Project No. 027763 – TRACE

D 5.2

Which Factors and Situations for Human Functional Failures? Developing Grids for Accident Causation Analysis

Contractual Date of Delivery to the CEC (new technical annex): June 2007

Actual Date of Delivery to the CEC: November 2007 (after revision)

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Workpackage: 5

Est. person months: 10

Security: Public

Nature: Report

Version: 2 (after revision)

Validation by WP leader: Pierre VAN ELSLANDE
Validation by TRACE Coordinator: Yves PAGE
Reviewed by external reviewer: John RICHARDSON (ESRI - UK)

Total number of pages: 54

Abstract:

This report describes the work undertaken in Task 5.2 of the TRACE project. Human failures are explained by factors characterizing the state of the system and of their interactions. A grid of factors which could lead to these human functional failures is given along with a grid of pre-accident driving situations. In addition to this, an overview is included of the background work undertaken to establish a methodology for classification of these factors and situations. Factors related to the 'User', 'Vehicle' and 'Environment' are described and classifications for use at a 'descriptive', 'generic' and 'in-depth' level are determined, to allow analysis at different levels of detail of accident data. These factors and situations will be used along with the Task 5.1 functional failures to help identify typical failure generating scenarios in Task 5.3, and the subsequent analysis of real world accident data in other work packages in TRACE. They will also be a useful basis for future improvements in the collection of accident causation data, avoiding the common over simplification whereby road users are seen as the main reason for the 'failure' in the accident scenario.

Keyword list: Accident factors - Driving situations - classifications

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1 Executive Summary

1.1 TRACE project: TRaffic Accident Causation in Europe

In spite of countless amounts of research and development, road safety is still one of the main societal concerns today. It is not only a matter of concern for the European Commission and National Governments but also for the vehicle industry, insurance companies, driving schools, non-governmental organisations and more generally for every single road user. Car manufacturers have made strong efforts and have dramatically improved passive (and also active) safety of their vehicle for the past 15 years. However, current road safety research has shown that an asymptote is about to be reached on this aspect in most countries and many experts agree that preventive (prevention of accidents) and active safety (recovery of an emergency situation) should now, particularly, be brought forward.

The TRACE project has 2 major objectives:

The first one addresses the determination and the continuous up-dating of the etiology (i.e. analysis of the causes) of road accidents and injuries, and the definition of the real needs of the road users as they are deduced from accident and driver behaviour analyses.

The second one aims at identifying and assessing, among possible technology-based safety functions, the most promising solutions that can assist the driver or any other road users in a normal road situation or in an emergency situation.

So the purpose is first to bring a comprehensive and understandable definition of accident causation which goes further and deeper than the usual statements. It is also to provide the scientific community, the stakeholders, the suppliers, the vehicle industry and the other Integrated Safety program participants with a global overview of the road accident causation issues in Europe and promising solutions based on technology.

1.2 WP5 "Human Factors"

In order to gain new knowledge on accident causation, several Methodological Work Packages (WP) have been defined in the structure of TRACE in order to give a support to the analyses conducted into the Operational Work Packages of the project.

As such, WP5 "Human Factors" has been defined to improve the multidisciplinary methodologies that allow the analysis of the role of "human factors" in road accident production. In brief, WP5 is oriented toward the diagnosis of the difficulties met by road users which lead them to an accident, toward the identification of the contexts in which they take place, and toward the definition of the origins of these difficulties whether they are human in nature otherwise.

The methods aim to standardise accident analysis in order to bring validated and comparable results from one study to the other, without loosing the scientific and academic background required for a comprehensive research work.

Four tasks compose this Work Package. The first three are oriented toward the elaboration of an operational model permitting a comprehensive analysis and classification of "human error" generating processes. The fourth one is devoted to a further and wider view on the influence of the social and societal context on accident occurrence.

- Task 5.1 A model for human functional failure analysis

The objective of this task is to define and characterize the different types of human errors, violations and difficulties which are involved in the accident generating process. Such modelling work is based both on scientific literature dealing with human error analysis, and on truly in-depth accident data. The purpose is to build an operational grid for human functional failures, consistent with ergonomics concepts and specifically adapted to the driving task.

- Task 5.2 A comprehensive grid of factors and situations for human functional failure

Human failures are explained by factors characterizing the state of system, i.e. the defects of its components (human and other) and of their interactions. These factors are then considered as the

explanatory elements of the road users' incapacity to adapt to the situation in hand. A grid of all the relevant elements contributing to human failures has been compiled, and differentiates those factors coming from the "human" part of the system, from those coming from the layout, the traffic interaction and the vehicle.

- Task 5.3 Typical failure-generating scenarios

The purpose of this third task is to combine the results from T5.1 and T5.2 in order to build a methodological frame allowing the aggregation of accident data under the form of generic accidental processes, viewed as an integration of the parameters characterizing the accident generation: which situation and context, which human failure, which explicative elements, which consequence, etc. They will allow putting forward the typical specificities of the difficulties encounters by different types of road users, in different types of situations.

- Task 5.4 Social and cultural aspects of human factors

The purpose of this task is more prospective. It is to analyze the socio-economic/socio-cultural dimension of human activity, its interaction with the driving system, to build a framework of analysis aimed at completing the accident analysis framework proposed in T5.3 by putting forward broader "upstream" factors of its production process.

1.3 Which Factors and Situations for Human Functional Failures? Developing Grids for Accident Causation Analysis: summary of TRACE report D5.2

This report describes the work undertaken for TRACE Work Package 5 Task 2, which aims to both determine the types and variations of potential factors which lead to the human functional failures that occur in road accidents, and also outline the types of pre-accident driving situations in which the road user is exposed to these factors. This work has been combined elsewhere with the work in the rest of Work Package 5, to develop analytical tools for analysing human functional failures and typical failure generating scenarios in real-world accidents.

It is generally acknowledged that the majority of road accidents are caused by not just one factor, but by the interaction of many different factors. Since the 1970's, accident causation has become an increasing concern and many newly developed data collection systems and their databases now include accident causation variables, including factors which contributed to the accident occurring. Many accident causation systems currently focus much of their attention on the road user and their 'failures' which led to the accident occurring. But often, the reason behind these 'errors' or failures (i.e. the 'factors') are given little consideration. Also, 'factors' are often confused with their resultant 'failures' in the analysis of accidents. The review of literature and current accident studies confirmed this and highlighted the need for a grid of factors which only includes factors that lead to human functional failure.

Using variables from current accident data collection studies as a basis, a grid of factors has been developed which is versatile enough to be used for analysis of different types of accident data having different levels of detail (descriptive, generic and in-depth). The factors are classified into three distinctive types: factors related to the human in control of the vehicle, factors related to the vehicle involved in the accident and factors related to the surrounding environment. An analyst can use this grid to identify potential factors in one or many accidents and also determine for each factor whether it was 'contributing', 'triggering' or 'aggravating' to the onset of the accident.

Pre-accident driving situations are also identified and presented in a grid, being defined by the manoeuvre and location of the road user prior to a 'failure' occurring, plus any potential opponent manoeuvres faced by the road user.

The grids of factors and situations are not only valuable analysis tools for use within TRACE, but also form a useful basis for future improvements in the collection of accident causation data. The work steers away from the road user always being the main reason for instigating the 'failure' in the accident scenario, as often seen for other accident studies, past and present.

2 Introduction

The TRACE project has the objective to promote a comprehensive view of accident causation in order to find the most promising solutions to enable road users to perform their tasks safely.

In line with this objective, Work Package 5 is a transversal Work Package aimed at providing operational models and methodological support concerning "human factors" aspects in road accidents to the other Work Packages of TRACE.

The second task (T5.2) of WP5 is devoted to the characterization of the Factors and the Situations of production of the human functional failures which have been clearly identified within the first task (Deliverable 5.1, Van Elslande & Fouquet, 2007).

2.1 TRACE project: TRaffic Accident Causation in Europe

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2.3 Which Factors and Situations for Human Functional Failures? Developing Grids for Accident Causation Analysis

Human failures are explained by factors characterizing the state of the system, i.e. the defects of its components (human and other) and of their interactions.

It is common knowledge that the majority of road accidents are caused by not just one factor, but by the interaction of many different factors. These factors could be related to the outside environmental conditions, the vehicle involved in the accident, or the human in control of the vehicle.

In terms of road accident causation, a factor has been defined as ‘any circumstance connected with a traffic accident without which the accident could not have occurred’. However, this factor alone ‘is not sufficient itself to cause an accident’ (Baker and Ross, 1961).

Depending on the specific accident scenario, the same factors can appear at different stages of the accident and may have different roles, being contributing, triggering, or aggravating factors to the process. In the Task 5.1 report, a division of the different phases within an accident scenario has been outlined and is reproduced in figure 1. A specific factor could appear within any of these four phases and influence the likelihood of a functional failure, which occurs between the rupture phase and emergency phase.

For example, a specific factor may already be present at the start of the ‘Driving phase’ (e.g. alcohol intoxication) and this would become a ‘Contributor’ when the ‘Triggering’ factor is introduced (e.g. animal runs out into the carriageway). The fact that the driver is ‘speeding’ when the animal appears both ‘Aggravates’ the likelihood of the functional failure occurring and also the severity of the outcome (i.e. more severe injuries).

However, in other accident scenarios where these similar factors appear, their role in the accident process may be different (e.g. the vehicle's speed may be the 'Trigger' or 'Contributor' of the functional failure).

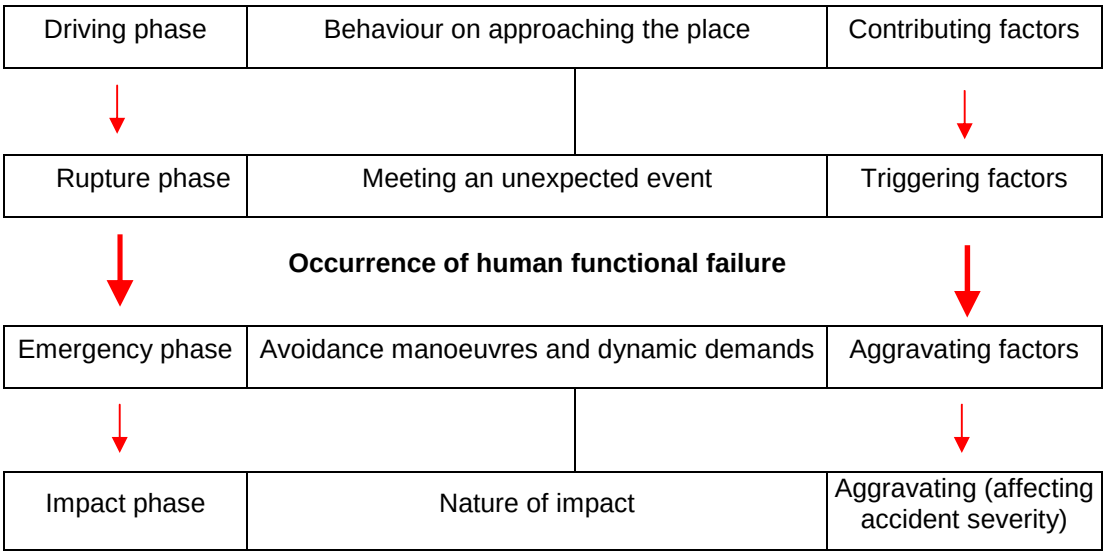

Figure 1 - Main Phases Within an Accident Scenario (extracted from Van Elslande & Fouquet, 2007)

Since the 1970's, accident causation has become an increasing concern and many newly developed data collection systems and their databases now include accident causation variables, including factors which contributed to the accident occurring. The classifications of potential factors vary between the different data collection systems and many of them include human functional failures alongside the factors which led to these failures, with no clarification given between factors and the failures. Many accident causation systems currently focus much of their attention on the road user and what their 'failures' were which led to the accident occurring. Therefore, it is not surprising that many reports quote that 'human error' is a major cause of 80-90% of accidents (e.g. Treat et al, 1977).. What is not given much attention is the reasons for these so-called 'errors' occurring in the first place. Was it really purely down to the road user or were there other factors related to the environment, road layout or the vehicle itself which increased the likelihood of the driver making their 'error' (see Task 5.1 report for further information regarding types of human functional failure)?

One of the aims of Task 5.2 is to determine the types and variations of factors which lead to the human functional failures that occur in accidents (these human functional failures being investigated in Task 5.1 and reported in Deliverable 5.1). Additionally, it is clear from viewing the types of 'factors' included in the various accident data collection systems used across Europe that further investigation is required to establish a grid or a list which includes only factors and not the resultant 'failures', and uses a clear and easily definable system of categorisation. A clearly defined classification of factors leading to functional failures will be useful within TRACE for defining failure generating scenarios (discussed further in Task 5.3, Deliverable 5.3). It will also be a useful basis for future improvements in the collection of accident causation data which steers away from the road user always being the main reason for the 'failure' in the accident scenario.

In addition to the factors which lead to human functional failures, the types of pre-accident driving situations in which the road user is exposed to these factors will also be investigated (the 'driving phase' outlined in Figure 1), including the location of the road user (intersection, bend…), and the specific driving task (turning, overtaking..) they were undertaking prior to meeting the 'unexpected event' (i.e. the rupture phase in figure 1), plus any opponent manoeuvres from other road users prior to the rupture phase.

As TRACE is focussing mainly on motor vehicles, in particular cars, the compilation of both the grid of factors and the pre-accident situations has also focussed mainly on motor vehicle drivers, in particular cars. Where possible, the involvement of pedestrians has been taken into consideration, but this is an issue that requires further in-depth investigation which is beyond the scope of TRACE.

