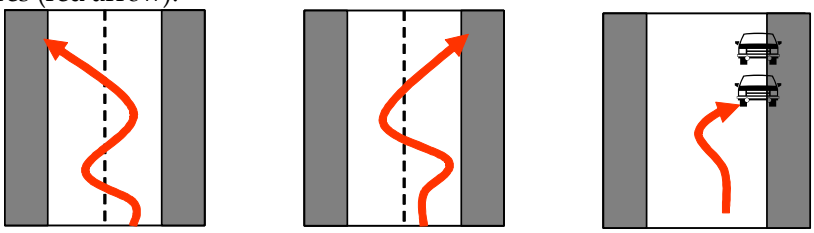


Figure 16: Type of configurations of the scenario related to 'Situation 2'.

- **Situation 3:** a 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, as the following figures show (red arrow).

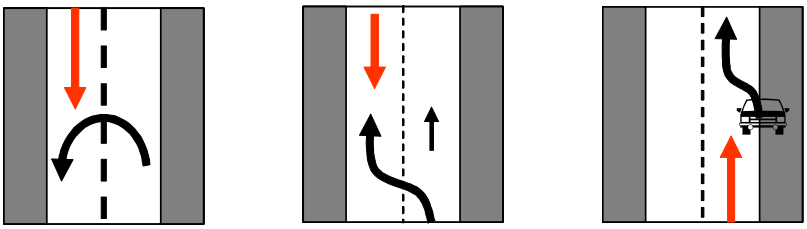


Figure 17: Type of configurations of the scenario related to 'Situation 3'.

- **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, as the following figures show (red arrow).

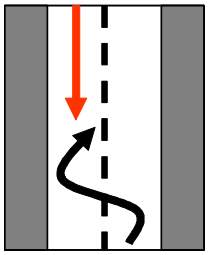


Figure 18: Type of configurations of the scenario related to 'Situation 4'.

6.3.5 Classification of the scenarios according to the severity

These four situations cover around 80% of the fatalities occurred in stabilized situations and 70% of the casualties. The scenario "other" gathers "other situations" and scenario 4 when data were not available in the extensive database.

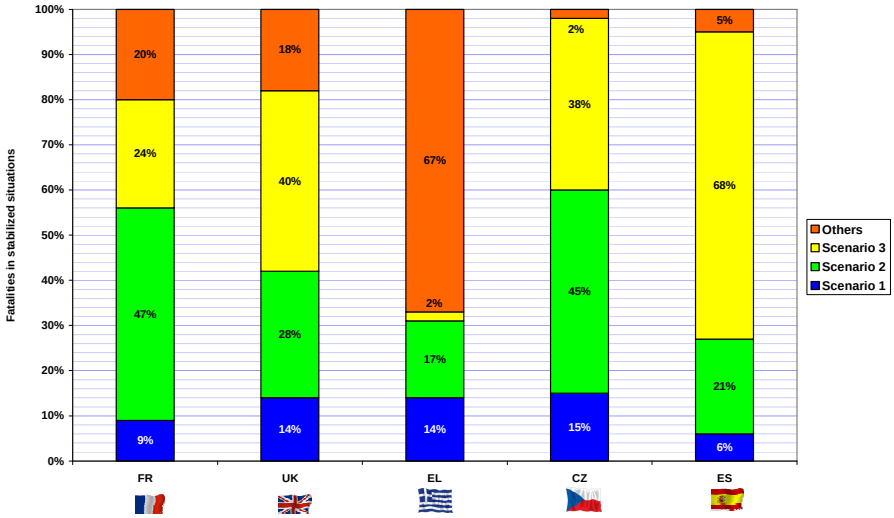


Figure 19: Distribution by country of the fatalities following the most important scenarios determined for stabilized situations (TRACE survey 2006-2007).

These results show that the scenario1 (dedicated to pedestrian accidents) is relatively the same in the 5 countries. The differences concern essentially the distribution between scenario 2 and 3 which have to be investigated during the in-depth analysis. The results from Greece regarding scenario 4 are surprising, maybe caused by the use of a different definition and the fact that ISS database is not representative of the whole national accidents.

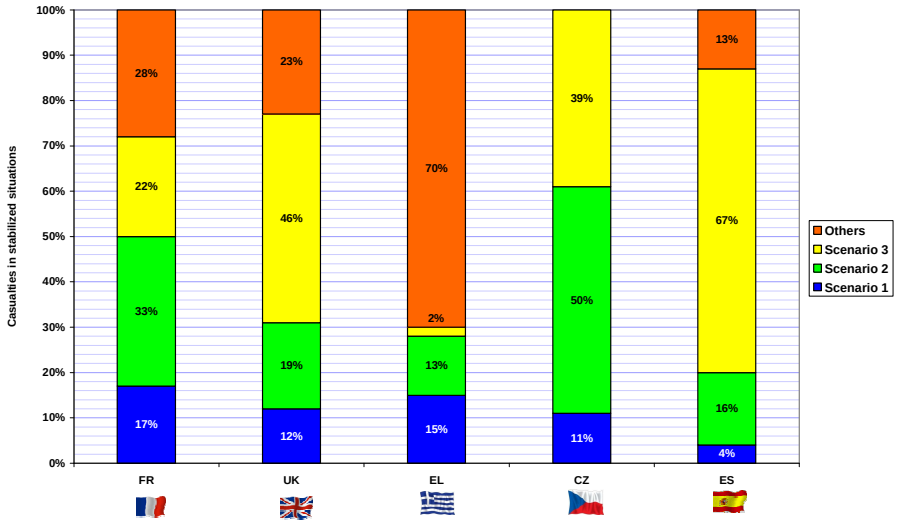


Figure 20: Distribution by country of the casualties following the most important scenarios determined for stabilized situations (TRACE survey 2006-2007)..

To give an overview of these percentages at the EU 25 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 EU25. This is the only approach data which can be used to give an overview at European level about Stabilized Situations means.

6.3.5.a Description of the scenarios

A complete analyze of the four final stabilized situations has been done in this part with the purpose of characterizing them with the relevant parameters such as:

- Driver action.
- Weather conditions.
- Daytime.
- Lighting conditions.
- Type of road.
- Type of driver.
- Surface condition.
- Contributing factors.

Other aspects would have been interested to study (for example, driver state) but not considered here because of the availability of the information. We will investigate this aspect through the in-depth analysis.

Situation 1: A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian.
The main characteristics of this situation are:

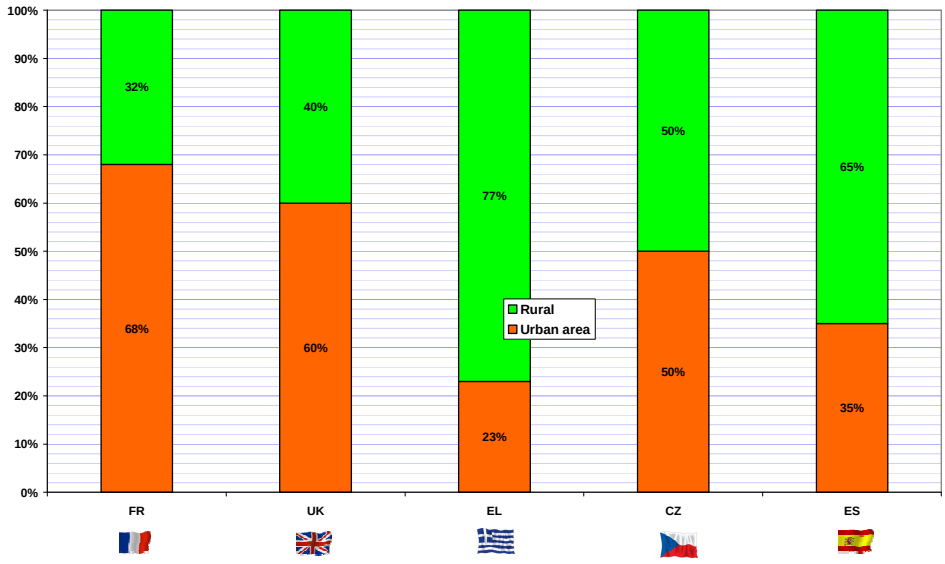


Figure 21: Distribution by country following the location (rural or urban) for injury accidents in which at least one vehicle was in stabilized situations (TRACE survey 2006-2007)..

Stabilized situations occurred rather outside the urban area except for Spain and Greece. Note that Greece analysis is based on the ISS data, not representative of the whole national database.

Casualties	daylight	night period	without enough luminosity	Driver age	Contributing factors (Pedestrian point of view)	Road alignment
Urban accidents	>65%			21-30 years	Distraction Disobeying a circulation rule	
Rural accidents	<50%	>50%	10 to 35%	21-30 years	Distraction Disobeying a circulation rule	Straight section

Table 10: Description of the scenario 1(TRACE survey 2006-2007)..

Regarding the 'urban accidents', more than 65% of casualties were during 'daylight'. Most fatalities (40%) and casualties (30%) happened when at least one driver was 21-30 years old. The contributing factors were distraction and/or disobeying a circulation rule (attributed to the pedestrian).
While in rural accidents, more than 50% of casualties happened during the 'night period' (where traffic flow is very reduced) and almost 35% occurred 'without enough luminosity' for GB and Spain, this value is near 10% in France. The road alignment associated was a 'straight section'. 25% of casualties and 30% of fatalities happened during accidents in which at least one driver was 21-30 years old. Finally, as police opinion, main contributing factors are: distraction and/or disobeying a circulation rule (both, especially, from the point of view of pedestrians). During night period and particularly in pedestrian accident collided along the road, alcohol problem are often present.
These aspects will be studied more carefully in report D2.2 dedicated to accident causation analysis.

Situation 2: A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident.
The main characteristics of this situation are:

Casualties	Rural (Spanish database)	Dry weather	Driver age	Driver experience	Contributing factors (Spanish database)	Visibility restriction	Road alignment
	90%	75%	21-30 years	2 to 5 years	Distraction Inadequate speed	30%	Bend section 45 to 65%

Table 11: Description of the scenario 2(TRACE survey 2006-2007)..

In the Spanish accidents, more than 90% of the casualties related to this scenario happened in a 'rural area'. In rural accidents, the road alignment was a 'bend section' (near 65% of casualties in all the countries, except in France where this percentage decreases to 45%). In 30% of casualties there were 'visibility restrictions', especially due to buildings, terrain profile or weather. Finally and related to weather, although the majority of casualties were in dry and clean conditions, near 25% of casualties were in a road whose surface was wet (due to drizzly weather).
Most fatalities happened when at least one driver was 21 to 30 years old, with 2 to 5 driving experience years.
The contributing factors were: distraction and/or inadequate speed. This information comes only from Spanish database where the information was available.

Situation 3: A 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 main characteristics of this situation are:

	Rural	Dry weather	Daylight (Spanish database)	Rural + restricted visibility	Contributing factors (Spanish database)	Driver age	Road alignment
Injuries accident	75%	60 to 70%	>50%	25%	Distraction Disobeying a circulation order Inadequate velocity	30% 21-30 years	50% straight section
Fatalities	70%						

Table 12: Description of the scenario 3(TRACE survey 2006-2007)..

Nearly three quarters of the total injured accidents and more than 70% of the fatalities occurred in 'rural zone'. In 25% of the Spanish rural accidents, there was a restricted visibility by different aspects such as: buildings, terrain profile, weather… although more than a half of the total was during daylight.

Most fatalities happened (30%) in accidents where younger drivers (21-30 years) were involved. Related to the road, while in 70% of injured accidents the surface was dry and clean, in 25% the surface was wet (in the case of U.K. this percentage reaches the 40%, due to a higher humidity level conditions in general in this country). Near one half of the fatal or injured accidents were in straight section. The main contributing factors in these accidents were: distraction, disobeying a circulation order and/or inadequate velocity. The most common type of crash has been: head-on crash (70% in rural accidents and 75% in urban accidents).

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.

In this situation, the only database used was the Spanish one (in the other three databases it was not possible to select this situation).

The main characteristics of this situation are:

	Rural	daylight	Restricted visibility	Contributing factors	Wet weather
Casualties	75%			Distraction Disobeying a circulation order Inadequate velocity	
Fatalities	95%				
accidents		75%	65% (weather)		65% when straight section

Table 13: Description of the scenario 4(TRACE survey 2006-2007)..

Nearly 75% of the injured and 95% of the fatalities occurred in 'rural zone'. Although 75% of these accidents were during day light, in 65% of them the visibility was restricted (55% due to weather). The road surface was wet in 60% of the accidents, having happened in a straight section. The main contributing factors in were: disobeying a circulation order, distraction and/or inadequate velocity.

In this last scenario, rear accidents (18%) and side impacts (17%) were the most common type of crashes.

6.3.6 Extrapolation to EU-27

To give an overview of these results at the EU-27 level, some specific data would be necessary. Although data related to the "stabilized situations" are not available in all databases, some assumptions and correlations can be made. For instance, analyzing data from Europe (2007), we assume 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) represent nearly 70% of the injuries accident in EU-25. We propose to exploit this approach to give an overall overview of the situation at a European level.

6.4 Summary and conclusion

All along the previous descriptive analysis, the four final scenarios have been characterized with the available national data.

Through the macro-analyses of national databases it is possible to 'draw a general picture' of the configuration which characterize each scenario.

The final four main scenarios detected are:

1. A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian in an urban area
2. A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident in rural area.
3. A 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 type of accident is a head-on accident in rural area.
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.

The main issue here is based on both the data availability and accuracy. To create scenario the information at the road user level (or vehicle level) is needed. However, most national databases don't provide this detailed level, while in-depth ones can give. This is the reason why, the descriptive part for the stabilized is mainly focused on overall stakes (day/night, weather conditions, etc.).

The scenarios presented here gather large accidents classes which will be split into more relevant sub-scenarios in the in-depth analysis. This is the challenge of this task for the next step.

7 Specific manoeuvres

The scope of this task is to firstly define 'specific manoeuvres' and give statistics about accidents corresponding to these situations. Secondly detailed statistics are given to identify which manoeuvres combined with what other factors are significant in accident causation. Examples of actual accident scenarios will be given and those which are significant in accident causation will be identified and quantified.

The overall objective in this part is to give an overview of the injury accident in which one of the vehicles was in specific manoeuvre situation before the collision, and also to identify the most relevant scenarios in order to study in the next step using in-depth data the associated causes (available in report D2.2).

This part is composed of different sections. Firstly, some definitions will be given in order to specify what we understand by specific manoeuvre and to delimitate the scope. Secondly, a literature review will present the studies on the topics related to the road safety. Then, the descriptive analysis will be shown using aggregated data coming from databases available in TRACE.

7.1.1 Definitions

Specific manoeuvres' in the context of Task 2.3 has been defined as a situation in which the drivers has to realize a specific manoeuvre for which a higher than usual solicitation is required. All specific manoeuvres performed at an intersection are excluded. In add, only specific situations for passenger car will be studied.

All driving actions made by the driver to follow his way without any change in direction or in lane are excluded of specific manoeuvres. This is the case for example of negotiating a bend, stopping at red light or at stop sign, etc. These situations have been studied in the previous chapter dedicated to "stabilized situations".

From this definition and the literature review, the following scope was defined for the initial descriptive data analysis on the British road traffic accident database:

All vehicles involved in an injury road traffic accident which took place away from a proper intersection and which were performing one of the following specific manoeuvres:

- Overtaking (a moving or static vehicle on the offside or a moving vehicle on the nearside)
- Changing lane (to the left or to the right)
- Turning (left, right or U-turning)
- Reversing

7.2 Literature review

Work package 2 is concerned with accident causation from the perspective of different driving situations. Task 2.3 deals with specific vehicle manoeuvres such as overtaking etc. Most studies addressing driver manoeuvres in the context of road safety are carried out by psychologists from the perspective of driver behaviour as influenced by factors such as age, gender, driving experience and in-car distraction. To a lesser degree, manoeuvres have been discussed with respect to road infrastructure, and vehicle type. The sections are organized according to the main vehicle manoeuvre definitions that appear in the literature; overtaking, changing lane, turning (left or right), U-turning and reversing. This list also defines the term 'vehicle manoeuvre' according to TRACE for the purposes of this study. Other manoeuvres discussed in the literature but not considered 'specific manoeuvres' by TRACE are slowing down or stopping and negotiating bends in the road.

7.2.1 Overtaking

7.2.1.a Vehicles overtaking other vehicles

According to one UK in-depth accident study, 'overtaking another vehicle on a single carriageway road is one of the most demanding of all driving tasks, and overtaking errors can have very serious consequences.' The study described six sets of circumstances in which overtaking accidents occurred:

The overtaking vehicle:

- hit a vehicle turning right when attempting to overtake it (35%)
- hit a vehicle travelling in the opposite direction when attempting to overtake another vehicle (16%)
- was overtaking on the nearside or 'undertaking' (14%)
- side swiped the vehicle it was trying to overtake (10%)
- lost control whilst overtaking and overturned to the nearside lane (8%)
- hit a vehicle making a turning or lane changing manoeuvre at a junction (6%)

A further 5% resulted from evasive action from another driver attempting to avoid someone else's risky overtaking manoeuvre. In two-thirds of cases, the accident resulted from a 'faulty go' decision (misinterpreting a right-indicator or deciding to overtake when there was inadequate visibility). Other accidents resulted from a stationary vehicle pulling out as it was being overtaken or by excess speed and recklessness leading to loss-of-control, particularly in the case of inexperienced drivers (Clarke et al. 1995; Clarke et al. 1998a).

Another study on overtaking manoeuvres by the same author (Clarke et al. 1998b) analyzed the main causes of overtaking accidents - taking into account road environment, vehicle and driver characteristics (particularly age) and specific driver actions from a sample of 973 in-depth cases compiled from police reports. Here, 'overtaking' was defined as 'the situation whereby any moving vehicle passes, or attempts to pass, another that is moving in the same direction, or is standing temporarily with a running engine'. Overtaking accidents were classified as follows:

- Type 1: Collision between an overtaking vehicle and an overtaken vehicle which turns right
- Type 2: A head-on collision with a vehicle travelling in the opposite direction
- Type 3: Side-swiping a vehicle which is being overtaken
- Type 4: Hitting a vehicle either in front or behind when returning to a gap after overtaking
- Type 5: Losing control after returning to the nearside following an overtake
- Type 5.1: Losing control while carrying out the overtake
- Type 6: An overtaker colliding with a vehicle emerging from a junction
- Type 7: A vehicle overtaking on the nearside (undertaking) and hitting another vehicle
- Type 8: Colliding as a result of avoiding action following another driver's risky overtaking manoeuvre
- Type 0: Unclassifiable / miscellaneous

The most common types (studied in more detail in the paper) were types 1, 2 and 5, caused by the following reasons:
Type 1 – Typically caused by poor observation with no significant driver age effects.
Type 2 – Caused by poor observation and misjudgement. The oldest group (age 75–81) was over-represented for this type whereas the (age 16–22) and (age 69–74) groups were under-represented.
Type 5 – Misjudgement and excess speed were found to be the common causes with an over-representation in younger drivers (age 16-22).

The study concluded that drivers under 22 tended to cause overtaking accidents due to excess speed or recklessness while drivers over 55 tended to cause overtaking accidents due to observational error. The most frequent driver error causing an accident in the study across all age groups was overtaking a vehicle which was turning right - generally these occurred because either a younger driver had made a faulty overtaking decision or an older driver had made a faulty right turn. In the case of head-on collisions, drivers generally misjudged the speed of the car they were overtaking or their own acceleration or underestimated the necessary amount of clear road in the opposite carriageway (Clarke et al. 1998b).

In agreement with this, a study on novice driver accidents in England reported that young male drivers have more overtaking accidents than older drivers or young female drivers (Maycock 2000) and others reported that overtaking manoeuvres, particularly risky ones, are more frequent amongst younger drivers (Matthews et al. 1998; Zhang et al. 1998).

A study on driver behaviour using a simulator concluded that drivers exhibit a strong tendency to overtake the vehicle in front of them even if it is travelling at the same speed or faster. The cause of this is ascribed to the range of preferred speeds that drivers have and the driver's perception of any vehicle in front of them travelling within that range as interference (Bar-Gera et al. 2005).

Wilson and Best, in their paper on 'driving strategies in overtaking', overtaking manoeuvres were defined as '*flying overtaking*' where the overtaking car overtakes a slower vehicle without slowing down, '*accelerative overtaking*' where the overtaking car slows down by taking their foot of the accelerator to match the speed of the car in front before overtaking and *'braking to follow'* as previous but requiring application of the brakes to avoid a collision prior to overtaking. They also noted whether or not the overtaker was '*lane sharing*' during the overtaking manoeuvre (where they don't cross fully into the other lane to overtake), '*cutting in*' after the manoeuvre (causing the overtaken vehicle to slow down or change direction to avoid conflict), *'piggy-backing'* (immediately following the car in front which is also overtaking) and whether the gap available for overtaking[7] was *small* (<400m) or *large (*>400m). Of the 422 overtaking manoeuvres observed, 7% involved *'piggy backing'*, 5% involved *'flying overtaking',* 3% involved '*braking to follow'*, 14% had only a *small* gap, 14% were '*lane sharing'* and 9% involved *'cutting in'*. Also, 4% had to apply their brakes after they have overtaken because of the speed of the new car in front. Studying the inter-relationships, when only a small gap (<400m) was available, there was a higher rate of '*lane sharing'* and '*cutting in'* (usually either one or the other with *'piggybackers'* preferring *'lane sharing'* and non-'*piggybackers'* preferring *'cutting in'*). Secondly, *'flying overtakers'*, '*piggybackers'* and '*brake to follow'* overtakers were all more likely to accept a *small* gap. (Wilson et al. 1982)

When studying drivers who followed the car in front closely on two-lane carriageways, Rajalin et al found that the most common reason was an intention to overtake. These overtaking intentions were described in the survey as 'waiting for an opportunity to overtake', 'preparing to overtake' or 'looking for a place to overtake'. As well as the overtaking manoeuvre itself being risky, this pre-overtaking 'tailgating' behaviour carries its own risks as a result of the shorter following distances leaving less time for the following driver to react to a lead car's braking. The study didn't however find a connection between close-followers and accident involvement, suggesting that this may be due to active overtakers being more alert drivers but that despite this, increased attentiveness did not compensate for the risks associated with close-following(Rajalin et al. 1997).

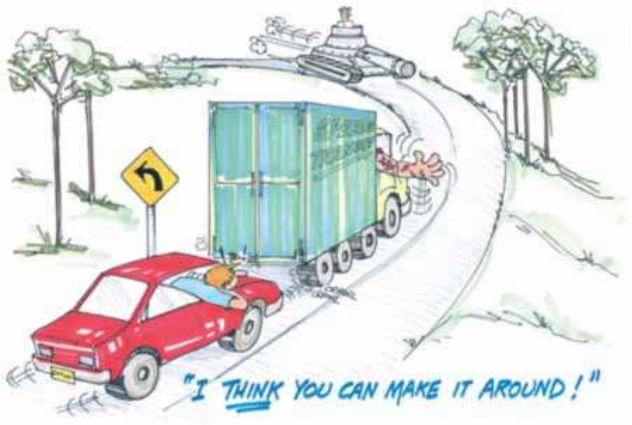


Figure 22: Illustration of a probable overtaking accident ...

[7] between the car being overtaken and the nearest car approaching in the opposite direction

7.2.2 Changing lane

This manoeuvre applies to carriageways with at least 2 lanes in the direction of travel (i.e. where there is a legitimate opportunity to change lane). A study on safety margins encountered during lane change manoeuvres analyzed the relation between perceived information and motor response during lane changing manoeuvres using a driving simulator. Results suggested that steering actions were controlled by the outcome of previous actions so that safety margins were maintained. Visual feedback is used in lane changing manoeuvres resulting in flexible, adaptive steering behaviour and this behaviour is a result of the driver learning the combined effects of speed and steering wheel amplitude on safety margins. Lane width did not affect dependant variables (van Winsum et al. 1999).

In a study on how novice drivers look before a lane change manoeuvre on dual carriageways, the novice drivers observed didn't change the amount they looked around depending on what type of road they were on (i.e. they didn't differentiate between rural, suburban and dual carriageway) unlike the more experienced drivers (Underwood et al. 2002). A German paper looking at age-related differences in driving performance on motorways found that the younger drivers changed lane with higher speeds and accelerations and entered motorways regardless of other traffic. The older drivers drove more slowly but demonstrated sharper decelerations and were the worst age group at lane keeping (Buld et al. 2006).

A US study on freeway (motorway) slip road accidents (where vehicles had to change lane) stated that the three main types of accidents occurring on motorways are rear end impacts, side swipes or hitting an object (while head-on and side impacts are very rare). In the study, slip road accidents were more likely to be side-swipes than any other type and the side-swipes were more likely to be caused by a failure to give way rather than speeding violations (Golob et al. 2004).

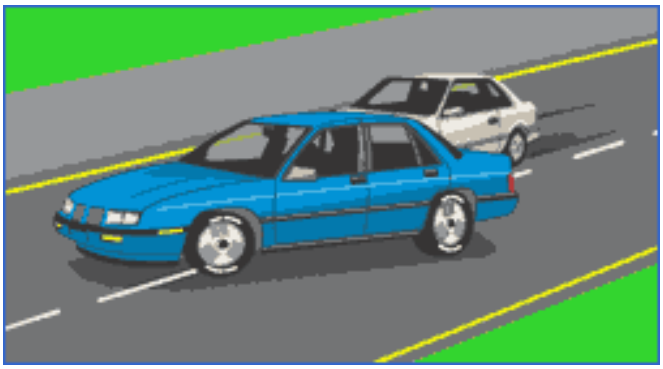


Figure 23 : Illustration of changing lane accident.

7.2.3 Turning

This task does not include manoeuvres which take place at intersections, but according to the definitions used, turning can still take place leaving or entering the main carriageway to or from a private driveway for example. No papers looked specifically at turning at locations away from intersections so findings on turning at intersections have been included in this literature review assuming that similar principles apply. Keskinen et al cited studies which found that older drivers were over-represented in accidents at intersections, particularly when the older driver was entering the main road without giving way to oncoming cars. Their own study[8] (comparing attention behaviour of older and younger drivers) found a difference in acceleration habits whereby older drivers took longer to turn right than younger drivers – but only when the oncoming car was approaching from the left (Keskinen et al. 1998). A study on accidents involving young drivers found that the right turn manoeuvre showed best rate of improvement with experience (Clarke et al. 2002). Another US paper looking at the gap acceptance behaviour of intersection left turns (right turn equivalent in UK) concluded that older drivers are the most vulnerable group for this manoeuvre due to their reduced driving ability but that older female drivers in particular compensated with a more conservative attitude (Yan et al. 2007).

[8] Carried out in Japan where vehicles drive on the left

7.2.4 U-turning

The only paper mentioning this particular manoeuvre was one on 'Collisions and casualties involving taxis in Greater London'. There were 740 injury accidents in London in 2003 where at least one of the vehicles was a 'black cab' taxi. Of the 1386 vehicles involved, 5.6% of the taxis were performing a U-turn compared with 1.2% of the cars. However, injury severity for taxi U-turn accidents was low - none were fatal and only 7% were serious (TfL 2004). This manoeuvre is therefore not a high priority.

7.2.5 Reversing

According to data from 3 accident driver surveys (1991 – 1996) which included damage only accidents, 10.1% of the accidents were caused by reversing manoeuvres but these reversing accidents rarely involved injury. In the same study, younger drivers had more reversing accidents than older, more experienced drivers and in a survey of drivers' first 3 years of driving, active reversing accidents fell from year 1 to year 2 (West 1997; West 1998).



Figure 24: Illustration of a reversing accident

Although most reversing accidents are not injurious, those carried out by larger vehicles where the driver cannot see where they are going are potentially more serious and sometimes fatal, particularly to young children. An investigation of one child fatality in England resulting from a reversing refuse collection vehicle concluded that a reversing assistant (person standing at the back while vehicle is reversing) would have prevented the tragedy (Mason 2003). In the UK, 15 million reversing manoeuvres are performed annually by refuse collection vehicles – the numbers of resulting pedestrian accidents are unknown.

In the US, at least 91 children were backed over and killed in 2003 (more than one children per week) often by a relative in their driveway, and often by a larger vehicle such as a van or pickup truck (J.E Fennell).

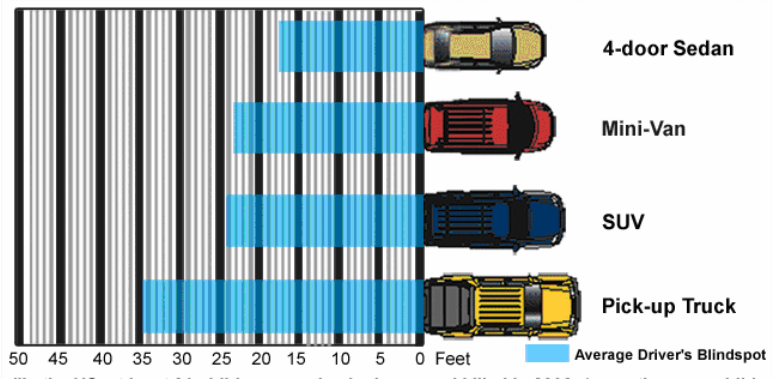


Figure 25: Illustration of the driver's blindspot following the type of vehicle (US)

7.2.6 Safety effect of infrastructure design

In a recent US paper, milled Centre-Line Rumble Strips (CLRS) on Kansas highways were assessed with respect to their ability to prevent crossover accidents (either due to improper overtaking or a vehicle inadvertently leaving their own lane). A previous estimate claimed that shoulder rumble strips reduce run-off-the-road crashes by up to 25%. Some other US states have CLRS on no-passing sections with no apparent negative effects. The conclusions were that these rumble strips are a viable cost-effective means of reducing cross-over crashes where a vehicle is overtaking on road sections where overtaking in prohibited and hits an oncoming vehicle or when it just veers off into the opposite lane (Russell et al. 2006).

Another paper recommended overtaking lanes and wide lanes to prevent both overtaking accidents and the associated close-following rear end shunts which occurred whilst vehicles were waiting to overtake (Rajalin et al. 1997) An analysis of 2-lane carriageway head-on collisions also recommended wider lanes to mitigate the severity of head-on collisions occurring as a result of overtaking manoeuvres since these encouraged a greater offset between the colliding vehicles and therefore reducing the severity of the crash (Deng et al. 2006).

7.2.7 Safety effect of education, awareness, training and legislation

A study into the issue of young driver's overestimation of their own skill, and the relation between training strategy and skill yielded the following observations and recommendations: Previous studies using questionnaires have shown that young drivers (especially men) overestimate their own driving skill, considering themselves as more skilled than other (more experienced) drivers, and underestimate risks - specifically, they drive faster, leave smaller gaps, drive in ways that increase the probability of conflict with other drivers and are less likely to wear a seat-belt. Studies have also found that driver training does not improve safety (possibly as a result of risk compensation). The conclusion was that driver training should focus on emphasizing the fact that the driver is less skilled than he thinks he is, encouraging him to drive with a larger safety margin. The author also expressed the need to identify the difference between skill acquisition from training courses and from long term experience (Gregersen 1996). Clarke et al also concluded that accidents were the result of attitude problems rather than any skills deficit (Clarke et al. 2002). Speeding on 2-lane carriageways was found to increase the frequency of situations when an overtaking manoeuvre is desired (mainly an issue of attitude affected by age and gender). In answer to this, chevrons painted on the road surface have been shown to increase awareness of close-following when attempting to overtake (Rajalin et al. 1997). Close-following (or 'tailgating') – often occurring prior to overtaking manoeuvres on two-lane carriageways – is widely prohibited in highly motorized countries due to the increased risk associated with this driving behaviour (Rajalin et al. 1997).

7.2.8 Literature review – summary

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 Task 2.1 '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.

7.3 Descriptive analysis

Task 2.3 is a study of how and why specific vehicle manoeuvres influence the likelihood of different types of accidents occurring in various locations and environments. **Data was taken from the British, French and Spanish databases, which hold data recorded by the police on all road traffic accidents involving an injury. 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.

7.3.1 Overview of vehicle manoeuvres

While the purpose of national statistic analysis is the identification of the problem and its magnitude through national approach, European statistics analysis should investigate the problem taking account the national specificities such as the road network, the atmospheric conditions, the type of drivers, the type of vehicles…

First of all we have focused our investigation on 3 countries Spain, Great Britain and France. In a second step we will generalize these results to the whole Europe with the help of statistics methods supported by the WP7. The aim of this general overview is to define scenarios that gather together accidents according to the specific manoeuvres. Scenarios are built on two parameters: the frequency and the severity.

The 2004 data was filtered to exclude accidents occurring at cross-roads, T-Junctions, roundabouts etc. but include those at slip roads and driveways.

In this context, tables of request were provided to the WP8, in order to encourage the different partners to fill in it with their own national data. Each table should be able to answer questions relating to the situation. The questions are:

1. What is at stake in 2004?
2. Frequency and severity. Which specific manoeuvre is the most frequent and the most serious (all vehicles)?2004
3. What is the distribution of the vehicle types performing a specific manoeuvre? All vehicles
4. Which specific manoeuvres are the most frequent and most severe? Scenarios for passenger cars
5. How the atmospheric and lighting conditions affect the accident : visibility (driver decision), Road grip (accident consequences)...) (at least one passenger car)
6. Road surface influence on the accident occurrence.(at least one passenger car)
7. Loss of control? Accident with at least one passenger car
8. How did the manoeuvre being performed affect the point of impact? The impact is not necessary the 1st one but the more serious for the case vehicle
9. On which 'types' of roads were specific manoeuvres performed by vehicles involved in injury accidents (sorted by accident severity)? At least one passenger car
10. Who is involved (driver or rider)? At least one specific manoeuvre and at least one passenger car
11. How are involved the vulnerable users ?2004
12. Vehicle manoeuvre x Pedestrian injury severity. 2004. at least one passenger car
13. Vehicle manoeuvre x PTW injury severity. 2004. all vehicles
14. Vehicle manoeuvre x PTW injury severity. 2004. at least one passenger car
15. Vehicle manoeuvre x PTW injury severity. 2004. all vehicles
16. Vehicle manoeuvre x PTW injury severity. 2004. at least one passenger car

In the following part, we will present only the most important results allowing to characterize this sample.

From the previous part it was define that specific manoeuvre situations are located out of intersection.

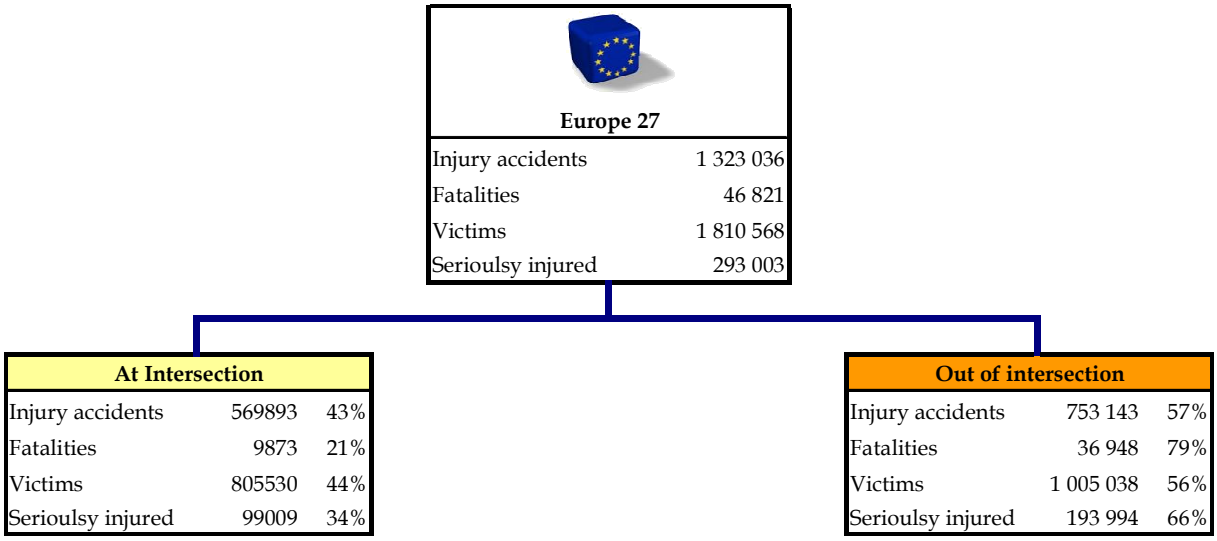


Figure 26: Distribution of road accidents following their location at or out of intersection in EU27 (year 2004, Source: CARE, IRF, IRTAD, TRACE and National Statistics Databanks)

In the EU27, the basic sample included 57% of the overall injury accidents, but represents 79% of the fatalities. However, from the situation point of view (a situation is directly related to one road user), the specific manoeuvres represent only 13% of the situations out of intersection and 7% of the overall situations.

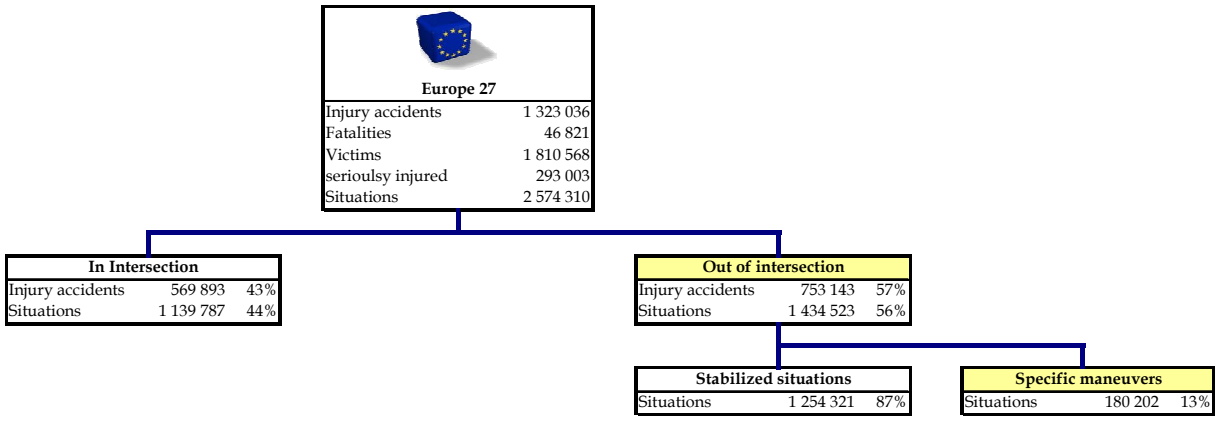


Figure 27: Distribution of the specific manoeuvres situations in EU27 (year 2004, Sources CARE, IRF, IRTAD, National Statistics Databanks).

The specific manoeuvres situation represents 25% of the total number of injury accidents, and around 20% of all fatalities.

7.3.2 Accident classification: accident or vehicle severity

Accident classification could be founded on different parameters such as the frequency, the severity, the specific manoeuvre… We looked at all specific manoeuvres and cluster them according to the frequency and the severity. So, the identification of the causes implicated in these accidents will lead to propositions of countermeasures which could be implemented and should avoid accident occurrences or mitigate the consequences when accident occurs.

As in the previous chapter, the needed information related to manoeuvres is not available in most of the databases. This is the reason why, the following results will be given on unless 3 countries in which the requested information was available.

Which manoeuvres are being performed by vehicles involved in injury accidents?

Can we define scenarios according to the frequency and the severity?

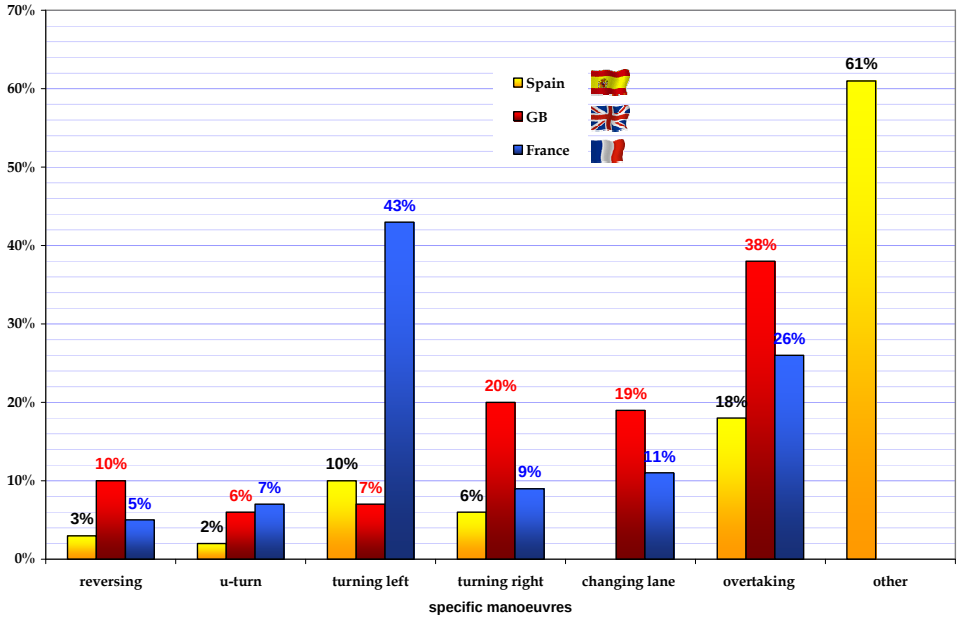


Figure 28: Distribution of the frequency of different specific manoeuvres by country (Year 2004, source: TRACE survey 2006-2007)

If we compare the results between different European countries, we can see significant differences. Overtaking seems to generate a problem in Great Britain while "other" manoeuvre is dominant in Spain because there is no way to distinguish this manoeuvre in the national database. Turning left out off intersection seems to be sensible in France. Note that English specific manoeuvre such as overtaking, changing lane or turning, are transposed (inversed) according to the common driving side in Europe.

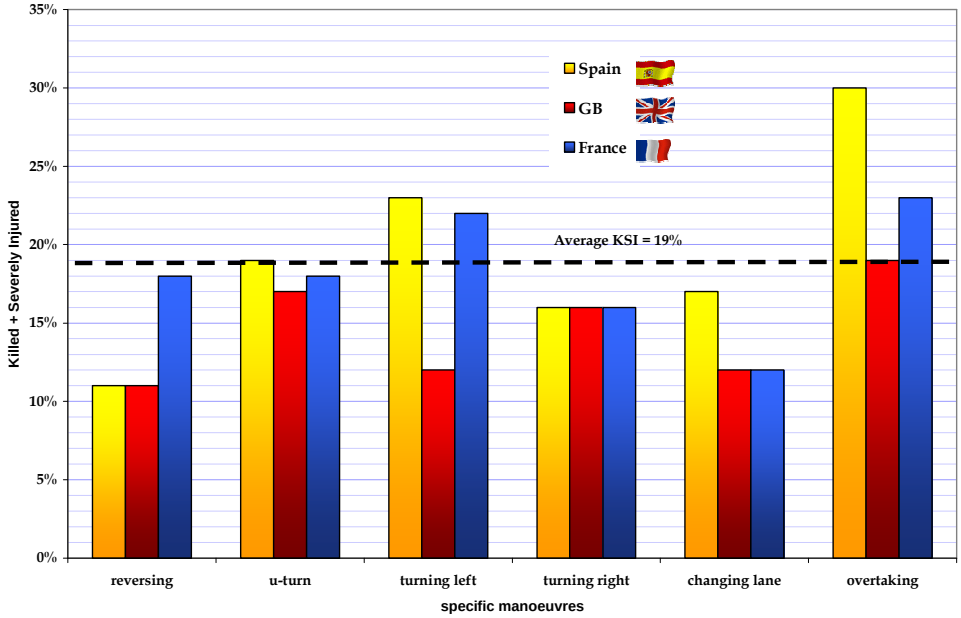


Figure 29: Distribution of the KSI following the specific manoeuvre situations (Year 2004, source: TRACE survey 2006-2007)

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 top 5 of the situations relating to the accident frequency where at least one specific manoeuvre is performed is sensibly different between countries.

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.

	France	Accidents with specific maneuver
1	Turning left	43%
2	Overtaking	26%
3	Changing lane	11%
4	Turning right	9%
5	U-turn	7%
	Total	96%

	Spain	Accidents with specific maneuver
1	Other*	61%
2	Overtaking	18%
3	Turning left	10%
4	Turning right	6%
5	Reversing	3%
	Total	98%

* Changing lane included

	Great Britain	Accidents with specific maneuver
1	Overtaking	38%
2	Turning left	20%
3	Changing lane	19%
4	Reversing	10%
5	Turning right	7%
	Total	94%

Table 14: Top 5 of specific manoeuvre according to the frequency of accidents with at least one specific manoeuvre performed (Year 2004, source: TRACE survey 2006-2007)

Important remark: In Table 14 and Table 15, the unit is the accident with at least one specific manoeuvre. So, because the number of situations is higher than the number of accidents the column total is not based on 100%.

	France	KSI	Accidents with specific maneuver
1	Overtaking	28%	26%
2	Turning left	22%	43%
3	Reversing	18%	4%
4	U-turn	17%	7%
5	Turning right	14%	9%
	Total	99%	89%

	Spain	KSI	Accidents with specific maneuver
1	Overtaking	27%	18%
2	U-turn	22%	20%
3	Turning left	19%	10%
4	Turning right	17%	6%
5	Other*	14%	61%
	Total	99%	115%

* Changing lane included

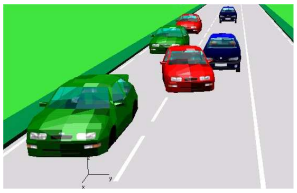
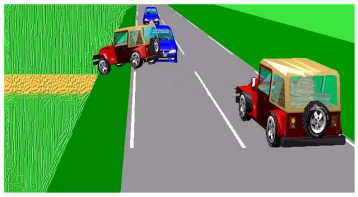
	Great Britain	KSI	Accidents with specific maneuver
1	Overtaking	20%	38%
2	U-turn	17%	7%
3	Turning left	16%	20%
4	Turning right	12%	7%
5	Changing lane	12%	19%
	Total	77%	91%

Table 15: Top 5 of specific manoeuvres according to the severity KSI (Year 2004, source: TRACE survey 2006-2007)

Overtaking manoeuvre is the top manoeuvre or the second manoeuvre according the frequency (top 1 in GB and top 2 in France and Spain) while this manoeuvre is the top 1 according to the severity illustrated by the KSI.
Turning left and U-turn follow overtaking according to the severity of the accident.

