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Accident causation and pre-accidental driving situations. Part 3. Summary report

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Abstract:

This report aims to present the final results of the descriptive statistical, in-depth and risk analysis performed within TRACE Work Package 'WP2-Type of situations', in order to identify the main problems and the magnitude of these problems related to accident causation and risk factors for the following four types of situations: the stabilized situations, the specific manoeuvres, the intersection situations and the degraded situations.

The different analysis (descriptive, in-depth and risk) of each of these five tasks has been performed using the available European accident databases within TRACE (national, in-depth and exposure databases).

The objectives achieved in this WP are:

- Identify and quantify **accident causation factors** associated to particular types of driving and pre-accidental situations, at a statistical level, by analyzing various available databases in Europe.
- Obtain a 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.
- Identify the **level of risk** associated to these selected types of situation in causing accidents.

Keyword list:

Descriptive analysis, in-depth databases, risk factors, accident causation, type of situations, stabilized situation, specific manoeuvre, intersection situations, degraded situation.

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1 Acknowledgements

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

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

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

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From UK:

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

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From Spain:

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

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

From France:

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

2 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 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 place and in terms of years of life lost (YLL) and ‘disability-adjusted life years’ (DALYs) will be in second and third place respectively.

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.

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 target, the progress 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 states¹, to 25 members² in 2002 and 27 countries³ in 2007, and unfortunately, the road safety target is not a criterion of eligibility for the integration of the new countries.

Figure 1 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).

Up to 2005, only EU15 was on the way to reach the EC target. But the last results (even if the numbers for 2007 are not completely fixed) show that in spite of a decline of the road fatalities, we deviate more and more from the target (+7% for EU15, +15% for EU25 and +19% for EU27).

If nothing is done today, the deadline cannot be reached at all. 2010 is tomorrow.

If current trends continue, the EU-27 is likely to reach its target only in 2019 and in 2017 for the EU25. The EU-15 countries, which originally set the target, are likely to halve the number of deaths in 2013 as the estimations (based on linear decreasing on 2001-2007 period) shows in Figure 2.

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.

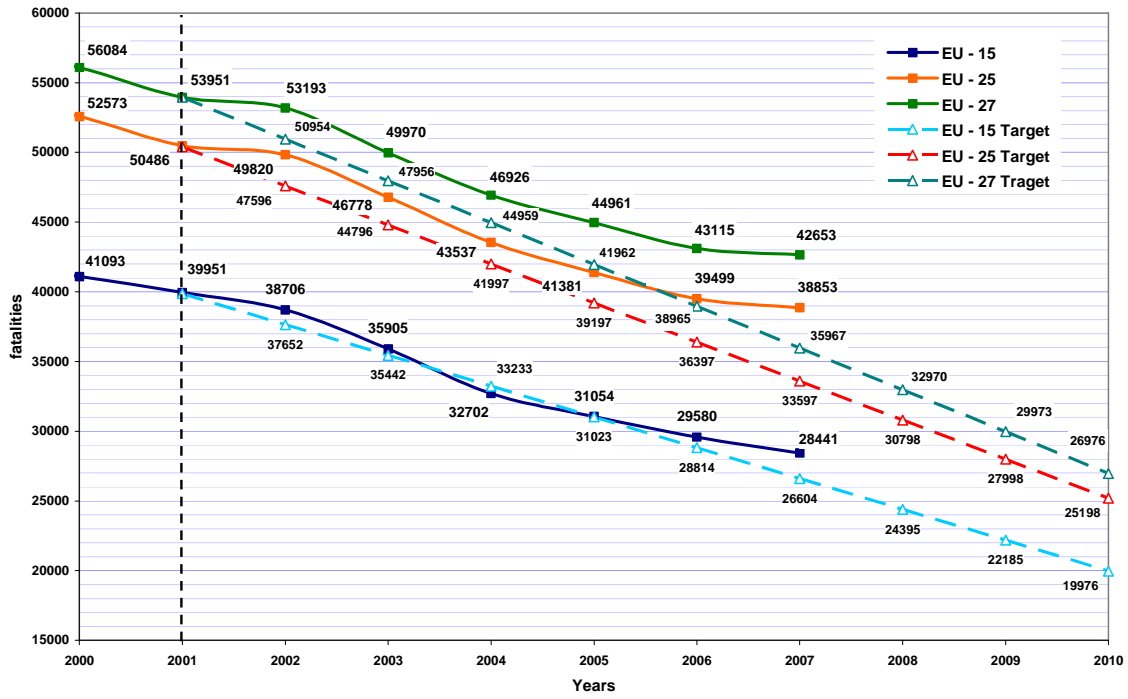
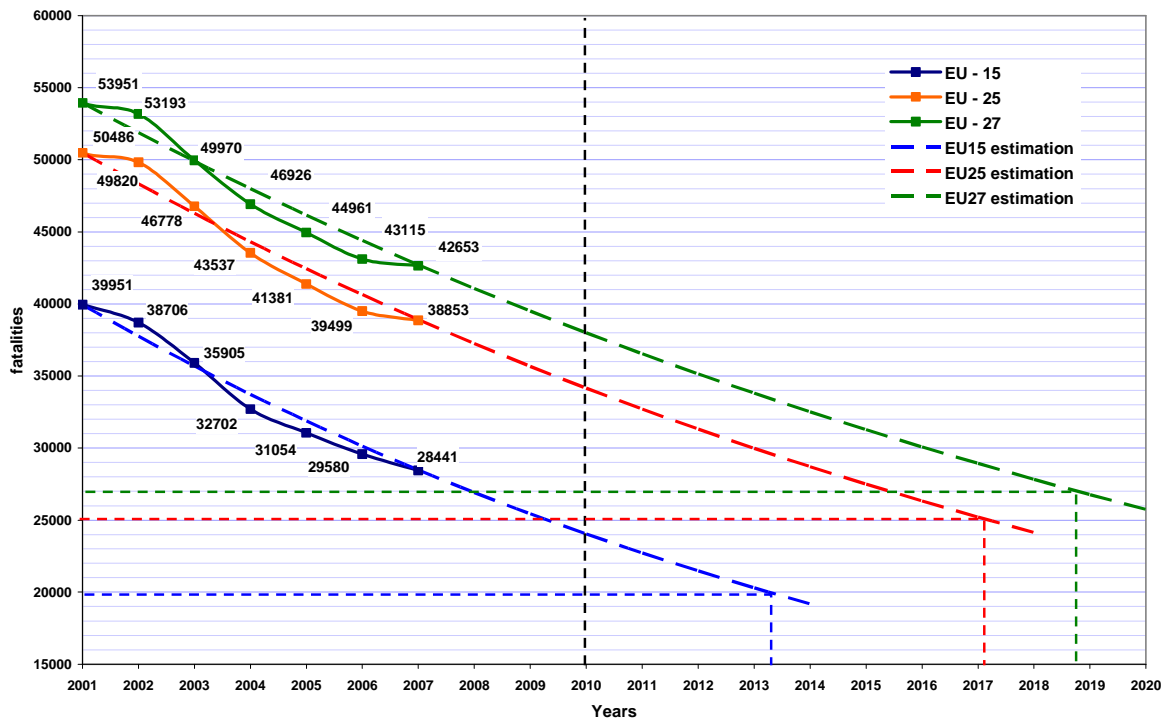


Figure 1: European road traffic fatalities from 1995 to 2007
(Source CARE, IRTAD, IRF, ETSC, and National Databank statistics).



Estimation based on the average annual percentage reductions fatalities over the period 2001-2007

Figure 2 : Expected year of reaching the target for EU27, EU25 and EU15
(Source CARE, IRTAD, IRF, ETSC, and National Databank statistics).

However, these global results hide the real problem. Due to the high contribution of the EU15 in the total number of fatalities (74%), the efforts in the western European countries compensates the worth results from the eastern countries. Now, if we consider the contribution of the different clusters composing the EU27, the deviations to the target are in 2007, +7% for EU15, +48.2% for EU25-EU15 and +64.5% for EU27-EU25.

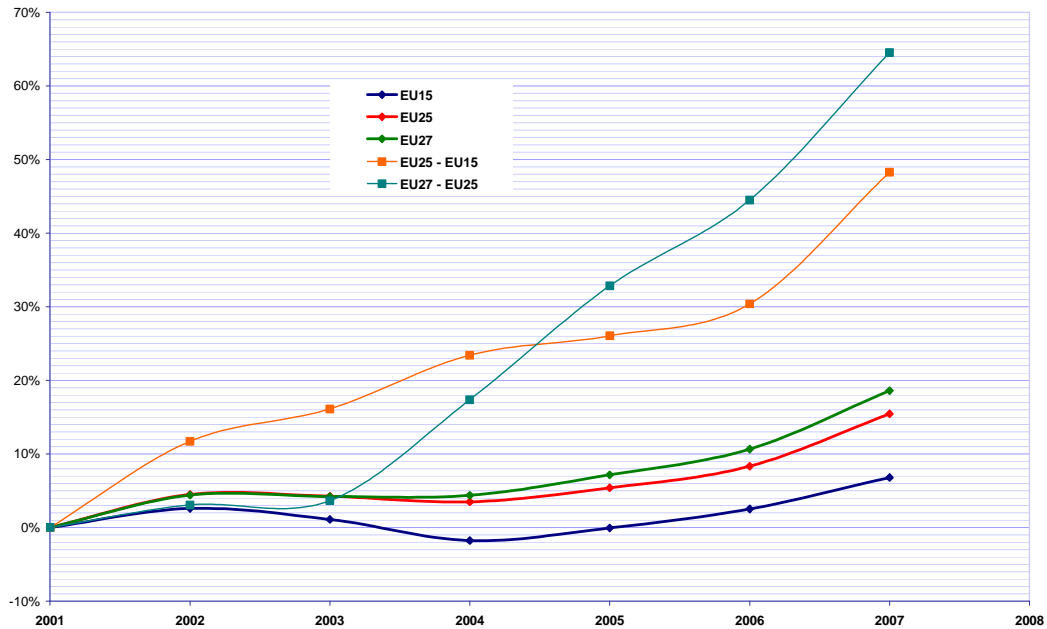


Figure 3: Evolution in time of the deviation to the target from 2001 to 2007
(Source CARE, IRTAD, IRF, ETSC, and National Databank statistics).

By fixing a target at the European level, the EC proved its commitment for decreasing the mortality on the European roads. But this objective is maybe too much abstracted for certain countries, not knowing well how to spread it inside. Specific indicators by country should have been proposed.

With a global target, we can judge only the performance at the European level. These can be enough when the results go in the right way, but in case of deviation, it could be difficult to identify where the weaknesses are and how to solve them.

A first analysis can be based on the evolution of the fatalities, applying the target (halved the number of fatalities in 2010 compared to 2001) at each country. For example in France, the target for 2010 is to decrease the number of road fatalities at least to 4081 deaths. Knowing the final target (-50%) and the deadline (9 years), we can calculate for each year an intermediate target. Each year, the country performance is given by the gap compared to the corresponding target (Figure 4).

In this figure, the dash lines (in red) describe the intermediate targets at each time step. If we look at the results country by country, for the majority of them the total number of fatalities in 2007 decreased compared to 2001, with all the EU15 states included in this set. Leaving the basic idea that the rate of decrease of the road fatalities should be the same for all countries (independently of its contribution on the total number of road fatalities in EU27), only 3 countries (France, Portugal and Luxembourg) are on the way. The situation can be raised for 5 countries (Spain, Germany, Austria, Belgium and Netherlands, worrying for 5 (Italy, Sweden, Latvia, UK and Ireland) inaccessible for 3 (Greece, Finland and Malta) and impracticable for the rest (Cyprus, Czech Republic, Denmark, Estonia, Hungary, Bulgaria, Poland, Slovakia, Lithuania, Slovenia and Romania).

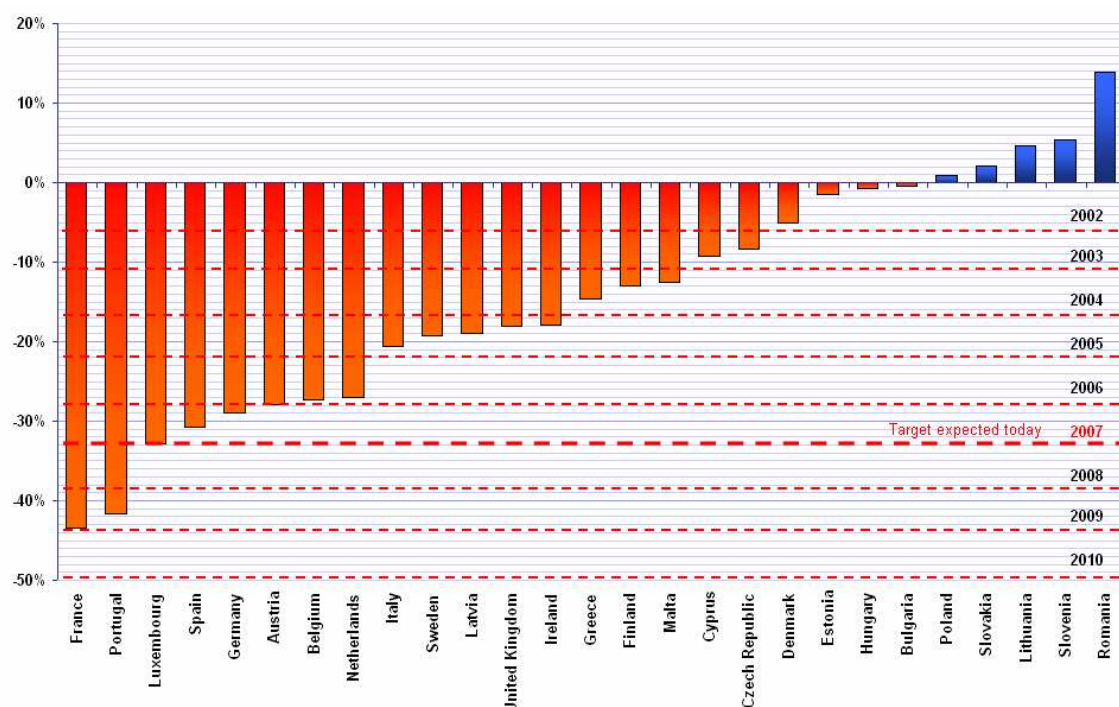


Figure 4 : Distribution of the road fatalities evolution in 2007 compared to 2001 for European states (Source CARE, IRTAD, IRF, ETSC, and National Databank statistics).

If this first indicator has merit to be simple and easy to set up, it does not take into account the contribution of the country to the total number of road fatalities in Europe.

In Table 1 are given the classification of the countries in decreasing order following its contribution to the European road fatalities in 2001 and 2007.

On the right side of this table (colored columns) are given the tendency in 2007 compared to 2001, first in percentage (increasing ↗, stable ← or decreasing ↘) and then in ranking (increasing ▲, stable ◀ or decreasing ▼).

Situation in 2001				Situation in 2007				Evolution	
Rank	Country	Contribution	Cumulated	Rank	Country	Contribution	Cumulated	%	Rank
1	France	15,13%	15%	1	Poland	13,09%	13%	↗	▲ -3
2	Germany	12,93%	28%	2	Italy	12,46%	26%	←	▲ -1
3	Italy	12,40%	40%	3	Germany	11,62%	37%	↘	▼ 1
4	Poland	10,26%	51%	4	France	10,83%	48%	↘	▼ 3
5	Spain	10,23%	61%	5	Spain	8,96%	57%	↘	▼ 0
6	United Kingdom	6,67%	68%	6	United Kingdom	6,91%	64%	←	◀ 0
7	Romania	4,55%	72%	7	Romania	6,55%	70%	←	◀ 0
8	Greece	3,48%	76%	8	Greece	3,76%	74%	←	◀ 0
9	Portugal	3,10%	79%	9	Hungary	2,88%	77%	↗	▲ -3
10	Belgium	2,75%	81%	10	Czech Republic	2,86%	80%	↗	▲ -1
11	Czech Republic	2,47%	84%	11	Belgium	2,53%	82%	←	▼ 1
12	Hungary	2,30%	86%	12	Bulgaria	2,36%	85%	↗	▲ -2
13	Netherlands	2,01%	88%	13	Portugal	2,28%	87%	↘	▼ 4
14	Bulgaria	1,87%	90%	14	Netherlands	1,85%	89%	←	▼ 1
15	Austria	1,78%	92%	15	Lithuania	1,73%	91%	↗	▲ -1
16	Lithuania	1,31%	93%	16	Austria	1,62%	92%	←	▼ 1
17	Slovakia	1,14%	94%	17	Slovakia	1,47%	94%	↗	◀ 0
18	Sweden	1,08%	95%	18	Sweden	1,10%	95%	←	◀ 0
19	Latvia	0,96%	96%	19	Latvia	0,98%	96%	←	◀ 0
20	Finland	0,80%	97%	20	Denmark	0,96%	97%	←	▲ -1
21	Denmark	0,80%	98%	21	Finland	0,88%	98%	←	▼ 1
22	Ireland	0,76%	99%	22	Ireland	0,79%	99%	←	◀ 0
23	Slovenia	0,52%	99%	23	Slovenia	0,69%	99%	←	◀ 0
24	Estonia	0,37%	100%	24	Estonia	0,46%	100%	←	◀ 0
25	Cyprus	0,18%	100%	25	Cyprus	0,21%	100%	←	◀ 0
26	Luxembourg	0,13%	100%	26	Luxembourg	0,11%	100%	←	◀ 0
27	Malta	0,03%	100%	27	Malta	0,03%	100%	←	◀ 0

Table 1 : Ranking of the country following its contribution to the number of fatalities in EU27 (Source CARE, IRTAD, IRF, ETSC, and National Databank statistics).

From this table, we can see that 80% of the total road fatalities in Europe rely only on 9 countries among which 5 have a contribution superior to 10 %. A solution would have been able to be to fix an objective of -36% for the 20% (representing an annual average decrease of 4%) and of a target to -54% for the others 80% (annual average decrease of 6%). The global objective so spread would have certainly asked a supplementary effort the countries where the road fatalities is high and a more realistic objective for the others (20% * 36% + 80% * 54% = 50%).

However, this type of classification based on the fatalities contribution at the EU27 level does not take into account the real risk associated to the population (road deaths per million of population). A strong correlation exists between a high fatality contribution and the number of population. For example, the 7 first countries ranking in table 1 are also the 7 first one for those the total number of inhabitants in the highest.

In the following table the situation in 2001 and 2007 for European countries ranked by road deaths per million of population is given. In 2007, we can see that some progresses have been done, especially in the EU15 countries. The situation worsened for 6 countries: Slovakia, Romania, Bulgaria, Poland, Slovenia and Lithuania, this last one having taken the last place. One of the reasons is due to the double effects of an increase of the road fatalities increased with a clear slowing down of the number of inhabitants. Certainly a variation of the number of deaths on roads plays on the number of inhabitants but this contribution remains negligible with regard to the other demographic parameters.



