MANUAL FOR

DREAM

VERSION 3.2

Ljung Aust, Habibovic, Tivesten, Sander, Bärgman, Engström,
120229

Table of Contents

1 INTRODUCTION 1

1.1 THE ACCIDENT MODEL UNDERLYING DREAM 1
1.2 REVISIONS OF DREAM 4

2 THE CLASSIFICATION SCHEME - AN OVERVIEW 6

3 THE CLASSIFICATION SCHEME IN DETAIL 8

3.1 THE PHENOTYPES 8
3.2 GENOTYPES 9
3.3 THE LINKS 10
3.4 THE STOP RULES 10
3.5 SCENARIO BASED RECOMMENDATIONS FOR PHENOTYPE CHOICES 11
3.5.1 INTERSECTION ACCIDENTS 11
3.5.2 LEAVING LANE ACCIDENTS 12
3.5.3 CHANGING LANE ACCIDENTS 13
3.5.4 REAR END ACCIDENTS 13
3.6 USING PRECIPITATING EVENTS TO HELP FIXATE THE PHENOTYPE 14
3.7 EXTENDING THE CLASSIFICATION SCHEME 14

4 DREAM ANALYSIS – STEP BY STEP EXAMPLE 15

4.1 DATA COLLECTION 15
4.2 ACCIDENT/INCIDENT DESCRIPTION 16
4.3 CONTEXT EVALUATION 17
4.4 CHOICE OF PRECIPITATING EVENT AND PHENOTYPE 17
4.5 FROM PHENOTYPE TO GENOTYPE 19
4.6 FROM GENOTYPE TO GENOTYPE 21
4.7 ENDING THE ANALYSIS 21

5 EXAMPLE ACCIDENTS 23

5.1 SCENARIO 1 (INTERSECTION ACCIDENT) 23
5.1.1 CONSTRUCTING THE DREAM-CHART FOR DRIVER A 24
5.1.2 CONSTRUCTING THE DREAM-CHART FOR DRIVER B 24
5.2 SCENARIO 2 (REAR END ACCIDENT) 25
5.2.1 CONSTRUCTING THE DREAM-CHART FOR DRIVER A 25
5.2.2 CONSTRUCTING THE DREAM-CHART FOR DRIVER B 27
5.3 SCENARIO 3 (LEAVING LANE ACCIDENT) 27
5.3.1 CONSTRUCTING THE DREAM-CHART FOR DRIVER A 28
5.3.2 CONSTRUCTING THE DREAM-CHART FOR DRIVER B 29
5.3.3 CONSTRUCTING THE DREAM-CHART FOR DRIVER C 29
5.4 SCENARIOS 4:I AND 4:II (LEAVING LANE ACCIDENTS) 30
5.4.1 CONSTRUCTING THE DREAM-CHART FOR DRIVER A IN SCENARIO 4:I 30
5.4.2 CONSTRUCTING THE DREAM-CHART FOR DRIVER A IN SCENARIO 4:II 31
5.5 SCENARIO 5 (UNINTENDED ACCELERATION) 32
5.5.1 CONSTRUCTING THE DREAM-CHART FOR DRIVER A 33
5.6 SCENARIO 6 (LEAVING LANE ACCIDENT) 33
5.6.1 CONSTRUCTING THE DREAM-CHART FOR DRIVER A 33

6 CODING THE RECOVERY PHASE 35

7 LEVEL OF CONFIDENCE 36

7.1 HIGH **36**
7.2 REASONABLE **36**
7.3 LOW **36**

8 AGGREGATION OF IN-DEPTH STUDIES **37**

9 REFERENCES **40**

LIST OF FIGURES

Figure 1: Contemporary Accident Model (Hollnagel, 2004) **2**
Figure 2: Example of DREAM causation chart **7**
Figure 3: Intersection **11**
Figure 4: Conflict with pedestrian / bicyclist at intersection **12**
Figure 5: Conflict with pedestrian / bicyclist on straight road **12**
Figure 6: Overtaking **12**
Figure 7: Straight road **12**
Figure 8: Curve **12**
Figure 9: Changing lanes **13**
Figure 10: Rear end accidents **13**
Figure 11: Intersection accident between two cars **16**
Figure 12: Extract of intersection accident examples for the phenotype *timing* from phenotypes table in Appendix A **18**
Figure 13: Extract of intersection accident examples for the genotypes in table C in Appendix A **20**
Figure 14. DREAM Chart for step-by-step walkthrough example **22**
Figure 15: Scenario 1 (intersection accident) **23**
Figure 16: Scenario 1 (intersection accident) – DREAM chart for Driver A **24**
Figure 17: Scenario 1 (intersection accident) - DREAM chart for Driver B **25**
Figure 18: Scenario 2 (catching up accident) - DREAM chart for Driver A **26**
Figure 19: Scenario 2 (catching up accident) – DREAM chart for Driver B **27**
Figure 20: Scenario 3 (leaving lane accident) - DREAM chart for Driver A **28**
Figure 21: Scenario 3 (leaving lane accident) - DREAM chart for Driver B **29**
Figure 22: Scenario 3 (leaving lane accident) - DREAM chart for Driver C **29**
Figure 23: Scenario 4:I (leaving lane accident) - Driver A **30**
Figure 24: Scenario 4:I (leaving lane accident) - DREAM chart for Driver A **30**
Figure 25: Scenario 4:II (leaving lane accident) - Driver A **31**
Figure 26: Scenario 4:II (leaving lane accident) - DREAM chart for Driver A **31**
Figure 27: Scenario 5 (Unintended acceleration) - DREAM chart for Driver A **33**
Figure 28: Scenario 6 (leaving lane accident) - DREAM chart for Driver A **34**
Figure 29: DREAM chart example aggregation **37**
Figure 30: Aggregated DREAM chart for 28 turning drives in Norwegian Intersection crashes with fatal outcome **39**

LIST OF TABLES

Table 1: ADAS: development challenges and data needs **4**
Table 2: Overall grouping of the genotypes and phenotypes in DREAM **6**
Table 3: Phenotypes and specific phenotypes of DREAM 3.2 **8**
Table 4: Genotype categories in DREAM 3.2 **9**

APPENDICES

Appendix A: Linking table - for phenotypes (critical events) and genotypes (contributing factors)
Appendix B: DREAM analysis linking template
Appendix C: Precipitating events

1 INTRODUCTION

The *Driving Reliability and Error Analysis Method* (DREAM) is based on the *Cognitive Reliability and Error Analysis Method* (CREAM; Hollnagel, 1998). CREAM was developed to analyse accidents within process control domains such as nuclear power plants and train operation, and DREAM is an adaptation of CREAM to suit the road traffic domain.

The purpose of DREAM is to make it possible to systematically classify and store accident and incident causation information. This means that DREAM, like all other methods for accident/incident analysis, is not a provider but an *organiser* of explanations. For any of the contributing factor categories available in DREAM to be used, it must be supported by relevant empirical information. DREAM in itself cannot tell us why accidents happen (if it could, we would need neither on-scene investigations nor interviews).

DREAM includes three main components: an accident model, a classification scheme and a detailed procedure description which step by step goes through what needs to be done in order to perform a DREAM analysis on an investigated accident/incident. Below, the accident model will be given more detailed descriptions. After this follows a description of the classification scheme, and then comes the analysis process, including example cases and recommendations for how to do the categorisation in certain typical scenarios.

1.1 THE ACCIDENT MODEL UNDERLYING DREAM

In formal terms, an accident model is an abstract conceptual representation of the occurrence and development of an accident. In less formal terms, an accident model describes how and why accidents happen, and by doing so also defines what counts as relevant causes and interactions. This is important because in doing so, the accident model directly steers what data we look for, how we analyse it, and which conclusions we draw from it. Every time an accident is analysed the analysis is grounded in some more or less explicit underlying accident model, and if that model is inadequate for describing the problems of the domain, then analysis and countermeasure development will be inadequate too (Huang *et al*, 2004).

On a general level, an accident model can be defined in two dimensions: (1) how it characterises human involvement in the accident process, and (2) its scope of contributing factors. While (1) defines the nature of causation in the model, (2) determines which (of all logically possible) contributing factors are to be considered relevant.

When it comes to characterizing human involvement, many researchers have recently argued that to understand the complex nature of contemporary accidents, accident models of a systemic character are necessary (Amalberti, 2001; Dekker, 2005; Hollnagel, 2004; Leveson, 2004; Reason et al., 2006; Rochlin, 1999). Systemic accident models take a holistic perspective on the accident process, considering not only the role of the humans involved but also the role that other system components play in the creation of an accident process (design, management, rules, etc.). This holds for driving as well. In the complex and dynamic domain of modern road traffic, systemic accident models seem best suited to account for how and why failures occur (Huang, 2005, 2007).

The accident model which DREAM is built on can be outlined as follows. Driving is as a multi-level control task which involves continuous adaptation to a changing environment in a way that promotes goal fulfilment (Engström & Hollnagel, 2007). Most of the time, this adaptation process is successful. The driver understands what the current safety margins are, and also successfully anticipates all events that will change the safety margin, and can therefore adapt his/her goal state accordingly. For example, if there is limited visibility or the vehicle in front behaves irrationally, the driver normally increases safety margins e.g. by slowing down and/or increasing headway.

However, as Brehmer (1990) put it, there exists an inherent variance in both peoples' perception and action capabilities, and this sets a limit to how well they can adapt to any given situation. Due to this limitation, the driver's continuous adaptation process sometimes generates responses that are insufficient to keep the level of control within the driving situation's current safety boundaries. The ratio between crashes and total mileage in the traffic system suggests that these unrecoverable adaptation failures are very rare, but they do happen. Accidents can thus be understood as a loss of control beyond recovery (i.e. there is insufficient time and/or resources to regain it), due to adaptation failures in goal state selection and/or achievement relative to the tolerance limits of the current traffic situation.

In terms of which contributing factors can contribute to this loss of control, the accident model underlying DREAM is based on an MTO perspective (Man, Technology, Organization). In road traffic, *Man* corresponds to the driver, *Technology* to the vehicle and *Organization* to the traffic environment, as well as the organisations responsible for shaping the vehicles and the traffic environment.

The accident model also distinguishes between contributing factors at *the sharp end* and at *the blunt end*. The *sharp end* is the time and place where drivers are actually controlling their vehicles. When something happens at the sharp end, e.g. a car skids off the road, it is called a *sharp end failure*. However, when trying to identify contributing factors that brought this sharp end failure about, one has to expand the search beyond the local time and place (the "then and there") to also include factors that may have contributed in the sense that they shaped the context where the accident took place. For example, lets say that friction was very low due to oil on the road from a previous oil spill. The actual oil spill is then said to have occurred at the *blunt end*, i.e. at another time and/or place than the crash, but the consequences of that *blunt end failure* have a large impact on the conditions for what happens at the sharp end if left unaddressed. Such non-remedied consequences go by the name of *latent conditions*.

A short summary of the accident model would thus be that latent conditions, together with locally dysfunctional adaptive behaviours "at the sharp end", create accident sequences. This can be illustrated as follows:

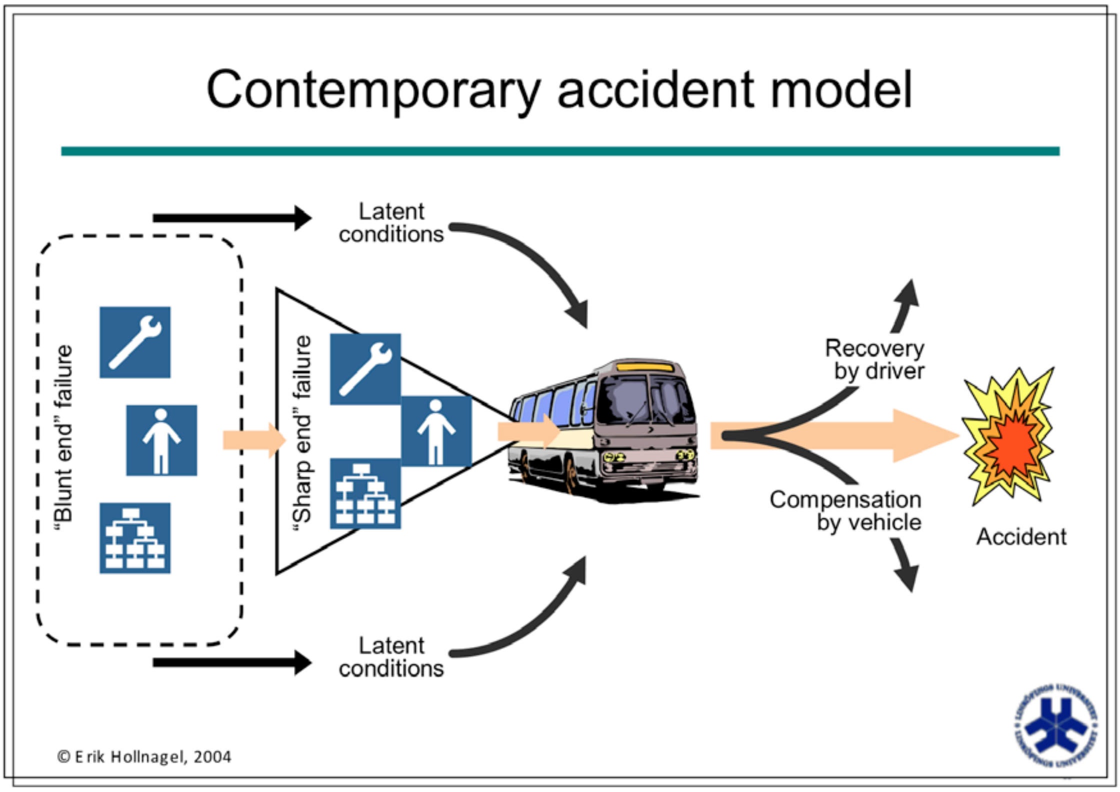


Figure 1: Contemporary Accident Model (Hollnagel, 2004)

As for the second dimension of the accident model, i.e. determining which (of all logically possible) contributing factors are to be considered relevant, it is important to point out that from a purely logical perspective, there exists an endless number of ways to explain why a particular crash has occurred which means that the scope of possible contributing factors is literally infinite. Defining crash contributing factors is therefore very much an exercise in limiting the list of all possible factors to a list of all project relevant factors. This means first selecting a subset of contributing factors that are scientifically believable (i.e. compatible with the selected accident model, and ruling out e.g. fate and bad luck).

Next, if the purpose of the analysis is to define countermeasures, an even smaller second subset should be selected from the first subset, consisting of factors which can be addressed through available or foreseen countermeasures. For example, it makes no sense to investigate the extent to which missing or malformed traffic laws contributed to the event if the project where the analysis takes place cannot influence or change those laws. Clearly, stakeholder analysis is a key issue here.

To understand the nature and scope of the contributing factors currently in DREAM, it is important to know that DREAM was developed to support development of *Advanced Driver Assistance Systems* (ADAS), i.e. vehicle based functions that are meant to help drivers avoid accidents altogether. ADAS can roughly be divided in four generic types (Table 1), i.e. they either target collision or risk avoidance, and they do this either interactively (driver in the loop) or autonomously (driver NOT in the loop). Each type of ADAS presents its own challenges for meaningful accident investigation and data collection. In the project where DREAM was first developed, the main focus was on supporting the development of *interactive systems for risk avoidance*, which corresponds to the lower right quadrant in Table 1 below.

Table 1: ADAS: development challenges and data needs

ADAS DEVELOPMENT AND CORRESPONDING DATA NEEDS		AIM			
		Collision avoidance		Risk avoidance	
		Development challenge	Data needs	Development challenge	Data needs
MODE	Autonomous systems (driver NOT in the loop)	Technically possible but challenging in the legal perspective.	Billiard ball kinematics - speed, mass, trajectory, available local space, angles to oncoming objects, etc.	Technically possible, but efficiency is threatened by driver adaptation	Closing velocities and yaw rotations associated with loss of control
	Interactive systems (driver in the loop)	Technically challenging, since the time needed for driver action puts high demands on sensor and algorithm performance in situation identification	The above (i.e. billiard ball kinematics), plus data on typical driver response times	Technically possible and often simpler than collision avoidance, but demanding from an HMI deign point of view.	Reasons why driver performance sometimes does not meet the situation requirements, for typical tasks such as route choice, detection of other vehicles, interpretation of other vehicles' intentions, own action choices…

The contributing factor categories in DREAM reflect this basic focus. Contributing factors that can lead to loss of control are given detailed attention, while what happens once control is lost is given less attention, i.e. the type and magnitude of the driver's emergency response is not treated in depth.

1.2 REVISIONS OF DREAM

The first version of DREAM was developed by Ljung (2002); see also Ljung *et al*. (2007). DREAM 2.1 (Ljung, Furberg and Hollnagel, n.d.) was the end result of the Swedish national project *Factors Influencing the Causation of Accidents and incidents* (FICA). When DREAM later was to be used in the European cooperation road safety project *SafetyNET*, DREAM 2.1 was translated into English and adapted to suit the traffic environment in the participating countries. The adapted version was called *SafetyNET Accident Causation System* (SNACS 1.1; Ljung, 2006) and uses the same method, accident model and main structure of the classification system as DREAM 2.1, while some of the individual genotypes have been altered.

During practical work with DREAM 2.1 and SNACS 1.1 in Sweden and other European countries suggestions for improvements were put forward. The method was therefore revised by a reference group led by Henriette Wallén Warner, a senior researcher in traffic psychology. The revision resulted in DREAM 3.0. DREAM 3.0 is based on the same accident model and classification scheme principles as the earlier versions. However, some genotypes were clarified by improving on their definitions, some new ones added a few old ones removed. Also, the possibility for indirect linking present in DREAM 2.1 (Ljung, Furberg & Hollnagel, n.d. pp. 26-27) was abandoned, and instead it is recommended that the classification scheme should be continuously updated to fit new types of accident scenarios as well as new scientific findings (see Section 3.7). In connection with the revision a literature review was also conducted to incorporate other empirical support from existing research for the links between the genotypes (Wallén Warner *et al*, 2008).

The update to DREAM 3.1 was done in DREAMi, a project focusing on evaluation of the suitability of DREAM for analysis of incidents/accidents in Naturalistic Driving Study (NDS) and Field Operational Test (FOT) data. A major difference between on-scene/on-site accident investigations and NDS/FOT data is the availability of video and detailed data on dynamic vehicle parameters and (in the FOT case) input from environment sensors mounted on the vehicle (such as radar). On the other hand, there are no driver interviews. The insight into the time history of an event that comes from the video data generally enables a more detailed coding of driver gaze, vehicle kinematics and the driver's response in a developing critical event. In terms of DREAM modifications, access to this more detailed information prompted definitions of some additional and more detailed specific genotypes relating to driver attention allocation. Some additional links between phenotypes and genotypes were also added, that previously had been judged impossible to verify due to lack of data.

In the DaCoTa update to DREAM 3.2, two issues have been addressed. First, the introduction and method description in the manual has been revised to provide an updated and improved reading experience. Second, a number of specific genotypes related to Powered-Two-Wheeler problems have been added.

2 THE CLASSIFICATION SCHEME - AN OVERVIEW

The classification scheme in DREAM has four elements; two obvious ones, one somewhat hidden and one that might initially be perceived as strange. The obvious ones are the *Phenotypes* and the *Genotypes,* the somewhat hidden one is the *Links*, and the unusual element is the *Stop rules*. In this section, these will be given an overview description to familiarize the reader with the concepts, and then more detailed descriptions are given in Section 4.