The present report gives the results of this methodological work. It presents a comprehensive review of literature and accident collection data studies, with the aim of integrating the different parameters identified. It proposes a grid of driving situations in which human failures are found and a grid of factors explaining these human failures. These two grids are then applied to examples of real accident cases in order to show how they can be used in the other Work Packages of TRACE.

It should be kept in mind that task 5.2 is specifically oriented toward the explanation of human failures, so, the grids of factors presented here correspond to the potential causes of these human failures, and should not be confused with a grid of accident factors which can measure rate or risk. Types of accident factors as a whole and their subsequent risk are the topic of Work Package 3 of TRACE.

To summarise, the main aims of D5.2 are:

- To establish an integrated list (grid) of all the elements (factors) contributing to all types of human functional failures in different situations, on the basis of both accidentologists experience and literature review.
- To develop a grid of pre-accident driving situations in which the road user will be exposed to these factors, also taking into account current accident data collection knowledge and previous studies.

3 Review of Literature and Accident Data Collection Studies

A comprehensive review of studies which outline the types of factors which contribute to human functional failure in accidents was undertaken, plus studies which attempt to classify different types of factors were also considered. In addition, current and future accident data collection studies were also reviewed for both typical pre-accident driving situations and to identify types of factors already considered in accident analysis. The concept behind reviewing the data collection studies (i.e. the types of factors included and the system of classifications used) is that it is highly likely that factors included in these accident data collection studies will be based on previous research, so they are a good base to start with.

3.1 Factors Leading to Human Functional Failure

In most studies investigated, the different types of accident-related factors were classified into three key categories. Factors which relate to the human, factors which relate to the tool (the 'vehicle') and factors which relate to the environment (including traffic and road layout). Therefore, this section outlines the type of factors related to these three 'components' found in the research.

3.1.1 Factors Related to the Human

In accident studies, factors related to the human normally relate to the human who was in charge of a vehicle (motorised or non-motorised) that was involved in the accident, or alternatively, a pedestrian who was injured in the accident. The decisions humans make or reactions they have at the point of a potential impact (i.e. the 'Rupture' phase – see Figure 1) can vary greatly between each driver, rider or pedestrian (known collectively from now on as 'road user') and can be influenced by the road user's individual character and their 'state' at that particular point in time.

A study by Fell (1976) presents 'a motor vehicle accident causal system, from a human factors viewpoint'. As part of this, a categorisation of the reasons for the failure in information processing by the road user (which leads to an accident) is given.

Five categories are outlined in this study, these being:

1. Physical or physiological 'failures' (e.g. heart attack, seizure, falling asleep)
2. Conditions or states - These states affect the road user's processing behaviour (e.g. alcohol or drug impairment, emotional state, fatigue (drowsy, not asleep), workload)
3. Experience or exposure (e.g. familiarity with driving, the vehicle, the environment or the route)
4. Conflicting behaviours or preoccupations – Often reported as simply 'inattention', but can be any behaviour which interferes with perception or comprehension of the task (e.g. any sort of 'distraction' such as talking to passengers, changing radio station etc..)
5. Risk-taking behaviour – actions by the road user which affect the ability to compensate for danger signals (e.g. speeding, following too close, driving through red traffic light).

Sivak (1980) suggests an approach to accident causation which assesses how frequently occurring transient human states affect driving-related skills (e.g. attention, perceptual, decision-making). The human states which are outlined include alcohol intoxication, drug intoxication, fatigue, nutritional deficit, sleep deprivation, and stress.

An accident study carried out on the 1970's outlined the main categories of driver 'error' found in the sample of over 2000 UK accidents (Sabey and Staughton, 1975). The most frequent 'errors' were lack of care, driving too fast, looked but failed to see, distraction and inexperience. The majority of the 'factors' behind all of the errors outlined could be included in one of the five categories outlined in the study by Fell, in particular, the 'experience', 'conflicting behaviour', and 'risk-taking behaviour' categories. In addition, alcohol intoxication (driver 'state') was also highly represented. This report shows another example of how 'errors' and the 'factors' leading to these errors are often included

together and not treated as two aspects of the accident process. 'Distraction' and 'inexperience' are not 'errors' in themselves, but the presence of either one can lead to 'errors', or more correctly, functional failures occurring (see Task 5.1 report for further details on functional failures).

A U.S. study by the AAA foundation for Traffic Safety funded by the University of North Carolina investigated how many accidents involved driver distraction and the types of reasons behind the distraction (Stutts et al, 2001). A comprehensive list of different types of distraction was identified, as shown in table 1.

Table 1 - List of Distraction Types Outlined in a Study by Stutts et al (2001)

Outside Person, Object or Event	Within vehicle/driver
Outside Traffic/Vehicle	Adjusting Radio/Cassette/CD
Police	Other Occupant
Animal in Roadway	Moving Object in Vehicle
Sunlight/Sunset	Using Other Device Brought into Vehicle
People in Roadway	Unknown Distraction
Crash Scene/Leaving crash scene	Using Other Device Integral to Vehicle
Road Construction	Adjusting Climate Controls
	Eating/Drinking
	Cell Phone
	Smoking
	Medical Problem
	Looking Outside Vehicle
	Looking Inside Vehicle
	Reaching for Object
	Inattentive/Lost in Thought

In Great Britain, the accident data collection system used to collate descriptive accident data, collected by the police for the UK Department for Transport, is known as STATS19 (STATS19 being the name of the form the police complete for every road traffic accident involving an injury on a public highway). In addition to this, the UK Department for Transport also funds an in-depth research project which collects in-depth accident data from the scenes of accidents, known as the On The Spot (OTS) accident research project. For OTS, two methods of collecting accident causation data are used. Both of these methods are based on systems for coding causation used by the STATS19 national road accident database. The 1995 police system for recording causation was developed by the former Department of Transport with TRL and has been adopted by 18 police forces in the UK since 1997. It is a harmonised two-tier system which seeks to identify (a) the critical failure or manoeuvre which led to the accident and (b) the factor or factors which contributed to this failure or manoeuvre. These are referred to in OTS as the precipitating and causal factors respectively. The causal factors included in this system which are related to the 'human' in the accident are shown in table 2.

Table 2 - 'Human'- Related Causal Factors Used in OTS (also found in original system used by STATS19)

Impairment through alcohol	Failed to look
Impairment through drugs	Looked but did not see
Impairment through fatigue	Inattention
Impairment through illness	Ignored lights at crossing
Distraction through stress or emotional state of mind	Excessive speed
Distraction through physical object on/ in vehicle	Following too close
Distraction through physical object outside of vehicle	Inexperience of driving
Panic behaviour	Inexperience of vehicle
Carelessness, reckless or thoughtless	Interaction/competition with other road users
Nervous or uncertain	Aggressive driving
In a hurry	Lack of judgement of own path
Failure to judge others persons path or speed	
Disability	

This two-tier system was reviewed as part of the SCRAS Quinquennial Review and a revised form was introduced nationally for all police forces in 2005 (Hickford and Hall, 2004), which is known in OTS as Contributory Factors 2005 and is a simplified system utilizing only so called contributory factor codes. A number of categories containing human-related factors are included in this system, such as 'injudicious action', 'driver/rider error or reaction', 'impairment of distraction' and 'behaviour or inexperience'.

From reviewing these UK data collection systems, it can be seen that a number of the 'factors' included could be better described as 'errors' (e.g. failed to look, failure to judge, …), which is something that the grid of factors to be formulated in this task is hoping to avoid using.

RISER (Roadside Infrastructure for Safer European Roads), an EC funded project, included a method of categorising accident factors in an in-depth accident database specifically created for single vehicle accidents (RISER Deliverable 01, 2006). The categorisation of these causation factors was determined by undertaking an overview of previous accident data collection systems which included accident causation (e.g. VALT in Finland, EDA in France, OTS in the UK). RISER identified different human-related accident factors (known as Risk Factors in RISER), which were grouped into the following 13 categories in table 3. In RISER, as all cases are single motor vehicle accidents with no pedestrian involvement, when a 'Factor' is related to the accident, it will therefore also be related to the driver of the vehicle in the accident.

Table 3 - Categorisation of 'Human'- Related Factors Used in RISER

Functional abilities	Prediction
Substances taken	Misinformation
Driver state	Ignored traffic guidance
Health	Distraction
Experience	Driving
Attitude	Speed
Journey	

3.1.2 Factors Related to the Vehicle

There was found to be a lack of studies specifically investigating vehicle factors. Most vehicle related-factors were investigated as part of studies investigating general accident factors, the main reason for this being that even when a vehicle 'failure' is the 'triggering' factor in an accident, this will lead to a human functional failure. Therefore, 'vehicle' factors need be investigated alongside the 'human' factor to understand the accident process as a whole. Also, much has been done over the years to reduce the likelihood of 'vehicle' factors leading to an accident (e.g. improved braking systems, stability control systems). Another reason why studies investigating vehicle factors are so rare is because it is the most difficult data to collect, in particular at the scene of the accident, due to the impracticalities of undertaking detailed examinations of the vehicle at the scene. Therefore it may not be known if there are any vehicle maintenance or structural issues to the vehicle until a detailed examination of the vehicle has been undertaken.

However, the MAIDS project (Motorcycle Accident In Depth Study, 2004) was a rare example of where vehicle factors have been investigated specifically. As part of this study, detailed vehicle examinations were undertaken to establish the condition of motorcycle components following on-scene investigations, and therefore able to determine the role vehicle defects in causing accidents.

In the Tri-Level study (Treat et al, 1977) of the causes of accidents, undertaken in the U.S. (University of Indiana), vehicle-related factors which were identified, in no particular order, included braking system, the tyres & wheels, body & doors, communication systems and steering systems. More specifically, the 'failures' related to the vehicle were identified as brake failure, inadequate tread depth, and brake imbalances.

As part of the TELAID project (a CEC DRIVE II Project), work was undertaken to identify and group the requirements for drivers with special needs and reported in Deliverable 3 (1992). Within this work, typical sub-tasks undertaken as part of the driving task have been identified and defined at different levels and the 'prompts' to these tasks. The 'prompts' include the features within a vehicle which the driver may need to operate as part of the driving task (vehicle control functions). As well as being useful data to help compile a list of vehicle-related factors, these vehicle issues can also help to compile a list of 'driving tasks' road users undertake throughout their journey. Vehicle features related to the 'Main handling' of the vehicle, those related to secondary tasks and those related to tertiary issues are considered (see table 4).

Table 4 - Examples of Vehicle 'Features' (Adapted from TELAID Deliverable 3, Annex 1)

Control/feature	Examples
Primary (Main Handling)	steering, braking, accelerator, gears…
Secondary	headlights, windscreen wipers, speedometer, Heating/Ventilation/Air Con (HVAC), driver assistance systems…
Tertiary (including those used pre-trip)	Seat adjusters, sunroof, door locks, radio…

The British National, UK OTS study and RISER accident databases all have various categorisations of vehicle-related factors. The vehicle-related factors included in these accident databases are outlined in table 5 below.

Table 5 – Vehicle Related Factors Included in Some Accident Data Collection Systems

STATS19	OTS	RISER
Tyres	Tyre pressures wrong	Steering
Defective light	Tyre deflated before impact	Brakes
Brakes	Tyre worn or insufficient tread	Engine
Steering/suspension	Defective lights or signals	Lighting
Mirrors	Defective brakes	Mirrors
Poor loading of vehicle/trailer	Windscreen condition	Front windscreen
Poor condition of visor/windscreen	Mirror condition	Rear/side windscreen
Vehicle blind spot	Drive train, steering & suspension defects	Load

3.1.3 *Factors Related to the Environment*

In the University of Indiana Tri-Level study (Treat et al, 1977), environmental factors which were identified, in no particular order, included an obstructed view, slick roads, transient hazards, design problems and control hindrances.

Environmental factors included in current accident data collection systems used in projects such as OTS and RISER are included in table 6.

Table 6 – Environment Related Factors Included in OTS and RISER Databases

OTS Environmental Causal Factors	Categorisations used for RISER Environmental Factors
Poor surface at site	Traffic guidance
Poor or no street lighting at site	Road geometry
Inadequate signing at site	Visibility
Steep hill at site	Road condition
Narrow road at site	Traffic condition
Bend or winding road at site	Fog
Road works at site	Wind
Slippery road at site	Obstruction to visibility
High winds at site	Other road user behaviour
Earlier accident	Obstacle on carriageway
View obscured from window	
Glare from sun	
Glare from head lights	
Surroundings obscured by bend or winding road	
Surroundings obscured by stationary or parked car	
Surroundings obscured by moving vehicle	
Surroundings obscured by buildings, fences, vegetation	
Obscuration due to weather	
Failure to see pedestrian in blind spot	
Animal out of control	

The British STATS19 police accident data collection system also contains the following environmental 'contributory' factors (table 7).

Table 7 – Environment Related Factors Included in GB STATS19 Data Collection System

STATS19 Environmental Contributory Factors	
Road surface	**Vision affected by :**
Road contaminants	Stationary/parked vehicle
Inadequate signage	Vegetation
Traffic calming	Road layout
Permanent or temporary road layout	Street furniture
Object in carriageway	Headlights
	Sun
	Rain/sleet/snow or fog

Using the above categorisation of factors identified in the studies and research identified, a method of creating a comprehensive grid of factors and classifying the types of factors was determined. The methodology for this is outlined in section 4.