Situation in 2001				Situation in 2007				Evolution	
Rank	Country	Road deaths per million population	Relative risk	Rank	Country	Road deaths per million population	Relative risk	Road deaths	Rank
1	Malta	41	1	1	Malta	34	1	↘	◀ 0
2	United Kingdom	60	1,5	2	Netherlands	48	1,4	↘	▲ 2
3	Sweden	66	1,6	2	United Kingdom	48	1,4	↘	◀ 0
4	Netherlands	67	1,6	4	Sweden	52	1,5	↘	▼ -1
5	Denmark	80	2,0	5	Germany	60	1,8	↘	▲ 2
6	Finland	83	2,0	6	Finland	71	2,1	↘	◀ 0
7	Germany	85	2,1	7	France	73	2,1	↘	▲ 11
8	Ireland	107	2,6	8	Denmark	75	2,2	↘	▼ -3
9	Romania	111	2,7	9	Ireland	78	2,3	↘	▼ -1
10	Slovakia	114	2,8	10	Austria	83	2,4	↘	▲ 2
11	Italy	116	2,8	11	Spain	86	2,5	↘	▲ 6
12	Austria	119	2,9	12	Italy	90	2,6	↘	▼ -1
13	Hungary	122	3,0	13	Portugal	92	2,7	↘	▲ 11
14	Cyprus	124	3,0	14	Luxembourg	99	2,9	↘	▲ 9
15	Bulgaria	128	3,1	15	Belgium	102	3,0	↘	▲ 5
16	Czech Republic	130	3,2	16	Cyprus	114	3,4	↘	▼ -2
17	Spain	135	3,3	17	Slovakia	116	3,4	↘	▼ -7
18	France	138	3,4	18	Czech Republic	119	3,5	↘	▼ -2
19	Slovenia	140	3,4	19	Hungary	122	3,6	↘	▼ -6
20	Belgium	144	3,5	20	Romania	130	3,8	↘	▼ -11
21	Poland	145	3,5	21	Bulgaria	131	3,9	↘	▼ -6
22	Estonia	146	3,6	22	Greece	144	4,2	↘	▲ 3
23	Luxembourg	159	3,9	23	Estonia	146	4,3	↘	▼ -1
24	Portugal	162	4,0	23	Poland	146	4,3	↘	▼ -2
25	Greece	171	4,2	23	Slovenia	146	4,3	↘	▼ -4
26	Lithuania	203	5,0	26	Latvia	184	5,4	↘	▲ 1
27	Latvia	219	5,3	27	Lithuania	218	6,4	↘	▼ -1
	Average	123			Average	104		↘	
	Mediane	124			Mediane	99		↘	
	 EU27	112			 EU27	86		↘	
	EU25	111			EU25	83		↘	
	EU15	105			EU15	73		↘	
	EU25-EU15	142			EU25-EU15	141		↘	
	EU27-EU25	115			EU27-EU25	130		↘	

Table 2 : Ranking of the country following the road deaths per population in EU27
(Source CARE, IRTAD, IRF, ETSC, and National Databank statistics).

Let us return on the situation in 2001. If we put the hypothesis of an increase of the European population of 3 % in 2010 with regard to 2001 (it is at present 2 % in 6 years), then the reduction by 2 of the road fatalities leads an average of 43 deaths per million of inhabitants. In 2007, this average is 104 (+142%).

All these results show that the distance between the western countries and the eastern ones in Europe increase time after time.

To show that there is problem is the easy step; find solutions to solve it can be more difficult because the problem is complicated by itself: many actors, many factors, several cultures, ..., and it can be different from a country to another one.

Everyone at different level has a role to play.

For example:

At European level:

- To update knowledge on road safety;
- to fix targets and deadlines;
- To spread the European target to the countries by fixing realistic objective;
- To define performance indicators to follow the progress;
- To develop the necessary tools of help to the safety diagnosis (common databases, causation model, etc.);
- To develop the tools useful for the evaluation of the safety measures
- To accompany countries on the safety improvement
- Etc.

At country level:

- To define with the Europe a realistic target;
- With the “local” actors (government, road maker, car manufacturer, politicians, associations, etc.) to define a safety policy
- To define the safety measures
- To define their own safety indicators adapted to the measures
- Set up the tools delivered by the Europe;
- To report to the Europe
- Etc.

Of course this list is not complete.

But, it is clear that before to launch anything, a complete diagnostic have to be set up (or update) in order to identify the problems.

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. 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 identifying two main issues:

- The determination and the continuous up-dating of the aetiology, i.e. causes, of road accidents under three different but complementary research angles: road users, types of situations and types of factors.
- The identification and the assessment (in terms of saved lives and avoided accidents), among possible technology-based safety functions, of the most promising solutions that can assist the driver or any other road users in a normal road situation or in a emergency situation or, as a last resort, mitigate the violence of crashes and protect the vehicle occupants, the pedestrians, and the two-wheelers in case of a crash or a rollover.

2.1 Objective of the TRACE project

The general objective of TRACE project (TRAffic Accident Causation in Europe) is to provide the scientific community, the stakeholders, the suppliers, the vehicle industry and the other Integrated Safety program participants with **an overview of the road accident causation issues in Europe**, and possibly overseas, based on the analysis of any current available databases which include accident, injury, insurance, medical and exposure data (including driver behaviour in normal driving conditions). The idea is to identify, characterise and quantify the nature of risk factors, groups at risk, specific conflict driving situations and accident situations; and to estimate the safety benefits of a selection of technology-based safety functions.

To carry out these 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.

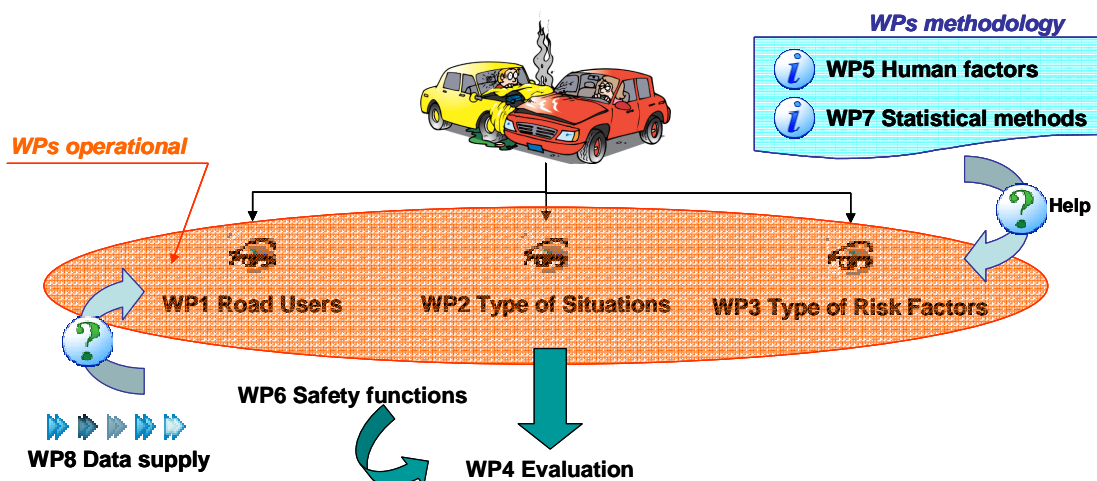


Figure 5: Organisation of the TRACE project.

2.2 The operational work packages in TRACE

The main objective of the operational work packages is to propose a detailed and a comprehensive study on accident causation, providing a framework to define accident causation and analysing European traffic accidents using existing data sources.

Today, accident analysis is a central point in a road safety approach. It allows either to identify solutions (technologies or safety measures) that well fit to the problems revealed by the analysis (top/down approach) or to quantify the effectiveness or such or such technology (or safety package) in face of the “real world” (bottom/up approach).

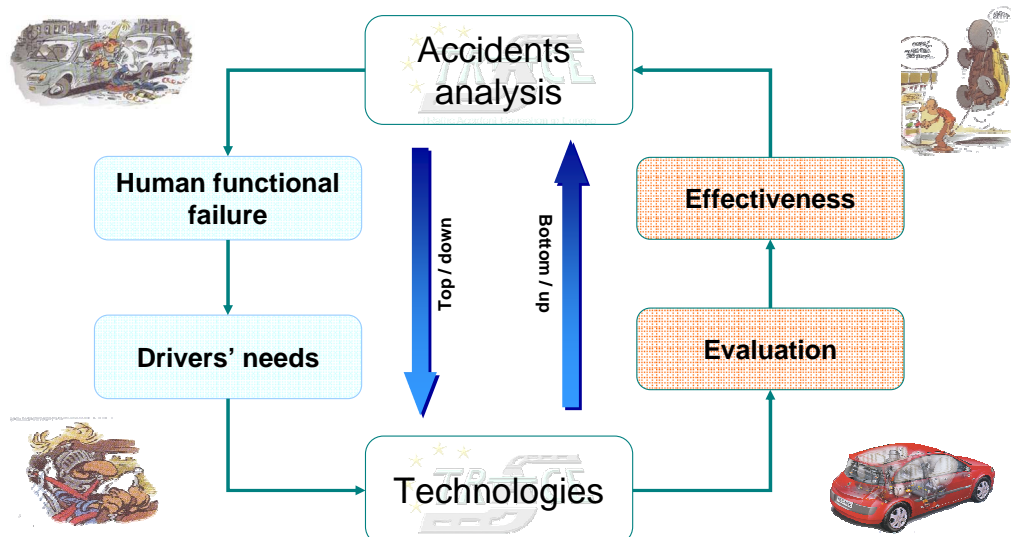


Figure 6 : Road safety approach using Top/down and Bottom/Up process

In road safety, the identification of the accident causes is necessary for the following reasons:

- To fight the disease it is necessary to be able to identify it, to quantify it (its magnitude) and to give its main characteristics (its frame). This is the safety diagnostic.
- Because the problems are several, their kinds different and their interaction varied, accident causation allows to define the road safety priorities according to the real life. These priorities can be different as we are responsible for public health (the states responsible of our security and safety), car manufacturer and suppliers to improve the safety of vehicles or road makers to build safer roads.
- To define performance key indicators in order to be able to measure their evolution and to be more reactive before the things get worse;
- To evaluate the a priori effectiveness of the most promising counter-measures;
- To measure the effectiveness of safety actions set up
- To prepare the future regulations in relationship with the real safety;
- To develop some performance tests to assume that the safety systems well answer to the regulations and the real safety;
- To know for each actor its responsibility part of the disease;
- In a competitive world, to be able to place oneself in relation to the others. For example make comparison between countries or regions, or between products proposed by the industrials;
- To identify the lack in the data collection displayed by the analysis and make propositions for the update.
- To anticipate the future problems on the road.

To reach the objective, several challenges have to be raised. Among these, the most important questions where we have to bring some elements of answer are the following:

- What is “accident causation”?
- What can we do with existing data?
- How can we update our knowledge?
- Can we represent the EU27?
- How can findings assist safety benefit analyses?

Of course, the first question remains the key of vault of this study, even if the others can have an influence on the orientations for the methodology to be applied.

In “accident causation”, the causes are related to the notion of accident. An accident can be defined as an unplanned event, generally associated with negative consequences such as fatalities, injuries, near misses, damaged materials or ... shattered nerves.

To understand the causes of accidents in order to be able to identify effective means for their prevention, several theories of accident causation have been proposed coming for most of them from accident prevention in enterprise:

- **The Domino theory:** developed in 1931 by *H. W. Heinrich*; it states that an accident is only one of a series of factors, each of which depends on a previous factor in the following manner (Heinrich 1980):
 1. Accident causes an injury.
 2. Individual's negligent act or omission, or a faulty machine, causes an accident.
 3. Personal shortcomings cause negligent acts or omissions.
 4. Hereditary and environment cause personal shortcomings.

The model relies on the facts that 88% of accidents caused by unsafe acts, 10% by unsafe conditions and 2% are unavoidable. The more remote causes of accident consisted of the environmental and social conditions, controlled by the management, within which the accident occurred. On this basis an accident investigation model can be developed. A salient feature of most of these immediate cause categories is the inclusion in their description of the characterization of the actions or conditions (e.g.: unsafe, inadequate, dangerous, etc.). These notions require definitions that except in specific cases (laws, regulations, etc.) are very difficult to catch, letting the investigator's subjective judgment (after the accident has occurred) to decide of what is safe and what is unsafe.

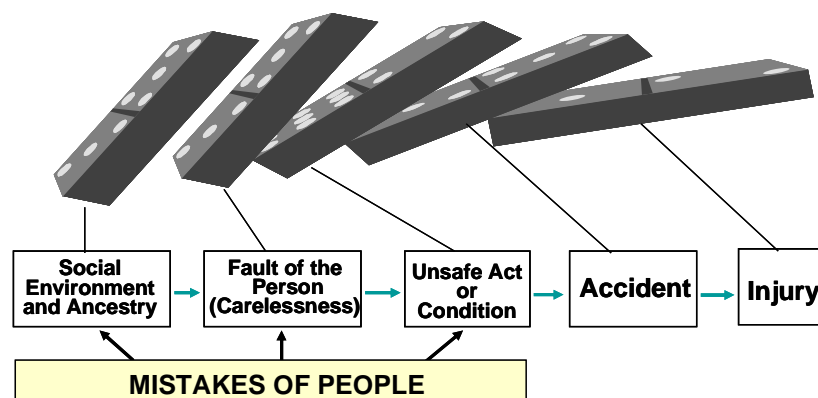


Figure 7: The domino theory developed by Heinrich H.

- **The “Human Factors” theory:** The accident causation can be attributed to a chain of events ultimately caused by human error, driven by overload (due to environmental factors such as noise, distraction, or internal factors - personal problems, emotional stress- or situational factors - unclear instructions, risk level), inappropriate response/compatibility (like identifying hazard but not correcting it, remove safeguards, ignoring safety , etc.) or inappropriate activities (performing tasks without the requisite training, misjudging the degree of risk involved with a given task, etc.).
- **The “Accident/Incident” model:** It is an extension of Human Error Theory by adding ergonomic traps and decision to err. This theory also includes system failure as a cause of accident. Petersen developed this model (Petersen D. 1975).

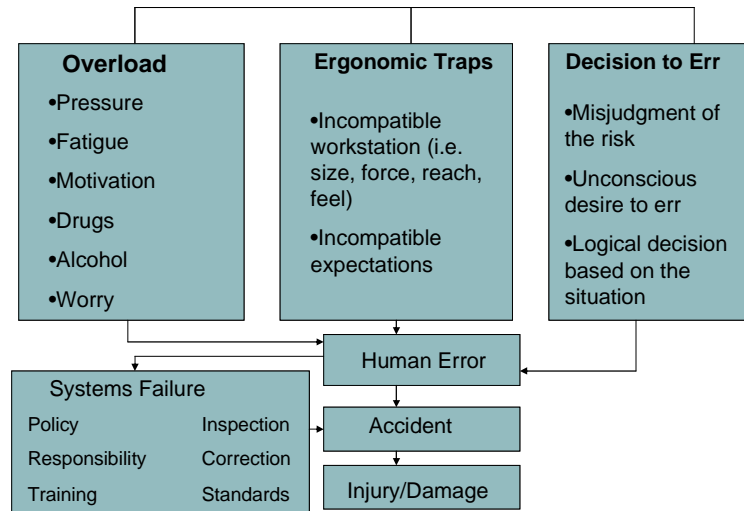


Figure 8 : Illustration of the Accident/incident theory developed by Petersen D.

- **The Epidemiological theory:** Traditionally, safety theories and programs focused on accidents and injuries. However, a broader perspective that includes industrial hygiene must also be considered. Industrial hygiene concerns environmental factors that can lead to sickness, disease, or other forms of impaired health. Epidemiological theory studies the relationship between environmental factors and accidents or diseases. The model is based on the identification on two characteristics :
 - Predisposition characteristics related to susceptibility of people, perceptions or environmental factors;
 - Situational characteristics such as risk assessment by individuals, peer pressure, priorities of the supervisor, or attitude, etc.
 The two characteristics, taken together, can result in or prevent conditions that might result in accident or illness. For example, a worker who is susceptible to peer pressure is more likely to have an occupational accident or illness.
- **The “Systems” theory:** The notion consist to consider accident causation as a system, a system being a group of regularly interacting and interrelated components that together form a unified whole. System theory views a situation in which an accident might occur as a system comprised of three components: the person (host), the machine (agency) and the environment. The likelihood of an accident is determined by how the three components interact. In industrial environment, 5 factors have to be considered: job requirements, the worker’ abilities and limitations, the gain if the task is successfully accomplished, the loss if the task is attempted but fails, and the loss if the task is not attempted.

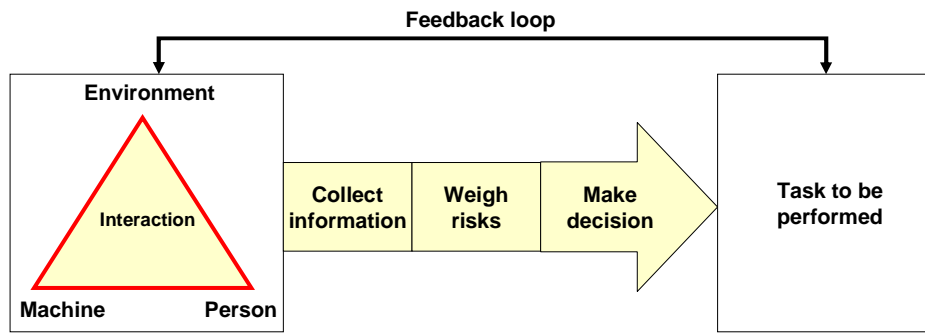


Figure 9 : Illustration of the « Systems » theory.

- **The “Combination” theory:** This theory starts from the fact that for some accidents, a given model can explain why accident happened and for others, the model cannot explain. According to the combination theory, the actual cause may combine parts of several different models. This theory is suitable for accident prevention and investigation.
- **The “Behavioural” theory:** Often referred to as behaviour-based safety (BBS). It is based on the 7 following principles:
 1. Intervention
 2. Identification of internal factors
 3. Motivation to behave in the desired manner
 4. Focus on the positive consequences of appropriate behaviour
 5. Application of the scientific method
 6. Integration of information
 7. Planned interventions

All these theory allow to establish models which must be then sustained by investigations on the scene and by the elaboration of databases including the relevant parameters for the analysis. This is the process used for in-depth investigations now.

Most of these theories have been used in road safety, still today, focusing in one specific point of view. But the road accident remains more complex than in other domain, because the human is at the centre of the regulation. He has to interact with the machine (drive his car: hold the steering wheel, change direction, brake, change gear, declutch, accelerate, look at mirrors, etc.), to interact with an unsettled environment (lighting conditions, weather conditions, road surface, road geometry, road signs, etc.), to interact with the other users (pedestrian, 2 wheelers users, etc.). All these factors and interactions make that the accident causes are multiple, not unique, can be independent each others, not having the same end, with different degree of implication, can be different following who makes the analysis, etc. in others words a not predictable system.

The analytic approach that allows decomposing into understandable elements a complicated system (which is predictable even if several iterations are useful to describe its behaviour) cannot be applicable to a complex system. The challenge is to build a model for a system, which is a priori not foreseeable.

A solution consists to use the theory based on the systemic approach. The target is to represent the systems as a “general system”, i.e. not as an aggregate of independent and understandable entities but rather as a system which is organized, which works, which evolves and which is finalized. The theory of the systems was based by Ludwig von Bertalanffy (Bertalanffy 1950, 1968, 1974), William Ross Ashby and the others between 1940s and 1970s and takes its inspiration from the previous works on the cybernetic (Wiener, 1950). Since, this theory evolved in several movements in United States and in France.