Note that U-turn is not a frequent scenario (<7%) but the severity is particularly high (KSI 16 to 23%).
It makes sense to choose the severity as the criterion of selection to define the scenarios according to the specific manoeuvres.

Three scenarios coexist in the concerned countries (France, Spain and GB):

Common scenarios	Pictograms	KSI %
Overtaking		21%
Turning left		17%
U-turn		17%



Note that "reversing", turning right and "changing lane" are in the top 5 of 2 countries.

7.3.3 Vehicle type

When we consider the specific manoeuvre, which vehicle type performed this manoeuvre?

If we compare for each specific manoeuvre the distribution of the vehicle type and the involvement of each vehicle type in all manoeuvres, we see that for passenger cars, U-turn, turning left and right and other manoeuvres are predominant. Note that in Spain, other manoeuvres included changing lane. Compare by vehicle type the manoeuvre/ all manoeuvres.

For moped and motorcycles, high involvement in overtaking nearside is observed especially for mopeds that are involved in high proportion in overtaking nearside (opposite to the driver side). **Overtaking nearside manoeuvres were over 3 times more likely to involve a moped and motorcycles (respectively 43% and 21%) than all specific manoeuvres in general (respectively** 11% and 6%).

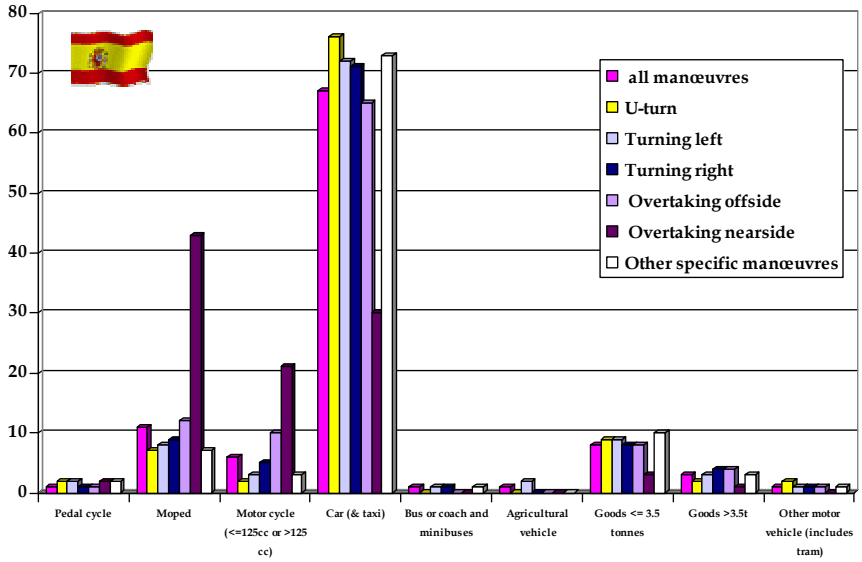


Figure 30: Distribution of the vehicle type related to the specific manoeuvre in Spain 2004 (source: TRACE survey 2006-2007)

If we compare for each specific manoeuvre the distribution of the vehicle type and the involvement of each vehicle type for all manoeuvres we see that in GB for cars, U-turn, turning left and right and reversing manoeuvres are predominant.
For moped and motorcycles, high involvement in overtaking nearside is observed. **Overtaking manoeuvres were over 3 times more likely to involve a MTW (mopeds and motorcycles) (17%) than specific manoeuvres in general** (5%).
Overtaking nearside manoeuvres were over 3 times more likely to involve a pedal cycle (11%) than specific manoeuvres in general (3%).
For goods vehicles, specially > 7,5 tones, high involvement in changing lane to the left and the right is observed.
Changing lane manoeuvres were over 3 times more likely to involve a goods vehicle (23%) than specific manoeuvres in general (7%).

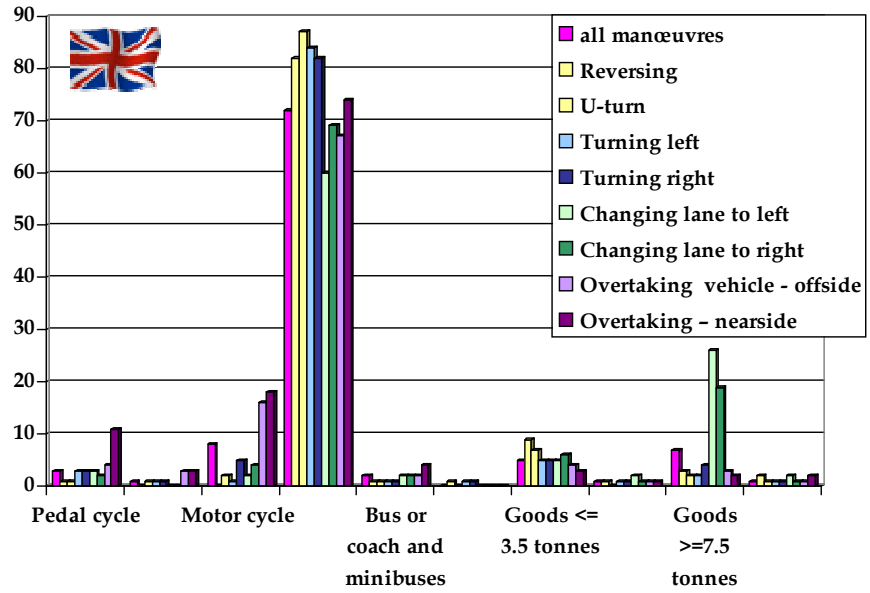


Figure 31: Distribution of the vehicle type related to the specific manoeuvre in Great Britain 2004 (source: TRACE survey 2006-2007)

If we compare for each specific manoeuvre the distribution of the vehicle type and the involvement of each vehicle type for all manoeuvres we see that in France for cars reversing manoeuvres are predominant.
For moped a higher involvement in overtaking nearside and turning right than in all manoeuvres is observed. We observe differences between mopeds and motorcycles involvement.
For goods vehicles (<3,5 tones), we observe a high proportion of reversing manoeuvres. **Reversing manoeuvres were over 3 times more likely to involve a Good vehicle (11%) than specific manoeuvres in general** (3%).
For all goods vehicles, changing lane to the right is predominant. **Changing lane manoeuvres were over 3 times more likely to involve a goods vehicle (23%) than specific manoeuvres in general** (7%).

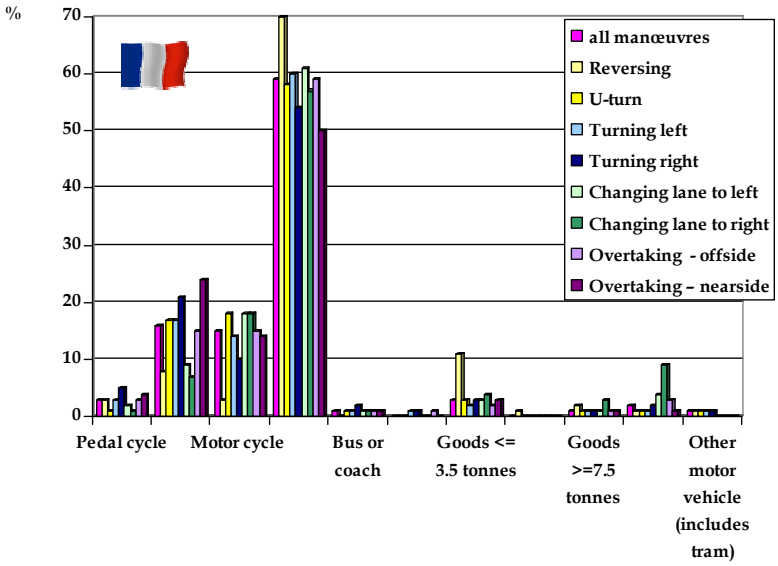


Figure 32: Distribution of the vehicle type related to the specific manoeuvre in France 2004 (source: TRACE survey 2006-2007)

For each vehicle type, what is the specific manoeuvres distribution?
If we look for each vehicle type, the distribution of the different manoeuvres, we see in Spain that pedal cycle and agricultural vehicles performed rather a turning left manoeuvre, MTW and cars an overtaking manoeuvre, bus is involved in other manoeuvres than those took into account and goods vehicles in overtaking and turning left manoeuvres.

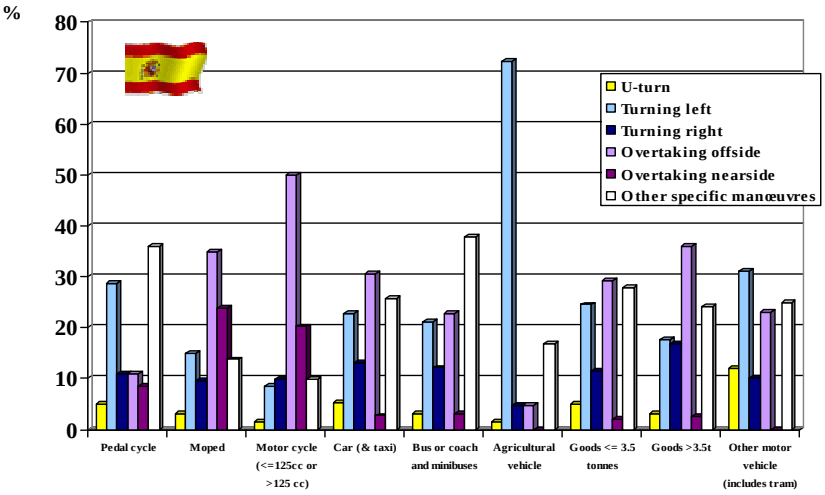


Figure 33: Distribution of the specific manoeuvre related to the vehicle type in Spain 2004 (source: TRACE survey 2006-2007)

If we look, for each vehicle type, the distribution of the different manoeuvres, we see in Great Britain that pedal cycle and cars performed rather turning left and overtaking manoeuvres, MTW and bus an overtaking manoeuvre, goods vehicles in overtaking, changing lane manoeuvres and agricultural vehicles in turning left manoeuvres.

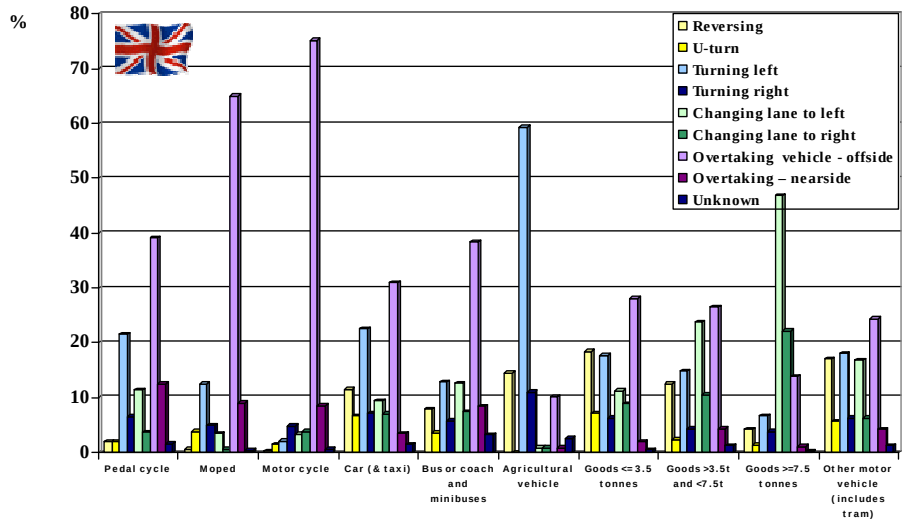


Figure 34: Distribution of the specific manoeuvre related to the vehicle type in Great Britain 2004 (source: TRACE survey 2006-2007)

I we look for each vehicle type, the distribution of the different manoeuvres, we see in France that all vehicle type performed rather turning left and overtaking manoeuvres than the other manoeuvres except for goods vehicles that performed also changing lane manoeuvres.

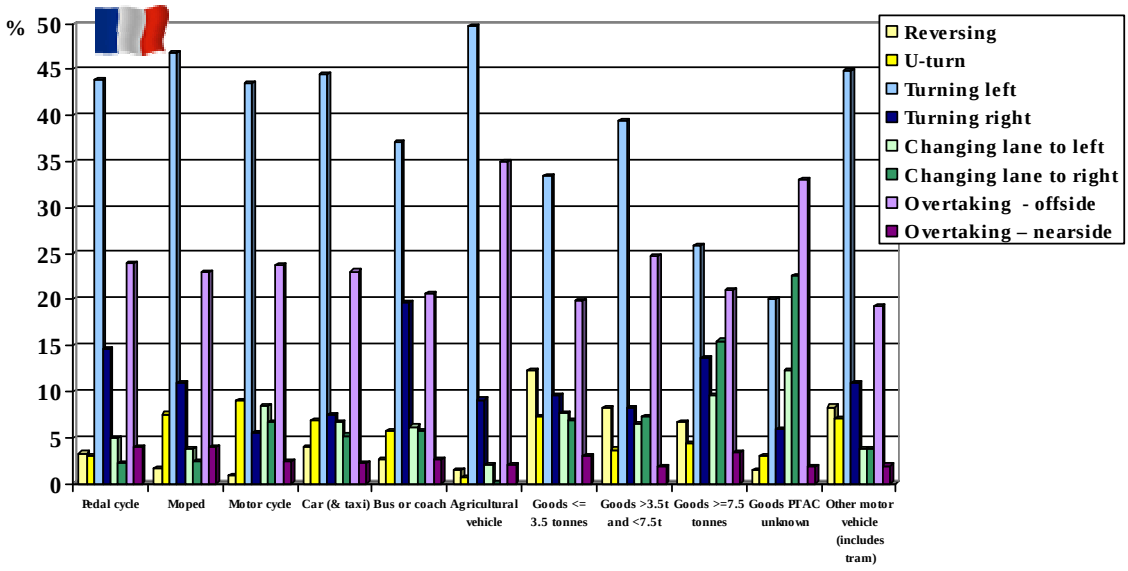


Figure 35: Distribution of the specific manoeuvre related to the vehicle type in France 2004 (source: TRACE survey 2006-2007)

7.3.4 Road class, road type and speed limit

European network repartition show that some countries have a higher proportion of dual carriageway than the others and than the average in EU-27 such as Portugal but the proportion is very low compared to the other road classes (from 0,1 to 2,5 % of the national network and an average of 1,2% for the EU-27).

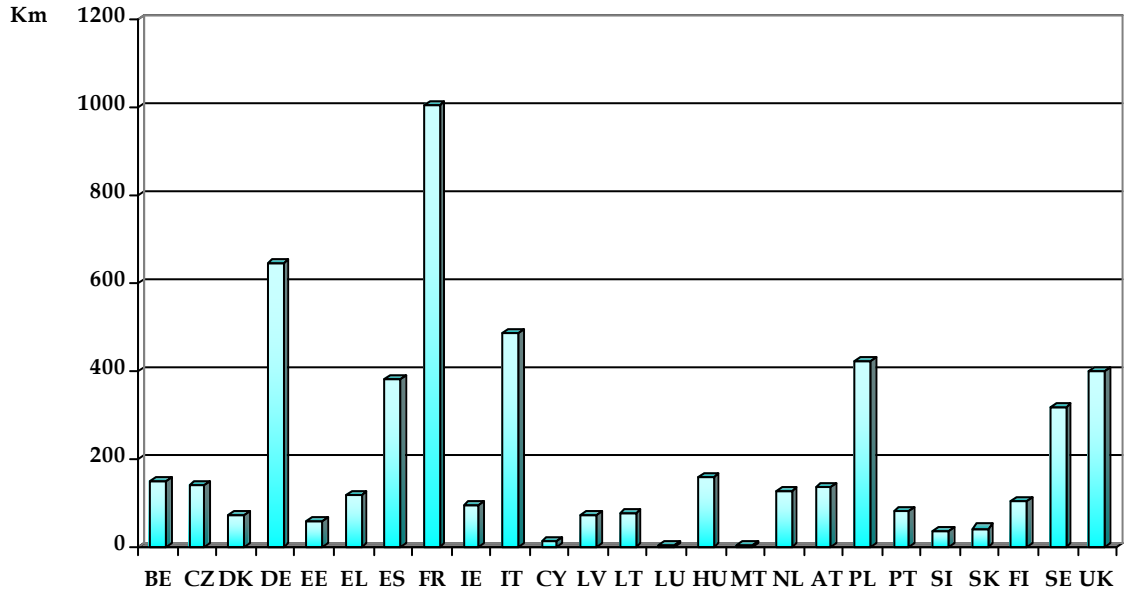


Figure 36: European network (Source IRF 2004)

Countries describe and define roads or sections of roads in different ways. Roads are here classified according to the number of carriageways and number of lanes. Dual carriageways correspond rather to motorways; single carriageway corresponds to national and departmental roads or main roads without any separation between ways.

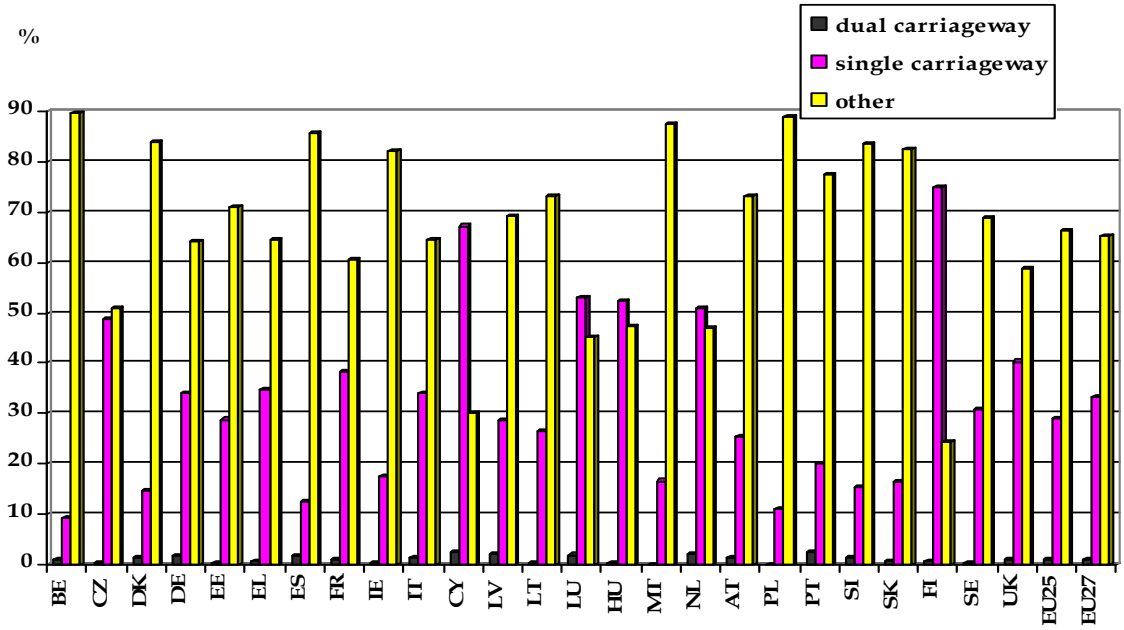


Figure 37: European network by road class (Source IRF)

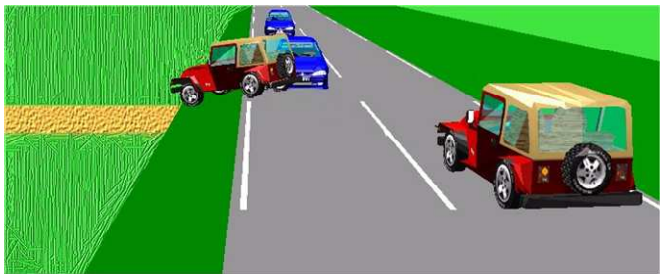
So the majority of vehicles involved in accidents away from junctions, regardless of manoeuvre, are typically driving on the following roads:

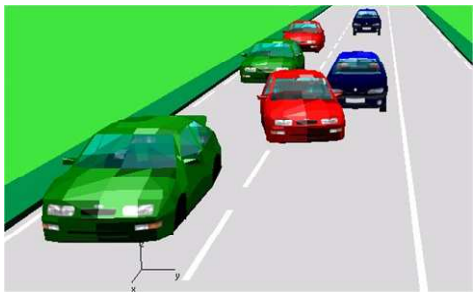
- On single carriageway, typically national roads and main secondary roads, turning left, U-turning and overtaking offside are the three major manoeuvres performed in high proportion.
- On dual carriageway, typically motorways, changing lanes are predominant. Note that Spain database is not accurate enough to distinguish the manoeuvre changing lane from the other manoeuvres.

The three last graphs show differences on road class distribution. One explanation is the classification itself! In fact, Spain and France show a lot of "other" roads class.

These data show in spite of the differences, that on dual carriageway (within ways physically separated), the main situations are overtaking, turning left and changing lane manoeuvres (for GB and France).





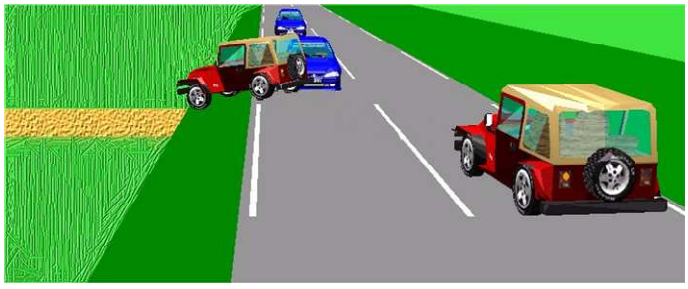


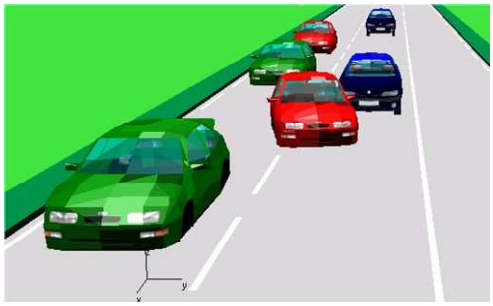
Spain has 1,62% of dual carriageways on which occurred 14% of situations when at least one passenger car was involved and at least one specific manoeuvre was performed in the accident.

UK has 0,9% of dual carriageways and GB sustained 27% of situations when at least one passenger car is involved and at least one specific manoeuvre is performed in the accident.

France has 1,19% of dual carriageways on which occurred 12% of situations when at least one passenger car is involved and at least one specific manoeuvre is performed in the accident.

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





7.3.5 Driver gender

From next figure, certain specific manoeuvres are associated more with male drivers than with female drivers or vice versa. Generally, there are more male drivers involved in accident as we can see in the figure 3-20 with "fatalities of drivers according to the gender" that gives us a magnitude of the male involvement, but comparisons for each manoeuvre can be made with the gender proportion for all specific manoeuvres and each country as a baseline (64 to 81% male). For example, **males are more strongly associated with U-turning, overtaking and changing lane manoeuvres while females are more prone to be involved in accidents whilst turning and were noticeably less involved in accidents whilst changing lane or overtaking.**

7.3.6 Lighting (weather and light) and road surface conditions

7.3.6.a Weather conditions

Bad weather conditions seem to have no relation with the manoeuvre performed in GB and France. Moreover, most specific manoeuvres are performed while the weather is fine.
But in Spain bad weather conditions such as rain presents more overtaking manoeuvres than all manoeuvres.

7.3.6.b Lighting conditions

In Spain, during **darkness**, **U-turning** manoeuvres are higher than the average (all manoeuvres).

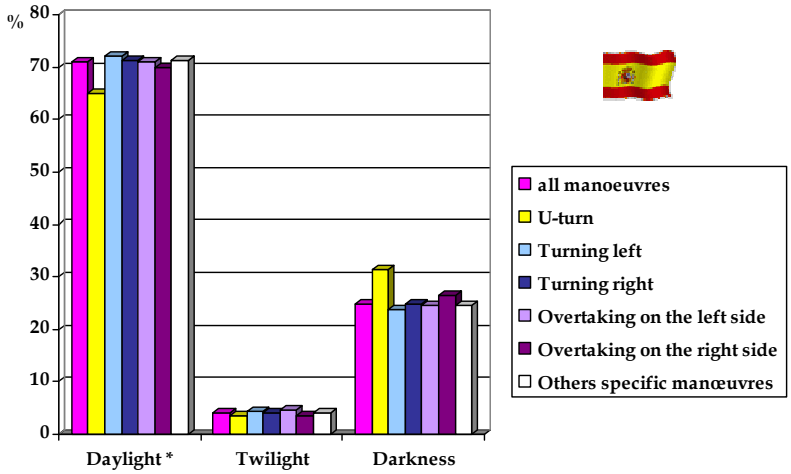


Figure 38: Distribution of each specific manoeuvres following the lighting conditions in Spain 2004 (source: TRACE survey 2006-2007).

In Great Britain, the proportions of reversing, turning left and right are higher during daylight than for all manoeuvres.

During **darkness**, **U-turning** manoeuvres are higher than the average (all manoeuvres).

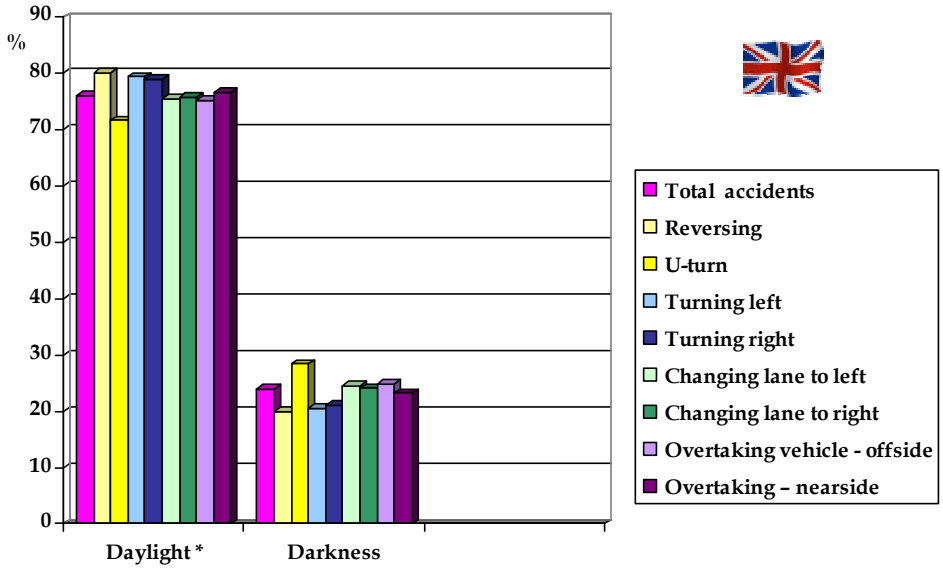


Figure 39 Distribution of each specific manoeuvres following the lighting conditions in Great Britain 2004 (source: TRACE survey 2006-2007)

In France, reversing occurred rather during daylight. No significant differences for the other manoeuvres except for **U-turning** which is higher than the average during **darkness**.

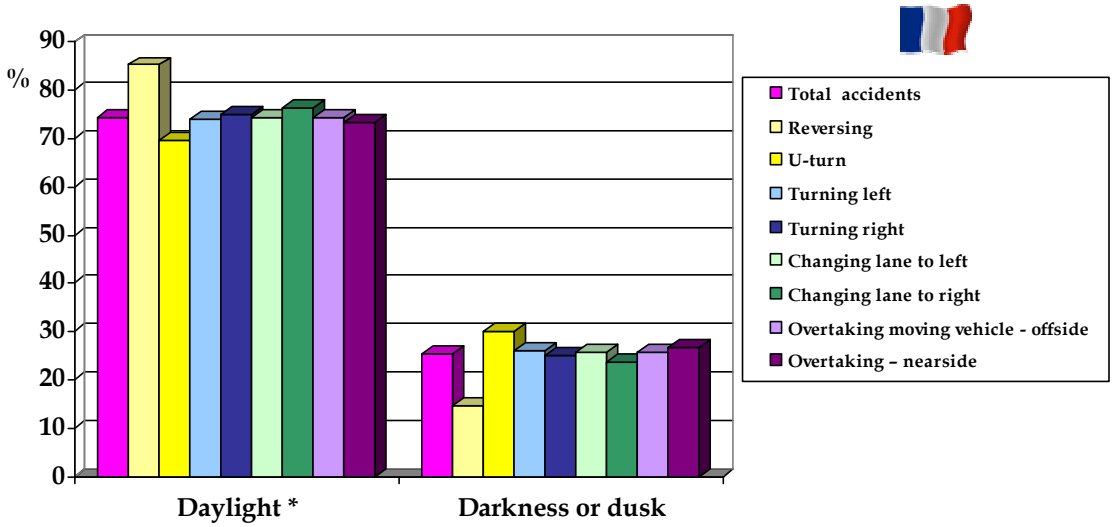


Figure 40: Distribution of each specific manoeuvres following the lighting conditions in France 2004 (source: TRACE survey 2006-2007).

In summary, all injury accidents with a specific manoeuvre occurred during daylight (between 70% and 80%). However, the rate of injury accidents with a U-turn manoeuvre is higher during darkness (between 5% and 10% more) than the other ones.

7.3.7 Vehicle trajectory and collision

One fundamental issue related to the accidents where at least one specific manoeuvre was performed concerns the severity of the crash. On the base of the national databases, we are only able to characterize the crash by the trajectory of the vehicle that leaves or not the carriageway after the driver had performed the manoeuvre and furthermore with the type of point of impact that should indicate the potential injuries sustained by the users (especially for lateral impact).

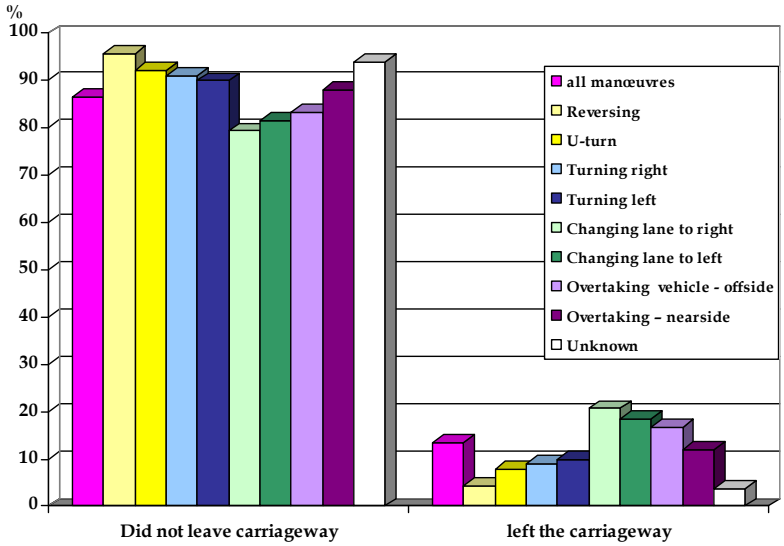


Figure 41: Vehicle trajectory and specific manoeuvres in Great Britain 2004 (source: TRACE survey 2006-2007)

If we compare the different manoeuvres with the vehicle trajectories, we see that in Great Britain, vehicles that left the carriageway had rather performed a changing lane and a overtaking offside manoeuvres (higher than average). We need to associate this observation with driving speeds that will be available in in-depth analysis.

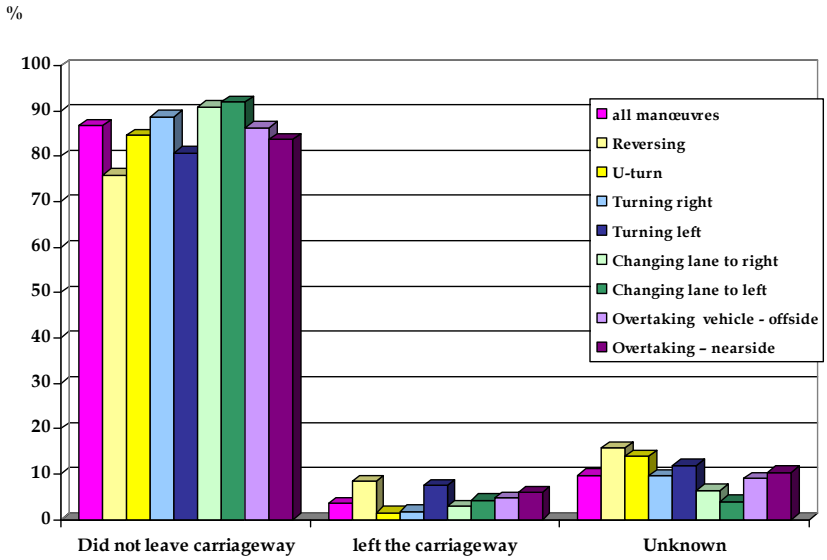


Figure 42: Vehicle trajectory and specific manoeuvres in France 2004 (source: TRACE survey 2006-2007)

If we compare the different manoeuvres with the vehicle trajectories, we see that in France, vehicles that left the carriageway had rather performed a reversing and a turning left manoeuvres (higher than average).

These differences need to be clarified within the in-depth analysis.

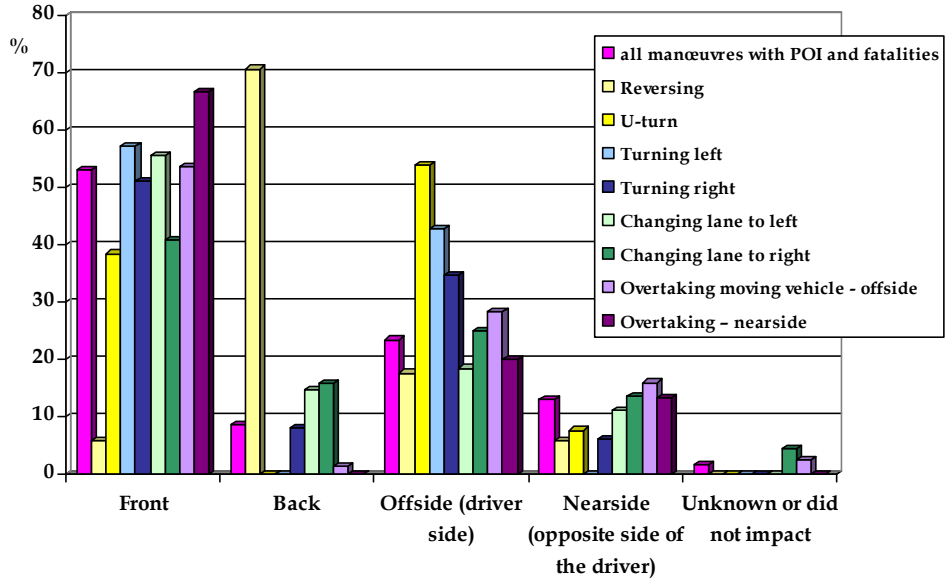


Figure 43: Vehicle impact and specific manoeuvres in Great Britain 2004 (source: TRACE survey 2006-2007)

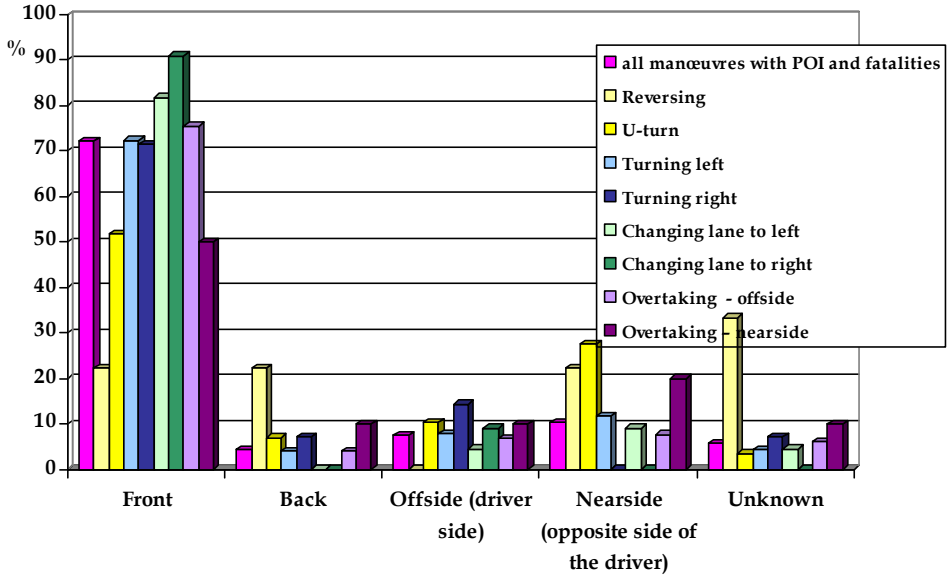


Figure 44: Vehicle impact and specific manoeuvres in France 2004 (source: TRACE survey 2006-2007)

If we look at the fatalities related to the point of impact of passenger cars performing a specific manoeuvre, we also see differences between the two countries. Note that it is difficult to define exactly the point of impact on the vehicle from a national database that is not accurate enough. Moreover, police agent has not the passive safety knowledge. The consequence could be a wrong codification of the crash point.

7.4 Conclusion

The specific manoeuvre situations represent only 13% of the situation out of intersection and 7% of the total number of situations.

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).

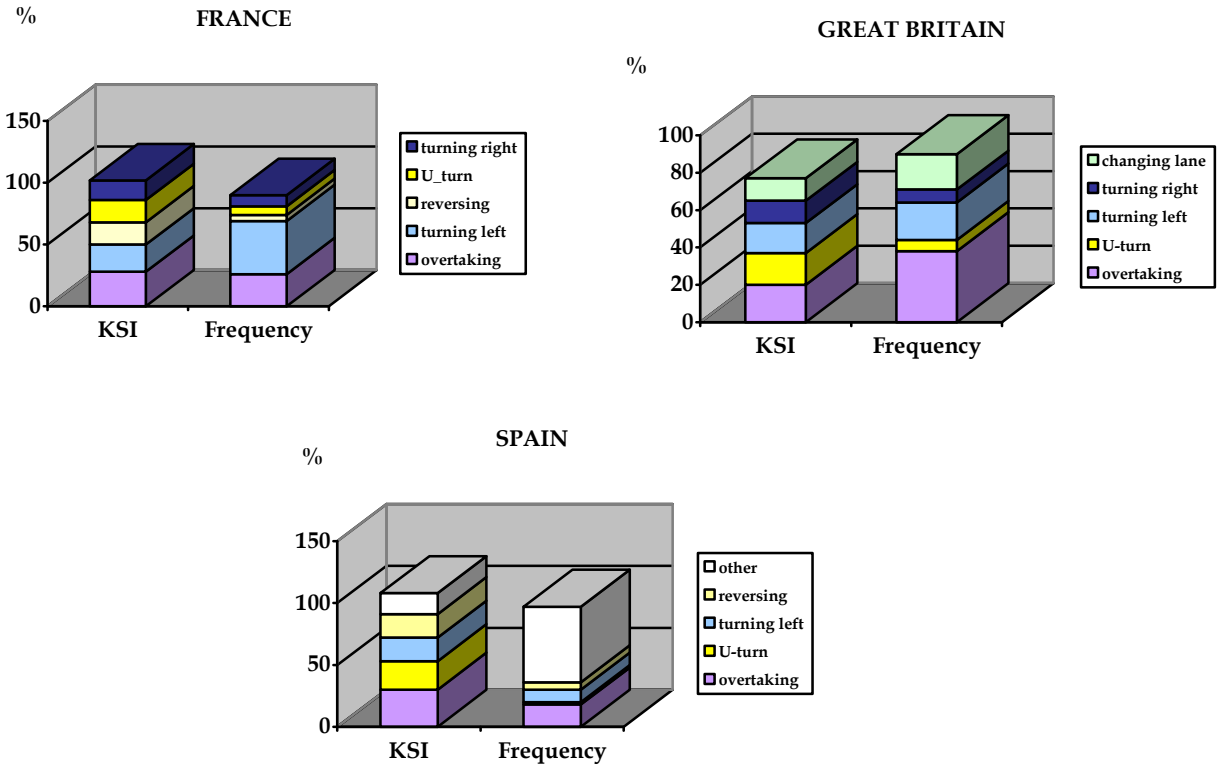
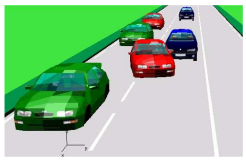
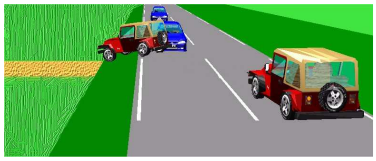


Table 16: Top 5 of specific manoeuvres according to the severity KSI (source: TRACE survey 2006-2007)

Three scenarios coexist in the concerned countries (France, Spain and GB):

Common scenarios	Pictograms	KSI %
Overtaking		21%
Turning left		17%
U-turn		17%

- In Spain and Great Britain, passenger cars performed rather U-turn, turning left and right and other manoeuvres. Reversing is predominant too in Great Britain and France.

  MTW performed rather an overtaking nearside manoeuvre in Great Britain, Spain and France. In France, turning right manoeuvre is also performed by the mopeds.

  Goods vehicles (<3.5t) are involved in France in reversing manoeuvres while all goods vehicle are rather involved in Great Britain and France in changing lane manoeuvres.

- 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.

8 Intersection situations

Intersection situation is one of the four situation types we have proposed to investigate in the TRACE project. The intersection accidents stakes are significantly high. In France for example intersection accidents represented 27 % of injury accidents and involved 15% of the fatalities in 2004.

This accident scenario is the result of different traffic flows crossing which takes place either in urban area where the panel of users increases the difficulties especially for the vulnerable users and where the geometric layout generate visibility masks, or in rural area where the speed and traffic differences between 2 crossing lanes lead to conflicts and to accidents.

These characteristics might help us to identify the causes and the factors contributing to the accident.

Although we will define below what is an intersection, we can already say that an intersection situation concerns all situations directly related to an intersection location. An intersection is an area formed by the connection of two or more roadways.

After a short definition of terms we will use all along this report, we present a general overview of the magnitude of the problem according to a European point of view with references to international issues. We are going thus to highlight the different surveys carried out on the subject. Then, we identify the subjects we will develop below through the national and European statistics analysis and further through in-depth analysis.

This task is in charge of causation analysis related to traffic accidents at intersection. A statistical and an in-depth analysis will provide the task with an overview of the conditions under which accidents at crossings and intersections occur. Magnitude of the intersection accidents and most relevant accident situations will be defined upon the pre-accidental manoeuvres and distributions of the main pre-crash parameters will be established for each situation.

This task is broken down into 3 parts:

Subtask 1: provides a short definition of what the intersection situations are, an overview of the studies carried out on the subject through the literature and presents general statistics (national and European) about injury and fatal accidents corresponding to these situations. This subtask should provide general accident scenarios through the national database analysis.

Subtask 2: provides detailed data of accidents scenarios with a view to identifying and quantifying significant causation factors which cause accidents.

Subtask 3: provides risk factors associated to the intersection scenarios.

This present report is dedicated to subtask 1. Its objectives are to define the scope of this study, to give its magnitude and its main characteristics, and to identify the most important scenarios. These scenarios, which gather all injury accidents presenting similarities in their process and covering 80% of the problem, will be studied in detail in report D2.2 with the identification of the main causes and the contributing factors. The main interest of this method is to analyse each configuration independently in order to be able to specify countermeasures more appropriated to each one and avoid considering the problem in its global nature with countermeasures covering more or less well the real needs. An other interest, is to give the possibility for car manufacturers or suppliers to set up upgradeable safety solutions regarding the availability and the progress of the new technologies.

8.1 The stakes and general overview

In the EU27, the accidents in intersection represent (see):

- 43% of road injury accidents;
- 45% of the total number of victims (death + injured)
- 21% of the fatalities
- 32% of fatalities and serious injuries.

If these accidents count around for the half of the total number of accidents in EU27, they contribute only for 21% of the fatalities and 32% of fatalities and serious injuries.

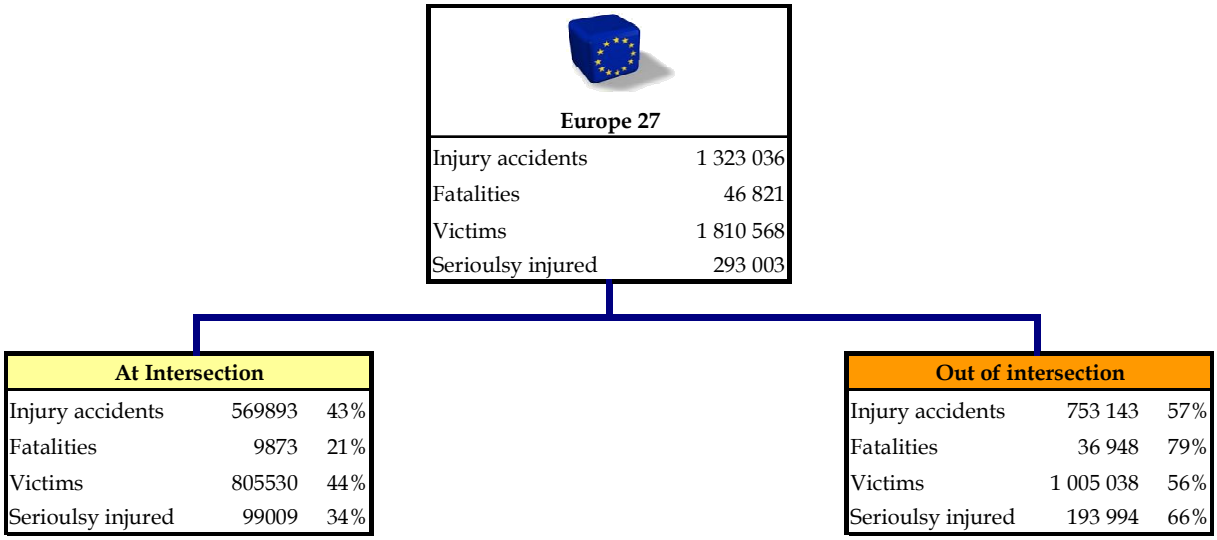


Figure 45: Distribution of road accidents following their location at or out of intersection in EU27 (year 2004, Source: CARE, IRF, IRTAD, TRACE and National Statistics Databanks)

The risk to be killed in an injury accidents in intersection is 2,8 times less than the risk to be killed in an injury accident out of intersection in EU27.