3.2 Pre-Accident Driving Situations

As it is undoubtedly useful to know the factors which cause human failures, we also need to know the characteristics of the driving situations in which these failures take place. These "pre-accident driving situations" can put into context the occurrence of the failures, giving the conditions in which road users are exposed to driving difficulties.

A situation can be defined, from an ergonomic point of view, as a task to perform at a given time within certain conditions, requirements and constraints (i.e. task demands).

In particular, a 'driving' situation can involve the following:
'The road user's specific manoeuvre and location (intersection, curve, straight line, etc.) and possible opponent manoeuvres prior to the onset of the accident' (from TRACE WP2).

In a given accident, each involved party has a specific pre-accident situation. A pre-accident situation can be defined as a malfunction in the execution of a task, the task being the 'driving' or 'riding' or even 'walking', depending on the type of road user.

Road users are faced with many types of situations prior to an impact occurring. They may be negotiating a turn into a side road, changing lanes, approaching traffic signals, driving down a straight road or, if a pedestrian, crossing a road. The situation the road user is faced with often determines whether elements within this situation will result in an accident occurring.

Many accident data collection systems include a method of classifying the different types of accidents that could occur. These can be used to create an initial classification of pre-crash driving situations that the road user is faced with.

As an example, seven different type of accidents are identified by the GDV (German Insurance Association) in their accident classification system:

1. Driving accident (also known as loss of control);
2. Turning off accident;
3. Turning in/crossing accident;
4. Pedestrian accident;
5. Accident with parking vehicles;
6. Accident in lateral traffic;
7. Other accident types (e.g. objects on road, reversing, u-turns etc..).

Similar classifications of accident types are also included in accident data collection systems used in other countries (OTS in the UK, GIDAS in Germany, LAB in France, the Definition for Classifying Accidents (DCA) used by MONASH in Australia etc...).

On South Africa's road safety website (Arrive Alive)[1], different accident types are identified, including:
- Encounters with pedestrian or cyclists;
- Encounters with vehicles travelling in the same direction (in particular involving rear-end collisions);
- Encounters involving vehicles travelling in the opposite direction;
- Encounters involving vehicles travelling at right angles to each other;
- Vehicles parking;
- Vehicles reversing.

In the UK, although accident types are not classified in STATS19, many different accident variables are included which can be combined to create a picture of the specific types of driving situations. For example, vehicle manoeuvres at the time of the accident are listed, as well as the vehicle location at the time of the accident (e.g. at an intersection or not).

When trying to define different types of driving situations for Task 5.2, in most cases, the classifications considered are too 'general' and often don't take into account the task and what it requires, which leads to a poor understanding of the difficulties met by the road user. Therefore, the 'situations' encountered by road users need to be further analysed and this is discussed further in section 5.

[1] http://www.arrivealive.co.za/

4 Methodology

The information collated in the review of literature and accident data collection systems was used to determine the type of systems already used to classify factors which lead to human functional failure in road accidents and the specific driving situations.

By applying a human factors approach, the factors and situations can be categorised into a comprehensive grid which is useful for non-human factors experts.

The review shows that the problem with many accident causation coding systems currently used across Europe is that they do not separate the 'errors' (or human failures) from the 'factors' which lead to these failures. The grid of factors compiled in task 5.2 aims to include only factors and these factors can then be linked to the human failures investigated in Task 5.1, and be used to create 'scenarios' as part of Task 5.3. The definition adopted in this report of a factor is given below:

Factors are identified as elements that 'influence' the road user's ability to undertake the task (i.e. driving/riding/walking) rather than just the 'causes' of the accident.

4.1 Approach

To overcome the confusion of factors and errors that was found in the literature review, it was decided that an holistic approach would be adopted, enabling the analyst to look at the factors in an encompassing and complete manner. The approach enables many of the potential factors to be identified. However it is then necessary to apply a systematic approach in dealing with the factors that were generated in order to create categories or lists. The systematic approach allows the categorisation process to be consistent and thorough which can be particularly difficult when processing large numbers of factors.

Using an holistic approach, the methodology of this task adopted a fundamental ergonomic model based on a model described by Eason (1981). The model is outlined in figure 2 below:

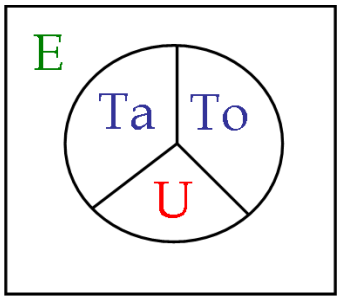

Figure 2 - Fundamental Ergonomic Model (Eason 1981)

This model is described in more detail in table 8 below:

Table 8 - Further Description of the Fundamental Ergonomic Model Outlined in Figure 2

User (U)	The individual involved and all of their personal demographic
Task (Ta)	The activity the user is attempting to undertake
Tool (To)	The equipment or devices the user is interacting with in the task
Environment (E)	The surroundings in which the user is carrying out their task

This model was adopted to assist in a logical and practical method for generating a grid of factors which contribute to functional failures occurring and the related driving situations.

When considering the driving situation, specifically in terms of accident analysis, the 'user', 'task' 'tool' and 'environment' can be interpreted in the following way (table 9):

Table 9 - Adaptation of Fundamental Ergonomic Model for Use in Accident Analysis

U = Road user	A human in charge of a vehicle (e.g. driver, motorcyclist, cyclist) or pedestrian involved in the accident
Ta = Task	Driving, riding, walking, running...
To = Vehicle	A **vehicle** involved in the accident (e.g. car, truck, bus, van, motorcycle, bicycle…). Consideration should also be given about whether a pedestrian has an equivalent 'tool'?
E = Environment	Encompasses all aspects related to the **road user's** surroundings (i.e. external to the vehicle and road user)

In addition to the holistic approach, in order to further identify the factors, a top-down, bottom-up [2] approach was also taken using the sources of potential factors identified in section 3. To expand, a classification system was created based on those factors identified in the literature and using the categories defined, the many factors identified were sorted into these categories. Conversely, similar factors were grouped together and from these, an effective way of categorising was devised. The results of both of these methods were summarised and a comprehensive grid of factors which lead to human functional failure and categorisations was defined.

The schematic in Figure 3 is divided into two parts, 'Pre-Accident Driving Situations' and 'Factors' which lead to functional failures. The pre-accident driving situation is related to the 'task' in Eason's model and the 'factors' are related to the 'user', 'tool (vehicle)' and 'environment' from the same model. In addition to the task, the 'driving situation' is further defined by the location of the accident and any opponent manoeuvres from other vehicles in the accident (described as 'conflict' from here on).

The concept outlined in the schematic also considers both 'Current' and also 'Future' issues. 'Current' issues describe the factors that are relevant in current accident analysis and are often considered in current accident data collection systems. The 'future' aims to describe potential 'future factors' which may not be considered in current data collection systems, but could contribute to functional failures in accidents as technologies and driving task demands change over the next 5-10 years (and may even be influencing current accidents) and may also affect the types of driving situations drivers are involved in.

From the compiled categories and the generated list of factors, it became possible to identify and look ahead to ask questions like: 'What factors are not considered in present classifications that could potentially be influential over the next 5-10 years, and would they still apply or fit with the current categorisation?' The overall approach is outlined in full using the example schematic shown in figure 3.

[2] top-down - firstly formulating an overview of the system and then each subsystem is then refined in greater detail, until the entire system is reduced to base elements.

bottom-up – firstly the base elements of the system are formulated in detail and then the elements are linked together until the complete system is formed.

To help focus on this holistic approach, each top level factor category was considered independently (User, Vehicle and Environment). Task was also considered in a similar way, but in order to define pre-accident driving situations. Sections 5 and 6 identify in detail how the holistic approach generated sub-categories and what factors were identified within each of these sub-categories.

As TRACE is focussing mainly on motor vehicles, in particular cars, the compilation of both the grid of factors and the pre-accident situations has also focussed mainly on motor vehicle drivers, in particular cars. Where possible, the involvement of pedestrians has been taken into consideration, but this is an issue that requires further in-depth investigation which is beyond the scope of TRACE.

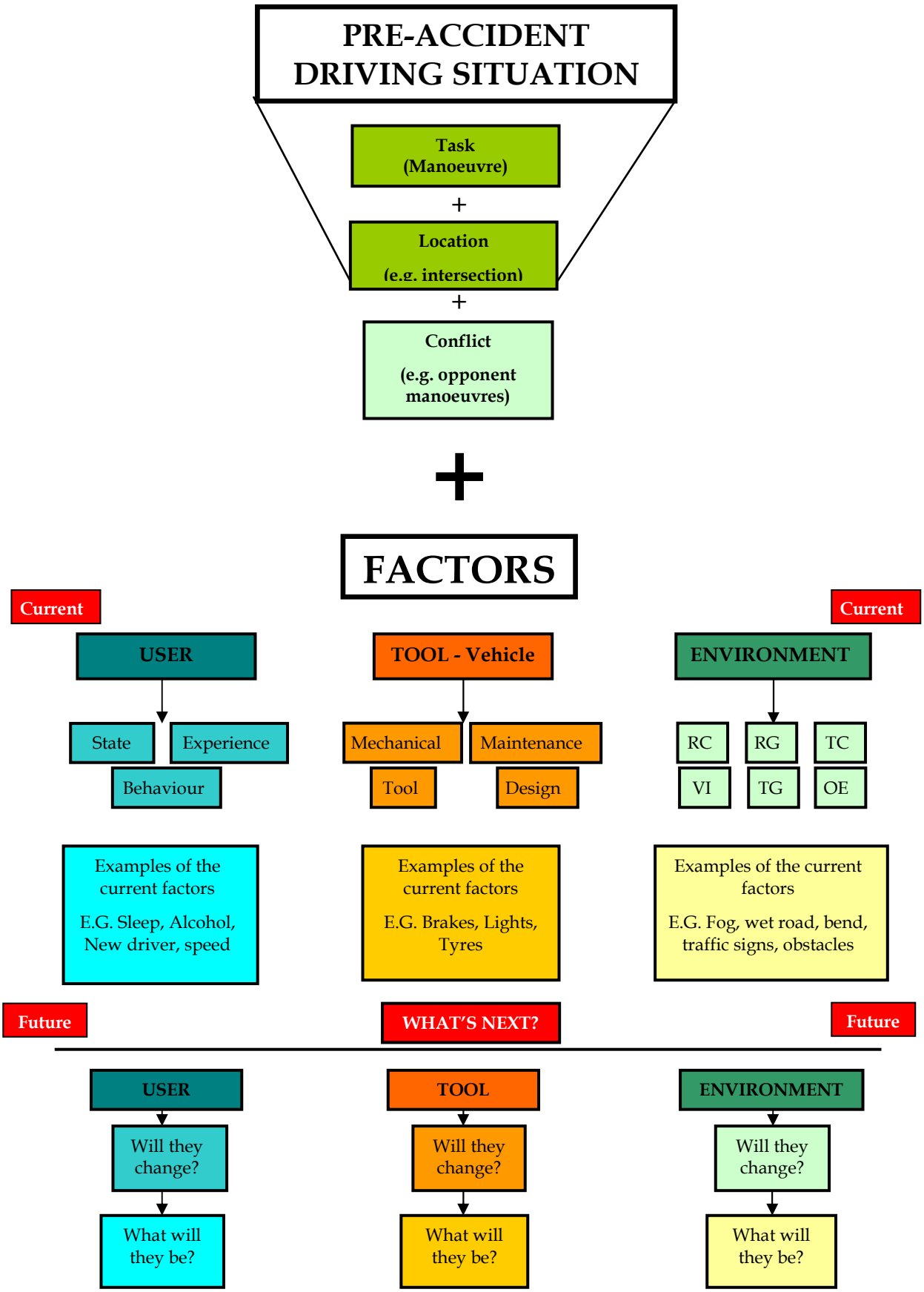

Figure 3 - Overall Approach for Determining Driving Situations and Factors

5 Pre-accident Driving Situations

As outlined in section 4.1, the pre-accident driving situation is defined by the type of driving task being performed, the location of the vehicle and any 'conflicts' (opponent manoeuvres from other road users) prior to an impact or any functional failures occurring. In the diagram shown in figure 1, section 2, the pre-accident driving situation can be defined as the 'driving phase' and describes what the road user was doing and the circumstances surrounding this prior to the rupture phase occurring.

This section outlines the types of 'tasks', their resultant manoeuvres and possible locations (e.g. intersection) and finally sets out to classify the main types of pre-accident driving situations that are possible, along with potential conflicts that led to a potential rupture phase.

5.1 The Task

In the Ergonomic model outlined in Figure 2, Section 4.1, 'Task' is the term used to describe what the road user is doing to undertake their 'journey'. This could be driving, riding or walking, depending on the type of road user and their 'vehicle'.

A number of subcategories were initially developed to understand further the complexity of the driving task and these were related to the importance of the aspect of the driving task being undertaken.

Primary level driving tasks are those that are essential to the task of driving as a whole and to the undertaking of the journey (i.e. without these, the journey is impossible to undertake). These tasks enable the road user to control their vehicle and allow them to undertake many different manoeuvres, such as overtaking, turning, reversing, stopping, starting, changing lane or even going ahead. These manoeuvres will be discussed in further detail later in Section 5.2.

Secondary level driving tasks are those that are important to the undertaking of the journey and improve the driving experience in terms of comfort, convenience and safety, but are not 'essential'. In other words, the journey can still be undertaken without these, but it will be more difficult.