The Phenotypes (also known as *critical events)* is a set of classifiers which are there to help investigators classify the moment when the driver lost control from a sort of physics perspective. Principally, all accidents take place in time and space and involve mass in motion. It is therefore possible to classify the dysfunctional behaviour that precedes an accident with a relatively limited set of categories based on the dimensions of time, space and energy. The point of doing the Phenotype categorisation is that it introduces a certain element of objectivity into the analysis. By discussing and classifying the loss of control in physical terms, the temptation to start discussing whose fault it supposedly was is hopefully easier to resist. This is important! We humans spend a lot of time discussing blame because it is socially important, but from a countermeasure development point of view, such discussions are not helpful. Instead, what matters is whether one by analysing the crash can identify an objective opportunity to help any of the drivers about to be involved in a similar crash, regardless of who would be blamed for it afterwards.

The Genotypes, (also known as *contributing factors)* are there to help investigators classify all information that relates to why control was lost. The terms *phenotype* and *genotype* come from biology. A phenotype is the set of observable characteristics of an individual, and these characteristics are the result of the interaction of its genotype (the genetic constitution of an individual organism) with the environment. All humans have identical genes, but we still look different because different genes are dominant or active in each person. The same can be said of accidents and near-misses; while they all look somewhat different, they can be said to share the same general set of possible underlying contributing factors. In Table 2 below, the Genotype and Phenotype groups are listed:

Table 2: Overall grouping of the genotypes and phenotypes in DREAM

GENOTYPES				PHENOTYPES
Driver		Vehicle	Organisation	**Timing**
Observation	in accordance with COCOM	Temporary HMI problems	Organisation	**Speed**
Interpretation		Permanent HMI problems	Maintenance	**Distance**
Planning		Vehicle equipment failure	Vehicle design	**Direction**
Temporary Personal Factors			Road design	**Force**
Permanent Personal Factors		**Traffic environment**		**Object**
		Weather conditions		
		Obstruction of view due to object		
		State of road		
		Communication		

The driver category consists of genotypes related to possible problems with cognitive functions in the driver, as well as more general states of temporary and permanent person related factors that can contribute to an accident (e.g. fatigue, disabilities). The cognitive factors (observation, interpretation and planning) are organised and defined based on the *Contextual Control Model* (COCOM; Hollnagel, 1998;

Hollnagel and Woods, 2005). COCOM recognises that cognition includes processing observations and producing reactions, as well as continuously revising goals and intentions which create a “loop” on the level of interpretation and planning. This is assumed to occur in parallel with whatever else is going on, at the same time as it also is determined by what is going on. In later work, COCOM has been extended into the *Extended Control Model* (ECOM; Hollnagel and Woods, 2005), recognizing that control includes working towards multiple parallel goals on different time scales, so in reality a number of parallel control processes are at play.

An important conclusion from this which has implications for DREAM is that cognition in the context of human-machine system performance can not be described as a sequence of steps, and a classification scheme for contributing factors must therefore be represented as a network rather than a hierarchy. This theoretical axiom leads to the somewhat hidden element and the strange element, which is the predefined *Links* included in the classification scheme and the *Stop rules*.

As for the Links, it is generally true that causation mechanisms can never be observed; they must always be inferred by reasoning. In addition to listing the Phenotypes (critical events) and Genotypes (possible contributing factors), the classification scheme therefore also prescribes which factors can be linked to each other (and thus implicitly which are not possible to link). These links represent existing knowledge about how different contributing factors can interact with each other (for a review see Wallén Warner *et al*. 2008), and are meant to both guide and set boundaries for the contributing factor analysis.

Now, since the links between Phenotypes and Genotypes as well as within the Genotypes must be represented as a network rather than a hierarchy, the analysis procedure needs to have formal rules (other than just reaching the top or bottom of a hierarchy) for establishing when an analysis is finished, to avoid arbitrary/subjective stopping points. The classification scheme therefore contains three Stop rules that determine when an analysis is finished. These are described in Section 3.4.

The final outcome of a DREAM analysis can be called a causation chart, where existing knowledge about the investigated crash is put into on or more analysis-chains, in which a genotype can be both the consequent of a previous genotype and the antecedent of another genotype, e.g. the cause of that genotype. In principle, one chart is produced per involved road user, on the grounds that each individual has his/her own reasons for failing to adapt in time to avoid the crash. An example of a causation chart is shown below.

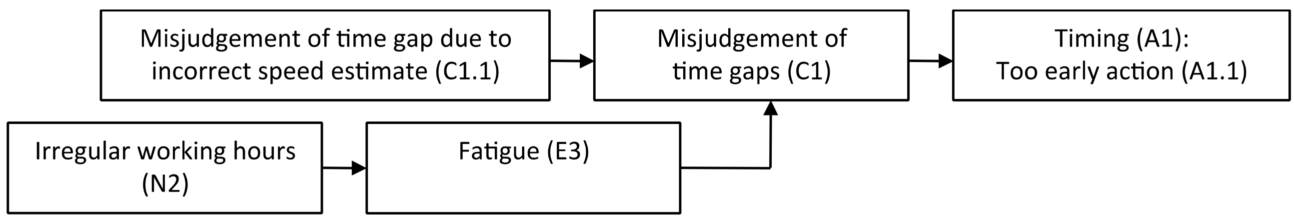


Figure 2: Example of DREAM causation chart

3 THE CLASSIFICATION SCHEME IN DETAIL

The classification scheme in DREAM 3.2 consists of phenotypes (the observable effects), genotypes (factors that can have contributed to the observable effects), links between the phenotypes and the genotypes as well as between different genotypes, and stop rules which define when an analysis is completed. For the complete classification scheme see Appendix A.

3.1 THE PHENOTYPES

Girard (1994) suggests that all accidents can be divided into four different phases: *the driving phase* (the “normal” driving situation where no unexpected demands are upon the driver; e.g. there is a balance between the demands and the ability of the system components to respond), *the discontinuity phase* (the “normal” driving situation is interrupted by an unexpected event; e.g. the demands suddenly exceed the ability of the system components to respond), *the emergency phase* (the time and space between discontinuity onset and potential impact, i.e. the time and space available for system components to respond to the sudden increase in demands) and (if applicable) *the crash phase* (the crash and its consequences).

When making a DREAM-analysis the first step is always to choose a phenotype, and the phenotype should identify the first observable effect of dysfunctional adaptive behaviour in the discontinuity phase (for further descriptions see section 3.5 below. Phenotype choices). Note that the discontinuity phase corresponds to the rupture phase as described by (Van Elslande & Fouquet, 2007a, 2007b, 2007c) in the similar HFF methodology.

In DREAM 3.2, there are six phenotypes which are all linked to one or more specific phenotypes. As could be expected, the specific phenotypes describe more specific effects than the general ones. If the investigator has sufficient information available, a specific phenotype should be chosen. The general and specific phenotypes are presented in Table 3, while definitions and more detailed descriptions can be found in Appendix A.

Table 3: Phenotypes and specific phenotypes of DREAM 3.2

Phenotypes	Specific phenotypes
Timing	Too early action; Too late action; No action
Speed	Too high speed; Too low speed
Distance	Too short distance
Direction	Wrong direction
Force	Surplus force; Insufficient force
Object	Adjacent object

Some of the phenotypes (e.g. timing, distance and speed) are very closely related even though they are conceptually separated. If, for example, a car collides with an oncoming car when overtaking, should that be seen as an effect of timing (the overtaking was initiated too early or too late), distance (the stretch of free road was too short in order to complete the overtaking) or speed (the speed was too low in order to complete the overtaking)? The answer is that the investigator has to choose the phenotype that makes most sense given what is known about the accident.

With regards to the example above, although all three phenotypes are logically possible, one of them is probably more appropriate given the circumstances. Let us suppose that the overtaking is made in 160 km/h (speed limit 110 km/h) close to the crest on an uphill slope. *Speed: too low speed* is then a less appropriate choice of phenotype as the speed was more than sufficient (given the speed limit). *Distance: Too short distance* seems more appropriate as the stretch of free road was too short to safely overtake.

However, it is common driver knowledge (taught in driver training) that one should not overtake unless there is a sufficient stretch of road with a free view and in this case the crest of the hill clearly blocked the view. Given this, the most appropriate phenotype would be *timing: too early action*.

Sometimes the choice of phenotype is difficult. In DREAM 3.2, all phenotypes do however link to the same genotypes. A less appropriate choice of phenotype does therefore not constrain the genotype classification.

3.2 GENOTYPES

Genotypes are factors which may have contributed to the phenotypes (the critical events). The genotypes can generally not be observed and therefore they have to be deduced from e.g. interviews with the drivers or other information available from the investigation. In DREAM 3.2 there are 50+ general genotypes, some of which are further specified through specific genotypes. As with the phenotypes, the use of specific and general genotypes depends on the level of detail in the information available, as the specific genotypes describe more particular factors than the general ones. Given that sufficiently detailed information is available, a specific genotype should be chosen.

The genotypes are organised according to the driver-vehicle/traffic environment-organisation triad. The genotypes are presented in Table 4 and a more detailed description can be found in Appendix A.

Table 4: Genotype categories in DREAM 3.2

GENOTYPES (B-Q)			
Human (B-F)	**P Technology (G-M)**		**Organisation (N-Q)**
Driver	Vehicle (G-I)	Traffic environment (J-M)	Organisation
B: Observation	**G: Temporary HMI problems**	**J: Weather conditions**	**N: Organisation**
Missed observation (B1)	Temporary illumination problems (G1)	Reduced visibility (J1)	Time pressure (N1)
Late observation (B2)	Temporary sound problems (G2)	Strong side winds (J2)	Irregular working hours (N2)
False observation (B3)	Temporary sight obstructions (G3)		Heavy physical activity before drive (N3)
	Temporary access limitations (G4)	**K: Obstruction of view due to object**	Inadequate training (N4)
C: Interpretation	Incorrect ITS-information (G5)	Temporary obstruction of view (K1)	
Misjudgement of time gaps (C1)		Permanent obstruction of view (K2)	**O: Maintenance**
Misjudgement of situation (C2)	**H: Permanent HMI problems**		Inadequate vehicle maintenance (O1)
Incomplete judgement of situation (C3)	Permanent illumination problems (H1)	**L: State of road**	Inadequate road maintenance (O2)
	Permanent sound problems (H2)	Insufficient guidance (L1)	
D: Planning	Permanent sight obstruction (H3)	Reduced friction (L2)	**P: Vehicle design**
Priority error (D1)		Road surface degradation (L3)	Inadequate design of driver environment (P1)
	I: Vehicle equipment failure	Object on road (L4)	Inadequate design of communication devices (P2)
E: Temporary Personal Factors	Equipment failure (I1)	Inadequate road geometry (L5)	Inadequate construction of vehicle parts and/or structures (P3)
Fear (E1)			Unpredictable system characteristics (P4)
Attention allocation towards other than critical event (E2)		**M: Communication**	
Fatigue (E3)		Inadequate transmission from other	**Q: Road design**
Under the influence of substances (E4)		road users (M1)	Inadequate information design (Q1)
Excitement seeking (E5)		Inadequate transmission from	Inadequate road design (Q2)

	road
Sudden functional impairment (E6) Psychological stress (E7)	environment (M2)
F: Permanent Personal Factors Permanent functional impairment (F1) Expectance of certain behaviours (F2) Expectance of stable road environment (F3) Habitually stretching rules and recommendations (F4) Overestimation of skills (F5) Insufficient skills/knowledge (F6)	

3.3 THE LINKS

Besides the phenotypes and genotypes mentioned above, the classification scheme in DREAM also includes links between the phenotypes and the genotypes, as well as between different genotypes. These links represent the existing knowledge about how different factors can interact with each other (for a review, see Wallén Warner *et al*. 2008) and help build analysis-chains where a genotype can be both the consequent of a previous genotype, and the antecedent of another genotype, e.g. the cause of that genotype. For example, if genotype A leads to genotype B and genotype B leads to genotype C, then A can be said to be an indirect cause of C, while B can be said to be both the result of A and a cause of C. The genotypes in DREAM can therefore function both as links forwards and links backwards in a chain of reasoning.

The links between the phenotypes and the genotypes, as well as between different genotypes, are described in Appendix A. The linking is to be read from left to right, e.g. genotypes in the left hand columns are antecedents to, or causes of, the genotypes/phenotypes in the right hand column. This is indicated in the tables through the headings ANTECEDENTS over the left hand columns and CONSEQUENTS over the right hand columns.

Please note that all included links are *possible* connections, not logically binding or inevitable connections. This means that you cannot use a link just because it is there in the classification scheme. *The use of a link must always be supported by the data available!*

3.4 THE STOP RULES

The DREAM 3.2 classification scheme is non-hierarchical, which means that no genotypes have precedence over others, and therefore no highest or lowest level exists where an analysis naturally ends. To avoid random or subjectively determined stops in the analysis process, three stop rules have been defined. Overall, general genotypes have the status of non-terminal events. If a general genotype is the most likely cause of a general consequent, that cause is chosen and the analysis must continue until one of the three stop rules below is fulfilled:

1. *Specific genotypes have the status of terminal events. Therefore, if a specific genotype is the most likely cause of a general consequent, that genotype is chosen and the analysis stops.*
2. *If there exists no general or specific genotypes that link to the chosen consequent, the analysis stops.*
3. *If none of the available specific or general genotypes for the chosen consequent is relevant, given the information available about the accident, the analysis stops*

These definitions are highly abstract and probably makes very little sense at this point in your enthusiastic and thorough reading of the manual. However, their use should become more transparent in the examples provided below.

Note that throughout the whole analysis process, the basis for genotype selection is the available accident/incident data. For each genotype selected, there should exist evidence in the incident/accident data which warrant's its use. This means that while the linking table in DREAM 3.2 in a couple of places allow for closed and thus potentially endless loops, this should in practice not be a problem, as the time resolution of the driver states which these genotypes refer to cannot be infinitesimally short.

3.5 SCENARIO BASED RECOMMENDATIONS FOR PHENOTYPE CHOICES

To help investigators select an appropriate phenotype in a consistent manner across crash scenarios, a number of common accident scenarios are described below, and for each of them a phenotype is suggested.

3.5.1 Intersection accidents

Vehicle to vehicle conflicts

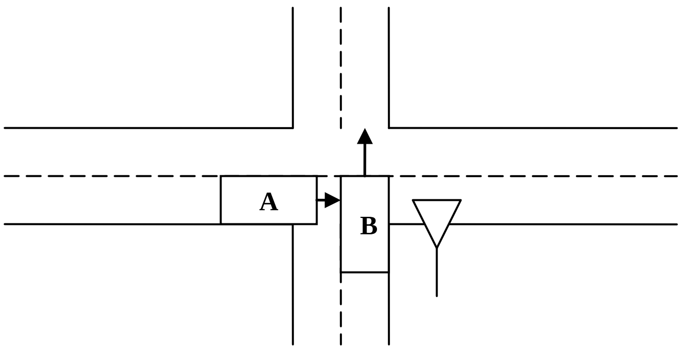


Figure 3: Intersection

Driver with right of way (A)

When: The phenotype is chosen when the driver's lane of travel starts to become blocked by the other vehicle

Phenotype: Timing: too early action, too late action, or no action
Speed: too high speed

Driver without right of way (B)

When: The phenotype is chosen when the driver passes the red traffic lights, the stop/give way sign or enters the intersection ignoring the right hand rule

Phenotype: Timing: too early action, too late action or no action

Illegally turning etc.

When: The phenotype is chosen when the driver initiates the illegal turn

Phenotype: Direction: wrong direction

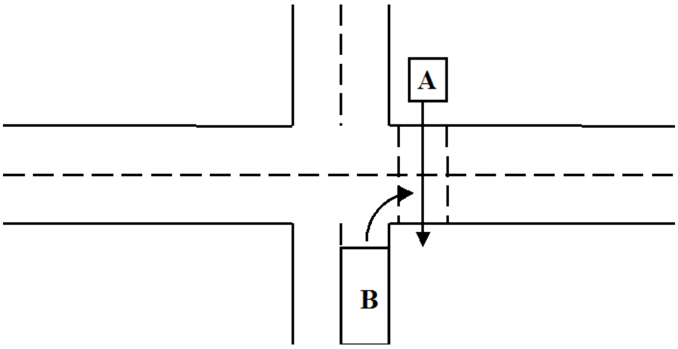


Figure 4: Conflict with pedestrian / bicyclist at intersection

Vehicle in conflict with Pedestrian / bicyclist or other Vulnerable Road User (VRU)

Turning vehicle (B)
When: The phenotype is chosen when the driver initiates the turning
Phenotype: Timing: too early action

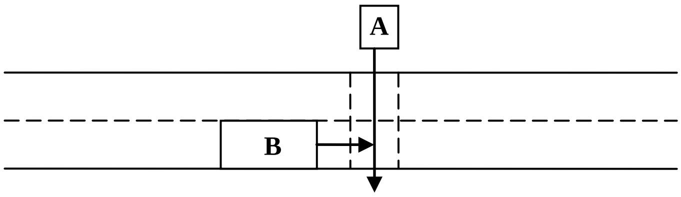


Figure 5: Conflict with pedestrian / bicyclist on straight road

Vehicle in constant motion (B)
When: The phenotype is chosen when the VRU moves out onto the roadway
Phenotype: Timing: too late action or no action

Vehicle in acceleration (B)
When: The phenotype is chosen when the driver accelerates from standstill or low velocity.
Phenotype: Timing: too early action

3.5.2 Leaving lane accidents

Includes accidents where the driver leaves his own lane (accidents where the driver is changing into a lane going in the same direction are described in the next section).

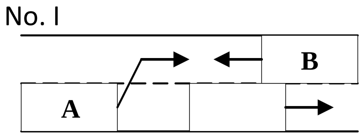


Figure 6: Overtaking

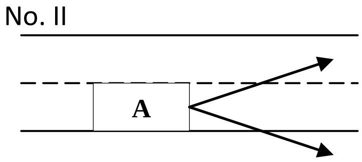


Figure 7: Straight road

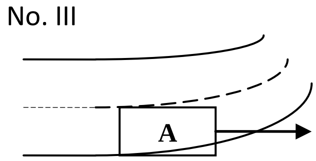


Figure 8: Curve

Overtaking driver (No. I: A)
When: The phenotype is chosen when the driver leaves his own lane

Phenotype:	Timing: too early action

Meeting driver (No. I: B)
When: The phenotype is chosen when the other vehicle enters the driver’s lane
Phenotype: Timing: too late action, no action
Speed: too high speed

Leaving lane on straight road (No. II: A)
When: The phenotype is chosen when the driver leaves his own lane
Phenotype: Direction: wrong direction
Force: surplus force

Leaving lane in curve (No. III: A)
When: The phenotype is chosen when the driver leaves his own lane
Phenotype: Direction: wrong direction
Speed: too high speed

3.5.3 Changing lane accidents

Includes accidents where the driver changes into another lane going in the same direction.