The risk to be severely injured or killed is 1,6 times less in injury accidents in intersection than the one out of intersection in EU27.

Unfortunately we are not able to estimate the risk to be killed in intersection without any exposure data related to intersection.

In the following figures the distribution of the rate of accidents, fatalities, victims and seriously injured road users in intersection accidents are presented for each country in EU27.

The different rates are calculated by dividing the number of the sub-set by the total number of the sample. For example, the fatality rate is the number of fatalities in intersection divided by the total number of fatalities in injury accidents.

Note: The next results are based on available data and for the missing ones by simple linear regression estimation. They do not represent the strict reality.

The first figure shows a comparison between the 27 European member states regarding the rate of injury accidents at intersection compared to the total number of injury accidents for each country. As we can see, UK differs by a very high rate compared to other states. This result can be explained partially by a more general definition of what an injury accidents in intersection is. For example in UK all injury accidents occurring close to an intersection is counted as accident in intersection even if the junction didn't play any role.Thus, it would be necessary to correct these figures so as to make comparable these results all over the European countries.

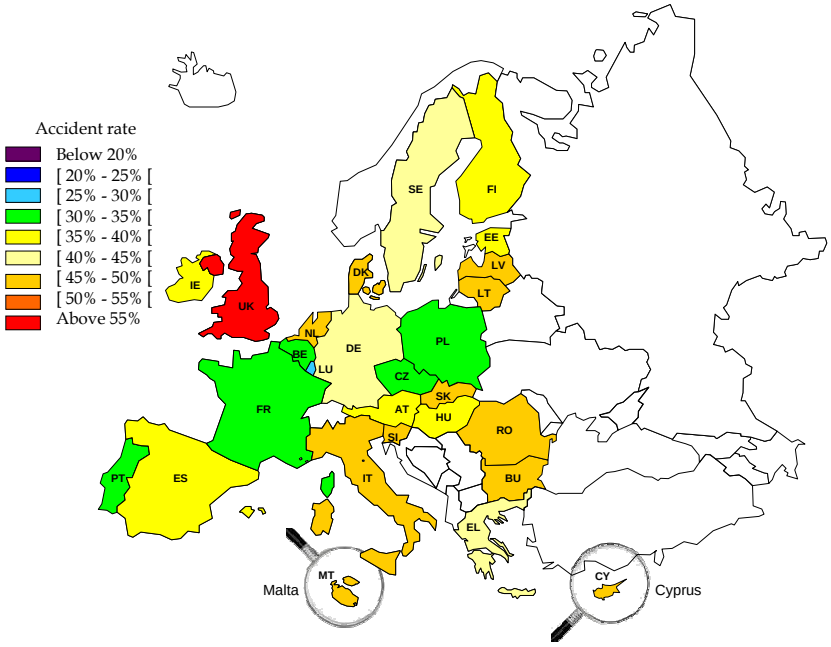


Figure 46: Distribution of the accident rate by EU27 countries
(Year 2004, Sources, CARE, IRF, IRTAD, TRACE, National Statistics Databank)

These two figures summarise clearly the fact that if the injury accidents in intersection cover a large number of the overall accidents (ascendancy of the range between 40% and 50% in Figure 46), they are not so fatal (range between 15% and 25%). The exception is for Netherlands, with the higher fatality rate.

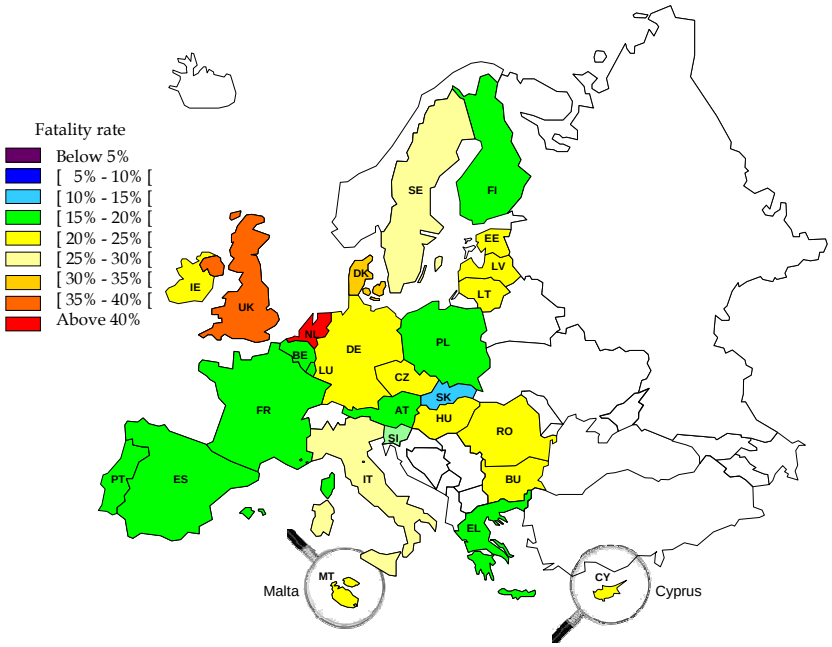


Figure 47: Distribution of the fatality rate by EU27 countries
(Year 2004, Sources, CARE, IRF, IRTAD, TRACE, National Statistics Databank)

For the victims, the rate for each country increase with an average of 10% more compared to the fatality one.

Regarding the higher score, if the case of UK can be explained, the Danish situation shows that the majority of the victims (including all injured persons) are in intersection. But, the risk to be injured in an accident in intersection is the same as in Netherlands, in Czech Republic, in Italy or in Latvia.

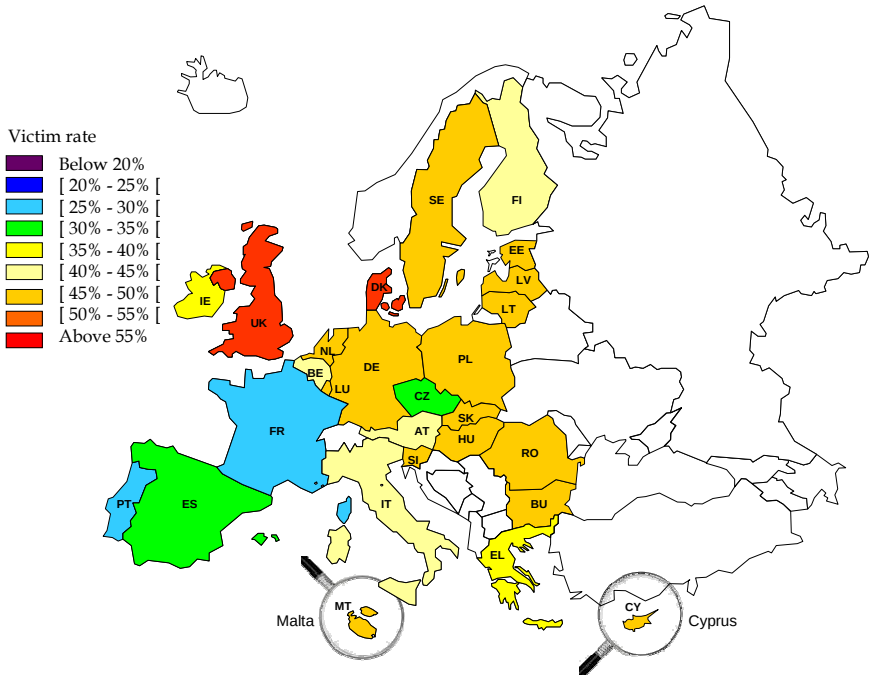


Figure 48: Distribution of the victim rate by EU27 countries
(Year 2004, Sources, CARE, IRF, IRTAD, TRACE, National Statistics Databank)

In the same way, the seriously injured rate is the highest in UK and Denmark. However, the risk to be severely injured in an accident in intersection is here the highest compared to the other countries.

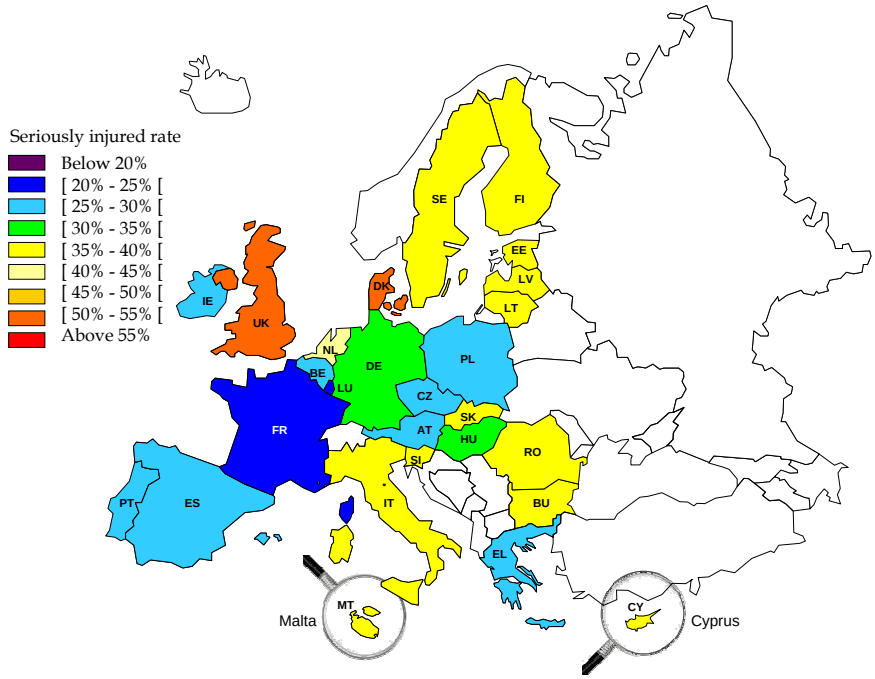


Figure 49: Distribution of the seriously injured rate by EU27 countries
(Year 2004, Sources, CARE, IRF, IRTAD, TRACE, National Statistics Databank)

8.2 Literature review

Intersection accidents obviously occurred at intersection. We are going to define below, the different terms we will use all along the report. Intersection means "crossing of at least 2 different roads and so 2 traffic flows". What could happen? If an accident happens, a dysfunction could be associated either with the driver, the vehicle or the infrastructure and could be related to:

- The infrastructure layout: conception, management, signalization, visibility, legibility.
- The user type: conflict between 2 different kinds of users (the eldest against the youngest, the eldest against the rider, the pedestrians…), conflict between traffic flows.
- The user dysfunction: conflict between 2 incompatible manoeuvres (one turns left while the other goes ahead).

We will highlight these different points through the literature. This exercise will lead to identify the aspects of the problem that are not illustrated as part of the known surveys. With the help of the national descriptive analysis we will be able to say that either the missing subjects are relevant according to their stakes or that although we note that the problem could be identified it is not relevant enough to hold a further investigation.

8.2.1 General overview : magnitude of the problem

Numerous surveys have shown that intersection crash avoidance represents a great challenge. Actually, i**n Europe (**14 countries), in 2004, 23406 fatal accidents occurred, including **22% at junction** (5078 fatal accidents, Safetynet and Care references).

	Fatal accidents							
				At junction				
	Not at junction	Cross road	**Level crossing**	**T or Y junction**	**Other junction**	**Roundabout**	Not defined	Total
BE**	881	0	**1**	**0**	**196**	**7**	11	1.096
DK	224	55	**4**	**1**	**52**	**3**	2	341
EL	1.366	0	**0**	**0**	**0**	**0**	118	1.484
ES	3.091	213	**0**	**191**	**88**	**60**	0	3.643
FR	4.036	422	**14**	**137**	**122**	**35**	0	4.766
IE	0	15	**0**	**39**	**5**	**4**	238	301
IT***	3.591	706	**5**	**0**	**715**	**65**	0	5.082
LU*	45	5	**0**	**2**	**0**	**0**	0	52
NL	635	150	**25**	**119**	**0**	**8**	3	940
AT	477	89	**16**	**29**	**1**	**4**	202	818
PT	653	56	**6**	**94**	**15**	**5**	195	1.024
FI	0	0	**0**	**0**	**60**	**0**	263	323
SE*	4	90	**0**	**0**	**25**	**0**	311	430
UK*	1.981	182	**0**	**648**	**231**	**63**	1	3.106
EU-14	16984	1983	**71**	**1260**	**1510**	**254**	1344	23406
% by junction	72.5%			**21.7%**			5.7%	100%

Source: CARE Database / EC / Date of query: 17-nov-2006 / * Data 2003 / ** Data 2002

Table 17: Number of fatal accidents by type of junction per country in Europe, 2004

Fatalities								
	Not at junction	At junction						
		Crossroad	Level crossing	T or Y junction	Other junction	Round -about	Not defined	Total
BE	940	**0**	**1**	**0**	**203**	**7**	11	1.162
DK	245	**59**	**5**	**1**	**54**	**3**	2	369
EL	1.548	**0**	**0**	**0**	**0**	**0**	122	1.670
ES	3.977	**319**	**0**	**257**	**110**	**77**	0	4.741
FR	4.708	**482**	**16**	**147**	**138**	**39**	0	5.530
IE*	0	**16**	**0**	**48**	**5**	**4**	264	337
IT	3.984	**774**	**7**	**0**	**789**	**71**	0	5.625
LU**	54	**6**	**0**	**2**	**0**	**0**	0	62
NL*	704	**161**	**29**	**122**	**0**	**9**	3	1.028
AT	507	**92**	**19**	**29**	**1**	**4**	226	878
PT	832	**68**	**9**	**112**	**17**	**7**	249	1.294
F I	0	**0**	**0**	**0**	**65**	**0**	310	375
SE	4	**98**	**0**	**0**	**27**	**0**	351	480
UK	2.178	**192**	**0**	**686**	**246**	**65**	1	3.368
EU-14	19.681	**5.699**					1.539	26.919
% by junction	73,1%	**21,2%**					5,7%	100,0%

Source: CARE Database / EC / Date of query: 19-Oct- 2006 / * Data 2003 / ** Data 2002

Table 18: Number of fatalities accidents by type of junction per country in Europe, 2004

In France, 84318 injury accidents occurred in 2004. **27% of injury accidents happened at intersections** and resulted in **15 % of the fatalities** and 27 % of the severely and slightly injured. Intersection accidents happened mainly in urban areas (80%) but the severity is lower (42 % of the fatalities in intersections occurred in urban areas). Of the injury accidents at intersection, 23 % involved at least one passenger car and resulted in 10 % of all fatalities.

Elsewhere**, UK** statistics (Department of the environment, transport and the region) indicate that **59%** of personal injury accidents happen within 20 meters of a junction. Note that this definition leads to take into account accidents with no relation with intersection.

The **German** Federal Statistical Office identifies that overall **34%** of accidents happen at intersections. In **Spain**, **34%** of injury accidents occurred at intersection. **Austrian** statistics show **32% of all accidents occurring at intersection** while **Switzerland** counts **24%**.

Where did occur intersection crashes?
39% of intersection accidents occurred at crossroad (at-grade intersection) and 25% at T or Y intersection. Round-about accounts for 5% of the fatal accidents at junction.

And overseas?
In **US**, crashes at junctions represent about 60% of all crashes with **44% at intersections** (intersection and intersection-related) (Wang 1994; Ragland 2003), and fatalities in crashes occurring at intersections account for slightly more than **20% of all motor vehicle traffic fatalities** in US every year.

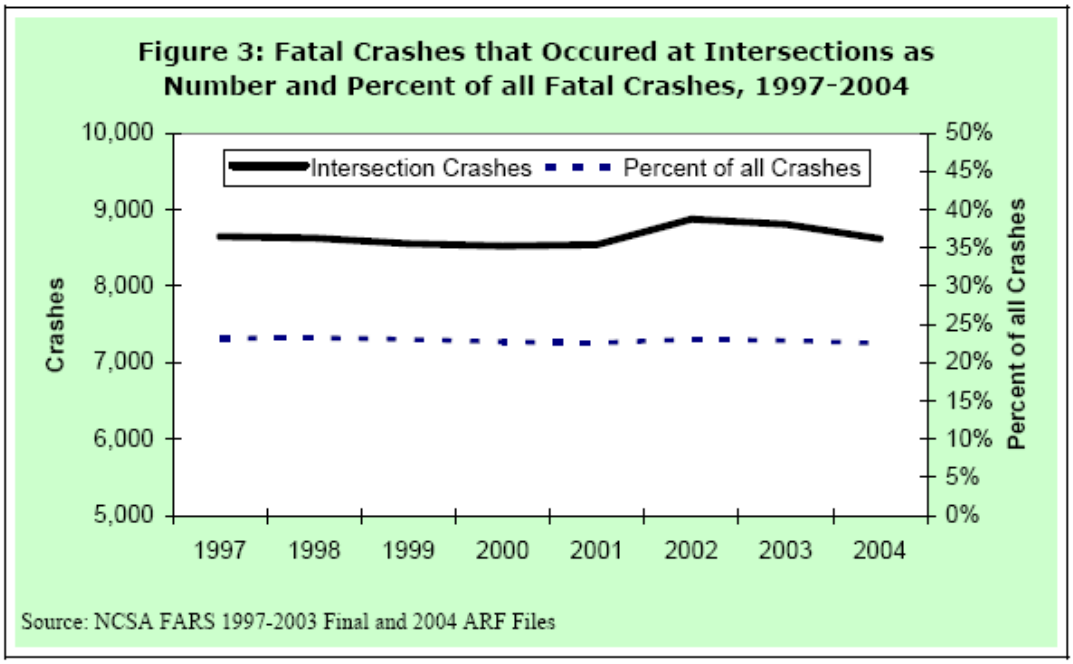


Table 19: Depicts the number of fatal intersection crashes and fatalities from 1997 to 2004 in US.

8.2.2 Taxonomy

Common definition is required to work out the situation. "Taxonomy, glossary, definition", each country, each continent has its standards and its definition according to the language, the translations, the habits. We tend here to clarify this field.

A **junction** is a location where traffic can change between different routes, directions, or sometimes modes, of travel.

An **intersection** is a type of junction that contains a crossing or a connection of two or more roadways not classified as a driveway access or alley access.

An intersection can be at-grade (same level) such as T junction, Y junction, crossroad, round about (CARE glossary) or grade separated (to permit traffic on at least one http://en.wikipedia.org/wiki/Road road to pass through the junction without crossing any other traffic stream such as interchange, slip roads and main carriageway, mainly motorway).

An **intersection-related** crash is when the first harmful event occurs outside but near an intersection and involves a vehicle which was engaged or should have been engaged in making an intersection-related manoeuvre such as a turn.

8.2.2.a Traffic control device

Another way of classifying intersections with the control device can include the following types:

- **Un-controlled intersections**, without signs or signals (or sometimes with a warning sign):
  - on a 4-way intersection, traffic from the right has priority,
  - on a 3-way intersection, rules may vary by country: either traffic from the right has priority again, or traffic on the continuing road,
  - for traffic coming from the same or opposite direction, that which goes straight has priority over that which turns off.
- **Un-signalized intersections**:
  - Give Way-controlled may or may not have specific "GIVE WAY" signs.
  - Stop-controlled intersections have one or more STOP signs. Two-way and four-way stops are common.
  - Signal-controlled intersections depend on traffic signals, usually electric, which indicate which traffic has the right of way at any particular time.

8.2.2.b Intersection types and channelization

Intersection type is a response by the road manager to the safety, the fluidity, the conspicuity. He takes into account the traffic, the local needs, the environment, the habits, the road type, the type of user and the legibility. Some may classify intersections as 3-way, 4-way, 5-way, 6-way, etc. depending on the number of road segments (or arms) that come together at the intersection. Another type of intersection are the roundabouts. Besides the fact of managing the conflicts between crossing roads, the round about also allows to limit speeds and thus to reduce strongly the serious accidents.

Channelization is the separation of conflicting traffic movements into defined paths of travel to facilitate the safe and orderly movement of vehicles, pedestrians, and bicycles. Channelizing islands are defined areas between traffic lanes that control vehicle movements and serve as refuge points for pedestrians. Islands also provide suitable locations to place traffic control devices. Islands vary in size and shape, as well as the type of surfacing material used.

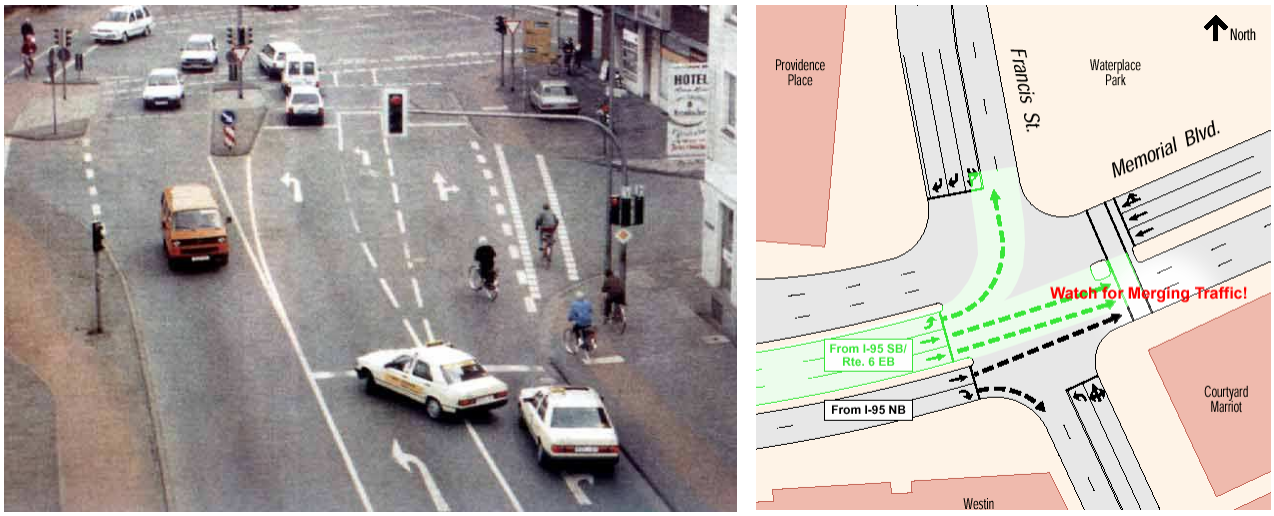


Figure 50: Examples of intersection with channelization.

8.2.2.c Intersection regulation.

Intersection regulation is an important complement to the intersection type. We see below that depending on the intersection type and regulation, the benefits of a device can be different.

European standard

Currently, signing systems in different European countries are based on similar signing forms (the ones prescribed by the Vienna Convention and its amendments[9]) and construction standards, but rest on different philosophies. Moreover, in many cases, national standards are obsolete (and, therefore, do not include the possibility of using modern, better performing, materials) and/or incomplete. Directional signs have not been harmonized under the Convention, at least not on ordinary roads. As a result, there are substantial differences in directional signage throughout Europe. Differences apply in typeface, type of arrows and, most notably, colour scheme. Signposting road numbers differs greatly as well.

A consequence of different signing standards:

A study conducted into a sample of Americans drivers in Europe (Summala 1996), shows that different signing policy may cause safety problems at uncontrolled intersections. For a European driver, an uncontrolled junction means an obligation to give way to vehicles on the right while for U.S. drivers, an intersection unsigned from his direction suggests priority for him, particularly in an urban area. Varying rules and practices in different jurisdictions call for further efforts in presenting vital information to foreign motorists and striving towards worldwide uniform traffic control.

8.2.3 Identification of the issues

This literature review will highlight the different issues we have identified related to the intersection accidents. The following points will be tackled:

- The traffic flows, the different users
- The infrastructure design layout
- The visibility and legibility
- The users and their functional failures
- The manoeuvre
- The vulnerable users

8.2.3.a The traffic flows

Most studies show the accident rate depends on the traffic flows of the main and minor roads.
The results are slightly different at inter-urban vs urban intersection and depend also on the type of intersection.
To sum up the main findings:

- For single and dual carriageway, an increase in the minor traffic flow results in an increase of the accident frequency) (INRETS Brenac 1994, Hughes & Amis, 1996; Hughes, Amis & Walford, 1996).
- For dual carriage-way T-junctions, a central reserve allowing for left turns (right turns in the UK) substantially increases the accident frequency.
- In urban roads, increasing numbers of crossing cyclists and pedestrians result respectively in lower accident rates for cyclists and pedestrians
- Rear-end crashes are correlated with the traffic flow in the minor and major roads (Wang 2006).

[9] In 1968, the European countries signed the Vienna Convention on Road Traffic treaty, the aim of which was to standardize traffic regulations in participating countries in order to facilitate international road traffic and to increase road safety. Part of the treaty was the Vienna Convention on Road Signs and Signals, which defined the traffic signs and signals.

8.2.3.b The infrastructure design layout

Intersection layout is designed to provide users safety through an understandable and considered network. Depending on the road class, the traffic and the environment, road managers are able to propose layout recommendations such as following (SETRA):

Road types	Intersection type recommended
Motorway or equivalent (express road)	Grade-separated intersection / No private access
Main rural roads	Round about / at-grade intersection (STOP or Give Way) /Private access
Secondary rural roads	Round about / at-grade Intersection
Urban service road	Round about / Intersection with priority to the right /Private access
Urban main road	At-grade intersection / Round about / Traffic lights/ Private access

Table 20: intersection layout and road class

These recommendations have to objective to improve the safety in adapting the intersection design to the environment and the traffic flow with an appropriate signalisation. Of course, these recommendations can be to improve for example with additional specific turn left or right lane or by separators. However, it is necessary to keep in mind that the intersection have to be legible for the driver. The addition of specific lanes, road marking and signalisation can engender problems of visibility and misunderstanding (for example the driver have to pay attention on where he has to go and not on the traffic) which can generate severe conflicts.

Safety efficiency of the Roundabout

When roundabout is provided, vulnerable road-users' risk is reduced significantly depending on the approaching speed, while there was no reduction for car occupants. Roundabout device lead to decrease the injury accident rate by 39%. The efficiency of the intersection type is classified increasingly from the intersection with no signalization to the roundabout and then the traffic lights.
Roundabout are nor always effective (depends on the speed limit before the round about).
Meanwhile, microscopic analysis reveals that roundabouts are not always effective. Serious injury accidents are estimated to increase by 117% on 70 km/h × 50 km/h intersections equipped with signalization before the roundabout. The number of injury accidents involving vulnerable road users is also found to increase (28%) on 50 km/h × 50 km/h junctions that were originally signalized. Moreover, the vulnerable road user is more likely to get fatally or seriously injured.



Figure 51: Illustration about safety on roundabout.

8.2.3.c The visibility

The visibility is an important parameter in the geneses of accidents in intersection. We can distinguish two aspects the sight distance and the legibility.

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. 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)…

Intersection with a poor sight distance leads to an increase of the accident rate (1.13 accidents per million entering vehicles to 1.33) (Hanna et al.). When sight obstruction is removed the accident rate can show a decrease by 67% (Mitchell).
Sight distance thresholds depend on the road layout, the approach speeds, the type of road, the difficulty of the itinerary, the crossing time and the stopping distance. It is recommended that the sight distance along the major road (priority way) 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 of the major road (6s is a minimum).
Visual restriction can result in decrease of approach speeds at rural intersection and a mitigation of the accident severity by limiting the driver anticipatory decision-making.

The **legibility** defines itself as the quality of what is legible. A legible road is a road, which is what the driver perceives and expects. Numerous things can produce a not legible road: a forest of road sign, the profile of the road, the complexity of the intersection, etc.



Figure 52: Example of non legibility.

Visibility and the crossing time

Visibility distances of the secondary road depend on the crossing times. Sight distances are very important for the driver who stopped at the STOP sign 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 of the major road (6s is a minimum). These results are confirmed by the AASHTO (American Association of State Highway and Transportation Officials) which worked out the policy for sight distance at stop-controlled intersections, based on a model of the acceleration performance of a minor-road vehicle turning left or right onto a major road and the deceleration performance of the following major-road vehicle (Harwood 1998).

Regulation /main road lanes		2 lanes	2 lanes + turn left lane	2x2 lanes : right insertion
STOP	**Recommended time**	8s	9s	8s
	Minimum time	6s	7s	6s
Give the way	**Recommended time**	10s	11s	9s
	Minimum time	8s	9s	7s
Left turn towards the secondary road	**Recommended time**	8s		
	Minimum time	6s		

Table 21: Crossing times depending on the roadway width and the regulation.

Visibility and the difficulty of the itinerary

The threshold of the sight distance varies according to the type of itinerary and the infrastructure layout. In intersection, the most common problem occurs when the local drivers cross slowly a high-speed main road. The problem is related to the road type, the road classification and to the design speed. For example, on a motorway (very high speed) with 20 000 vehicle/day, the problem occurs when the sight distance is less than 300m, on a 2 wide lane road (high speed), the problem emerges under 150 m and when the itinerary is difficult, 125 m. (INRETS 1986, SETRA 1992).

Visual restriction could lead to a decrease of the accident rate and a mitigation of the accident severity by decreasing the approach speeds at rural intersection.

Charlton 2002, reports the field test of a visual restriction treatment for a rural intersection with a high rate of injury crashes. A human factors analysis of the asymmetric pattern of crashes at the site suggested that most of the crashes were the result of anticipatory decision-making occasioned by visual characteristics of the eastbound approach to the intersection.

As mentioned in several studies, the problems related to the visibility play an important role on the occurrence of accidents. This field will be particularly studied in the intersection situation during the in-depth analysis.

8.2.3.d The users

In this chapter we approach the User according to his behaviour and his vulnerability.

Since literature has reported that pedestrians and older drivers are overrepresented in injury accidents at intersection, we gathered studies related to these 2 categories.

Pedestrians

In Europe, 14% of the road fatalities were pedestrians in 2004, 11%in France, and 21% in UK (Traffic Safety basic facts 2007 : pedestrians). 67% of pedestrian fatalities occurred inside urban areas, 34% of pedestrian fatalities are aged 65+ and 45% are aged 0 to 24 (CARE 2006). The proportion of fatalities who are pedestrians is higher for children (0 – 14) and the elderly than for other age groups.

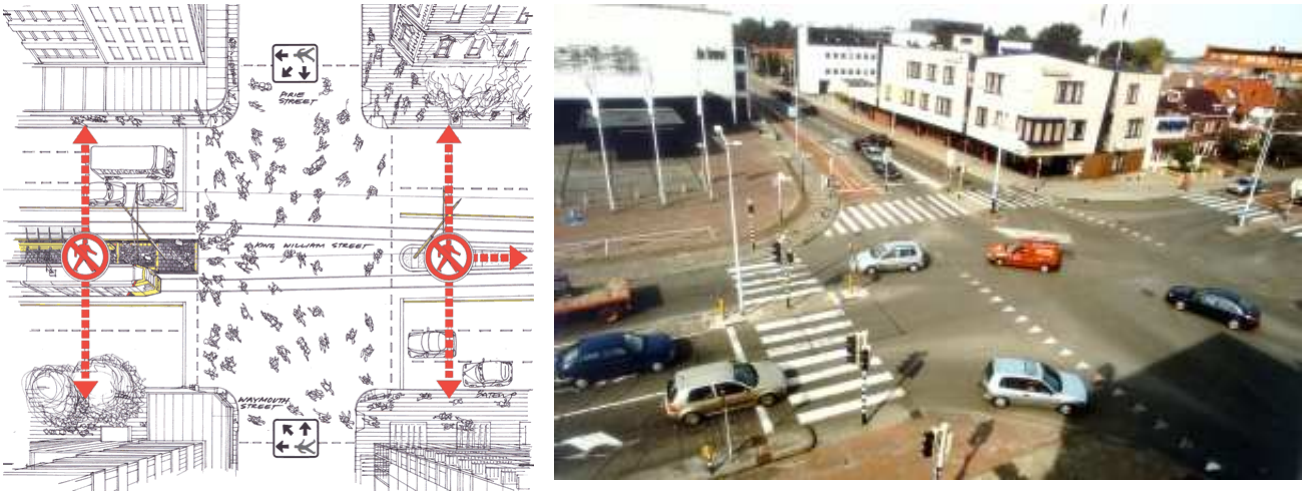


Figure 53: Illustration of intersection and pedestrian crossing

Young pedestrians

Fifty-six children, aged 5–6 years, took part in a 'treasure trail' activity (Zeedik 2000) in which they were confronted with two road crossings, one at a T-junction with a moving car and the other between parked cars. Children's performance was videotaped and coded for relevant behaviours such as stopping at the pavement, looking for traffic, direction of the look, and style of crossing (i.e. walking vs. running). Results revealed that performance was extremely poor.

60% of the children failed to stop before proceeding from the pavement onto the road. Looking for oncoming traffic was exhibited by no more than 41% of the sample, dropping to as low as 7% in some instances.

When looking did occur, it was initially as likely to be in the inappropriate direction (i.e. to the left) as in the appropriate direction (i.e. to the right).

Strategies for making safer pedestrian crossings can be boiled down to four essentials:

- Reduce the number of lanes to cross
- Shorten the crossing distance
- Slow the traffic
- Let the pedestrian see and be seen.

Consequently, road specialists such as SETRA in France propose urban layout recommendations for the pedestrian safety (SETRA 2006 & CERTU 2006):

- Global layout for all sorts of pedestrians (reduced mobility, children, elderly pedestrian…)
- Progression continuity is more important than width of the pavement (minimum 1.40m, 2m are recommended)
- Visibility distances of a pedestrian or for the pedestrian must be bigger than the stopping distance.
- Visibility distances of a pedestrian crossing must be bigger than 50 m. No crossing in a bend, no crossing on high speed road.
- The pedestrian crossing must be relevant: it must be drawn such as the pedestrian doesn't make a detour without vehicle or crosses behind the stopped vehicles.
- At a bus stop, the pedestrian crossing must be behind the bus (5 to 10 m).
- The pedestrian crossing must be less than 8 m without traffic lights and 12 m with traffic lights long.



Elderly driver and intersection

Most of the studies reports that elderly driver are over-represented in injury accidents in intersection. Hauer (1988) reported that 37 % of the fatalities and 60 % of the injuries experienced by older drivers occur at intersections. For drivers age 80 and older, more than half of fatal crash involvements occur at intersections, compared to 25 percent or less for drivers up to age 45 (Insurance Institute for Highway Safety, 1988). In US, older drivers (65 and older) were involved more in fatal crashes occurring at intersections as compared to those that occurred at non-intersection areas. In fact, 31% of all fatal crashes occurring at intersections involved at least one older driver as compared to 13% of all crashes occurring at non-intersection areas. More recently, Preusser & al (1998) argued that drivers aged 85 years and older were 10.6 times more at risk of being involved in multiple-vehicle crashes at intersection than younger drivers (40 to 49 years). One of the principal concerns surrounding older road users is the ability of these persons to safely manoeuvre through intersections Safe and efficient driving requires the adequate functioning of a range of abilities including vision, perception, cognitive functioning and physical abilities and loss of efficiency in any of these functions can reduce performance and increase risk on the road (Janke 1994, Marottoli & al 1998, OCDE 2001).



Figure 54 : Illustration of an elderly driver

To sum up the main findings:

- Older road users may experience greater difficulties at intersections as the result of diminished capabilities, which limit both response initiation and movement execution.
- Deficits in vision and vision-dependent processes that probably have the greatest impact on older road users at intersections include diminished capabilities in spatial vision,
- Older persons require up to twice the rate of movement to perceive that an object's motion-in-depth is approaching, and require significantly longer to perceive that a vehicle is moving closer at a constant speed. It has been shown that older persons require up to twice the rate of movement to perceive that an object's motion-in-depth is approaching, and require significantly longer to perceive that a vehicle is moving closer at a constant speed (Hills, 1975).
- A principal source of risk at intersections is the error of an older, turning driver in judging gaps in front of fast vehicles
- The older drivers showed more difficulty making right and left turns at intersections and negotiating traffic signals
- Greater difficulty in situations where planned actions must be rapidly altered (Goggin, et al.,1989)
- Age-related decline in head and neck mobility (Ostrow & al, 1992).
- The time margins to the vehicles on the main road were shortest when an old driver was turning and a young driver approached on the main road.

8.2.3.e The driver

In the systemic approach of the accident, the driver is either a passive or an active actor. In both cases, his behaviour is conditioned by different factors, especially the behaviour of the opponent driver. This chapter targets the factors that could influence the driver behaviour at intersection.

The driver strategy is linked to the transversal traffic and the intersection layout. So when there is perceptible traffic on the other intersection arms, despite the fact that they have the right of way, the drivers regulate their speed. But when there is no traffic on the other intersection arms, driver strategies depended on the characteristic and the approach of the intersection.
The study was carried out by INRETS in 1992 and analyzed driver strategies when passing through intersections. The methodology used entailed making observations into an equipped vehicle during an actual journey on the public highway. The results showed that drivers passed through the intersection according to different strategies. They showed that:

- The drivers don't regulate systematically their approach speed. 9% of the crossing speeds are greater than 95 Km/h and 33% from 85 to 95Km/h.The greater speeds are linked to the absence of interfering traffic.
- The driving experience influence the driver's strategy. Novice drivers tend to drive faster and reduce less their approach speed than skilled drivers.
- The driver strategy is linked to the transversal traffic and the intersection layout. When there is no traffic on the other intersection arms, driver strategies depended on the characteristic and the approach of the intersection. Factors that influenced the speed regulation are linked to the visual aspect of the intersection (sight distance) or to a structural modification of the approach of the intersection (modification of the number of lanes, raised island…) leading to a rupture in the driving situation. When there is perceptible traffic on the other intersection arms, despite the fact that they have the right of way, the drivers regulate their speed. They take into account different parameters to evaluate risk of interference with the other vehicle (location on the intersection, respective location, approaching speed…). Interviews showed that regulations are interactive. In-depth analysis also showed the drivers having the right of way have difficulties to interpret the behaviour of the other user.

The gender and the age of the driver
The youngest and oldest groups of drivers were found to be over-represented in the junction accidents and were the least likely to stop before turning. The young drivers had particular problems turning onto major roads. Women were more likely than men to stop before turning; they tended to have their collisions with other women; and they were under-represented as drivers of the non-turning vehicle (Clarke 2005).

8.2.4 Intersection Scenarios

Roadway intersections are areas of potential conflict that increase risk exposure for vehicles attempting to pass through these locations. The varying nature of intersection geometries and the number of vehicles approaching and negotiating through these sites result in a broad range of crash scenarios. One of the suitable factors that allow building an intersection accident classification is the pre-accident manoeuvre which characterizes the driver action before the conflict. Different criteria are thus used to build the classification. Criteria are extracted either from national injury accident statistics and/or from in-depth analysis databases. This approach already used in the European project INTERSAFE, will be seen out here.



Figure 55: Illustration of accident in intersection

8.2.4.a Statistical & in-depth approach

A recent French survey showed the relevance of the combination of a statistical classification with an in-depth analysis. This new approach is original and useful to describe the most relevant scenarios according to the statistical pertinence of the factors (independent of subjective expert judgements). Accidents were clustered in 16 scenarios gathering the same relevant factors such as general circumstances of the accident, contributory factors, pre-accident situation, road geometry, driver failures, dynamic parameters (speed, acceleration,), drivers' actions, etc.

A representative dimension was then brought with a random sample of 500 police fatal accident reports. These accidents were classified into the 16 clusters (5 classes are related to the intersection and 1 class to pedestrian accidents) and give the distribution of the fatal accidents that occurred in France in 2001-2002 (Page & Driscoll ARCOS).

More recently, 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 provides an overview of the magnitude and the conditions under which accidents at crossings and intersections occur. The magnitude of intersection accidents and the most relevant accident situations are defined according to pre-accident manoeuvres. This distribution was basically made upon the French National. The study ended up with a list of 50 accidental situations (The unit of the analysis is a vehicle involvement, not an accident). Out of these 50, about 20 concern intersections 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 represent 60-70 % of intersection injury accidents depending on the country.



(a) **(b)**

Figure 56: Accident in intersection with traffic ligth. (a) just before the crash. (b) crash.

8.2.5 Literature review Summary

Actually, i**n Europe (**14 countries), in 2004, 23406 fatal accidents occurred, including **22% at junction.**
I f we look at France, Great Britain, Spain, Switzerland data, from 24 to 59% of injury accidents occurred at intersection with a KSI (Killed and Serious Injuries) of 19% in France to 48% in UK. Further investigation will be carried out with the descriptive analysis.
This literature review highlighted the different issues we have identified related to the intersection accidents. The following points were tackled:

- The traffic flows, the different users
- The infrastructure design layout
- The visibility and legibility
- The users and their functional failures
- The manoeuvre
- The vulnerable users

The main findings are gathered below:

Traffic flows

- For single and dual carriageway, an increase in the minor traffic flow results in an increase of the accident frequency.
- For dual carriage-way T-junctions a central reserve allowing for left turns (right turns in the UK) substantially increases the accident frequency.
- In urban roads, increasing numbers of crossing cyclists and pedestrians result respectively in lower accident rates for cyclists and pedestrians.

Infrastructure layout

- Road lighting, STOP signs, signal control, and lowering of the speed limit value were found to decrease the number of accidents.
- Through-flow junction widening, additional lanes for turning vehicles, and road widening, however, did not seem to affect the safety at junctions to any marked extent.
- Channelization reduces the conflict between pedestrians and vehicles, reduces the pedestrian accident rate by 11% and reduces the accident rates by 100% after a training period.
- Addition of left-turn at intersection decreases the accident rates of 18% to 76% depending upon the intersection device (3-arm or 4-arm intersection), the number of lane, the traffic flow, the presence of raised island & the intersection regulation. The efficiency depends on the accident type. For example, the efficiency is greater to avoid rear-end accidents. The decrease is greater at rural intersection and greater at un-signalized intersection
- Addition of right-turn at intersection increases (by 27%) or decreases the accident rate. This device can create problem of conspicuity.
- 4-arm intersections experience from twice to 5 times as many accidents as 3-arm intersections. No evidence when the traffic flow is less than 20 000 veh/day.
- Y intersection experience more accidents than T intersection. Conventional 4-arm intersections experience more accidents than offset 4-arm intersections.
- Accident rate increases with increasing skew angle.
- When roundabout is provided, vulnerable road-users' risk is reduced significantly depending on the approaching speed, while there was no reduction for car occupants. Roundabout device lead to decrease the injury accident rate by 39%.
- The efficiency of the intersection type is classified increasingly from the intersection with no signalization to the round about and then the traffic lights.
- Round about are nor always effective (depends on the speed limit before the round about).
- Widening of the shoulders may reduce accidents by providing space for collision-avoidance manoeuvres and by providing better sight lines if sight distance is limited on the approach.

- Widening the approach allow a decrease of the accident rate. But widening the main road may increase the accident rate.
- Accident rate decreases at rural intersection and increases at urban intersection with increasing median width.
- In general, grade-separated junctions are safer than at-grade junctions. Grade separations resulted in 50 % accident reduction at a cross junction and 10 % reduction at a T-junction.
- In order to optimize safety of grade-separated junctions, on-ramps and off-ramps should be level and should have wide verges.
- Merging lanes need to be sufficiently long and junctions should not be located too close to each other.
- Increase in traffic flow (on-ramps and off-ramps) results in an increase in the accident rate.

The Sight distance

- Intersection with a poor sight distance leads to an increase of the accident rate (1.13 accidents per million entering vehicles to 1.33) (Hanna et al.). When sight obstruction is removed the accident rate can show a decrease by 67% (Mitchell).
- Conspicuity thresholds depend on the road layout, the V85, the type of road, the difficulty of the itinerary, the crossing time and the stopping distance. 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).
- Visual restriction can result in decrease of approach speeds at rural intersection and a mitigation of the accident severity by limiting the driver anticipatory decision-making.
- But Visual restriction could lead to a decrease of the accident rate and a mitigation of the accident severity by decreasing the approach speeds at rural intersection.

Traffic regulation

- Intersection with no control experience less accident than the other (due to the traffic?).
- Traffic lights intersection experience less accident than 4-arm intersection with no control (no effect on 3-arm intersection) and the accident severity decreases when STOP or Give Way are transformed in Traffic lights.
- Round about reduces the accident severity (except for 2-wheelers).
- Signal controlled intersections experience less total and angle accidents but more rear-en collisions

Vulnerable users

- Left-turning vehicles caused higher risks for pedestrians than right-turning vehicles.
- while 77% of pedestrians used marked pedestrian crossings, 85% of the collisions occurred in them.
- marked pedestrian crossings correlate with higher crash rates.
- Where volumes were 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.

Elderly users

- 37 % of the fatalities and 60 % of the injuries experienced by older drivers occur at intersections. For drivers age 80 and older, more than half of fatal crash involvements occur at intersections, compared to 25 percent or less for drivers up to age 45.
- Older road users may experience greater difficulties at intersections and show deficits in vision and vision-dependent processes and spatial visual functions, including acuity and contrast sensitivity.