Tertiary level driving tasks are those not directly related to the undertaking of the journey. They may improve the comfort or convenience for the road user but may also decrease the safety of the road user.

Table 10 outlines examples of primary, secondary and tertiary level driving tasks which the road user may have been undertaking (one or more) at the driving phase of an accident scenario (i.e. prior to the rupture phase – see figure 1).

Table 10 - Examples of Primary, Secondary and Tertiary Level Driving Tasks Which May be Undertaken by the Road User at the Driving Phase

Task Level	Task Examples
Primary	Steering
	Braking
	Accelerating
	Changing gear
Secondary	Operating vision/visibility controls
	Operating HVAC (Heating, Ventilation & AC)
	Checking warnings/displays
	Using driver assistance systems
	Opening/closing door
Tertiary	Using entertainment system
	Eating/drinking
	Using mobile phone

As will be shown in Section 5.4, the types of secondary and tertiary level tasks presented in Table 10 have been considered as part of classifying the factors which lead to functional failure, in terms of both user distraction and the design of vehicle controls and displays.

However, at a primary level, the driving task and their associated manoeuvres (see section 5.2) have been used to form part of the pre-accident 'driving' situation.

5.1.1 Manoeuvres

When a road user carries out a primary level driving task, such as the examples given in Table 10, it will more than likely lead to a manoeuvre being undertaken. The primary level driving tasks were used to define the types of manoeuvres that could potentially be undertaken. In addition to this, current accident data collection systems and previous studies were also investigated (see section 3.2) to identify pre-defined manoeuvres.

From these sources, the following list of general manoeuvres was developed:

- **Going ahead** - The user was 'going ahead' and not making any specific manoeuvres prior to the rupture phase;
- **Changing lane** - The user changed lane into another lane travelling in the same direction, but was not overtaking another vehicle;
- **Overtaking** - The user was overtaking another road user or a stationary vehicle;
- **Turning -** The user was making a turning manoeuvre (e.g. at an intersection, u-turn …);
- **Stopping -** The user was stopping/slowing in the carriageway (e.g. parking, approaching stationary traffic queue, approaching a junction/traffic control, slowing to turn into driveway/side road...);
- **Reversing -** The user was reversing (e.g. on main carriageway, into side road/private drive, out of side road/private drive, into roadside parking space..);
- **Starting** - The user was pulling away from a parking space/driveway/ junction/traffic control/traffic queue.

5.2 Locations

From investigating the different types of accident locations defined in accident data collection systems across Europe and Australia (e.g. GDV, GB STATS19, DCA used in Australia), a number of general location types were identified. These included:

Not at intersection:

- Straight road;
- Road with bend.

At intersection:

- Give-way;
- Stop;
- Traffic signal controls;
- No traffic control (road user has right of way).

Other locations:

- Roundabout;
- Slip road;
- Pedestrian crossing (not at intersection);
- Railway crossing.

Along with the manoeuvre undertaken by the road user, these locations will form part of the driving situation, which is discussed further in the next section.

5.3 Grid of Driving Situations

In addition to an overview of pre-defined accident types found in a number of current accident data collection systems across Europe, the manoeuvres and the locations defined in sections 5.1 and 5.2 have been used to define the pre-accident driving situations. From these, an extensive list of driving situations were identified and are displayed in table 11. Following on from this table, definitions of these situations are given.

- Level 1 is a basic description of the manoeuvre that is being undertaken as part of the driving task and/or the location where it was being undertaken;
- Level 2 includes further detail about the manoeuvre and the location.

Table 11 - Classification of Pre-Accident Driving Situations (Manoeuvre and Location)

Level 1	Level 2
A. Stabilised Situation	
Going ahead	Going ahead on a straight road
	Going ahead on a left bend
	Going ahead on a right bend
B. Intersection	
On approach	Approaching a 'give way' intersection
	Approaching a 'stop' intersection
	Approaching a 'traffic signal' intersection
	Approaching intersection where road user has right of way
Stopped	Stopped at a 'give way' intersection
	Stopped at a 'stop' intersection
	Stopped at a 'traffic signal' intersection
	Stopped in road/ turning lane waiting to turn
Going ahead	Going straight on at a 'give-way' intersection
	Going straight on at a 'stop' intersection
	Going straight on at a 'traffic signal' intersection
	Crossing intersection where road user has right of way
	Travelling on roundabout (not turning on/off)
	Travelling on slip-road (not turning on/off)
Turning	Turning across traffic at a 'give-way' intersection
	Turning across traffic at a 'stop' intersection
	Turning across traffic at a 'traffic signal' intersection
	Turning across traffic from main road into side road
	Turning away from traffic at a 'give-way' intersection
	Turning away from traffic at a 'stop' intersection
	Turning away from traffic at a 'traffic signal' intersection
	Turning away from traffic from main road into side road
C. Manoeuvre	
Overtaking	Overtaking stationary vehicle on left
	Overtaking stationary vehicle on right
	Overtaking moving vehicle on left
	Overtaking moving vehicle on right
Changing lane	Moved into lane on left (NOT overtaking)
	Moved into lane on right (NOT overtaking)
Slowing	Stopping (not at junction)
	Parking (roadside)
Starting	Starting (not at junction)
	Leaving parking space (roadside)
Turning (not at intersection)	Turning across traffic from main road into private drive
	Turning away from traffic from main road into private drive
	Turning across traffic out of private drive
	Turning away from traffic out of private drive
Reversing	Reversing
U-turn	U-turn
In wrong direction	Driving in wrong direction (e.g. down a one-way road)
D. Other	
Parked	Parked
Stopped in traffic queue	Stopped in traffic queue
Pedestrian crossing	Approaching pedestrian crossing
	Stopped at pedestrian crossing
Railway crossing	Approaching railway crossing
	Stopped at railway crossing

5.3.1 Types of Driving Situations

A. Stabilised Situations

The situations defined in this category are those which do not occur at intersections and where no manoeuvres are being undertaken, so the road user is:

A.1 Going Ahead

i) Going ahead on a straight road;

ii) Going ahead on a left bend;

iii) Going ahead on a right bend.

B. Intersection Situations

Situations which occur at or on approach to an intersection. An intersection is defined as a connection of two or more public roadways (i.e. a main road and at least one side road). These roadways do not include slip roads or private roads, driveways or paths. Intersection includes those controlled by 'give way' signs and markings, 'stop' signs and markings and those controlled by traffic lights. The road user will either be on the main road or on the side road, and will either:

- Have to 'give way': 'give way' signs/markings present;
- Have to 'stop': traffic signals on red, or 'stop' signs/markings present;
- Have to obey the traffic signals;
- Have right of way: no 'give way', 'stop' or traffic signals present.

B.1. On Approach

A situation where the road user is on a final approach to an intersection crossing and the conflict or initial loss of control (e.g. rupture phase) occurs here. For example, a road user approaches a traffic signal intersection at speed and the lights change to red, which leads to a conflict or loss of control at the intersection. Four sub-categories have been defined:

i) Approaching a 'give way' intersection;

ii) Approaching a 'stop' intersection;

iii) Approaching a 'traffic signal' intersection;

iv) Approaching intersection where road user has right of way.

If a road user is approaching a roundabout, the appropriate category should depend on the traffic control at the entry to the roundabout. For example, if the road user is approaching a traffic light controlled roundabout, the category "Approaching a 'traffic signal' intersection" is the most appropriate.

B.2. Stopped

A situation where the road user is stopped/waiting at an intersection. Again, four sub-categories have been defined:

i) Stopped at a 'give way' intersection;

ii) Stopped at a 'stop' intersection;

iii) Stopped at a 'traffic signal' intersection (i.e. red traffic lights);

iv) Stopped in road/ turning lane waiting to turn (e.g. into side road).

If a road user is stopped at the entry to a roundabout, the most appropriate category should depend on the traffic control at the entry to the slip road/roundabout or the end of the slip road. For example, if the road user is stopped at a 'give-way' roundabout, the category "Stopped at a 'give way' intersection" is the most appropriate.

B.3. Going Ahead

There are a number of types of 'going ahead' at an intersection:

i) Going straight on at a 'give-way' intersection (i.e. road user does not have right of way so has to wait until it is clear to cross);

ii) Going straight on at a 'stop' intersection (i.e. road user does not have right of way so has to wait until it is clear to cross);

iii) Going straight on at a 'traffic signal' intersection (i.e. traffic lights on green);

iv) Crossing intersection where the road user has right of way (i.e. no 'give way', 'stop' or 'traffic signals');

v) Travelling on roundabout – the road user is travelling around the roundabout, but NOT turning on to or off the roundabout. Turning onto or off a roundabout would be classed as 'Intersection: Turning' (see next section B4);

vi) On slip road – the road user is travelling on a slip road, but not turning on or off the slip road.

B.4. Turning

At an intersection, the road user could make one of two turn manoeuvres from the road they are travelling on into another road; either a left turn or a right turn. In the UK, road users travel on the left hand side of the road, as opposed to most of Europe, who drive on the right hand side. Therefore, 'turning right' in the UK is the same manoeuvre as 'turning left' in the rest of Europe, as they will both involve turning across an opposing lane of traffic (see figure 3). To avoid the confusion of using 'left' or 'right' to describe the situation type, the following descriptions will be used:

- Turning away from traffic = turning left in UK or turning right in rest of Europe;
- Turning across traffic = turning right in UK or turning left in rest of Europe.

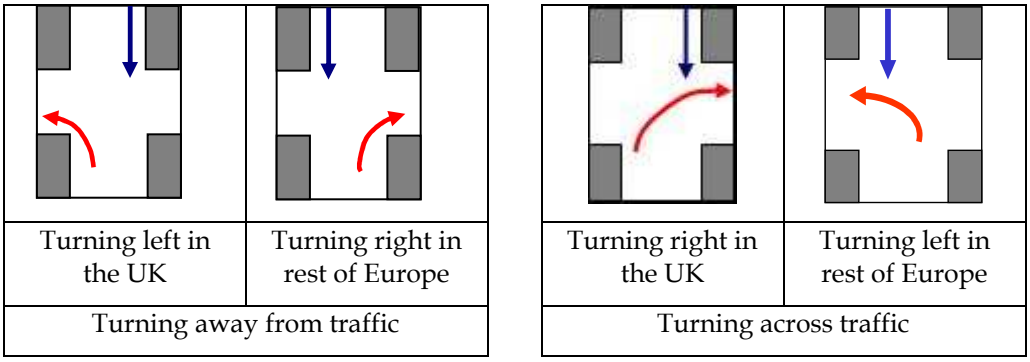

Figure 4 - Differences Between Left and Right Turns in the UK Compared to the Rest of Europe

Eight sub-categories of turning at intersection have been defined:

i) Turning away from traffic at a 'give-way' intersection*;

ii) Turning away from traffic at a 'stop' intersection*;

iii) Turning away from traffic at a 'traffic signal' intersection*;

iv) Turning away from traffic from main road into side road**;

v) Turning across traffic at a 'give-way' intersection;

vi) Turning across traffic at a 'stop' intersection;

vii) Turning across traffic at a 'traffic signal' intersection;

viii) Turning across traffic from main road into side road.

* includes turning onto roundabout

** including turning off roundabout

C. Manoeuvre Situations

These are situations where the road user is undertaking a specific manoeuvre which does not necessarily occur at an intersection (i.e. those already specified in the previous section).

C.1. Overtaking

The road user was:

i) Overtaking a stationary vehicle on the left, (e.g. parked on the roadside, broken down or stationary in a traffic queue);

ii) Overtaking a stationary vehicle on the right, (e.g. parked on the roadside, broken down or stationary in a traffic queue);

iii) Overtaking a moving vehicle on the left which was travelling in the same direction;

iv) Overtaking a moving vehicle on the right which was travelling in the same direction.

C.2. Changing Lane

The road user has changed lanes, but NOT to overtake another vehicle, either on the (i) left or (ii) right. For example, in preparation to leave or turn off the road or to avoid a pedestrian or obstacle, or in preparation for lanes merging or separating.

C.3. Slowing

The road user was:
i) Slowing or stopping, because of a traffic queue or obstacle ahead;
ii) Slowing to park or parking the vehicle on the roadside (but NOT reversing).

C.4. Starting

The road user was:
i) Starting/speeding up from stationary;
ii) Leaving a parking space on the roadside.

C.5. Turning (not at intersection)

The road user undertook at turning manoeuvre NOT at an intersection:
i) Turning across traffic from main road into a private driveway or path;
ii) Turning away from traffic from main road into private driveway or path;
iii)Turning across traffic out of private driveway or path;
iv) Turning away from traffic out of private driveway or path.

C.6. Reversing

The road user was reversing their vehicle.

C.7. U-turn

The road user was making a u-turn manoeuvre.

C.8. Wrong Direction

The road user was driving in the wrong direction, (e.g. on a one way road or dual carriageway with separation). This does not include where a road user was making an overtaking or lane change manoeuvre.

D. Other

These are other types of situations which do not involve a specific manoeuvre and did not occur at an intersection (as defined in 'B').

D.1. Parked

The road user was in their vehicle which was parked on the roadside.

D.2. Stopped in Traffic Queue

The road user was stationary in a traffic queue. This was a result of either road-works, previous traffic accident, traffic congestion or other incident blocking the road. If the road user was stopped at an intersection (give way or traffic light controlled), 'Intersection: Stopped at Intersection' is the most appropriate situation category.