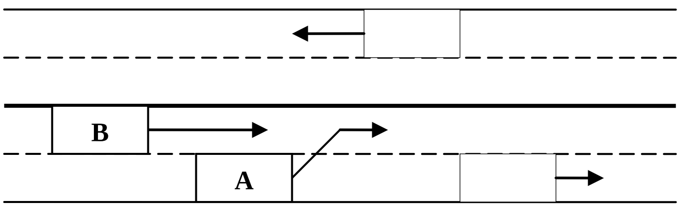


Figure 9: Changing lanes

Driver who is changing lane (A)
When: The phenotype is chosen when the driver leaves his own lane
Phenotype: Timing: too early

Driver who is catching up the car changing into his lane (B)
When: The phenotype is chosen when the other vehicle enters the driver’s lane
Phenotype: Timing: too late action, no action
Speed: too high speed

3.5.4 Rear end accidents

Includes accident where one driver catches up with another.

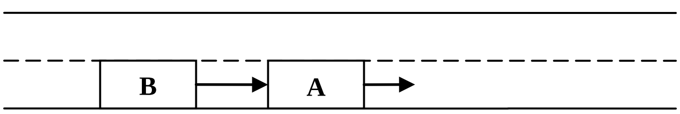


Figure 10: Rear end accidents

Driver of the lead vehicle (A)
When: The phenotype is chosen when there is no longer any time/space left for the driver to act in order to avoid the accident
Phenotype: Timing: no action
Force: surplus force
Speed: too low speed

Driver of the following vehicle (B)

When: The phenotype is chosen when there is no longer any time/space left for the driver to act in order to avoid the accident

Phenotype: Timing: late action, no action
Speed: too high speed
Distance: too short distance

3.6 USING PRECIPITATING EVENTS TO HELP FIXATE THE PHENOTYPE

In order to pin-point the time and place where control is lost, and thus the placement of the Phenotype more precisely, DREAM 3.2 has added the parallel use of Precipitating Events. A Precipitating Event is defined as the state of environment or action that began the critical event sequence i.e. the critical event which made the crash or near-crash possible. This definition coincides quite well with the general aim in DREAM to place the phenotype at the time and place where control is lost. A dictionary definition of the verb precipitate says the following:

> **precipitate**
> verb |priˈsipəˌtāt| [with obj.]
> • (**precipitate someone/something into**) send someone or something suddenly into a particular state or condition: *they were precipitated into a conflict for which they were quite unprepared*.
>
> ORIGIN early 16th cent.: from Latin ***praecipitat- 'thrown headlong,'*** from the verb ***praecipitare***, from ***praeceps***, ***praecip(it)- 'headlong,'*** from ***prae 'before'*** + ***caput 'head.'*** The original sense of the verb was ***'hurl down, send violently'***; hence ***'cause to move rapidly,'*** which gave rise to sense 1 (early 17th cent).

Precipitating Events have been used in NDS/FOT coding for quite some time to classify the event type from each involved road user's perspective. Precipitating Events can be said to be overall labels on the conflict travel paths seen from each involved vehicle's stand point, and thus capture the pre-crash movements more precisely than crash types normally do. For example, Precipitating Event no 44 in Appendix C is *Other Vehicle Oncoming - Over Left Line,* which further is defined as "*Other vehicle crosses subject vehicle's left lane line while traveling in the opposite direction from subject vehicle".*

How does this help Phenotype selection? Well, if the driver you're trying to DREAM code can be classified as having been in the type 44 Precipitating Event, then control can be said to be lost when the oncoming vehicle starts crossing into the driver's lane and the lateral safety margin is compromised. This suggest using the Phenotype (lateral) *Distance: too short* to classify the event.

Importantly, Precipitating Events are meant to be a vehicle kinematic based classification that does not include what the driver did or did not do, i.e. they are meant to be independent of who caused the conflict. This makes them different from for example the GDV-codes used in GIDAS, since the usage of the latter in several instances depends on a prior classification of which driver was responsible for the event.

Note also that DREAM 3.2 is the first version of the method where Precipitating Events are coded and used to help fixate the DREAM Phenotypes. If this proves to be more of a hindrance than a help in practical work (which is the ultimate standard against which all methods need to be measured), it will be removed later on.

3.7 EXTENDING THE CLASSIFICATION SCHEME

Obviously, the classification scheme in Appendix A does not cover all possible genotypes or all possible links between the existing genotypes. Even though there may have been traffic accidents due to grand pianos dropping out of the blue this is not included as a genotype. Instead, a selection has been made in order to avoid an endless list of genotypes making the tool impossible to use. This does however also mean that the classification scheme should be continuously updated to fit new types of accident scenarios as well as new scientific findings.

This is unproblematic, as long as certain rules are followed. When adding or removing genotypes, as well as changing the links between them, the links must be checked for consistency such that each general consequent must be found as a general antecedent in at least one place (e.g. in one or more of the tables in Appendix A). Also, any additional general genotypes must be clearly defined and for specific genotypes, examples must be added. This is simple in theory, but we recommend that primarily persons with good knowledge of the accident model, the classification scheme as well as the method used in DREAM make such alterations.

4 DREAM ANALYSIS – STEP BY STEP EXAMPLE

Below, a DREAM-analysis will be described step by step. In order to carry out the analysis you need this manual, including Appendix A with the linking table for phenotypes (observable effects) and genotypes (causes). You also need a copy of Appendix B with the linking template.

As investigators with different basic professional training (e.g. engineering or human factors) tend to focus on different aspects of the system interaction (Svenson, Lekberg and Johansson, 1999) it is recommended that the data collection as well as the analyses is carried out by a multidisciplinary accident investigation team.

4.1 DATA COLLECTION

The minimum criteria for making a DREAM-analysis for in-depth accident studies is that you have information about all drivers for which analyses are to be made as well as information about the accident scene. The information about the drivers is preferably collected through interviews with the drivers, passengers and other witnesses conducted as soon as possible after the accident. The information about the accident scene should also be collected as soon as possible – preferably before the involved vehicles have been moved, before the weather has changed, etc. It is also recommended that photos are used for documentation of the accident scene.

When data from naturalistic driving studies is used, the information should include video recordings of the driver, preferable from a perspective (or with a complementary channel such as an eye tracker) which allows identification of the driver’s gaze direction, along with views of at least the forward roadway. There should preferably also exist acceleration data and/or video information showing driving primary tasks, e.g. braking.

The interviews and the documentation of the accident scene should together contain the information needed in order to confirm or dismiss the presence of every single genotype. The overview of genotypes in Appendix A, page 6 can be used as a checklist.

It is also important that your project decides how to deal with missing, ambiguous and/or conflicting data before starting the data collection. In cases where the data collection and/or the analyses are carried out by a team of investigators, you also need to decide how to deal with different conclusions made within this team.

4.2 ACCIDENT/INCIDENT DESCRIPTION

After the data collection is completed the first step in the analysis is to describe the accident or incident in as much detail as possible based on data collected at the scene of the accident or available from video and/or CAN bus recordings. This accident/incident description should include all information needed to confirm the presence of different genotypes. It should also include information needed to dismiss genotypes that otherwise might have been expected to contribute to the accident, e.g. if the driver was *not* tired even though he was driving at night.

When writing the accident/incident description it is important to be as neutral as possible and avoid jumping to conclusions. When writing and reading the accident/incident description, remember that for a DREAM-analysis, who the police or insurance company will hold responsible is irrelevant. The aim of the analysis is not to shift blame, it is to provide means for future identification of countermeasures. Furthermore, never start the DREAM-analysis before you have been through the whole material a few times. Otherwise you may find yourself searching for facts that might support your current theory rather then trying to take a neutral look at the whole picture.

Below follows a description of an intersection accident seen from the perspective of Driver A. Note that in all accidents, a separate DREAM-analysis should be conducted for each involved road user. However, to keep this step by step section short enough to read, only the analysis of Driver A will be described here. The results of the analysis of Driver B are however presented under Section 5 (Example Accidents).

Accident description for an intersection accident

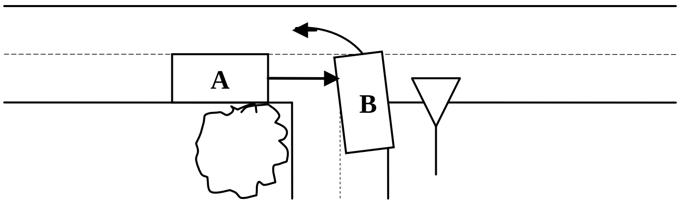


Figure 11: Intersection accident between two cars

Driver A

A is on her way home and is driving on a priority road, approaching a T-junction (approximately 200 meters away from her house) in 45-50 km/h (speed limit 50 km/h). A is planning to continue straight ahead in the intersection and states that there is no other traffic around. When A discovers B, the vehicles are so close to each other that A does not have time to brake or to make an avoidance manoeuvre before A drives into B's left side. A states that she is well aware that the intersection is difficult to negotiate because the hedge limits the lines of sight, and that she has experienced several incidents there. A also states that she is very familiar with the road which makes it easy for her to forget to adapt the speed.

Driver: 38-year old woman (has had a driving licence for 20 years), was not tired or distracted, was not under the influence of alcohol, drugs or medication, does, however, she states that she is very familiar with the intersection and she did not pay much attention to driving, rather she was thinking about what her husband might have made for dinner.
Vehicle: Peugeot in good condition.
Traffic environment: T-intersection where vehicles on the connecting road should give way. The view is obstructed by an overgrown, two meter high hedge in a private garden, which the local authorities has asked the person living there to cut down, though without success so far. Speed limit is 50 km/h.

4.3 CONTEXT EVALUATION

After the accident description is written and read, the next step is to evaluate the context for the accident. This can, for example, be done by highlighting all factors which can have contributed to the accident. Based on the highlighted information the actual DREAM-analysis is then performed.

4.4 CHOICE OF PRECIPITATING EVENT AND PHENOTYPE

After the evaluation of the context the actual DREAM-analysis starts. One analysis is done for each vehicle involved and the first step is to choose a precipitating event as described above in Section 3.6 and then a phenotype, (with help from the recommendations in Section 3.5 if needed).

For this example, the correct Precipitating Event would no 49: *Other vehicle entering intersection - turning onto opposite direction*. This is the vehicle movement that initiates the critical sequence. This corresponds well with the general advice in Section 3.5 on Phenotype choice, which states that the phenotype in intersection accidents should be chosen when the travel path for the driver with right of way is starting to become blocked.

Example from Section 3.5.1

Driver with right of way (A)

When:	The phenotype is chosen when the driver 's travel lane is starting to become blocked
Phenotype:	Timing: too early action, too late action, no action Speed: too high speed

The suggested phenotypes are *timing: too early action*, *timing: too late action*, *timing: no action* and *speed: too high speed*. Definitions of these can be found in table A in Appendix A. This table contains all available phenotypes, as well as the possible genotypes that can link to each phenotype. Figure 9 shows an excerpt from this table.

In the first column in Figure 12, under the heading of ANTECEDENTS, there is a list of all general genotypes that can link to the phenotype, e.g. all genotypes that are suggested as possible causes underlying the phenotype. In the second column, under the heading of CONSEQUENTS, the general phenotypes are listed and described and in the third column, specific phenotypes are listed and described. In the fourth and last column, examples for specific genotypes are given.

As Driver A did not drive faster than what could be expected we start with looking at the different alternatives for the phenotype *timing*. As Driver A did not brake before Driver B entered the intersection, the most appropriate choice is the last alternative in Figure 12.

> The driver enters the intersection without doing anything to avoid another road user entering his/her travel path. (e.g. does not brake or steer to avoid the conflict).

The phenotype *timing: no action* is therefore chosen and written in the phenotype box in Appendix B (see Figure 11).

PHENOTYPES (A)			
ANTECEDENTS (CAUSES)	CONSEQUENTS (EFFECTS)		
GENERAL Genotypes	Definition of GENERAL Phenotypes	Definitions of SPECIFIC Phenotypes	Examples for SPECIFIC Phenotypes
Misjudgement of time gaps (C1) Misjudgement of situation (C2) Incomplete judgment of situation (C3) Fear (E1) Fatigue (E3) Under the influence of substances (E4) Sudden functional impairment (E6) Temporary access limitation (G4) Equipment failure (I1) Strong side wind (J2) Missed observation (B1) Late observation (B2)	**Timing (A1)** The timing for initiating an action.	**Too early action (A1.1)** The action is initiated too early, before the signal is given or the required conditions are established.	*Intersection accidents* Starting from a stand still the driver passes the traffic light too early - before it has turned green. Starting from a stand still the driver passes the stop/give way sign too early - before the intersection is free. Starting from a stand still the driver enters the intersection too early - before the intersection is free (this is regardless of whether or not it is the driver's right of way). *OBS! If the driver has past a red traffic light or a stop/give way sign (see above) before entering the intersection the analysis should start by the traffic light/stop sign/give way sign.*
		Too late action (A1.2) The action is initiated too late.	*Intersection accidents* The driver starts to brake too late in order to stop for the red traffic light. The driver starts to brake too late in order to stop in front of the stop/give way sign. The driver starts to brake too late in order to avoid another road user entering his/her travel path. *OBS! If the driver has past a red traffic light or a stop/give way sign (see above) before entering the intersection the analysis should start by the traffic light/stop sign/give way sign.*
		No action (A1.3) No action is initiated.	*Intersection accidents* The driver passes the red traffic light without doing anything (e.g. does not brake in order to stop). The driver passes the stop/give way sign without doing anything (e.g. does not brake in order to stop). The driver enters the intersection without doing anything to avoid another road user entering his/her travel path. (e.g. does not brake or steer to avoid the conflict). *OBS! If the driver has past a red traffic light or a stop/give way sign (see above) before entering the intersection the analysis should start by the traffic light/stop sign/give way sign.*

Figure 12: Extract of intersection accident examples for the phenotype *timing* from phenotypes table in Appendix A

4.5 FROM PHENOTYPE TO GENOTYPE

The next step in the analysis is to choose the first genotype(s) contributing to the phenotype. As mentioned above, all phenotypes link to the same set of genotypes which can be found in the first column in Figure 9. As Driver A misjudged the situation thinking the intersection was free and safe to enter, the second general genotype – *Misjudgement of situation* – is chosen[1].

It is important to keep the accident description and context evaluation at hand so you can easily check the facts and circumstances for the accident you are analysing. Also, it is important that you know the meaning of all general genotypes listed in order to make a correct choice. If you need to check the meaning of one or more of the general genotypes you look at the code within the brackets. For *misjudgement of situation* the code is C2 which means that you can find a description of *misjudgement of situation* in table C row 2 in Appendix A. An extract from this table can be seen in Figure 10.

In the first column, is a list of all the general genotypes linking to each of the two genotypes *Misjudgement of time gaps* and *Misjudgement of situation,* respectively. In the second column, the specific genotypes are listed and described. In the third column, examples for the specific genotypes are given. In the fourth and last column, the two genotypes (*Misjudgement of time gaps* and *Misjudgement of situation)* that can be caused by the general genotypes in the first column, or by the specific genotypes in the second column, are listed and described.

When you have chosen one or more general genotypes, you write these in the genotype boxes closest to the phenotype box in Appendix B (see Figure 11).

[1] Note here that the genotype *Incomplete judgment of situation* might have been another option here. However, the definition for *Incomplete judgment of situation* states that in order for it to apply, one has to argue that it could not reasonably be expected of the driver to predict the event at the time it occurred (see definition in Table C). In the current example, the driver states that she has experienced several similar conflicts at this location before, which means that the example event should not come as a complete surprise. In other situations where such information is missing or unknown, use of *Incomplete judgment of situation* might be more appropriate.

INTERPRETATION C

Interpretation includes, for all but novice drivers, quick and automated (routine) procedures where typical situations and their associated actions are recognized and acted upon (script choice).
Mistakes in interpretation occur at the sharp end – within the local event horizon.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
Late observation (B2) False observation (B3) Attention allocation towards other than critical event (E2) Fatigue (E3) Under the influence of substances (E4) Psychological stress (E7) Permanent functional impairment (F1) Expectance of certain behaviours (F2) Habitually stretching rules and recommendations (F4) Overestimation of skills (F5) Insufficient skills/knowledge (F6) Incorrect ITS-information (G5) Reduced visibility (J1) Insufficient guidance (L1) Reduced friction (L2) Inadequate road geometry (L5) Inadequate transmission from road environment (M2) Unpredictable system characteristics (P4)	**Misjudgement of time gap due to incorrect speed estimate (C1.1)** The driver misjudges the time gap due to a misjudgement of the approaching vehicle's speed.	*Intersection* The driver is waiting to cross a street and assumes that the approaching car is keeping the 50 km/h speed limit. The car is, however, approaching at 70 km/h and as a result the driver overestimates the time gap he has to the approaching car.	**Misjudgement of time gaps (C1)** The estimation of time gaps (e.g. time left to approaching vehicle, stop sign, traffic lights etc.) is incorrect.
Missed observation (B1) Late observation (B2) False observation (B3) Priority error (D1) Attention allocation towards other than critical event (E2) Fatigue (E3) Under the influence of substances (E4) Psychological stress (E7) Permanent functional impairment (F1) Expectance of certain behaviours (F2) Habitually stretching rules and recommendations (F4) Overestimation of skills (F5) Insufficient skills/knowledge (F6) Incorrect ITS-information (G5) Reduced visibility (J1) Insufficient guidance (L1) Reduced friction (L2) Road surface degradation (L3) Object on road (L4) Inadequate road geometry (L5) Inadequate transmission from road environment (M2) Unpredictable system characteristics (P4)	None defined		Row 2 **Misjudgement of situation (C2)** The situation is misjudged (e.g. the driver thinks that it is safe to enter the intersection as he/she has not noticed the traffic lights turning red or the vehicle approaching).

Figure 13: Extract of intersection accident examples for the genotypes in table C in Appendix A

4.6 FROM GENOTYPE TO GENOTYPE

The next step in the analysis is to choose the specific or general genotype(s) contributing to the genotype linked to the phenotype. You start with the first genotype chosen (*misjudgement of situation* in table C in the current example) which you find in the last column in one of the tables B - Q in Appendix A (in the current example you find the genotype in table C).

When looking for specific or general genotype(s) *you should always start with looking for a specific genotype.* These are found in column 2. In the current example, there is however no specific genotype available for *Misjudgement of situation* (for examples with specific genotypes see section 5. Example Accidents) and therefore general genotypes has to be chosen in this example. Three contributing general genotypes can be found in the first column corresponding to *Misjudgement of situation* in table C (see Figure 13). These general genotypes are *Missed observation* (Driver A states that there was no other traffic around which implies that Driver A did not see Driver B approaching the intersection), *Attention allocation towards other than critical event* (Driver A states that her attention was more on dinner than on driving, due to the familiarity of the road) and finally *Expectance of certain behaviours* (Driver A drives on a priority road and therefore expected crossing traffic to give way).

Again, it is important to keep the accident description and context evaluation at hand so you can easily check the facts and circumstances for the accident you are analysing. Also, it is important that you know the meaning of all general genotypes listed in order to make a correct choice. In Appendix A, *Missed observation* is described in table B row 1, *Attention allocation towards other than critical event* is described in table E row 2 and *Expectance of certain behaviours* is described in table F, row 2.

When you have chosen one or more specific or general genotypes, you write these down in the genotype boxes in Appendix B to the left of the general genotype they are contributing to (see Figure 14).

4.7 ENDING THE ANALYSIS

The step described above is then repeated for each of the general genotypes chosen until the analysis is complete, e.g. one of the three stop rules is fulfilled.