Consequences :

- Older persons require up to twice the rate of movement to perceive that an object's motion-in-depth is approaching, and require significantly longer to perceive that a vehicle is moving closer at a constant speed
- A relative insensitivity to the speed of an approaching vehicle was shown for older versus younger drivers
- Thus, a principal source of risk at intersections is the error of an older, turning driver in judging gaps in front of fast vehicles.
- They also show greater difficulty in situations where planned actions must be rapidly altered. Moreover, they present age-related decline in head and neck mobility. The older drivers show more difficulty making right and left turns at intersections and negotiating traffic signals.
- One important factor is the interaction between older and younger road users. No differences appear in attention behaviour between the age groups but different acceleration habits and thus different turning time. The outcome of the turning manoeuvre was dependent on age. The time margins to the vehicles on the main road were shortest when an old driver was turning and a young driver approached on the main road.

The driver

- Drivers would give way less to the opponent driving on the straight road (right of way) in 3-arm intersection (60 to 69%) than coming from his right in a 4-arm intersection (75 to 78%).
- The expectation is based on what the drivers think is the rule in force (priority rule or road design).
- It was also shown that the drivers' behaviour was more dependent on the other driver's behaviour (approach speed) than on road breadth (priority to the broader road is commonly admitted) and that the right-hand rule was equally important as the other driver's behaviour.
- The driver strategy is linked to the transversal traffic and the intersection layout. So when there is perceptible traffic on the other intersection arms, despite the fact that they have the right of way, the drivers regulate their speed. But when there is no traffic on the other intersection arms, driver strategies depended on the characteristic and the approach of the intersection.
- The youngest and oldest groups of drivers were found to be over-represented in the junction accidents and were the least likely to stop before turning. The young drivers had particular problems turning onto major roads. Women were more likely than men to stop before turning; they tended to have their collisions with other women; and they were under-represented as drivers of the non-turning vehicle. Younger respondents were more likely to be violators such as beating the red lights.

8.3 Descriptive analysis

This section is dedicated to the descriptive analysis of the accidents in intersection. The objective is to give an overview of what the main characteristics of this type of accidents are and create some specific scenarios corresponding to the main configurations.

These configurations will be studied in details in the next step (dedicated to the in-depth and risk analysis). For each of them, we will determine the causes and the contributing factors

8.4 General Overview

25% to 59% of road injury accidents occurred at intersection in Europe, an average of 44% estimated in Eu-27 in 2004. If the results for the EU15 can be considered as close of the reality, on the other hand those related both EU25 and EU27 are only estimations and are strongly correlated to the EU15 ones.

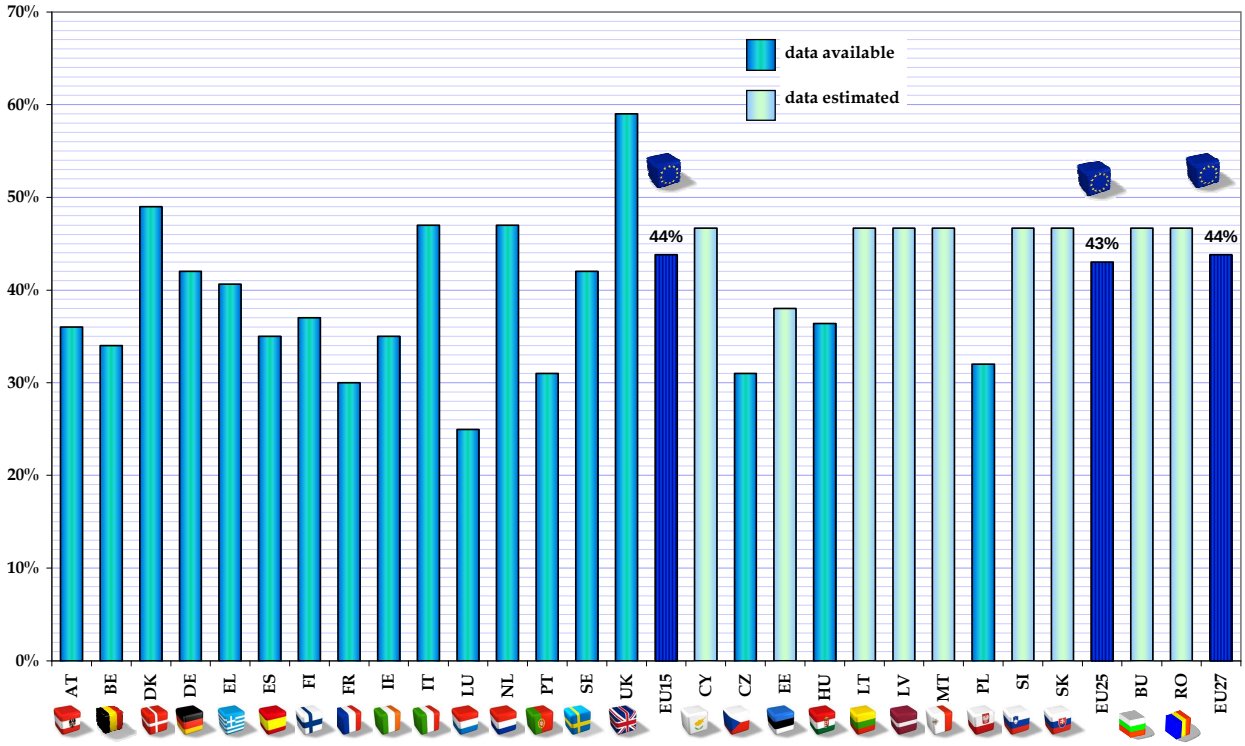


Figure 57: Distribution of the rate of accidents in intersection by EU27 countries (Year 2004, Sources CARE, IRF, IRTAD, TRACE, National Statistics Databanks)

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 a dispersion between countries that could be explain with the differences of network, urbanization, fleet of vehicles and also with the differences of definition used in the national databases such as the definition of the intersection which takes into account the 20 meters before and after the intersection in Great Britain.

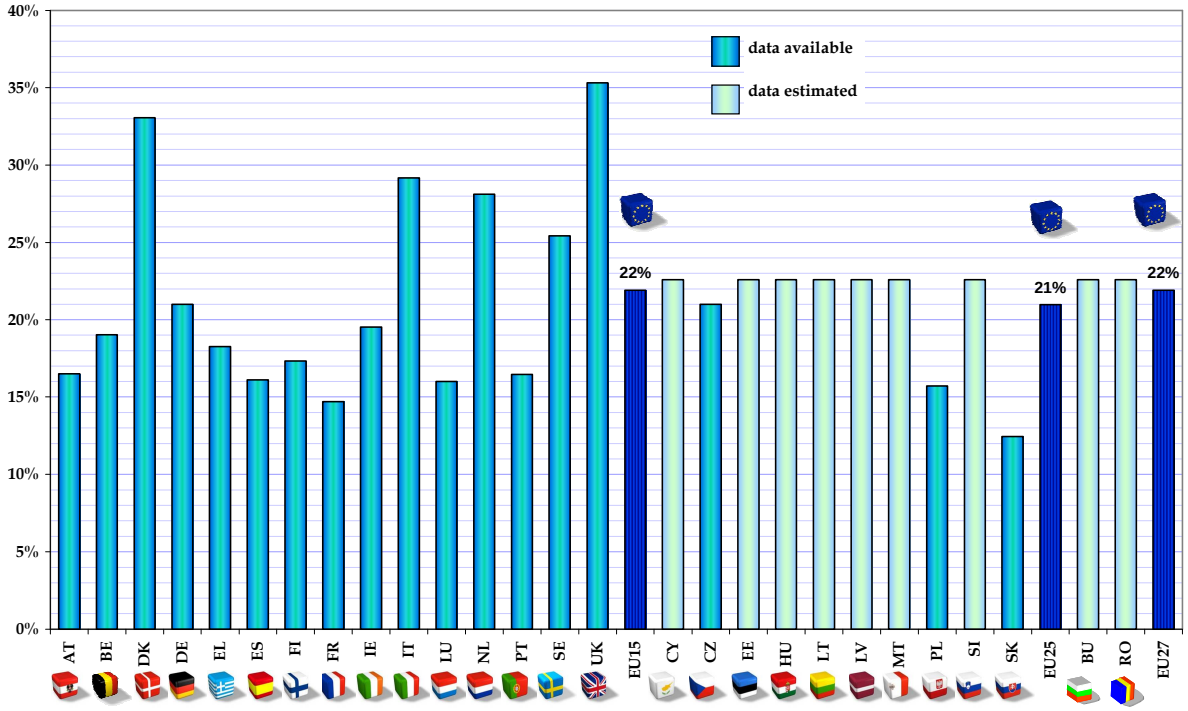


Figure 58: Distribution of the rate of fatalities in intersection by EU27 countries (Year 2004, Sources CARE, IRF, IRTAD, TRACE, National Statistics Databanks)

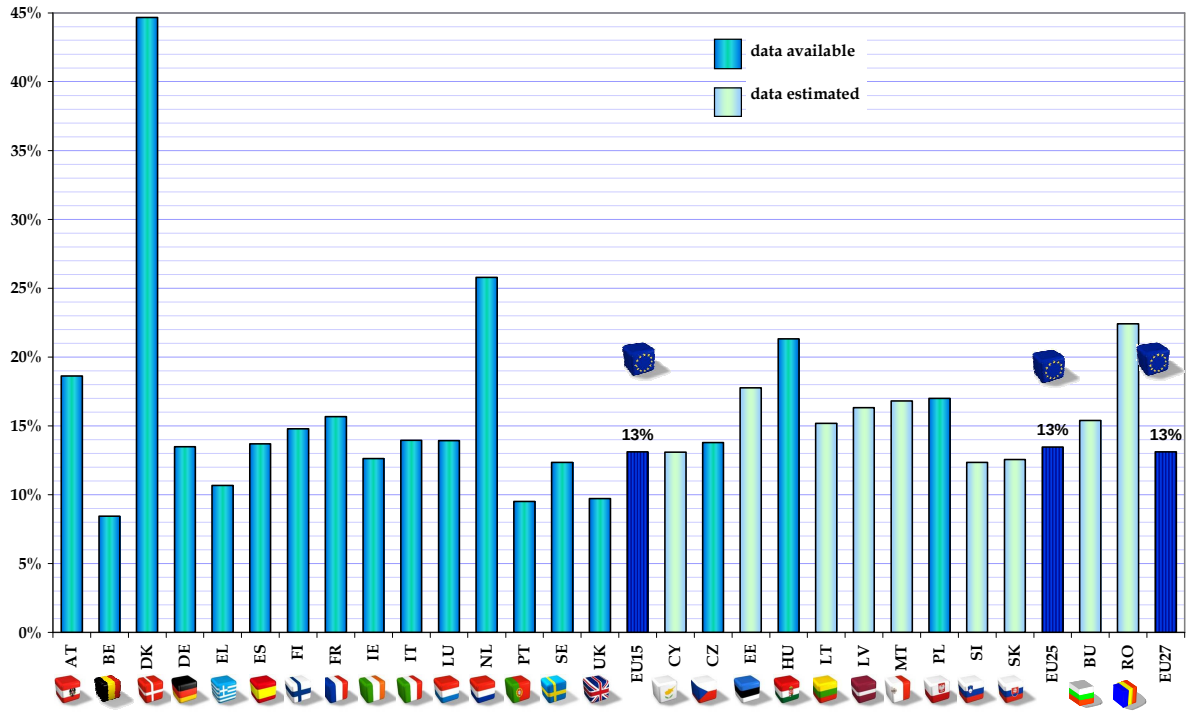


Figure 59: Distribution of the Intersection accidents severity KSI[10] in EU27 (Year 2004, Sources CARE, IRF, IRTAD, TRACE, National Statistics Databanks)

This data show that European countries are not equal in terms of accident risk. Further national data will allow us to describe the differences and the similarity.

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

How can we characterize the intersection accidents?

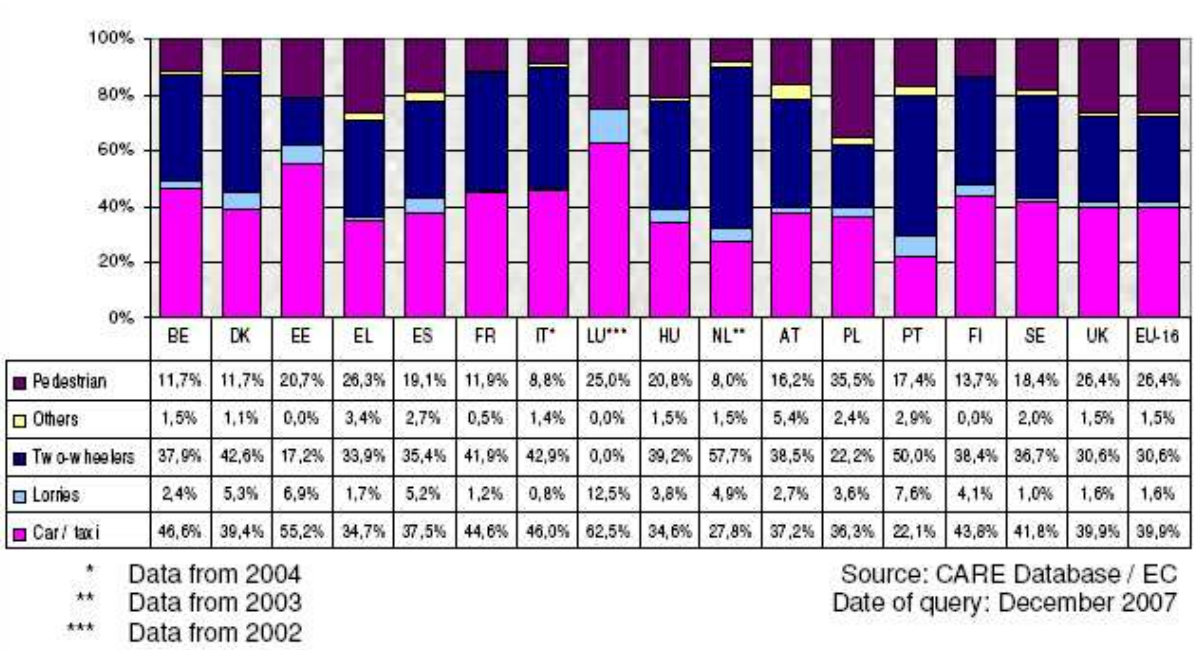
First of all, we are going to describe the location, inside or outside urban area, the intersection type and the regulation of the intersection with and without pedestrians involved. Meanwhile we compare intersection data with European data in order to put into context our sample in the whole database.

Some data characterizing these type of accident and available at national database level are investigated such as the lighting and visibility conditions, the weather, the road conditions. Further more, variables such as pre-accident manoeuvre, type of collision type of user, type of driver (age, gender) will complete the analysis.

8.4.1 Mode of transport

This first part is dedicated to the distribution of fatalities in intersection by mode of transport.

As mentioned in the "Traffic safety basic facts 2007" produced by SafetyNet, for fatalities in intersection, the passenger car is the mode of transport the most often involved in the European countries, followed by two wheelers (pedal cyclist + moped + motorcycle) and by pedestrians.



	BE	DK	EE	EL	ES	FR	IT*	LU***	HU	NL**	AT	PL	PT	FI	SE	UK	EU-16
Pedestrian	11,7%	11,7%	20,7%	26,3%	19,1%	11,9%	8,8%	25,0%	20,8%	8,0%	16,2%	35,5%	17,4%	13,7%	18,4%	26,4%	26,4%
Others	1,5%	1,1%	0,0%	3,4%	2,7%	0,5%	1,4%	0,0%	1,5%	1,5%	5,4%	2,4%	2,9%	0,0%	2,0%	1,5%	1,5%
Two-wheelers	37,9%	42,6%	17,2%	33,9%	35,4%	41,9%	42,9%	0,0%	39,2%	57,7%	38,5%	22,2%	50,0%	38,4%	36,7%	30,6%	30,6%
Lorries	2,4%	5,3%	6,9%	1,7%	5,2%	1,2%	0,8%	12,5%	3,8%	4,9%	2,7%	3,6%	7,6%	4,1%	1,0%	1,6%	1,6%
Car / taxi	46,6%	39,4%	55,2%	34,7%	37,5%	44,6%	46,0%	62,5%	34,6%	27,8%	37,2%	36,3%	22,1%	43,8%	41,8%	39,9%	39,9%

* Data from 2004
** Data from 2003
*** Data from 2002

Source: CARE Database / EC
Date of query: December 2007

Figure 60: Distribution of fatalities at junctions by mode of transport in the EU-16 (Source: Traffic Safety Basic Facts 2007, SafetyNet)

If these results are interesting for an overall view, they are also to put on perspective according to the use of certain mode of transport. Example, in Netherlands or in Finland, we know that the number of trip by bicycle is higher than in the other European countries.

Unfortunately, we don't know any exposure data for pedal cyclists.

Most of the results showed in this report are based on injury accident with at least one passenger car.

But, we will try to give some information about pedestrians accidents in particularly in intersection.

In EU27, the pedestrian fatalities in intersection represent between 14% to 35% of the overall pedestrian fatalities. The only exception is for UK with a rate of 45% but this result is the consequence of a different definition about what an injury accident in intersection is. UK included, the EU27 average rate is about 22%.

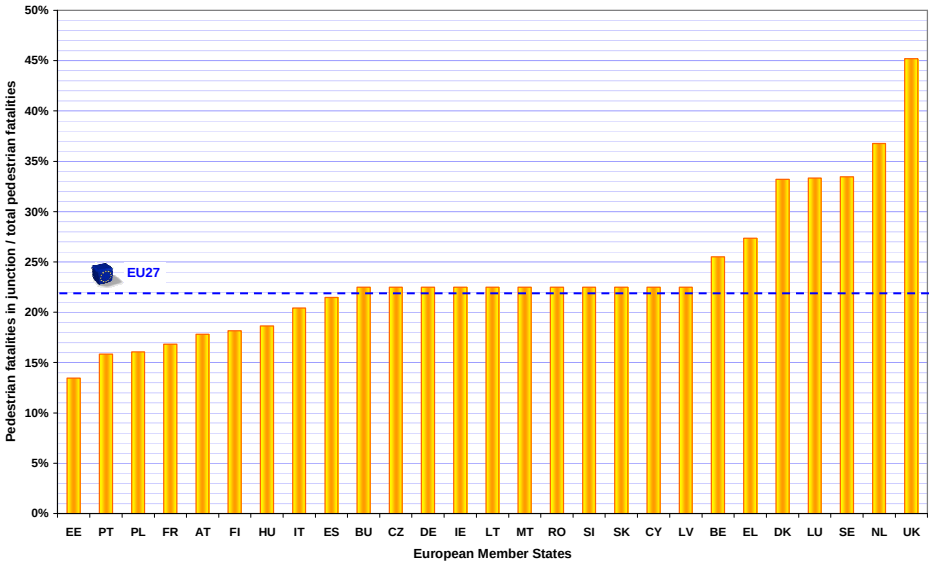


Figure 61: Distribution of pedestrian fatalities in intersection compared to the pedestrian fatalities in EU27 (Year 2004, Sources: CARE, IRF, IRTAD, National Statistics Databanks)

If we now compare the proportion of pedestrian fatalities in the overall fatalities in intersection accidents, we can see that this rate varies between 9% (Italy) to 44% (Romania). The EU27 average rate is around 21%.

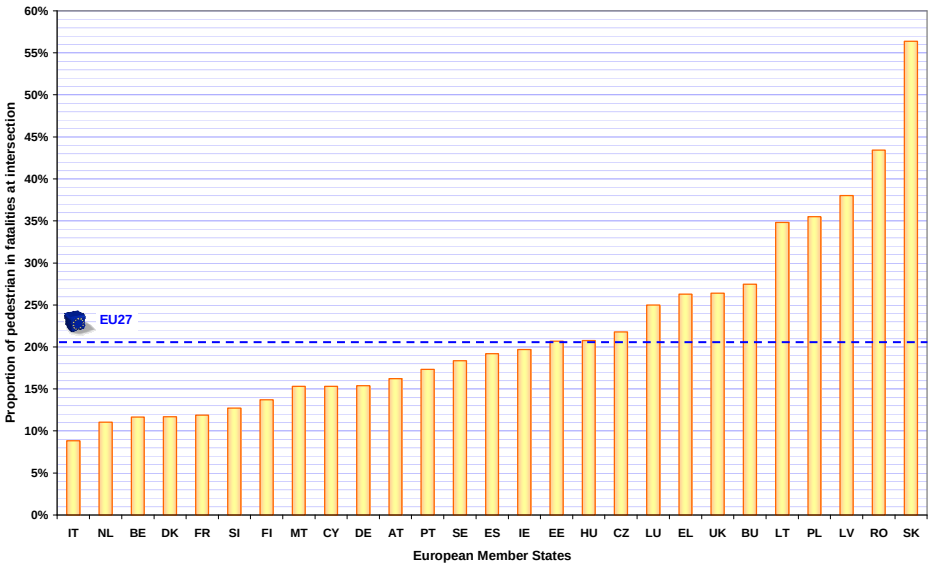


Figure 62: Distribution of the Pedestrian fatalities in intersection in EU27 (Year 2004, Sources: CARE, IRF, IRTAD, National Statistics Databanks)

If we try to apply the same definition of what is an injury accident in intersection, the rate of the pedestrian fatalities is then of 15% in UK.
KSI (Killed or Serious Injured compared with all casualties) of pedestrian accidents in the sample is ranged between 10% and 25%.
In GB for example, 15% of intersection accidents involved pedestrians and account for 25% of the whole KSI at intersection.

8.4.2 Location

In this part, we will try to characterize the injury accidents in intersection regarding the location such as urban/rural, type of intersection or type of regulation. We will focus only on injury accidents with at least one passenger car. We will distinguish accident with and without pedestrians.

8.4.2.a Area Type

In spite of the missing data on some countries (data which were estimated by a simple linear regression), the mortality of the accidents in intersection is widely more important in rural areas than in urban area. This can explain partially by the simple fact that the practised speeds are much more important outside urban area and thus the more violent accidents.

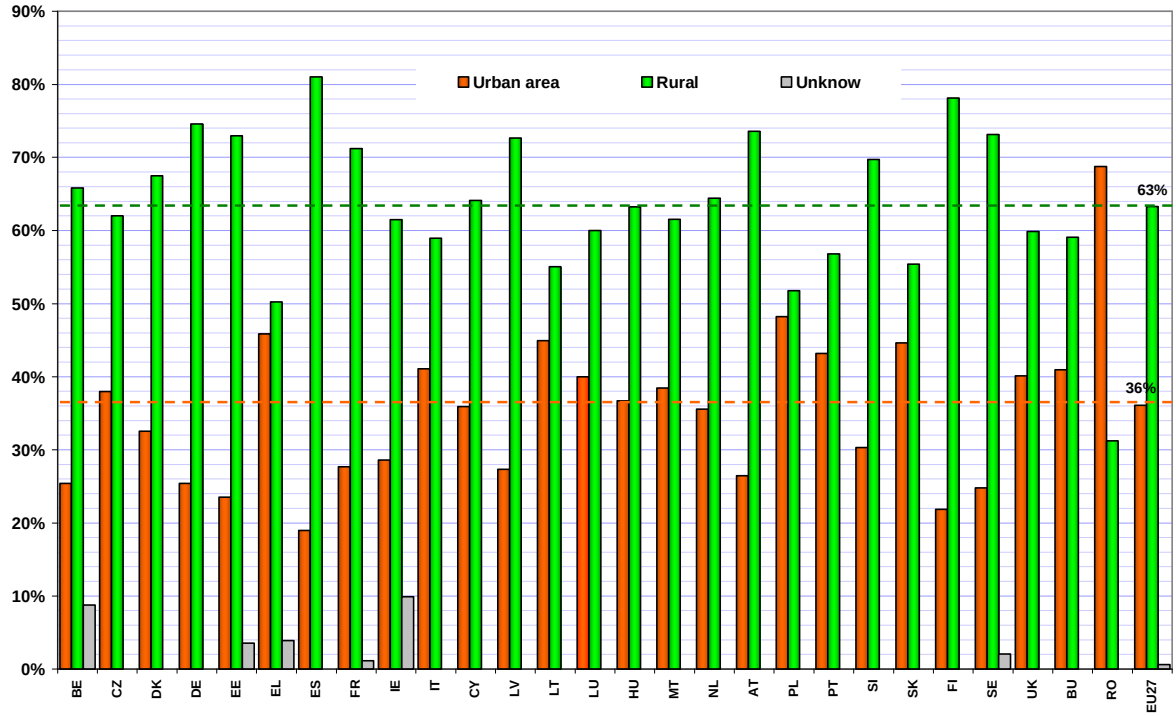


Figure 63: Distribution of the fatalities of accidents in intersection following the location (urban/rural) for the EU27 (Year 2004, Sources: CARE, IRF, IRTAD, National Statistics Databanks)

Unfortunately, we don't have any information about the distribution of the victims in injury accident in intersection following the location.

But, if we base our analysis on Spain, France, UK and Hungary, we can see that more than 90% of pedestrian injury accidents in intersection () and around 65% of injury accidents without pedestrian in intersection () occur in urban area. So that we can consider that for the accidents in intersection the mortality is especially situated in rural area and the morbidity rather in urban area.

In the following figure, we tried to estimate the relative risk to be killed in an injury accident in intersection regarding the location. The basic rates both for rural and urban area are taken at EU27 level. For each country, the risk is estimated by dividing the number of fatalities in intersection accidents in and outside urban area by the total number of injury accidents in intersection.

Example: the risk to be killed in an injury accident in intersection in urban area (in red) in Bulgaria (BU) is (close to) 4 times higher than the EU27 one.

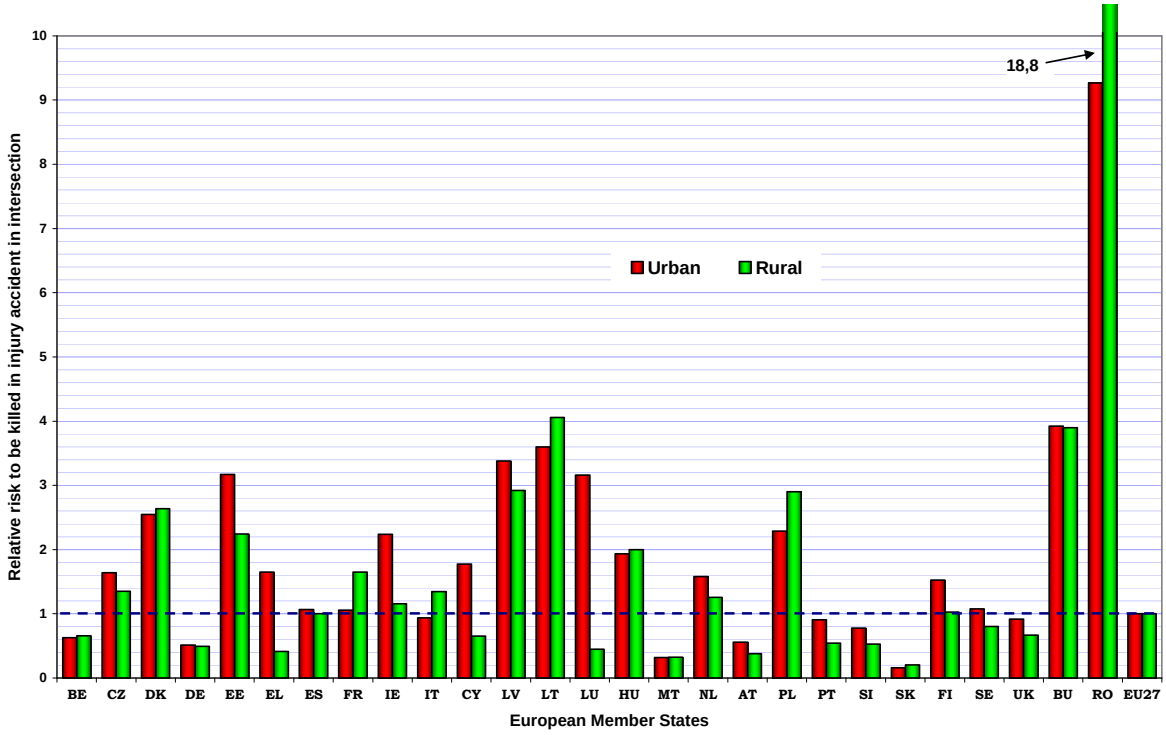


Figure 64: Estimation of the relative risk to be killed in intersection accidents following the location (Year 2004, Sources: CARE, IRF, IRTAD, National Statistics Databanks)

In the previous figure, we can see that the countries outside EU15 have the higher the risk to be killed in an injury accident in intersection (in rural and/or in urban area). It is particularly true for the two newer, Bulgaria and Romania.

Accidents with pedestrians

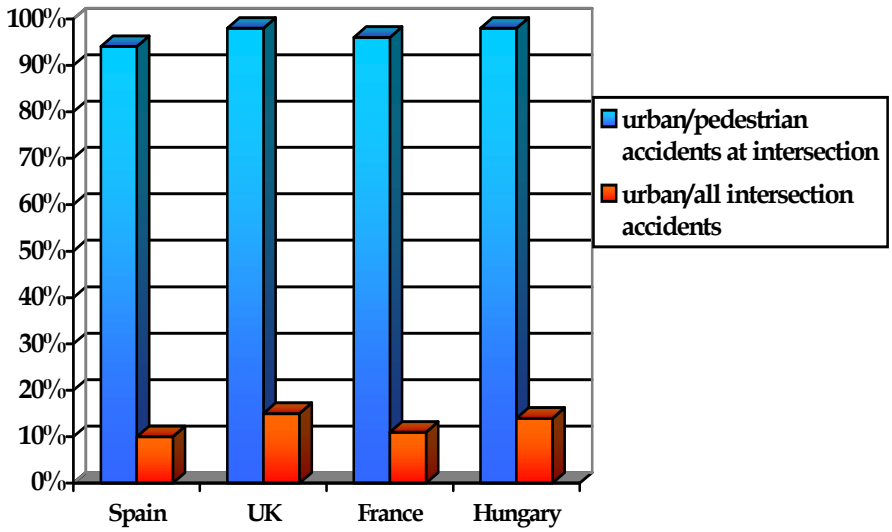


Figure 65 : Distribution of injury accidents with pedestrian following the location, year 2004 (Source: TRACE survey 2006-2007)

Whereas pedestrians are involved, 88% to 98% (Hungary) of pedestrian accidents occurred inside urban area which represents 8% to 15% (Great Britain) of intersection accidents.

Urban/rural accidents for all vehicles

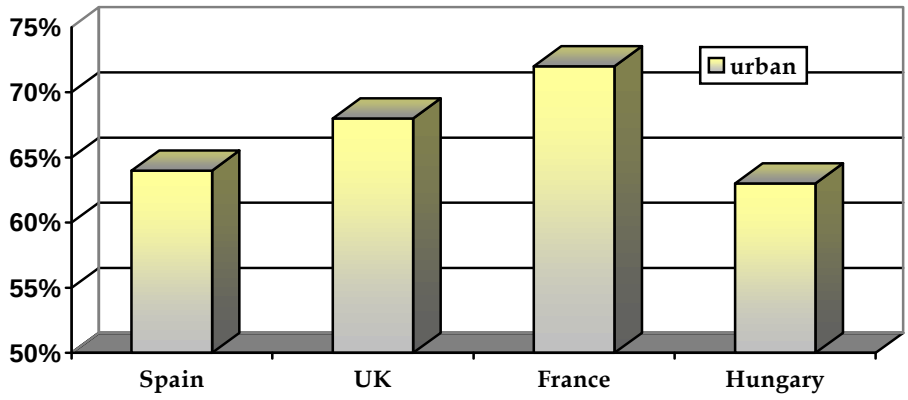


Figure 66: Distribution of injury accidents in intersection without pedestrian in urban area, year 2004 (Source: TRACE survey 2006-2007)

74% to 83% of intersection accidents occurred inside urban area (with or without pedestrians). Whereas no pedestrian is involved, 64 to 73% of intersection accidents occurred inside urban area

Urban/rural accidents with at least one passenger car

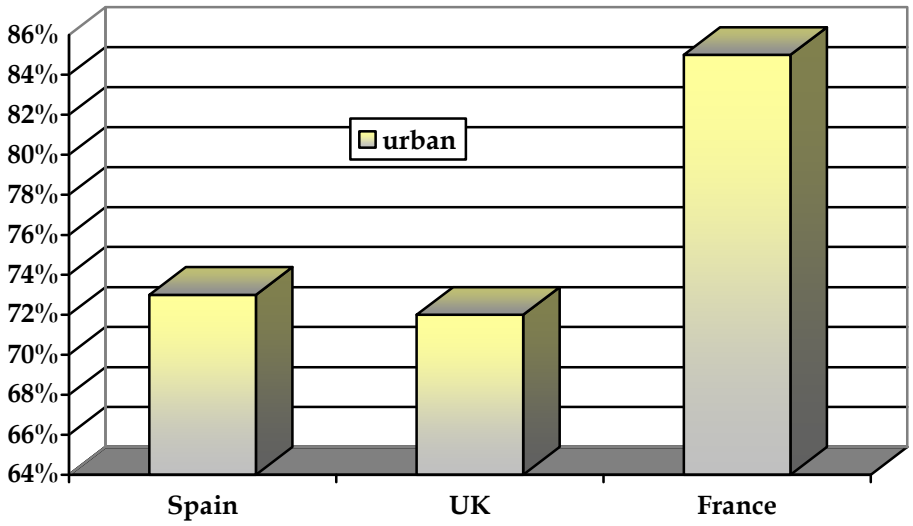


Figure 67: Distribution of injury accidents in intersection with at least one passenger car in urban area, year 2004 (Source: TRACE survey 2006-2007)

Whereas no pedestrian is involved, 73 to 85 % of intersection accidents (at least one car) occurred in urban area.

8.4.2.b Type of intersection

Accidents with pedestrians

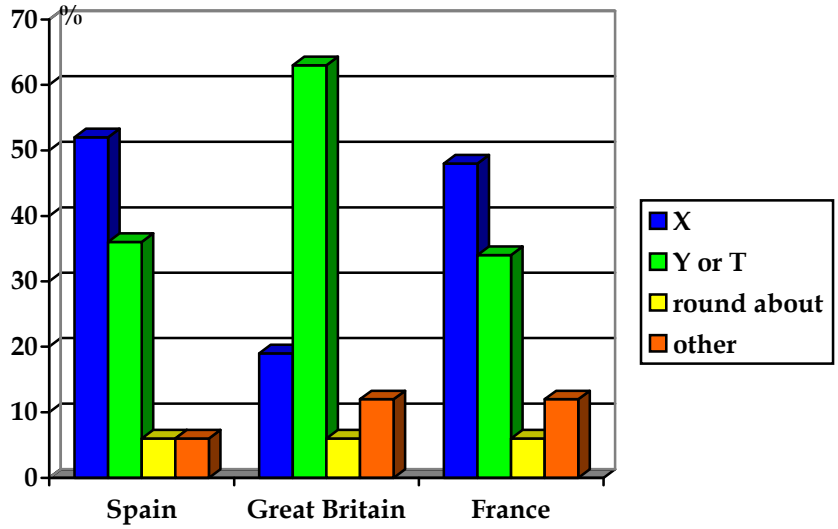


Figure 68: Intersection accidents with pedestrian. Type of intersection 2004 (Source: TRACE survey 2006-2007)

Whereas pedestrians are involved, 19% to 52 % (Spain) of pedestrian accidents at intersection occurred at X intersection, 34% to 63% (GB) at T or Y intersection.

Intersection type for all vehicles

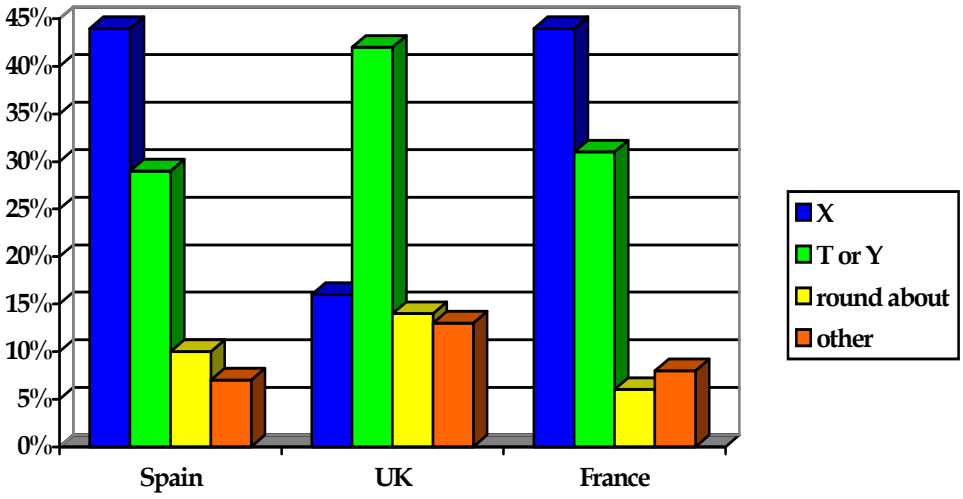


Figure 69: Intersection accidents without pedestrian. Intersection type 2004 (Source: TRACE survey 2006-2007)

Whereas no pedestrian is involved, 16 to 44% of intersection accidents occurred at X intersection. 29% to 44% occurred at T or Y intersection.

Intersection type with at least one passenger car

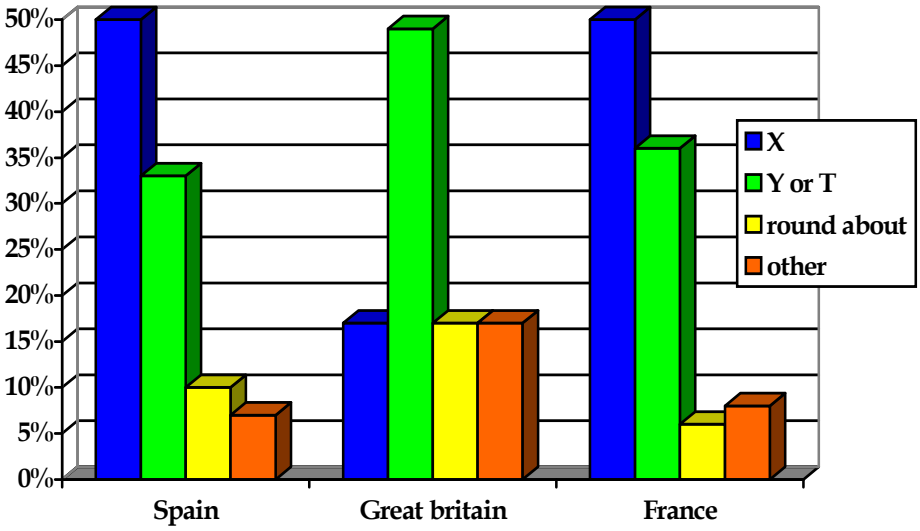


Figure 70: Intersection type in accidents with at least one passenger car 2004 (Source: TRACE survey 2006-2007)

Whereas no pedestrian is involved, 17 (GB) to 50 % (France) of intersection accidents (at least one car) occurred at X intersection, 33 to 49 % at T or Y intersection. Great Britain shows a different trend. More Y or T intersection crashes occurred in GB than anywhere else.

8.4.2.c Type of regulation

Even though some of intersections are traffic control-free (right of way mode), most of them are found with traffic control such as the following ones, which enables the management and the fluidity of the traffic:



Signalized intersection: traffic control with traffic lights



Signalized intersection: traffic control with *stop* sign or *give way* sign

Accidents with pedestrians

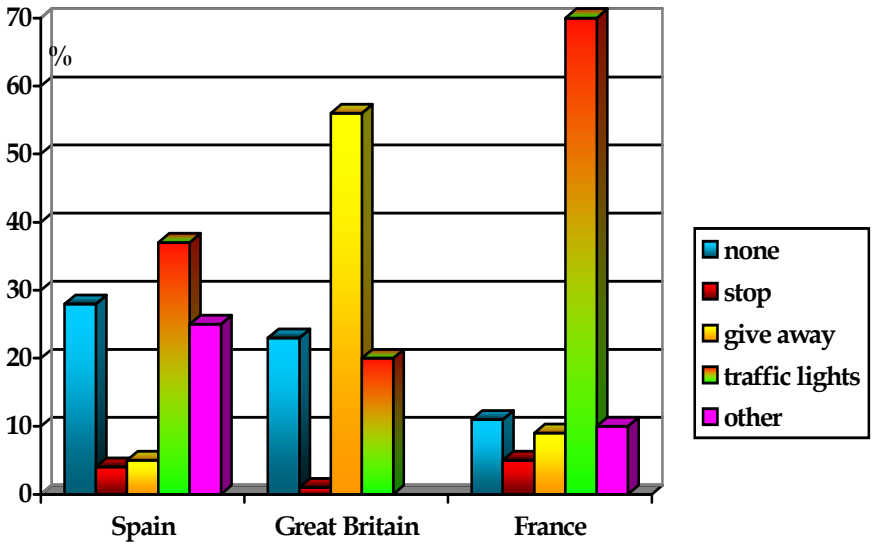


Figure 71: Intersection crashes with pedestrians following the type of regulation in intersection, year 2004 (Source: TRACE survey 2006-2007)

Whereas pedestrians are involved, 46% to 79% of pedestrian accidents at intersection occurred at intersection with regulation.

France shows a bigger rate of pedestrian accidents at intersection with traffic lights than anywhere else whereas Australia shows a big rate of pedestrian accidents where no regulation is fitted.

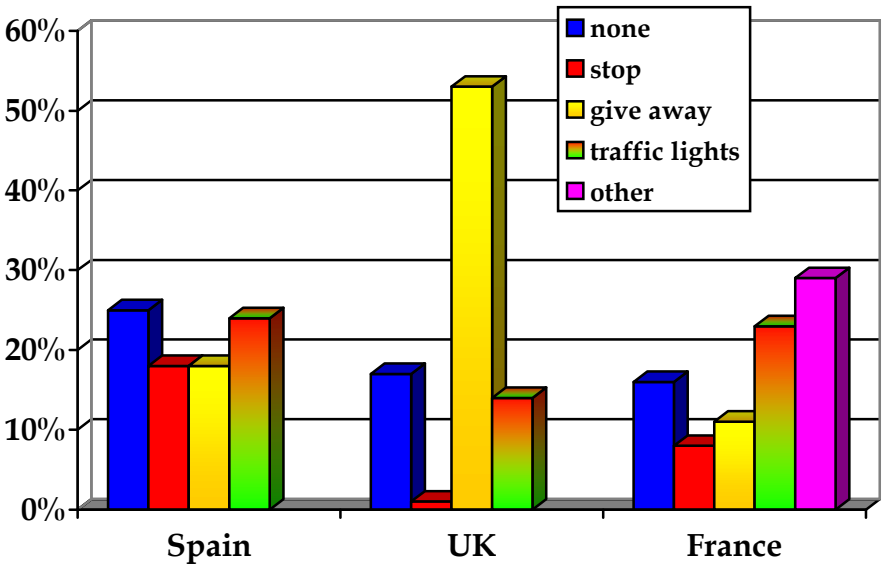


Figure 72: intersection regulation 2004 (Source: TRACE survey 2006-2007)

Whereas no pedestrian is involved, 45 to 68% of intersection accidents occurred at intersection with regulation.

8.4.3 Conditions

8.4.3.a What were the lighting and visibility conditions?

Accident involving all vehicles

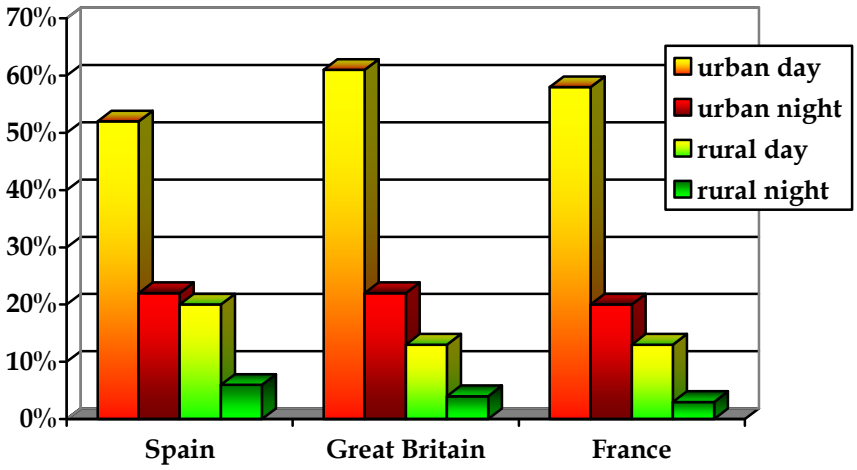


Figure 73: Intersection crashes day/night 2004 (Source: TRACE survey 2006-2007)

62 to 75% of intersection accidents occurred in the daylight, 52 to 61% inside urban area and 13 to 20% outside.

Accidents involving at least one car

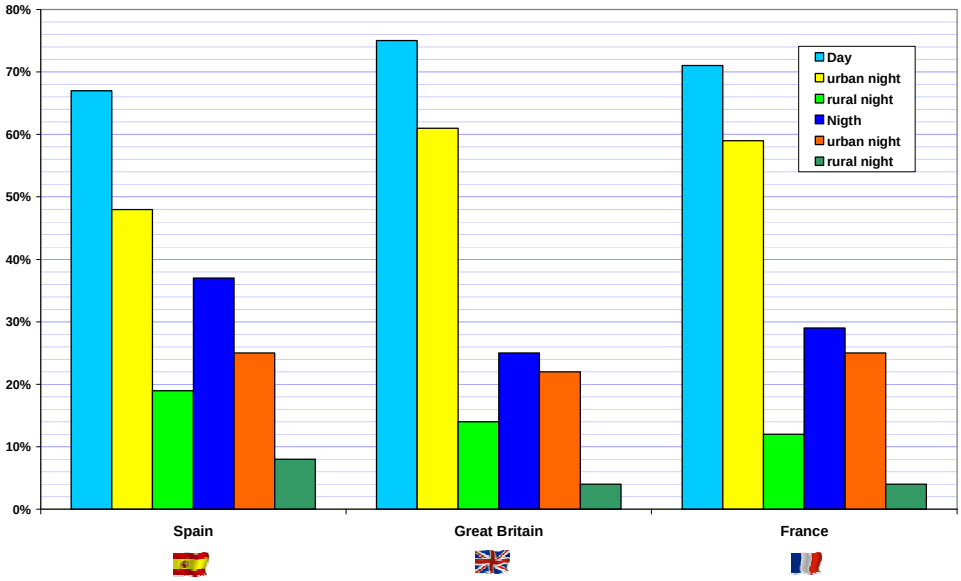


Figure 74: Intersection crashes day/night with at least one passenger car 2004 (Source: TRACE survey 2006-2007)

67% to 75% of intersection accidents (at least one car) occurred in the daylight, 25% to 33% during the night. No differences between all vehicles implication and car implication/ light conditions.