All the interest of this new concept relies on the various points of view allowing to define an object. In this theory a system can be viewed by four fundamental axes (see Figure 10):

- The ontological axis which defines all the components of the studied object.
- Teleological axis which allows to define the purposes and the motivations associated to the object.
- Functional axis which defines its function or process
- Transformational axis, which takes into account the development of the object.

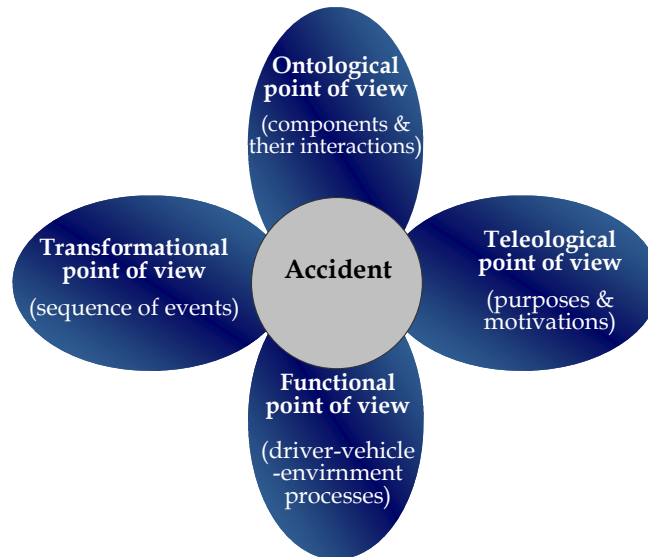


Figure 10 : A new framework for accident description based on systemic approach

In fact, if we look at this approach in details for the road safety field, we can see this theory as a “meta model” which contains all the models usually used in accident research:

- ✓ For the ontological axis, we can find the HVE model (Human, Vehicle, and Environment) allowing to describe the three main components of the accident.
- ✓ For the transformational axis, we have the Sequential model, which allows to describe the dynamic aspect of the accident process (see Figure 11);
- ✓ For the functional axis, we have the Human functional failure model which allows to analyse the process of the human malfunction;
- ✓ For the teleological axis, different elements more or less structured (social aspects, driver tasks, etc.) but a real model is missing for the moment.

Its applications can be numerous in road safety, in particular to analyze databases and to report weaknesses on points of view not well documented (Ben Ahmed 2003).

Another more interesting application is for the accident causation analysis. Even if this theoretical model is not clearly visible in TRACE, it is used as the frame of the analysis proposed in operational work-packages.

Firstly, as a “user” of a data accident collection defined on the different points of view as we seen before. For example, the risk factors analysis (WP3) starts with a review on the state of art and the identification of the factors (ontological), then looks for the contextual and underlying elements which can explain the presence of the factor (teleological), such as cultural or social aspects for example, and look at how these factors contribute (functional), what is their role during the accident process (transformational).

Secondly, as theoretical base allowing to carry out a complete analysis:

- Teleological aspect: the objectives of the accident causation analysis in TRACE are on one hand to update our knowledge on the road safety problems in Europe and on the other hand to identify the most effective counter-measures.
- Ontological aspect: the three work packages (WP1: Road users, WP2: type of situations, WP3: risk factors) are the main components of the accident causes and are complementary.
- Functional aspect: Different approaches (or models) exist to identify the accident causes (see the different theories exposed above). In TRACE, this analysis relies on a common methodology based on three steps: descriptive analysis (define the stake and magnitude of the problems), in-depth analysis (understand how the problems occur) and risk analysis (identify the most exposed “population” to the problem). During each analysis, the interactions between the different components (road users, type of situations and risk factors) are also taken into account.
- Transformational aspect: the change of the road safety context, the contribution of each study and the availability of the data sources make that the knowledge on the topic evolves. Especially in TRACE, the use of the statistical tools brought by the WP7, the type of data supplies by WP8, the new approach HFF (Human Functional Failure) developed by the WP5, and the progress made on the evaluation methods carried out under WP4 contribute to the evolution of the topic.

It is this theoretical frame that we tried to use for the analysis of the accident causes in Europe.

2.3 Accident causation and type of situations

As previously seen, the accident can be considered as a complex object, and consequently the study of its causes too. A way to dread this scientific challenge is either to work on a more simplified problem (Cartesian model) or to divide the problem into understandable, controllable and complementary elements describing entirely⁴ the object (Systemic approach).

The first approach gives the opportunity to have an immediately update using By using a tried methodology but which can be incomplete and reveal only a part of the “iceberg”, the other part being either not visible or not accessible with this theory.

The second approach much more theoretical allows to improve the representation of the studied object, to take into account new approaches, and to make progress on the data collection putting finger on the weaknesses. This approach (described in the previous chapter) is the one addressed by TRACE for the part dedicated to the improvement and the update of the knowledge on accident causation.

From the state of art, 3 research angles have been proposed to cover the accident causation in TRACE:

- The study of the accident causation related to the road users (WP1 – Road users). Because problems are often different for each type of road users, this angle is particularly appropriate to identify specific and dedicated safety measures or actions.
- The study of the accident causation related to the situation in which a road user is involved (WP2 - type of situations). Starting from the principle that the accidental mechanism can be different according to the accident situation, it is important to be able to identify them to find adequate solutions well fitted with the needs of the driver/rider.
- The study of accident causation from the main risk factors (WP3 – Risk factor). Most of these accidental risks are known and have already studied (alcohol, speed, distraction, etc.). However their consideration in the in-depth data collections are specific to each study, and their joint analysis can raise some problems mainly due in interpretations which can be different. This approach allows to target the safety measures regarding the most important risk factors independently (at least at the beginning of the analysis) of the road users or the accidental situation, and also to be able to identify the future ones.

⁴ Entirely is not in absolute sense but refers to the knowledge at the time where description is done.

These 3 views only define the “vital lead” of the accident causation in TRACE, the first door of the analysis and we can guess that the respective classifications which will ensue from it will be richer and complementary.

These various analyses allow to raise a good diagnosis of the current road safety problems and so to help in the selection of the actions to set up.

Another point is that they can be applied as well at the European level (to define general orientations) as at the level of every country where locally the problems can be different.

The WP2 is one of the 3 operational work packages of TRACE. Its objective is to improve the knowledge on the accident causes by analyzing the accident from the point of view of the pre-accidental situation in which the road users were involved just before the collision.

2.3.1 The types of situation

First, we need to clarify what we understand here by situation.

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

- **The driving phase:** the driving situation can be described as the one in which the user is before a problem arises. It is the 'normal' situation, which is characterised for the driver by the performance of a specific task in a given context, with certain objectives, certain expectations, and so on. It is 'normal' because no unexpected demands are made upon him.
- **The rupture phase:** the 'rupture' is an unexpected event that interrupts the driving situation by upsetting its balance and thus endangering the system.
- **The emergency phase:** it is the period during which the driver tries to return to the normal situation by carrying out an emergency manoeuvre.
- **The crash phase:** the crash phase comprises the crash and its consequences. It determines the severity of the accident in terms of material damage and bodily injury.

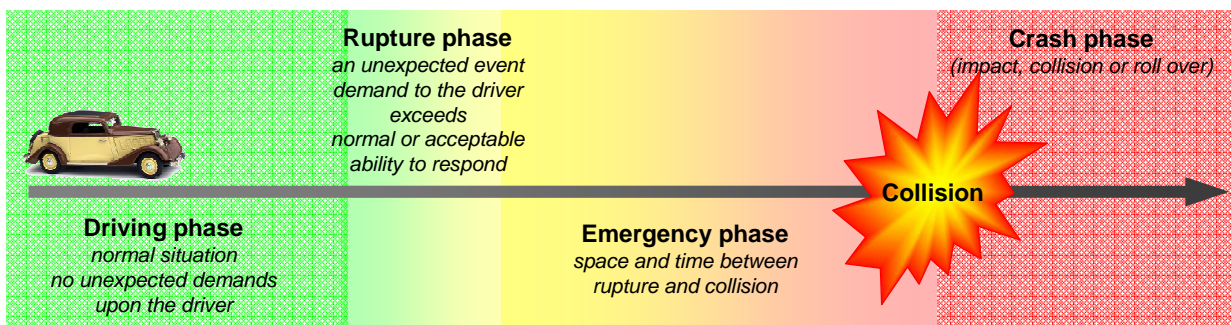


Figure 11: Accident view as a sequential event

In this report a situation is defined as a pre-accidental situation to which the driver/rider/pedestrian is confronted in normal driving conditions just before it turns into an accident situation⁵ (corresponds to the end of the green area in the previous figure). 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 scenarios⁶ which contributed to the accident.

By this definition, we can see that a situation can be directly related to a road user. In other words, there are as much situations as number of road users involved in injury accidents (pedestrian included).

⁵ A situation is linked to a vehicle. One accident with two vehicles count two situations

⁶ A scenario clusters several similar situations according to predefined criteria.

It is very important to well distinguish the notions of accident and situation. Let us see the following example.

This case represents the pre-accidental scene between a car (noted A, in blue) a motorcycle (noted B, in red) and a truck with trailer (noted C, in grey). The driver decides to overtake the truck moving ahead, changes the lane and the car collides the motorcycle coming in the opposite direction. In this case, 3 road users are present (the car, the motorcycle and the truck + trailer) but only 2 are involved in this accident (the car and the motorcycle). For the accident causation analysis only these 2 road users will be studied, each of them with its own corresponding situation.

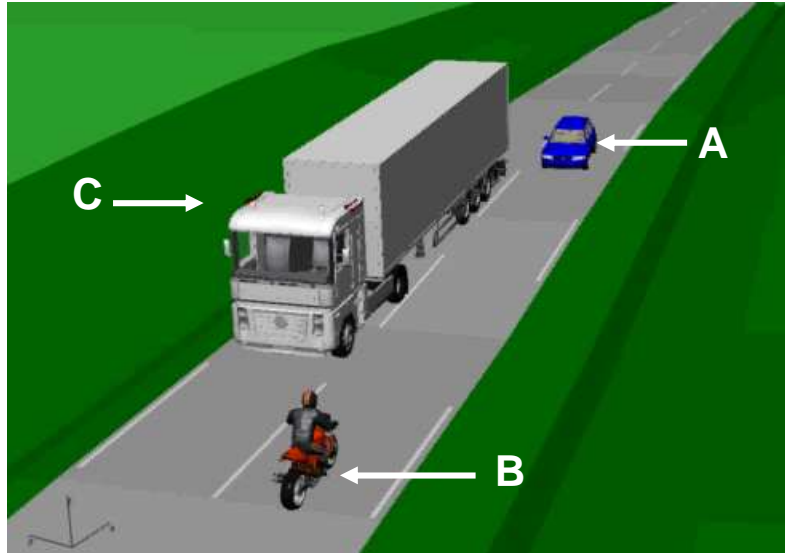


Figure 12 : Example of road accident with 2 different situations

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

- **Stabilized Traffic Scenarios:** The idea is to analyze the accident causation 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 a road user driving normally on a straight road or entering a curve, etc. This type of situation corresponds to the motorcycle one in the previous example.
- **Intersection Scenarios:** The target is to analyze the accident causation for each road users involved in accident at intersection. 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.
- **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.
- **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 has been defined as the beginning of the project and they should be covering the majority of the real situations which may occur in road injury accidents. Certain atypical accidents or situations will never fit neatly into a fixed classification.

The first three situations (Stabilized, Intersection and Specific Manoeuvres) are mutually exclusive without overlap (see next figure). The degradation scenarios are however a subset of the other scenarios. We can find so degraded situations at intersection for example.

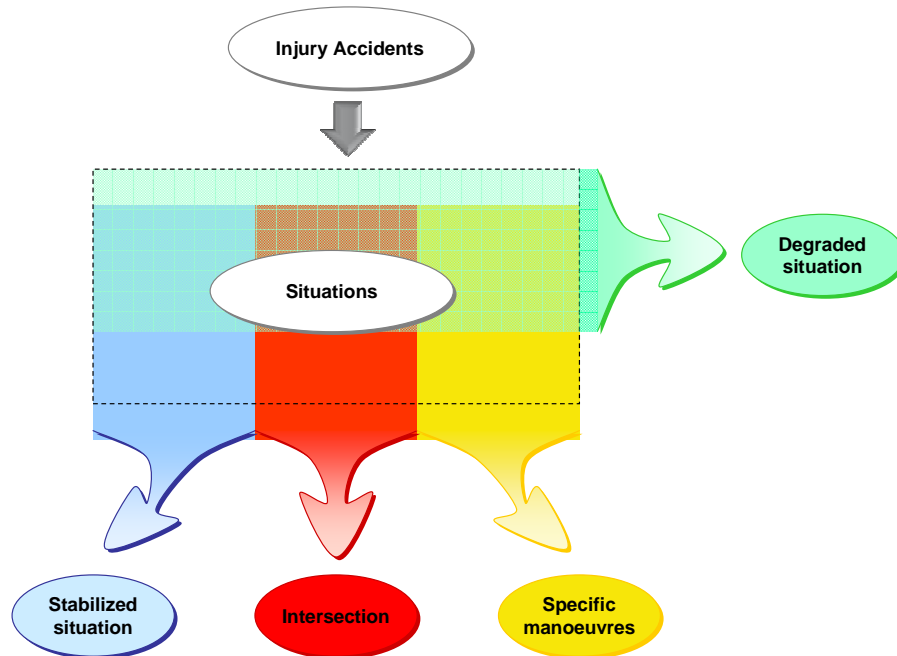


Figure 13 : Scope of each situation studied in TRACE

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 to identify the problems at the “source” of the accident.
- The selected situations have to be as generic as possible and do not have to answer to a specific technology. In this top/down approach (see Figure 6) the most important is to identify the problems.
- Because accident process is sequential, all phases have to be taken into account, not only one. Others contributing factors (some are news, others were presents but not “active”) can play a role in this process. The pre-accidental situation is only the “root” of the analysis.
- The complementarity 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.).

2.3.2 The methodology used for the accident causation analysis

The objective of this study is to identify the main accident causes from the pre-accidental situation in which each road users was involved.

Given that several causes can exist for a given accidental situation and that there are so many situations as road users involved in these same accidents, we see that without a good methodology this study can become very hard.

Rather than to study the causes situation by situation, we chose to group together the situations having resemblances in scenario then to identify the causes from each scenario (see Figure 14).

The concept of scenario allows to simplify the analysis by working only on monograms where only the most frequent causes will be held.

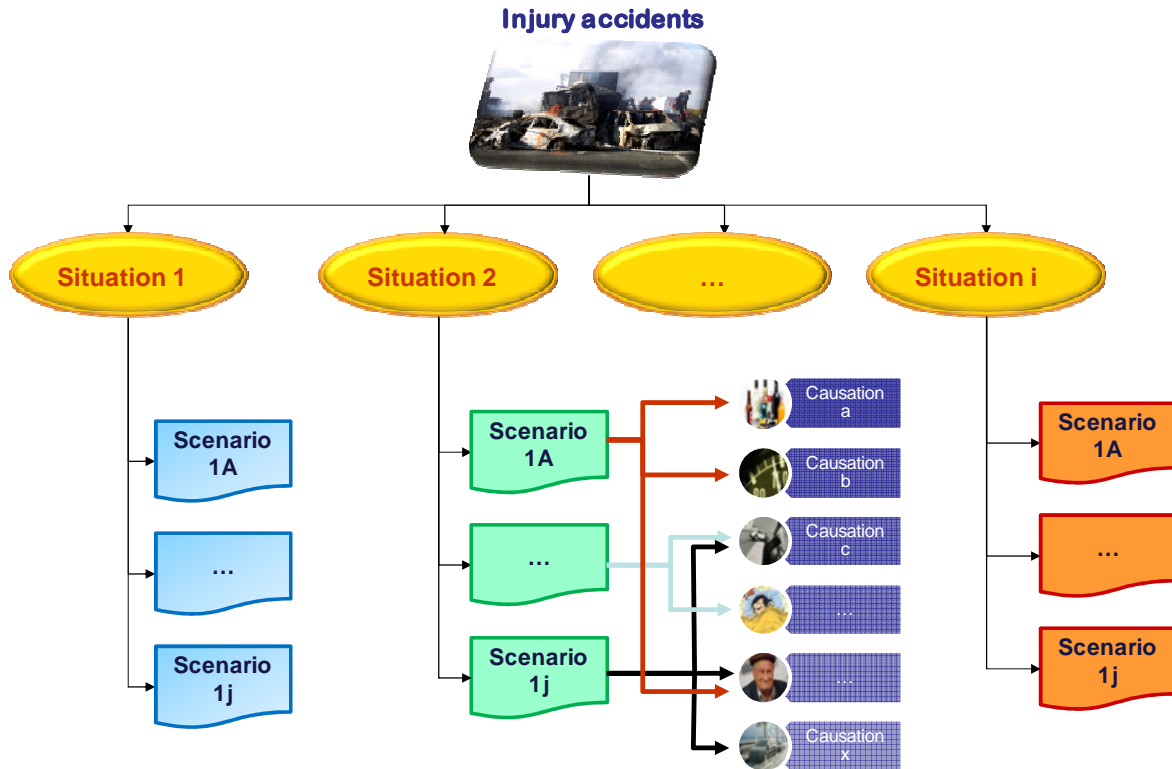


Figure 14 : Methodology applied to the accident causation analysis

To do that we propose to work on the following scheme:

1. Classification of the accident situations into 4 representatives clusters. These 4 types have already been defined at the beginning of the project. They are: stabilized situations, intersection, specific manoeuvres and degraded situations. In this first step, the main idea is to convert injury accident cases into situations.
2. Identification and description of scenarios for each type of situations. Inside the 4 pre-defined types of situations, the target is to gather in a same monograms (or class) situations having similarities. These similarities have to be defined not only with the help of the available variables from accident databases, but also have to take into account the specificity of the studied situation, the accident process, the manoeuvres and the knowledge of the expert. The number of scenarios depends of the degree of the similarities researched. One of the criteria is that the identified scenarios have to be consistent, i.e. they have to be few and to represent a non neglected part of the situations inside the considered type. From this step, only the most representative scenario will be studied.
3. Identification of the main causes for each important scenario. From the previous step, the idea here is to analyse in details each scenario in order to identify and to characterize the problems having been at the origin of the accident. The idea is to identify relevant indicators and to use the Human Functional Failure analysis developed by WP5.
4. Identification of the risks of being involved in this type of situations. For each scenario the idea is to identify among the included road users a population where the risk of involvement would be more important than for the others.

In this scheme, the first step represents the criteria to select the corresponding sample that will have to be studied. For the situations occurring at intersection, this sample will be composed by every road users involved in injury accident at intersection.

The only issue in this step relies only on a clear definition of the scope of each type of situations and on its translation in criteria of selection.

These basic elements will be defined at the beginning of each part dedicated to the results for each type of situations.