D.3. Pedestrian Crossing

A situation where the road user is at or on a final approach to a pedestrian crossing, which is where the rupture phase occurs. This only applies to pedestrian crossings which do not also function to control traffic flow at intersections. Pedestrian crossings located at intersections which also control traffic flow are classed under 'Intersection' situations (e.g. B1 and B2). Two sub-categories of pedestrian crossing which are not intersections have been defined:

i) Approaching pedestrian crossing – e.g. the road user is approaching a pedestrian crossing and a pedestrian unexpectedly runs/walks across at or near the crossing;

ii) Stopped at pedestrian crossing – e.g. the road user is stationary at a pedestrian crossing and another vehicle approaches from behind.

D.4. Railway Crossing

A situation where the road user is on approach to, or stopped at, a railway crossing. Two sub-categories of railway crossing have been defined:

i) Approaching railway crossing;

ii) Stopped at level crossing.

5.4 Conflicts

Conflicts can be described as potential opponent manoeuvres that the road user could be faced with during the pre-accident driving situation. In most 'situations', each road user will not experience more than one conflict at the rupture phase.

However, on some occasions, it is possible that more than one conflict could occur. However, it is the first conflict that led to the rupture phase which makes up the pre-accident driving situation that is described here. It is possible that this first conflict may involve a vehicle that is not involved in the eventual collision, so is not recorded in the accident (e.g. a vehicle swerves to avoid a stationary vehicle ahead but then eventually has a head-on impact with a vehicle travelling in the opposite direction).

The following describes the types of conflicts which have been identified (outlined in table 12). Again, two levels have been developed:

Level 1 – Providing a basic level of information;

Level 2 – Providing a more detailed level of information.

Table 12 - Potential Conflicts That the Road User Could be Faced With During the Pre-Accident Driving Situation

Level 1	Level 2
None	None
Oncoming vehicle(s)	Oncoming vehicle(s) in correct lane
	Oncoming vehicle(s) in wrong lane
Vehicle ahead (moving in same direction or stationary)	Moving vehicle(s) ahead
	Stationary vehicle(s) ahead (congestion or accident)

	Stationary vehicle(s) ahead (parked)
	Car door open on stationary vehicle
Following vehicle(s)	Following vehicle(s)
Vehicle from side	Vehicle(s) from side road/path
	Vehicle in lateral lane travelling in same direction
Obstacle(s) ahead (non-vehicle)	Moving obstacle(s) ahead
	Stationary obstacle(s) ahead
Pedestrian in road ahead	Pedestrian crossing over
	Pedestrian walking along road
	Pedestrian playing/ running on road

A) None

There was no other road user involved and no obstacles ahead, therefore there was no potential conflict (opponent manoeuvre). This situation would generally lead to a single vehicle loss of control accident.

B) Oncoming Vehicle(s)

The road user was faced with an oncoming vehicle travelling in the opposite direction, the vehicle being either in the;

i) Correct lane - if the road user is in the wrong lane;

ii) Wrong lane – if the road user is in the correct lane.

C) Vehicle(s) Ahead

The road user was faced with a vehicle ahead which was:

i) Travelling in the same direction (i.e. slower);

i) Stationary - in a traffic queue or was parked;

ii) Stationary with a car door open.

D) Following Vehicle

The road user was faced with a potential conflict from a vehicle behind who was following the same direction.

E) Vehicle from Side

The road user was faced with a potential conflict from a vehicle approaching from the side, either from:

i) A side road or path;

ii) A lateral lane, travelling in the same direction.

F) Obstacle(s) Ahead

The road user was faced with a potential conflict from an obstacle ahead which was NOT another road user. Either a:

i) Moving obstacle - e.g. animal, a lorry shedding its load, an exhaust breaking off another vehicle…;

ii) Stationary obstacle - e.g. animal, stationary objects from discarded load, tree...

G) Pedestrian(s) in Road Ahead

The road user was faced with a potential conflict from a pedestrian or pedestrian(s) ahead, either:

i) Crossing over;

ii) Walking along the road;

iii) Playing/running on the road.

5.5 Grid of Pre-Accident Driving Situations and Potential Conflicts

The Grid in Table 13 shows in summary the possible combinations of pre-accident driving situations (as previously shown in Table 11) and the potential conflicts (as previously shown in Table 12) that could be experienced by a road user prior to a rupture phase.

Table 13 - Grid Showing Combinations of Pre-Accident Driving Situations (Shown Previously in Table 11) and Potential Conflicts (Shown Previously in Table 12)

PRE-ACCIDENT DRIVING SITUATIONS				Conflict														
			Level 1	None	Oncoming vehicle(s)		Vehicle ahead (moving in same direction or stationary)				Following vehicle(s)	Vehicle from side		Obstacle(s) ahead (non-vehicle)		Pedestrian in road ahead		
	Level 1	Level 2	Level 2	None	Oncoming vehicle(s) in correct lane	Oncoming vehicle(s) in wrong lane	Moving vehicle(s) ahead	Stationary vehicle(s) ahead (congestion or accident)	Stationary vehicle(s) ahead (parked)	Car door open on stationary vehicle	Following vehicle(s)	Vehicle(s) from side road/path	Vehicle in lateral lane travelling in same direction	Moving obstacle(s) ahead	Stationary obstacle(s) ahead	Pedestrian crossing over	Pedestrian walking along road	Pedestrian playing/ running on road
Manoeuvre and Location	**Stabilised situation**																	
	Going ahead	Going ahead on a straight road																
		Going ahead on a left bend																
		Going ahead on a right bend																
	Intersection																	
	On approach	Approaching a 'give way' intersection																
		Approaching a 'stop' intersection																
		Approaching a 'traffic signal' intersection																
		Approaching intersection where road user has right of way																
	Stopped	Stopped at a 'give way' intersection																
		Stopped at a 'stop' intersection																
		Stopped at a 'traffic signal' intersection																
		Stopped in road/ turning lane waiting to turn																
	Going ahead	Going straight on at a 'give-way' intersection																
		Going straight on at a 'stop' intersection																
		Going straight on at a 'traffic signal' intersection																
		Crossing intersection where road user has right of way																
		Travelling on roundabout (not turning on/off)																
		Travelling on slip-road (not turning on/off)																
	Turning	Turning across traffic at a 'give-way' intersection																
		Turning across traffic at a 'stop' intersection																
		Turning across traffic at a 'traffic signal' intersection																
		Turning across traffic from main road into side road																
		Turning away from traffic at a 'give-way' intersection																
		Turning away from traffic at a 'stop' intersection																
		Turning away from traffic at a 'traffic signal' intersection																
		Turning away from traffic from main road into side road																
	Manoeuvre																	
	Overtaking	Overtaking stationary vehicle on left																
		Overtaking stationary vehicle on right																
		Overtaking moving vehicle on left																
		Overtaking moving vehicle on right																
	Changing lane	Moved into lane on left (NOT overtaking)																
		Moved into lane on right (NOT overtaking)																
	Slowing	Stopping (not at junction)																
		Parking (roadside)																
	Starting	Starting (not at junction)																
		Leaving parking space (roadside)																
	Turning (not at intersection)	Turning across traffic from main road into private drive																
		Turning away from traffic from main road into private drive																
		Turning across traffic out of private drive																
		Turning away from traffic out of private drive																
	Reversing	Reversing																
	U-turn	U-turn																
	In wrong direction	Driving in wrong direction (e.g. down a one-way road)																
	Other																	
	Parked	Parked																
	Stopped in traffic queue	Stopped in traffic queue																
	Pedestrian crossing	Approaching pedestrian crossing																
		Stopped at pedestrian crossing																
	Railway crossing	Approaching railway crossing																
		Stopped at railway crossing																

6 Grid of Factors Leading to Human Functional Failure

As part of classifying factors which lead to human functional failure, three integrated levels of categorisation were developed, corresponding to the types of real world accident data commonly available to analysts. This would ensure the classifications were versatile and flexible enough to be of use in accident data analysis at the following levels of detail:

1. Descriptive – When undertaking analysis using descriptive level (police or national-level) data;

2. Generic – For use in analysis of the failure generating scenarios in Task 5.3;

3. In-depth – When undertaking analysis using in-depth accident data.

The 'generic' level overlaps partly with both 'descriptive' and 'in-depth' levels. Therefore, this level could also be used for analysis of descriptive data where the information collected is at a greater depth than at the 'Descriptive' level of classification (so that information is not lost), or alternatively could be used for analysis of in-depth data when the information collected is not as detailed as in the 'in-depth' classification.

When using these factors as part of an analysis of real-world accidents, for each factor identified, it should be determined, if possible, whether each was a 'contributing' factor to the onset of the accident, a 'triggering' factor (i.e. led to the rupture phase), or an 'aggravating' factor (increased the likelihood of an impact occurring at the emergency phase), as outlined in Figure 1 of section 2.

6.1 User (Human)

This category of factors is described as any factors related to the individual and personal demographic. This includes any physical and psychological disorders that may be of relevance or any psychosomatic states that the user may have incurred through alcohol or misuse of drugs or emotional/motivational states. The user is defined as any human in charge of a vehicle within the accident (e.g. driver, motorcyclist, cyclist) or any pedestrian injured in the accident, and is described as a 'road user'.

From reviewing the literature and current data collection systems, three main subcategories of user factors were decided on, as follows:

1. User State
2. Experience
3. Behaviour

Table 14 outlines the classification of road user-related factors which could potentially lead to functional failures. The three main categories of user factors defined (plus a number of sub-categories) are outlined at a 'descriptive', 'generic' and 'in-depth' level.

Table 14 - Grid of User Related Factors Which Could Lead to Human Functional Failures

Descriptive		Generic	In-depth Examples
A. User State	1. Physical/ Physiological	Medical condition	Heart condition/Epilepsy/Other brain condition/Respiratory condition/Blood condition/Other condition
		Pre-existing impairment	Hearing/Visual/Physical disability/Other impairment
	2. Psycho-physiological condition	Substances taken - alcohol	Above 'legal' limit/ Below 'legal' limit
		Substances taken - drugs	Illegal drugs/ Correctly used medication/ Misused medication
		Emotional	Upset/Angry/Anxious/Happy/Other emotion
		Fatigue	Physical/Mental
		In a hurry	In a hurry
	3. Internal conditioning of performed task	Right of way status	Rigid attachment to the right of way status
		Excessive confidence	Excessive confidence in signs given to others
		Identification of potential risk	Identification of potential risk about only part of the situation
B. Experience	1. Little/None	Driving	Learner/New driver/Infrequent driver/Other
		Route	New route/Road type/New road/Road feature/Driving on the left/Driving on the right/Other
		Vehicle	New vehicle/ Transmission type/ Left hand drive vehicle/ Right hand drive vehicle/ Other vehicle feature
		Environment	Night driving/City driving/Country driving/Driving in snow/Driving in fog/Driving in wet or flood/Driving in ice/Other
	2. Over-experienced	Driving	Change in driving rules/Other
		Route	Route in general/Road type/New road/Road feature/Other
		Vehicle	New vehicle/ Transmission type/Other vehicle feature
		Environment	Night driving/City driving/Country driving/Driving in snow/Driving in fog/Driving in wet or flood/Driving in

			ice/other
C. Behaviour	1. Conflicting (Distraction)	Distraction outside vehicle*	Police/Animal in road/ Sunlight or sunset/ People in roadway/ Crash scene/Other perceived danger/Road construction/ Searching for directional information/ Unspecified outside distraction
		Distraction within vehicle*	Adjusting radio/ Adjusting cassette/ Adjusting CD/ Other occupant/ Moving object in vehicle/ sing or viewing device integral to vehicle/ Using other device brought into vehicle/ Adjusting climate controls/ Eating/Drinking/ Cell phone/ Smoking/ Looking inside vehicle/ Reaching for object/ Unspecified inside distraction
		Distraction within user*	Lost in thought/ Medical problem
	2. Risk taking	Speed	Illegal/Legal but inappropriate/Erratic/Other
		Vehicle positioning	In front/Lateral/Other
		Traffic control	Signs disobeyed/Signals disobeyed /Markings disobeyed/Other
		'Eccentric' motives	Testing a vehicle/Thrill-seeking/Competing/'Stunt'/Unspecified eccentric motives

** The distractions described at an 'in-depth' level are based on the sources of distraction described by Stutts et al. (2001) (see section 3.1)*

A. User 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.

A1. Physical/physiological

The physical or physiological state of the user can have a major effect on the outcome of a potential accident situation. Often, the danger signal is never perceived because either the road user does not know they have a medical condition or the user does not realise that their pre-existing 'state' puts them in a position of having a higher likelihood of a failure occurring.

- **Medical condition** - The road user is suffering from a medical condition, known or unknown to the user, which in a potential accident situation will increase the likelihood of a failure occurring. The examples of medical conditions shown in table 13 above will lead to a deterioration in the

user's physical state, possibly leading to a loss of consciousness, therefore leading directly to a human functional failure.

- **Pre-existing impairment** - The road user had a pre-existing impairment (e.g. hearing, visual, physical…). The examples of pre-existing impairments shown in table 13 above will not normally lead to a deterioration in the user's physical state. It is normally the combination of the pre-existing impairment and at least one other factor which leads to a failure.

A2. Psycho-Physiological Condition

The psycho-psychological condition of the user will also have a major influence over the potential for functional failures to occur, as will any substances they have taken.