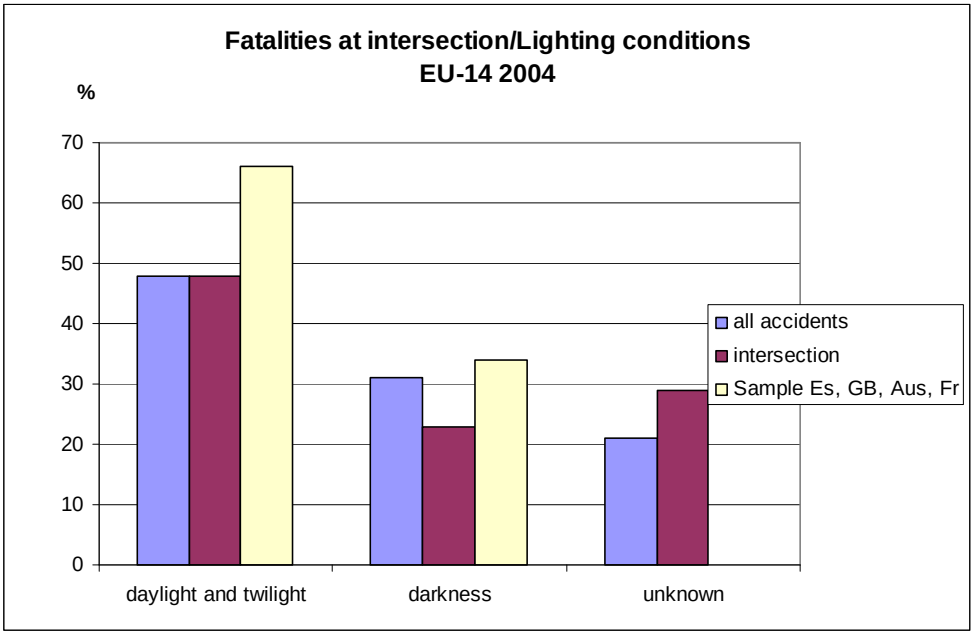


Figure 75: Fatalities at intersection – lighting conditions
(Source: CARE 2004, TRACE survey 2006-2007)

In Europe-14, 23% of fatalities at intersection accidents occurred when it was dark (34% in our sample), 31% of all injury accidents. Lighting conditions seem to not affect intersection accident fatalities in a different way than the overall accident fatalities.

8.4.3.b What was the weather like?

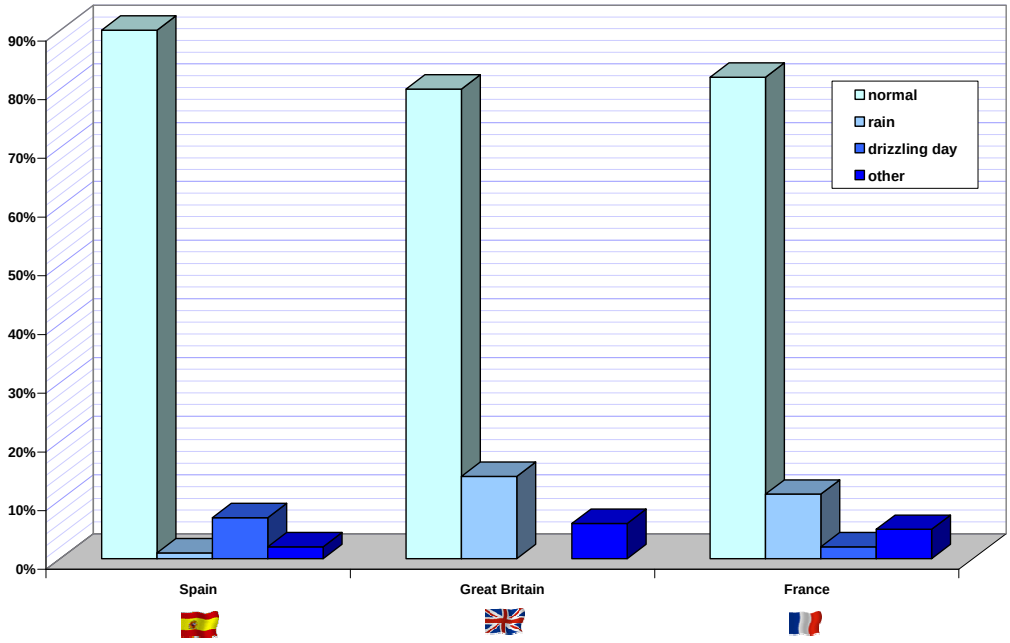


Figure 76: Intersection crashes – weather conditions 2004 (Source: TRACE survey 2006-2007)

82% to 90 % of all intersection accidents occurred while the weather condition was normal.

8.4.3.c What were the road surface conditions?

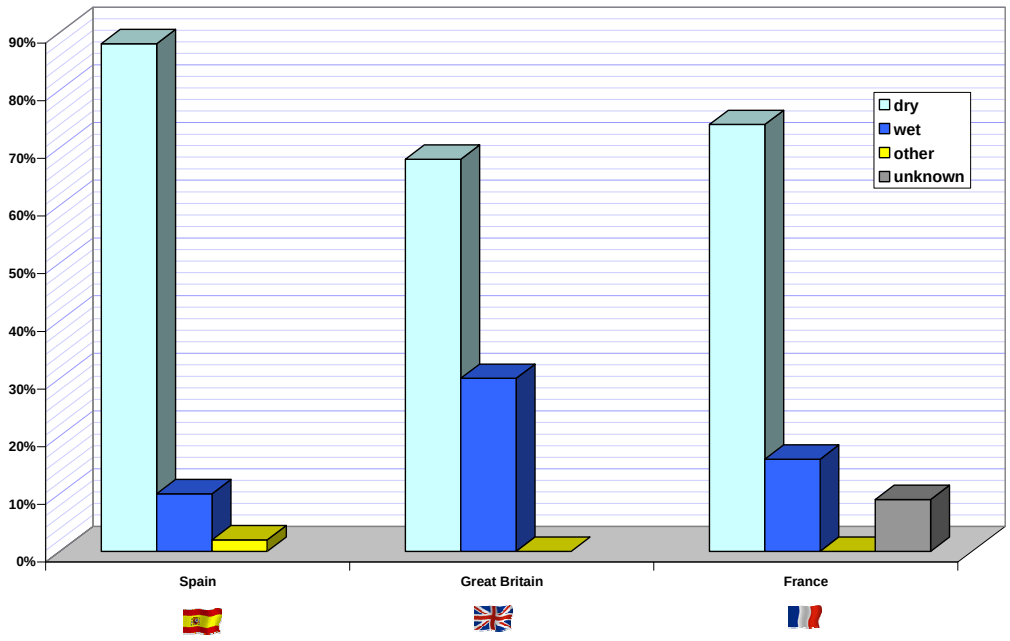


Figure 77: Intersection crashes – road surface 2004 (Source: TRACE survey 2006-2007)

68 to 88 % of all intersection accidents occurred while the road surface was dry.

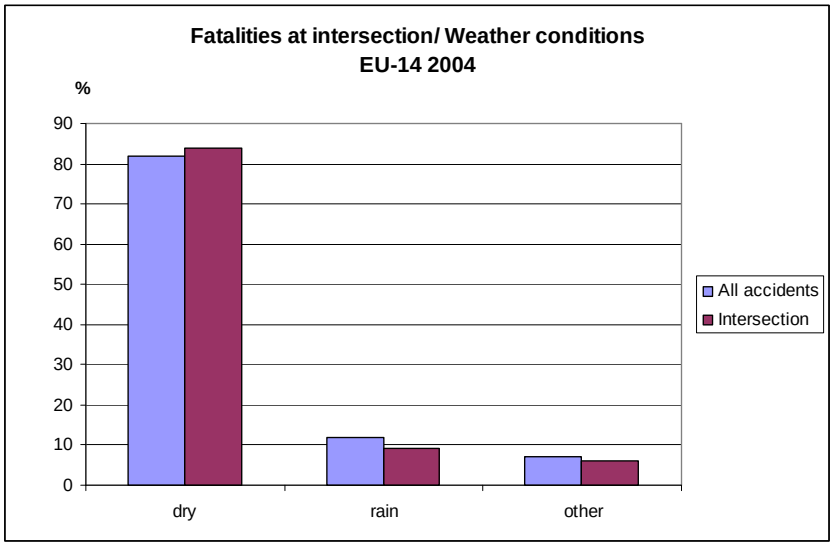


Figure 78: fatalities at intersection – weather conditions (Source CARE 2004)

Weather conditions do not affect intersection accident fatalities in a different way than the overall accident fatalities.

8.4.4 Who is involved in accident at intersection?

8.4.4.a Accident type

Accidents for all vehicles

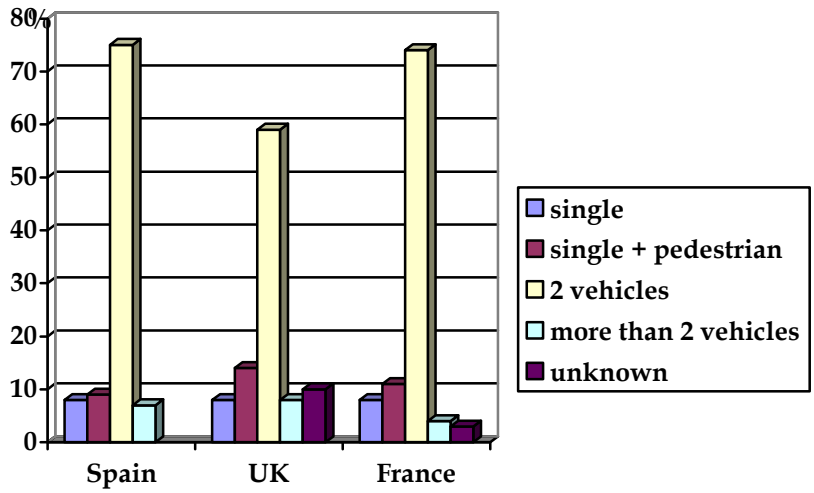


Figure 79: Intersection crashes – accident type 2004 (Source: TRACE survey 2006-2007)

67% to 82 % of all intersection accidents involved 2 vehicles or more. 9 to 14 % involved at least one pedestrian.

Accidents with at least one passenger car

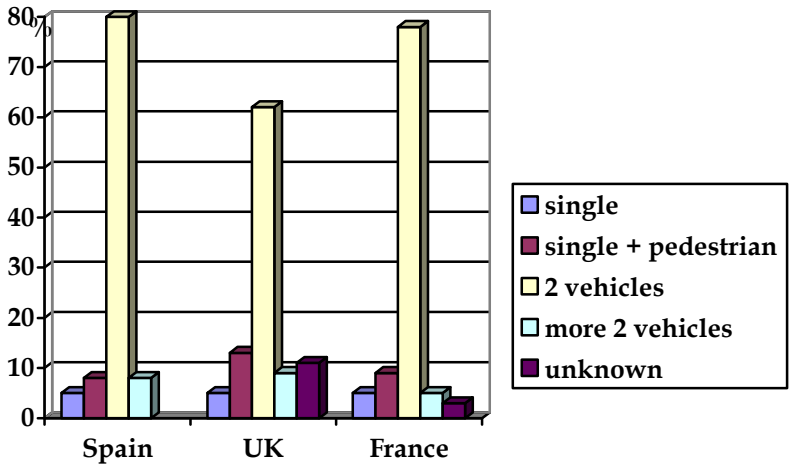


Figure 80: intersection crashes with at least one passenger car – accident type 2004 (Source: TRACE survey 2006-2007)

71% to 88 % of intersection accidents involving at least one car involved 2 vehicles or more. 9 to 13 % involved at least one pedestrian

8.4.4.b Road Users

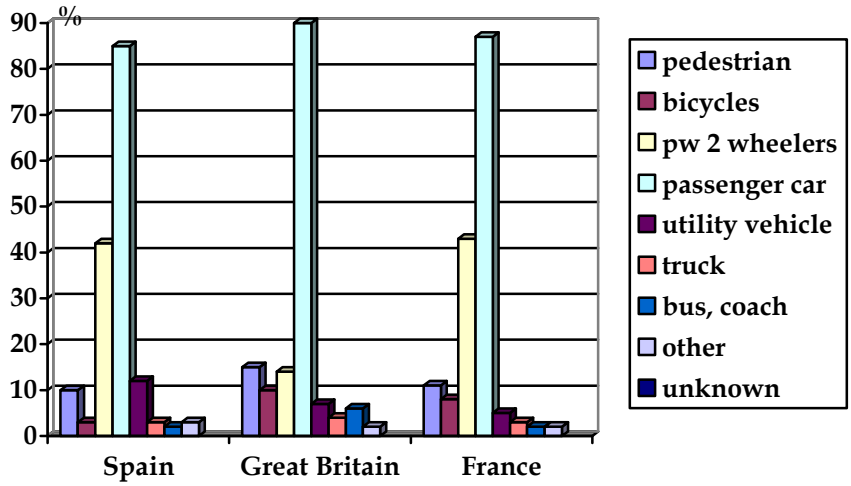


Figure 81: intersection crashes – users 2004(Source: TRACE survey 2006-2007)

85 to 90% intersection accidents involved passenger cars. The accidents involving pw 2 wheelers are second in number especially in Spain and France.

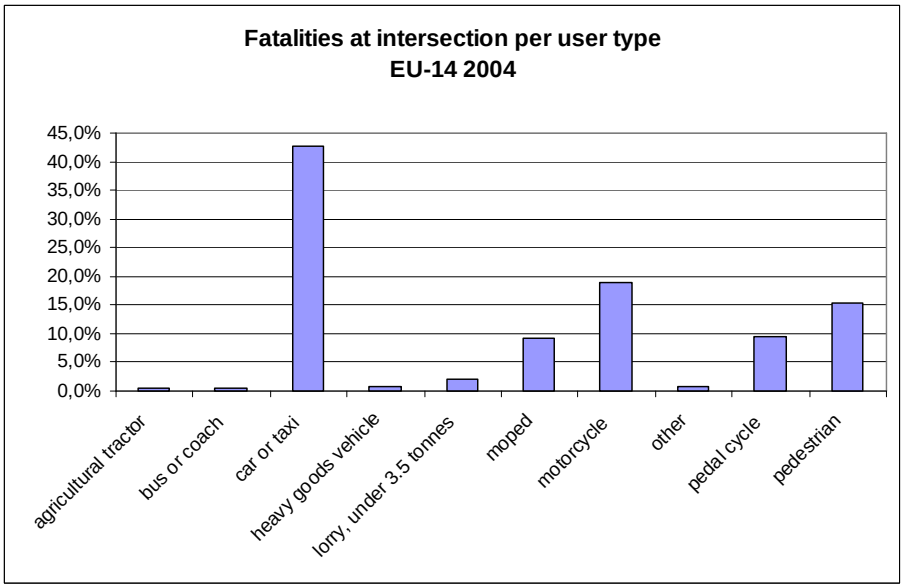


Figure 82: Fatalities at intersection according to the road user (Source CARE 2004)

In 14 European countries, in 2004, the user who showed the biggest rate of fatalities was the passenger car (and taxi) followed by the 2-wheelers and the pedestrians.
If we look at the details, in the Netherlands more than half of the overall fatalities at junctions are 2-wheelers, a higher proportion than any of the other countries.

8.4.4.c The collision type

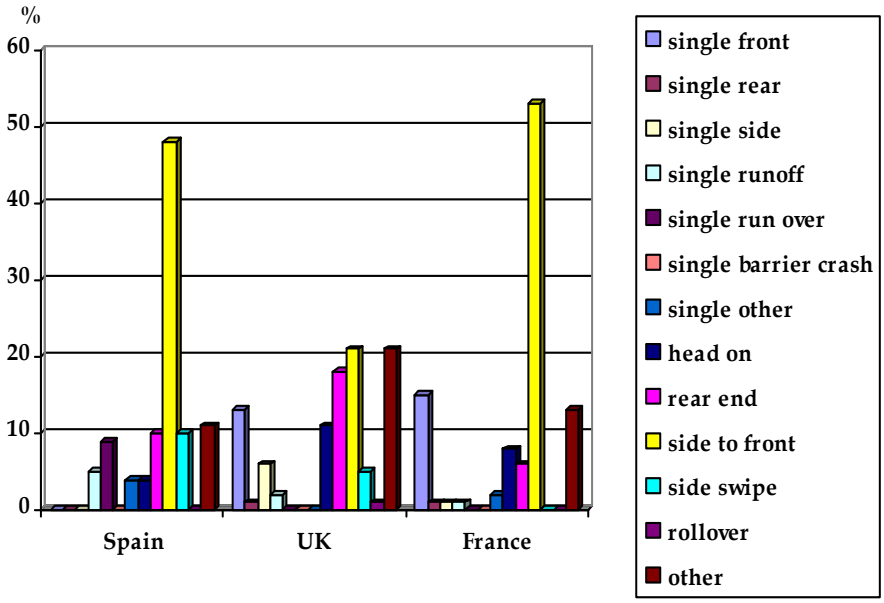


Figure 83: intersection crashes – collision type 2004 (Source: TRACE survey 2006-2007)

21% to 53 % of all intersection accidents were side to front collisions. In GB rear end collisions are overrepresented compared

8.4.5 The Driver

In Europe-14 in 2004, the distributions of car driver fatalities over the age groups vary between countries. Luxembourg has a high proportion of 25-49 year old car driver fatalities. Sweden and Finland have a high proportion of 60 years and older. Low proportion is found in Luxembourg for 65+ drivers. Low proportion is found in Luxembourg for 15-24 old drivers and in Finland and Sweden in the age group 25-39.
In Europe-25 and for all type of users, the percentage of fatalities by age group shows the same trend.

8.4.5.a Age

Accidents involving all vehicles

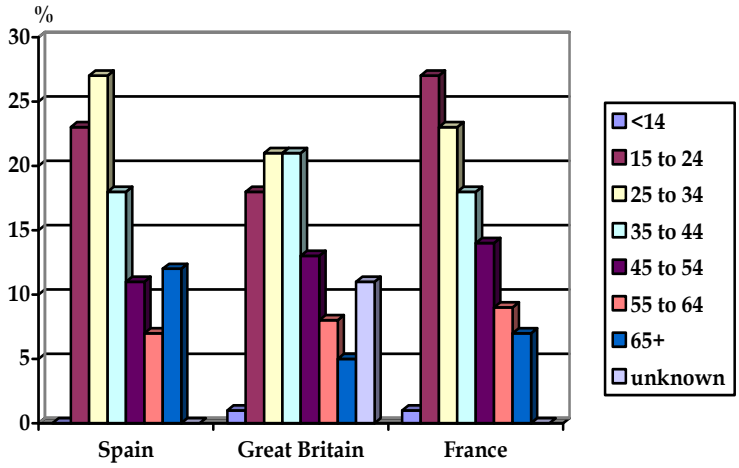


Figure 84: intersection crashes – driver age 2004 (Source: TRACE survey 2006-2007)

Accidents with at least one passenger car.

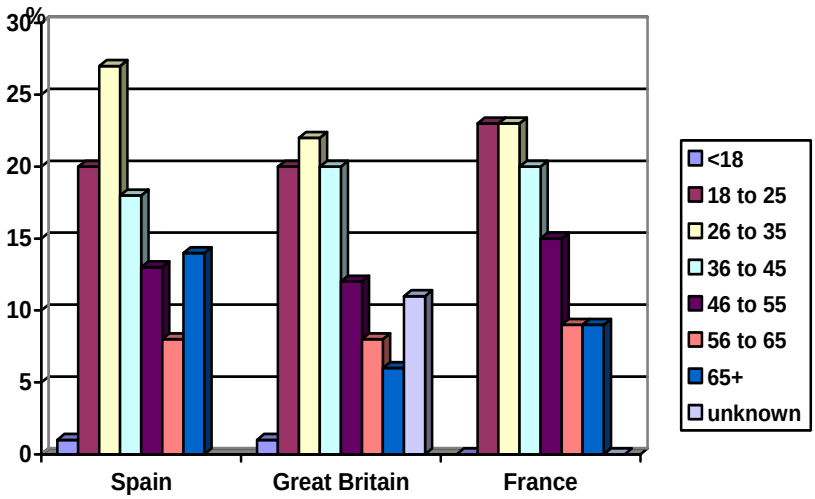


Figure 85: Intersection crashes with at least one passenger car – driver age 2004 (Source: TRACE survey 2006-2007)

21% to 27 % of drivers involved in intersection accidents involving at least one car are less than 25 years old. 6% to 14 % of drivers are 65+.

8.4.5.b Driver's experience

In the following figure, only accidents with at least one passenger car are considered.

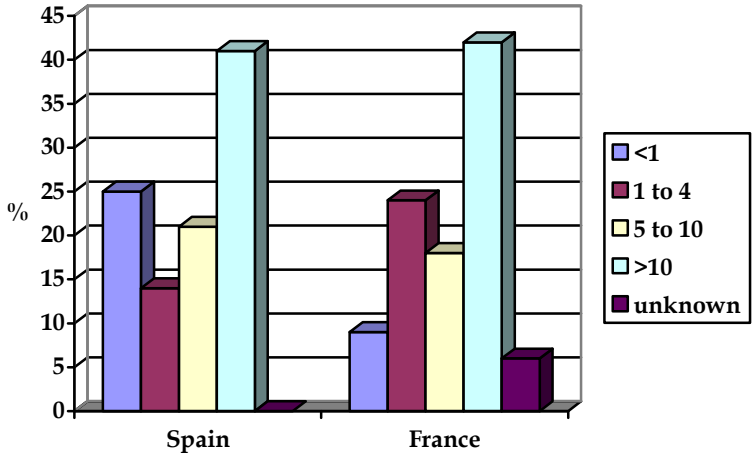


Figure 86: intersection crashes – driver experience 2004 (Source: TRACE survey 2006-2007)

9% to 25 % of drivers involved in intersection accidents involving at least one car are novice (< 1 year experience). 60% to 62 % of drivers are skilled drivers (>5 years experience).

8.4.5.c Driver gender

In the following figure, only accidents with at least one passenger car are considered.

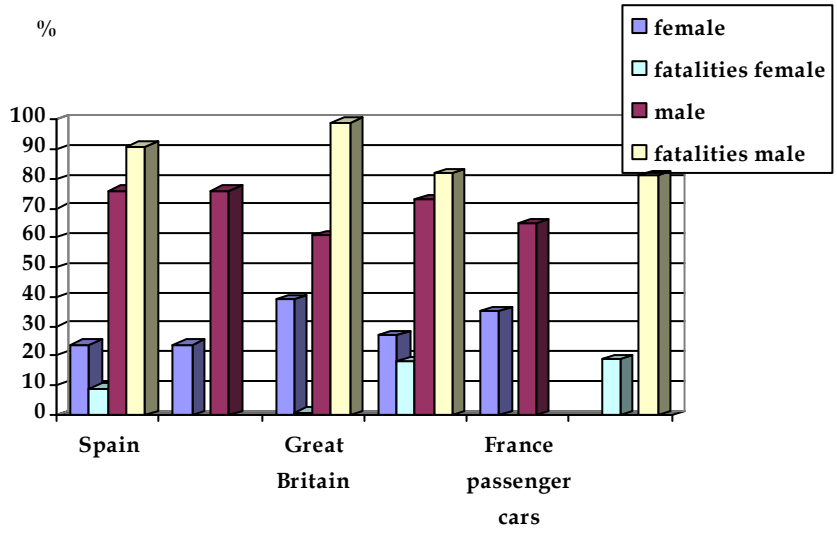


Figure 87: Intersection crashes – driver gender 2004 (Source: Safetynet 2004, TRACE survey 2006-2007)

59% to 76% of drivers involved in intersection accidents are male, 65 to 76% of drivers who are involved in intersection accidents with at least one car are male.

In France 74 % of drivers involved in injured accidents are male while they represent 65% of drivers involved in intersection accidents with at least one car. The involvement of male drivers is low than the female involvement at intersection. Whereas in Spain, the involvement of mal drivers injured is the same in the whole database as in intersection crashes sample.

In Europe-14, when comparing the fatality rates of men and women during the last ten years, the fatality rate of women was consistently around a third of that of men. The proportion of all killed drivers who were female varies between 9 (Greece) to 23% (France, Finland and United Kingdom).

We can also remark that the driver male fatality rates show a higher difference. Accident with male drivers seems to be more severe in our sample.

8.4.5.d Description of the driving phase

59% to 67 % of all intersection situations occurred while the driving phase was normal (no manoeuvre). 9% to 18 % drivers turned left (right for UK).

% situations 2004	Sp	UK	Fr
normal	39	64	56
crossing the road	28		3
overtaking	3	4	2
turning left (right for UK)	9	18	17
coming from as lip road	5	3	0
turning right (left for UK)	5	6	5
other	11	5	17

Table 22: description of the driving phase (Source: TRACE survey 2006-2007)

8.4.5.e Principal manoeuvre

In the following table, only accidents with at least one passenger car are considered.

51% to 64 % of intersection situations involving at least one car occurred while the driving phase was normal (no manoeuvre). 11% to 24 % drivers turned left (right for UK), is the second in number.

% situations 2004	Sp	UK	Fr
normal driving	36	60	51
overtaking	1	2	1
u-turn	1	1	1
crossing	28	0	4
parking	0	1	2
reversing	1	1	0
from slip road	6	2	0
turning left (right for UK)	11	24	24
turning right (left for UK)	6	7	5
other	10	2	8
unknown	0	0	4

Table 23: pre accidental manoeuvre at intersection with at least one passenger car (Source: TRACE survey 2006-2007)

8.4.6 Intersection scenarios

From the analysis, the accidents in intersection have been divided into 6 main scenarios.

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

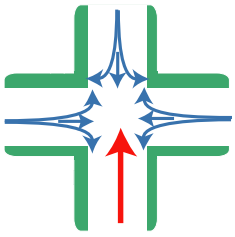


Figure 88: Pictogram related to the accident configurations cover by scenario 1

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

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

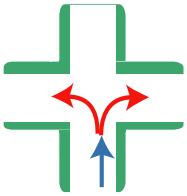


Figure 89: Pictogram related to the accident configurations cover by scenario 2

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

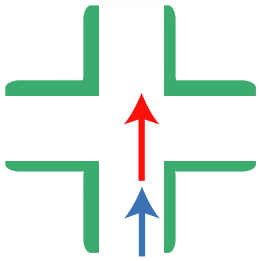


Figure 90: Pictogram related to the accident configurations cover by scenario 3

Scenario 4: **"Incoming" scenarios (except pedestrian)**

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

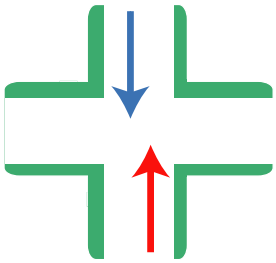


Figure 91: Pictogram related to the accident configurations cover by scenario 4

Scenario 5: **Roundabout**

Characteristics: concern all injury accident happening in roundabout.

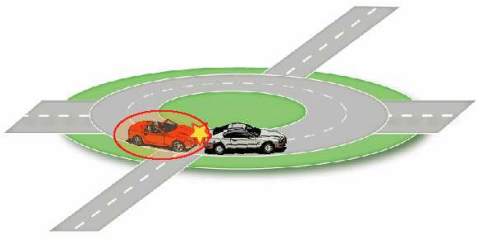


Figure 92: Pictogram related to the accident configurations cover by scenario 4

Scenario 6: **Others**

Characteristics: gather all injury accidents that not interested by the other scenarios.

Comparison

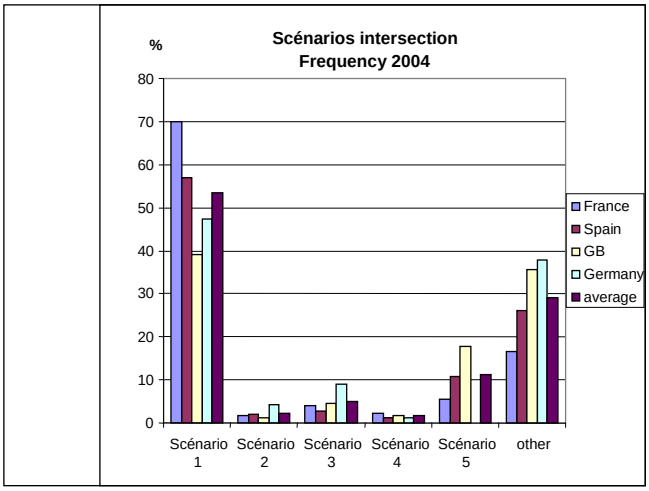


Figure 93: Intersection scenarios (Source: TRACE survey 2006-2007)

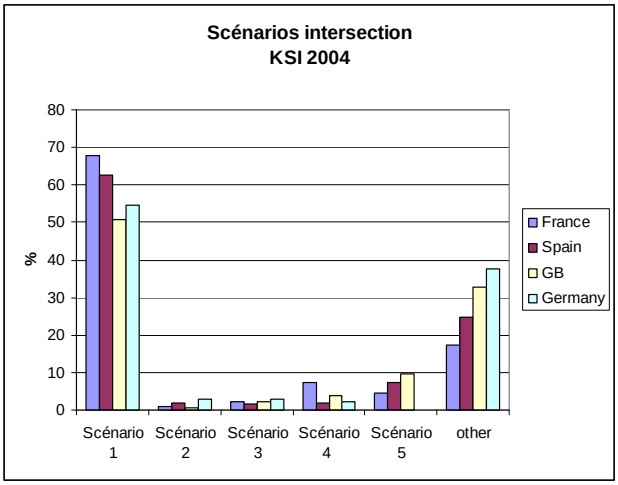


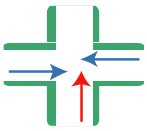
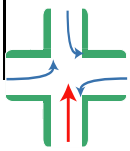
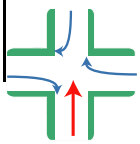
Figure 94: intersection scenario severity (Source: TRACE survey 2006-2007)

Frequency and KSI graphs show the same trend. Scenario 1 (one driver turns left or right or crosses the roads while the opponent comes from left or right) is predominant according to the frequency and the severity of the crashes followed by the category "other" (consequence of the differences between database details) then by the scenario 5 "round about crashes" and at last the scenario 3 is more frequent than the scenario 4 but seems to be less severe according to the KSI criteria.

France and Spain show a higher frequency than the average frequency of this scenario.



So, the scenario 1 where vehicles crossed the roads and the trajectory of the opponent vehicle (while the drivers turned left or right or not) is more frequent and more severe than anyone else.

All intersection except "rear end" and pedestrian crash scenarios					
"cutting" scenarios : the oncoming vehicle comes from the left or the right		turn scenarios LTIP (Left turn into path) LTAP (Left turn across path) and RTIP (Right turn into path) RTAP (Right turn across path)			
Scenario 1.1		**Scenario 1.2**		**Scenario 1.3**	
	Crossing paths, No manoeuvres, The OV vehicle comes from left or right		Crossing path or oncoming vehicle with one driver turns left (right in GB)		Crossing path or oncoming vehicle, with one driver turns right (left in GB)

Details are usually known in the different databases related to the scenario 1 for 3 of 4 countries. No information at this level is available in German database.

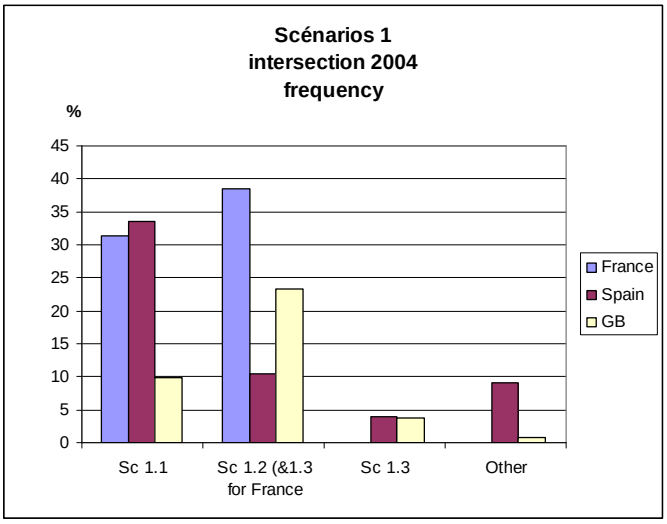
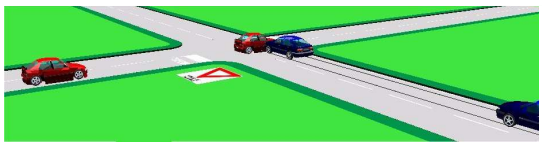


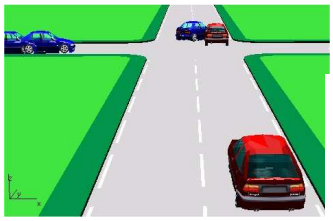
Figure 95: intersection sub-scenarios 1 frequency (Source: TRACE survey 2006-2007)

In Great Britain, scenario 1.2 (crossing path or coming vehicle with one driver turns right equivalent of our turning left) is prevalent whereas in France and Spain it is rather the scenario 1.1 (straight crossing path). The scenarios 2 and 3 are gathered in France. It is not possible to distinguish the vehicle driver who turned left from the driver who turned right.

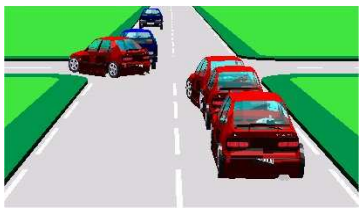
Nevertheless, we can say that within the scenario 1, the scenarios 1.1 and 1.2 are predominant.



Scenario 1.1



Scenario 1.2



Scenario 1.2

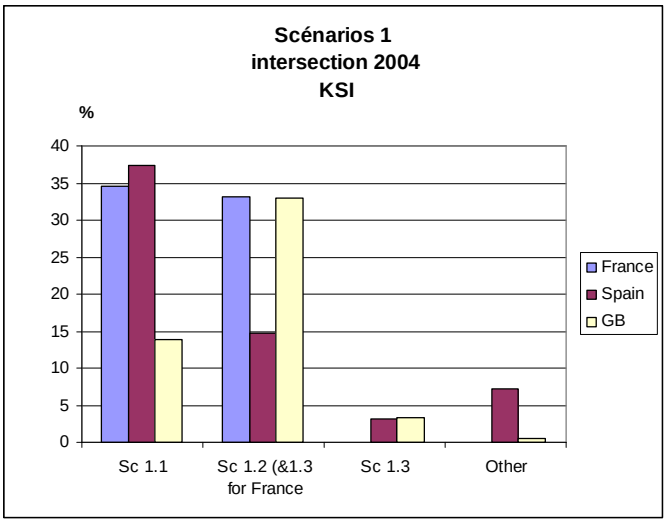
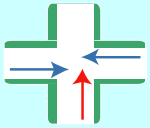
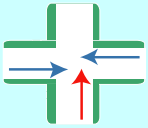
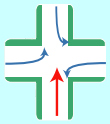
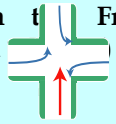
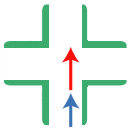
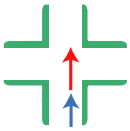
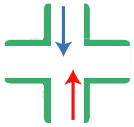
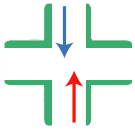
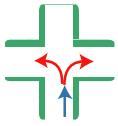


Figure 96: intersection sub-scenarios 1 severity (Source: TRACE survey 2006-2007)

According to the severity of the scenario, France and Spain show an equivalent severity related to the scenario 1.1 whereas in Great Britain the scenario 1.2 (turned right in GB, left in the other countries) is more severe. In France, whatever the driver is performing, turning left or right (scenario 1.2 & 1.3) the crashes are as severe as scenarios 1.1.

This information leads us to think that the severity of the intersection crashes should be closely linked to the collision type, the vehicle velocities, the seat belt wearing and of course to the vehicle equipment such as lateral airbag. We will investigate this hypothesis through the in-depth analysis.

According to the previous graphs, we are able to classify the intersection scenarios as following:

Scenarios	According to the frequency/all intersection accidents 2004	Scenarios	According to the severity (KSI) % all fatalities at intersection
Scenario 1 	53	**Scenario 1** 	59
Scenario 1.1 	25	**Scenario 1.1** 	29
Scenario 1.2 	24 (overestimated with the France data 1.2 + 1.3)	**Scenario 1.2** **(overestimated with t France data** 	27
other	4	**other**	3
Scenario 5 	11	**Scenario 5** 	7
Scenario 3 	5	**Scenario 4** 	4
Scenario 4 	2	**Scenario 3** 	2
Scenario 2 	2	**Scenario 2** 	2
Scenario other	29		

8.4.7 Summary of the descriptive analysis

8.4.7.a General overview

27% to 59 % of injury accidents occurred at intersection.

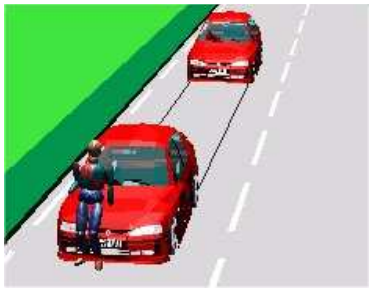


In Great Britain, in 2004, the junction accidents represented more than a half of overall accidents whereas in France one third of overall accidents were concerned.

31% of intersection accidents are "cutting accidents".

8.4.7.b Pedestrian accidents

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



Whereas pedestrians are involved, 88% to 96% of pedestrian accidents occurred inside urban area.

Whereas pedestrians are involved, 8% to 15% of intersection accidents occurred inside urban area.

Whereas pedestrians are involved, 2% to 5% of intersection accidents occurred at X intersection, 3% to 9% at T or Y intersection.

Whereas pedestrians are involved, 5% to 8% of intersection accidents occurred at intersection with regulation.

Whereas pedestrians are involved, 52% to 77 % of pedestrian accidents occurred at intersection with regulation.

12% to 41 % of pedestrians are 65+. Pedestrians 65+ are overrepresented in Spain and to a lesser extent in France.

8.4.7.c Accident without pedestrians

Whereas no pedestrian is involved, 64% to 73% of intersection accidents occurred inside urban area

Whereas no pedestrian is involved, 73% to 85% of intersection accidents with at least one car occurred in urban area.

Whereas no pedestrian is involved, 40% to 44% of intersection accidents occurred at X intersection. 29% to 44% at T or Y intersection

Whereas no pedestrian is involved, 17% (GB) to 50 % of intersection accidents (at least one car) occurred at X intersection, 33 to 49 % at T or Y intersection

Whereas no pedestrian is involved, 45% to 68% of intersection accidents occurred at intersection with regulation

8.4.7.d Characteristics of intersection accidents for all vehicles

74% to 83% of intersection accidents occurred inside urban area.



50% to 79% of injury accidents occurred inside urban area in Europe in 2004.

While in Spain, France and Italy the inside urban area accidents are predominant, the fatalities outside the urban area are overrepresented. In GB the distribution follows the same trend between the injury accidents and the fatalities.

65% to 74% of intersection accidents occurred in the daylight.

49% to 61% of intersection accidents occurred in urban area, in the daylight; 19 to 22 % in urban area, at night with lighting.

In Europe-14, 23% of fatalities at intersection accidents occurred when it was dark, 31% of all injury accidents.

82% to 90 % of all intersection accidents occurred while the weather was normal.

68% to 88 % of all intersection accidents occurred while the road surface was dry.

67% to 82 % of all intersection accidents involved 2 vehicles or more.

59% to 67 % of all intersection situations occurred while the driving phase was normal (no manoeuvre). 9% to 18 % drivers turned left (right for GB).

21% to 53 % of all intersection accidents were side to front collisions.

In GB rear en collisions are overrepresented compared to the other countries.

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

In France 74 % of drivers involved in injured accidents are male.

France 2004: drivers 65+ are not overrepresented in intersection crashes.

In Europe-14, in 2004, concerning the passenger car driver age, Luxembourg has a high proportion of 25-39 year old car drivers and Sweden of 60 years and older. Low proportion are found in Luxembourg, Greece and Spain for 65+ car drivers, in Luxembourg for 15-24 old car drivers and in Finland and Sweden in the age group 25-39.

8.4.7.e Characteristics of intersection accidents with at least one passenger car

85% to 90% intersection accidents involved passenger cars. The accidents involving powered 2 wheelers are second in number.

In 14 European countries, in 2004, the main user type involved in accident is the passenger car (and taxi) followed by the 2-wheelers and the pedestrians.



If we look at the details, in the Netherlands more than half of the overall fatalities at junctions are 2-wheelers, a higher proportion than any of the other countries.

67% to 75% of intersection accidents (at least one car) occurred in the daylight.

No differences between all vehicles implication and car implication/ light conditions.

71% to 88 % of intersection accidents involving at least one car, involved 2 vehicles or more. 9% to 13 % involved at least one pedestrian.

21% to 27 % of drivers involved in intersection accidents involving at least one car are less than 25 years old; 6% to 14 % of drivers are 65+. In France, The drivers 65+ are not overrepresented unlike the literature reports.

9% to 25 % of drivers involved in intersection accidents involving at least one car are novice (< 1 year experience); 60% to 62 % of drivers are skilled drivers (>5 years experience).

65% of drivers involved in intersection accidents with at least one car are male.

The involvement of male drivers is lower in number than the female at intersection if we compare the sample at intersection with the sample all injury accidents.

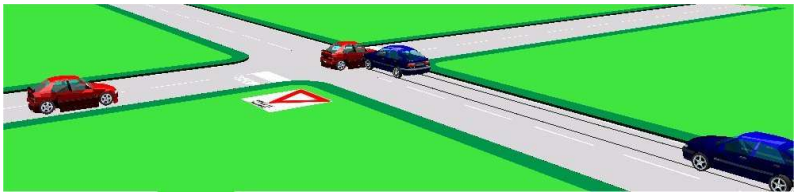
In Europe-14, when comparing the fatality rates of men and women during the last ten years, the fatality rate of women was consistently around a third of that of men. The proportion of all killed drivers who were female varies between 9 (Greece) to 23% (France, Finland and United Kingdom).

51% to 64 % of intersection situations involving at least one car occurred while the driving phase was normal (no manoeuvre). 11% to 24 % drivers turned left (right for GB), is the second in number.

Intersection accidents (at least one car) occurred in urban area: 73% to 85% of intersection accidents involving at least one car.

17% (GB) to 50 % of intersection accidents (at least one car) occurred at X intersection, 33% to 49 % at T or Y intersection

8.4.7.f Scenarios



The scenario 1 where vehicles crossed the roads and the trajectory of the opponent vehicle (while the drivers turned left or right or not) is more frequent and more severe than anyone else. 70% of all intersection accidents belong to the scenario 1. The KSI (killed and severely injured) of this scenario is 68%.

The scenario 4 account for 2% of all intersection accidents but the KSI is 7%.

71% of intersection accidents involving at least one car belong to the scenario 1.

The KSI of this scenario is 69%.

The scenario 4 accounts for 2% of the intersection accidents involving at least one car but the KSI is 8%.

The proportion of scenario 1.1 is fewer in number than the scenario 1.2&1.3 but the KSI of Sc1.1 is higher: the scenario 1.1 generates more fatalities and severe injuries than the scenario 1.2 and 1.3.

8.5 Conclusion

Most of intersection accidents occurred during the daylight, in urban area, the weather is normal and the road is dry.

Most of accidents occurred while no manoeuvre was performed; the second in number is 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. The scenario 1.1 is fewer 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.

9 Degradation situations

One of the targets of the accident analysis in TRACE is the identification of parameters that contribute to the occurrence of road accidents. Many parameters can be associated to an accident; therefore it is difficult to isolate the influence of any one single parameter. These parameters can include, but not be limited to:

- Endogenous to the driver such as speed, inattention, illness, alcohol…,
- Exogenous to the driver and either:
- Relating to the road and the environment (road layout, weather, traffic…),
- Or relating to the vehicle (tyres, brakes…).

Task 2.4 is investigating the parameters that are exogenous to the driver and relating to the road and the environment. Endogenous parameters relating to the driver and exogenous parameters relating to the vehicle are being studied elsewhere in TRACE (e.g. in WP3).
In particular, the exogenous parameters linked to the road and the environment that are investigated in this report are those that lead to a degradation in the driving situation. A degraded situation is therefore an accident situation with unfavourable conditions. These unfavourable conditions lead to a difficulty in the driver's:

- Visibility of the road ahead. The parameters which could influence the visibility include poor weather, lighting conditions, environment maintenance, and obstructions such as poor road side maintenance leading to overhanging trees or temporary road works etc…;
- Control. This is either the control by the driver (obstructions which block the road ahead e.g discarded vehicle load, animal…); or the control of the vehicle (dynamic control, e.g. a low grip which is the result of the weather conditions, road maintenance, surface contamination…).