The next 3 steps represent the core of this study (see Figure 15). They are based on 3 types of analyses very different due to their objective and the type of data used:

- The descriptive analysis. It corresponds to the 2nd step. For each predefined situations, 3 main objectives are looked for here: which are the associated stakes, which are the most represented scenarios and which are their main characteristics. This analysis essentially relies on descriptive statistics. As regards the data to be used it has to allow defining the stakes as well as general characteristics at the European level. This support must thus be the most representative as possible of the road injury accidents in Europe and to include some descriptive variables rather "rough" to be easily mixed but rather relevant for the elaboration of the scenarios. We shall thus appeal to said "extensive" (or descriptive) injury accidents databases based on the national data of every European country (CARE, IRTAD, other).
- The in-depth analysis. It corresponds to the third step. After the identification of the main scenarios defined in the previous step, this analysis details each of them providing information on their accident mechanisms, their main causes and other relevant factors characterizing them.(such as precipitating event, contributing factors, driver failures, etc.). This analysis requires the use of in-depth databases.
- The risk analysis. It corresponds to the last step. The objective is to identify among the appropriate samples for each scenarios if a particular population (or group of individuals) has a risk more or less raised to be involved in this kind of situations. The idea is not to evaluate and to compare the risk for each population, but rather to identify those who distinguish themselves by either an over-risk or an under-risk of being involved in an injury accident. This analysis requires the use of exposure data (related to the exposed population) and in-depth data also.



Figure 15 : Scheme of the methodology used for the accident causation analysis

2.3.3 The Human functional failure analysis

There are many ways to analyze accidents and accident mechanisms. For example, LAB developed its own accident analysis model in order to understand the production of the accidental situation. This model was inspired by previous work and especially those carried out by INRETS at the beginning of the nineteen eighties in the south of France and identify:

- The sequential description of the accident circumstances,
- The events that could have contributed to convert a driving situation into an accident situation,
- The nature of the driver functional failure (e.g. perception, comprehension, decision, action) and the mechanism of the human failure (e.g. driving errors, unavailability of information, under-activation to driving),
- An identification of manoeuvres carried out by the drivers and the trajectories of the vehicles.
- And finally the sequential correspondence between car kinematics parameters and human cognitive parameters, from the initial conflict situation to the impact. This is the final step of the accident analysis: its reconstruction.

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

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

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

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

The categories are defined as follow:

- Internal condition of the task: it is related to the task that the driver is performing, but refers more specifically to the ‘conditioning’ of the driver to the task (i.e. the informal rules the driver follows, either consciously or sub-consciously, the driver adopts a non adapted speed considering its driving situation).
- Driver behaviour: behaviour of the road user can affect the way they control their vehicle and respond to both their internal and external surroundings. This category refers to a problem of inattention, distraction or perception.
- Driver state: The ‘state’ of the user includes physical, physiological or psychological conditions, either pre-existing or brought on by substances taken, such as alcohol or drugs.
- Experience: The user’s prior exposure to the task in hand or their surroundings will affect the way they process information. Experience can be related to the non experience of the situation or of the driving task or to the over experience of the driver.

- **Road environment:** it deals with factors linked to infrastructure such as a visibility limited by infrastructure or a road layout not adapted to the situation.
- **Traffic condition:** it refers to the conditions in which the user is driving. The flow, speed or density of the traffic on the road will potentially affect the road user's ability to undertake their journey
- **Vehicle:** This category involves the equipment or devices the user is interacting with in the task such as the maintenance of the vehicle, all mechanical or electro-mechanical problems or the load.

2.3.3.1 The human functional failure

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

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

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

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

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

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

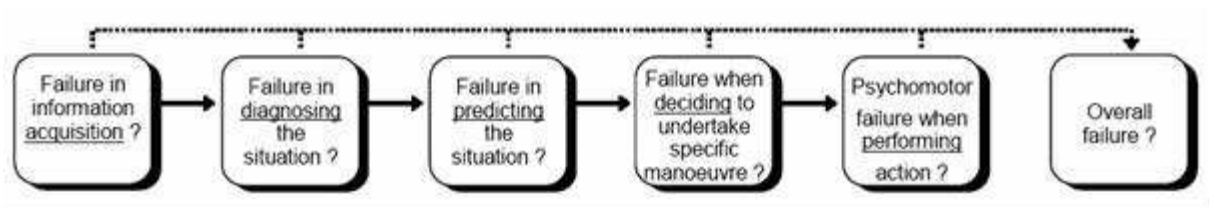


Figure 16: Human functional failure analysis

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

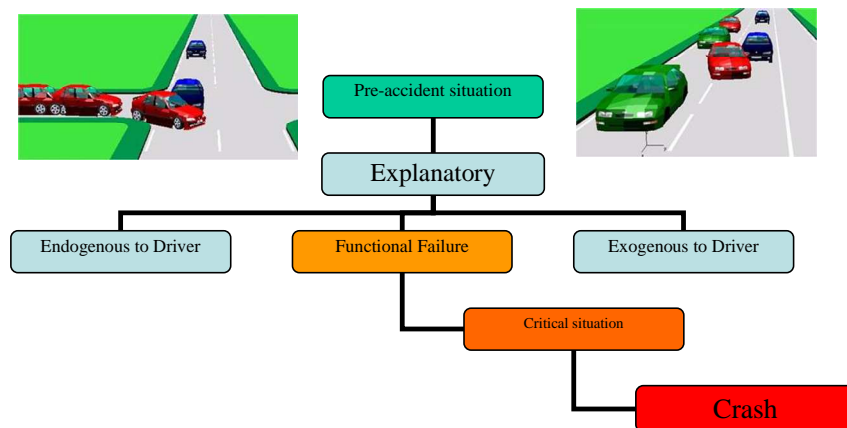


Figure 17: Human functional failure and explanatory elements

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

2.3.3.2 Degree of involvement of the driver

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

Primary active: this modality designates the drivers who 'provoke the disturbance'. They have a determining functional involvement in the genesis of the accident: they are directly at the origin of the destabilization of the situation.

Secondary active: these drivers are not at the origin of the disturbance which precipitates the conflict, but they are however part of the genesis of the accident by not trying to resolve this conflict. Potentially able to anticipate whereas they do not, they so contribute to the genesis of the accident by the absence of adapted preventive strategies. Examples: absence of behavioural adaptation because they expect an adjustment from the other user, no anticipation of a possible conflicting pathway with others although alarming indications, etc.

Non-active: these drivers are confronted with an atypical manoeuvre of others that is hardly predictable, whether it is or not in contradiction with the legislation. They are not considered as 'active' subjects because the information they had did not enable them to prevent the failure of others.

Passive: these drivers are not involved in the destabilization of the situation but they are nevertheless an integral part of the system. Their only role consists in being present and they cannot be considered as an engaging part in the disturbance. No measure may a priori be beneficial to them, except to act on the other driver. Examples: drivers who are collided when stopped at a traffic light or on a parking spot, drivers confronted with stone falls, etc.

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

2.3.4 Data supply

As in most of the studies, the data is one of the main keys in the success of this analysis.

Considering the objectives, the means and the time allocated to the project, the methodology set up in TRACE relies on the following “rules”:

- Only the databases brought or accessible by each of the TRACE partners will be used.
- No new database presenting a common structure will be elaborated from available databases. No “Common European Road Accident Database” will be set up.
- Neither the available databases nor the extraction of these will be given to the consortium. Only requests based on crossed tables (Excel files) can be asked for the realization of analysis.
- Only the partner holder or having access to a database can realize the sorting asked for the other partners.
- It is the WP8 which pilots the data supply. Any demands have to be sending to the WP8. It is WP8 which has to verify if tables are understandable, to transfer the requests to the concerned teams, to gather and check the return (consistency) and to broadcast all the individual filled tables to the requester. The WP8 is not responsible for the concatenation of all the tables. It is the requester who takes care of it.
- Because road accident databases can be classified in 3 very different types (descriptive, in - depth and exposure), the WP8 will be structured on the same way. Every requester will have to specify on which type of data he wish that his sorting are realized.
- For every analysis the process is the following one:
 - Analysis realized with its own accessible data. The objective is to be able to use all the variables at its disposal. So this first analysis can be made without limitation (numbers of sorting, crossings tables, etc.).
 - From step 1, this “local” analysis has to be extent to the European level. For that, only the relevant tables have to be selected and gathered on an Excel file on a specific and predefined format. It is these tables which the partners will have to fill.
 - The Excel file is sent to WP8, according to the type of requested data be going to transfer it to the dedicated coordinator. In the following example (Figure 18), descriptive data are requested and are managed by the “Descriptive Data” leader.
 - It is the coordinator who has the responsibility to check the coherence and the understanding of the requested tables. Once done, he then distributes the file to be filled to all the partners possessing this type of data.
 - Each TRACE partner who received the request has to fill the file as well as possible. The main difficulty is here to fill tables from the available variables which sometimes do not correspond exactly to the request. In case of such problem, a solution is found with the agreement of the requester and a warning is put in the header of the table.
 - Once files filled, each partner sent them back to the coordinator who checks that tables are correspondingly completed.
 - The corresponding Excel files are sent back to the requester without any concatenation.
 - The requester received the “n” files that he has now put together. However the concatenation of all these files (including those resulting from these own data) give only an incomplete picture of the European panorama.
 - The analysis must be completed thanks to the help of the statistical tools (see WP7) which are going to allow to spread these results to the whole Europe.

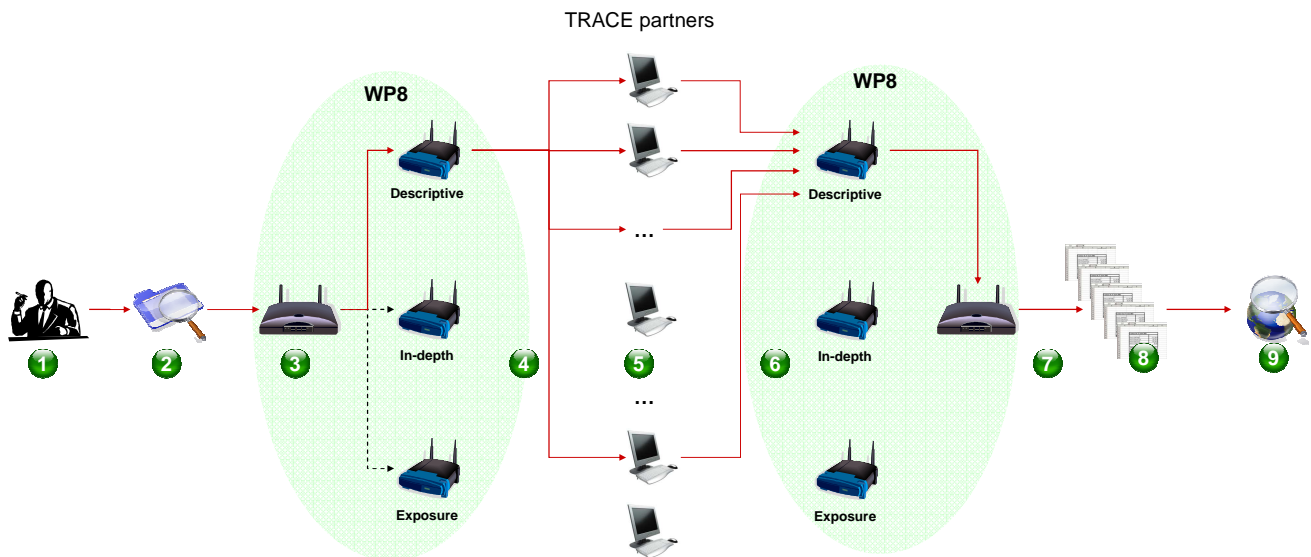


Figure 18: Process used in TRACE for the data supply.

To have more details concerning databases, we invite you to read reports produced by the WP8.

2.3.5 Main issues

We detailed up to here the work plan as well as the methodology which we intend to set up for the analysis of the causes of road accidents. Naturally, some of difficulties raise themselves on our way, some people can be already identified (and thus anticipated), and the others will arise during our study. Here are those whom we can right now listed:

- On the methodology.
 - The methodology proposed here bases on the determination of scenarios from which we are going to look for then the most relevant causes. This method has already tested and proved its efficiency in others projects such as Intersafe. However, the used data (essentially French, German and English) fit perfectly to this method. Its application at large-scale risks to be more difficult if the necessary information is not available.
 - The contribution of the HFF analysis proposed by WP5 will allow to complete the accident causation analysis. However, a lot of work of codification has to be made to arrange this information and requires a case by case analysis of accidents.
- On the risk analysis.
 - This type of analysis is not an evident work and requires a good knowledge of the manipulated notion and tools. A literature review as well as the help of WP7 (Statistical methods) in this task will be necessary.
 - The risk analysis bases largely on exposure data. These data allow to count or to characterize a targeted population. The most classic of them (such as the population of a country, car fleet, the number of km driven, etc.) are available in most of the countries. On the other hand, those related to the driver and to his driving behavior (such as naturalistic driving, FOT, etc.) are rare and often not accessible to the scientific community.
- On the data supply.
 - The process set up in TRACE requires to have a good knowledge of databases.
 - This process also requires on behalf of the Operational WPs a just balance in the requested data between quantity and relevance.
- On the European overview.
 - Most of the European countries present in TRACE are the main countries where the road safety problems are well known. Our difficulty relies on the lack of information about Eastern European countries. Can we build a knowledge which wants representative of Europe on only a part of the countries which composes it?

3 The stabilized situations

3.1 Definition

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

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

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

3.2 Descriptive analysis

The stabilized situations represent 87% of the situations occurring out off 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.

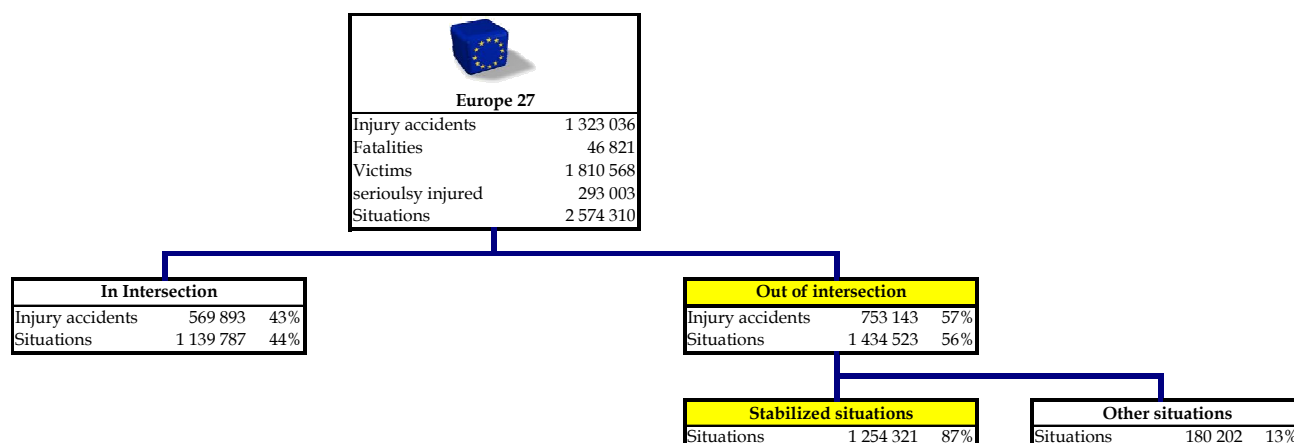


Figure 19: Distribution of stabilized and “specific manoeuvres” situations in EU27
(year 2004, Sources CARE, IRF, IRTAD, National Statistics Databanks)

The main results obtained after the analyses over extensive database in TRACE shows the main configurations (scenarios) that are going to be analysed in different ways with the aim of gathering the main purpose of this WP2. The ‘final stabilized scenarios’ are:

Situation ST-1: A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian. This scenario can be split into the following sub-scenarios:

Situation ST-1.a (‘Pedestrian crossing from offside’): A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a **pedestrian crossing from driver side**. The following figure shows this situation.



Situation ST-1.b (‘Pedestrian crossing from nearside’): A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a **pedestrian crossing from opposite side to the driver**. This situation is shown in the following figure.



Situation ST-1.c (‘Pedestrian moving along the road on nearside’): A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian moving along the road on the opposite side to the driver.



Situation ST-2: A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident.

Situation ST-2.a (‘Lane departure’): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a **lane departure** with an initial loss of control.



Situation ST-2.b (‘Run-off accident offside’): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a **run-off accident to the driver side**.



Situation ST-2.c (‘Run-off accident nearside’): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a **run-off accident to the opposite side to the driver**. The dynamic of the accident can be shown as follows in the next figure.

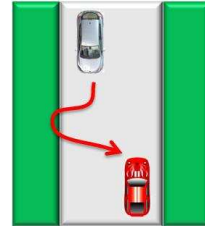


Situation ST-3: A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle.

Situation ST-3.a ('Reduction of driving space due to opponent overtaking'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver (red car) was performing a normal driving. This driver is confronted to a opponent vehicle (grey car) which is **reducing his driving space** (this **opponent vehicle is overtaking** another vehicle). In this case, only the situation relative to the red car is concerned by this scenario.



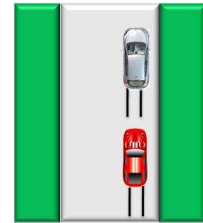
Situation ST-3.b ('Reduction of driving space due to opponent loss of control'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver (red car) was performing a normal driving. The driver is confronted to an opposite vehicle (grey car) which is **reducing his driving space** (the opponent vehicle leaves its lane for any reason). As it can be seen in the following figure, this situation is very different to situation 3.a. Only the situation for the red car is included in this scenario. The situation of the grey car can be located in scenarios covered by ST2.



Situation ST-3.c ('Same lane but the opponent is stopped'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver (red car) was performing a normal driving. The driver confronted to an opposite vehicle (grey car) moving in front of him, in the **same way but this opponent vehicle is stopped**. In the following example only the situation relative to the red car is concerned by this scenario.



Situation ST-3.d ('Same lane but the opponent is with lower speed'): A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver (red car) was performing a normal driving. The driver confronted to an opponent vehicle (grey car) which moving in front of him, in the **same way but the opponent vehicle was with a lower speed**.



Situation ST-3.e ('Same lane but the opponent is coming rear'): The stabilized driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver was performing a normal driving. The driver (red car) confronted by **other vehicle coming rear** (grey car). This configuration can be seen as the opposite situation to the scenarios ST-3c and ST-3d



Situation ST-4: a driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle. This driver had to perform an emergency manoeuvre in order to avoid an obstacle or a vehicle.

Although these four ‘stabilized situations’ are the main ones, the first three scenarios will be the final scenarios to be analysed in this report, covering near 80% of the fatalities occurred in stabilized situations and 70% of the casualties. The focus on only the three most common stabilized situations will not move away the gathering of the initial objectives because the majority of these accidents are covered (the three first scenarios were selected in order to assure data suppliers did not apply the difficult criteria related to this fourth scenario).