In the current example, the reason for Driver A not seeing Driver B was that her view was blocked by the hedge and therefore the general genotype *Permanent obstruction to view* is chosen as contributing to missed observation. With regards to reasons for the *Permanent obstruction to view,* the local authorities has asked the garden owner to cut down the hedge but the garden owner has not complied, and the issue has not been enforced by the authorities (a good example of a latent condition, see Figure 1). In other words, the local authorities are clearly aware that the hedge constitutes a problem for the intersection layout but have failed to successfully address it. This information can be classified as *Inadequate road design* (Q2), which links to K2 (see Table K). The general genotypes are written in the next genotype boxes in Appendix B (see Figure 14). As there exists no general or specific antecedents for *Inadequate road design,* this contributing-factor-chain then stops in accordance with **stop rule number 2**:

> *If there exists no general or specific genotypes that link to the chosen consequent, the analysis stops.*

With regards to Driver A's *Attention allocation towards other than critical event*, the driver states that her mind was on what would be for dinner. This can be classified with the specific genotype - *Mind off critical event - Daydreaming* (E2.8). Since specific genotypes are terminal events in any contributing-factor-chain, the analysis then stops in accordance with **stop rule number 1**:

> *Specific genotypes have the status of terminal events. Therefore, if a specific genotype is the most likely cause of a general consequent, that genotype is chosen and the analysis stops.*

Finally, with regards to *Expectance of certain behaviours* there are no specific or general genotype listed for this general genotype and therefore the analysis-chain stops in accordance with **stop rule 2**:

> *If there exists no general or specific genotypes that link to the chosen consequent, the analysis stops.*

When all analysis-chains have come to an end the analysis is completed (see Figure 14).

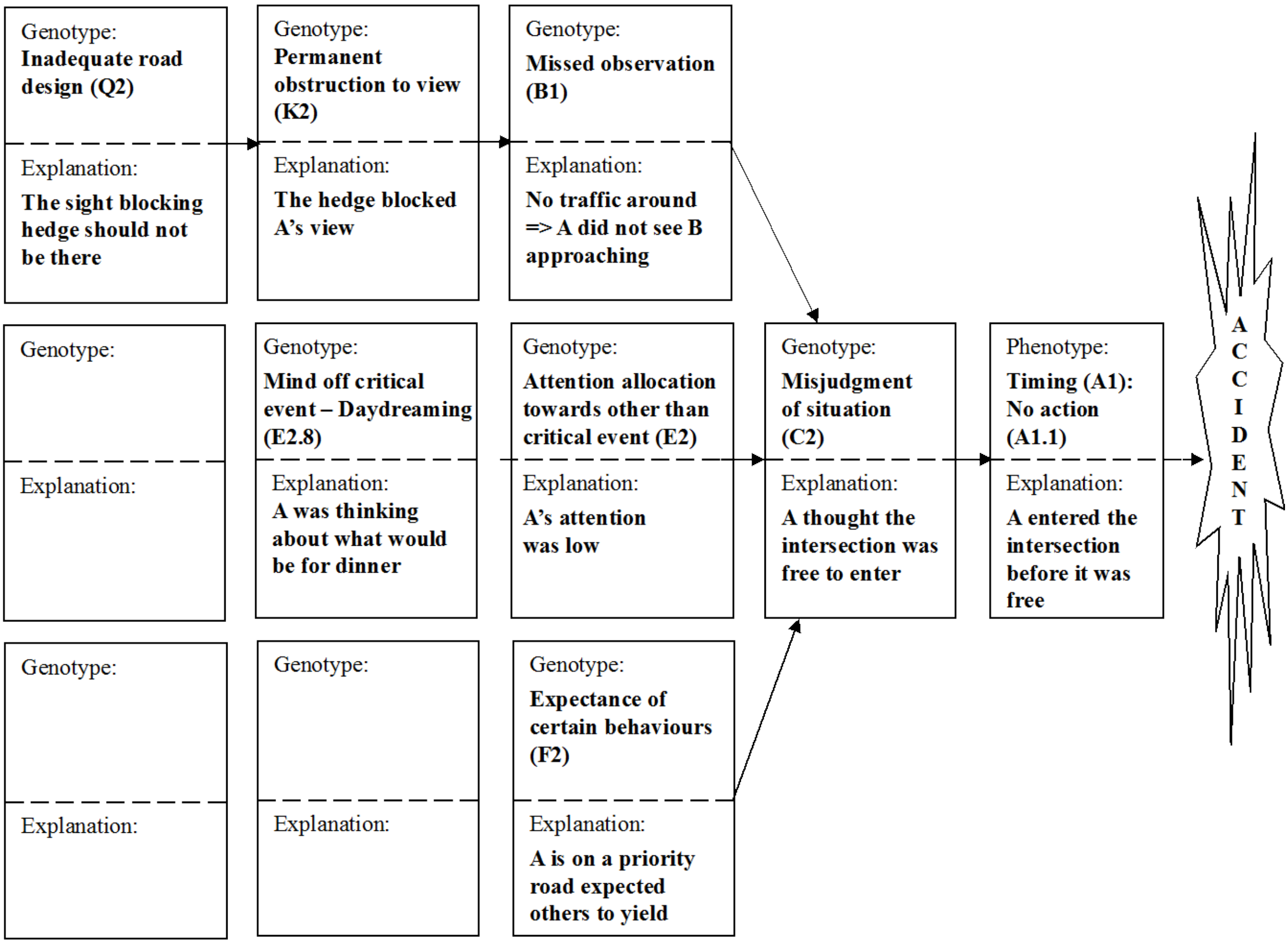


Figure 14. DREAM Chart for step-by-step walkthrough example

Note that in Figure 14 above, A discovers B after she enters the intersection, and Missed observation (B1) rather than Late observation (B2) is therefore chosen.

IMPORTANT: Completing the analysis does not necessarily mean that we have succeeded in fully explaining why the accident took place. It just means that *we have categorised everything we know* about the accident as well as possible. Letting go at this point is sometimes difficult. People in general, and accident investigators in particular, tend to hate unfinished and/or incomplete stories. However, the job here is to classify, not speculate, and that can only go as far as the empirical data allows.

In cases where you have hard to choose between two or more genotypes it is very important that you make a comment and motivate your choice for future reference (see Figure 14).

If this was a real accident analysis we would now repeat the whole procedure for Driver B. In this case, this will not be done but the results of the analysis of Driver B, together with a short explanation as to why the specific phenotype and general genotypes were chosen can be found in the first accident scenario in Section 5 (Example accidents).

5 EXAMPLE ACCIDENTS

Some of the examples below are inspired by accidents described by Englund, Jarleryd, Lindkvist and Pettersson (1978).

5.1 SCENARIO 1 (INTERSECTION ACCIDENT)

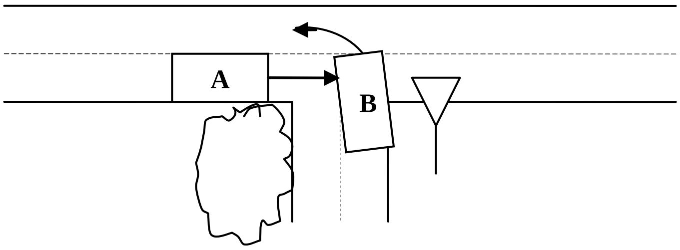


Figure 15: Scenario 1 (intersection accident)

Driver A

A is on her way home and is driving on a priority road, approaching a T-junction (approximately 200 meters away from her house) in 45-50 km/h (speed limit 50 km/h). A is planning to continue straight ahead in the intersection and states that there is no other traffic around. When A discovers B the vehicles are so close to each other that A does not have time to brake or to make an avoidance manoeuvre before A drives into B’s left side. A states that she is well aware that the intersection is dangerous and that she has experienced several incidents there. A also states that she is very familiar with the road which makes it easy for her to forget to adapt the speed.

Driver: 38-year old woman (has had a driving licence for 20 years), was not tired or distracted, was not under the influence of alcohol, drugs or medication, does, however, state that she is so familiar with the intersection that her level of attention was low
Vehicle: Peugeot in good condition
Traffic environment: T-intersection where vehicles on the connecting road should give way, the view is obstructed by a 1.6 meter high hedge in a garden, speed limit is 50 km/h

Driver B

Just before the intersection B has stopped to look at a house and therefore she is approaching the intersection in a low speed (35-40 km/h). B notices the sign telling her to give way. There are no other road users around. B stops before the dotted white line painted on the tarmac in her lane. B looks to the right and to the left but does not see any vehicles approaching and therefore she drives into the intersection. Suddenly A appears from the left and drives into B’s side. There are no brake marks in the intersection.

Driver: 36-year old woman (has had an African driving licence for 15 years and a Swedish driving licence for 10 years), was not in a hurry
Vehicle: Volvo in good condition which she has had for 6 months
Traffic environment: connecting road in T-junction, should give way which is signposted as well as marked with a dotted white line painted on the tarmac, the view is obstructed by a 1.6 meter tall hedge in a garden – to get a free view in the intersection it is necessary to stop <u>after</u> the dotted line.

5.1.1 Constructing the DREAM-chart for Driver A

The DREAM chart for Driver A is constructed in the following way. First, the phenotype is chosen when B starts to encroach on A's travel path the intersection even though B is approaching. Since A does not respond to this event, (e.g. does not brake in order to avoid the conflict) the phenotype *timing: no action* is chosen.

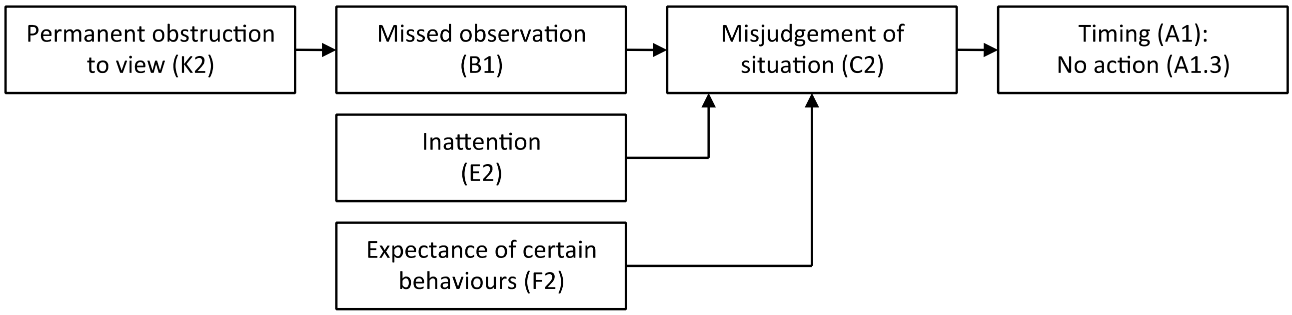


Figure 16: Scenario 1 (intersection accident) – DREAM chart for Driver A

The reason for A entering the intersection is that A misjudges the situation and thinks the intersection will remain free and safe to pass. Therefore the genotype *misjudgement of situation* is chosen.

There are three different factors contributing to A's misjudgement of the situation.

Firstly, A stated that there was no other traffic. This implies that A did not see B approaching and therefore the genotype *missed observation* is chosen. The reason for A not seeing B is the hedge blocking A's view. This justifies selection of the genotype *permanent obstruction to view* as contributing to the *missed observation*. This contributing-factor-chain then stops in accordance with **stop rule number 2**:

> *If there exists no general or specific genotypes that link to the chosen consequent, the analysis stops.*

The second factor contributing to A's misjudgement of the situation was that, according to A, her attention was low as she is very familiar with the road. Therefore the genotype *Attention allocation towards other than critical event* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 3**:

> *If none of the available general or specific genotypes for the chosen consequent is relevant, given the information available about the accident, the analysis stops.*

The third factor contributing to A's misjudgement of the situation is that A drives on a priority road. It is thus reasonable to assume that A expects crossing traffic to give way. Therefore the genotype *expectance of certain behaviour*s is chosen. This contributing-factor-chain then stops in accordance with stop rule number 2 (see above).

5.1.2 Constructing the DREAM-chart for Driver B

The phenotype is chosen when B passes the give way sign even though A is approaching the intersection. As B enters the intersection before A has safely passed, the phenotype *timing: too early action* is chosen.

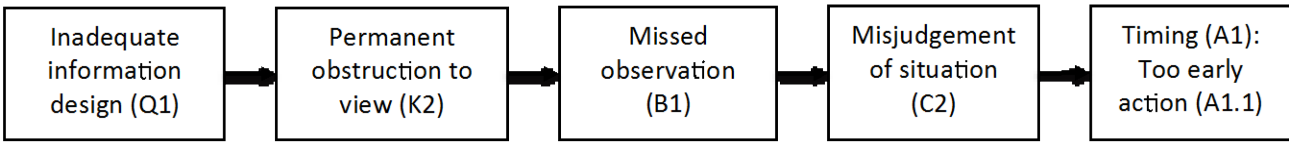


Figure 17: Scenario 1 (intersection accident) - DREAM chart for Driver B

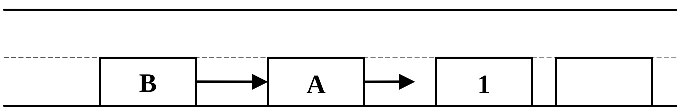
The cause behind B entering the intersection before it is free is that B misjudges the situation and thinks the intersection is free and safe to enter. Therefore the genotype *misjudgement of situation* is chosen.

B's misjudgement of the situation is caused by B not seeing A approaching. Therefore the genotype *missed observation* is chosen.

B not seeing A approaching is caused by the hedge blocking B's view. Therefore the genotype *permanent obstruction to view* is chosen.

B's view being blocked by the hedge is caused by the give way line painted on the tarmac being placed too far back in the intersection, making it impossible to see vehicles approaching from the left when stopping before the line. Therefore the genotype *inadequate information design* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 2** (see above).

5.2 SCENARIO 2 (REAR END ACCIDENT)



A still standing car queue has formed and vehicle 1 (which stands still) is last in this queue.

Driver A
A is driving in 50 km/h on a busy street. A is talking with her daughter who sits next to her in the front passenger seat. Suddenly the daughter says that the car in front of them has stopped. A brakes very hard and stops the car at least 10 meters behind the still standing car (position 1). A few second later, A is hit from behind by B.

Driver: 58-year old woman (has had a driving licence for 40 years), has previously been involved in an accident where she was hit from behind resulting in her getting a whip-lash injury, stats that she panicked when she, completely unprepared, found herself in the same kind of situation again, was not tired, was not under the influence of alcohol, drugs or medication.
Vehicle: Toyota in good condition
Traffic environment: Busy city-street with a 50 km/h speed limit

Driver B
B is in a hurry to get to work and is driving 55-60 km/h on a busy street with a 50 km/h speed limit. Suddenly B sees A braking very hard. B brakes as hard as she can but still drives into A's rear end.

Driver: 25-year old woman (has had a driving licence for 5 years), was not tired or distracted, was not under the influence of alcohol, drugs or medication
Vehicle: Opel in good condition
Traffic environment: Busy city-street with a 50 km/h speed limit

5.2.1 Constructing the DREAM-chart for Driver A

The phenotype is chosen when A suddenly brakes very hard. As A brakes unnecessarily hard (stopping 10 meters behind the queue) the phenotype *Force: surplus force* is chosen.

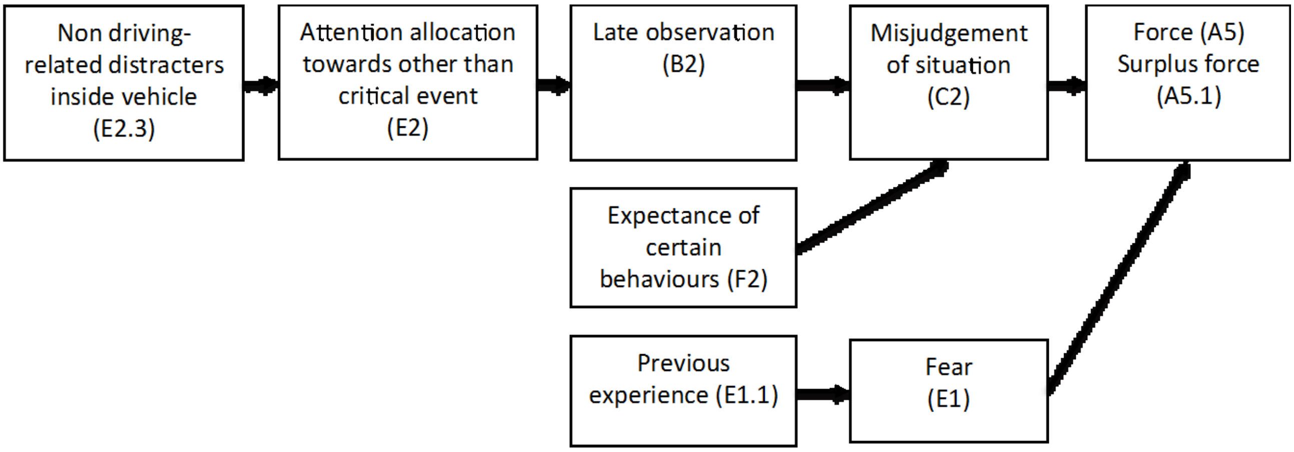


Figure 18: Scenario 2 (catching up accident) - DREAM chart for Driver A

There are two factors contributing to A braking so hard.

Firstly, A panics and therefore the genotype *fear* is chosen. A's panic is caused by the fact that A, in the past, has been involved in a similar situation resulting in A getting a whiplash injury. Therefore the specific genotype *previous experience* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 1**:

> *Specific genotypes have the status of terminal events. Therefore, if a specific genotype is the most likely cause of a general consequent, that genotype is chosen and the analysis stops.*

The second factor contributing to A braking so hard is that A misjudges the situation thinking that braking really hard is the safest way of avoiding an accident. Therefore the genotype *misjudgement of situation* is chosen.

There are two factors contributing to A's misjudgement of the situation.

Firstly, A is not prepared for the situation as she does not expect cars in her lane to slow down and therefore the genotype *expectance of certain behaviours* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 2**:

> *If there exists no general or specific genotypes that link to the chosen consequent, the analysis stops.*

The second factor contributing to A's misjudgement of the situation is that A does not see the car queue until her daughter informs her about it at which time it is too late for A to properly judge the situation and brake smoothly. Therefore the genotype *late observation* is chosen.

A's late observation is caused by her not focusing her attention on the road in front of her (if she had done she would have reacted to the car queue before her daughter informed her of it). Therefore the genotype Attention allocation towards other than critical event is chosen.

A's Attention allocation towards other than critical event is caused by her talking to her daughter. Therefore the specific genotype *non driving-related distracters inside vehicle* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 1** (see above).

5.2.2 Constructing the DREAM-chart for Driver B

The phenotype is chosen when there is no longer any time/space left for B to act in order to avoid the accident. As B cannot avoid driving into A even though she brakes as hard as she can as soon as A starts braking, the phenotype *distance: too short distance* is chosen.