The effects of these types of degradation were initially investigated by undertaking a study of relevant literature. It was then possible to highlight the areas not covered so well by the literature, so that these areas could be investigated through the national statistics analysis or further through the in-depth analysis in case they are just as relevant in terms of accident causation as those which are reported frequently in the literature. Therefore, by using both relevant literature and the analysis of accident data, the magnitude of the 'degradation' problem in road accidents could be quantified.

9.1 Definitions and scope

Work package 2 is investigating different types of accident situations. This Work Package is divided into 4 main tasks, with Task 2.4 being concerned with presence of factors that degrade the roadway or the environment and give rise to accident occurrence. Some of the factors that are considered include:

- Night-time and lighting issues;
- Weather conditions which affect visibility & speed potentially leading to a loss of control (e.g. fog, heavy rain, strong wind);
- Inferior highway conditions as result of:
  - obstruction (e.g. discarded vehicle load, stray animal);
  - surface contamination (e.g. wet, ice, oil, diesel).

Like the other task, task 2.4 is further broken down into 3 subtasks: descriptive analysis, In-depth analysis and Exposure data analysis.
The present results are focused on the descriptive analysis. The objective is to provides a short definition of what the different altered situations are, an overview of the studies carried out on the subject through the literature and presents general statistics (national and European) about injury and fatal accidents corresponding to these situations. This subtask should provide general accident scenarios through the national database analysis that will be studied in more details in the next step dedicated to the in-depth analysis. In other words, the descriptive analysis is the first step of the identification of the accident causes.

To know exactly the scope of this part, is useful to give a clear definition of what a degradation scenario is. We propose the following definition:

A **'Degradation Scenario'** has been defined as a scenario 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).

Contrary to the other task studied in this WP which are complementary (each of them is limited itself to a restricted sample of injury accidents, the sum of these samples covering the overall injury accidents, see Figure 6), situations in degraded conditions cover all the situations. It is independent of the location (on or out of intersection) or if a specific (or not) manoeuvre was realized by one of the road users. In the other words, some injury accidents studied in the previous chapters can be cover by the scope of this one.
Because here one of the main factors is clearly identified (directly connected to the degradation) the interest is to determine what are the additional causes as well as the other contributory factors which played a role in this type of injury accident.

9.2 Research review

9.2.1 Literature

The starting point for this literature review was to define a degradation scenario.

9.2.1.a The driver's visibility of the road ahead

Nearly half of injury accidents have been found to involve a perception or data processing dysfunction. A clear visibility of the road ahead is essential to provide crucial information for the task of driving or riding. The driver needs to consider their environment and take into account useful information to carry out their journey. In the driving loop, which consists of 'perception-understanding-decision-action', information should be visible so that the driver performs optimal data processing. The visibility of an object depends on its intrinsic physical parameters such as the dimension, the contrast and the visual abilities of the driver. A study carried out by Driscoll and Page (2003), highlighted that 12% of 1350 accident situations (in-depth analysis) involved a visibility problem relating to the driver, the vehicle or the environment. Concerning the environment, 33% were related to a physical obstruction to visibility, 18% to the lighting conditions, 7 % to the conspicuity, 6 % to the fog and 4% to the heavy rain.

In this section, all parameters degrading the visibility and linked to the road and the environment have been considered, including:

- poor visibility due to the weather conditions (rain, fog, spray);
- poor visibility due the lighting conditions (daytime or night-time, with/without street lights lit);
- poor visibility due to a physical obstruction (vehicle, road works or vegetation).

Weather

The weather conditions are considered here through their contribution to poor visibility. Conditions such as heavy rain, thick fog or snow could reduce the driver's field of view/visibility or influences the driver behaviour.

Driver behaviour

J. Edwards (1999) recorded a study on the effects of weather on driver behaviour. This study reported driver behaviour in three categories. These were "fine", "rain" and "misty conditions". In total, the study recorded the speed of 200 vehicles in the outside lane of the M4 motorway in the UK. For consistency, they recorded these speeds at the same time on the same weekday for a total of 6 months. The study found that there was a small but significant reduction in mean speeds in both wet and misty conditions.

Roger K. Hawkins (1988) undertook a comprehensive study of motorway traffic behaviour in reduced visibility conditions on the M1 motorway (Nottinghamshire in the UK). This study involved a range of traffic flows of which various parameters were measured under different weather conditions. The collected parameters were as follows:

- Vehicle lengths;
- Speeds;
- Time and distance gaps between vehicles
- Lane distributions;
- Platooning incidence.

The objective of the study was to understand change in traffic behaviour with adverse weather, particularly reduced visibility. The conclusions obtained from analysing the results were that fog with a visibility of less than 100m remains a major hazard and also that reduced speeds are often higher than the advisory maximum speeds.

These results indicate that although drivers do change their behaviour in adverse weather, these changes are still not sufficient enough to reduce the risk of collisions occurring.

Wet weather spray

R.G.Mortimer & J. Monaco (1986) carried out a study into visibility in wet weather spray. It also included a review of research over the last two decades concerned with splash and spray from motor vehicles, mainly large goods vehicles. From previous studies, it was found that up to 1 in 245 accidents might have involved splash or spray. The previous research showed that hazards due to splash and spray included:

- Reduced forward visibility beyond the truck for vehicle drivers approaching a truck;
- Splash on an approaching vehicle's windscreen, reducing visibility;
- Vehicle headlights will become covered in road deposits;
- Truck driver's rear visibility reduced (due to spray and dirty side mirrors);
- Obscured road signs.



Bad conditions normal conditions

Figure 97: Illustration of the reduced visibility in bad weather condiotns

The main aim of this study was to evaluate spray suppression devices on a highway environment. The results demonstrated that trucks with suppression devices consisting of textured flaps, fibre side skirts or air deflectors produce less apparent spray and provide better visibility for surrounding road users than unequipped trucks. Therefore, this could lead to a reduced risk of accidents involving wet weather spray.

Fog

Reduced visibility due to fog increases the accident risk by 1.5 times, the accident severity by 2 times and the risk of a multi-vehicle collision by 3 times.

Dumont et al (2004) investigated, as part of the project "Percevoir", the visual perception of the road as the way that improves the road safety. They perfected an artificial fog simulator as part of the European project FOG and developed a photometric model of the fog effect on the visual environment of the driver.



Figure 98: Illustration of reduced visibility on the road by fog.

Lighting

In this section, the effect of lighting conditions on poor visibility is considered, such as darkness at night, no lighting in urban areas, sun dazzle, shade and anything else that reduces the driver field of view/visibility.

Y. Page, S. Cuny, M. Montel (2002) investigated road accidents at night. They state in their paper that in-depth accident investigations can be used to identify the type of night problems that increase accident risk. From undertaking a case-by-case review of approximately 52 in-depth 'night' accident cases, some of these problems were identified and are listed below:

- Irregular lighting,
- Low contrast,
- Presence of vulnerable road users wearing dark clothing (e.g. motorcyclists, cyclists, pedestrians),
- Reduced driver opportunities for the detection or recognition of opponents,
- Obstacles,
- Road profile or road signs,
- Impossibility of seeing obstacles until they enter the headlight beam,
- Glare from street lamps or headlights,
- Alternation of dark and lit areas.

However, it was also identified that night accidents are not solely due to problems concerning visibility. They are generally combined with other factors.

From identifying the problems, the authors were able to propose seven distinct and general accident clusters which show that, most of the time, a human failure is the cause. These were stated as being:

- Selective or incorrect information taking,
- Low expectancy level,
- Bad speed and distance evaluation due to drowsiness,
- Fatigue,
- Distraction or inattention,
- Violation such as a high speed, alcohol or fatigue impairment,
- Risk taking.

These result in a driving error or an inappropriate manoeuvre, which are identified in the accident mechanism. They state that these failures are sometimes governed by other elements of the transport system. They describe that in some cases, for example, that the lack of lighting or uneven lighting

generates pitfalls. These result in the driver not seeing or incorrectly recognizing road profiles, road signs, or the presence and shape of another road user.

Paul L. Olson & Michael Sivak (1984) undertook a study into the affects on visibility in night time driving conditions. They categorised variables that affect visibility into four classes. These were as follows:

- Headlights,
- Target objects,
- Atmospheric conditions,
- Human visual system.

It was found that the acquisition of visual information under night-time driving conditions is often uncertain. It was concluded that better understanding of the principles would help decrease the frequency of situations in which drivers or pedestrians make unwarranted assumptions about their sight distances or visibility at night.

Dumont & al (2004) investigated, through the project "Percevoir", the visual perception of the road as the way of improving the road safety. They focused on the photometric characterisation of the visual environment of the road user. This survey led to the ICI (INTERNATIONAL COMMISSION ON ILLUMINATION) road surface standard being called into question, which is a standard used to evaluate the lighting features.



Figure 99: Illustration of good visibility during night time on lighted motorway.

Other visibility issues

The presence of temporary physical obstructions on the road or roadside may also have an affect on the visibility of the road ahead. In the absence of specific studies, a brief analysis of the UK Government funded 'On The Spot' (OTS) in-depth database was undertaken. OTS provides a representative sample of in-depth data from the year 2000 onwards, with 500 cases per year covering the Midlands & South-East regions of England. From the OTS data from the years 2000-2006 (3024 cases), 29 cases (1%) were identified where restricted visibility of the road ahead by vegetation or roadside objects (i.e. potential maintenance issues) were found to be a probable or definite contributory factor in the accident. In addition, visibility obstructed by other vehicles on the road or vehicles parked on the roadside were found to be a contributory factor in 96 cases (3%). These results indicate that, despite identifying this potential problem, the magnitude of the problem will not be significant enough to carry out investigations in the descriptive analysis, but further consideration may given in the in-depth analysis.

9.2.1.b The control of the vehicle

In France, about 20% of injury accidents occurred on wet roads, while roads are wet during 10 to 12% of the time. Research on the influence of the weather and the adherence on the accident risk was found to be of great interest amongst international scientists.
The control of the vehicle is defined either by the driver and their abilities to manage the events or, the vehicle dynamic and its limits according to the physical point of view.

The driver

In this section, all factors which could influence the driving and the control of the vehicle by the driver are considered, for example, wind (e.g. cross-wind, gusty wind), or a sudden obstruction on the road (e.g. discarded vehicle load, animal…).

Wind

J. P. Pauwelussen & A. P. Vos (1991) carried out a study as part of the DRIVE project CROW (Conditions of ROad & Weather) investigating traffic safety under bad weather conditions. The objective of this whole study was to develop and improve data acquisition techniques for an integrated road and weather monitoring system. As part of this, the effects of cross-wind using this system was discussed. Driver reactions under various cross-winds and road conditions were recreated using a simulation model and driver deviations from the 'desired path' were measured. The greater the deviation, the greater the risk of an impact occurring (i.e. if the driver deviates into oncoming traffic on the opposing side of the road). The risk under cross-wind was found to be significantly increased in wet weather conditions (i.e. deviations were found to be greater, up to 1m when the road was dry and often over 4m in the wet). Therefore to conclude, the risk under cross-wind is significantly greater when in combination with other poor weather conditions. Other parameters found to affect the risk levels include vehicle speed, cross-wind direction, tyre properties, aerodynamic vehicle properties and also the behaviour of the driver.



Physical obstruction in road

A limited number of published papers relating to physical obstructions in road were identified. However, studies to detect the way road obstacles through the on-board stereovision have been undertaken by research teams (Aubert et al, INRETS). The stereovision ensures the distinction between the shapes on the road surface and the obstacle. This tool is a basic technologic step to develop driver assistances such as the inter-vehicle distance, emergency braking and obstacle avoidance. The presence of physical obstructions on the carriageway may have an affect not only on the visibility of the road ahead, but also in the way the road user controls their vehicle, in particular if there are insufficient advance warnings of the obstructions ahead. A brief overview of the OTS data revealed 39 cases (1% of all cases) which involved an animal or object on the carriageway. Although at a low level, these results show that this type of accident is known to occur. However, these results also indicate that despite identifying a potential problem, the magnitude of the problem may not be significant enough to investigate beyond the descriptive analysis.

The vehicle

Considered in this section are all factors which could influence the dynamic of the vehicle, such as the grip of the road surface (e.g. weather, contamination) or road defects.

Weather, grip and driver behaviour

Weather condition can influence the dynamic of the vehicle through the change of the road surface grip, for example:

- heavy rain leading to a wet or flooded road,
- first rain after a long dry period leading to a slippery road,
- wet weather and low temperatures leading to a risk of ice.

The increase in degradation of the road when the surface is wet encouraged several scientists to find the relation between the road surface characteristics and the accident rates. M.Gothié gathered this information and showed a relation between the 'Coefficient of road risk' ('Crr' - the ratio of accident rate on wet road) and the 'grip coefficient' at 65km/h. It was shown that the accident rate tends to increase when the grip coefficient decreases.

Delanne and Violette (2001) undertook a survey of published papers to investigate and report on wet road accidents in relation to driver behaviour, safety margins and road design. The following section is an extract from the conclusions of the paper and summarises what the main findings were:

- "Wet road accident risk is significantly higher than accident risk on dry roads. 'In most cases, the risk was found to be twice is great. Excess risk coefficients (ERC = wet road accident rate: dry road accident rate) from a number of studies are given, which range from 1.7 to 2.9";
- "The frictional mechanism is reduced by a lubricating film of water between the tyre and the road. The grip potential is reduced by 25 to 30 % when the road is just damp but not wet. In this case the drivers don't change their speed because they don't interpret the situation as a risky one";
- "A light rain can actually make the pavement more slippery than a heavy rain, especially if it comes after a dry period in which oil and other automotive liquids have been deposited on the roadway. The resulting mixture of oil and water caused by a light rain can be extremely hazardous. The main degradation of the adherence occurs on damp road (depth of water<several 10mm). The influence of the depth of water depends on the he sliding speed of the couple tire/surface as well as the tire pressure and wear";
- "During inclement weather, water can create a critical situation by increasing potential for hydroplaning or skidding, in particular when the skid resistance of a pavement is low";
- "Heavy rain: a patterned tire provides grooves or channels into which the water can squeeze as the tire rolls along the road, thus again providing a region of direct contact between tire and road."

In addition, it was found that 'motorists often fail to "remember" to change driving attitudes and actions'. Driver speed was only affected during heavy rain, but is not affected by drizzle or light rain. And when drivers do adjust their speed, it is not sufficient enough 'to maintain their safety margin'.

The risk of driving around bends during wet weather was also discussed. It was found that 'drivers have a general impression of the degree of risk of curves', but that 'wet weather is not felt as a modified situation.' Therefore, speed is not reduced enough on bends and therefore leads to a greater level of accident risk.

Accident cinematic reconstruction confirms that the road grip is a factor decisive in the initiation of a loss of control and above all, manoeuvres performed to keep control are inefficient. Offering a high level of grip in high-risk zone and especially when the surface is damp or wet is a quick countermeasure to reduce the frequency and the severity of the accidents.

Valerie Muzet, Gerard Queyrel & Jean Livet, (2002) undertook a study into precipitation and road surface information. Although this report is not related directly to accident risk, it evaluates the use of a weather data collection system to collect weather and road surface information that will be useful for road maintenance, in particular the winter, and therefore assist in improving the surface state of the road during inclement weather. It was considered whether it was possible to make a road weather climatology with RWIS data (Road Weather Information Systems)). RWIS are installed on roads to collect information for road maintenance, such as temperatures, precipitations and road surface state. This was a prospective study. Twelve RWIS were studied for 12 months. The outcome of the study was that RWIS data can be used to produce climatology data with some road information, but it is important to consider the 'implantation and localisation of these stations', for example the incline of the road and solar exposure levels, as these will affect the reliability of the RWIS data.



A.D.Vos (1992) presented a paper reporting on a study into traffic safety and efficiency in adverse weather conditions. The accident statistics indicate a substantial impact of precipitation on traffic safety, while fog is responsible for large-scale accidents. 25-30% of accidents were found to occur during poor weather conditions and in the Netherlands, 'accident risk on wet roads was found to be 2.5 higher than on dry roads'. A major cause for these accidents is inadequate longitudinal control. In fog accidents, 70% involved rear-end collisions. They concluded that the main factors that determine weather impact on vehicle behaviour are the presence of water, ice or snow. Combine this with reduced friction on a humid road that is enhanced by the presence of dirt causes accident potential to increase. Following on from this they state that with increasing water levels and vehicle speed induce a further decline in friction. They also found that the slipperiness of icy and snowy road surfaces is most distinct or at its most dangerous near the freezing point.

The studies investigating road grip degradation highlighted here have shown that degraded roads greatly increase accident risk compared to dry roads. When roads are wet, although drivers often perceive a risk, or perceive the difference, they do not perceive the risk to be as great as it is (especially the degradation of the road grip and the increase of the braking distance), therefore do not adjust their speed enough. Therefore, it is important that the state of the road surface is monitored and this information is conveyed to the road users to help them make informed decisions about their driving actions.

U. Postguard (2001) carried out a study looking at the adjustments in road surface temperature during weather changes. The objective of this study was to develop a model that can determine road surface adjustment times to new conditions after weather changes, as changes in road surface temperatures, in particular temperature reductions, can lead to slippery roads. This was based on situations where the weather changes from clear to overcast to give a worst case scenario. The outcome demonstrated that it was possible to use clear day relationship to predict the decrease in road surface temperature for situations with weather changes, however during these situations the deviations between the modelled and measured values were higher and demonstrated a positive bias.

J. Luoma & P. Rama (2000) undertook a study investigating the effects of variable message signs for slippery road conditions on reported driver behaviour. The findings showed that there was a 1-2 km/h reduction in speed. The study also showed that a variable message sign recommending a minimum headway (i.e. vehicle spacing) between vehicles decreased the proportion of short headways.



Road surface defects

There were no reported papers found in the public domain regarding road surface defects. This suggests that further research is needed in this area.

In light of the lack of finding, a short review of the UK in-depth 'On-the-spot' (OTS) database was undertaken looking at in-depth data on road surface defects as a contributing cause to an accident. From a brief analysis, road surface defects were present at the scene of approximately 13% of cases, but were a potential cause in 1% (approximately 29 cases, of which 19 were 'very likely' to be a cause). These results suggest that despite identifying a potential problem, the magnitude of the problem may not be significant enough to further investigate beyond the descriptive analysis.





Figure 100: Illustration of road surface defects.

9.2.1.c Summary of literature review

The extensive literature review that was undertaken discovered research in a variety of different topic areas. The types of studies that were found related to the effects of weather and lighting conditions on driver behaviour and accident risk. These studies related to both driver visibility and driver control of the vehicle. Up to now, little relevant research has been found on the effects of degraded road layout, degraded road maintenance or the presence of carriageway hazards. This is true for any research that has been published in the public domain. It suggests that further research in these areas is needed to determine if these accident causation factors are issues or not.

The main findings from the literature relate to behaviour studies and simulation model studies. To begin with, the behaviour studies are summarised. For instance, drivers will slow down in inclement weather but not sufficiently enough. There is little difference when studies investigated vehicle positioning. In relation to accident statistics, 25-30% of accidents occur in adverse weather. The accident risk on a wet road was found to be 2.5 times higher than on dry roads. In other words, when driving on a wet road, the likelihood of an accident occurring is much greater. Finally although fog accident rates are low, the risk of a fatal accident proportionally is high.

The Simulation model studies identify that risk under cross wind is significantly increased in wet weather (the deviation from the 'desired driving path' was sometimes found to be up to 4 times greater in the wet than in the dry). Also the presence of water, ice or snow is the main factors that determine weather impact on vehicle behaviour. As before, this may seem obvious but these statements need to be made to ensure the literature confirms common thoughts. Other studies found that up to 1 in 245 accidents involves splash or spray from HGV's and that driving visibility at night is influenced by a number of aspects, such as headlights, target objects, atmospheric conditions and the human visual system.

Where relevant studies were not identified in certain areas (i.e. degraded visibility due to obstruction on road or roadside, road defects and road obstacles which suddenly degraded the control of the vehicle (e.g. debris or animals)), a brief review of the UK OTS database, as an example, showed that although relevant literature was not found, these type of accidents do occur. Although they are more rare than other accident types, it could still be useful to undertake further investigation of these types of accidents.

9.2.2 Review of published accident studies which include 'degradation'-related data

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.

9.2.2.a Descriptive Data - Published Great Britain (GB) Statistics

The following tables are taken from published National Statistics in the United Kingdom (Road Casualties Great Britain (RCGB) 2004) and give details of road casualties in Great Britain in 2004. The tables represent the number of accidents and casualties under the different types of road degradation included in the GB data. In all cases these are related to the following variables - lighting conditions (daylight or darkness), type of road environment the accident occurred on (motorway, built-up, non built-up and all speed limits) and finally the condition of the road surface (dry, wet/flood, snow/ice or all).

Road Surface Conditions

Road Condition – All severities	Daylight			
	Dry	Wet or Flood	Snow or Ice	All
Motorways	4,352	1,751	60	6,359
Built-up	79,819	26,236	1,131	107,585
Non Built-up	21,202	13,011	1,146	35,860
All Speed Limits	105,553	40,998	2,337	149,804

Table 24: Accidents by daylight, road surface condition, built-up & non built-up roads & severity (RCGB 2004)

Road Condition – All severities	Darkness			
	Dry	Wet or Flood	Snow or Ice	All
Motorways	1,442	1,193	72	2,713
Built-up	23,008	16,788	861	40,792
Non Built-up	5,983	7,160	781	14,101
All Speed Limits	30,433	25,141	1,714	57,606

Table 25: Accidents by darkness, road surface condition, built-up & non built-up roads & severity: (RCGB 2004)

Road Condition – All severities	Daylight			
	Dry	Wet or Flood	Snow or Ice	All
Motorways	7,081	2,786	102	9,997
Built-up	99,449	34,429	1,465	135,863
Non Built-up	32,078	19,802	1,615	54,207
All Speed Limits	138,608	57,017	3,182	200,067

Table 26: Casualties by daylight, road surface condition, built-up & non built-up roads & severity: (RCGB 2004)

Road Condition – All severities	Darkness			
	Dry	Wet or Flood	Snow or Ice	All
Motorways	2,243	1,929	119	4,311
Built-up	30,104	23,005	1,160	54,455
Non Built-up	9,445	11,185	1,118	22,007
All Speed Limits	41,792	36,119	2,397	80,773

Table 27: Casualties: by darkness, road surface condition, built-up & non built-up roads & severity: (RCGB 2004)

In summary the following can be stated about accidents with various road surface conditions during daylight and at night from the 2004 published results:

- Approximately 75% of accidents occurred during daylight;
- Over 30% of accidents occurred on a wet or flooded road, with 2% occurring on ice or snow and 66% on dry roads;
- During daylight, over 25% of accidents occurred on wet/flooded roads. During darkness, the proportion of wet road accidents increases to 44%;
- On dry roads, 22% of accidents occurred at night. However, during snowy/icy conditions, 42% occurred at night.

In conclusion, accidents during daylight were more likely to occur on dry road conditions, whereas during darkness, there was an increased likelihood of accidents occurring on wet roads.

Weather Conditions

Road Condition – All severities	Daylight			
	Fine	Raining	Snowing	Fog
Motorways	5,285	915	29	25
Built-up	91,131	13,107	352	150
Non Built-up	28,373	5,919	252	233
All Speed Limits	124,789	19,941	633	408

Table 28: Accidents by daylight, weather condition, built-up & non built-up roads & severity (RCGB 2004)

Road Condition – All severities	Darkness			
	Fine	Raining	Snowing	Fog
Motorways	1,990	593	38	21
Built-up	30,383	8,169	347	202
Non Built-up	10,092	2,822	220	295
All Speed Limits	42,465	11,584	605	518

Table 29: Accidents by darkness, weather condition, built-up & non built-up roads & severity: (RCGB 2004)

Road Condition – All severities	Daylight			
	Fine	Raining	Snowing	Fog
Motorways	8,347	1,413	49	35
Built-up	114,834	16,935	422	186
Non Built-up	42,964	9,014	371	359
All Speed Limits	166,145	27,362	842	580

Table 30: Casualties by daylight, weather condition, built-up & non built-up roads & severity (RCGB 2004)

Road Condition – All severities	Darkness			
	Fine	Raining	Snowing	Fog
Motorways	3,165	934	57	35
Built-up	40,449	11,023	458	285
Non Built-up	15,917	4,287	319	427
All Speed Limits	59,581	16,244	834	747

Table 31: Casualties by darkness, road surface condition, built-up & non built-up roads & severity (RCGB 2004)

In summary the following can be stated about accidents in various weather conditions during daylight and at night:

- More 'fine' accidents occurred during the day (25%) than in darkness, whereas more fog accidents occurred in darkness (56%) than in day;
- The 'proportion' of rain, snow and fog accidents all increased during darkness compared to daylight, whereas the proportion of 'fine' accidents decreased at night.

In conclusion, accidents during daylight were more likely to involve fine weather, whereas during darkness, there was an increased likelihood of accidents occurring during fog, rain, snow.

Skidding accidents

The following table shows the distribution of accidents where vehicle skidding has occurred, by road surface conditions and vehicle type.

From this table, the following summary of results can be given on vehicles skidding accidents in Great Britain in 2004:

- 65% of all vehicles skidded in dry road conditions and 32% in wet conditions;
- 77% of skidding vehicles were cars, with 7% motorcycles (3-4.5% for other vehicle types);
- When only mud/oil skids are included, 16% (254/1622) were found to be motorcycles (more than the average involvement under all conditions, 9%);
- When motorbikes, bicycles and buses are involved in a skidding accidents, they are more likely to skid on dry roads than other vehicle types (73-78% compared to approximately 64%).

Road Surface	Cycles	Motor bikes	Cars	Buses	Light goods vehicle	Heavy goods vehicle	Other motor vehicles	Other vehicles
Dry	13,288	19,708	185,992	8,110	9,999	8,074	3,251	334
Wet	3,650	6,622	98,845	2,321	5,311	4,136	1,417	114
Snow – Ice	110	246	5,588	102	307	222	83	5
Mud – Oil	12	254	1,125	31	90	75	33	2
All conditions	17,084	26,857	291,842	10,573	15,728	12,516	4,787	458

Table 32: Vehicles skidding: by road surface conditions & vehicle type (RCGB 2004)

In conclusion, skidding accidents are more likely to occur during dry road conditions compared with wet road conditions.

9.2.2.b Contributory Factors

In 2005, after a 5 year trial and as part of the STATS19 national system of collecting road injury accident data (Mosedale et al, 2004, Hickford & Hall, 2004), all police forces in Great Britain started collecting data about the contributing factors in road accidents. The contributory factors system would allow, for each accident, up to 6 contributory factors be recorded from a pre-defined list. Using the system, multiple factors can be recorded against any individual participants in the accident or vehicle (i.e. if defective), or the same factor can be coded for more than one participant (i.e. weather or road surface condition). An average of 2.4 contributory factors were recorded for each accident in 2005.

A report documenting the overall results for 2005 (Robinson and Campbell, 2006) show that the road environment contributed to 15% of all accidents where a contributory factor was reported (12% of fatal accidents). Slippery road and road layout were most frequent (10% and 3% of all accidents respectively, and 6% and 4% of fatal accidents). 'Defective road surface', 'deposit on road' and 'animal/object on carriageway' each contributed to 1% of all accidents (also 1% of fatal accidents).

In addition, 'going too fast for conditions' was a factor in 12% of all accidents (17% of fatal), whereas vehicle defects were a factor in 2% of all accidents (defective tyres or brakes) and 3% of fatal accidents.

In 10% of all accidents, the driver's vision was affected (8% fatal). In 3% of all accidents, this was by a parked vehicle (1% fatal). Vision was affected by weather, sun or road layout in 2% of all accidents, while in under 0.5% of all accidents, the driver's view of the road was affected by vegetation (1% of fatal accidents). The road user's vision was affected by a dirty windscreen or visor in only 0.1% of all cases.

When comparing road class, it was found that the percentage of accidents where slippery road was a factor was slightly less on motorways (8%) than on non-motorways (9% on A-roads, 13% on B-roads, and 10% on other road types).

Although these results are of great interest, the authors comment on the accuracy of the findings, stating that due to this system being in it's first year of full use, the results may contain some

'reporting errors'. However, in future years, the authors believe it will be possible to reduce these errors by introducing validation checks. Also, the analysis includes only accidents where contributory factor data was reported and a police officer attended the scene. In 2005, 74% of accidents satisfied these conditions. Also, some factors will be more difficult for police officers to identify at the scene than others, and therefore less likely to be reported, so may be under-represented in the findings. These points are important to consider when utilising these results.

SafetyNet Annual Statistics report using CARE data

Included in the results of the CARE database published as part of the SafetyNet Annual Statistics (SafetyNet 2007) is an overview of weather conditions and the amount of fatalities by each type of weather condition across 14 of the EU countries (EU15 minus Germany). In 2004, 18% of all accidents involved poor weather conditions (18% of fatal accidents). Rain was present in nearly 12% of these accidents (12% of fatal cases), while fog/mist was present in 1.5% (1.4% of fatal accidents).

In addition, some information is also provided for lighting and weather conditions within the SafetyNet 'basic fact sheets' (SafetyNet 2007). In 2004, 31% of fatalities occurred on motorway during darkness, whereas on non-motorways, the figure was 30%. At junctions, 23% of fatalities at junctions in the 14 EU countries occurred during darkness, whereas the figure was 31% for all fatalities.

Adverse weather conditions only appear to make a small difference to the proportion of fatalities at junctions (16%) compared with the percentage of all fatalities at junctions (18%).

Statistics specifically related to pedestrian fatalities are also given. As part of these results, it was found that, where the lighting condition was known, 47% of fatalities occurred during darkness, the average percentage for each country ranging from 35% in the Netherlands to 58% in Austria.

9.2.3 Summary of published data review

From the overview of published results in Road Casualties Great Britain 2004 which are related to accidents in degraded road conditions, the results implied that:

- More accidents occur during daylight;
- Road surfaces are more likely to be wet or flooded in an accident than any other type of road surface degradation;
- The likelihood of a road user driving on a degraded road surface (e.g. wet..) being involved in an accident increases greatly during darkness;
- The likelihood of a road user driving during degraded weather conditions being involved in an accident increases greatly during darkness;
- This implies that the combination of darkness with degraded road and/or weather conditions greatly increases the risk of an accident occurring;
- Skidding on dry roads are more likely and two wheel vehicles and buses are more likely to skid during dry conditions than cars.

Studies which have investigated rates of 'degradation' accidents have found that, across Europe, poor weather conditions were present in 18% of all accidents and approximately 30% of accidents occurred in darkness.

In Great Britain, it was found that the road environment contributed to 15% of all reported accidents where contributory factors were recorded, with 'slippery road' being the most frequent factor (10%). 'Going too fast for conditions' was a contributory factors in 12% of accidents. It would be interesting to investigate what proportion of these cases were a result of going too fast for weather or road surface conditions. This will be considered during the in-depth analysis.

It will be interesting to observe whether similar results are found when a full analysis of Great Britain descriptive data is. In addition, it will also be useful to investigate further the types of degradation where no literature was found (e.g. obstacles on the road, road surface defects, temporary obstructions to visibility on the road/roadside…) by analysing descriptive and/or in-depth accident data.

9.3 Descriptive analysis

As described before in the general methodology, a common methodology was devised to undertake the descriptive data analysis. The stages of this analysis were as follows:

- The task leader identifies relevant parameters in their own country's database,
- Using the relevant parameters, an analysis of the task leader's own country's data was undertaken,
- The most interesting results from this analysis were used to create a data request which was forwarded to WP8 to request similar tables of aggregated data from other TRACE partners who have access to their national data,
- Once the data tables from other countries were returned, a full analysis was carried out on all the data.

Therefore, in Task 2.4, relevant parameters were first identified from the GB STATS19 National database. The following types of degradation-related variables are included in STATS19:

- Weather conditions;
- Light conditions;
- Road surface contaminants;
- Carriageway hazards;
- Special conditions at site, including road works present, road surface defective.

These degradation variables are further classified into the following sub-categories. These sub-categories are outlined in Table 33 with the 'non-degradation' variables highlighted.

1.Weather conditions	2. Lighting Conditions
Fine without high winds	Daylight: street lights present
Raining without high winds	Daylight: no street lighting
Snowing without high winds	Daylight: street lighting unknown
Fine with high winds	Darkness: street lights present and lit
Raining with high winds	Darkness: street lights present but unlit
Snowing with high winds	Darkness: no street lighting
Fog or mist - if hazard	Darkness: street lighting unknown

3. Road surface Conditions	4. Carriageway Hazards
Dry	None
Wet / Damp	Dislodged vehicle load in carriageway
Snow	Other object in carriageway
Frost / Ice	Involvement with previous accident
Flood	Dog in carriageway
Oil or diesel	Other animal or pedestrian in carriageway
Mud	

5 Special conditions at site
Road works present
Road surface defective

Table 33: Sub-categories of degradation variables in GB national statistics

For the purpose of this analysis, a 'degradation' situation is defined as when at least one of the four previously mentioned degraded conditions was present (poor lighting, poor weather, poor road surface, carriageway hazards). Once the analysis of the GB data was complete, a request was issued to partners in six countries for national data based on the results of the GB analysis for the previously defined four categories. The countries included were Czech Republic, France, Germany, Greece, Spain and Australia. To encourage consistency and assist the work of each partner, a template based on existing WP8 data request forms was created of the parameters to give to WP8 as part of the first WP2 data package request. Due to the comprehensive nature of Task 2.4 investigating weather, road surface conditions, carriageway hazards and lighting conditions, the data request contained 70 tables in total. A selection of these is included in this first (subtask 1) report which is aimed at providing general statistics. It is expected that further tables will be included in the report for subtask 2 which will address degradation-related factors that cause accidents.

To determine the frequency and severity of accidents occurring during 'degradation' and 'non-degradation' situations and to determine the magnitude of the 'degradation' problem over recent years, the following research questions were asked:

- What proportion of passenger car accidents and injuries occur during a degraded road situation and how does this change between 2000 and 2004?
- How do the proportion of 'degradation' car accidents compare with the proportion of 'non-degradation' car accidents (for 2004 only)?

For each of the four degradation parameters identified, a table of the total number of car accidents, passenger cars and casualties in passenger cars (broken down by casualty severity) was produced and, to determine the frequency and severity of different types of accidents where degradation was present, the following research questions were also asked:

What are the lighting conditions when road accidents occur?
What are the weather conditions when road accidents occur?
What are the road surface conditions when road accidents occur?
How often are carriageway hazards present when road accidents occur?

In this analysis, only injury accidents are included.

As this analysis is only focusing on passenger car accidents, unless otherwise specified, the data only includes accidents involving at least one passenger car, or all passenger cars (vehicle severity is highest than casualty severity in car) or causalities in passenger car accidents, depending on the level of data being analyzed. Accident rates were analyzed across both severity type and also across degradation type. Figure 101 gives a summary of the prevalence of degradation in accidents across the seven countries included in the analysis. As can be seen from the table, degraded conditions were found in about half of all accidents, with Australian (Victoria) data having a slightly less proportion and Great Britain having a slightly greater proportion. In Great Britain, Czech Republic and Germany, degraded road surface conditions were the most prevalent degraded condition, while in France, Greece, Spain and Australia (Victoria) degraded lighting conditions were the most prevalent.

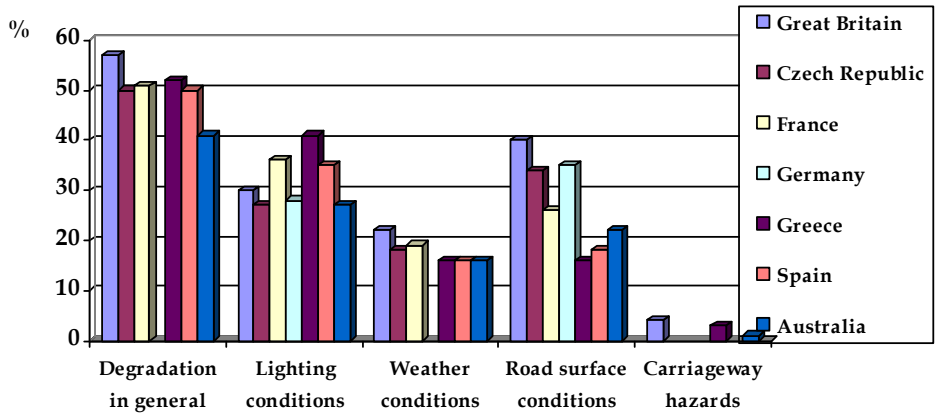


Figure 101: Distribution of passenger car accidents in each country where each type of degraded conditions were present 2004.

'Lit darkness' was the most prevalent degraded lighting condition in Great Britain, Greece, Spain, Australia and the Czech Republic (by 1%) (**Erreur ! Source du renvoi introuvable.**: In France, 'unlit darkness' was just as prevalent as 'lit darkness' (15%). The German data did not distinguish between 'lit' and 'unlit' darkness. The larger proportion of accidents occurring on unlit roads in the Czech Republic and France suggests either that unlit roads are more dangerous in these countries or more likely that these countries have a greater proportion of unlit roads, so road users are exposed to more unlit roads.

Rain was by far the most prevalent degraded weather condition in all six countries where different weather conditions were recorded. In Germany, weather was only coded as a causation factor and different types of weather conditions were not distinguished.

The results also show that wet or damp roads were the most prevalent degraded road surface conditions in all 7 countries. However, in Germany, 'wet/damp' was the only specific road surface condition recorded.

Data for carriageway hazards was available in 5 out of the 7 countries (Great Britain, Germany, Greece, Spain and Australia). In Great Britain, Germany and Spain, 'road-works present' was the most prevalent. However, in Germany and Spain, this was the only carriageway hazard defined. 'Vehicle load on road' was the most frequent carriageway hazard recorded in Greece and in Australia, 'animals on road' was the most frequent. In all countries, the proportion of accidents where carriageway hazards were present was much smaller than the proportion of lighting, weather or road surface conditions.

9.3.1 Overview of national accident data from Europe and Australia

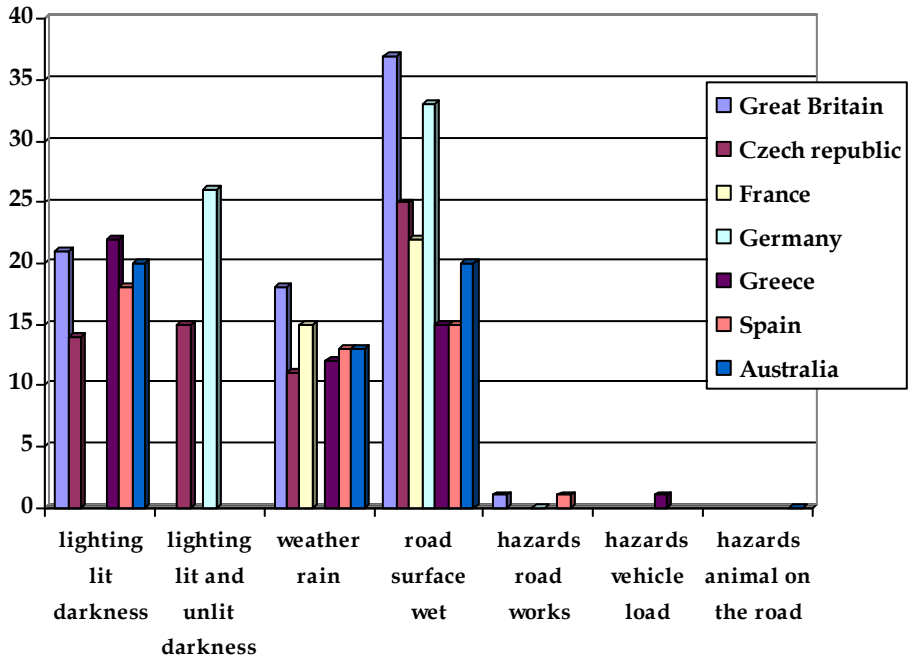


Figure 102: The most prevalent degraded conditions in accidents across each country

When considering Killed and Seriously Injured (KSI) passenger car occupant rates, 'unlit darkness' was the degraded lighting condition with the greatest KSI accident rate across all seven countries included in the analysis, ranging from 18% in Great Britain to 43% in Australia (Table 34). Interestingly in Spain, France, Czech Republic and Greece, the KSI accident rate was greater during

daylight conditions than 'lit darkness'. Three countries were able to provide data for 'dawn/dusk' or 'twilight' conditions. In France and Spain, the dawn/dusk conditions data greater KSI accident rate than both daylight and 'lit darkness'. In Germany, dawn/dusk was also found to have a greater KSI accident rate than daylight and darkness in general (German data does not distinguish between 'lit' and 'unlit' darkness).

For the six countries were data was available, fog/mist and high winds were the degraded weather conditions with the greatest KSI accident rates.

Table 34 shows that there wasn't a specific degraded road surface condition which had the greatest KSI accident rates across all countries.
'Road-works present' was the carriageway hazard with the greatest KSI rate in three of the five countries with 'carriageway hazard' data. However, in two of these cases, 'road-works present' was the only carriageway hazard included in the national database.

Country	Degraded condition with the greatest KSI rate (% of all KSI car accidents)			
	Lighting conditions	Weather conditions	Road surface conditions	Carriageway hazards
Great Britain	Unlit darkness (18)	Fog/mist (15)	Oil/diesel (13) Defects (12.5)	Other object on road (11)
Czech Republic	Unlit darkness (19)	Fog/mist (16)*	Oil/diesel (18)*	-
France	Unlit darkness (34)	High winds (36) Fog/mist (33)	Frost/Ice (32) Flood (30) Oil/diesel (29)	-
Germany	Unlit darkness (20)	-	Wet/damp (16)*	Road-works (16)*
Greece	Unlit darkness (35)	Fog/mist (34) High winds (32)	Snow (35)	Vehicle load on road (34)
Spain	Unlit darkness (27)	Fog/mist (23) High winds (21)	Gravel (24) Shady (21) Mud (20)	Road-works (18)*
Australia (Victoria)	Unlit darkness (43)	High winds (39)	Wet/damp (32)	Road-works (33)

* Only one condition included in database

Table 34: The degraded conditions with the greatest KSI accident rates across each country

9.3.2 Analysis of the Characteristics of 'Degradation' Accidents

In addition to analysing the frequency of different types of degradation in accidents across the seven countries, an analysis was undertaken of the general characteristics of accidents where at least one type of degradation was present. This would help to obtain an overall 'picture' of the characteristics of accidents involving a degraded situation, and therefore determine 'typical degradation scenarios'.

9.3.2.a Selection and description of accident variables included in analysis

A number of explanatory variables were selected and Table 35displays the types of accident variables which were included in the analysis. A bivariate analysis (cross-tabulations) of each type of degradation with other accident variables was undertaken and the most interesting results are displayed and discussed in this section.

Accident characteristics	Lighting	Weather	Road surface condition	Carriageway hazards
Accident level:				
Accident configuration (vehicle involvement)	X	X	X	X
Vehicle level:				
Intersection (Yes/No & type)	X	X	X	X
Road type	X	X	X	X
Carriageway type	X	X	X	X
Speed limit	X	X	X	X
Vehicle type (all vehicles)	X	X	X	X
Type of manoeuvre	X	X	X	X
Vehicle left carriageway (Yes/No)	X	X	X	X
Alcohol impairment (driver only)	X	X	X	X
Driver age	X	X	X	X
Driver gender	X	X	X	X

Table 35: Other accident characteristics analyzed for each type of degradation.

The explanatory variables included in the analysis are described below in more detail:

- Accident configuration (vehicle involvement) – The type and number of vehicles involved in the accident. As this study is focusing mainly on cars, only accidents involving at least one car were included. The categories in the following table were defined to investigate whether impacts between certain vehicle types are more or less likely to occur during degraded conditions.

Accident configuration (vehicle involvement)	Definitions
Single car accident	No other vehicle/pedestrian involvement
Car versus pedestrian	Accidents involving one car and at least one pedestrian
Two vehicle: car versus car	Two vehicle accident involving two cars and no other vehicles/pedestrians
Two vehicle: car v Motorcycle/pedal cycle	Two-vehicle accidents involving a car and a motorcycle or pedal cycle (no other vehicles/pedestrians involved)
Two vehicle: car v large vehicle (HGV/Bus/Coach)	Two-vehicle accidents involving a car and a large vehicle, such as a HGV, bus or coach (no other vehicles/pedestrians involved)
Multiple vehicle: 3 or more cars	Accidents involving three or more passenger cars (no other vehicle type or pedestrians involved)
Other car accidents	Other accidents involving at least one car, which cannot be included in any of the above categories (e.g. 1 car v 2 HGV's, 3 cars v 1 Motorcycle, 2 car v 1 HGV v 1 Motorcycle….)

Table 36: Definitions of accident configurations included in analysis of degraded situations

- Intersections – Whether or not each car was at an intersection at the time of the accident, and if so, the type of intersection.
- Road type – The type of road each car was on at the time of the accident, including road class (motorway or non-motorway), and location (rural or urban).
- Carriageway type – Whether the road each car was travelling on was a single carriageway road (1 lane in travelled direction) or dual carriageway road (2 or more lanes in travelled direction).
- Speed limit of the road – The posted speed limit of the road each car was travelling on at the time of the accident.
- Vehicle type – The type of vehicle involved, so that an overall comparison of vehicle types could be undertaken.
- Vehicle manoeuvre – The manoeuvre being undertaken by each car at the time of the accident.
- Vehicle left carriageway – Whether each car did or did not leave the carriageway during the accident.
- Driver alcohol breath test – If taken, the result of each car driver's alcohol breath test (positive or negative).
- Driver age – The age of the driver of each car.
- Driver gender – The gender of the driver of each car.