3.3 Accident causes and risk

For the analyses of accident causation and risk, 1,760 stabilized accidents were gathered from the in-depth databases available to this task (showed in Figure 20). The distribution of these stabilized accidents is:

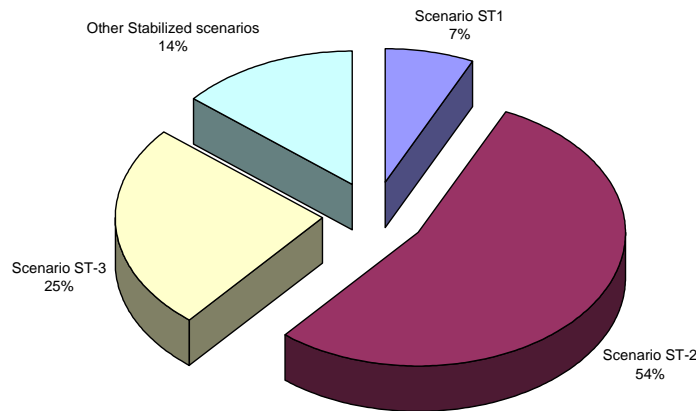


Figure 20 : Distribution of accidents within the sample according to the stabilized scenarios

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

3.3.1 Situation ST-1

A driver, not performing any specific manoeuvre and not crossing an intersection, collides with a pedestrian. The number of accidents analysed related to this scenario was 117 cases (this means, 7% of all the stabilized situations), being almost 80% of them came from pedestrians crossing the road (situations 1a and 1b) as it can be showed in the figure below.

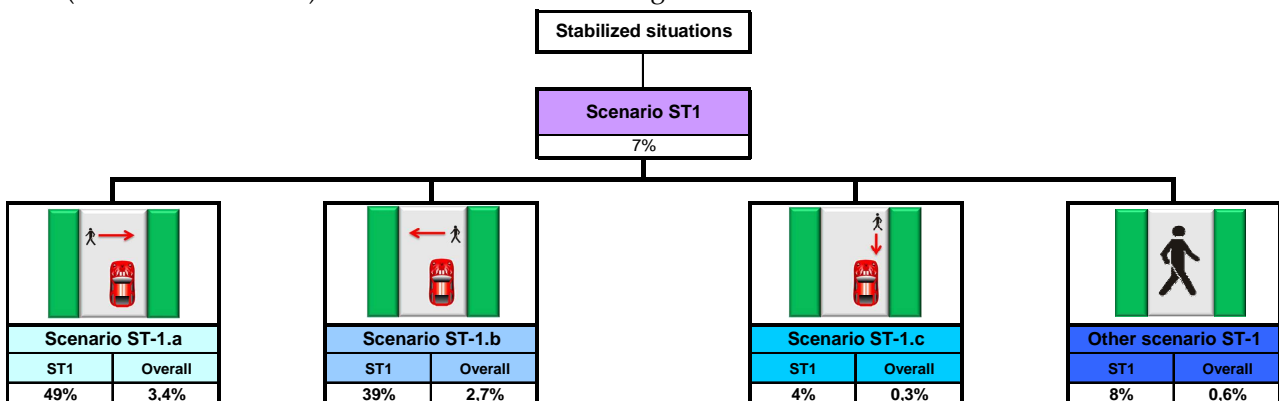


Figure 21 : Distribution of stabilized accidents with pedestrian involved (Scenario ST-1)

3.3.1.1 Situation ST-1.a ('Pedestrian crossing from offside')

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

The analyses performed over the in-depth databases available to this task shows that the main accident causation was a pedestrian error (61%), being 'recognition error' and 'to invade or cross the road illegally' the most common. During the analysis of the Human Function Failures (HFF), the HFF analysis was applied over the accidents belonging to this situation. Confirming the mechanism of these accident, the most common failure found in these accidents was related to the perception, 'Non detection in visibility constraint detection' (P1), specifically, the passenger car driver was surprised by the pedestrian (P1C) non visible when the car is approaching. Also, it has been found that the pedestrian crossed not obeying the rules, so the most possible configuration of accident could be a pedestrian, non visible by other vehicle, was knocked down whilst the pedestrian was crossing the road illegally (there was not pedestrian cross).

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

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

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

3.3.1.2 Situation ST-1.b ('Pedestrian crossing from nearside')

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

The Human function failures detected were 'P1C' (Passenger car driver surprised by a pedestrian non-visible when approaching' in 65% of the occasions and 'P2C' (Passenger car focalisation towards a source of information regarding the importance of the traffic flow) in 20%. This means that in these accidents, the passenger car driver was surprised by the pedestrian in visibility constraint conditions and also, the passenger car driver was focalising towards a source of information regarding the importance of traffic flow.

Of course, there is a perception problem in this situation due, linked mainly to the surprising pedestrian way of crossing.

According to the previous circumstances and the causation factors explained below, these accidents seem to happen when a pedestrian was trying to cross the road illegally (out of a pedestrian cross) made a recognition error due to low level of attention and got knock down by another vehicle which could not see the pedestrian on time due to visibility limitation (trees, road layout, parked cars...). As it can be understood, this is very important finding because here a possible detection device will not be able to help the driver, except if the device could detect the pedestrian after these visibility limitation.

In this case three causation factors have been found as relevant:

PEDESTRIAN ERROR:

The pedestrian is crossing the carriageway not obeying traffic rules.
There is a recognition error made by the pedestrian.

PEDESTRIAN STATE:

Low level of attention

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

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

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

3.3.1.3 Situation ST-1.c ('Pedestrian moving along the road on nearside')

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

3.3.2 Situation ST-2

A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in a lane departure/run-off accident.

This is the most common situation in the sample from the information requested to In-depth suppliers. 920 cases were gathered, which represents 54% of all the stabilized accidents analyzed.

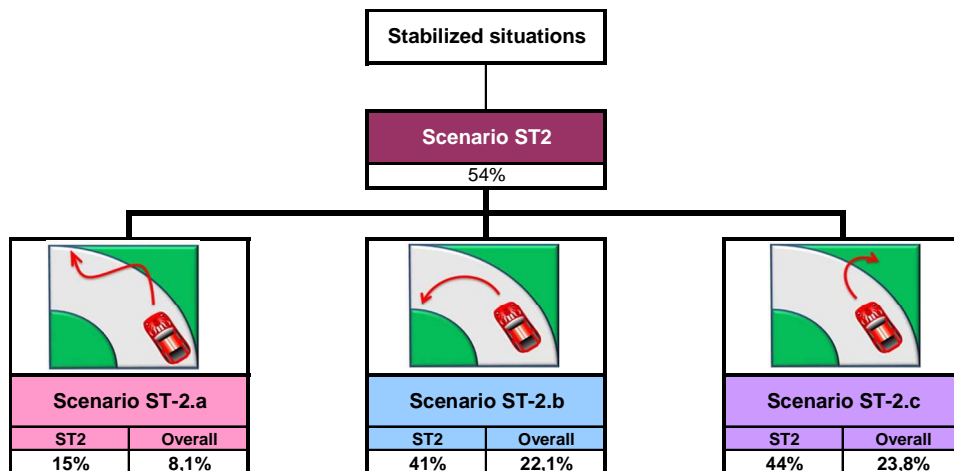


Figure 22: Distribution of stabilized lane departure or-run off accidents (Scenario ST-2).

3.3.2.1 Situation ST-2.a ('Lane departure')

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

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

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

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

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

PASSENGER CAR ERROR:

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

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

PASSENGER CAR STATE:

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

PASSENGER CAR TRAFFIC:

In this case, the causation factor is related to the environment around the passenger car which runs off.

- Environmental perturbation (loss of adherence such as ice, aquaplaning, oil, snow..., 22%). Factors that increase the probability of having this causation factor are a single carriageway road (OR = 2.87, p - value = 0.05 compared to double carriageway), sharp bend (OR = 4 compared to soft curves and 11.76 compared to straight, p - value = 0.05), male driver (OR = 2.32, p - value = 0.05) and bad conditions (OR= 4.07, p - value = 0.05 compared to good weather).

3.3.2.2 Situation ST-2.b ('Run-off accident to the offside')

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

A description of how these accidents occurred could be: male driving at night in with a low level of attention due to the road layout (accidents in double carriageway road 29%) or a secondary task when confront a sharp bend. Other possible explanation of this type of accidents is a driver confronting a bend loses the control due a recognition error by excessive speed and/or bad weather conditions

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

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

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

Four accident causation factors have been found relevant:

PASSENGER CAR ERROR:

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

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

PASSENGER CAR STATE:

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

PASSENGER CAR ENVIRONMENT:

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

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

3.3.2.3 Situation ST-2.c ('Run-off accident to the nearside')

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

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

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

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

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

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

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

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

PASSENGER CAR ERROR:

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

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

PASSENGER CAR STATE:

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

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

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

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

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

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

3.3.3 Situation ST-3

A driver, not performing any specific manoeuvre and not crossing an intersection, is involved in an accident with more than one vehicle.

The number of cases analyzed from the In-depth suppliers was equal to 442 cases (25% of the total stabilized sample). Different sub-scenarios were detected:

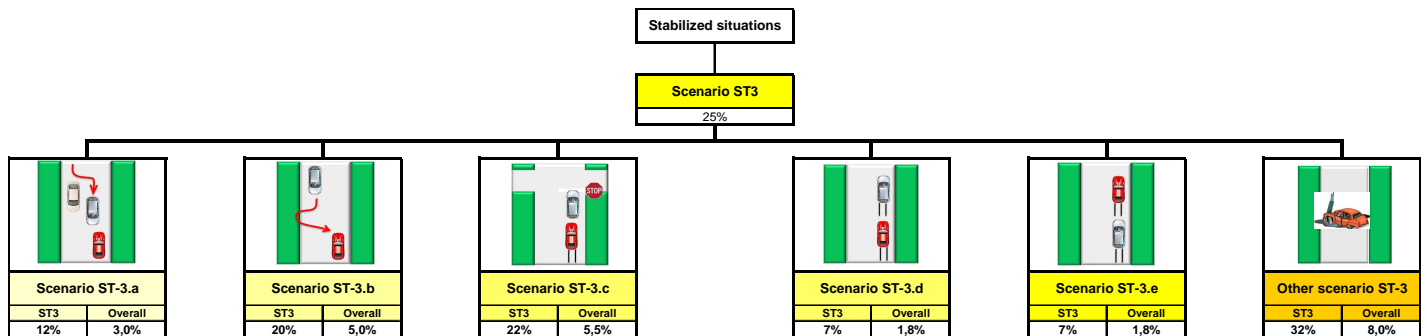


Figure 23: Distribution of stabilized lane departure or run off accidents (Stabilized Situation 3)

3.3.3.1 Situation ST-3.a ('Reduction of driving space due to opponent overtaking')

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

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

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

- Decision (32%). This causation factor showed to be more likely when the following factors are present:
 - Curve (O.R. = 8.35, p - value = 0.05 compared to straight sections). To be more concrete, slight curves are 2.33 times more than sharp curves and 10.57 times more than straight.
- Male drivers are 2.55 times more likely to suffer this kind of accidents than females.

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

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

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

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

Why did the opponent driver lose control? The analyses over the human function failure show us that the opponent vehicle loss control due to loss of psycho-physiological capacities consequently to a failing asleep or ill-health (G1A from the opponent point of view) and what happens is that the stabilized vehicle does not detect the rapprochement of the vehicle ahead.

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

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

OPPONENT ERROR:

Speeding (16%). This causation factor showed to be more likely when the following factors are present; bad weather conditions (OR = 3.06, p - value = 0.05 compared to good weather conditions), during night lighting conditions (OR = 2.41, p - value = 0.05 compared to daylight conditions), curves (OR = 2.3 compared to straight sections, p - value = 0.05), and, finally, female drivers (OR = 1.74, p - value = 0.05).

3.3.3.3 Situation ST-3.c ('Same lane but the opponent is stopped')

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

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

STABILIZED ERROR:

- Decision error (46%). This causation factor showed to be more likely when the following factors are present; double carriageway road (OR = 2.08 compared to single ones, p - value = 0.05), and, male drivers (OR = 1.84, p - value = 0.05). Near 96% of the accidents were in straight sections.
- Not keeping safe distance (42%). During the logistic regressions, no significant variables were found to be significant. The only important aspect was the fact that 95% were in straight sections, and near all of them (except one accident) were rear-end accidents.

STABILIZED STATE:

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

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

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

This type of accidents could be considered similar to ST-3.c, but now, the difference is in the targeted vehicle. Instead of being stopped, the targeted vehicle is with lower speed while the stabilized vehicle comes from rear and impact against this first vehicle.

At a first view, it can be thought that the mechanism of the accident and the accident causation can be very similar to the main findings in the previous situation ST-3.c (in those accidents, the main accident causations came from the stabilized vehicle) but the analyses over the in-depth information show that is the opponent vehicle (targeted vehicle) which is the cause of the accident. The data sample had 33 cases which belong to this scenario.

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

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

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

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

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

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

3.3.3.5 Situation ST-3.e ('Same lane but the opponent is coming rear')

The number of accidents from In-depth suppliers was equal to 32 cases, what it means 7% of the stabilized accidents. The accident mechanism associated to this scenario could include different situations already mentioned previously.

In this case, the opponent vehicle comes from rear and impacts the stabilized vehicle. Although this general explanation does not detail what each vehicle was doing, from the opponent vehicle point of view, this vehicle could be in the following situations:

- The opponent vehicle could be also the stabilized vehicle belonging stabilized situation ST-3.c.
- The opponent vehicle could be also the stabilized vehicle belonging stabilized situation ST-3.d.
- The opponent vehicle could be doing a specific manoeuvre and collides against the stabilized vehicle which is ahead.

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

A general description of these scenarios shows that the majority of the accidents happen outside urban area, in dual carriage way (74%) and in straight section (85%). Looking at these main characteristics could seem difficult to understand why these accidents happen in these locations. If we have a look at the visibility conditions, a high percentage of these accidents happen during the night (near 40%), this means the visibility conditions are constraint. Also, it has been seen that other kind of 'degraded conditions' like bad weather conditions (fog, raining...).

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

It is clear that the cause of the accident comes from the opponent vehicle in a recognition error. The opponent vehicle was travelling in an 'easy road' (this could mean: straight section in double carriageway road), but due a failure at the moment of looking, the vehicle collides against the stabilized vehicle.

As the in-depth information gives, it was not a problem of speed, but in many occasions there is a lack of visibility due, specially, to the following degraded situations (where the visibility is deteriorated):

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

These degraded situations will be studied later from that point of view, although the conclusion will be showed in a different way.

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

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

4 The situations involving specific manoeuvres

4.1 Definition

The specific manoeuvres cover the situations in which the driver has to realize a specific manoeuvre for which a higher than usual solicitation is required and without any environmental or human degradations. All specific manoeuvres performed at an intersection are excluded. This situation type is a “non-stabilized situation + no intersection”.

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”.

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

- Location : out of intersection
- Vehicle : at least one passenger car in the accident
- Driver manoeuvres: every specific manoeuvres done by the driver allowing to change the initial trajectory such as overtaking, changing lane, u-turning, etc.

4.2 Descriptive analysis

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

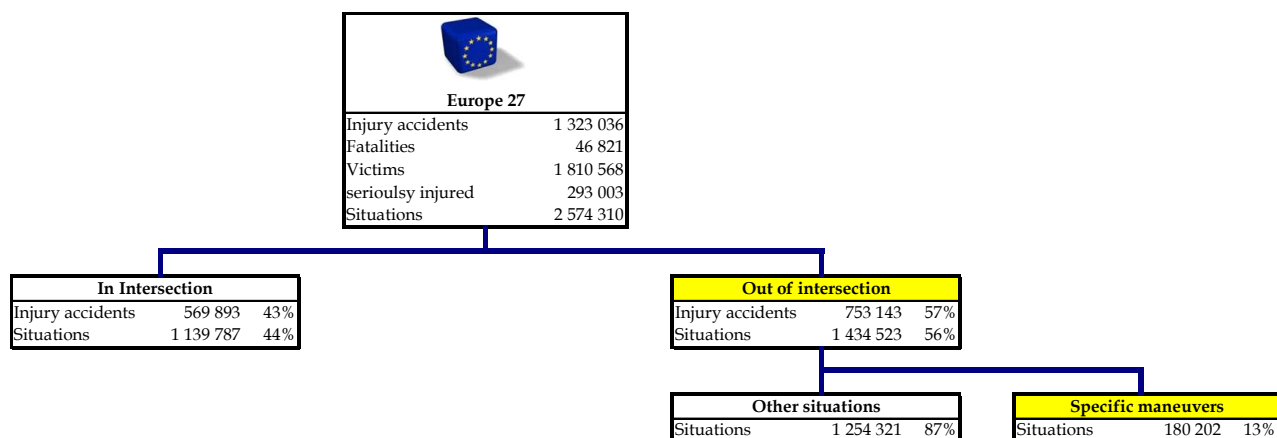


Figure 24: Distribution of stabilized and “specific manoeuvres” situations in EU27 (year 2004, Sources CARE, IRF, IRTAD, National Statistics Databanks)

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

Situation SP-1 The overtaking manoeuvre: the accident takes place away from a proper intersection and the driver is performing an overtaking manoeuvre. He overtakes a moving or a static vehicle on the offside or a moving vehicle on the nearside.



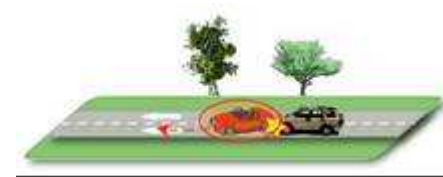
Situation SP-2 The turning left manoeuvre (or right, in countries where drive is on the left): the accident takes place away from a proper intersection and the driver is performing a turning left manoeuvre in order to join a private road or a parking for instance.



Situation SP-3 The u-turning manoeuvre: the accident takes place away from a proper intersection and the driver turns in order to completely reverse his direction of travel.



Situation SP-4 The changing lane manoeuvre: the accident takes place away from a proper intersection and the driver is performing a changing lane manoeuvre. This one applies to carriageways with at least 2 lanes in the direction of travel (i.e. where there is a legitimate opportunity to change lane). It differs from the overtaking manoeuvre because the vehicle has no vehicle to overtake and the aim of the manoeuvre is to change lane in order to change direction.



Accidents occurring in the year 2004 were considered for analysis. It should be noted that in Great Britain, vehicles drive on the left side of the road. This has implications when interpreting data on vehicle manoeuvres.

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

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

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

- On single carriageway, typically national roads and main secondary roads, turning left, U-turning and overtaking offside are the three major manoeuvres performed in high proportion.
- On dual carriageway, typically motorways, changing lanes are predominant.
- On dual carriageway (within ways physically separated), the main situations are overtaking, turning left and changing lane manoeuvres (for GB and France).
- On single carriageway, such as national roads and main secondary roads, overtaking and turning left manoeuvres are the main performed manoeuvres.

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

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

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





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

Table 3: Fatality for 1,000 accidents for specific manoeuvre accidents and accidents at intersection (Year 2004, Sources CARE, IRF, IRTAD, TRACE, National Statistics Databanks)

4.3 Accident causes and risk


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

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

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

The next paragraphs will summarize the causes of such problems according to specific manoeuvre. And the main counter-measures identified focus on “how can we help the driver in performing his manoeuvre in good conditions?”. And this is what is presented below according to specific manoeuvres.