- **Substances taken – alcohol** - The user was under the influence of alcohol. At the in-depth level, a distinction has been made between alcohol levels above and below the 'legal' limit. The 'legal' limit is defined as the legal limit in the country where the accident occurred.
- **Substances taken – drugs** – Either the road user:
  - was under the influence of drugs illegal in the country where the accident occurred;
  - had taken medication correctly but had an adverse reaction;
  - had misused medication (e.g. taken too much or had used someone else's prescribed medication).
- **Emotional -** The user was in a highly emotional state, either negative (e.g. upset or angry) or positive (e.g. happy or euphoric).
- **Fatigue -** The user was fatigued either physically (e.g. due to exertion) or mentally (e.g. due to busy day or lack or sleep) but had not fallen asleep.
- **In a hurry -** The road user was affected by time constraints by being in a hurry.

A3. Internal Conditioning of Performed Task

These factors are 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).

- **Right of way status** – The road user has a rigid attachment to their right of way status. This refers to the situation before an emergency manoeuvre has taken place. For example, when a road user is approaching an intersection where they have right of way, they can see a vehicle waiting to turn from a side road but not pay any further attention to it, as they consider no danger could come from it because they have the right of way. Or alternatively, the road user pays no further attention and expects no danger from an oncoming vehicle, as they have right of way in the lane they are in.
- **Excessive confidence** - The road user has excessive confidence in the signs given to others. For example, when a road user activates their indicator to turn or change lane, but does not check before making the turn, as they are confident that using their indicator guarantees them a free manoeuvre.
- **Identification of potential risk** - The road user has identified a potential risk but only about part of the situation. For example, when a road user is concentrating on an aspect of the road ahead that they are perceiving to be 'dangerous' (e.g. another road user) and overlooks, as a consequence, another 'danger' (e.g. another vehicle approaching from another direction).

B. Experience

The user's prior exposure to the task in hand or their surroundings will affect the way they process information.

B1. Little/None

If a road user has little or no experience of a situation, whether it be related to the route they are taking, the vehicle they are in control of, the environment surroundings or the driving task itself, danger signals may not be comprehended appropriately.

- **Driving -** The user had little/no experience of driving:
  - *Learner driver* who has not passed their test;
  - *New driver* who has recently passed their test;
  - *Infrequent driver* who has passed their test a while ago, but has not driven regularly since.
- **Route** - The user had little/no experience of the route:
  - *New route*: the road user had never driven this route before;
  - *Road type:* the user was new to the road type (e.g. motorway);
  - *New road:* the driver had not driven on the road before because the road construction was new;
  - *Road feature:* the driver had little experience of the road feature (e.g. a roundabout);
  - *Driving on the left*: the driver had little experience of driving on the left hand side of the road (i.e. foreign driver);
  - *Driving on the right*: the driver had little experience of driving on the right hand side of the road (i.e. foreign driver).
- **Vehicle** - The user had little/no experience of the vehicle:
  - *New vehicle*: the vehicle was new or was new to the road user;
  - *Transmission type:* the driver had not driven a manual/automatic car before;
  - *Left hand drive vehicle:* the driver had never driven a left hand drive vehicle before;
  - *Right hand drive vehicle:* the driver had never driven a right hand drive vehicle before.
- **Environment** - The user had little/no experience of the driving environment, for example:
  - *Night time driving;*
  - *City driving;*
  - *Country driving;*
  - *Driving in poor weather.*

B2. Over-Experienced

Conversely, if a road user has a great deal of experience of their surroundings, their habitual responses may make them more prone to functional failures situations where sudden changes to the driving rules, route, vehicle or environment occur.

- **Driving** - The user had a high experience of driving (e.g. was confident of their driving ability).
- **Route** - The user had a high experience of the route (e.g. a route the user travelled every day to work).
- **Vehicle** - The user had a high experience of the vehicle.
- **Environment** - The user had a high experience of the driving environment.

C. Behaviour

The behaviour of the road user can affect the way they control their vehicle and respond to both their internal and external surroundings.

C1. Conflict (Distraction)

Fell (1976) described distraction as being '..behaviours which interfere (or 'conflict') with the perception of comprehension of the stimuli..', when the '..operator is simply attending to some other information processing task…'.

- **Distraction outside vehicle** - The user was distracted by an object/event/ person outside the vehicle, including when a road user is searching for directions.

- **Distraction within vehicle** - The user was distracted by an object/event/person within the vehicle, including using controls and viewing displays integral to the vehicle and navigation devices.
- **Distraction within user** - The user was distracted by their own thoughts/condition (e.g. thinking about work...).

C2. Risk Taking

Fell (1976) also described risk-taking as another form of behaviour stating it as being '…intentional risk-taking actions by a driver which ultimately affects their ability to process and compensate for danger signals'. The road user is normally aware of the 'chance' they are taking but, for other reasons (e.g. experience, substances taken...) they still choose to proceed with the action.

- **Speed** - The user was either travelling above the speed limit or travelling at an inappropriate speed for the road layout or environmental conditions.
- **Vehicle positioning -** The user was positioned close to either another road user in front or laterally (including in poor environmental conditions).
- **Traffic control** - The user disobeyed traffic control signs/signals/markings (including pedestrians).
- **'Eccentric' motives -** The road user had 'eccentric' motives at the time of the functional failure occurring. For example, thrill or sensation seeking is a type of risk taking that some road users strive to experience as part of the driving experience. In addition to this, a road user who is testing a vehicle for a possible purchase, competing with their friends or are intentionally trying to undertake 'stunt' manoeuvres will also have very unconventional motives compared to most road users. Although the 'eccentric motives' of a road user may involve excessive speed, close positioning to other vehicles or disobeying traffic control signals, the thrill seeking itself can be considered as a separate or additional factor.

6.2 Environment

The environment encompasses all aspects related to the users' surroundings (i.e. external to the vehicle and road user). Six categories of environment-related factors have been defined and are outlined below:

1. Road Condition
2. Road Geometry
3. Traffic Condition
4. Visibility Impaired
5. Traffic Guidance
6. Other Environmental Factors

Table 15 outlines in detail the classification of factors related to the environment.

Table 15 - Grid of Environment Related Factors Which Could Lead to Functional Failures

Descriptive	Generic	In-depth examples
A. Road Condition	Contaminants: Wet/Flood/Snow	Wet/Flood/Snow
	Contaminants: Ice/Frost	Ice/Frost
	Contaminants: Oil/Diesel	Oil/Diesel
	Contaminants: Sand/Gravel/Mud	Sand/Gravel/Mud
	Surface defects	Potholes/Cracks/Bumps
	Surface type	Asphalt/Concrete/Untreated/Cobbles /Brick/Other

B. Road Geometry	Bend(s)	Left/Right/Wide/Tight/Multiple bends
	Slope(s)	Decline/Incline/Multiple slopes
	Road width	Wide/Narrow/Single lane/Multiple lanes/Change in width
	Adverse camber	Left/Right
	Traffic calming	Road hump/Speed table/Throttle/Chicane
	Temporary road layout	Roadworks/Other
	Misleading/complex road layout	Misleading/Complex
	Speed-inciting layout	Bend in road/Straight road/Gradient/Wide road/Continuity effect
C. Traffic Condition	Flow	Smooth/Erratic
	Speed	High/Low/Stationary
	Density	Low/High
	Other road user(s) : Absence of clues to manoeuvre	Absence of clues to manoeuvre
	Other road user(s) : Ambiguity of clues to manoeuvre	Ambiguity of clues to manoeuvre
	Other road user(s) : Atypical manoeuvres	Atypical manoeuvres
	Being drawn into manoeuvre	Passenger/Vehicle ahead/Vehicle behind/Pedestrian/Cyclist
D. Visibility Impaired	Road lighting	Type/Colour/Intensity/No lighting
	Vehicle lighting	Type/Colour/Beam type/No lighting
	Day/night	Daylight/Darkness/Dusk/Dawn
	Sun glare	Direct from sun/Reflection from wet road
	Weather	Rain/Fog or mist/Snow/Hail
	Smoke	Vehicle/Nearby fire/Other
	Terrain profile	Bend/Slope/Side slope(s)/Other
	Other vehicle(s)	High vehicle/Wide vehicle/Parked vehicle/Vehicle stopped in traffic/Other
	Roadside objects	Overhanging tree(s)/ Overhanging shrubbery/Sign(s)/Bridge structures/Barrier(s)/Wall(s)/Boundary fence(s)/Other
E. Traffic Guidance	Traffic signs/signals - Insufficient	Signs present but insufficient/Signals present but insufficient/Signs absent/Signals absent/Other
	Traffic signs/signals – Maintenance	Signs damaged/Signals damaged/Signs poorly maintained/Signs poorly maintained/Signs positioned incorrectly/Signs positioned incorrectly/Other
	Traffic signs/signals – Unexpected	Signs replaced/Signals replaced/Signs new/Signals new/Other
	Traffic signs/signals – Inappropriate	Signs inappropriate/Signals inappropriate/Signs confusing/Signals

		confusing /Other
	Road markings (visual/tactile) - Insufficient	Visual markings present but insufficient/Tactile markings present but insufficient/Visual markings absent/Tactile markings absent
	Road markings (visual/tactile) - Maintenance	Visual markings damaged/ Tactile markings damaged/ Visual markings poorly maintained/ Tactile markings poorly maintained/ Visual markings positioned incorrectly/ Tactile markings positioned incorrectly/Other
	Road markings (visual/tactile) – Unexpected	Visual markings replaced/ Tactile markings replaced/ Visual markings new/ Tactile markings new/Other
	Road markings (visual/tactile) - Inappropriate	Visual markings inappropriate/ Tactile markings inappropriate/ Visual markings confusing/ Tactile markings confusing /Other
F. Other Environmental Factors	Earlier collision	Vehicle(s)/Debris/Other
	Pedestrian in road	Adult/Child/Other
	Fire in road/roadside	Car in Road/Car in Roadside/Other in Road/Other in roadside
	Level crossing	Controlled/Uncontrolled
	Animal in road	Dog/Cat/Horse/Cow(s)/Pig(s)/Sheep/ Deer/Rabbit/Badger(s)/Fox(es)/Bird(s)/ Reptile(s)/Other animal(s)
	Other obstacle(s) in road	Vehicle part/Dead animal/Discarded vehicle load/Other
	Road works	Major/Minor/Other
	High wind	Gale force/Storm Force/Hurricane force/Other

A. Road Condition

The condition of the road surface will affect the road user's ability to be able to control their vehicle on the road. The condition of the road will be affected by the contaminants and defects, plus the road surface type itself.

- **Contaminants: Wet/Flood/Snow -** Rain, flooding or snow on the road surface which affected the user's control of the vehicle.
- **Contaminants: Ice/Frost -** Ice or frost on the road surface which affected the user's control of the vehicle.
- **Contaminants: Oil/Diesel -** Oil/diesel on the road surface which affected the user's control of the vehicle.
- **Contaminants: Sand/Gravel/Mud -** Contaminants such as sand, gravel or mud on the road surface which affected the user's control of the vehicle.
- **Surface defects** - Surface defects which affected the user's control of the vehicle (e.g. potholes, cracks, bumps etc..).
- **Surface type -** The type of road surface affected the user's control of the vehicle (e.g. asphalt, concrete, untreated, cobbles, brick, etc….), including changes in road surface type.

B. Road Geometry

The layout of the road itself will also affect the road user's ability to control their vehicle, potentially in one of the following ways:

- **Bend(s)** - Bend(s) on the road affected the user's control of the vehicle.
- **Slope(s)** - Slope(s) on the road affected the user's control of the vehicle.
- **Road width** - A wide/narrow road, carriageway or lane affected the user's control of the vehicle, or a change in road width.
- **Adverse camber** - An adverse camber in the road affected the user's control of the vehicle.
- **Traffic calming** - Traffic calming devices affected the user's control of the vehicle.
- **Temporary road layout** - A temporary road layout (e.g. road works) affected the user's control of the vehicle.
- **Misleading/complex road layout** - A misleading or complex road layout affected the user's control of the vehicle.
- **Speed-inciting layout –** All or part of the road layout incited the road user to travel at an inappropriately high speed (e.g. road alignment, gradient, width, continuity…).

C. Traffic Condition

The flow, speed or density of the traffic on the road will potentially affect the road user's ability to undertake their journey:

- **Flow** - The flow of traffic was smooth, erratic etc…
- **Speed** - The speed of the traffic was high, low, stationary etc…
- **Density** - The density of the traffic was low, high etc…
- **Other road user(s) : Absence of clues to manoeuvre–** Other road user(s) failed to give any clues as to what their next manoeuvre would be (e.g. turned without indicating).
- **Other road user(s) : Ambiguity of clues to manoeuvre –** Other road user(s) gave misleading signs of what their next manoeuvre would be (e.g. indicated left but turned right).
- **Other road user(s) : Atypical manoeuvres –** Other road user(s) undertook a manoeuvre which was unusual/not expected.
- **Being drawn into manoeuvre –** The road user was drawn (forced, pressurised or sub-consciously 'guided') into undertaking a manoeuvre by either another vehicle (e.g. following a vehicle across an intersection or driving faster because of a vehicle close behind them), a passenger (e.g. a passenger indicates to the driver that they can make the manoeuvre) or another person outside the vehicle (e.g. a pedestrian indicates to the driver at a blind junction that it clear for them to turn).