For each of these explanatory variables, a basic comparative analysis was undertaken to determine whether specific accident characteristics were more likely to be present in accidents with degraded conditions. For example, do single car accidents occur more often in degraded lighting conditions than accidents involving a car and a large vehicle, or are male drivers more likely to be involved in accidents involving degraded road surface conditions than female drivers?
This analysis was undertaken separately for degraded lighting conditions, degraded weather conditions, degraded road surface conditions and when carriageway hazards were present.
As with the frequency analysis, the selection process to identify these variables was initially undertaken using Great Britain data. From the results of this analysis, the explanatory variables to be analyzed were selected, and the same data was then requested from the other partners involved in TRACE who were able to provide their county's descriptive data.
Relevant data from 7 countries were available for analysis, 6 countries in Europe and also Australia (specifically from the State of Victoria).
As part of the initial analysis of GB data, an additional analysis of KSI rates for each variable was also undertaken. However, it was not possible to undertake this analysis for the remaining countries' data as this was beyond the scope of the original proposed work.

9.3.3 Degraded lighting conditions

9.3.3.a General overview

In 2004, data concerning lighting conditions during accidents was available from all seven countries included in the analysis.

When analyzing the various characteristics of degraded lighting accidents, it was found that more accidents occurred during the day than night (59-73%), and when at night, more occurred during lit darkness (darkness with street lights lit) (14-22%) than unlit darkness (darkness with street lights unlit or no street lighting). However, when KSI passenger car rates were analyzed using Great Britain data, it was found that unlit darkness led to a greater proportion of KSI cars than during lit darkness. This was found to be the situation when comparing lighting with all of the explanatory variables outlined in this section.

French, German and Spanish databases specifically code whether the accident occurred during twilight hours (dawn/dusk). This data showed that accidents occurring during dawn or dusk led to a greater proportion of KSI cars than during daylight and (where known) during darkness when street lights were lit. KSI car rate was greater during unlit night than during dawn or dusk.

9.3.3.b Accident configuration (vehicle involvement)

In 2004, for five of the countries analyzed, degraded lighting conditions were found to feature more often when vehicles were involved in single car accidents than in other types of accidents. From **Erreur ! Source du renvoi introuvable.**, it can be seen that the percentage of accidents with degraded lighting ranges from 41-54% across the countries. In the Czech Republic and Australia, 'car versus pedestrian' accidents had the greatest percentage of degraded lighting (52 and 50% respectively).

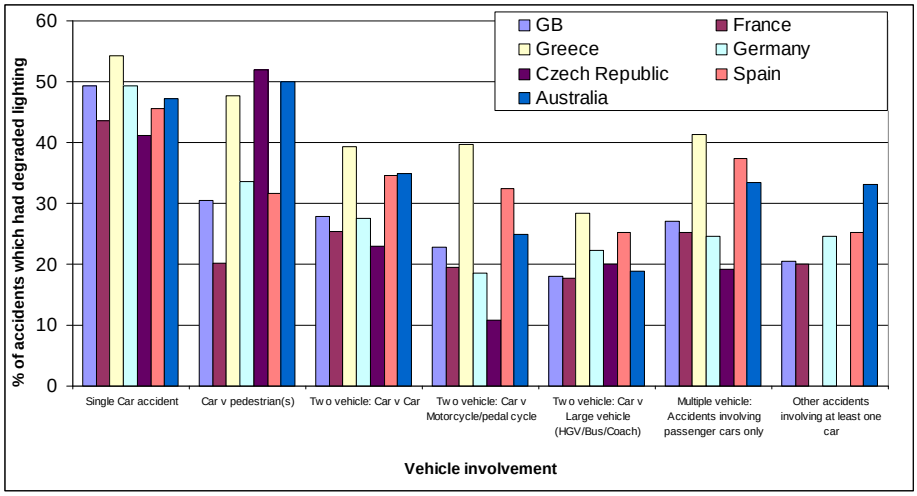
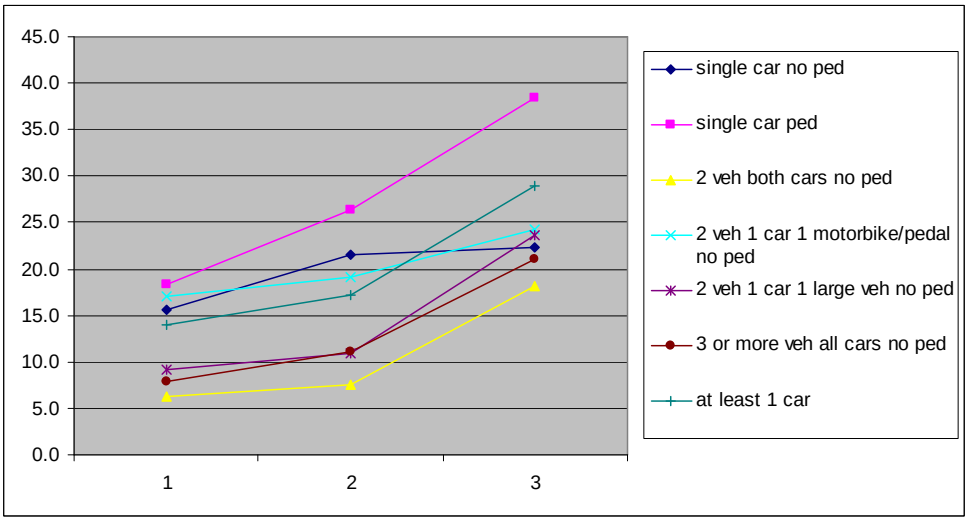


Figure 103: Frequency of degraded lighting for different accident configurations (vehicle involvement) across Europe and Australia

In Great Britain, the KSI (Killed and Seriously Injured) rates were found to be the greatest for car versus pedestrian accidents during unlit darkness (38% KSI)



1 = Daylight 2 = Lit darkness (lit street lighting) 3 = Unlit darkness (no/unlit street lighting)

Figure 104: KSI rates for different accident configurations during various lighting conditions (GB data only)

9.3.3.c Intersections

Using vehicle (passenger car) severity, there was found to be little difference between the prevalence of degraded lighting when the accident occurred at an intersection from those which did not occur at intersections. There was no more than a 3% difference between intersections and non-intersections across all 7 countries. When comparing the types of intersections and when there was data available, it

was found that the intersection type which had the greatest percentage of 'degraded lighting' accidents varied between countries. In France, Czech Republic and Australia, it was a roundabout, in Spain, it was a roundabout and a slip road, in Germany, it was a T-junction and in Great Britain, it was crossroads and multiple intersections.
In Great Britain, the greatest KSI rate was on a multiple intersection during unlit darkness. Overall, injury cars involved in accidents at non- intersections had higher KSI rates during degraded lighting.

9.3.3.d Road type

There was little difference in the prevalence of degraded lighting for all classes and types of road in France, Great Britain and Spain. However, in Greece, degraded lighting was more prevalent when cars were involved in accidents on urban (non-motorway) roads compared with rural roads; in Czech Republic on motorways (compared with non-motorways); in Germany on motorways or rural (non-motorway) roads compared with urban roads; and in Australia on rural (non-motorway) roads compared with motorways.
In Great Britain, the KSI car rates on motorway increased the greatest between day and night on urban roads. The KSI car rates on motorways was found to be less on unlit roads than other road types.
Carriageway type

In France, Spain and Great Britain, there was no difference in the prevalence of degraded lighting when cars were involved in accidents on either single or dual carriageway roads. In Greece and Czech Republic, degraded lighting was more prevalent when cars were involved in accidents on dual carriageways than on single carriageway roads (by 7% and 5% respectively).
In Great Britain, KSI car rates were found to be greater on dual carriageways than single carriageways and greatest during unlit night.

9.3.3.e Speed limit

Only two countries were able to provide data about speed limits, these being Australia and Great Britain. The analysis revealed that there were no major differences in the proportion of degraded lighting across all speed limits.

9.3.3.f Vehicle type

In all countries, degraded lighting was most prevalent when accidents involved injury cars compared with other vehicle types. The frequency of degraded lighting was also high when accidents involved mopeds in France, Spain, Greece, Germany and Australia.
In Great Britain, the greatest KSI rates were found to be Powered Two Wheelers >125cc during unlit darkness.

9.3.3.g Vehicle manoeuvres

There were only 4 countries with available 'manoeuvre' data. In France and Great Britain, cars 'going ahead on a bend' had the greatest percentage of degraded lighting. In Greece, it was 'changing lane' and in Spain, it was 'going ahead (no further detail)'.
In Great Britain, the greatest KSI car rate was 'u-turn' on an unlit road.

9.3.3.h Vehicle left carriageway

In France, Great Britain and Greece, degraded lighting was found to be much more prevalent in samples of injury cars involved in an accidents where the car left the carriageway than when the car did not leave the carriageway (e.g. 42% compared with 26% in Great Britain). In Spain and Australia, the analysis found the opposite.
In Great Britain, the KSI car rate was the greatest when vehicle left the carriageway on an unlit road at night.

9.3.3.i Driver alcohol breath test

For all countries where alcohol breath test data was available, it was found that degraded lighting was much more common in the sample of injury vehicles where drivers tested positive for alcohol (50-76%) compared with those where the driver tested negative (25-42).

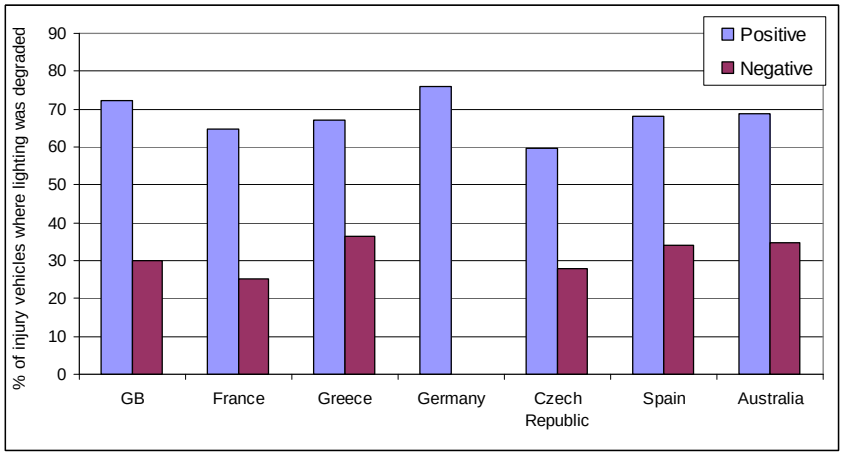


Figure 105: Prevalence of degraded lighting conditions amongst passenger cars where the drivers tested positive/negative in countries across Europe and Australia

In Great Britain, the KSI car rate was greatest during unlit night when a positive breath test was given.

9.3.3.j Driver age

Across all 7 countries where data was available, there was a greater rate of drivers under 25 years old found to be involved in accidents involving degraded lighting than drivers over this age. The rate of degraded lighting present generally decreased progressively as the age of the driver increased.

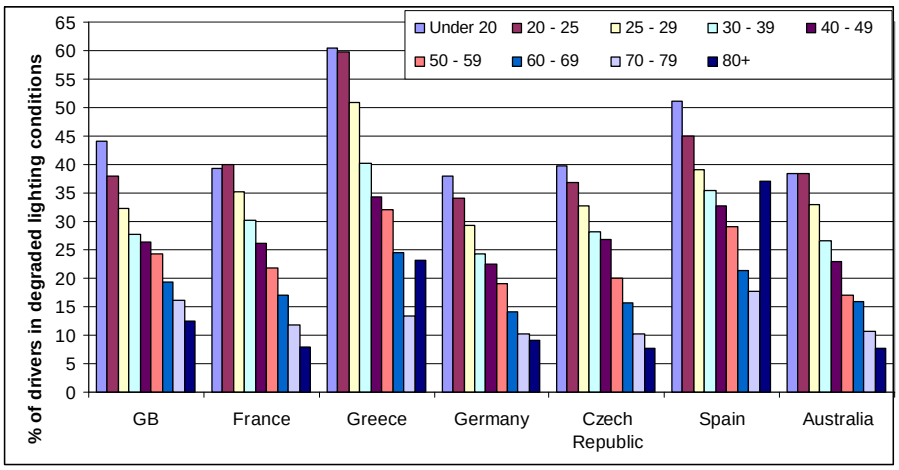


Figure 106: Prevalence of degraded lighting conditions amongst passenger car drivers of various ages involved in accidents across Europe and Australia

In Great Britain, the KSI car rate was found to be the greatest during unlit night and when the driver was under 20 years old or greater than 70 years old.

9.3.3.k Driver gender

In all 7 countries, degraded lighting was found to be more prevalent in the sample of injury cars driven by male drivers than those driven by female drivers.

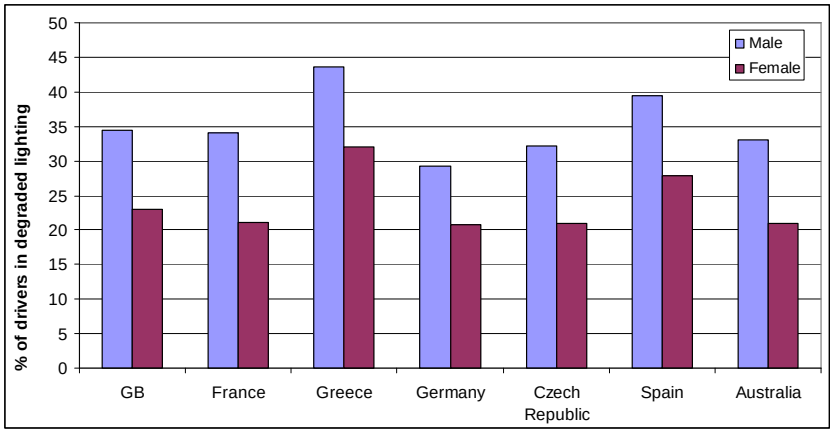


Figure 107: Prevalence of degraded lighting conditions amongst male and female passenger car drivers involved in accidents across Europe and Australia

In Great Britain, KSI car rate was found to be greatest during unlit darkness when the driver was male.

9.3.3.1 Summary

'Typical degraded lighting accident scenario', as indicated by the European and Australian data

From the results found in the analysis of the characteristics of degraded lighting accidents, the most typical 'degraded lighting scenario' in the 7 countries included in the analysis were found to have the following characteristics:

Typical degraded lighting accident scenario

- Single car accident (also car versus pedestrian accident in the Czech Republic and Australia),
- Involved either a car or a moped,
- The vehicle was going ahead (i.e. not turning, overtaking, starting, stopping…) (Great Britain, France, Spain only)
- Dual carriageway road (Greece, Czech Republic only)
- Driver gave positive alcohol breath test,
- Driver under the age of 25,
- Male driver.

Degraded lighting conditions were found to be just as prevalent in samples of accidents on most road types, speed limits, intersections and non-intersections and when the vehicle did/did not leave the carriageway after losing control.

'Killed and Seriously Injured' (KSI) rates in GB data

Using the analysis of KSI rates in Great Britain, the risk of serious of fatal injuries was found to be the greatest during unlit night when the following accident characteristics were present:

Killed and serious Injured KSI in GB

- Car versus pedestrian accident,
- Not at an intersection,
- Single carriageway road,
- Road with a high speed limit,
- Powered Two-Wheelers (PTW),
- A vehicle undertaking a u-turn,
- A vehicle which left the carriageway after losing control,
- Driver gave positive alcohol breath test,
- Driver under the age of 20 or over 70 years old,
- Male driver.

9.3.4 Weather conditions

Degraded weather = weather conditions which affect the control of the vehicle (e.g. wind) or visibility of the road ahead (e.g. raining, fog, mist, snowing…)

When analysing weather conditions, six countries had available data. Only data regarding fog accidents was available for Germany.

When analysing the various characteristics of weather accidents for the six countries, it was found that more accidents occurred when the weather was fine (78-84% of cases). But when the weather was degraded, more occurred when it was raining (11-17.5% of all cases). However, when KSI passenger car rates were analysed using Great Britain data, it was found that the presence of fog/mist or windy conditions led to a greater proportion of KSI cars than other degraded weather conditions. This was found to be the situation when comparing degraded weather conditions with most of the explanatory variables outlined in this section.

9.3.4.a Accident configuration (vehicle involvement)

In 2004, across the six countries analysed, degraded weather conditions were present more often in single car accidents (19-28%) than accidents involving other combinations of vehicles. However, the difference is not as great as was found with lighting conditions.

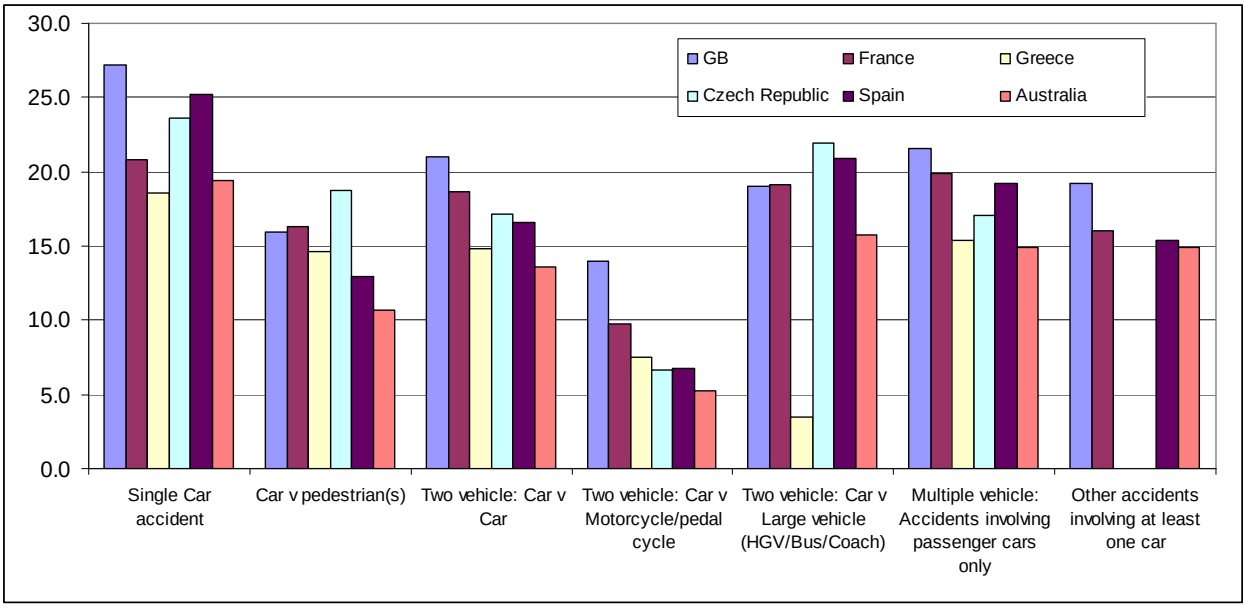


Figure 108: Frequency of degraded weather for different accident configurations (vehicle involvement) across Europe and Australia

When analysing KSI accident rates from Great Britain, there was found to be little difference in the proportion of KSI accidents when degraded weather conditions were present compared to when non-degraded weather conditions were present for all 'accident types'. 'Car versus pedestrian' accidents had slightly higher KSI rates compared with other accident configurations.

9.3.4.b Intersections

Using passenger car injury levels, degraded weather conditions were generally more prevalent when cars were involved in accidents which did not occur at intersections compared to those involved in accidents at intersections.

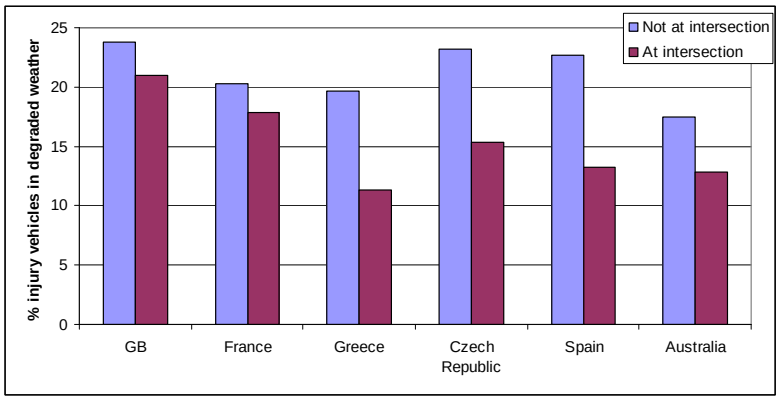


Figure 109: Frequency of degraded weather when cars were/were not at an intersection when the accident occurred (Europe and Australia data)

When comparing the different types of intersections, no major differences were found between the prevalence of degraded weather conditions.

When analysing Great Britain data, KSI car rates were the greatest during fog/mist conditions than other degraded weather conditions. KSI car rates were much greater for cars involved in accidents at non-intersections than those at intersections. When an intersection was involved, there was little difference between KSI rates for the various intersection types.

9.3.4.c Road type

In France, Australia and Great Britain, there was found to be little difference in the prevalence of degraded weather conditions when passenger cars were involved in accidents on motorways compared with those on non-motorways (urban and rural) . However, in Spain and the Czech Republic, degraded weather conditions were more frequent when cars were involved in motorway accidents. In Greece, degraded weather was more prevalent when cars were involved in accidents on rural roads.

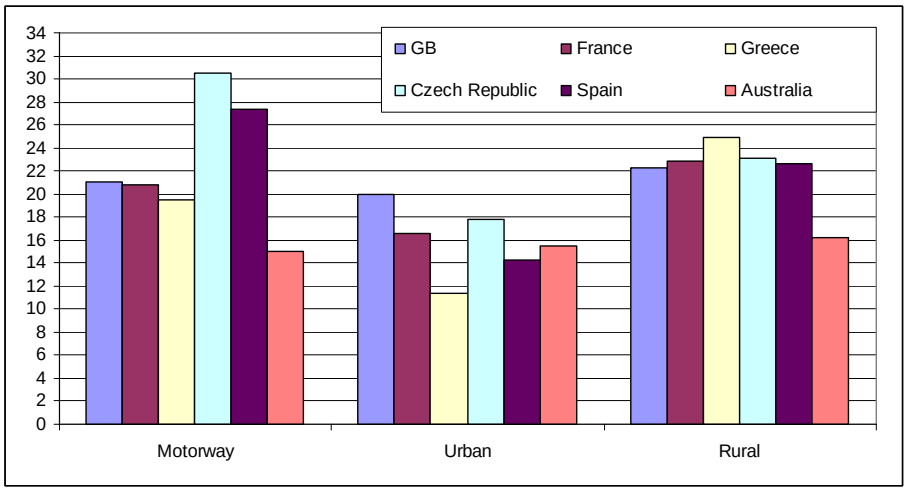


Figure 110: Prevalence of degraded weather conditions amongst passenger cars involved in accidents on different types of roads for data across Europe and Australia

In Great Britain, KSI car rates were highest for rural roads during fog/mist.

9.3.4.d Carriageway type

When comparing the sample of cars having accidents on single carriageway roads with those on dual carriageway roads, there was found to be no difference between the prevalence of degraded weather conditions. This was the case for France, Spain, Great Britain and Czech Republic. However in Greece, a greater proportion of cars involved in accidents on single carriageway roads had degraded weather conditions than those involved in accidents on dual carriageway roads (19% compared with 15%). In Great Britain, KSI car rates were found to be greatest on single carriageway roads when there was fog/mist or when snow with strong winds were present.

9.3.4.e Speed limit

Speed limit information was only available for Great Britain and Australia. In both countries, there was a very slight increase in the percentage of cars involved in accidents with degraded weather conditions on roads with higher speed limits compared to those involved in accidents on roads with lower speed limits.
In Great Britain, KSI car rates were the greatest for roads with speed limits 40mph (64 kph) or greater and when there was fog/mist or snow with high winds.

9.3.4.f Vehicle type

Across the countries analysed, a greater proportion of cars (Great Britain, France, Spin, Czech Republic & Australia) goods vehicles (Great Britain, France, Spain, Czech Republic, Australia & Greece) and minibuses (Great Britain, Spain) involved in injury accidents were found to involve degraded weather than other vehicle types.
In Great Britain, KSI car rates were greatest for powered two-wheelers and when there was fog/mist or snow with high winds.

9.3.4.g Vehicle manoeuvre

In Great Britain and France, 29% of injury vehicles were 'going ahead on a bend' during degraded weather conditions, compared with 23% or under for other types of manoeuvres in these countries. In Spain, 'going ahead' (bend not specified) was the vehicle manoeuvre which had the greatest prevalence of degraded weather (20% of injury vehicles compared with 16% and under for other manoeuvre types). In Greece, the manoeuvre with the greatest degradation was 'turning' (22% compared with 16% and under for other types). In the Czech Republic, Germany and Australia, manoeuvre data was not available (i.e. not collected in national database).
In Great Britain, the manoeuvres with the greatest KSI car rates were 'u-turn' and 'reversing', in particular during fog/mist or snow (with and without strong wind).

9.3.4.h Vehicle left the carriageway

In Great Britain, France, Greece and Spain, degraded weather featured more often when cars left the carriageway after losing control compared to those which did not, but only in Spain was there a noticeable difference (19% compared with 11%). In Australia, degraded weather featured more often when vehicles did not leave the carriageway. No data was available for Germany and the Czech Republic.

In Great Britain, the KSI car rate was greatest when the vehicle left the carriageway when there was fog/mist.

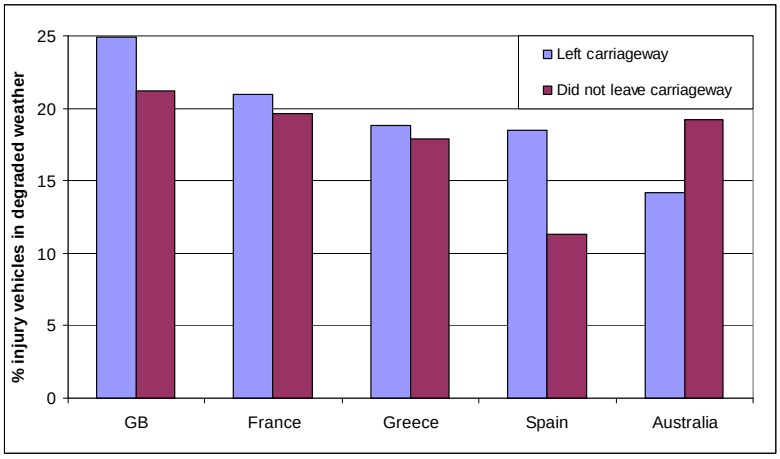


Figure 111: Prevalence of degraded weather conditions when passenger cars did/did not leave the carriageway during the accident (Europe and Australia data)

9.3.4.i Driver alcohol breath test

In Great Britain, Czech Republic and Spain, degraded weather conditions were slightly more prevalent when car drivers tested negative for alcohol (22, 23 & 20% compared with 18, 17 & 15% for positive tests). In France, Greece and Australia, there was little difference between the percentage of degraded weather present when drivers tested positive for alcohol compared to negative tests. No data was available for Germany.

In Great Britain, the KSI car rate was greater when driver alcohol tests were positive, but little difference in KSI rates was found between types of degraded weather.

9.3.4.j Driver age

In Great Britain and Australia, it was found that degraded weather was most prevalent when the driver of an injury car was under 20 years old. It was also found that as the age of the driver increased, the prevalence of degraded weather being involved in the accident decreased.

In France, Czech Republic and Spain, a similar correlation was not found. In Greece, the prevalence of degraded weather increased and peaked at the 50-59 age group.

In Great Britain, KSI car rates were greatest when the driver was less than 25 years old or greater than 70 years old and when there was fog/mist or snow and high winds were present.

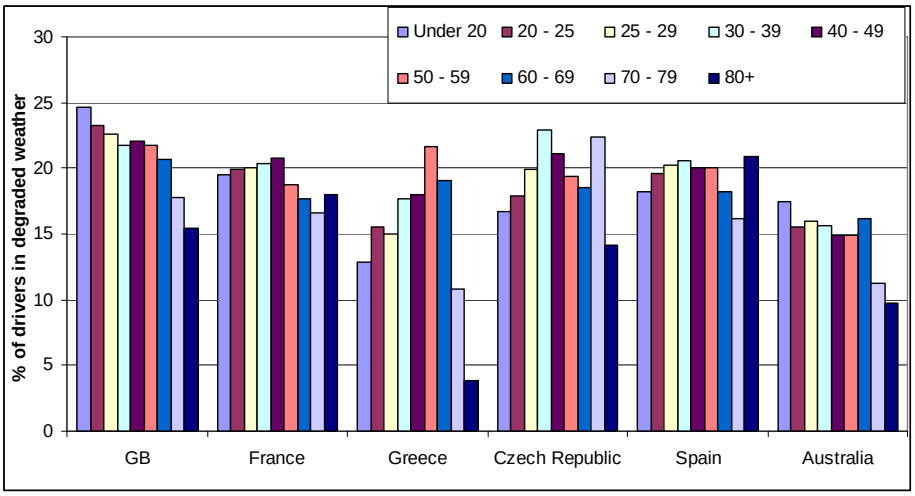


Figure 112: Prevalence of degraded weather conditions amongst passenger car drivers of various ages involved in accidents across Europe and Australia

9.3.4.k Driver gender

For Great Britain, France, Czech Republic and Australia, little difference was found between the percentage of degraded weather when the driver was male compared with when the driver was female. In Greece and Spain, the proportion of degraded weather when the driver was male was greater than when the driver was female.
In Great Britain, KSI car rates were greatest when the driver was male and when there was fog/mist.

9.3.4.l Summary

'Typical degraded weather accident scenario', as indicated by the European and Australian data
From the results found in the analysis of the characteristics of degraded weather accidents, the most typical 'degraded weather scenario' in the 6 countries included in the analysis were found to have the following characteristics:

Typical degraded weather accident scenario
• Single car accidents,
• Not at an intersection,
• Not on an urban road,
• Involved either a passenger car, goods vehicle or minibus,
• The vehicle was going ahead (i.e. not making a manoeuvre; GB, France and Spain only),
• Male driver (Greece and Spain only),
• Driver under the age of 20 (Great Britain and Australia only),

Degraded weather conditions were found to be just as prevalent when the vehicle did/did not leave the carriageway after losing control, for all speed limits and when drivers gave positive or negative breath tests.

'Killed and Seriously Injured'(KSI) rates in GB data
Using the analysis of KSI rates in Great Britain, the risk of serious or fatal injuries was found to be the greatest during either fog/mist conditions or high winds (often with snow) when the following accident characteristics were present:

Killed and Seriously Injured KSI in GB 2004
• car versus pedestrian accident,
• Not at an intersection,
• Single carriageway road,
• Roads above 40mph speed limit,
• Powered Two Wheelers (PTW),
• A vehicle undertaking a u-turn or reversing,
• A vehicle which left the carriageway after losing control,
• Driver gave a positive alcohol breath test,
• Driver under the age of 25 or over 70 years old,
• Male driver

9.3.5 Road surface conditions

Degraded road surface conditions = road surface contaminants (wet, snow, ice, flood, oil/diesel, mud, etc.) or defective road surface (cracks, bumps, holes, etc.)
When analysing road surface conditions, all seven countries had available data.
When analysing the various characteristics of 'degraded road surface condition' accidents for the six countries, it was found that more accidents occurred when the road surface was dry (60-84%), but

when the road surface was degraded, more occurred when the surface was wet or damp (15-37%). However, when KSI passenger car rates were analysed using Great Britain data, it was found that the presence of oil/diesel, surface defects, flood or frost/ice led to a greater proportion of KSI cars than other degraded road surface conditions.

9.3.5.a Accident configuration (vehicle involvement)

When investigating the type of vehicle involvement in accidents, it was found that for all countries analysed apart from Greece, a greater proportion of accidents involving a single car only occurred on degraded road surface conditions compared with other 'accident type. In Greece, degraded road surface conditions featured more often during two-vehicle accidents involving a car and a large vehicle.

In Great Britain, KSI accidents rates are generally greater for single car versus pedestrian accidents and when there was oil/diesel on the road or the road surface was defective.

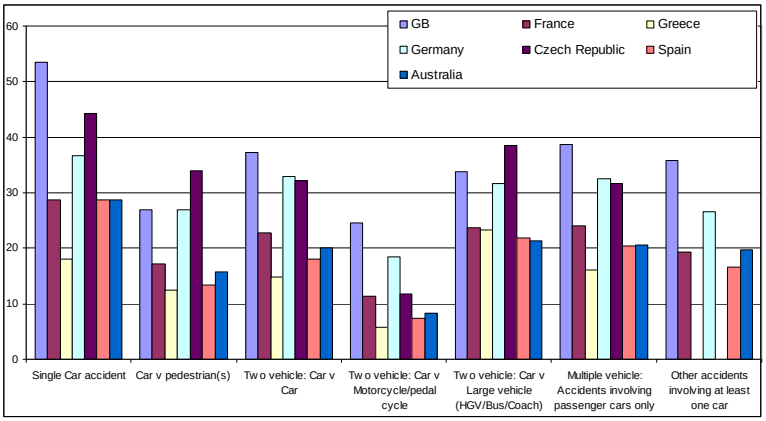


Figure 113: Frequency of degraded road surface conditions for different accident configurations (vehicle involvement) across Europe and Australia

9.3.5.b Intersections

When comparing the sample of passenger cars involved in accidents at intersections compared to those not at intersections, it was found that, for most countries, degraded road surface conditions were more prevalent at when cars were involved in accidents which did not occur at intersections than those occurring at intersections. Only 'intersection' data was available in the German data, so no comparison with 'no intersection' data could be made. Little difference was found when comparing the prevalence of degraded road surface conditions at accidents at different types of intersections.

In Great Britain, KSI car rates were generally greater when cars were involved in accidents not at intersections. However, KSI car rates were overall the greatest on slip roads when there was oil or diesel on the road or the road surface was defective.

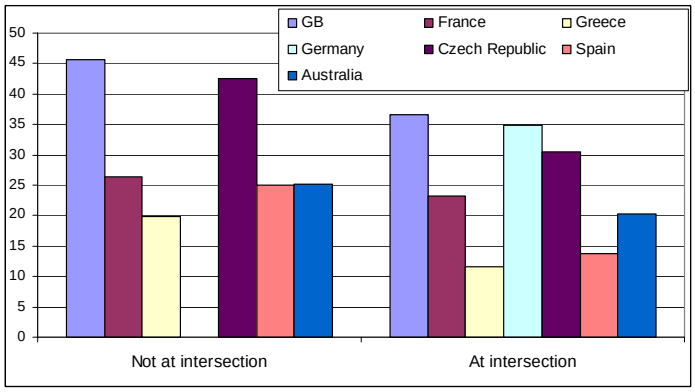


Figure 114: Frequency of degraded road surface conditions for vehicles involved in accidents at intersections compared with those not at intersections (Europe and Australia data)

9.3.5.c *Road type*

When comparing road type, in most countries analysed, a higher proportion of vehicles involved in accidents on rural (non-motorway) roads occurred on degraded road surface conditions than those on motorways and rural (non-motorway) roads. However, in Spain, degraded road surface conditions were more common when vehicles were involved in accidents on motorways, and in Australia, there was found to be little difference in the prevalence of degraded road surface conditions on the various road types.

In Great Britain, KSI car rates were lower when vehicles were involved in accidents on an urban road (2-12% compared with 7-18% on rural roads and motorways). Overall, KSI car rates were greater on rural roads when the road surface was defective.

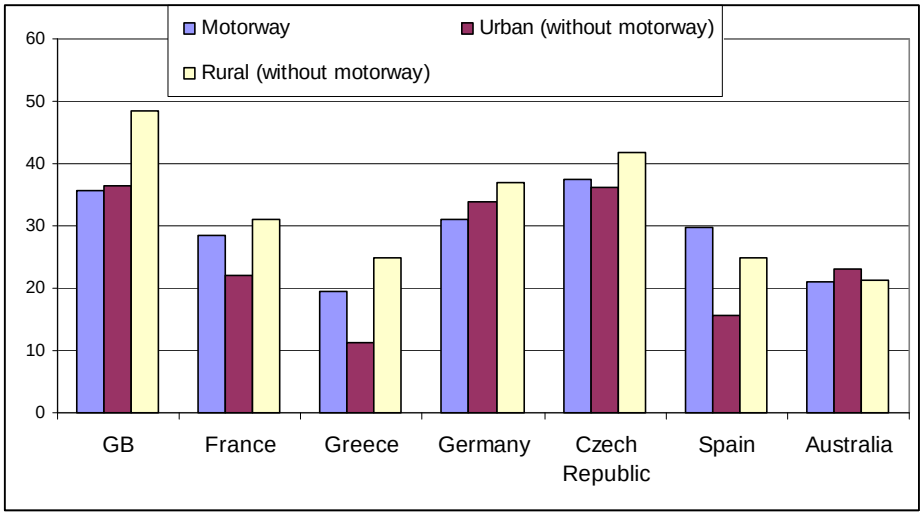


Figure 115: Frequency of degraded road surface conditions for vehicles involved in accidents on various road types across Europe and Australia

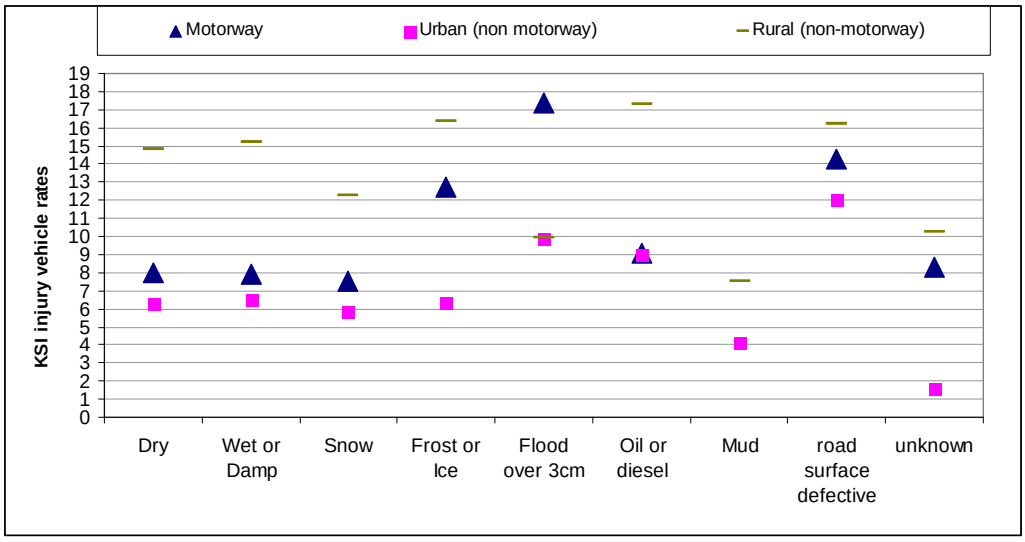


Figure 116: KSI rates for different road types on various degraded road surface conditions (GB data only)

9.3.5.d Carriageway type

In Greece, Great Britain and the Czech Republic, a greater proportion of injury vehicles involved in accidents on single carriageway roads involved degraded road surface conditions compared with vehicles involved in accidents on dual carriageway roads. In France and Spain, the proportion of degraded road surface conditions present when cars had accidents in single carriageway roads was similar to those on dual carriageway roads. 'Carriageway type' data from Germany and Australia was not available.

In Great Britain, KSI car rates were generally slightly greater on single carriageway roads compared with dual carriageway roads and when the road surface was defective.

9.3.5.e Speed limit

Speed limit information was only available for Great Britain and Australia. In Great Britain, 51% of cars involved in accidents on 60 mph (97 kph) roads involved degraded road surface conditions, compared with 34% - 42% for speed limits of 50 mph (80kph) or less. The percentage of degraded road surface conditions was also less for cars involved in accidents on 70mph (113 kph) roads (38%). In Australia, little difference was found between the various speed limits (20-25% degraded road surfaces for speed limits from 40-90kph).

In Great Britain, KSI car rates were generally greater for roads with speed limits of 60mph (97 kph) or greater, and when road surface defects were present.

9.3.5.f Vehicle type

Across all countries, a greater proportion of cars and/or goods vehicles were found to have had an accident on degraded a road surface compared with other vehicle.

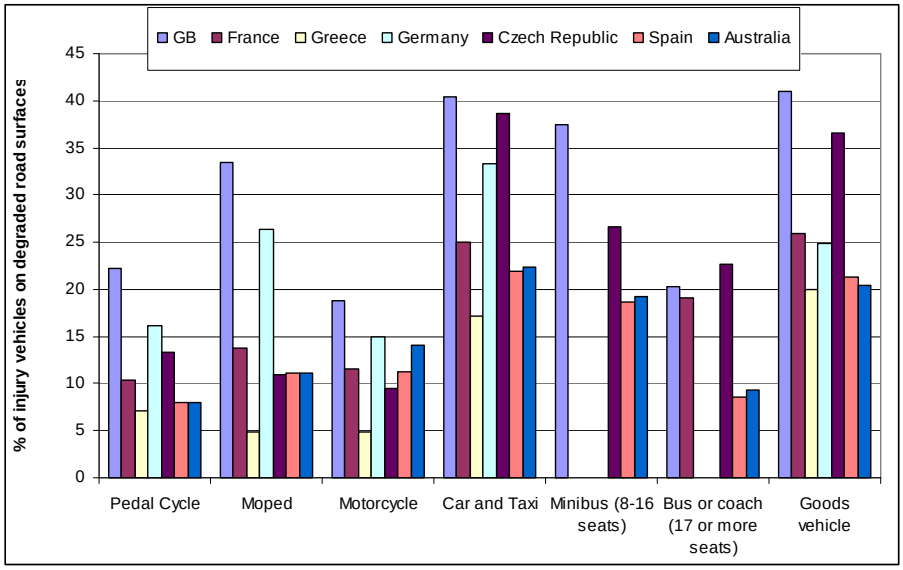


Figure 117: The prevalence of degraded road surfaces for different types of vehicles involved in accidents (Europe and Australia data)

In Great Britain, KSI car rates were greater when the vehicle was a motorcycle or goods vehicle and when there was a defective road surface.

9.3.5.g Vehicle manoeuvre

In France and Great Britain, a greater percentage of injury cars were on degraded road surfaces when going ahead on a bend compared with other types of manoeuvres. In Greece, degraded road surface conditions featured much higher when a car was 'turning' or 'going ahead' than other manoeuvres, whereas in Spain, cars 'stopping' and 'starting' were more likely to involve degraded road surface conditions. No manoeuvre data was available for Germany, Czech Republic and Australia (not in the national database).

In Great Britain, no major differences were found between KSI car rates for different vehicle manoeuvres, although rates were generally higher when the road surface was defective or there was oil or diesel on the road.

9.3.5.h Vehicle left carriageway

In Great Britain, France and Greece, degraded road surfaces were more prevalent when the vehicle left the carriageway during the accident. In Spain and Australia, degraded road surfaces featured more often when the vehicle did not leave the carriageway. No data was available for Germany and the Czech Republic.

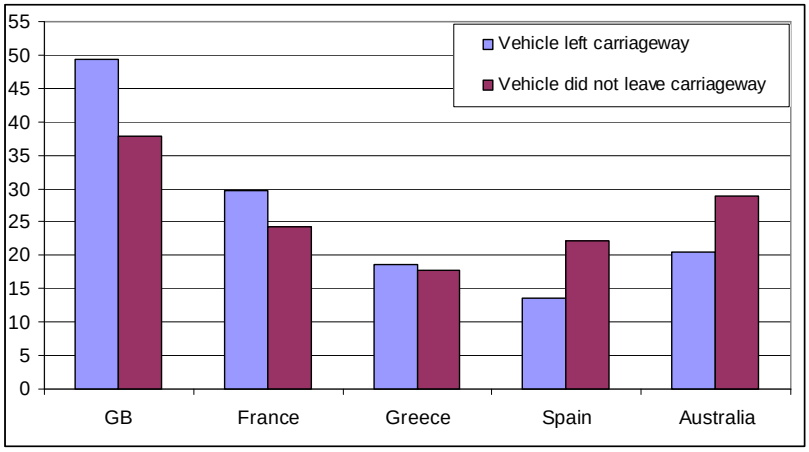


Figure 118: Prevalence of degraded road surface conditions when passenger cars did/did not leave the carriageway during the accident (Europe and Australia data)

In Great Britain, KSI car rates were the greatest when the vehicle left the carriageway on a dry road. When the road surface was degraded, the KSI car rate was greatest when the vehicle left the carriageway and the road was wet or damp.

9.3.5.i Driver alcohol test

In Great Britain, France, Greece, the Czech Republic and Spain, for drivers of injury cars who tested positive for alcohol, the proportion of degraded road surface conditions was slightly lower than for the sample of drivers who tested negative. In Australia, the percentage of degraded road surfaces was greater for drivers who tested negative. Only data for drivers who tested positive for alcohol was available for Germany, so no comparison could be made.