4.3.1 Situation SP-1 : Overtaking manoeuvre

	<p>Prevalence in Europe: 18% to 38%</p> <p>Severity KSI⁷: 20% to 28%</p> <p><u>In-depth databases used:</u> LAB, INRETS, OTS and GIDAS</p> <p><u>Sample:</u> 190 accidents</p>
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The passenger car overtaking is a *primary active driver* in the genesis of the accident. When another road user is involved in the accident, this one is a passive driver. His only role consists in being present and he cannot be considered as an engaging part in the disturbance. So, if we want to avoid the accident, we need to find appropriated safety measures linked to the passenger car overtaking.

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

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

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

Some factors linked to the state of the driver can explain why there is a poor diagnosis of the situation. Indeed, the analysis showed that the driver was careless, reckless, in a hurry or restlessness. If it is difficult to find a system which could change your mental state, we can all the same prevent or help him to diagnose the situation. The systems which could help the driver are a


⁷ Severity KSI: fatalities+severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

collision warning system, a collision avoidance system, an inter-vehicle communication system or a lane changing assistance. These systems could also help the driver when the visibility is deteriorated.

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

The last result shows that there is a problem of loss of control during the realization of the overtaking. Indeed, the passenger car driver, during the stabilized phase and the cutting one, crossed respectively the left and right shoulder and this crossing are often at the origin of the loss of control. Naturally systems which could avoid a loss of control are the most appropriated such as ESC⁸ or TCS⁹. Nevertheless, it is possible to associate counter-measures to the road. Indeed, we could think that a larger road would have avoided the crossing on the shoulders or warning painting on the road would have inform the driver that he is very close to the shoulder.

4.3.2 Situation SP-2: Turning left manoeuvre

	<p>Prevalence in Europe: 10% to 43%</p> <p>Severity KSI¹⁰: 16% to 22%</p> <p>In-depth databases used: LAB, INRETS and OTS</p> <p><u>Sample</u>: 62 accidents</p>
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The in-depth analysis of passenger car realizing a turning left manoeuvre shows that the main problem related to the manoeuvre is linked to the preparation of it. It means that it is not realized in good safety conditions.

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

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

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

There is also a problem of bad visibility of the situation. The driver is not aware of all the elements helping him to perform his manoeuvre. When the road layout is at the origin of the problem of

⁸ Electronic Stability Control


⁹ Traction Control System

¹⁰ Severity KSI: fatalities + severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

visibility, it is necessary to work on the traffic regulation surrounding the turning left place. When the lack of visibility is linked to weather condition or mobile mask, a system helping the driver to see the other road user not visible should be efficient. Once again, the inter-vehicle communication system gives to the road users advanced knowledge of approaching vehicles outside their field of vision.

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

4.3.3 Situation SP-3: U-turning manoeuvre

	<p>Prevalence in Europe: 7% to 20%</p> <p>Severity KSI¹¹: 17% to 22%</p> <p>In-depth databases used: LAB, INRETS and OTS</p> <p><u>Sample</u>: 27 accidents</p>
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The main problem of u-turning manoeuvres is not the manoeuvre realization but is the preparation of the manoeuvre. It means that it is what has to be done before realizing the manoeuvre. Indeed, the human functional failure analysis shows that the main failure is a perception one.

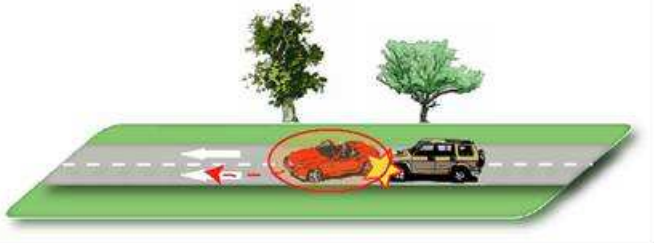
Indeed, the in-depth analysis indicates that drivers coming from a parking place on the nearside of the side have problems of visibility. Due to other vehicles parked, they are not able to access to some potential useful items of information and the opponent road users have also problem to see case vehicles.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

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

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

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

4.3.4 Situation SP-4: Changing lane

	<p>Prevalence in Europe: 11% to 19%</p> <p>Severity KSI¹²: 12% to 17%</p> <p>In-depth databases used: LAB and OTS</p> <p><u>Sample</u>: 56 accidents</p>
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The in-depth analysis shows that the state of the driver has an important influence on the changing lane realization. Even if the human functional failure analysis is not available for this manoeuvre, we can think that perception failures are conditioned by the driver state. Indeed, we determined that most of the key events were a poor evaluation/anticipation of the situation. So the counter-measure should help the driver in warning him of the proximity of other road users. And the inter-vehicle communication well answers to the problem.

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

¹² Severity KSI: fatalities + severe injuries in accident with at least the specific manoeuvre/all injuries in the accident with at least one specific manoeuvre.

5 The intersection situations

5.1 Definition

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

5.2 Descriptive analysis

The accidents in intersection represent 43% of road injury accidents in EU27. This result is pulled 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.

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

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

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

Figure 25: Distribution of road accidents following their location at or out off intersection in EU27 (year 2004, Source: CARE, IRE, 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.

The descriptive analysis showed the following results:

- **Users:** 85 to 90% of the intersection accidents involved at least one passenger car. 9% to 15% of intersection accidents are pedestrian accidents. Pedestrian accidents occurred rather inside urban area, at intersection with traffic regulation. Older pedestrian are well represented (12 to 41% of the pedestrians involved at intersection).
- **Gender:** 65% to 76% of drivers involved in intersection accidents involving at least one passenger car are male.
- **Location:** Inside or outside urban area? 64% to 73% of intersection accidents occurred inside urban area. Moreover 73% to 85% of intersection accidents with at least one passenger car occurred in urban area and 45% to 68% of intersection accidents occurred at intersection with regulation.
- **Luminosity:** 65% to 74% of intersection accidents (with at least one car) occurred in the daylight.
- **Weather:** 82% to 90 % of all intersection accidents occurred while the weather was normal. Moreover, 68% to 88 % of all intersection accidents occurred while the road surface was dry

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

In order to identify the parameters linked to the intersection circumstances, the accidents occurring at intersection have been split into scenarios. In order to identify the relevant scenarios we have based our selection onto the available parameters such as the pre-accidental manoeuvre, the relative speed direction, the right of way, the vehicle type.

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

Obviously, we were confronted to the problem of data compatibility. Each European partner had to adapt the data in order to be in accordance with the scenario requested. The main difficulty of most of the national road accidents databases is the absence of the identification of the pre-accidental manoeuvre of each vehicle involved in intersection accident. This forced to us to formulate scenarios which are more similar to the accident configuration rather than the situation.

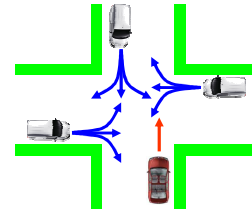
We decided to gather scenarios into 6 main common European scenarios. They represent 97% of all intersection accidents in Europe.

Scenario IN-1:

All intersection except "rear end" and pedestrian crash scenarios

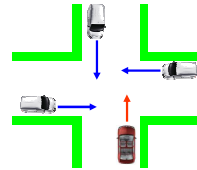
Characteristics: one driver turns left or right or crosses while the opponent comes from left or right

70% of intersection accidents (KSI¹³ : 68%).

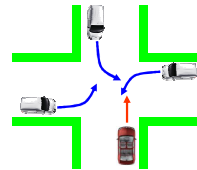


The scenario IN-1 where vehicles crossed the roads and/or the trajectory of the opponent vehicle (the drivers turned left or right or not) is more frequent and more severe than anyone else. 70% of all intersection accidents and 68% of the fatalities and the serious injuries at intersection belong to the scenario IN-1. This scenario is split into 3 accident types:

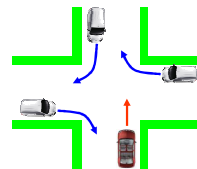
Situation IN-1.a intersection Driver confronted to vehicle going straight at.



Situation IN-1.b Driver confronted to vehicle turning to the left at intersection



Situation IN-1.c Driver confronted to vehicle turning to the right at intersection

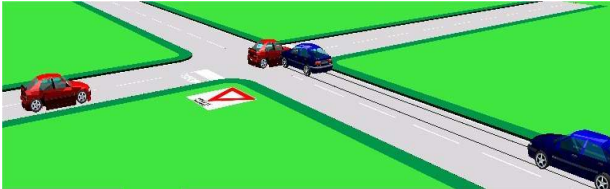


In this first intersection situation, the scenarios IN-1.1 and IN-1.2 are predominant.

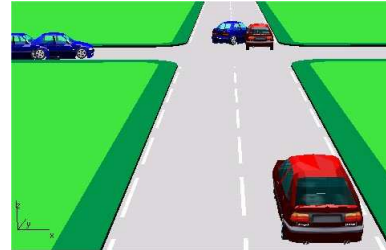
¹³ KSI: (Killed + Seriously Injured) / all casualties

When the road users go straight, cross the intersection perform no manoeuvre and the 2 road users come from crossed directions, we call this situation “Straight Cutting Path accidents”.

When at least one of the drivers turns left or right on crossed roads, we call these situations either LTIP (Left Turn Into Path), LTAP (Left Turn Across Path), RTIP (Right Turn Into Path) or RTAP (Right Turn Across Path).



Scenario IN-1.a SCP - Straight Crossing Path
Crossing paths, No maneuvers,
The other vehicle (OV) comes from left or right



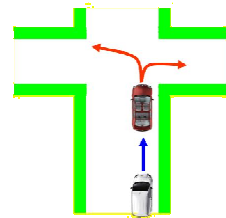
Scenario IN-1.b LTIP and LTAP
Crossing path or oncoming vehicle
with one driver turns left (right in GB)

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

Scenario IN-2:

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

Characteristics: 2 vehicles on the same road same direction, 1 driver turns left or right
2% of intersection accidents (KSI : 2%).

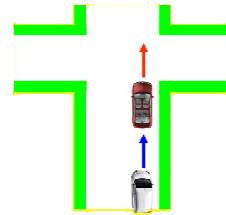


The scenario 2 where the two vehicles involved are on the same road, same direction, one of the two drivers is turning left or right represents 2% of the intersection accidents

Scenario IN-3:

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

Characteristics: 2 vehicles on the same road same direction, no manoeuvre except slowing down
5% of intersection accidents (KSI: 2%)



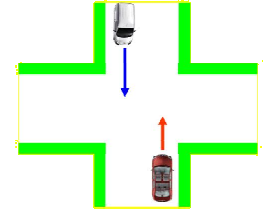
The scenario 3 where the two vehicles involved are on the same road, same direction, no manoeuvre is performed, represents 5% of the intersection accidents.

Scenario IN-4:

"Incoming" scenarios (except pedestrian)

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

2% of intersection accidents (KSI 4%)



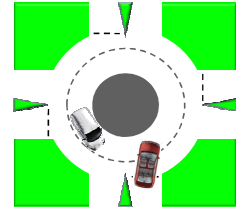
The scenario 4 where the two vehicles involved are on the same road, different directions, no manoeuvre is performed, represents 2% of the intersection accidents.

Scenario IN-5:

Roundabout

Characteristics: concern all injury accident happening in roundabout.

10% of intersection accidents (KSI: 7%)

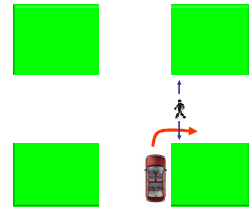


The scenario 5 where the two vehicles involved are moving in a roundabout, represents 10% of the intersection accidents.

Scenario IN-6:

Pedestrian accidents

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



The scenario 6 where at least one pedestrian and a passenger car are involved represents 9 to 15% of the intersection accidents.

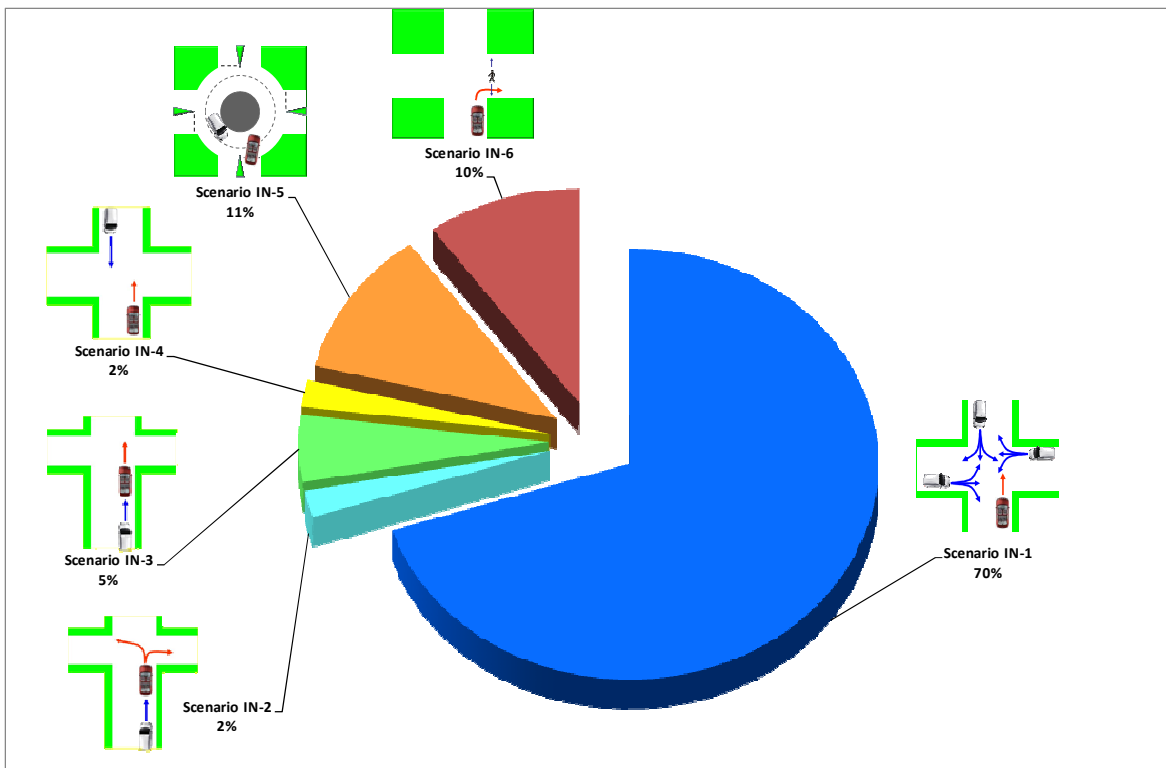


Figure 26 : Distribution of accidents within the sample according to the intersection scenarios

5.3 Accident causes and risk

The analysis of the pre-accidental events through the different concepts or approaches exposed above, will allow identifying the accident mechanisms with:

- The key event that switch the driving phase onto the rupture phase. Remind that accident occurrence is the result of different related causes affected to the system Driver/Vehicle/Environment. Key events are the events that explain the rupture between the driving phase and the rupture phase. At last, key event is mainly attributed to the driver having not the right of way, sometimes to both drivers.
- The Human Functional Failures
- The accident causes:
 - Explanatory elements of the Human Functional Failures
 - Initial speed
 - Sight distance
 - Stopping distance
 - Emergency reaction

Through the literature review and our experience, we know that the road layout, the traffic flows, the speed and the sight distance have a great effect on the accident occurrence.

Most of the studies mention the speed is a crucial factor in the severity of a crash and obviously in the crash avoidance. Speed has different impact according to the related moment along the sequential phases of the occurrence of the accident.

The driving speed is the speed during the driving phase or initial speed. The speed can be adapted or not-adapted to the circumstances (according to the difficulties of the situation such as road layout, weather conditions), excessive (higher than the speed limits) or not. At last this speed will allow the driver to perform or not an emergency manoeuvre, will allow the vehicle to help the driver to perform the manoeuvre.

The speed at the beginning of the crash phase which conditions the crash violence.

The speed at the end of the crash phase which conditions the post collision phase

Because the TRACE project aim is to define the main causes related to the intersection situations, we focused our analysis on the initial speed to show the effect of this parameter in the genesis of the accident.

So, we analyzed:

- The initial speed for both drivers according to the right of way and the respective directions.
- The sight distance which is determinant to cross the main road and depends on the vehicle speed on the main road.
- At last the emergency reaction for both drivers according to the location and to the right of way at intersection.

The intersection scenarios were previously identified (descriptive analysis) on one hand according to the driver manoeuvre, the relative direction of the vehicles and the regulation and in the other hand according to the frequency and the severity KSI. In-depth analysis highlights how accidents occurred (accident mechanisms) and what are the main causes. The following analysis will show that among the relevant parameters, regulation (right of way or not) and direction of the opponent vehicle are the main parameters showing different and relevant causes. This analysis led us to split the results according to the right of way. Obviously the related counter-measures we can propose will be adapted to the driver according to his driving tasks and his needs.

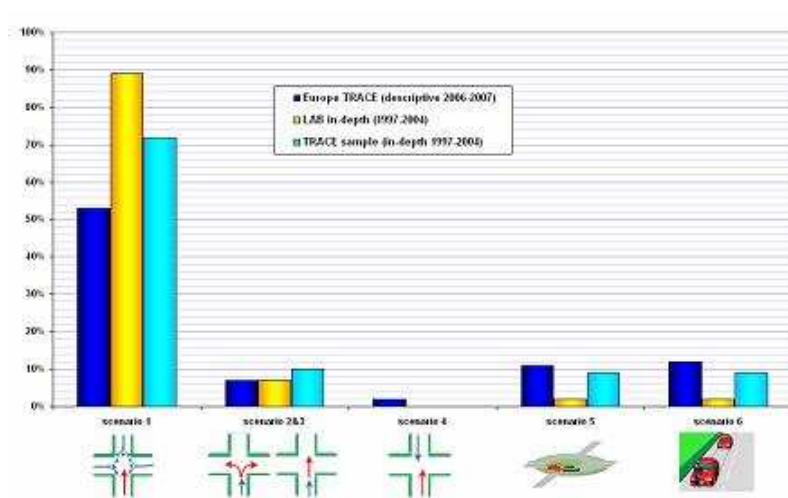


Figure 27: Intersection scenarios distribution in the TRACE sample

The distribution of the main scenarios into the TRACE sample show that we will perform a more accurately analysis with a more representative sample. In fact, the scenario distribution is very close to the European situation (closer than in-depth LAB database on its own).

In order to propose an accurate analysis and to avoid sample size bias, we have focused the analysis on the 2 main intersection accidents scenarios:

- Scenario IN-1 covers 53% of all intersection accidents in Europe and 59% of the KSI. So we have focused our in-depth analysis onto this scenario.
- Scenario IN-6 (pedestrian scenario). Despite the lack of information concerning the pedestrian accidents in the in-depth databases, we intend to analyze the circumstances of such cases and highlight the requirements for a further investigation.

Because in Europe, 85 to 90% of intersection accidents involved at least one passenger car and the scenarios were defined on the base of the involvement of at least one passenger car, we have focused our analysis onto accidents involving at least one passenger car. The analysis showed that more than the respective directions (the opponent coming from the left or the right) or the vehicle type, the priority nature leads to relevant conclusions.

So we have gathered similar scenarios according to the priority point of view:

- Drivers having not the right of way HNROW.
- Drivers having the right of way HROW.
- According to the priority point of view, we highlight the accident mechanisms through:
 - The Key events that switch the driving phase to the rupture phase
 - The Human Functional Failures that identify which driver function failed in the functional loops Perception-Diagnostic-prognostic-Decision-Action.
 - The explanatory elements that explain the HFF.
 - The cinematic parameters such as initial speed, sight distance or emergency reaction
 - The driver age, parameters highlighted in the literature review as a determinant factor.