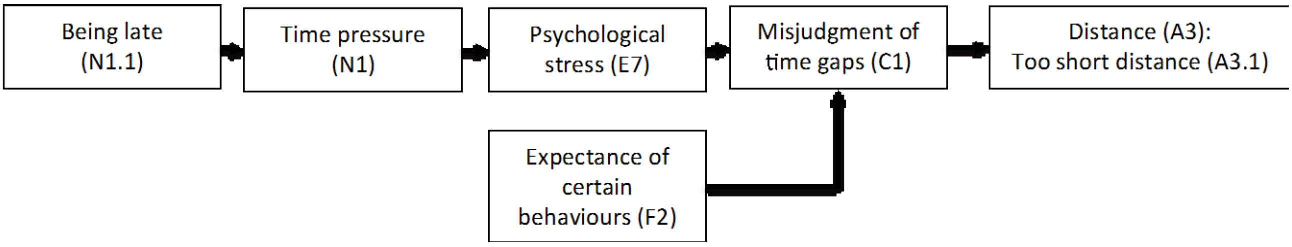


Figure 19: Scenario 2 (catching up accident) – DREAM chart for Driver B

The cause behind B starting to brake too late is that B misjudges the time gap needed to the car in front (A) at the speed she is travelling. Therefore the genotype *misjudgement of time gaps* is chosen.

There are two factors contributing to B's misjudgement of the time gap.

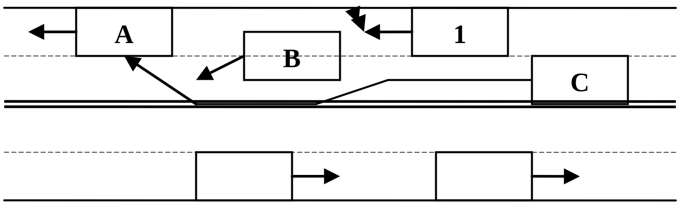
Firstly, B does not expect A to suddenly brake so hard and therefore the genotype *expectance of certain behaviours* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 2** (see above):

The second factor contributing to B's misjudgement of the time gap is that B is stressed. Therefore the genotype *psychological stress* is chosen.

B being stressed is caused by time pressure. Therefore the genotype *time pressure* is chosen.

B experiencing time pressure is caused by her being late for work. Therefore the specific genotype *being late* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 1** (see above).

5.3 SCENARIO 3 (LEAVING LANE ACCIDENT)



Driver A

A is driving on a motorway with a 110 km/h speed limit. It is late afternoon and A has just picked up his car at a garage where the chassis had been coated to resist rust. To avoid getting dust and dirt in the new coating A drives with a top speed of 50 km/h (which is also supported by other evidence at the scene). A drives as far to the right as he can, without crossing the white line painted on the tarmac. Suddenly – completely unexpected – A's left side is hit by C. A loses control over the car and drives down a slope to the right of the road. A stops against a bank of soil. Straight after the accident A does not understand what really happened.

Driver: 38-year old man (has had a driving licence for 20 years), was not tired or distracted, was not under the influence of alcohol, drugs or medication
Vehicle: Volvo in good condition
Traffic environment: Motorway with a 110 km/h speed limit, late afternoon with dark but clear weather

Driver B
B is driving 100-110 km/h when he approaches a vehicle which he judges to drive approximately 80 km/h. In the rear mirrors B sees the head lights from a vehicle behind him. B does, however, judge the vehicle to be so far behind that he can start to overtake the slow vehicle in front of him. B can not recall that there was any vehicle right behind him (position 1). B indicates to change lane and starts the overtaking. Suddenly, B sees C cut in front of him and drive into the left side of A. B brakes and stops his car at the road side.

Driver: 29-year old man (has had a driving licence for 10 years), was not in a hurry or distracted but has, during the previous week, slept worse than normal because of night duty, was not under the influence of alcohol, drugs or medication
Vehicle: Opel in good condition
Traffic environment: Motorway with a 110 km/h speed limit, late afternoon with dark but clear weather

Driver C
C is driving 100-110 km/h when he discovers a car queue in front of him. C judges the queue to drive quite fast – but slower than him. C changes to the left lane in order to overtake the queue. Suddenly B pulls out in front of C in the left lane. C has not seen B indicate to change lane and judges the distance to B to be between three to four car lengths. C judges it being impossible to slow down enough not to drive into the rear end of B and therefore he overtakes B by using the left shoulder. When C has nearly passed B he gets a skid and loses control over the car. C cuts in front of B and drives into A's left side. C then manages to stop his car on the right shoulder.

Driver: 66-year old man (has had a driving licence for 48 years), was not tired or distracted, was not under the influence of alcohol, drugs or medication
Vehicle: Ford in good condition which he has had as a company car – before that he had another car of the same brand
Traffic environment: Motorway with a 110 km/h speed limit, late afternoon with dark but clear weather

5.3.1 Constructing the DREAM-chart for Driver A

The phenotype is chosen when A decides to drive in 50 km/h on a motorway with a 110 km/h speed limit. As A drives slower than what can be expected by other drivers the phenotype *speed: too low speed* is chosen.

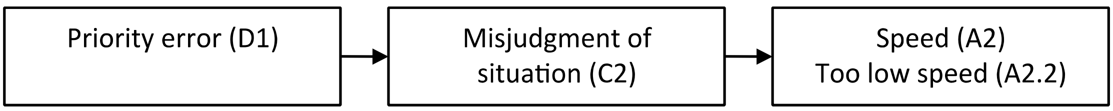


Figure 20: Scenario 3 (leaving lane accident) - DREAM chart for Driver A

The cause behind A driving so slow is that A misjudges the situation thinking it is safe to drive 50 km/h on a motorway with a 110 km/h speed limit. Therefore the genotype *misjudgement of situation* is chosen.

A's misjudgement of the situation is caused by him choosing to drive slowly to protect his new coating on the chassis rather than keeping to the traffic rhythm – as he thinks both options are safe. Therefore the genotype *priority error* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 3**:

> *If none of the available general or specific genotypes for the chosen consequent is relevant, given the information available about the accident, the analysis stops.*

5.3.2 Constructing the DREAM-chart for Driver B

The phenotype is chosen when B leaves his own lane in order to overtake A. As B enters the lane next to him before C has safely passed the phenotype *timing: too early action* is chosen.

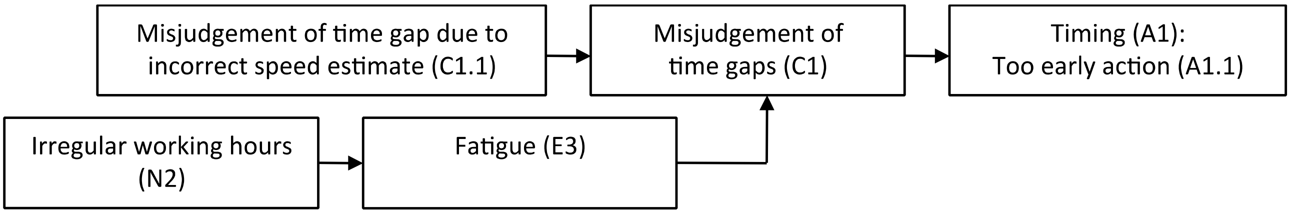


Figure 21: Scenario 3 (leaving lane accident) - DREAM chart for Driver B

The cause behind B leaving his lane too early is that he misjudged the gap to C approaching from behind. Therefore the genotype *misjudgement of time gaps* is chosen.

There are two factors contributing to B's misjudgement of the time gap.

Firstly, B underestimates the time gap available until C will reach him (which is easily done when looking in the rear mirror) and therefore the specific genotype *misjudgement of time gap due to incorrect speed estimate* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 1**:

> *Specific genotypes have the status of terminal events. Therefore, if a specific genotype is the most likely cause of a general consequent, that genotype is chosen and the analysis stops.*

The second factor contributing to B's misjudgement of the time gap is that B is tired after having slept worse than normal. Therefore the genotype *fatigue* is chosen.

B having slept worse than normal is caused by him having night duty. Therefore the genotype *irregular working hours* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 2**:

> *If there exists no general or specific genotypes that link to the chosen consequent, the analysis stops.*

5.3.3 Constructing the DREAM-chart for Driver C

The phenotype is chosen when, there is no longer any time/space left for C to act in order to avoid the accident. As B reacts too late to avoid an accident, the phenotype *timing: too late action* is chosen.

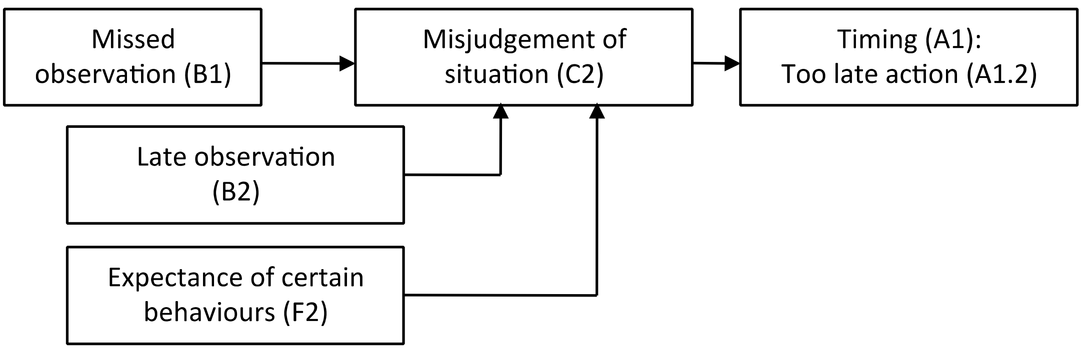


Figure 22: Scenario 3 (leaving lane accident) - DREAM chart for Driver C

The cause behind reacting too late is that C thought it was safe to pass the car queue. Therefore the genotype *misjudgement of situation* is chosen.

There are three factors contributing to C’s misjudgement of situation.

Firstly, C does not see B indicating to change lane and therefore the genotype *missed observation* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 3** (see above).

The second factor contributing to C’s misjudgement of the situation is that C suddenly sees B change lane - too late to avoid an accident. Therefore the genotype *late observation* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 3** (see above).

The third factor contributing to C’s misjudgement of the situation is that it is reasonable to assume that C does not expect B to suddenly change lane right in front of him. Therefore the genotype *expectance of certain behaviours* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 2** (see above).

5.4 SCENARIOS 4:I AND 4:II (LEAVING LANE ACCIDENTS)

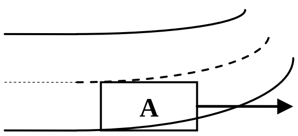


Figure 23: Scenario 4:I (leaving lane accident) - Driver A

Driver A (Scenario 4:I)
A is driving 130 km/h on a road with a 70 km/h speed limit (that the speed was high is also supported by other evidence at the scene). A is on his way to a party but states that he is not in much of a hurry. There are four passengers (males in the same age of the driver) in the car. When A enters a sharp curve he gets a skid. A tries to control the skid but fails. A ends up, upside down in a ditch.

Driver: 19-year old man (has had a driving licence for 1 year), was not tired and states that he was not distracted by his passengers, was not under the influence of alcohol, drugs or medication
Vehicle: Older Volvo in good condition
Traffic environment: Rural road in normal condition with a 70 km/h speed limit

5.4.1 Constructing the DREAM-chart for Driver A in Scenario 4:I

The phenotype is chosen when A leaves his own lane. As A drives too fast to take the curve under the prevailing conditions, the phenotype *speed: too high speed* is chosen.

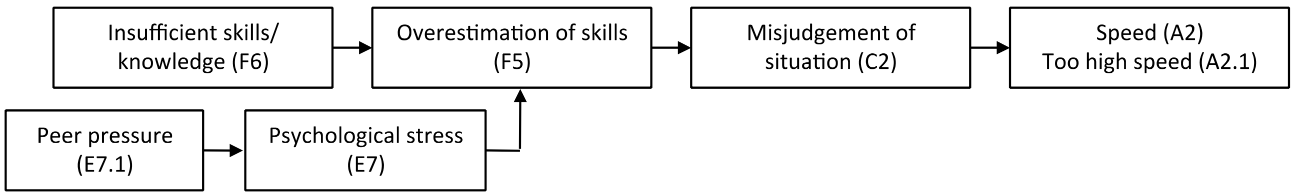


Figure 24: Scenario 4:I (leaving lane accident) - DREAM chart for Driver A

The cause behind A driving too fast is that A misjudges the situation thinking it is safe to enter the curve in that speed. Therefore the genotype *misjudgement of situation* is chosen.

A’s misjudgement of the situation is caused by A overestimating his own skills thinking he can handle the car in that speed. Therefore the genotype *overestimation of skills* is chosen.

There are two factors contributing to A's overestimation of his own skills.

Firstly, A has only had his driving licence for one year and has not enough skills and knowledge in order to handle the situation safely and therefore the genotype *insufficient skills/knowledge* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 3**:

> *If none of the available general or specific genotypes for the chosen consequent is relevant, given the information available about the accident, the analysis stops.*

The second factor contributing to A's overestimation of his own skills is that A is stressed. Therefore the genotype *psychological stress* is chosen.

C's stress is caused by him having several male passengers in his own age. Therefore the specific genotype *peer pressure* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 1**:

> *Specific genotypes have the status of terminal events. Therefore, if a specific genotype is the most likely cause of a general consequent, that genotype is chosen and the analysis stops.*

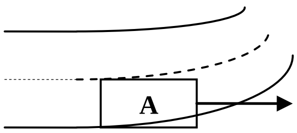


Figure 25: Scenario 4:II (leaving lane accident) - Driver A

Driver A (Scenario 4:II)
A is driving 130 km/h on a road with a 70 km/h speed limit (that the speed was high is also supported by other evidence at the scene). When A enters a sharp curve, which is incorrectly cambered and the surface is covered in gravel, he gets a skid. A tries to control the skid but fails. A ends up, upside down in a ditch.

Driver: 19-year old man (has had a driving licence for 1 year), was not tired or distracted, was not under the influence of alcohol, drugs or medication
Vehicle: Older Volvo in good condition
Traffic environment: incorrectly cambered curve on a 70km/h-road. The surface in the curve was covered with gravel.

5.4.2 Constructing the DREAM-chart for Driver A in Scenario 4:II

The phenotype is chosen when A leaves his own lane. As A drives t too fast to take the curve under the prevailing conditions the phenotype *speed: too high speed* is chosen.

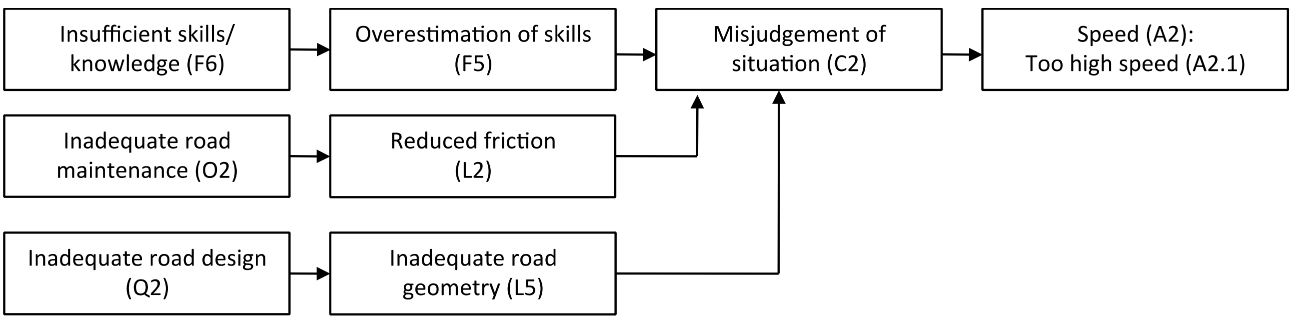


Figure 26: Scenario 4:II (leaving lane accident) - DREAM chart for Driver A

The cause behind A driving too fast is that A misjudges the situation thinking it is safe to enter the curve in that speed. Therefore the genotype *misjudgement of situation* is chosen.

There are three factors contributing to A's misjudgement of the situation.

Firstly, A overestimating his own skills thinking he can handle the car in that speed and therefore the genotype *Overestimation of skills* is chosen.

A's overestimation of his own skills is caused by A only having had his driving licence for one year and therefore not having enough skills and experience in order to handle the situation safely. Therefore the genotype *insufficient skills/knowledge* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 3** (see above).

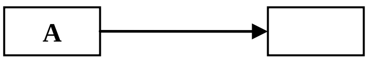
The second factor contributing to A's misjudgement of the situation is the gravel covering the tarmac resulting in poor friction. Therefore the genotype *reduced friction* is chosen.

The reduced friction is caused by the fact that no one has removed the gravel from the road. Therefore the genotype inadequate road maintenance is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 3** (see above):

The third factor contributing to A's misjudgement of the situation is the curve is being incorrectly cambered. Therefore the genotype *inadequate road geometry* is chosen.

The incorrect camber is caused by a poor road design. Therefore the genotype *inadequate road design* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 3** (see above).

5.5 SCENARIO 5 (UNINTENDED ACCELERATION)



Driver A
A has just been shopping and gets into the car to drive home. A starts the car to turn out of a narrow parking space. To lower (the already low) speed A presses the brake. Instead of slowing down the car accelerates and therefore A presses the brake pedal to the floor. According to A something must be wrong with the brake because when she presses it to the floor the speed quickly increases and A drives into a parked car. After the accident A steps out of the car and could be interviewed. Nothing suggests that A was ill or has had some kind of seizure.

Driver: 67-year old woman (has had a driving licence for 45 years), was not tired or distracted, was not under the influence of alcohol, drugs or medication
Vehicle: Newer Toyota which she has had for 6 months, the vehicle has automatic gear change and is in good condition. No failures were found on the brake- and fuel-systems.
Traffic environment: Fairly narrow parking space

5.5.1 *Constructing the DREAM-chart for Driver A*

The phenotype is chosen when A presses the wrong pedal. As A presses the acceleration pedal, instead of the brake pedal, the phenotype *object: adjacent object* is chosen.

Object (A6):
Adjacent object (A6.1)

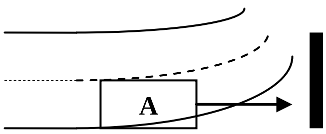
Figure 27: Scenario 5 (Unintended acceleration) - DREAM chart for Driver A

The analysis then stops in accordance with **stop rule number 3**:

> *If none of the available general or specific genotypes for the chosen consequent is relevant, given the information available about the accident, the analysis stops.*

5.6 SCENARIO 6 (LEAVING LANE ACCIDENT)

This example is based on an accident described by Rasmussen, Duncan and Leplat (1987).



Driver A

A is a lorry driver and is preparing a delivery. As A's usual lorry is at the garage he picks up a replacement lorry, which is unfamiliar to him. The borrowed lorry is somewhat smaller than the one A normally drives and its brake system has not been properly maintained (but A is unaware of this). The lorry is loaded with the cargo adapted to A's normal lorry which results in the borrowed lorry being somewhat overloaded. A leaves with his cargo but the route he normally takes is closed due to road repair. A takes a detour which turns out to have an unexpected long, steep and curvy slope downhill. A puts in a low gear and starts to brake. After a while A realises that the brakes are not working properly and the lorry catches speed. The speed is finally so high that the lorry continues straight ahead in a curve and hits a rock wall.

Driver: 58-year old man (has been driving lorries for 38 years), was not tired or distracted, was not under the influence of alcohol, drugs or medication
Vehicle: Lorry with a badly maintained brake system
Traffic environment: Long, steep and curvy slope downhill.

5.6.1 *Constructing the DREAM-chart for Driver A*

The phenotype is chosen when A leaves his own lane. As A drives too fast to take the curve under the prevailing conditions the phenotype *speed: too high speed* is chosen.