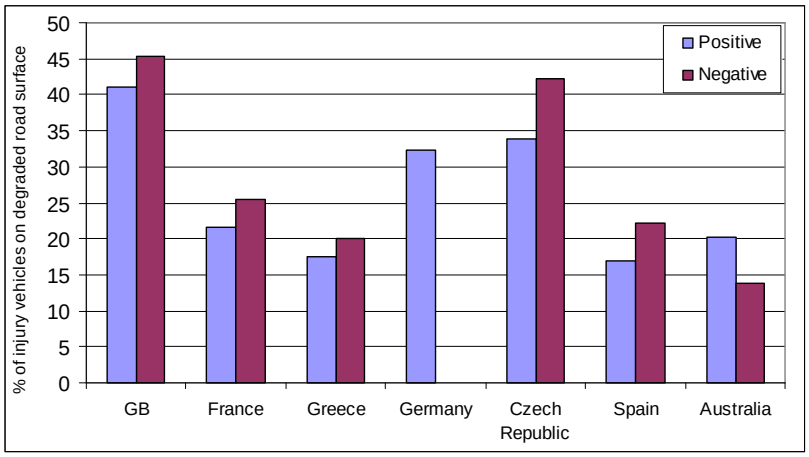


Figure 119: Prevalence of degraded road surface conditions when car drivers tested positive/negative for alcohol (Europe and Australia data)

In Great Britain, the KSI car rate was much greater for car drivers who tested positive for alcohol when the accident occurred on a road with poor surface conditions (20-33% KSI compared with 7 – 15% for car drivers who tested negative)

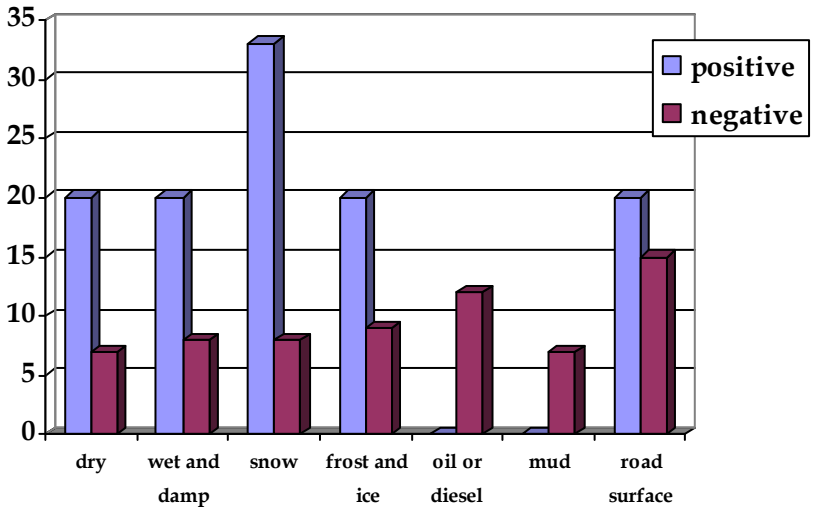


Figure 120: KSI car rates for various road surface conditions when drivers gave positive/negative alcohol breath tests (GB data only)

9.3.5.j Driver age

In France, Great Britain, Germany and Australia, the prevalence of degraded road surface conditions present when young car drivers were involved in accidents was greater than when older drivers were involved. In Greece and the Czech Republic, there was found to be an increase in the percentage of degraded road surfaces present up to the 50-59 driver age group. In Spain, similar proportions of the presence of degraded road surfaces were found for all driver age groups.

In Great Britain, the KSI car rate was greatest when drivers were over 70 years old (14% for 70-79 yrs & 20% for >80 yrs), and when either oil or diesel was present (16%) or the road surface was defective (17%).

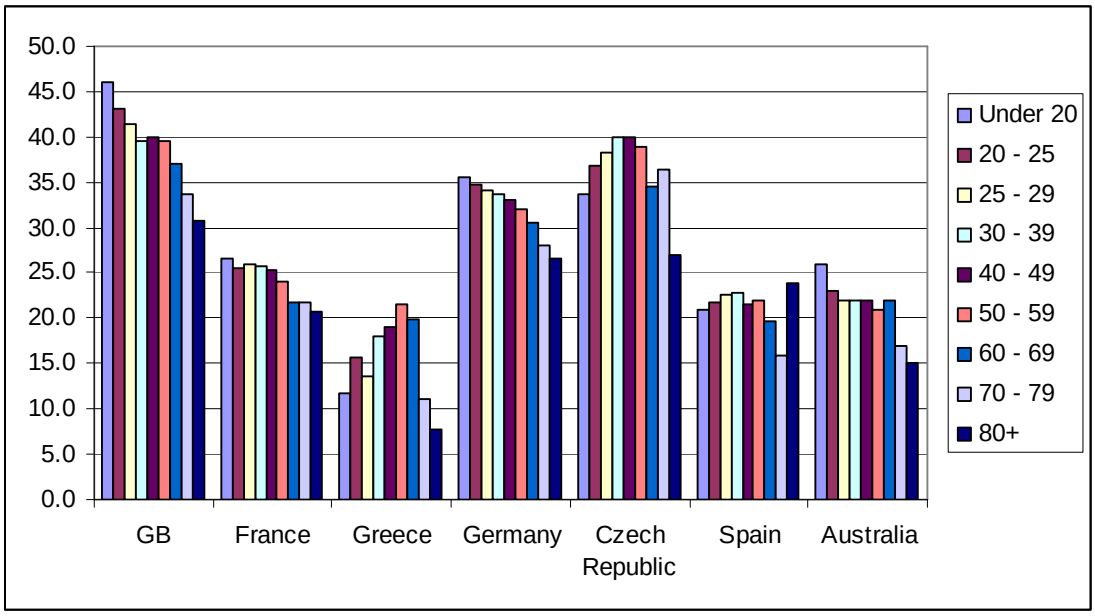


Figure 121: Prevalence of degraded road surface conditions amongst passenger car drivers of various ages involved in accidents across Europe and Australia

9.3.5.k Driver gender

In Great Britain, France, Germany, Czech Republic and Australia, there was found to be little difference between the prevalence of degraded road surfaces when the driver was male compared with when the driver was female. In Greece and Spain, degraded road surface conditions were slightly more prevalent when the driver was male.

In Great Britain, the KSI car rates were greater when the driver was male and when either oil or diesel was on the road or the road surface was defective (Figure 4-67).

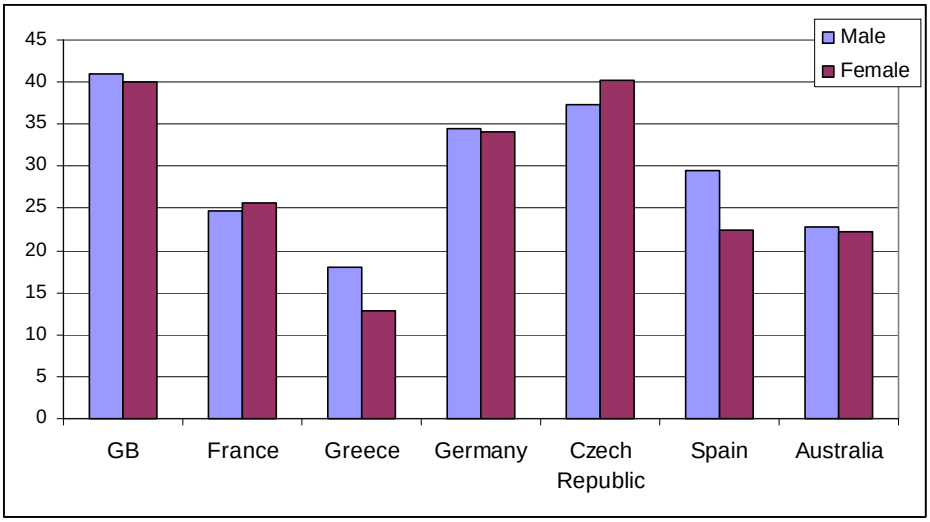


Figure 122: Prevalence of degraded road surface conditions amongst male and female passenger car drivers involved in accidents across Europe and Australia

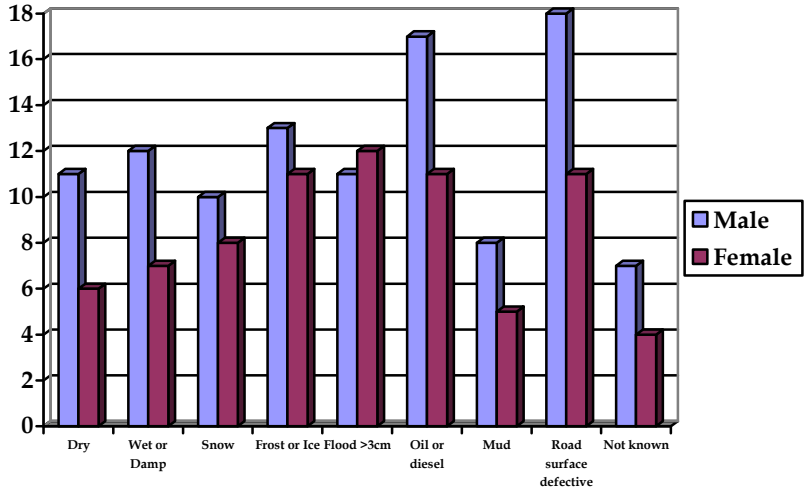


Figure 123: KSI car rates for various road surface conditions when drivers were male/ female (GB data only)

9.3.5.1 Summary

'Typical degraded road surface accident scenario', as indicated by the European and Australian data:

From the results found in the analysis of the characteristics of accidents with degraded road surface conditions, the most 'typical degraded road surface scenario' in the 7 countries included in the analysis were found to have the following characteristics:

Typical degraded road surface accident scenario

- Single car accident (apart from Greece),
- Not at an intersection,
- Rural road (apart from Spain and Australia),
- Single carriageway road (GB, Greece & Czech Republic),
- Road with a high speed limit (Great Britain only),
- Cars and/or goods vehicles,
- The vehicle was going ahead (i.e. no manoeuvre being undertaken – GB, France, Greece only),
- A vehicle which left the carriageway after losing control (Great Britain, France only),
- Driver gave negative alcohol breath test (all but Australia),
- Younger age groups (in Great Britain, France, Germany and Australia),
- Male driver (Greece, Spain only)

Degraded road surface conditions were found to be just as prevalent when the injury car driver was male compared to when the car driver was female. The most frequent degraded road surface condition was wet/damp.

'Killed and Seriously Injured' (KSI) rates in GB data

Using the analysis of KSI car rates in Great Britain, the risk of serious or fatal injuries was generally found to be the greatest when there was oil/diesel on the road or the road surface was defective and

when the following accident characteristics were present:

Killed and seriously Injured

- Car versus pedestrian accident,
- Not at an intersection,
- Rural (non-motorway) road or motorway,
- Single carriageway road,
- Speed limit great than ≥60mph,
- Motorcycle or goods vehicle,
- A vehicle which left the carriageway after losing control,
- Driver gave positive alcohol breath test,
- Driver over 70 years old,
- Male driver.

The manoeuvre of the driver made no difference to the KSI car rates in Great Britain.

9.3.6 Carriageway hazards

Degraded = when carriageway hazard(s) were present (e.g. discarded vehicle load, object in road, animal in road, road-works…)
When analysing carriageway hazards, five countries had available data (Greece, Great Britain, Australia, Germany and Spain), although two of these countries (Germany and Spain) only had data related to the presence of road-works.
For many of the tables where data was available, only small numbers of cases occurred in 2004, so only limited analysis could be undertaken.

9.3.6.a Accident configuration

In Great Britain, Greece and Australia, carriageway hazards were found more often in single car accidents than other accident configurations. In Spain, 'car versus large vehicle' accidents had a larger proportion of carriageway hazards than other accident configurations. No/little data was available for France, Germany and the Czech Republic.
In Great Britain, KSI accident rates were generally greater for 'car versus pedestrian' accidents or 'car versus motorcycle/pedal cycle' accidents. In general, KSI accident rates were also greater when the carriageway hazard was a 'previous accident'.

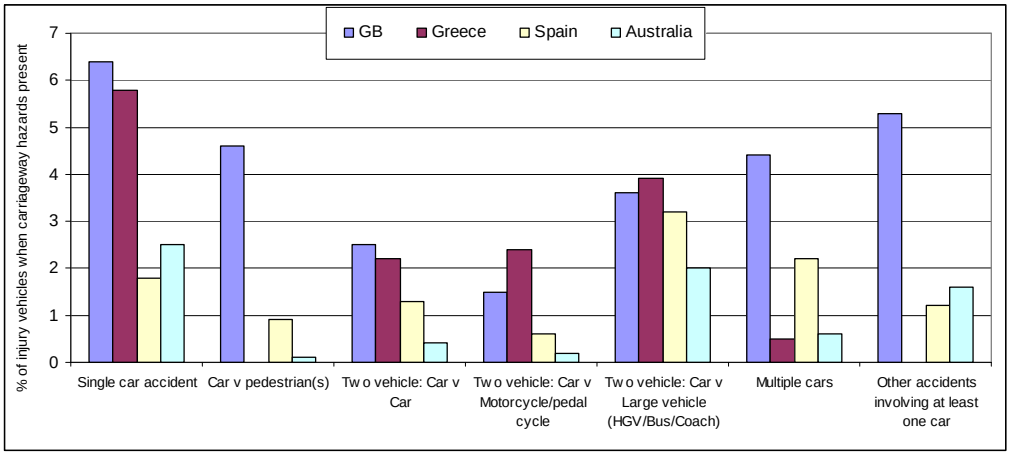


Figure 124: Frequency of 'carriageway hazards present' for different accident configurations (vehicle involvement) across Europe and Australia

9.3.6.b Intersections

In Greece, Australia, Spain and Great Britain, cars involved in accidents at intersections were less likely to involve carriageway hazards than those not a intersections. No data was available for Germany, France and Czech Republic.

In Great Britain, KSI car rates were generally higher when the vehicle was not at an intersection and also when there was no carriageway hazard (13%). When a carriageway hazard was present at an intersection, KSI rates were greatest when at a private drive and the hazard was a previous accident, dog on road or 'other' unspecified object, and when at a multiple junction when there was an animal on the road.

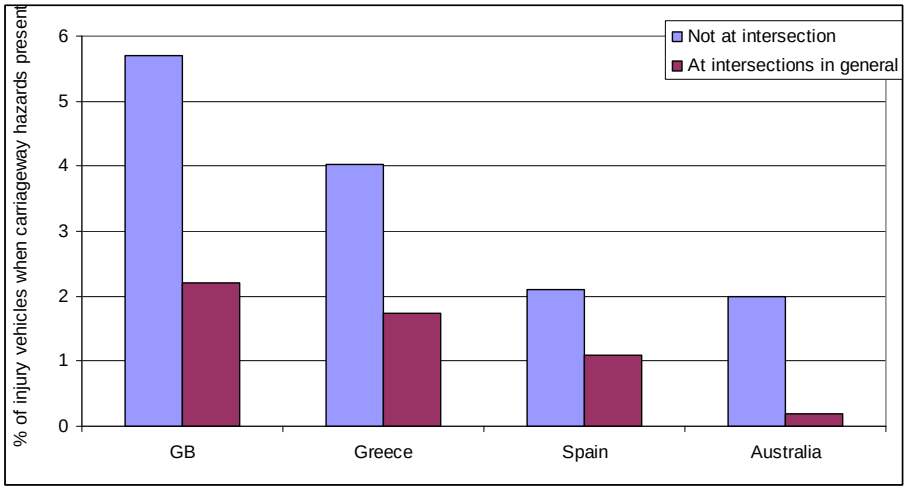


Figure 125: The prevalence of carriageway hazards for vehicles involved in accidents at intersections/non-intersections (Europe and Australia data)

9.3.6.c Road type

In Greece, Spain, Great Britain and Australia, cars which had an accident on an urban road involved carriageway hazards less often than those on rural roads and motorways.

In Great Britain, KSI car rates were greater on motorways and less on urban roads. No specific carriageway hazard had greater KSI levels.

9.3.6.d Carriageway type

In Greece, Great Britain and Spain, no differences were found when comparing the prevalence of carriageway hazards when vehicles had an accident on single carriageways compared with dual carriageways. No data was available for France, Germany, Australia and the Czech Republic.

In Great Britain, KSI car rates were greater when the vehicle had an accident on a single carriageway road and when there was a previous accident or an animal/pedestrian was present.

9.3.6.e Speed limit

Speed limit data was only available for Great Britain and Australia. In Great Britain, the prevalence of carriageway hazards was the greatest for accidents on 70 mph (113 kph) roads. In Australia, cars involved in accidents on roads with a speed limit of 90kph or greater involved a greater proportion of carriageway hazards.
In Great Britain, KSI car rates were greater on 60 mph (97 kph) and 70mph (113 kph) roads when, in particular when 'other object', 'animal on road' or 'previous accident' was the carriageway hazard.

9.3.6.f Vehicle type

In Great Britain, carriageway hazards were present more often when the vehicle involved in the accident was a goods vehicle or a minibus. In Spain, it was a goods vehicle, while in Greece, it was a goods vehicle or a bus/coach. In Australia, it was a motorcycle or a buses/coach. No data was available for Germany, France and the Czech Republic.
In Great Britain, KSI vehicle rates were greatest for motorcycles, goods vehicles and minibuses, in particular when the hazard was an animal on the carriageway.

9.3.6.g Vehicle manoeuvres

In Great Britain, Greece and Spain, little difference was found in the proportion of carriageway hazards present for all manoeuvre types. No data was available for Germany, Australia, France and the Czech Republic.
In Great Britain, there was little difference in KSI car rates for all manoeuvre and carriageway hazard combinations.

9.3.6.h Vehicle left carriageway

In Greece, carriageway hazards were present more often when vehicles left the carriageway compared vehicles which did not. In Great Britain, Spain and Australia, there was found to be little difference between the percentage of carriageway hazards present when vehicles left the carriageway and when they did not. No data was available for France, Czech Republic and Germany.
In Great Britain, KSI car rates were greater when the vehicle left the carriageway compared with KSI rates when the vehicle did not leave the carriageway, in particular when road works were present.

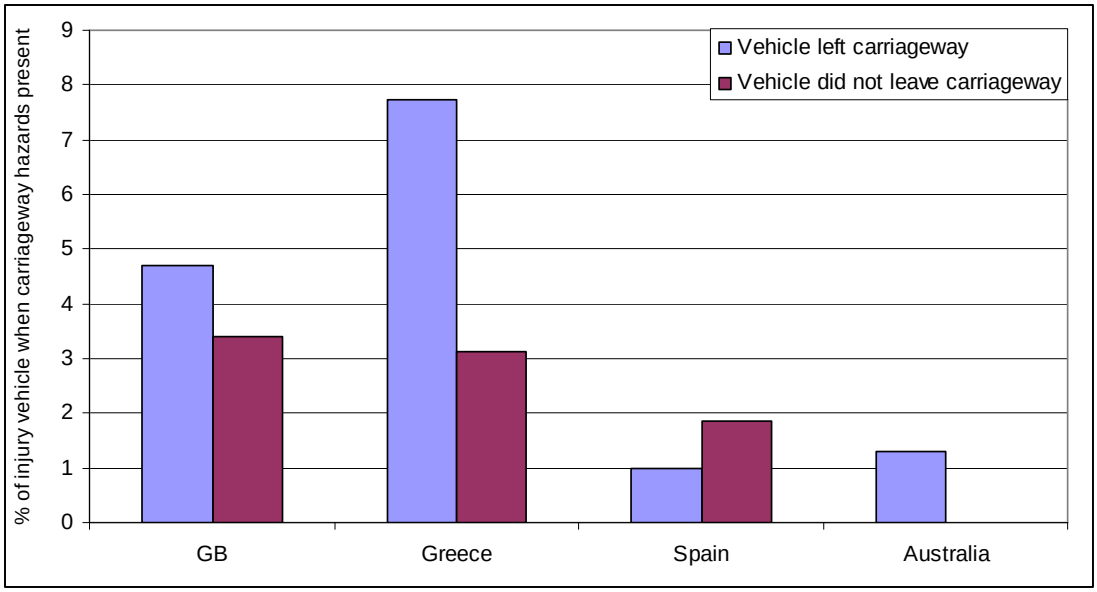


Figure 126: Prevalence of carriageway hazards when passenger cars did/did not leave the carriageway during the accident (Europe and Australia data)

9.3.6.i Driver alcohol breath test

In Greece, Great Britain, Australia and Spain, similar proportions of 'carriageway hazards' were found when drivers tested positive for alcohol compared with drivers who tested negative. No data was available for France, Germany and the Czech Republic.
In Great Britain, KSI car rates were greater when the driver tested positive for alcohol and when there was a 'previous accident' or 'dog in the road'.

9.3.6.j Driver age

In Greece, Great Britain, Spain and Australia, similar proportions of 'carriageway hazards' were present in accidents involving drivers of all ages, although in Great Britain, there was a minor decrease the older the driver was. No data was available for Germany France and the Czech Republic.

In Great Britain, KSI car rates were greater when the driver was under 20 years old and also when a vehicle load had been dislodged onto the carriageway.

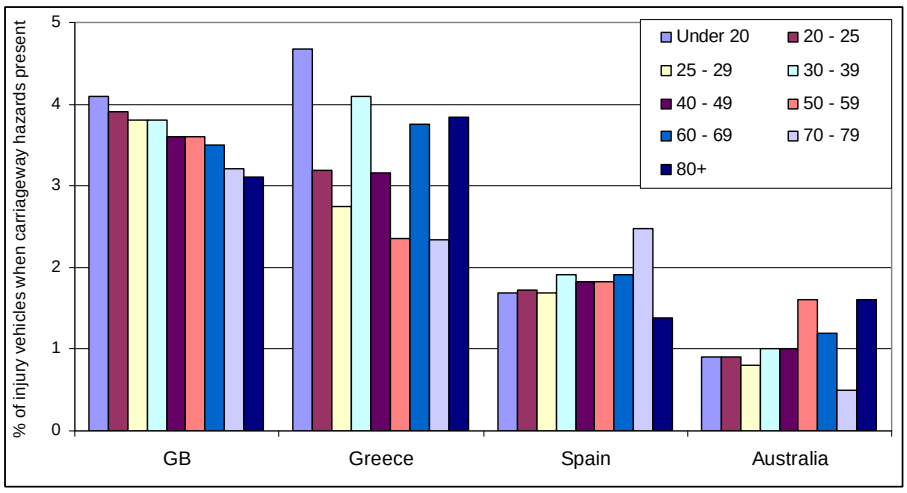


Figure 127: Prevalence of carriageway hazards for passenger car drivers of various ages involved in accidents across Europe and Australia

9.3.6.k Driver gender

In Greece, Great Britain, Spain and Australia, similar proportions of 'carriageway hazards' were present in accidents involving male and female drivers No data was available for Germany, France and the Czech Republic.

In Great Britain, KSI car rates were greater when the driver was male and an 'other' (unspecified) object was present on the carriageway.

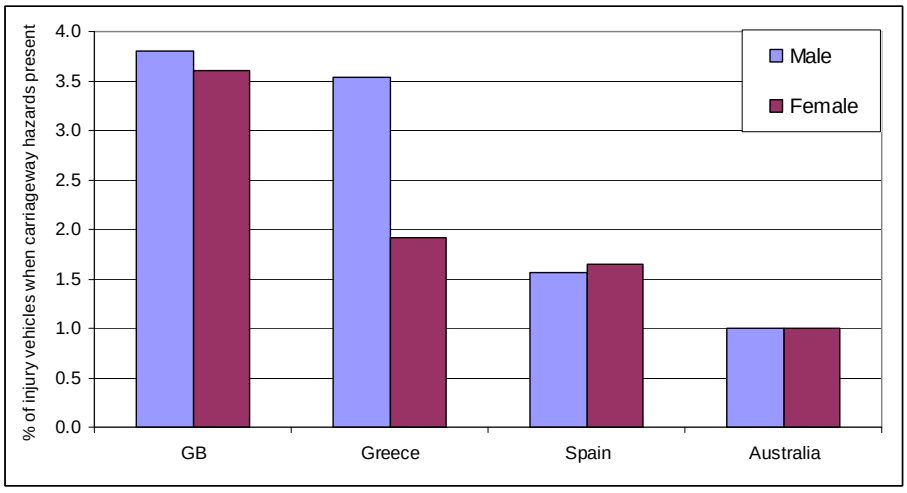


Figure 128: Prevalence of carriageway hazards amongst samples of male and female passenger car drivers involved in accidents across Europe and Australia

9.3.6.1 Summary

'Typical carriageway hazard accident scenario', as indicated by the European and Australian data
As opposed to the three other types of 'degradation' analysed in this study, the results were not as conclusive to enable a typical carriageway hazard scenario to be defined. For one reason, the number of cases in the samples were much smaller, and also, data was only available from 4 countries (information regarding carriageway hazards were not included in the other countries' databases). However, from the limited data available, the most typical scenario was found include the following characteristics:

Typical carriageway hazard accident scenario
• Single car accidents,
• Involved either a goods vehicle, bus or motorcycle,
• Not at an intersection,
• Rural road or motorway,
• High speed roads (90-113kph),
• A vehicle which left the carriageway after losing control (Greece only),

Carriageway hazards were found to be just as prevalent on single and dual carriageways, for all types of manoeuvres, for a positive and negative alcohol breath test, and for all driver ages and genders.

'Killed and Seriously Injured' (KSI) rates in GB data
Using the analysis of of KSI rates in Great Britain, the risk of serious or fatal injuries was generally found to be greatest when the carriageway hazard was an 'animal', 'previous accident' or 'other (non specified) object' and when the following accident characteristics were also present:

Killed and seriously Injured KSI in GB 2004
• Car versus pedestrian/motorcycle/bicycle;
• Not at an intersection,
• Motorway,
• Single carriageway road,
• Speed limit greater than 60mph (97kph);
• Involved either a motorcycle, goods vehicle or minibus,
• A vehicle which left the carriageway after losing control,
• Driver gave a positive alcohol breath test,
• Driver under the age of 20,
• Male driver.

9.4 Conclusion

From the analysis undertaken to investigate the typical characteristics of 'degradation' accidents, it was found that, overall, degraded lighting was more prevalent in car accidents involving one single car or a single car and a pedestrian, when the vehicle was 'going ahead' (i.e. not performing a specific manoeuvre), when the driver gave a positive alcohol breath test, was under 25 years old and/or when the driver was male. Degraded lighting was more prevalent when the vehicle in the accident was either a car or a moped. Degraded lighting was no more or less prevalent when investigating other accident characteristics.

Degraded weather was more prevalent in car accidents involving one single car, when the vehicle was not at an intersection, not on an urban road and more often when the vehicle was going ahead (i.e. not performing a specific manoeuvre). Degraded lighting was more prevalent when the vehicle was a car or a goods vehicle. In some but not all countries, degraded weather conditions were more common on roads with higher speed limits (>90kph), when the vehicle left the carriageway after losing control, when the driver was male, was under the age of 20 and/or when the driver gave a negative alcohol breath test.

Degraded road surface conditions were more commonly present in single car accidents, when vehicles were not at an intersection at the time of the accident, when the road was not an urban road and when drivers gave a negative alcohol breath test. Cars and goods vehicles were more often involved in accidents on degraded road surfaces. In some but not all countries, degraded road surface conditions were more prevalent on single carriageway roads, on roads with higher speed limits (97kph), when the vehicle was not making a specific manoeuvre (i.e. 'going ahead'), when the vehicle left the carriageway after losing control and when the driver was young (when compared to drivers over 50 years old) and/or male.

Data concerning carriageway hazards were only available from 4 countries and the number of cases was much smaller than for other degraded conditions. From the data available, it was found that carriageway hazards were present more often in single car accidents in three of the countries (Great Britain, Greece and Australia) and in the fourth country (Spain), it was accidents involving a car and a large vehicle. However, in all four countries, the difference was no more than 2%. In the four countries, carriageway hazards were present more often when vehicles were involved in accidents not at an intersection compared to those at an intersection (1-3.3% difference) and/or when it was not an urban road (i.e. rural or a motorway) (1.5-13% difference). In the only two countries where speed limit data was available, carriageway hazards were more prevalent when cars had accidents on high speed roads (>90kph). While across all four countries, accidents involving goods vehicles, minibuses, bus/coaches and motorcycles were more likely to be involved in an accident with a carriageway hazard (1-3% difference). Little difference was found in the prevalence of carriageway hazards when the driver did/did not test positive for alcohol, when the driver was old/young and when the driver was male/female.

10 General conclusion and discussion

The overall objective of this report is to improve the knowledge on road accident causation from pre-accidental driving situation point of view. The idea is to give a better understanding on what happen in accident focusing the analysis on the phase just prior of the accident for each road users involved. The analysis is related to the "actors" and not to the accident. The causes are then identified for every participant. This identification of causes requires detailed information on the road accidents only available in disaggregated data collection (in-depth road accidents databases). If these databases gather very detailed parameters on the accident (to identify the accidental and injury mechanisms), they are collected on a delimited territory which in most of the cases is not representative of the overall road injury accidents.

If determining the accident causes is an important part of the road safety improvements, it is also necessary to have an idea of the magnitude (in term of occurrence, victims, fatalities, etc) that they represent. This prevalence allows ranking by priority the causes. Another criterion can be found from the risk analysis identifying the most exposed population related to a potential danger, inherent to the studied situation.

From the points previously exposed, we proposed to conduct the accident causation analysis on a dedicated methodology based on the three complementary approaches:

- A statistical analysis describing the different pre-accidental driving situations studied here from aggregated data. The objective is to identify among these situations those who are most represented and to describe them with general statistics as much as possible at the EU27 level.
- An in-depth analysis identifying from the previous selected situations the relevant causes using disaggregated data. The aimed objective here is to determine and to understand what the related problems are.
- A risk analysis describing among the population concerned by these situations those which present an higher risk compare to others.

The present report concerns only the first part of the methodology based on the overview and the general statistics about pre-accidental driving situation.

This descriptive analysis was conducted in the same way on the 4 pre defined type of situations:

- Accidents in intersection
- Stabilized situations
- Specific manoeuvres
- Degraded situation

These generic types cover the vast majority of situations which may occur in road injury accidents. Certain atypical accidents or situations will never fit into a fixed classification.
In order to simplify the accident causation analysis, the first three situations have been defined without overlap, i.e. if a situation is included in one type, it is not included in another one. The exception is for the degradation scenarios because the interest is to focus the analysis on the situation with one of the contributing factor (the environmental degradation) already known.

For each pre defined situations, this study has these objectives for each type of situations:

- To define the scope, in order to identify what accidents are concerned
- To make a literature review to know the state of art
- To characterize the relevant injury accidents with some general statistics
- To classify these accident into scenarios (except for degraded situations).

This present analysis is based on aggregated data such as national road injury accidents census or European databases (CARE, IRTAD, etc).

The results are given from the data available in TRACE via WP8, and are extended to EU25 or EU27 when possible. However, because the data are not available for all the European countries, these extensions have to be considered as estimations.
The most important results regarding each pre-defined type of situations are the following:

10.1 Main results

Situations in intersection:

This situation concern all road users involved in injury accident occurring at intersection/junction.

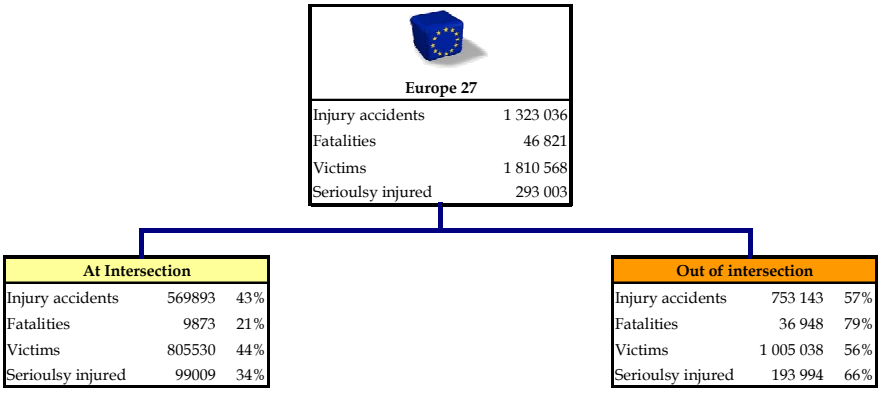
From the literature review, the thematic on the intersections is one of subjects most often approached.

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 to 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:



In the EU27, the accidents in intersection represent:

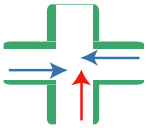
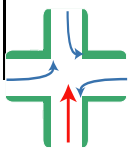
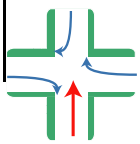
- 43% of the total number of injury accidents.
- 21% of the overall fatalities (1% of the casualties in intersection)
- 34% of severely injured (11% of the casualties in intersection)

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.

All intersection except "rear end" and pedestrian crash scenarios					
"cutting" scenarios : the oncoming vehicle comes from the left or the right		turn scenarios LTIP (Left turn into path) LTAP (Left turn across path) and RTIP (Right turn into path) RTAP (Right turn across path)			
Scenario 1.1		**Scenario 1.2**		**Scenario 1.3**	
	Crossing paths, No manoeuvres, The OV vehicle comes from left or right		Crossing path or oncoming vehicle with one driver turns left (right in GB)		Crossing path or oncoming vehicle, with one driver turns right (left in GB)

Stabilized situations:

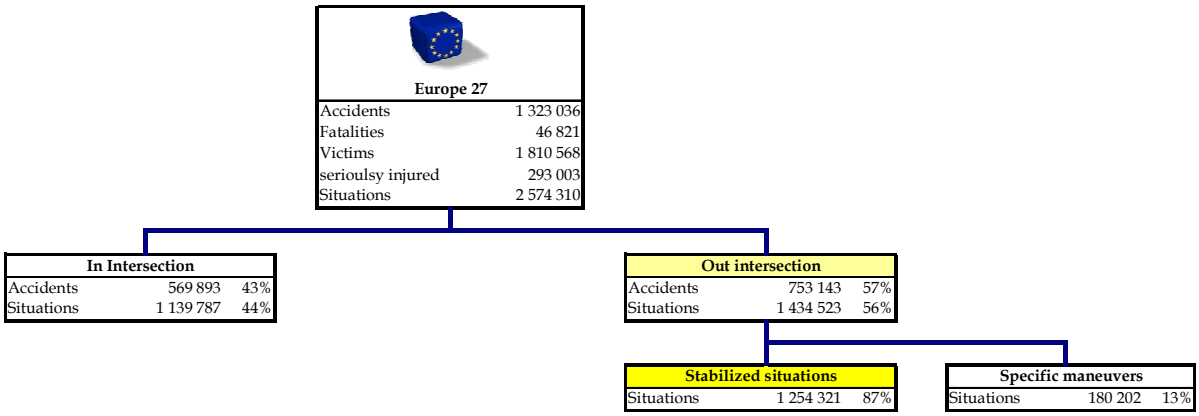
A stabilized situation is defined as the driving situation just prior the accident that can be considered as “normal”, i.e. a situation in which a driver/rider does not have any difficulty in the driving task, and without any particular or abnormal solicitation. All stabilized situation occurred in intersection are here excluded.

In our sample, we can find situations where the driver is confronted to another road user reducing his driving space (overtaking manoeuvre made by the opponent, pedestrian walking along the road, vehicle moving slowly in front during night time, etc), lane departure or loss of control (at the origin of the accident and not as a consequence of a specific manoeuvre made by the driver).

The literature dedicated to this specified situation is very poor, firstly because most of the studies about causes focus their analyse at the accident level and not at the road users level (most of time the driver who is in stabilized situation is confronted to another road user making a particular manoeuvre), and secondly because we can suppose that these drivers are “passive” and sustain more than instigate the accident.

The only exception is for the lane departure and vehicle alone accidents.

From the general statistical approach, the main results are the following:

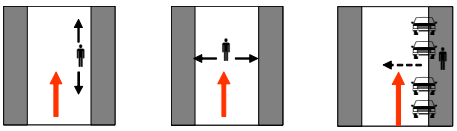


In EU27, the stabilized situations represent:

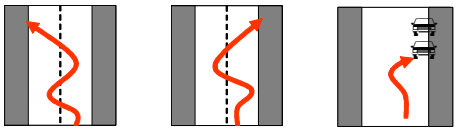
- 49% of the total number of situations.
- 33% of the total number of injury accidents in Europe (estimation relying on results coming from Spain, UK, France, Greece and Czech Republic)

The 'final stabilized scenarios' are:

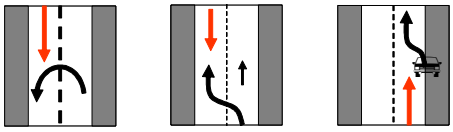
- **Situation 1:** a driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian. This situation can be drawn in the following figures which shown this situation (red arrow):



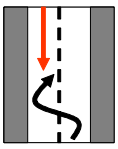
- **Situation 2:** a driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident. This situation is shown in the following figures (red arrow):



- **Situation 3:** a 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, as the following figures show (red arrow).



- **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, as the following figures show (red arrow).



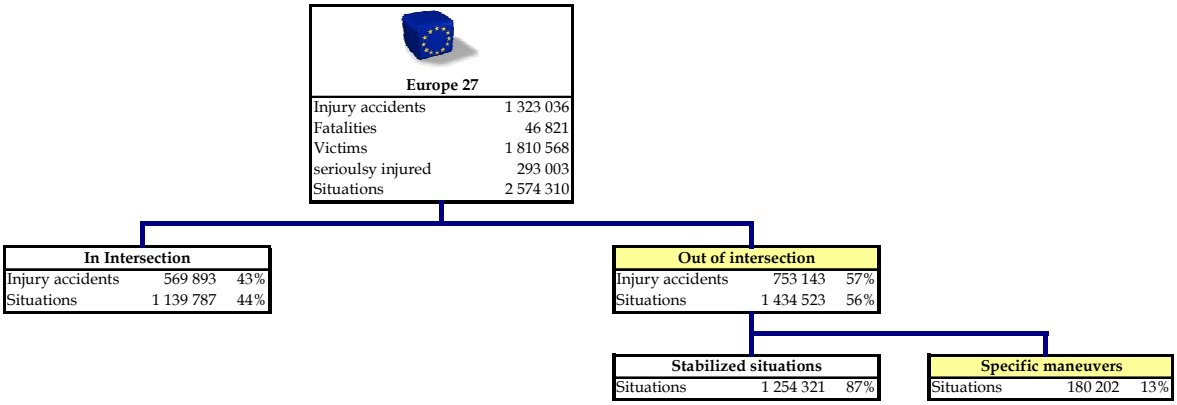
Specific manoeuvres situations:

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 identification of the relevant scenario revels that the top 3 ranking in term of severity (KSI) are the following

rank	KSI	Scenario
1	21%	Scenario 1: **Overtaking**
2	17%	Scenario 2: **Turning left**
3	17%	Scenario 3: **U-turning**

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:

(c) 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);
(d) 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).

The extensive literature review that was undertaken discovered research in a variety of different topic areas. The types of studies that were found related to the effects of weather and lighting conditions on driver behaviour and accident risk. These studies related to both driver visibility and driver control of the vehicle. Up to now, little relevant research has been found on the effects of degraded road layout, degraded road maintenance or the presence of carriageway hazards. This is true for any research that has been published in the public domain. It suggests that further research in these areas is needed to determine if these accident causation factors are issues or not.

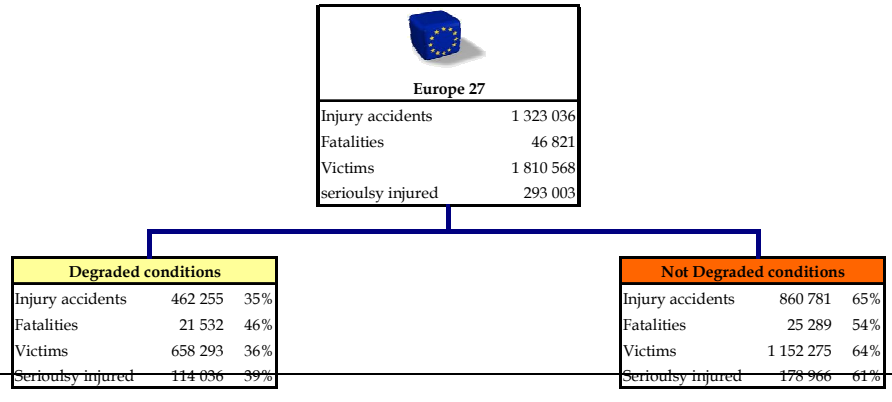
The main findings from the literature relate to behaviour studies and simulation model studies.
Where relevant studies were not identified in certain areas (i.e. degraded visibility due to obstruction on road or roadside, road defects and road obstacles which suddenly degraded the control of the vehicle (e.g. debris or animals)), a brief review of the UK OTS database, as an example, showed that although relevant literature was not found, these type of accidents do occur. Although they are more rare than other accident types, it could still be useful to undertake further investigation of these types of accidents.

From the overview of published results in Road Casualties Great Britain 2004 which are related to accidents in degraded road conditions, the results implied that:

- More accidents occur during daylight;
- Road surfaces are more likely to be wet or flooded in an accident than any other type of road surface degradation;
- The likelihood of a road user driving on a degraded road surface (e.g. wet..) being involved in an accident increases greatly during darkness;
- The likelihood of a road user driving during degraded weather conditions being involved in an accident increases greatly during darkness;
- This implies that the combination of darkness with degraded road and/or weather conditions greatly increases the risk of an accident occurring;
- Skidding on dry roads are more likely and two wheel vehicles and buses are more likely to skid during dry conditions than cars.

Studies which have investigated rates of 'degradation' accidents have found that, across Europe, poor weather conditions were present in 18% of all accidents and approximately 30% of accidents occurred in darkness.

From the general statistical approach, the main results are the following:



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)

Regarding scenarios elaborated in this first step of the global analysis, there are only available for intersection accidents, specific manoeuvres and stabilized situations.
In each type of situations, and when it was possible, we tried to rank the different scenario following the KSI parameter. This is the case only for the two first situations.

For the main specific degradations, some characterization has been identified.

The four following classes has been determined:

Typical degraded lighting accident scenario

- Single car accident (also car versus pedestrian accident in the Czech Republic and Australia),
- Involved either a car or a moped,
- The vehicle was going ahead (i.e. not turning, overtaking, starting, stopping…) (Great Britain, France, Spain only)
- Dual carriageway road (Greece, Czech Republic only)
- Driver gave positive alcohol breath test,
- Driver under the age of 25,
- Male driver.

Typical carriageway hazard accident scenario

- Single car accidents,
- Involved either a goods vehicle, bus or motorcycle,
- Not at an intersection,
- Rural road or motorway,
- High speed roads (90-113kph),
- A vehicle which left the carriageway after losing control (Greece only),

Typical degraded weather accident scenario

- Single car accidents,
- Not at an intersection,
- Not on an urban road,
- Involved either a passenger car, goods vehicle or minibus,
- The vehicle was going ahead (i.e. not making a manoeuvre; GB, France and Spain only),
- Male driver (Greece and Spain only),
- Driver under the age of 20 (Great Britain and Australia only),

Typical degraded road surface accident scenario

- Single car accident (apart from Greece),
- Not at an intersection,
- Rural road (apart from Spain and Australia),
- Single carriageway road (GB, Greece & Czech Republic),
- Road with a high speed limit (Great Britain only),
- Cars and/or goods vehicles,
- The vehicle was going ahead (i.e. no manoeuvre being undertaken – GB, France, Greece only),
- A vehicle which left the carriageway after losing control (Great Britain, France only),
- Driver gave negative alcohol breath test (all but Australia),
- Younger age groups (in Great Britain, France, Germany and Australia),
- Male driver (Greece, Spain only)

10.2 Discussion

The main difficulty appeared while performing the descriptive analysis (difficulty shared by all the operational work packages) remains on the data available for each country of the EU27.

The objective of the intensive databases is to collect data on individual accidents as collected by each Member States. The principle of this common database is to gather all accidents with a high level of disaggregation. Of course, quantity and detailed are more often not compatible and have a high influence on the structure of the database, i.e. on the data to collect. This is the case for CARE.

However, if the creation of this common database is very useful, it arises some difficulties:

- In the European Union in constant growing, the information on the new member states are not available right now. Today, where the road traffic safety is one of the main preoccupation in the EU, why the immediate contribution to the accident collection is not a necessary condition ?
- The access to the data. It is true that these databases have to have a restricted access. The data manipulation has to be done by experts. This is the case for CARE. Unfortunately, only one institute by member states have the right to make request on it. Of course, some indicators are available and update every year (e.g. Safetynet), but not on all the data available.

Another difficulty arises on the exposure data. A very difficult question, for which the Safetynet project has dedicated a specific work package.

From this study realized in WP2, it has taught us many things that we can summarize in the following, using a "SWOT" analysis:

Strengths

- Because the comprehension of an accident cannot be limited to the identification of the general causes (more often relied on the responsibility of the such or such implied), the idea proposed here is to analyse the situations of each participant instead of the whole accident. This approach offers opportunities to determine what are the problems for each road users involved in the same accident, to identify their needs and to find solutions (counter-measures) for each of them, whether they are at the origin of the accident or simply present in the bad place at the wrong time.
- The concept of scenario: The scenarios based on the pre accidental situation allow to cluster on the same class situations presenting similarities. This approach offers the opportunity to be able to work either in a global way but by taking advantage specificities brought by every typology. The efforts and the progress in safety being today more and more expensive because requiring evolved technologies, this braking down of the problem would allow to offer progressive counter measures that could be upgraded according to the technological progress during time.
- From scenario, some performance indicators dedicated to each typology can be defined, allowing to follow their evolution year by year.
- Today, there are multiple safety systems on the market. For some their potential efficiency was demonstrated, for of the other one it still remains to prove. To assure a bigger and equitability safety for all, the temptation is big to want to equip our vehicles with a multitude of these systems, just in case... However, the only question that we are entitled to arise is the following ones: are these safety systems solve to the real problems or answer to the real driver needs?. Are there main problems having no solution? An answer can be given with this analysis.

Weaknesses

- The analysis is made on available countries (essentially in West part of Europe where the road traffic safety is now is a "standard") which can not be considered, to a certain extent, as representative of the EU27. However, a lot of efforts have been in analysing data in a few countries, and/or to expand data at the closest European level achievable.
- The differences between the countries are not well visible for the road traffic safety problems. Effectively the needs in term of safety devices/measures can be not the same following the countries.
- The concept of scenario, easily to understand, can make hide complicated accidental mechanisms, that will be further described in Deliverable D.2.1.

Opportunities:

- Update of the knowledge on accident causation with an original approach relying on 3 different and complementary points of view to analyse the accident (road users, type of situations and risk factors).
- The concept of situation allows us to make a more complete study of the accident causes by identifying for each road users involved its degree of participation. This analysis could help the decision maker to find more appropriate counter-measures instead to base its opinion on a unique overall point of view.
- The lack of data put in evidence in this report can be a good opportunity to improve the information system on road traffic accidents by identifying the real needs to perform a good analysis. This could be a good opportunity to complete the Safetynet approach in its definition of a "European standard" for both descriptive and exposure data.

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12 Annex I
Available sources for the descriptive analysis