5.3.1 Scenario IN-1

This scenario represents:

- 53% of European intersection accidents
- 59% of fatalities and severely injuries
- 70% TRACE sample

The scenario 1 is a set of several sub-scenarios in which the Opponent Vehicle comes from the left or the right. The Case Vehicle has the right of way or not and is going straight or turning.

5.3.1.1 Scenario IN-1.A

This scenario represents 57% intersection accidents in the TRACE sample. In this case we distinguish:

- The driver having the right of way going straight confronted to the other vehicle coming left or right.
- The driver having not the right of way turning left while the other vehicle is going straight

5.3.1.1.1 The drivers having not the right of way (HNROW)

For the drivers having not the right of way, the issues are different from the drivers having the right of way. It is important to highlight the differences in order to adapt accurate counter-measures.

In this case, the key events are mainly Endogenous (related to the driver) with:

The factors linked to the “internal conditions of the task” (factors related to the driving task such as the driving manoeuvre (turning, going straight) correctly performed or not). These drivers are more likely concerned by “incorrect driving manoeuvre” such as “non respect of regulation” and “incorrect decision” to perform a manoeuvre according to the available information (visibility or the available time opposite the main road traffic). Then a “poor evaluation” of the situation or of the opponent manoeuvre (means that drivers saw the other vehicle (on the main road) but all the drivers estimated having time to cross) and last a “misinterpretation of the situation” (includes poor experience of the site, misleading infrastructure leading to legibility problems (the road is not like we think it is!) and several factors such as driver state or visibility (mask)).

The factors linked to the “driver behaviour” (factors directly linked to the driver awareness of the situation (attention, distraction for example)). In this case, most drivers “failed to look” because of exogenous factors related to the infrastructure and the environment (road layout, mask, weather luminosity) and to problem of geometrical visibility (sight distance), directly linked to the road layout.

Drivers having not the right of way present mainly “Perception Failures”. The “Perception Failures” can be explained by a quick look (rapid information search such as a quick look at the environment and the opponent), a focused attention (failure in the information search organisation such as a focus on a part of the situation at the expense of the opponent vehicle), no look (break in information search such as the driver stopped searching information (ex: he performed other task than the driving task)), no visibility (information detection strain such as the information is not available or there is a geometric mask)) and last inattention (information search negligence such as low driving task strain, inattention...).

Because, the driver didn’t perceive correctly the opponent vehicle, he couldn’t anticipate and avoid the crash. Only 1/3 drivers HROW, with Perception Failures, attempted to avoid the crash by braking or accelerating while 2/3 didn’t react before the crash. Moreover, 20% of these drivers drove at excessive speed reducing the chance to avoid the crash with a braking action.

We also highlighted that despite the fact the proportion of older drivers (65+) in the TRACE sample is low (11% of the drivers at intersection), they are more often involved as “driver Having Not the Right Of Way” than the other age classes. It means that older drivers have problem to manage the driving task at intersection and especially when they have not the right of way. These drivers (65+) are also more involved turning at “Yield” regulated intersection than other regulation while younger drivers (<25) are more likely involved at traffic lights. It means that when older drivers have not the right of way and have to manage with Yield regulation, they fail to perform their manoeuvre.

5.3.1.1.2 The drivers having the right of way (HROW)

For the drivers having the right of way, the key events are also mainly endogenous (related to the driver) but closely linked to the fact they have the right of way, drove on the main road and didn't expect the situation.

We distinguish first the factors linked to the "internal conditions of the task" with the "Incorrect driving manoeuvre" (related to the risk taking; the driver sees the other driver, understands the danger but doesn't anticipate), the "Misinterpretation of the driving situation" (related to the driver who misunderstands the intentions of the other driver; he anticipates and tries an avoidance or thinks that danger is gone but he is wrong), the "Excessive speed" related to the speed limits (superior to the speed limits) while inappropriate speed is related to the driving conditions (weather, road surface, traffic...) even if the speed limit is not reached and last the "Inappropriate reaction" related to the driver who brakes to avoid the crash but locks the wheels (sample of accidents with passenger car not equipped with ABS). The vehicle slides on the road without any control. Moreover, the stopping distances are not long enough to perform a correct avoidance of the crash. The drivers HROW see the other driver (on the secondary road), but understands too late his intentions.

Then, as endogenous key events, are factors related to the "driver behaviour" mainly represented by the drivers who "failed to look". The driver looked at the traffic but didn't see the other vehicle because he didn't search the information (right of way feeling).

Driver having the right of way presents mainly Prognostic Failures. This driver is waiting for the regulation performed by the other driver (sees the other vehicle slowing down up to the intersection but thinks he is going to stop) or waiting for no manoeuvre performed by the other driver (sees the other vehicle stopped on the secondary road but doesn't anticipate his manoeuvre) or last waiting for no obstacle on the carriageway (unusual manoeuvre performed by the other driver). The $\frac{3}{4}$ of "prognostic failures" find explanation with endogenous explanatory elements (related to the driver) such as the right of way feeling, the inappropriate speed and last the time constraint, risky driving and misunderstanding of the situation. In almost nine cases on ten "Prognostic Failures", the drivers having the right of way braked before the crash. Despite these drivers has performed a braking manoeuvre to avoid the crash, the accident happened.

Then driver having the right of way presented "Perception Failures". These failures can be explained by a focused attention (on the priority rules) or inattention (lost in thought), no visibility (moving mask), no look (break in information search because of non driving task) and last a quick look (feeling of right of way). Half of these drivers braked before the crash. The last half didn't react.

Whatever is the human functional failure (perception or prognostic), most of drivers having the right of way performed an emergency action to avoid the crash. If we compare the stopping distance (distance required to stop) to the available distance (distance to crash from the perception or the understanding of the situation), 66% of the drivers had not the distance required to stop their vehicle and avoid the crash. The drivers braking before the crash didn't avoid the accident because they had not the time and the space to perform a manoeuvre, they drove too fast (excessive speed), the road surface was wet, decreasing the efficiency of the braking and last they had not the visibility to see the other driver.

The other drivers didn't react before the crash because they had no time to perform an emergency manoeuvre. It means that despite they have seen the other driver (on the secondary road) it was too late to react. Because the other driver (on the secondary road) performed an atypical or illegal manoeuvre (didn't stop at STOP, pulled out while crossing traffic don't allow the manoeuvre), the driver having the right of way couldn't anticipate.

5.3.1.1.3 Generic counter-measures

The main generic counter-measures related to the scenario 1A drivers as a whole involved at intersection are first closely linked to the older drivers then the driver perception in the whole and last the driver emergency manoeuvre.

In this way we need to think about the best way to help the older drivers at intersection. Drivers are getting older as the population and this problem is going to be predominant in the future. Today the best way to help them with the available ITS is the detection of obstacle. But when older drivers perceived the other vehicle and performed a manoeuvre such as crossing the main road or turning left into the main road, they are confronted to a rapid traffic while they need more time to perform their manoeuvre. So, the best help is to reduce the approach speed limits on the main road to allow older drivers to perform the manoeuvre.

Then drivers having not the right of way need to be helped to perceive the other vehicle to look properly and to detect the other vehicle. It is necessary to control the available geometric visibility (sight distance) and improve the visibility in case of problems, to develop new road layout with appropriate sight distances.

Last, the drivers having the right of way need to be helped first to be more attentive (more concentrated on his driving task) and last to anticipate the other driver manoeuvre. These drivers have a strong feeling of right. They don't appreciate the situation as a risky one but rather as a security one. They see but don't anticipate or too late. They need to be informed of the risky situation with an up-to-date navigation tool that informs the driver of the risk to be confronted to a risky situation according to the geometric, visibility constraints, to the referenced black spots. They also need to be help along their emergency manoeuvre. EBA (Emergency Brake Assist) can reduce the braking distances.

5.3.1.2 Scenario IN-1.B

Accident occurring at intersection, vehicles moving on the same road with different directions. One driver is turning left.

Despite most of key events are related to the driver turning left, both driver situations, turning left or going straight, are characterized by endogenous key events (related to the driver).

Drivers turning left endogenous events reflect the misunderstanding of the driver and the problem of perception of the other vehicle.

Drivers going straight endogenous events are related to the excessive speed, the poor experience and the fact they failed to look.

Human Functional Failures depends on the driving manoeuvre performed. Drivers who are turning left presented rather perception failures while the drivers who are going straight presented perception and prognostic failures.

Emergency reaction depends on the driving manoeuvre performed. Drivers turning left didn't react while the drivers going straight braked.

The problem related to the age of the driver is mainly present for older drivers having turning left.

5.3.1.2.1 Generic Counter-measures

The main generic counter-measures related to the scenario 1B drivers as a whole involved at intersection are closely linked to the older drivers performing the manoeuvre and to the drivers having the right of way.

In this way we have to think about the best way to help the older drivers at intersection. Older drivers do need a regular training to learn the best way to perform manoeuvres especially at intersection. Other solution is to think about the environmental planning and the road layout to improve the legibility of the road.

The drivers having the right of way need to be helped to anticipate the other driver manoeuvre. These drivers need to be informed of the intentions of the other driver in order to be able to anticipate the situation even if they have the right of way.

5.3.2 Scenario IN-6

This scenario gathers intersection accidents involving a passenger car and a pedestrian

Remind that in Europe, 14% of the road fatalities were pedestrians in 2004, 11% in France, and 21% in UK. 67% of pedestrian fatalities occurred inside urban areas, 34% of pedestrian fatalities are aged 65+ and 45% are aged 0 to 24 (CARE 2006).

Despite the lack of information we know that pedestrian are mostly involved at intersection with no regulation or traffic lights. In this configuration, youngest and eldest are overrepresented.

Most of time the accident causation factors are first related to the “pedestrian” and then to the “internal conditions of the passenger car driver task”.

For both pedestrian and passenger car, “failed to look properly” is the first causation factor. In fact the visibility problem related to this scenario is particular. The visibility is linked to the manner the pedestrian cross the road. Half of intersection accidents involving pedestrian in our sample occurred during the night and most of them inside urban area. We suppose that in daylight the problem can be linked to the different traffic flows, the urban environment, and the “visual pollution”. The literature review highlighted that when volumes are higher than 12 000 vehicles/day, marked pedestrian crossings on multi-lane roads were more prone to crashes than unmarked locations, and the risk goes up as the volume rises. During the night the problem is different. We know that factors such as contrast related to the vehicle colour and lights and to the pedestrian clothes appear to have an effect on the conspicuity of both users.

However, pedestrian are mostly involved at intersection with no regulation or traffic lights. In this configuration, youngest and eldest are overrepresented. Moreover, half of youngest are less 10 while half of eldest are 70+.

Half of the pedestrians are crossing at intersection with no regulation. But the half of them is crossing at traffic lights intersection! The studies that have been done indicate that pedestrians look before crossing at both marked and unmarked pedestrian crossings, except at signalized intersections.

In spite of the fact that 60% of passenger car drivers braked before the crash, 40% of them didn't react! In fact 9 pedestrian accidents out of 10 engaged the pedestrian fault and could explain the lack of reaction. Moreover, all intersection accidents involving a pedestrian occurred when the initial speed of the passenger car was lower than 60 km/h. For half of them, the initial speed was lower than 40 km/h. Passive safety survey (ref LAB) performed on pedestrian accidents shows that when the impact speed is raised from 45 km/h to 55 km/h that is to say “only” 10 km/h, the fatal risk (the risk to sustained fatal injuries) is raised as well from 30% to 50%!

5.3.2.1.1 Generic Counter-measures

Generic counter-measures linked to the pedestrian intersection accidents are related to the vehicle (passenger car) driver.

In this way, the passenger car driver needs to be helped to perform his emergency manoeuvre. The driver broke most of time (60%) but didn't avoid the crash. Brake assist can be useful and help the driver.

They also need to be helped to prognostic the presence of a pedestrian, to see the pedestrian and to anticipate the avoidance. Obstacle detection is required when the pedestrian is on the road but when pedestrian is previously masked the detection is more difficult. Navigation tools can be useful to inform the driver about a potential risk zone (pedestrian presence likelihood).

5.3.3 Risk factors

In road traffic, according to WHO World Health Organization, risk is a function of four elements:

- The exposure which reflects the amount of movement or travel by different users or a given population density
- The underlying probability of a crash
- The probability of injury, given a crash
- The outcome of injury
- The factors influencing the crash involvement arises as the result of various factors:
 - Endogenous (or related to the driver) such as the speed, the alcohol, the fatigue, the gender
 - Or exogenous (related to the environment) such as the vehicle state, the road design, the visibility, the road surface.

In this part of the project we focused the risk analysis onto the risk related to the situation on the base of the in-depth data such as the key events (previously defined).

Relative risk is defined as the ratio of the probability of the event occurring in the exposed group (intersection situations) versus the control (non-exposed) group (out off intersection).

$$RR = (P_{\text{exposed}}) / (P_{\text{control}})$$

This risk analysis was based on the in-depth LAB database.

5.3.3.1 Factors influencing the risk

Risk arises largely as a result of various factors such as factors related to the driver, the environment, the conditions of the traffic, the conditions of the road.

Among all these factors in-depth analysis highlighted factors that have a great impact on the occurrence of accident

Road layout (at intersection/out off intersection)

Speed (excessive speed)

Visibility (longitudinal geometric visibility)

Emergency reaction

Human Functional Failures (perception)

5.3.3.2 Main relative risk factors

Risk analysis led us to confirm that the probability to be killed when the user is involved in accident at intersection is higher (1.3) than the probability to be killed when the user is involved out off intersection.

Excessive speed is also a risk factor that increases the risk to be killed at intersection. So, when users driving with excessive speed are involved at intersection accident, the risk to be killed or MAIS3+ is 1.44 higher than for users driving fast (excessive speed) out off intersection accidents.

Sight distance was also highlighted as a fundamental risk factor. Geometrical visibility increases the risk to be involved at intersection accidents. It is more likely probable (4 times) to be involved out off intersection when the geometrical visibility is reduced than at intersection.

Drivers having the right of way performed more likely an emergency manoeuvre when they had the right of way. The conditions at intersection allow to perform slightly less emergency manoeuvre than out off intersection.

Human functional failures are fundamental too to explain the way the drivers failed. In fact, it was highlighted that the risk to have a problem of perception is 1.4 higher at intersection than out off intersection.

6 The degraded situations

6.1 Definition

As defined in TRACE Deliverable D 2.1 (Types of Situations: The Descriptive Analysis), factors that degrade the road or the environment, giving rise to accident occurrence include:

Night time and lighting issues;

Weather conditions affecting visibility and speed leading to a potential for loss of control (e.g. fog, heavy rain, strong wind)

Road surface conditions (e.g. wet road, ice, contaminants on surface, defects)

Physical obstructions or hazards in the road (e.g. vehicle loads, stray animals) or temporary/sudden obstructions to visibility in the road/roadside (e.g. parked vehicles, overhanging trees)

6.2 Descriptive analysis

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.

We can see that this kind of accidents is in proportion more severe than the intersection ones (46% for degraded situations against 21% for intersection). 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 (respectively 50 and 13 deaths).

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

Degraded conditions		
Accidents	462 255	35%
Fatalities	21 532	46%
Victims	658 293	36%
Seriously injured	114 036	39%

Not Degraded conditions		
Accidents	860 781	65%
Fatalities	25 289	54%
Victims	1 152 275	64%
Seriously injured	178 966	61%

Figure 28: Distribution of road accidents following the degraded situation in EU27 (year 2004, sources: CARE, IRF, IRTAD, and National Statistics Databanks)

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)

Four main types of degradation were identified: degraded lighting, degraded weather, degraded road surfaces and hazards present. From the data that was available, the proportion of car accidents (injury only) occurring in each type of degraded condition ranged from:

27% to 41% in degraded lighting accidents;

16% to 22% in degraded weather accidents;

16% to 40% in degraded road surface accidents;

1% to 4% when hazards were present.

Analysis was also undertaken to identify certain characteristics of accidents which were found to be significantly more prevalent in accidents when each type of degradation was present compared to when the degraded condition was not present (using statistical tests for significance).. The 'typical' characteristics of these four types of degradation accidents were identified and are shown in **Table 4** below.

Accident characteristic	Degradation type (as a contributory factor)			
	Lighting	Weather	Road surface	Carriageway hazard present
Single car accident	Y	Y	Y	Y
Non-intersection		Y	Y	Y
Non-urban roads		Y	Y	Y
Cars	Y	Y	Y	
Good vehicles		Y	Y	
Mopeds	Y			
Non-manoeuvre	Y	Y		
Driver - positive alcohol test	Y			
Driver - negative alcohol test			Y	
Driver <25 years old	Y			
Male drivers	Y			

Table 4: Typical accident characteristics identified in the descriptive analysis for each type of degradation accident (=Y)

Degradation accidents involving these 'typical' characteristics were investigated further as part of the in-depth accident causation analysis.

6.3 Accident causes and risk

As a result of the descriptive analysis, degraded scenarios and the related typical accident characteristics were identified, and data requested from the TRACE partner organisations

The information requested included the number of accidents where degradation was present and where it was a causation factor, the number of accidents involving specific degradation-related causation factors, the five most common causation factor groups in accidents when degradation in general was present, the five most common causation factor groups in 'typical' accidents were degraded lighting, degraded weather, degraded road surface conditions or hazards were present. Causation factor groups were used rather than specific factors as an attempt to harmonise the data collected and therefore overcome the variation in the type of causation data collected by each data source. The causation factor groups used in this analysis were based on the categories used in the grid of factors developed as part of the WP5 methodology. See TRACE Deliverable D5.2 for further details.

A 'pattern analysis' was initially undertaken to identify the most frequently occurring types of causation factor groups in these degradation accidents.

To supplement the analysis of grouped data and to investigate further the results found, an additional case by case analysis was undertaken involving a series of 80 detailed accident cases from the UK OTS database. In each case, degradation had been determined by the on-scene accident investigator as one of the causes of the accident and the aim was to determine in more detail the additional types of causes that had been highlighted in the pattern analysis.

Finally, 20 of these 80 case were selected for recoding using the TRACE Work Package 5 methodology, with the aim of identifying typical failure generating scenarios where degraded conditions contributed to the accident occurring.

There were large variations in the total number of accidents supplied from each source (150 cases to 120,000+ cases) and there were also differences between sources in their recording of presence of accident severity. For injury cases the KSI rate varied from 17-56% suggesting either differing priorities in data collection, or maybe varying availability on minor injury data.

The level of recording whether degradation was **present** varied between 29-80% (see [Table 5](#)). These variations were directly related to the type of data collected by each data source, as some were more comprehensive than others.

Accident type	Range of % of degradation accidents from sample of all available car accidents
Any 'degraded' situation present	29-80%
Degraded lighting conditions present	2-37%
Degraded weather conditions present	0.2-25%
Degraded road surface conditions present	1-46%
Hazards present	0.2-15%

Table 5: The proportion of car accidents where degradation was present

Therefore, caution should be expressed regarding any comparisons between the countries' data in light of these variations found. If the data were grouped together, the inconsistencies would mean some individual contributions would be overwhelmed by much higher numbers from others. Therefore, it was decided to keep the analysis of country's data separate, but to also give an overall view of the results across the sources.