D. Visibility Impaired

If the road user's visibility of road ahead is impaired in some way, this will undoubtedly increase the possibility of a functional failure occurring. The road user's visibility of the road ahead can be affected by the following:

- **Road lighting** - Road lighting affected the road user's visibility of the road ahead (e.g. road lighting was not present, not working, poor colour etc….)
- **Vehicle lighting** - The vehicle lighting of other vehicles affected the road user's visibility of the road ahead (e.g. full beam was activated or poor alignment of the beam which caused glare; vehicle lighting was not activated at all etc…)

- **Day/night** - The driver's vision was affected by the natural lighting levels (e.g. daylight, darkness, dusk, dawn...). Does NOT include sun glare.
- **Sun glare** - Sun glare caused reduced visibility to the driver (e.g. from low sun or sun reflecting off wet road...).
- **Weather** - Weather conditions caused reduced visibility (e.g. raining, snowing, hailing, fog, mist…).
- **Smoke** - Smoke caused reduced visibility (e.g. from vehicle or nearby fire...)
- **Terrain profile** - Terrain profile caused reduced visibility (e.g. sharp bend, steep hill, steep side slopes etc…).
- **Other vehicle(s)** - Vehicle(s) on the road/roadside caused reduced visibility (e.g. HGV in front reduced forward visibility, parked vehicle obstructed driver's view of pedestrian crossing ahead..).
- **Roadside objects** - Roadside objects caused reduced visibility (e.g. overhanging trees, large signs). Roadside objects includes median objects (e.g. signs in central reservation).

E. Traffic Guidance

If there is a fault or a failure in the traffic guidance system (signs, traffic signals and road markings, including reflective studs and painted lines), this will affect the road user's ability to undertake the driving task:

- **Traffic signs/signals – Insufficient** - The signs/signals provided were insufficient (e.g. insufficient warning prior to hazard/junction, appropriate signs/signals were absent...).
- **Traffic signs/signals – Maintenance -** The messages displayed by the signs/signals were not clearly visible to road user (e.g. sign/signal was poorly maintained, damaged or was not facing in correct direction...).
- **Traffic signs/signals – Unexpected** - The signs/signals provided were unexpected to the road user (e.g. had been recently replaced by previous signs/signals or were completely new to the road location...).
- **Traffic signs/signals – Inappropriate** - The signs/signals provided were inappropriate or confusing to the road user (e.g. if a road layout had recently been changed but the old road signs were still present...).
- **Road markings (visual/tactile) – Insufficient -** The road markings provided were insufficient (e.g. insufficient warning prior to hazard/junction, appropriate markings were absent...).
- **Road markings (visual/tactile) – Maintenance** - The road markings were not clearly visible to road user (e.g. markings were poorly maintained or damaged...).
- **Road markings (visual/tactile) – Unexpected** - The road markings provided were unexpected to the road user (e.g. had been recently replaced by previous road markings or were completely new to the road location...).
- **Road markings (visual/tactile) – Inappropriate -** The road markings provided were inappropriate or confusing to the road user (e.g. if a road layout had recently been changed but the old road markings were still present...).

F. Other Environmental Factors

Obstacles and other factors which suddenly appear within the road/roadside will affect the road user's ability to undertake their journey, even when an impact does not occur with these obstacles.

- **Earlier collision** - The user had to take evasive action to avoid an earlier collision which was still blocking the roadway ahead (includes vehicles, debris etc..).
- **Pedestrian in road** - The user had to take evasive action to avoid a pedestrian in the roadway ahead.
- **Fire in road/roadside** - The user had to take evasive action to avoid a fire in the road/roadside (which was not part of an earlier collision, such as a stationary car fire..).

- **Level crossing** - The user had to take evasive action to avoid a collision at a level crossing (includes controlled crossings (with barriers) and uncontrolled crossings, trains etc..).
- **Animal in road** - The user had to take evasive action to avoid a live animal in the roadway ahead.
- **Other obstacle(s) in road** - The user had to take evasive action to avoid obstacle(s) in the roadway ahead (e.g. vehicle exhaust, dead animal, a discarded load from a goods vehicle..).
- **Road works** - The user had to take evasive action to avoid road-works in the roadway ahead (e.g. minor road-works where no prior warning was given).
- **High wind** - High winds were present which affected the user's control of the vehicle.

6.3 Vehicle (Tool)

This category involves the equipment or devices the user is interacting with in the task. The subcategories developed to deal with the vast array of tools were:

- Mechanical – Vehicle failures which directly affects vehicle control;
- Maintenance - Anticipated vehicle fault, indirectly affects control of vehicle;
- Design - Design of vehicle affects safe/efficient operation;
- Load - Did a vehicle load affect ability to control vehicle?

Further thought is needed to ensure that the 'tool' can be related to any type of 'vehicle' used on the road, including car, van, truck, bus, motorcycle, bicycle. Also, if this tool is also to be relevant for pedestrians, consideration must be given to what the 'pedestrian's' equivalent 'tool' (vehicle) is? For example in OTS, 'shoe' is coded as the pedestrian's vehicle. However, as TRACE is focussing specifically on motor vehicles, in particular cars, this should be a consideration for further work.

Table 16 outlines the classification of factors related to the tool, which is defined as any vehicle involved in an accident (e.g. cars, trucks, buses, vans, motorcycles, bicycles etc…).

Table 16 – Grid of Vehicle (tool) Related Factors Which Could Lead to Functional Failures

Descriptive	Generic	In-depth examples
A. Electro-mechanical	Steering	Partial failure/Total failure
	Brakes	Partial failure/Total failure
	Engine	Partial failure/Total failure
	Suspension	Partial failure/Total failure
	Electrical/electronics	Partial failure/Total failure
B. Maintenance	Windscreen/Glass	Front chipped/ Front cracked/ Front misted/Front dirty / Front scratched/Rear chipped/ Rear cracked/Rear misted/ Rear dirty/Rear scratched/ Side chipped/ Side cracked/ Side misted/Side dirty/ Side scratched/Other
	Tyre(s)	Incorrect type/Air pressure/ Tread/ Blow-out/Other
	Exterior lights	Headlight type/Headlight bulb needs replacing/Headlight cracked/Headlight broken cover/ Rear light type/ Rear light bulb needs

		replacing/ Rear light cracked/ Rear light broken cover/ Brake light type/ Brake light bulb needs replacing/ Brake light cracked/ Brake light broken cover/ Indicator type/ Indicator bulb needs replacing/ Indicator cracked/ Indicator broken cover/ Fog light type/ Fog light bulb needs replacing/ Fog light cracked/ Fog light broken cover/Other
	Interior lights	Fuel light/Oil light/Water light/Parking brake light/Other dashboard light/Other interior lighting
C. Design	Visibility	A-pillar(s)/B-pillar(s)/C-pillar(s)/Steering wheel blocking view/Rear view mirror/Wing mirror(s)/Seating/Other
	Auditory	Auditory warnings confusing
	Displays	Colour/Size/Confusing information/Other
	Controls	Colour/Size/Confusing information/Reach/Other
D. Load	Heavy	On vehicle/Within vehicle/Other
	Uneven	On vehicle/Within vehicle/Other
	Visibility obstructed	On vehicle/Within vehicle/Other

A. Electro-Mechanical

Electro-mechanical factors are 'failures' which directly affect the vehicle's control. This type of failure would generally result in it being physically difficult/impossible to drive/control the vehicle.

- **Steering** - The vehicle's steering system was defective.
- **Brakes** - The vehicle's braking system was defective.
- **Engine** - The vehicle's engine or transmission was defective.
- **Suspension** - The vehicle's suspension system was defective (includes wheels, but not tyre defects).
- **Electrical/electronics –** There were defects in the vehicle's electronic components.

B. Maintenance

Maintenance factors are anticipated vehicle faults, indirectly affecting the control of the vehicle. They may make it more difficult (e.g. in terms of visibility) or 'illegal' to drive/ride the vehicle, but it is still possible.

- **Windscreen** - The condition of the windscreen reduced the user's ability to drive (e.g. cracked, misty, dirty, scratched…).
- **Tyre(s)** - The condition of the tyre(s) reduced the user's ability to control the vehicle (e.g. wrong air pressure, poor tread, blow-out).
- **Exterior lights** - One or more of the vehicle's exterior lights were not functioning properly (e.g. bulb needs replacing, cracked/broken cover ..).

- **Interior lights** - One or more of the vehicle's interior lights were not functioning properly (e.g. dashboard lighting..).

C. Design

Design factors are those related to the ergonomic design of vehicle, which affect the it's safe/efficient operation by the road user.

- **Visibility** - Design of the vehicle restricted the visibility of road ahead (or to the side) or visibility of other parts of the vehicle interior (e.g. a-pillar obstruction, steering wheel blocking dashboard displays…).
- **Auditory** - Auditory warnings within vehicle were unclear.
- **Displays** - Design of in-vehicle displays were not clearly understandable (e.g. confusing information…).
- **Controls** - Design of in-vehicle controls were not clearly understandable (e.g. activating control incorrectly, activating the wrong control...).

D. Load

Did a vehicle load affect ability to control vehicle? These factors relate to the load of a vehicle involved in an accident. If a vehicle drove into another's vehicle 'poorly secured' discarded load, this would be an 'obstacle in the road'.

- **Heavy** - A heavy load on/within the vehicle was present.
- **Uneven** - An uneven load on/within the vehicle was present.
- **Visibility obstructed** - A load on/within the vehicle obstructed the visibility of the road user in charge of the vehicle.

7 Application of the Grid of Factors and Situations to Real-World Use

As the aim of Task 5.2 is to develop grids of situations and factors that can be adapted to the analysis of real world accidents, it was decided that a small number of cases would be analysed using factors and situations set out in sections 5 and 6. This also acted as a validation of the classifications determined within these grids.

A number of new cases from the UK OTS project were analysed using the grid of situations and factors to determine what led to the accident occurring. Three case examples are described below. Relevant cases were selected before the OTS investigators had undertaken any coding using the OTS system. This would reduce the potential for bias when selecting appropriate factors, which could occur if accidents were recoded from factors selected using the OTS system.

For each case, the most appropriate pre-accident driving situation for each road user involved in the accident was selected. Secondly, the factors which were relevant to each road user in the accident were selected. In addition, it has been determined whether each factor was a 'contributor', 'trigger' or an 'aggravator' in the process (terminology described in section 2, figure 1). In this validation, 'aggravating' factors only refers to factors at the 'emergency' phase, but not at the impact phase where factors can only aggravate the severity.

Both the situations and the factors are displayed in the tables at the various levels of detail, level 1 and level 2 for the driving situations and 'descriptive', 'generic' and 'in-depth' for the factors.

7.1 Case Example One

Road user 1, the driver of a left hand drive Heavy Goods Vehicle (HGV) (non UK vehicle and driver) was travelling in lane 1 of a roundabout and continued past an exit. Road user 2, the driver of a car who was travelling in lane 2, pulled off the traffic island towards this same exit, leading to road user 1 (HGV) colliding with the side of road user 2's car. Both lanes 1 and 2 were marked for the exit of the roundabout, but only lane 2 was marked for traffic to continue around the roundabout.

To determine the most relevant pre-accident driving situation from the grid for each road user, both the location (intersection - roundabout) and manoeuvre (going ahead/turning) have been identified, plus the potential conflict (opponent manoeuvres) of other road users. The pre-accident driving situations are displayed in Table 17

Table 17 - Pre-Accident Driving Situations for Road Users 1 and 2 in Case Example One

Road Users	Manoeuvres/location		Conflict	
	Level 1	**Level 2**	**Level 1**	**Level 2**
1 (HGV)	Intersection: Going ahead	Travelling on roundabout (not turning)	Vehicle from side	Vehicle in lateral lane travelling in same direction
2 (Car)	Intersection: Turning	Turning away from traffic from main road into side road	Vehicle from side	Vehicle in lateral lane travelling in same direction

For road user 1, it was known that the driver had a lack of experience driving in the UK, so would also have little experience of driving on the left hand side of the road. Because of their lack of knowledge

of the route, the driver was also looking for directional information which would have distracted the driver from the driving task and the surroundings (e.g. other road users). However, the factor which triggered the rupture phase (i.e. where it started to go wrong) was the road markings, which confused the driver (HGV) and led to road user 1 being in the incorrect lane. What would have aggravated the likelihood of an impact occurring was the design of the HGV's wing mirror, which led to road user 1 not seeing road user 2 ('blind-spot'). Ta**ble 18** summarises the factors which led to the human functional failure occurring for road user 1.

Table 18 - Factors Which Lead to the Human Functional Failure for Road User 1 (HGV)

Factor Type	Classification	Descriptive	Generic	In-depth
Contributing	User	Experience: Little/None	Route	Driving on the left
Contributing	User	Behaviour: Distraction	Distraction outside vehicle	Searching for directional information
Triggering	Environment	Traffic guidance	Road markings inappropriate	Visual markings confusing
Aggravating	Vehicle	Design	Visibility	Wing mirror

For road user 2, it was known that they regularly travelled this route and because of this, would have been confident that they had right of way in that lane. Also, road user 2 would not have considered that driving alongside road user 1 in the lateral lane on exit to the roundabout would have been a risky manoeuvre. However, road user 1 (HGV) undertook a manoeuvre which road user 2 found to be ambiguous or did not expect, which triggered the rupture phase that led to the impact. Table 19 shows a summary of road user 2's factors.

Table 19 - Factors Which Lead to the Human Functional Failure for Road User 2 (Car)

Factor type	Classification	Descriptive	Generic	In-depth
Contributing	User	Experience: Over-experienced	Route	Route in general
Contributing	User	Internal conditioning of performed task	Right of way status	Rigid attachment to the right of way status
Contributing	User	Behaviour: Risk taking	Vehicle positioning	Lateral positioning
Triggering	Environment	Traffic condition	Other road user(s) : Ambiguity of clues to manoeuvre	

7.2 Case Example Two

Road user 1 (HGV) failed to stop for a traffic queue ahead and swerved into the opposing traffic to avoid the vehicle stopped in front. The stationary vehicle was part of a queue of stationary traffic

waiting for a vehicle to turn. Road user 2 (van) was travelling in the opposite direction and was unable to stop in time, which resulted in a head-on collision.