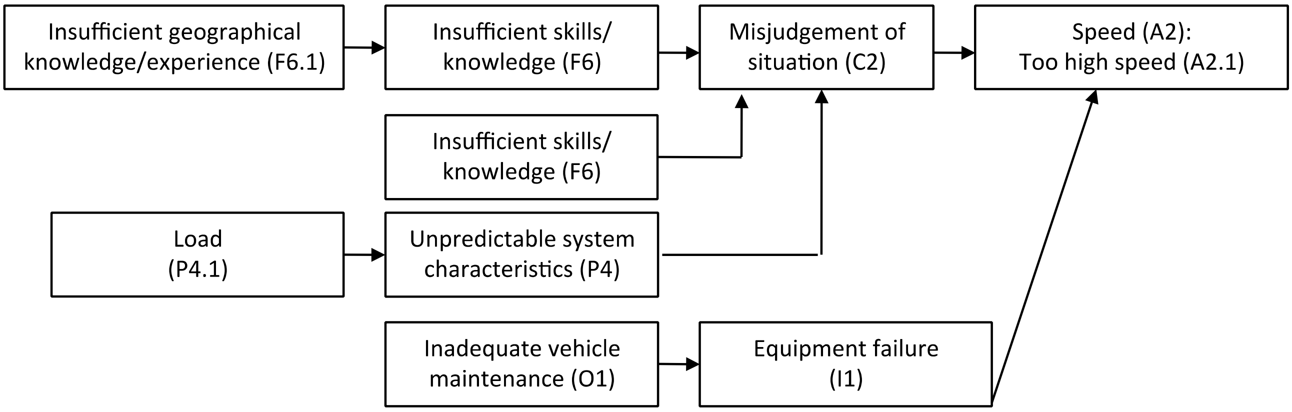


Figure 28: Scenario 6 (leaving lane accident) - DREAM chart for Driver A

There are two factors contributing to A entering the curve too fast. Firstly, the brakes are not working properly and therefore the genotype *equipment failure* is chosen.

The equipment failure is caused by poor maintenance of the brakes. Therefore the genotype *inadequate vehicle maintenance* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 2**:

> *If there exists no general or specific genotypes that link to the chosen consequent, the analysis stops*

The second factor contributing to A entering the curve too fast is that A misjudges the situation thinking he could safely drive the chosen route. Therefore the genotype *misjudgement of situation* is chosen.

There are three factors contributing to A's misjudgement of the situation.

Firstly, A does not have enough knowledge about the chosen route and therefore the genotype *insufficient skills/knowledge* is chosen, with the addition of the specific genotype *insufficient geographical knowledge/experience*. This contributing-factor-chain then stops in accordance with **stop rule number 1**:

> *Specific genotypes have the status of terminal events. Therefore, if a specific genotype is the most likely cause of a general consequent, that genotype is chosen and the analysis stops.*

The second factor contributing to A's misjudgement of the situation is that A does not have enough knowledge about the lorry he borrowed resulting in him overloading it and also not being aware of the fact that the brakes had been poorly maintained. This fact also fits under the genotype *insufficient skills/knowledge,* which therefore will be present twice in this chart. This contributing-factor-chain then stops in accordance with **stop rule number 3**:

> *If none of the available general or specific genotypes for the chosen consequent is relevant, given the information available about the accident, the analysis stops.*

The third factor contributing to A's misjudgement of the situation is that the brakes do not work as he expects. Therefore the genotype *unpredictable vehicle characteristics* is chosen.

The brakes not working as expected are caused by the lorry being overloaded. Therefore the specific genotype *heavy load* is chosen. This contributing-factor-chain then stops in accordance with **stop rule number 1** (see above).

6 CODING THE RECOVERY PHASE

To code a recovery phase, or in the case of a crash an attempted recovery, a prerequisite is that the driver must have observed and responded to the critical event in some way. This results in two top level categorisations, i.e. : *Recovery* or *No recovery*, where *No recovery* identifies either a crash or a proximity event.

If the event warrants a *Recovery* coding, the following two information categories are of interest to code:

Critical event recognition			
Primary recovery cue (what was it that made the driver realise s/he is in an emergency phase?)	R1	Visual (observation of critical event)	If possible, assess if direct or peripheral (i.e. does the driver initiate response prior to foveal focus on critical event)
	R2	Auditory	Name source if possible (passenger, other vehicle, ADAS,…?)
	R3	Haptic	Name source if possible (rumble strip, shoulder drop, intersection approach strips, etc.)
	R4	ADAS cue? (yes/no)	if yes, which type? Estimate if it influenced driver response (i.e. does the driver respond prior to the cue)

Driver response			
Qualitative		Give short narrative (what does the driver do?)	
Quantitative	S1	braking (yes/no)	if yes, details of braking response (does brake release occur before standstill, etc.?)
	S2	steering (yes/no)	if yes, type of steering (panic vs. controlled, into vs. away from object, left/right, etc.)
	S3	Braking AND steering	See above.
	S4	Autonomous braking / steering	If yes, by which ADAS? Can an onset point be identified?

Note that a recovery can be coded independently of phenotype choice. In cases where *late action* is the selected phenotype, there will obviously be an overlap, but that is ok, as the recovery coding is centered on different aspects of the event.

7 LEVEL OF CONFIDENCE

To help analysts assess which causation information is more and which is less trustworthy, but also to allow for insightful analysis on behalf of the investigator, each causation chain should be coded with the level of confidence one has in that chain. In other words, when you reach the end of an analysis chain, you need to indicate whether you think that the chain represents solid reasoning that is backed up by good data or whether it is more of a conjecture on your part.

There will be three levels of confidence:

- High level of confidence (or confident)
- Reasonable level of confidence (or probable)
- Low level of confidence (or possible)

Below, guidelines for how to code the level of confidence are given. However, the investigator must not follow the guideline recommendation at all times, since it has proven very hard to cover all possibilities in a guideline. For example, the guidelines do not work very well when a driver has told an obvious lie but all other information is coherent and trustworthy. According to the guidelines causation chains that in any way involve driver data should be coded as low but based on the investigator we want this to be possible to code as high.

7.1 HIGH

A causation chain has a high level of confidence if:

- the on-scene investigation is performed while markings and traffic environment conditions used in the analysis are still distinct and in that way the course of event can clearly be established by objective facts, and
- the interviews (with the road user and, if applicable, with witnesses) are carried out within maximum two days after the accident (but the sooner the better of course), and
- data from interviews and on-scene investigation is in accordance with each other.

7.2 REASONABLE

A causation chain has a reasonable level of confidence if:

- some markings or traffic environment conditions used in the analysis are unclear (because the vehicles do not remain on scene, the weather conditions have changed, markings have fade away etc) but the course of event can still be reasonable established by objective facts, and/or
- the interviews are carried out more than two days after the accident, but
- data from interviews and on-scene investigation is still in accordance with each other.

7.3 LOW

A causation chain has a low level of confidence if:

- on-scene investigation has not been performed, or
- driver interview(s) is missing, or
- data from interviews and on-scene investigation contradict each other.

8 AGGREGATION OF IN-DEPTH STUDIES

In-depth accident studies are often used on a case by case basis to get a feeling for a problem or an accident type. This is very valuable, and should continue to be so. There are however also many efforts ongoing at coding the accident contributing factors into some sort of meta-data system, which can then be used as a tool for comparison of different sets of in-depth studies, to identify similarities and/or differences.

The structure of the DREAM classification scheme makes it possible to aggregate any number of DREAM charts to look for patterns among contributing factors. The actual aggregation is very simple. Since all charts must follow the same basic link structure, any number of charts can be "superimposed" on each other by just counting how many times each factor is present at a certain place in the charts. This is illustrated in Figure 29. The two first charts, A and B, are aggregated by counting the frequency of occurrence for all phenotypes, genotypes and links that exist in the carts, and then drawing the aggregated chart C, where the occurrence frequency of contributing factors is added in the boxes, and also highlighted by thicker box borders and arrows. In this example, when A and B are combined, there are two instances of C2, B1 and K2, while the other factors have only one occurance.

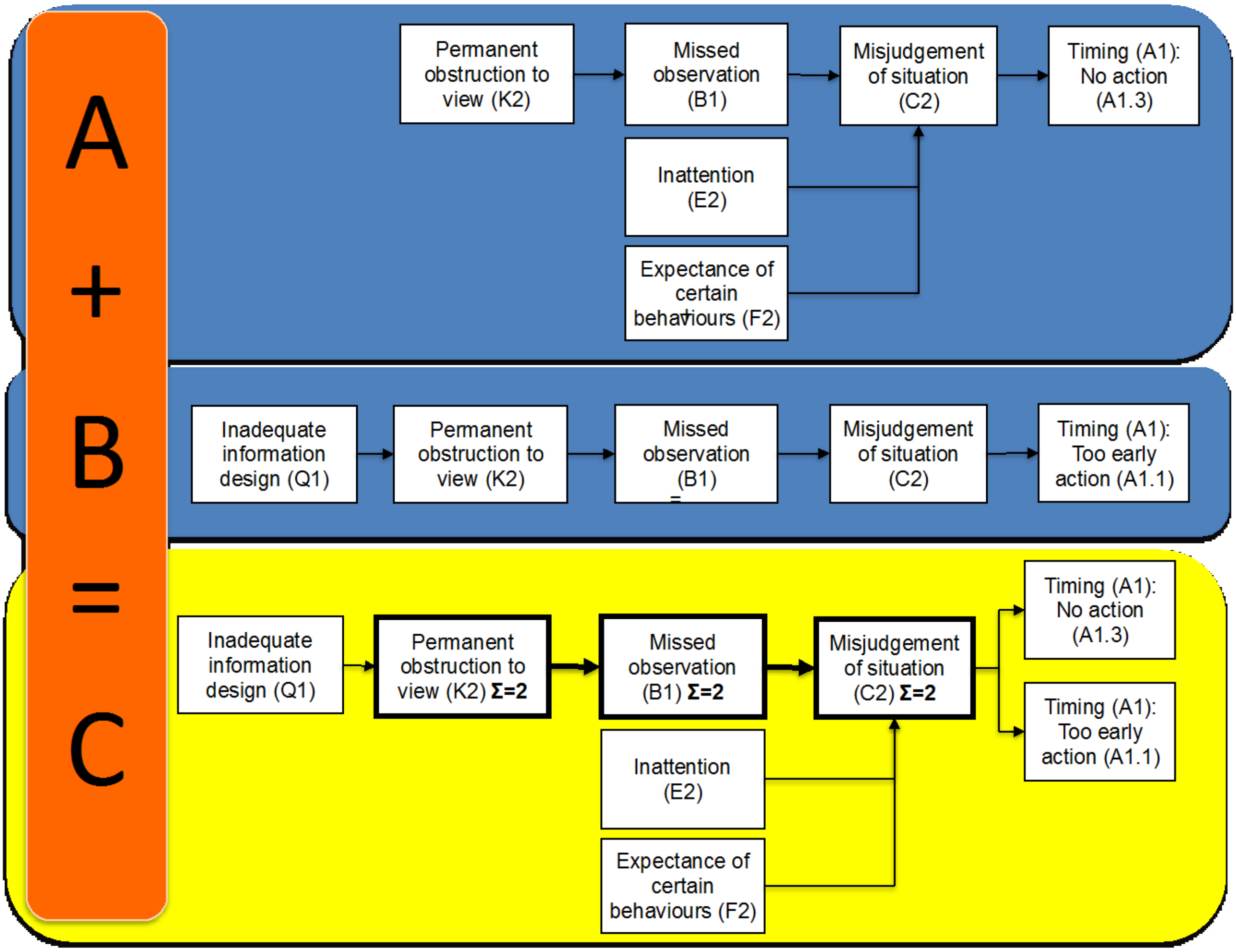


Figure 29: DREAM chart example aggregation

While the aggregation itself is simple, DREAM does in itself not provide principles for how to select which cases to aggregate. The simple reason for this is that it all depend on what the analysis is meant to show. It is possible to identify numerous aggregation principles, some of which are described below:

- Cause based aggregation is where one starts with a particular set of contributing factors, selected on for example a frequency of occurrence basis, and then pulls out all the cases which has these factors as contributors and start looking at which are the most common accident types for these causes. For example, for which crash types is alcohol typically a contributing factor?

- Context based aggregation is virtually the opposite of cause based aggregation, i.e. one selects and aggregates cases based on the context in which they occurred rather than on any particular contributing factor. For example, an aggregation may focus on all accidents that occur in foggy weather on rural roads, or all fatal crashes at intersections. For examples, see Ljung Aust (2010) and Ljung Aust *et al* (2012).

- Trajectory based aggregation is where a conflict typology is defined based on logically possible vehicle movements that can result in a conflict. In this view, three main conflict types (with numerous sub-groups) exist (crashing while in lane, crashing after leaving lane and crossing path crashes), and aggregation is based on these groups. For examples, see SafetyNet D5.8 (2008).

- An event based aggregation is based on some interesting pattern occurring during the sequence of events prior to crash. For example, one accident type may be drivers who panic steer to the left for no apparent reason, all drivers who turn prematurely, all who misses a red light, all who drive much faster than regulations allow, etc. Setting up an event based typology has a large resemblance with detective work, and one has to be very familiar with the source material to find these interesting events. For examples, see Sandin and Ljung (2007).

For a more general review of the opportunities and limitations with aggregation of DREAM charts, see Sandin (2008). However, fur purposes of illustration, an aggregated DREAM chart is provided below. This chart is an aggregation of all the individual DREAM charts for turning drivers involved in fatal intersection crashes in Norway in the years 2005-2007 (n=28).

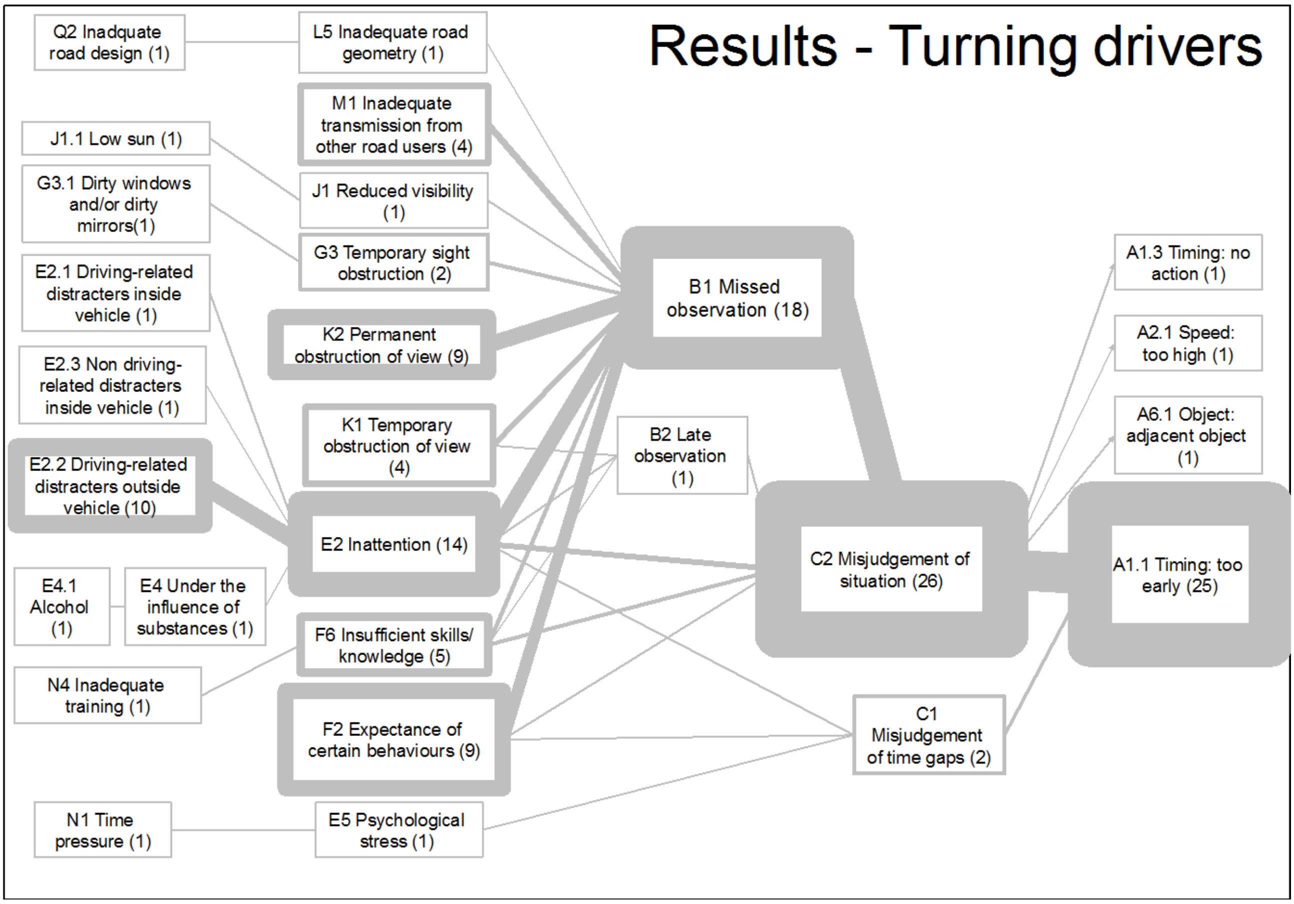


Figure 30: Aggregated DREAM chart for 28 turning drives in Norwegian Intersection crashes with fatal outcome

9 REFERENCES

Allen, T.M., Lunenfeld, H., & Alexander, G. J. (1971). Driver information needs. Highway Research Record, 366(366), 102-115.

Amalberti, R. (2001). The paradoxes of almost totally safe transportation systems. Safety Science, 37(2-3), 109-126.
Brehmer, B. (1990). Variable error set a limit to adaptation. Ergonomics, 33, 1231-1240.

Dekker, S. (2005). Ten questions about human error: a new view of human factors and system safety. Mahwah, N.J.: Erlbaum.

Englund, A., Jarleryd, B., Lindkvist, O., & Pettersson, H.-E. (1978). *TRKs haverikommission. Redovisning av försöksverksamhet* [Traffic Safety Committee of Insurance Companies: Research results]. TRK rapport nr 1. Stockholm, 1978.

Engström, J. and Hollnagel, E. (2007). A General Conceptual Framework for Modelling Behavioural Effects of Driver Support Functions. In P. C. Cacciabue (Ed.), Modelling Driver Behaviour in Automotive Environments Critical Issues in Driver Interactions with Intelligent Transport Systems. London: Springer. pp. 61-84.
Girard, Y. (1994, March). *In-depth accident investigation: A road safety tool.* Paper presented at the 1st Panhellenic Conference on Road Safety, Thessalonique, Greece.

Hockey, G.R.J. (1997). Compensatory control in the regulation of human performance under stress and high workload: A cognitive energetical framework. Biological Psychology 45, 73-93.

Hollnagel, E. (1998) *Cognitive Reliability and Error Analysis Method: CREAM.* Oxford, UK: Elsevier Science Ltd.

Hollnagel, E. (2004) *Barriers and Accident Prevention*, Ashgate, Aldershot.

Hollnagel, E. and D.D. Woods, "Cognitive Systems Engineering: New Wine in New Bottles," *International Journal of Man-Machine Studies*, Vol. 18, pp. 583-600, 1983.

Hollnagel, E. and Woods, D. D. (2005). *Joint cognitive systems. Foundation of cognitive system engineering.* New York: CRC Press, Taylor and Francis Group.

Huang, Ljung, Hollnagel & Sandin, *Accident models for modern road traffic – changing times creates new demands,* IEEE International Conference on Systems, Man & Cybernetics, Hague, Netherlands, 2004.