Findings from the analysis of accidents where the degraded accident scenarios were present As can be seen from [Table 5](#), there is much variation in how the four main forms of degradation are present in the accidents records from the available partner's databases from across Europe. In order to overcome this variation, a "pattern" analysis was carried out to investigate the most common causation factor groups within the accident data. A summary of the main finds is:

- In general, human factors dominated the causation factors for degradation scenarios;
- "Risk taking" was the most commonly identified factor group within degraded lighting, degraded weather and degraded road surface;
- "Distraction" was also a commonly occurring factor group within carriageway hazards, along with "visibility impaired".

For each type of degradation accident with ‘typical’ characteristics present, the most common factor groups were also identified and are displayed in below.

Degraded scenario	‘Typical’ accident characteristic	Most common causation factor groups
Lighting	single car	risk taking, psychological condition, substances taken
	non-manoevre	risk taking, psychological condition,
	alcohol	substances taken, risk taking
	young driver under 25	risk taking, distraction, psychological condition
	male driver	risk taking, distraction, psychological condition
Weather	single car	risk taking, distraction
	non-intersection	risk taking, distraction, psychological condition
	non-urban	risk taking, psychological condition, visibility impaired
	non-manoevre	risk taking, distraction, psychological condition
Road surface	single car	risk taking, psychological condition
	non-junction	risk taking risk taking, distraction, psychological condition, road condition
	non-urban	risk taking, road condition
	non-alcohol	risk taking, road condition
Hazard	single car	Distraction, risk taking, hazards, visibility impaired
	non-junction	Distraction, risk taking, visibility impaired
	non-urban	risk taking, distraction, visibility impaired

Table 6: The most common causation factor groups for each type of ‘typical’ degradation scenario

As can be seen from this table, risk taking (e.g. speeding) was again found to be one of the most prevalent factor groups in all the degradation scenarios investigated. Other human-related factors were also found to be frequent in these accidents, such as psychological condition (e.g. ‘in a hurry’, ‘emotional’) and distraction (e.g. within/outside vehicle, within user), with environmental-related factor groups such as ‘road condition’ (e.g. wet, oil, defects) and ‘visibility impaired’ (e.g. by weather, roadside objects) also being prevalent.

6.3.1 Accidents where degradation was a causation factor

Using 80 in-depth cases from the UK OTS database, the next aim was to try and further explain, within these factor groups, the specific type of causation factors involved in accidents where degraded conditions were not only present, but also contributed to these accident occurring. Approximately 20 cases per degraded condition were analysed.

When degraded lighting was a causation factor, the most common individual accident causations were glare from either the sun or headlights and inattention. Excessive speed was also often a cause. ‘Carelessness, recklessness or thoughtlessness’ and slippery road surfaces were also reoccurring causation factors.

Examining the causation factors that lead up to accidents where degraded weather was a cause, the weather itself impairing visibility was the most frequently occurring factor. Interestingly, in approximately a quarter of the accident cases examined, a degraded road Condition is adjudged to have been a causation factor. This suggests that accidents in degraded weather conditions are also

due to the way vehicles are driven and not just the environment they are being driven in. As well as the road user's visibility being impaired due to the weather conditions, in the majority of the remaining cases, the weather-related causation factor was found to be high winds. Other human-related factors were found to be 'carelessness, recklessness or thoughtlessness', 'in a hurry', 'inattention' and 'excessive speed'. This also supports the suggestion that degraded weather has just as great a bearing on the way drivers drive, and react to the conditions, as it does detrimentally affecting the environment they are driving in.

When degraded road surface conditions contributed to the accident occurring, slippery road surface at site' was most frequently occurring, but 'deposits on the road' and 'poor or defective road surface' were also found to be causation factors related to the road surface condition itself. 'Excessive speed' (including travelling too fast for conditions), 'in a hurry' and 'carelessness, recklessness and thoughtlessness' were the most occurring human-related factors, which suggests that there is a connection between drivers taking risks and degraded road surface conditions in the lead up to catastrophic situations.

When the presence of hazards contributed to the accident occurring, the main accident causations were found to be related to the hazard itself, in particular 'animals out of control on the road'. Directly related to this, the most common human-related factor was 'panic behaviour'. This would support the indication given by the type of accidents in this sample that it was not necessarily the hazard that caused the accident but the way the driver dealt with the situation that was a significant factor in the accident. It is also interesting to note that vehicles being driven at excessive speed were thought to be a causation factor in a smaller proportion of these accident cases than with the other types of degradation.

The overall impression from the information gathered on accidents where lighting, weather or the carriageway surface has been degraded was causative was that the way the vehicle was being driven was equally as important in the build-up to an accident. The most common causation factors attributed to these accidents have tended to be associated with drivers knowingly, or unknowingly taking risks with their vehicles or psychological conditions which have affected the way drivers are driving their vehicles.

In particular, when road or roadside hazards were the degraded situation, and causative, the other common factor appearing in the accident records is panic behaviour. While the largest proportion of drivers involved in these accident in the sample were male, a large proportion of the females drivers involved were aged between 17 and 24 years old. A large proportion of these types of accidents in the UK OTS database also occurred in darkness which would suggest that there is a link between the two degraded situations.

6.3.2 Findings of analysis using HFF methodology

As a comparison with the more conventional analyses undertaken previously, an analysis of 20 of the 80 cases outlined in the previous section was undertaken using the human factors methodologies developed in Work Package 5. These methodologies were the classification model of human functional failures, the grid of factors and pre-accident driving situations and 'typical failure generating scenarios', all of which are described in detail in the TRACE Deliverables D5.1, D5.2 and D5.3.

The aim was to try and identify some typical failure generating scenarios from each sample and identify whether these are 'typical' scenarios already identified in TRACE Deliverable 5.3 ('Typical Failure Generating Scenarios) or whether new scenarios can be identified.

The results revealed that the majority of the primary active road users were going ahead, the remaining were approaching (but not at) an intersection. Therefore, none involved a manoeuvre being undertaken. Also, in the majority of cases, there was no conflict (i.e. it was a single vehicle accident).

The majority of cases involved either a failure in detection or a failure when taking action. For accidents where degraded lighting was a cause, it appears to be detection-related failures. When a degraded road surface was a cause, it appears to be taking action-related failures. When degraded weather or a hazard was a cause, it appears to be both detection and taking action-related failures.

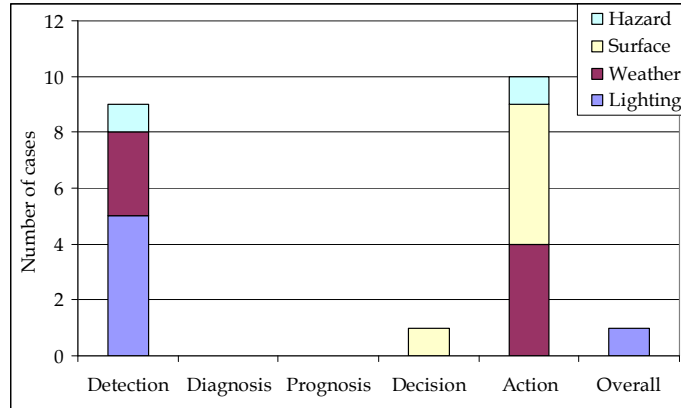


Figure 29: The type of human functional failures experienced by the primary active road users in the sample of 20 UK accidents where degradation was a cause*

*in one case the degraded road surface and a hazard were causative.

When looking at the specific type of failures involved, it was found that most involved either a ‘non-detection in visibility constraint conditions’ or ‘poor control of external disruption’ (Table 7).

Human Functional Failure		Number of cases
Detection	P1 - Non-detection in visibility constraint conditions	8
	P2 - Information acquisition focussed on part of situation	1
Decision	D2 - Deliberate violation of safety rule	1
Action	E1 - Poor control of an external disruption	9
Overall	G2 - Alteration of sensor motor and cognitive capacities	1

Table 7: Types of human functional failures in sample of 20 UK cases where degradation was a cause

In terms of the factors which contribute to these failures occurring, ‘risk taking: speed’ was the most frequent factor, with ‘bend’, ‘visibility impaired: weather’, ‘visibility impaired: road lighting’ and ‘alcohol impaired’ also being contributory in a number of cases.

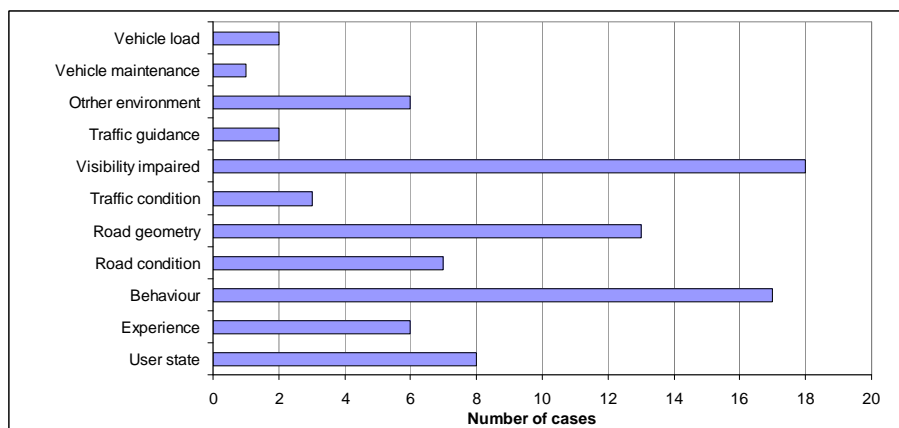


Figure 30: Factors which led to the failures in 20 UK cases where degradation was a cause

When looking separately at the accidents where each type of degradation was contributory the following was found:

Accidents where degraded lighting was a cause mainly involved a detection failure involving the degraded lighting itself (e.g. sun glare, poor street lighting, darkness) and additional contributory factors included speed and the road user being lost in thought.

Accidents where degraded weather was a cause mainly involved failures in either detection or taking action. The detection failures involved the road user's visibility of the road being restricted by weather conditions (i.e. fog), while the taking action failures involved the road user losing control because of 'an external disruption' (e.g. high winds, snowing, raining). Speed and alcohol were additional factors identified in these degraded weather accidents.

Accidents where a degraded road surface was a cause mainly involved failures in taking action, again losing control because of an external disruption which should have been expected by the road user, but because over their over-familiarity with the road, did not adjust their driving for the conditions. This time, the external disruption was found to be ice/oil/flood/defective surface and additional factors included speed.

In the two accidents where a hazard was contributory, one involved a failure in detection related to their focussing on only part of the situation (and therefore not detecting the actual hazard) and one involved a failure in taking action related to encountering a sudden disruption (in this case, road works beyond a hump-back bridge). Again, speed was found to be an additional contributory factor.

It was concluded that degradation scenarios can be hazardous, either by restricting the view of possible danger or by being the main cause of the conflicting situation, suddenly appearing when the road user is not always expecting it or prepared. If the road user is risk taking, in particular speeding, as was often found in this analysis, this will only make it more inevitable for an impact to occur in either one of these situations.

6.3.3 Potential solutions

From the in-depth analysis undertaken in this study, a number of solutions could be suggested which could help to reduce accidents involving degradation. These include information systems which would assist the road user in detecting potential conflicts in degraded lighting or weather (visibility) conditions, plus those which would assist the driver in controlling their vehicle when faced with sudden degraded road or weather conditions or hazards (e.g. braking systems, traction control). The importance of highway design and maintenance was also highlighted, in particular street lighting and maintenance of road surfaces. Finally, improving driver awareness through education of the dangers of driving in degraded situations was also suggested.

6.3.4 Risk Analysis

The objective of the risk analysis is to compliment the causation analysis. Where an accident problem is identified with a high occurrence, it is important to determine whether it really is a real risk. For example, if 10% of drivers have an accident at night, but only 2% of the traffic occurs at night, the risk for those drivers of driving at night is higher than for other drivers travelling at other times of the day.

Exposure data was sought from published sources and from the TRACE Task 8.4 collective data resource to compare with the accident analyses carried out. Information was derived for up to 5 European countries (United Kingdom, Germany, France, Italy and Spain) on hours of darkness, rainfall, driving population, males in the population, road classification and vehicle fleet.

Most of this information did not appear to be directly comparable to the accident analyses carried out. A comparison was made between some of the descriptive accident data for dark accidents and wet accidents, and the proportion of darkness hours and time that it rains respectively, which are highlighted in the following table.

Country	% accidents in darkness from descriptive analysis	% darkness days in a year	% accidents in rain from descriptive analysis	% rain days in a year
Great Britain	30	45	17	70
France	36	49	15	54
Germany	26	49	n/k	66
Spain	35	49	13	25

Table 8: General comparison of degraded conditions ‘darkness’ and ‘rain’ from descriptive analysis with sourced exposure data

The analysis revealed no correlation across countries between darkness accidents and the proportion of hours of darkness, although a relationship appeared to be made between accidents on a wet road and days of rain for the UK, France and Spain (i.e. wetter countries had more accidents on wet road surfaces). However, when comparing proportions of darkness accidents and the proportion of darkness in general compared with the same for rainfall, in general, the tables appear to show that there is a slightly greater risk of an accident when travelling at night than when it was raining, as the difference between the proportion of accidents in darkness compared to the proportion of general darkness is generally less than those related to rainfall. It would also be interesting to compare these results with exposure information for proportion of darkness days when it is also raining. This information would really help to highlight in which of these two degraded conditions the greatest risk lies. However, this data could not be located.

In order to carry out a true exposure to risk analysis for this type of study, it would be necessary to collect data specific to the study, for example, the number of hours in a year in which a road surface was wet or the amount of driving carried out by different age/gender groups at different times of day.

6.3.5 Overall Conclusions and Recommendations

While some accident causation factors associated with specific accident scenarios dominated the accident causations, such as accidents where the driver had consumed alcohol, the background picture remained that of risk taking and distracted drivers being involved in accidents where degraded lighting, weather and road surface were present and distracted drivers unable to react to sudden hazards in accidents where a road and roadside hazard was present.

Measures to reduce the possibility of these forms of accidents occurring in the future would need to be based around driver education and awareness, so that they are aware of the how the degraded situations affect the way their vehicle interacts with the surrounds, and have a greater appreciation of the risks they are taking, the potential problems these risks present and the consequences of these risks. To fully appreciate the degraded drivers will also need to be warned of the degraded situation. To do this fully interactive driver information systems will also need to be available.

The very nature of road and roadside hazards mean that it is not always possible to forewarn drivers so vehicle improvements such as intelligent braking and vehicle traction systems would be an aid to drivers, helping to reduce the possibility of them losing control of their vehicle in an emergency situation.

Difficulties were found in attempting to harmonise the data across the available data sources and countries. This highlights the importance of using harmonised data not just in analysis of descriptive data, but also in the analysis of in-depth accident causation data. Research such as the type being carried out by other European projects (e.g. SafetyNet) are valuable in trying to overcome the data harmonisation issues that were found in this study.

In order to carry out a true exposure to risk analysis for this type of study, it would be necessary to collect data relevant to the study. Therefore recommendations for future risk analysis would be for easily accessible sources of better quality, detailed exposure, relevant to this sort of study, to be

made available. It could be accessed via a collective data resource, such as the one developed in TRACE Task 8.4.

Due to the variations in findings across data sources, further studies investigating the role of hazards in accidents would be beneficial to determine a clearer definition of what a hazard is and to gain a clearer insight into where the greatest risk lies (i.e. which types of hazards?).

Although data issues were identified in the analysis, this report has been able to highlight some interesting issues related to accidents which occur in different types of degraded situations, which were found to be common across a number of countries in Europe. Issues were highlighted, such as 'typical' characteristics and why drivers fail to successfully overcome the difficulties that these degraded situations bring.

7 Conclusions and perspectives

The general objective of the TRACE project is to provide the scientific community, the stakeholders, the suppliers, the vehicle industry and other Integrated Safety program participants with an overview of the **road accident causation** issues in Europe, and possibly overseas, based on the analysis of any current available databases which include accident, injury, insurance, medical and exposure data (including driver behaviour in normal driving conditions). In accordance with these objectives, TRACE has been divided into 3 series of technical Workpackages:

- The Operational Workpackages (WP1 Road Users – WP2 Types of driving situations and types of accident situations – WP3 Types of risk factors – WP4 Evaluation of the effectiveness of safety functions in terms of expected (or observed) accidents avoided and lives saved).
- The Methodologies Workpackages (WP5 Analysis of Human factors – WP7 Statistical Methods – WP6 Determination of Safety Functions).
- The Data Supply Workpackage (WP8).

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

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

Question	Methodology	Deliverable
What knowledge has already been obtained for each road user?	Literature review	Deliverable D2.1
What are the most relevant accident configurations at European level?	Descriptive analysis	Deliverable D2.1
Why accidents of those configurations take place?	In-depth analysis	Deliverable D2.2
Which factors increase the risk of each accident configuration?	Risk analysis	Deliverable D2.2

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

- Innovative statistical methods, developed by WP7, have been applied as much as possible in order to provide data at EU27 level related to the magnitude of the accident figures for each type of situation although this was an initial target of the project. When available, these figures have been combined with exposure data in order to provide general risks estimations.
- Relevant & specific accident configurations have been detected and describing for each type of situations at macroscopic level. This means that safety solutions addressing these configurations would benefit to larger groups of road users.
- Contributory factors have been identified through microscopic analysis in order to detect what aspects have contributed to the accident. This is what topics should new safety systems would be addressing. The WP5 methodology to identify Human Functional Failure has been applied in this step allowing the identification of the human decisions mechanisms that did not perform positively in each accident configuration.
- Last but not least, the different risk analyses performed allow deciding which new systems should be prioritized as they address factors that induce a higher level of risk for each road user.

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

Nevertheless, this does not mean that everything is achieved in accident causation.

This project has also encountered some relevant difficulties that should help the research community to identify the next actions to be taken:

About the data.

- Whether it is for road accident databases so called aggregated (such as CARE) or detailed (in-depth) it is important that a common structure to all the European countries is set up and applied. If descriptive analyses regarding situations have to be made, the information regarding the pre-accidental manoeuvres for each road users involved in the accident have to be included. This implies to take into account the 2 following aspects:
 - To add at accident level a pictogram describing the main pre-accidental situation, i.e. the one who led to the accident.
 - To identify a road users level with information related to its manoeuvre (overtaking, changing lane, u-turning, turning to the left, turning to the right, go straightforward reversing, etc.).
- There is not enough data to perform all the ideal risk analyses in accident causation. Sometimes there is a lack of data related to the detail on the studied population and sometimes it is not possible to get the necessary exposure data to perform risk (e.g. on driving behaviour, elder driver, etc.).

If a common accident investigation methodology is applied in the future (as proposed by the SafetyNet project), this will allow performing a new updating of the accident causation knowledge under this approach.

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

- We need to well understand the new approach if we want to have relevant results and to have the same understanding of the approach between all the partners.
- Once the approach understood, we have to find in our database the appropriated information which could help us to apply the new approach on our sample.

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

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Typical human functional failure scenarios at the information detection stage

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

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

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

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

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