The pre-accident driving situations for case example 2 are displayed in Table 20, including the manoeuvre (going ahead) and location (not at intersection: straight road), plus the conflict (opponent manoeuvre) from other road users during the driving phase (vehicle ahead/oncoming vehicle).

Table 20 - Pre-Accident Driving Situation for Road Users 1 and 2 in Case Example Two

Road User	Manoeuvre/location		Conflict	
	Level 1	Level 2	Level 1	Level 2
1 (HGV)	Stabilised situation: Going ahead	Going ahead on a straight road	Vehicle ahead	Stationary vehicle ahead (congestion)
2 (Van)	Stabilised situation: Going ahead	Going ahead on a straight road	Oncoming vehicle	Oncoming vehicle in wrong lane

For road user 1 (HGV), the density of the traffic on the road plus the stationary traffic ahead were the main factors which led to the rupture phase. However, the high density of traffic on the road would also have aggravated the likelihood of an impact occurring at the emergency phase. It was not known why road user 1 did not detect the stationary traffic ahead earlier. Table 21 shows the known factors which led to road user 1's functional failure.

Table 21 - Factors Which Lead to the Human Functional Failure for Road User 1 (HGV)

Factor Type	Classification	Descriptive	Generic	In-depth
Contributing, Aggravating	Environment	Traffic condition	Density	High density
Triggering	Environment	Traffic condition	Speed	Stationary traffic

There was little road user 2 (van) could do to avoid the collision. However, it is likely that the driver was not paying any specific attention to the surrounding traffic and was expecting no danger from an oncoming vehicle because they had right of way in the lane. This, coupled with the atypical manoeuvre from road user 1, would have led to road user 2's involvement in the impact (see Table 22).

Table 22 - Factors Which Lead to the Human Functional Failure for Road User 2 (Van)

Factor Type	Classification	Descriptive	Generic	In-depth
Contributing	User	Internal conditioning of performed task	Right of way status	Rigid attachment to the right of way status
Triggering	Environment	Traffic condition	Other road user: Atypical manoeuvre	

7.3 Case Example Three

Road user 1 (motorcycle) was following road user 2 (car) home on a newly purchased motorcycle. On approach to traffic light signals, road user 2 decided to stop when the lights changed so as not to be

separated from road user 1. Road user 1 braked abruptly but skidded on the road surface (due to a combination of a wet road and diesel on the road) and impacted the rear of road user 2 (car).

The pre-accident driving situations for case example 3 are displayed in Table 23, including the manoeuvre (on approach) and location (traffic signal intersection), plus the conflict (opponent manoeuvre) from other road users during the driving phase (vehicle ahead/following vehicle).

Table 23 - Pre-Accident Driving Situation for Road Users 1 and 2 in Case Example Three

Road Users	Manoeuvre/location		Conflict	
	Level 1	**Level 2**	**Level 1**	**Level 2**
1 (motorcycle)	Intersection: On approach	Approaching a 'traffic signal' intersection	Vehicle ahead	Moving vehicle ahead
2 (car)	Intersection: On approach	Approaching a 'traffic signal' intersection	Following vehicle	Following vehicle

Road user 1 (motorcycle), had only just bought the vehicle and had not ridden a similar vehicle before (motor-tricycle). Therefore, this will have increased the likelihood of an impact occurring when road user 2 undertook the unexpected/ambiguous manoeuvre at the traffic signals (triggering factor). After this rupture phase, the condition of the road (i.e. wet road and presence of diesel) would have further aggravated the likelihood of an impact occurring. Table 24 shows the known factors which led to road user 1's functional failure.

Table 24 - Factors Which Lead to the Human Functional Failure for Road User 1 (Motorcycle)

Factor type	Classification	Descriptive	Generic	In-depth
Contributing	User	Experience: Little/No Experience	Vehicle	New vehicle
Triggering	Environment	Traffic condition	Other road user: Ambiguity of clues to manoeuvre	Ambiguity of clues to manoeuvre
Aggravating	Environment	Road condition	Contaminants: Wet/Flood/Snow	Wet
Aggravating	Environment	Road condition	Contaminants: Oil/Diesel	Diesel

Road user 2 (car) applied their brakes suddenly on approach to traffic signals which had just changed to amber. The reason for the sudden braking was that road user 2 did not want to be separated from road user 1 (motorcycle) because road user 1 was following road user 2 home. Therefore, road user 2 would have identified the risk of being separated from road user 1 by continuing at the traffic signals, but had not identified the further risk of road user 1 also having to brake suddenly in response to road user 2's braking. Also, road user 2 would have been drawn into braking suddenly just by the presence

of road user 1 following behind and by the awareness that they did not want to be separated at the traffic signals. Table 25 shows the two identified factors associated with road user 2.

Table 25 - Factors Which Lead to the Human Functional Failure for Road User 2 (Car)

Factor type	Classification	Descriptive	Generic	In-depth
Contributing	User	Internal conditioning of performed task	Identification of potential risk	Identification of potential risk about only part of the situation
Contributing	Environment	Traffic condition	Being drawn into manoeuvre	Vehicle behind

7.4 Discussion

These three example cases show that by using the grid of factors and situations, an overall picture of the factors associated with individual accidents, plus each individual road user, can be created. Also, where detailed information about an accident is not available, these grids can still be used at a more general or descriptive level, by determining the overall categories of factors that occur in accidents and the general types of driving situations that road users are involved with prior to a collision occurring.

The grids help the analyst to focus their thoughts on the type of factors involved in the accident, at what stages in the accident process they were present (i.e. contributing factors at the driving phase, triggering factors at the rupture phase or aggravating factors at the emergency 'collision avoidance' phase) and the types of potential driving situations that road users find themselves in prior to the rupture phase occurring. However, the level of detail that the grid of factors and situations can provide can only reflect the level of information that is available from the accident itself. For example, in case example 2, it could not be determined why the driver did not detect stationary traffic earlier, so no factors could be selected for this. Instead of this information being lost because the factors were not known, a future system could also potentially include 'not known' factors, where the failure was known, but some or all of the factors leading to this failure could not be determined (e.g. have 'not known' codes). This is an important issue to consider when analysing the 'failure generating scenarios' behind accidents which are being investigated in Task 5.3.

It is envisaged that the grid of factors will be a valuable tool in TRACE, helping analysts determine the factors involved in accidents at a greater depth than other research studies have undertaken in the past. It will also help to form a basis of the types of typical failure generating scenarios that have been investigated as part of Task 5.3.

8 The Way Forward

As can be seen in this report, comprehensive research has been undertaken to identify and classify the types of potential factors that could lead to human functional failures in road accidents. However, this research has been mainly based on what is known about accidents that have already occurred. As well as considering the factors that are relevant for the analysis of accidents in TRACE, some thought should be given to looking towards the future and considering the factors which may influence the likelihood of future accidents occurring using the concept outlined in this report.

As can be seen in section 4 (figure 3), the concept outlined in the diagram does also suggest that 'future' issues can be considered using the grid of factors as well as 'current' issues. The 'current' issues are those describing the factors that are relevant in current accident analysis (i.e. accidents that have occurred). The 'future' issues aim to describe aspects of potential future accidents which may not be considered in current data collection systems, but could contribute to functional failures in accidents as technologies and the demands of the driving task change over the next 5-10 years (and may have already started to influence current accidents).

From the compiled categories and the generated list of factors, it is now possible to identify and look ahead asking potential questions like: 'What factors are not considered in present classifications that could potentially be more influential over the next 5-10 years, and would they still apply or fit with the current categorisation?' Although beyond the scope of TRACE, a brief review was undertaken of the types of future issues which could potentially affect the prevalence of certain factors occurring in 'future' accidents. This demonstrated how the scope of the classification used in the Task 5.2 grid of factors is both flexible and robust enough to be used to analyse the prevalence of factors influential in future accidents as well as current accidents, and therefore detect the changes between current and future accident issues. Outlined in section 8.1 are a number of examples; future issues related to the road users, those related to their 'vehicles' and those related to the road environment.

8.1 Examples of 'Issues' Affecting Future Accidents

8.1.1 Road Users

- User state

- It is a known fact that there is an increasing aging population across most countries in Europe and the rest of the world (United Nations 2005). This could lead to a greater amount of road users with pre-existing impairments and a higher occurrence of medical deteriorations while in control of a vehicle.
- In an age where society is generally more 'high-pressure' than ever before, this could lead to an increase in the amount of risk taking (and therefore poor judgements) that occurs on the roads as road users are under greater pressure to get to their destinations on time, often without taking enough breaks.

- Experience

- Changes in the process of learning to drive (e.g. graduated driver training system) could lead to new drivers being more experienced on the road by the time they pass their test and therefore lead to a reduction in the amount of accidents related to low experience.

- Behaviour

- As vehicles become more 'automated' in the future and the control is taken away from the road user (e.g. speed limiters, lane departure assist..), this may lead to the road user being more complacent and there may be a higher likelihood of distraction in more road users.
- Self explaining roads and better vehicle protection may lead to more risk taking if the road user believes they are better protected if they do have a collision.

8.1.2 Tool (Vehicle)

- Mechanical/electrical

- In the future, there will be more 'automation' of vehicles. However, if a part of the systems fails, it may be harder for the road user to overcome the failure if they are not so experienced in controlling that aspect of the vehicle without the automation.

  - Maintenance

- New and 'future' vehicles will be more difficult for the road user to maintain themselves, so self-checking may become less likely. Road users may just rely on warning systems to tell them when maintenance is required. However, maintenance aspects which do no have a warning system will be checked less often as road users get out of the habit of self-checking.

  - Design

- As driving becomes a more 'comfortable' experience, this may lead to a greater likelihood of 'falling asleep' in drivers!

- Ever-changing designs in vehicle may lead to great difficulties for road users to keep up with new displays/controls/technologies.

8.1.3 Environment

- Road condition

- Possible environmental changes (e.g. wetter winters, drier summers) will affect the type of accidents which occur on the roads, as the exposure to various types of road surface conditions changes.

  - Geometry

- Changes in road layouts and more 'self-explaining' roads may lead to more risk taking. Whereas more complex layouts may lead to more driver confusion.

  - Visibility

- New vehicle/road lighting technologies could affect the view of the road ahead (e.g. give a clearer view, potentially leading to greater risk taking).

  - Traffic guidance

- New traffic guidance technologies may lead to overuse or confusion due to complexity.

8.2 Discussion

Section 8.1 shows just a small number of examples of how future issues could potentially affect the prevalence of factors that lead to human functional failure in future accidents. This highlights the need for a grid of factors and also pre-accident situations such as those outlined in this report, to be able to function as an analysis tool not just for issues that are relevant in current accident analysis, but also issues that could potentially affect future accidents.

Along with the human functional failures investigated in Task 5.1, the grids of factors and pre-accident situations compiled in Task 5.2 will also be utilised for the analysis of 'Typical Failure Generating Scenarios' which is being investigated as part of Task 5.3.

Also to be considered for the future should be a validation of how to treat the factors (in particular the 'vehicle' related factors) so that issues related to specific road users, such as pedestrians, cyclists and also motorcyclists, are adapted into the grids. Where possible, the involvement of pedestrians has been taken into consideration in Task 5.2, but this an issue that requires further in-depth investigation beyond the scope of TRACE.

9 Summary and Conclusions

- This task has prepared comprehensive grids of factors and pre-accident situations that combine with work from Task 5.1 (analysis of human functional failures) to allow the development of Task 5.3 (analysis of typical failure generating scenarios).
- This work therefore supports the overall aim of WP5, which is to develop analytical tools to aid the analysis of real world accidents and furthermore contribute to a better standardisation of accident studies, notably in Europe.
- To achieve this task, a review of current accident collection systems and literature was carried out to identify the factors already considered in accident analysis. This review highlighted that factors are often confused with failures (errors) in accidents analysis, which therefore highlights the need to develop a grid which includes only factors that lead to human functional failures.
- The grid of factors consists of three main sections: factors relating to the user, factors related to the vehicle and factors related to the surrounding environment. To ensure the grid of factors is as flexible and usable as possible, this task has taken into account the different detail levels of accident data commonly encountered by analysts (descriptive, generic and in-depth), so that when the data is more in-depth, the more detailed the factors can be defined.
- Consideration has also been given to the role of factors in the accident process and whether they can be 'contributing', 'triggering' or 'aggravating' to the onset of the accident.
- The identification of pre-accident driving situations has also been undertaken, and have been defined by the manoeuvre being undertaken by the road user prior to the 'rupture phase' occurring, the location of the road user and also any opponent manoeuvres (potential 'conflicts') the road user is faced with. These situations are presented at two analysis levels.
- A short validation of previously un-coded cases has been undertaken to test the validity of the grids of factors and situations. This activity highlighted the usefulness of the grids as tools for accident analysis when enough information is known about the accident. It is also considered that the work is robust enough to deal with future issues that are not already addressed in current accident data collection systems.
- As well as being a valuable analysis tool for use within TRACE, the work of Task 5.2 will also form a useful basis for future improvements in the collection of accident causation data. The work steers away from the road user always being the main reason for instigating the 'failure' in the accident scenario, which has often been the case in past and current accident data studies.

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