Huang, Y.-H. (2005). A systemic traffic accident model. Thesis (Licentiate). Linköping: Department of Computer and Information Science, Linköpings universitet.

Huang, Y.-H. (2007). Having a new pair of glasses: applying systemic accident models on road safety. Thesis (PhD). Linköping University, Linköping.

Leveson, N. (2004). A new accident model for engineering safer systems. Safety Science, 42(4), 237-270.

Ljung, M. (2002). *DREAM: Driving Reliability and Error Analysis Method.* (Master's thesis). Retrieved December 10, 2007, from University of Linköping's web site: http://urn.kb.se/ resolve?urn=urn:nbn:se:liu:diva-2033

Ljung, M. (2006). *Manual for SNACS 1.1: SafetyNET Accident Causation System*. Gothenburg, Sweden: Chalmers University of Technology.

Ljung, M., Fagerlind, H., Lövsund, P. & Sandin, J. (2007). Accident investigations for active safety at c Chalmers: New demands require new methodologies. *Vehicle System Dynamics*, *45*, 881–894.

Ljung, M., Furberg, B., & Hollnagel, E. (n.d.). *Handbok för DREAM 2.1.* [Manual for DREAM 2.1]

Ljung Aust, M., (2010). Generalization of case studies in road traffic when defining pre-crash scenarios for active safety function evaluation. Accident Analysis & Prevention 42(4), 1172-1183.

Ljung Aust, M., Fagerlind, H., Sagberg, F. (2012), Fatal intersection crashes in Norway: Patterns in contributing factors and data collection challenges. Accident Analysis and Prevention 45(0): 782-791.

Michon, J.A. (1985). Critical view of driver behavior models: what do we know, what should we do? In Evans, L. and Schwing, R. (eds) Human Behaviors and Traffic Safety, Plenum Press, New York

Rasmussen, J., Duncan, K., Leplat, J, (Eds) (1987). *New technology and human error.* New York: John Wiley and Sons inc.

Reason, J. (1990) *Human Error*, Cambridge University Press, Cambridge.

Reason, J., Hollnagel, E., & Paries, J. (2006). Revisiting the "Swiss cheese" model of accidents, Brétigny-sur-Orge, France: EUROCONTROL Experimental Centre. Report Number: EEC Note Number 13/06.

Rochlin, G.I. (1999). Safe operation as a social construct. Ergonomics, 42(11), 1549-1560.

SAFETYNET (2008). Deliverable 5.8: In-depth Accident Causation Database and Analysis Report. European Road Safety Observatory.

Summala, H. (1996). Accident risk and driver behaviour. Safety Science, 22, 103–117.

Summala, H. (2007). Towards Understanding Motivational and Emotional Factors in Driver Behaviour: Comfort Through Satisficing. In P.C. Cacciabue, ed. Modelling driver behaviour in automotive environments: critical issues in driver interactions with intelligent transport systems. London: Springer. pp. 189-207.

Sandin, J., (2008). Aggregating Case Studies of Vehicle Crashes by Means of Causation Charts: An Evaluation and Revision of the Driving Reliability and Error Analysis Method. Dissertation, Applied Mechanics,Vehicle Safety. Chalmers University of Technology.

Sandin, J., (2009). An analysis of common patterns in aggregated causation charts from intersection crashes. Accident Analysis and Prevention 41(3), 624-632.

Sandin, J. and Ljung, M., (2007). Understanding the causation of single-vehicle crashes: a methodology for in-depth on-scene multidisciplinary case studies. International Journal of Vehicle Safety 2007 2(3), 316 - 333.

Svenson, O., Lekberg, A., and Johansson, A. E. L. (1999). On perspectives, expertise and differences in accident analyses: Arguments for a multidisciplinary integrated approach. *Ergonomics, 42,* 1561-1571.

Wallén Warner, H., Björklund, G., Johansson, E., Ljung Aust, M., and Sandin, J. (2008). *DREAM 3.0. Documentation of references supporting the links in the classification scheme.*

Van Elslande, P., & Fouquet, K. (2007a). Analyzing 'human functional failures' in road accidents Deliverable 5.1, TRACE project

Van Elslande, P., & Fouquet, K. (2007b). Which Factors and Situations for Human Functional Failures? - Developing Grids for Accident Causation Analysis (2007). Deliverable 5.2: TRACE project.

Van Elslande, P., & Fouquet, K. (2007c). Typical human functional failure-generating scenarios: a way of aggregation, Deliverable 5.3, TRACE project.

LINKING TABLE WITH GLOSSARY
FOR phenotypes (CRITICAL EVENTS) AND GENOTYPES (Contributing factors)

PHENOTYPES (A)

General Phenotypes	**Specific Phenotypes**
Timing (A1)	Too early action (A1.1)
	Too late action (A1.2)
	No action (A1.3)
Speed (A2)	Too high speed (A2.1)
	Too low speed (A2.2)
Distance (A3)	Too short distance (A3.1)
Direction (A4)	Wrong direction (A4.1)
Force (A5)	Surplus force (A5.1)
	Insufficient force (A5.2)
Object (A6)	Adjacent object (A6.1)

See section 3.2 Phenotype choices for further information
about at which point in an accident scenario a phenotype should be chosen.

PHENOTYPES (A)

ANTECEDENTS (CAUSES)	CONSEQUENTS (EFFECTS)		
GENERAL Genotypes	**Definition of GENERAL Phenotypes** [2]	**Definitions of SPECIFIC Phenotypes**	**Examples for SPECIFIC Phenotypes**
Misjudgement of time gaps (C1) **Misjudgement of situation (C2)** **Incomplete judgement of situation (C3)** **Fear (E1)** **Fatigue (E3)** **Under the influence of substances (E4)** **Sudden functional impairment (E6)** **Temporary access limitation (G4)** **Equipment failure (I1)** **Strong side wind (J2)** **Missed observation (B1)** **Late observation (B2)**	**Timing (A1)** The timing for initiating an action.	**Too early action (A1.1)** The action is initiated too early, before the signal is given or the required conditions are established.	*Intersection accidents* Starting from a stand still the driver passes the traffic light too early – before it has turned green. Starting from a stand still the driver passes the stop/give way sign too early - before the intersection is free. Starting from a stand still the driver enters the intersection too early - before the intersection is free (this is regardless of whether or not it is the driver's right of way). *OBS! If the driver has past a red traffic light or a stop/give way sign (see above) before entering the intersection the analysis should start by the traffic light/stop sign/give way sign.* *Leaving lane accidents* The driver leaves his own lane in order to overtake the vehicle in front of him too early – before he has free visibility of a stretch of road long enough for him to complete the manoeuvre. *Changing lane accidents* The driver leaves his own lane in order to change lane too early - before the lane he is changing into is free. *Non-crashes* Conditions: 1. Initiation of movement, i.e. starting from stand-still when performing a manoeuvre, such as pulling out, backing-up or turning 2. Initiation of action while moving, indicated by change in velocity and/or direction (reference: precipitating event set at local velocity minima closest to

[2] For non-crashes, code phenotype just before start of evasive maneovre – The end point of the DREAM-analysis should be when/where the evasive maneouvre begins. If there is no evasive maneouvre, use the trigger timing instead. Evasive manouvre definitions can be had from EuroFOT codebook definition.

			action), such as starting a lane change. pulling out or turning. **EXCEPTION**: If there is no state change, it should be coded as late action. A lack of change can refer to either travelling at constant velocity or being in (relatively) constant low acceleration/deceleration. Note that a high acceleration/deceleration rate would be associated with the initiation of an action, and thus fall into category 1 above.
		Too late action (A1.2) The action is initiated too late, for example due to low/late stimuli saliency or unexpected behaviour of another road user. *Note that use of this phenotype is independent of the coding of the recovery phase, i.e. whether they overlap of not does not matter, since the recovery coding focuses on a different aspect of the event.*	*Intersection accidents* The driver starts to brake too late in order to stop for the red traffic light. The driver starts to brake too late in order to stop in front of the stop/give way sign. The driver starts to brake too late to avoid another road user entering his/her travel path. *NOTE! If the driver has gone past a red traffic light or a stop/give way sign (see above) before entering the intersection the analysis should start by the traffic light/stop sign/give way sign.* *Leaving lane accidents* The driver starts to brake and/or make an avoidance manoeuvre too late to avoid an accident when a car (e.g. making an overtaking manoeuvre) is coming towards the driver in his own lane. *Changing lane accidents* The driver starts to brake and/or make an avoidance manoeuvre too late in order to avoid an accident with the car changing into his lane. *Catching up accidents* The driver starts to brake and/or make an avoidance manoeuvre too late in order to avoid an accident with the slow driving/still standing car in front of him. *Non-crashes* For non –crashes, a prerequisite for using this category is that the driver has performed an evasive manoeuvre, i.e. the driver is experiencing a conflict.
Misjudgement of time gaps (C1) **Misjudgement of situation (C2)** **Incomplete judgement of situation (C3)** **Fear (E1)** **Fatigue (E3)**		**No action (A1.3)** No action is initiated.	*Intersection accidents* The driver passes the red traffic light without doing anything (e.g. does not brake in order to stop). The driver passes the stop/give way sign without doing anything (e.g. does not

Under the influence of substances (E4) **Sudden functional impairment (E6)** **Temporary access limitation (G4)** **Equipment failure (I1)** **Strong side wind (J2)** **Missed observation (B1)** **Late observation (B2)**			brake in order to stop). The driver enters the intersection without doing anything to avoid another road user entering his/her travel path. (e.g. does not brake or steer to avoid the conflict). *NOTE! If the driver has past a red traffic light or a stop/give way sign (see above) before entering the intersection the analysis should start by the traffic light/stop sign/give way sign.* *Oncoming accidents* The driver does not act when another vehicle is coming towards the driver in his own lane (e.g. does not brake and/or make an avoidance manoeuvre to avoid an accident). *Changing lane accidents* The driver does nothing to avoid an accident with a vehicle moving into his lane (e.g. the driver might not have seen the vehicle and thus does not act). *Single vehicle accidents* The driver does not act vhen leaving the roadway *Catching up accidents* The driver (e.g. caught in a car queue) does not do anything to avoid being hit from behind (this is regardless of whether or not he has the time and/or space to act). The driver does nothing to avoid an accident with the slow driving/still standing car in front of him (e.g. the driver might not have seen the car in order to act). The driver brakes softly in order to stop in time (for the traffic light, stop/give way sign, traffic in intersection or car queue in front) but does not make any manoeuvres in order to avoid being hit from behind. *Non-crashes* For non- crashes, *no action* means the driver did not perform an evasive manoeuvre. The only way this may instantiate for non-crashes is therefore through high hazard proximity without kinematic change, such as: 1. The ego vehicle crosses the path of another vehicle at relatively constant speed. Support for use of this category is enhanced if the other vehicle performs an evasive manoeuvre. Otherwise, PET should be < 1.5 s. 2. The ego vehicle crosses the lane boundary when there is oncoming traffic without driver intervention

			3. The ego vehicle leaves the roadway without driver intervention 4. The ego vehicle passes close to a VRU at relatively constant speed and performs no detectable evasive manoeuvre. Support for use of this category is enhanced if the VRU performs an evasive manoeuvre.
Misjudgement of time gaps (C1) **Misjudgement of situation (C2)** **Incomplete judgement of situation (C3)** **Fear (E1)** **Fatigue (E3)** **Under the influence of substances (E4)** **Sudden functional impairment (E6)** **Temporary access limitation (G4)** **Equipment failure (I1)** **Strong side wind (J2)** **Missed observation (B1)** **Late observation (B2)**	**Speed (A2)** **The travelling speed.** **Driver compromises margins through inappropriate choice of travelling speed**	**Too high speed (A2.1)** Driving too fast.	*Intersection accidents* The driver approaches the intersection faster then what can be expected by other drivers. *Leaving lane accidents* The driver approaches the meeting car (e.g. making an overtaking manoeuvre) faster then what can be expected by the overtaking driver. The driver drives too fast to take the curve, and stay within his own lane, under the prevailing conditions. *Changing lane accidents* The driver approaches the car changing lane faster then what can be expected by the lane changing driver. *Catching up accidents* The driver catches up with a slower car due to excessive speed. *Non-crashes* 1. The driver is clearly speeding in relation to posted speed limit OR surrounding traffic 2. The driver self-selects a speed which is permitted but which also results in reduced braking and steering vehicle performance (which often comes as a surprise to the driver),e.g. driving fast on icy roads or gravel roads 3. The driver self-selects a speed which is permitted but which results in very short time horizon for detecting unfolding events, e.g. driving fast under reduced visibility conditions (darkness, fog, snow)
		Too low speed (A2.2) Driving too slowly.	*Catching up accidents* The driver is caught up because he drives slower than what can be expected by other drivers.

Misjudgement of time gaps (C1) **Misjudgement of situation (C2)** **Incomplete judgement of situation (C3)** **Fear (E1)** **Fatigue (E3)** **Under the influence of substances (E4)** **Sudden functional impairment (E6)** **Temporary access limitation (G4)** **Equipment failure (I1)** **Strong side wind (J2)**	**Distance (A3)** **The space between objects.**	**Too short distance (A3.1)** The distance between the vehicle and other objects(margins in space and/or time) is kept too small.	*Catching up accidents* The driver keeps a too short distance to the car in front of him. *Non-crashes* An evasive manoeuvre is preceded by the driver compromising margins through inappropriate choice of following distance to moving object or lateral distance to moving and/or stationary objects: 1. (Self selected) time headway in LV following situation < 0.5 s (the actual number used in analysis can be either regional or driver adapted), and forced to perform evasive manoeuvre when LV brakes even for moderate LV braking levels. 2. (Self selected) lateral distance to moving object < 0.5 m for more than 1.0 s, and when vehicle in adjacent lane swerves this triggers evasive lateral manoeuvre in ego vehicle driver (due to being too close to begin with) 3. Ego vehicle (by own choice) enters a situation with obviously tight lateral margins, such as overtaking a truck on 2+1 road (truck width = 2.6 m, lane width = 3.25 m. 4. Driver performs lateral evasive manoeuvre due to own perception of lateral distance to stationary object(s) being insufficient (the evasive manoeuvre acts as evidence of driver perception).
Misjudgement of time gaps (C1) **Misjudgement of situation (C2)** **Incomplete judgement of situation (C3)** **Fear (E1)** **Fatigue (E3)** **Under the influence of substances (E4)** **Sudden functional impairment (E6)** **Temporary access limitation (G4)** **Equipment failure (I1)** **Strong side wind (J2)**	**Direction (A4)** **The direction of the vehicle.**	**Wrong direction (A4.1)** The manoeuvre is made in the wrong direction.	*Intersection accidents: Illegally turning etc.* The driver initiates an illegal left/right turn. *Leaving lane accidents* The driver leaves his own lane on a straight road or in a curve. *One-way lane/street accidents* The driver enters a lane or a one-way street against the traffic flow.
Misjudgement of time gaps (C1) **Misjudgement of situation (C2)** **Incomplete judgement of situation (C3)** **Fear (E1)** **Fatigue (E3)** **Under the influence of substances (E4)** **Sudden functional impairment (E6)** **Temporary access limitation (G4)** **Equipment failure (I1)** **Strong side wind (J2)** **Missed observation (B1)**	**Force (A5)** **The force with which an action is conducted.**	**Surplus force (A5.1)** Too much force is used.	*Leaving lane accidents* The driver steers too hard resulting in him leaving his own lane. *Catching up accidents* The driver brakes harder (e.g. emergency braking) than what can be expected by other drivers.
		Insufficient force (A5.2) Too little force is used.	*Insufficient brake accidents* The driver does not brake hard enough to stop in time (this can also be caused by insufficient brakes).

Late observation (B2)			
Misjudgement of time gaps (C1) **Misjudgement of situation (C2)** **Incomplete judgement of situation (C3)** **Fear (E1)** **Fatigue (E3)** **Under the influence of substances (E4)** **Sudden functional impairment (E6)** **Temporary access limitation (G4)** **Equipment failure (I1)** **Strong side wind (J2)** **Missed observation (B1)** **Late observation (B2)**	**Object (A6)** **An item or a control.**	**Adjacent object (A6.1)** An item/control in close proximity to the correct item is wrongly chosen.	*Unintentional acceleration accidents* The driver mistakes the accelerator pedal for the brake pedal.

GENOTYPES (B-Q)

HUMAN (B-F)

Driver

B: Observation
Missed observation (B1)
Late observation (B2)
False observation (B3)

C: Interpretation
Misjudgement of time gaps (C1)
Misjudgement of situation (C2)
Incomplete judgement of situation (C3)

D: Planning
Priority error (D1)

E: Temporary Personal Factors
Fear (E1)
Attention allocation (E2)
Fatigue (E3)
Under the influence of substances (E4)
Excitement seeking (E5)
Sudden functional impairment (E6)
Psychological stress (E7)

F: Permanent Personal Factors
Permanent functional impairment (F1)
Expectance of certain behaviours (F2)
Expectance of stable road environment (F3)
Habitually stretching rules and recommendations (F4)
Overestimation of skills (F5)
Insufficient skills/knowledge (F6)

TECHNOLOGY (G-M)

Vehicle (G-I)

G: Temporary HMI problems
Temporary illumination problems (G1)
Temporary sound problems (G2)
Temporary sight obstructions (G3)
Temporary access limitations (G4)
Incorrect ITS-information (G5)

H: Permanent HMI problems

Permanent illumination problems (H1)
Permanent sound problems (H2)
Permanent sight obstruction (H3)

I: Vehicle equipment failure
Equipment failure (I1)

Traffic environment (J-M)

J: Weather conditions
Reduced visibility (J1)
Strong side winds (J2)

K: Obstruction of view due to object
Temporary obstruction of view (K1)
Permanent obstruction of view (K2)

L: State of road
Insufficient guidance (L1)
Reduced friction (L2)
Road surface degradation (L3)
Object on road (L4)
Inadequate road geometry (L5)

M: Communication
Inadequate transmission from other road users (M1)
Inadequate transmission from road environment (M2)

ORGANISATION (N-Q)

Organisation

N: Organisation
Time pressure (N1)
Irregular working hours (N2)
Heavy physical activity before drive (N3)
Inadequate training (N4)

O: Maintenance
Inadequate vehicle maintenance (O1)

Inadequate road maintenance (O2)

P: Vehicle design
Inadequate design of driver environment (P1)
Inadequate design of communication devices (P2)
Inadequate construction of vehicle parts and/or structures (P3)
Unpredictable system characteristics (P4)

Q: Road design
Inadequate information design (Q1)
Inadequate road design (Q2)

OBSERVATION (B)

Observation includes detection as well as recognition of information that should have been the start of an action.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
Fear (E1) **Attention allocation towards other than critical event (E2)** **Fatigue (E3)** **Under the influence of substances (E4)** **Sudden functional impairment (E6)** **Psychological stress (E7)** **Permanent functional impairment (F1)** **Expectance of certain behaviours (F2)** **Expectance of stable road environment (F3)** **Insufficient skills/knowledge (F6)** **Temporary illumination problem (G1)** **Temporary sound problems (G2)** **Temporary sight obstruction (G3)** **Permanent illumination problem (H1)** **Permanent sound problems (H2)** **Permanent sight obstruction (H3)** **Equipment failure (I1)** **Reduced visibility (J1)** **Temporary obstruction to view (K1)** **Permanent obstruction to view (K2)** **Inadequate road geometry (L5)** **Inadequate transmission from other road users (M1)** **Inadequate transmission from road environment (M2)** **Misjudgement of time gaps (C1)** **Misjudgement of situation (C2)**	**Tunnel vision (B1.1)** The driver's peripheral vision is limited.	When the driver experiences high speed, the peripheral vision diminishes from 180 degrees to as little as 20-30 degrees thus reducing awareness of, or possibility to detect, objects to the side of the road.	**Missed observation (B1)** Some information (signal, sign or event) is missed. The reason for this can either be visual restrictions, i.e. that something is hidden, or that it is not noticed by the driver because s/he is not looking in the direction where the information can be obtained (such as a driver who does not look to the left at an intersection where s/he has a green light). For some situations, B1 is not appropriate. For example: if a driver already has seen a pedestrian (the pedestrian is clearly visible),but that pedestrian suddenly (unexpectedly) starts to cross the street, then choose C3 and link to F2 instead If a driver already has seen a pedestrian but looks away when the pedestrian initiates a sudden action (crossing street): choose C3 and link to F2 and/or E2 as appropriate

Fear (E1) **Attention allocation towards other than critical event (E2)** **Fatigue (E3)** **Under the influence of substances (E4)** **Sudden functional impairment (E6)** **Psychological stress (E7)** **Permanent functional impairment (F1)** **Expectance of certain behaviours (F2)** **Expectance of stable road environment (F3)** **Insufficient skills/knowledge (F6)** **Temporary illumination problem (G1)** **Temporary sound problems (G2)** **Temporary sight obstruction (G3)** **Permanent illumination problem (H1)** **Permanent sound problems (H2)** **Permanent sight obstruction (H3)** **Equipment failure (I1)** **Reduced visibility (J1)** **Temporary obstruction to view (K1)** **Permanent obstruction to view (K2)** **Inadequate road geometry (L5)** **Inadequate transmission from other road users (M1)** **Inadequate transmission from road environment (M2)** **Misjudgement of time gaps (C1)** **Misjudgement of situation (C2)**	**Tunnel vision (B2.1)** The driver's peripheral vision is limited.	When the driver experiences high speed, the peripheral vision diminishes from 180 degrees to as little as 20-30 degrees thus reducing awareness of, or possibility to detect, objects to the side of the road.	**Late observation (B2)** The observation of some information (signal, sign or event) is correct but comes late, i.e. the observation is made after entering the discontinuity or emergency phase of the event, when the time and space available to respond is severely limited.
Attention allocation towards other than critical event (E2) **Fatigue (E3)** **Under the influence of substances (E4)** **Sudden functional impairment (E6)** **Psychological stress (E7)** **Permanent functional impairment (F1)** **Temporary illumination problem (G1)** **Temporary sound problems (G2)** **Temporary sight obstruction (G3)** **Equipment failure (I1)** **Reduced visibility (J1)** **Misjudgement of time gaps (C1)** **Misjudgement of situation (C2)**	**None defined**		**False observation (B3)** Some information (object, signal, sign or event) is misunderstood / misinterpreted as something else (e.g. the driver mistakes a motorcycle for a moped or thinks it is green because of looking at the wrong traffic light).

<table>
<tr><th colspan="4">INTERPRETATION (C)
Interpretation includes, for all but novice drivers, quick and automated (routine) procedures where typical situations and their associated actions are recognized and acted upon (script choice). Mistakes in interpretation occur at the sharp end - within the local event horizon.</th></tr>
<tr><th colspan="3">ANTECEDENTS</th><th>CONSEQUENTS</th></tr>
<tr><th>GENERAL Genotypes</th><th>SPECIFIC Genotypes (with definitions)</th><th>Examples for SPECIFIC Genotypes</th><th>GENERAL Genotypes (with definitions)</th></tr>
<tr>
<td>Late observation (B2)
False observation (B3)
Attention allocation towards other than critical event (E2)
Fatigue (E3)
Under the influence of substances (E4)
Psychological stress (E7)
Permanent functional impairment (F1)
Expectance of certain behaviours (F2)
Expectance of stable road environment (F3)
Habitually stretching rules and recommendations (F4)
Overestimation of skills (F5)
Insufficient skills/knowledge (F6)
Incorrect ITS-information (G5)
Reduced visibility (J1)
Insufficient guidance (L1)
Reduced friction (L2)
Inadequate road geometry (L5)
Inadequate transmission from road environment (M2)
Unpredictable system characteristics (P4)</td>
<td>Misjudgement of time gap due to incorrect speed estimate (C1.1)
The driver misjudges the time gap due to a misjudgement of the approaching vehicle’s speed.</td>
<td>Intersection
The driver is waiting to cross a street and assumes that the approaching car is keeping the 50 km/h speed limit. The car is, however, approaching at 70 km/h and as a result the driver overestimates the time gap he has to the approaching car.
Overtaking
The driver is overtaking another car when he suddenly realise that he has underestimated the meeting car’s speed and therefore also overestimated the available gap for the overtaking.
Catches up from behind
The driver is changing lanes when he suddenly realise that he has underestimated the speed of the car catching up from behind (in the lane he is changing into), and therefore he has also underestimated the available time gap.
Approaches from behind
The driver underestimates the time gap to the car in front of him because he overestimates its speed.</td>
<td>Misjudgement of time gaps (C1)
The estimation of time gaps (e.g. time left to approaching vehicle, stop sign, traffic lights etc.) is incorrect. In order to misjudge a time gap the object (e.g. approaching vehicle, stop sign, traffic lights etc.) must have been observed!</td>
</tr>
</table>

Missed observation (B1) **Late observation (B2)** **False observation (B3)** **Priority error (D1)** **Attention allocation towards other than critical event (E2)** **Fatigue (E3)** **Under the influence of substances (E4)** **Psychological stress (E7)** **Permanent functional impairment (F1)** **Expectance of certain behaviours (F2)** **Expectance of stable road environment (F3)** **Habitually stretching rules and recommendations (F4)** **Overestimation of skills (F5)** **Insufficient skills/knowledge (F6)** **Incorrect ITS-information (G5)** **Reduced visibility (J1)** **Insufficient guidance (L1)** **Reduced friction (L2)** **Road surface degradation (L3)** **Object on road (L4)** **Inadequate road geometry (L5)** **Inadequate transmission from road environment (M2)** **Unpredictable system characteristics (P4)**	**None defined**		**Misjudgement of situation (C2)** The situation is misjudged, i.e. the cues necessary for anticipating the critical event are present in the environment, but the driver either interprets them erratically or not at all. (e.g. the driver thinks that it is safe to enter the intersection as he/she has not noticed the traffic lights turning red or another vehicle with right of way approaching). *- Do not use if the driver is in full control and prepared to act (e.g. a pedestrian suddenly turns and steps out in front of the car, and the driver immediately brakes but the available time/space is insufficient to avoid a collision). In this case, use* ***Incomplete Judgement of Situation (C3)*** *- Do not use for totally unexpected and/or very sudden events that could not have been anticipated by the driver (e.g. animal suddenly jumping up on road at night). In this case, use* ***Incomplete Judgement of Situation (C3)***
Missed observation (B1) **Late observation (B2)** **Expectance of certain behaviours (F2)** **Expectance of stable road environment (F3)** **Incorrect ITS-information (G5)** **Reduced visibility (J1)** **Insufficient guidance (L1)** **Reduced friction (L2)** **Road surface degradation (L3)** **Object on road (L4)** **Inadequate road geometry (L5)** **Inadequate transmission from road environment (M2)** **Unpredictable system characteristics (P4)**	**None defined**		**Incomplete judgement of situation (C3)** In retrospect, the driver's (road user's) understanding of the situation was incomplete; however, it could not reasonably be expected of the driver (road user) to predict the event at the time it occurred. This code is valid for events which are very surprising, either in terms of their nature (e.g. an airplane landing on the road) or in terms of how quickly they happen, i.e. they develop so fast a normal driver cannot be expected to respond in time (e.g. an animal suddenly running out on the road at night),

PLANNING (D)

Planning includes fairly conscious and time consuming processes covering upcoming situations and eventualities beyond the local event horizon.
Planning is a less frequent event than interpretation.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
Fear (E1) **Excitement seeking (E5)** **Psychological stress (E7)** **Habitually stretching rules and recommendations (F4)**	**None defined**		**Priority error (D1)** The driver prioritizes something else above safe arrival at the destination (e.g. uses the bus lane to save time or drives very fast to impress friends). This covers strategic planning where there is a conflict between safety and other goals independent of if the driver is aware of this conflict or not (see definition for planning). **Guidelines for coding:** Less severe traffic violations are not considered if it is part of the normal traffic culture at the location, e.g. slowing down but not stopping at stop signs are common traffic behaviour in Japan, and is therefore not considered as a priority error. Priority errors, e.g. excessive speeding, may be assessed for the whole trip (or several seconds to minutes if this is the only option) before the accident/incident. Crossing an intersection where the light is yellow and about to turn red is not coded as priority error unless there is information suggesting that the driver is taking a deliberate risk. Instead this is included in misjudgement of time gaps OR misjudgement of situation. Situations where the driver is trying to get ahead of another vehicle or traffic light can be coded as a priority error. In video data, the drivers intention to get ahead can be judged by for instance speeding up when the light turns yellow, or as a combination of maintaining speed and looking at the other vehicle s/he is trying to get ahead of.

TEMPORARY PERSONAL FACTORS (E)

Temporary personal factors includes temporary, or short-term, factors influencing driver’s perception, interpretation, planning etc.

ANTECEDENTS			CONSEQUENTS)
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
Sudden functional impairment (E6)	**Previous experience (E1.1)** The driver has previously experienced a similar traffic situation in which it was a negative outcome.	The driver is anxious about a particular situation due to previous bad experience or accident.	**Fear (E1)** Being afraid of something or being scared by a sudden event (e.g. the lead vehicle making an emergency brake or an animal jumping onto the road in front of you).
Under the influence of substances (E4) **Expectance of certain behaviours (F2)** **Inadequate design of driver environment (P1)**	**Attention allocation towards driving-related event other than the critical event INSIDE vehicle (E2.1)** The driver is distracted by a driving-related object or event inside the vehicle.	The driver focuses his attention on the how far s/he can travel given how much fuel is left or what to do about an error message that has popped up.	**Attention allocation towards other than critical event (E2)** Any condition, state or event that causes the driver to allocate gaze attention elsewhere than towards critical event. *The distinction driving-related vs. non-driving related is artificial, and introduced only to separate out phenomena which are interesting from a vehicle manufacturer perspective. From a driver perspective, any activity done in the car on a repetitive basis would probably be conceived of as part of normal driving (VTTI estimates 23.5 % secondary task engagement during total driving time)*
	Attention allocation towards driving-related event other than the critical event OUTSIDE vehicle (E2.2) The driver is distracted by a driving-related object or event outside the vehicle.	The driver focuses his attention on road signs or an animal standing dangerously close to the road.	
	Attention allocation toward non-driving related event INSIDE vehicle (E2.3) The driver is looking at non driving-related object or event inside the vehicle.	The driver looks at cell phone	
	Attention allocation toward non-driving related event OUTSIDE vehicle (E2.4) The driver is looking at a non driving-related object or event outside the vehicle.	The driver looks at a friend walking past on the pavement.	
	Intentional gaze blocking (hiding from the law) (E2.5) The driver is covering his eyes/face to avoid identification	The driver is speeding past an automatic speed camera and hides his/her face to avoid identification	
	Taking part in conversation (E2.6) The driver/VRU is preoccupied with an ongoing conversation topic.	The driver/VRU is speaking and/or listening to another person present , or someone on the phone.	

	Performing secondary task (E2.7) The driver/VRU is performing one or more secondary tasks which do not involve a clear and/or continuous diversion of gaze from the forward roadway, but which may still influence primary task performance (i.e. driving/walking).	The driver adjusts seat, climate settings, radio channel or volume, etc. A VRU is attending a nomadic device A VRU attending other VRU (e.g. parent is attending walking child or child on a bike)	
	Mind off critical event - Daydreaming (E2.8) The driver is distracted by his/her own thoughts – for example, by thinking about a pressing personal problem or other emotional condition	The driver is en route to/from a funeral, or driving home from the hospital after having received some form of bad news.	
	Mind off critical event - Way finding (E2.9) The driver is preoccupied by figuring out which way to go	The driver is considering for example which is the best overall route choice, which exit to take, or whether to turn at the next intersection.	
	Other (E2.10) Some form of attention allocation towards other than critical event, which is not covered by E2.1-E2.9.		

Under the influence of substances (E4) **Reduced visibility (J1)** **Time pressure (N1)** **Irregular working hours (N2)** **Heavy physical activity before drive (N3)** **Inadequate design of driver environment (P1)**	**Sleep disorders (E3.1)** The driver suffers from a sleep disorder.	The driver suffers from sleep apnoea syndrome, of which the symptoms are heavy snoring and sleep disturbance resulting in daytime sleepiness.	**Fatigue (E3)** Being sleepy, tired or exhausted (mentally or physically).
None defined	**Alcohol (E4.1)** The driver is under the influence of alcohol.	The driver's performance is impaired as a result of being influenced by alcohol.	**Under the influence of substances (E4)** Being affected by different sorts of substances.
	Drugs (E4.2) The driver is under the influence of non-prescribed drugs.	The driver's performance is impaired as a result of taking ecstasy.	
	Medication (E4.3) The driver is under the influence of prescribed drugs.	The driver's performance is impaired as a result of taking strong sedatives.	
None defined	**None defined**		**Excitement seeking (E5)** Looking for adrenaline-kicks (e.g. by driving in high speed)
None defined	**Epilepsy (E6.1)** The driver suffers an epileptic seizure.	The driver is unresponsive or unconscious due to an epileptic seizure.	**Sudden Functional Impairment (E6)** Sudden onset of functional impairment due to illness. Does not include different kinds of sleep disorders!
	Diabetes (E6.2) The driver suffers a critically low concentration of insulin in the blood.	The driver is sweating and shivering before becoming unconscious due to low concentration of insulin in the blood.	
	Stroke (E6.3) The driver suffers a stroke.	The driver is sweating and shivering before becoming unconscious due to a stroke.	
	Coughing /Sneezing (E6.4)	The driver suffers a violent burst of coughing or sneezing	
Fatigue (E3) **Reduced visibility (J1)** **Inadequate road maintenance (O2)** **Time pressure (N1)** **Irregular working hours (N2)** **Inadequate road design (Q2)**	**Peer pressure (E7.1)** The driver experiences stress due to peer pressure.	The driver is feeling stressed because the car is full of passengers he wants to impress.	**Psychological stress (E7)** Different mental factors putting a strain on the driver.
	Stressful life events (E7.2) The driver experiences stress due to stressful life events (e.g. receiving bad news, newly divorce, recent loss of a loved one).	The driver is experiencing stress as he has just filed for divorce.	

PERMANENT PERSONAL FACTORS (F)

Permanent personal factors includes permanent, or long-term, factors influencing driver's perception, interpretation, planning etc.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
None defined	**Reduced vision (F1.1)** The driver's ability is impaired due to reduced vision.	The driver finds it difficult to drive at night due to reduced vision.	**Permanent functional impairment (F1)** Permanent or long term, functional impairment due to, for example, ageing, chronic illness or injury.
	Reduced hearing (F1.2) The driver's ability is impaired due to reduced hearing.	The driver finds it difficult to hear another road user honking his horn due to reduced hearing.	
	Reduced motor skills (F1.3) The driver's ability is impaired due to reduced motor skills.	The driver finds it difficult to look around properly when reversing due to reduced mobility.	
	Reduced cognitive capacity (F1.4) The driver's ability is impaired due to reduced cognitive capacity.	The driver finds it difficult to make decisions in complex traffic environments due to reduced cognitive capacity.	
None defined	**Violation of continuation expectancy (F2.1)** The driver does not expect other traffic elements to change their style of movement abruptly	Sudden braking, steering or acceleration manoeuvres by another traffic element when there is nothing in the environment that could warrant or predict such behaviour. Examples include sudden accelerations by motorcycles and sudden changes of direction and/or speed by VRUs	**Expectance of certain behaviours (F2)** Expecting other road users to behave in certain ways following praxis.
	Rule following expectancy (F2.2) Expecting other road users to behave in certain ways following praxis	Expecting other drivers to stop for stop signs and red-lights, give way when driving on a non-priority or minor road and mostly comply with the speed limits. Expecting pedestrians to use zebra crossings when near those. This expectancy is still present even if no other road users are in view (e.g. when	

		approaching a blind corner drivers expect oncoming traffic to keep to their lane).	
	Expectancy of recurrent patterns (F2.3) – (requires interview data)	"There should be no traffic from the right in this local intersection where I've not encountered any vehicle from the right in all my driving career".	
	Action completion expectancy (F2.4) The driver expects other traffic elements to complete rather than abort manoeuvres once they are initiated	Vehicles which initiate lane changes, turns at intersections and/or start to pull out from stopped position (e.g.at traffic light) should complete the initiated manoeuvre (no mid-action abortions of manoeuvres).	
	Illusion of visibility (F2.5) Driver of PTW or bicycle believes other road users can see him/her clearly, and thus for example will give right of way		
None defined	**None defined**		**Expectance of stable road environment (F3)** Expecting no changes to the road environment (e.g. no new road signs or roundabouts) on familiar roads.
None defined	**Driving on rear wheel (F4.1)**		**Habitually stretching rules and recommendations (F4)** Habitually stretching rules and recommendations (e.g. habitually speeding or not stopping at stop signs or red traffic lights) as previous performance has not resulted in any negative consequences
	Straddling lane (F4.2) A PTW advances in dense traffic by driving between other vehicles (i.e. on the lane marker)		
	Slalom (F4.3) A PTW advances in dense traffic by slaloming between other vehicles		
Under the influence of substances (E4) **Insufficient skills/knowledge (F6)**	None defined		**Overestimation of skills (F5)** Overestimating one's own driving skills (e.g. overestimating the speed in which one is able to keep control over the vehicle).

Inadequate training (N4)	**Insufficient geographical knowledge/experience (F6.1)** The driver has insufficient knowledge or experience about the local area.	The driver, who is a visitor from a country with left-hand traffic, ends up, by mistake, on the wrong side of the road in a country with right-hand traffic.	**Insufficient skills/knowledge (F6)** Lack of practical skills (e.g. having to look down in order to change gear) and/or theoretical knowledge (e.g. not knowing the give way rules or the meaning of a road sign).

TEMPORARY HMI PROBLEMS (G)

Temporary HMI problems include temporary, or short-term, problems with human-machine-interfaces related to the vehicle.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
Equipment failure (I1)	**None defined**		**Temporary illumination problems (G1)** The light inside the vehicle is too strong (e.g. causing reflexes) or too weak (e.g. causing reduced colour vision).
Equipment failure (I1)	**None defined**		**Temporary noise problems (G2)** Noise levels surrounding the driver are too high (e.g. the driver cannot hear the sirens on the ambulance as music is played at high volume).
Equipment failure (I1)	**Dirty windows and/or dirty mirrors (G3.1)** Dirty windows or dirty mirrors obstruct the driver's view.	The driver cannot see the car ahead clearly because of dirt on the wind screen.	**Temporary sight obstruction (G3)** The view is temporarily obstructed.
	Luggage (G3.2) Luggage or other objects obstruct the driver's view.	The driver cannot see out of the rear window because of bags obstructing the view.	
	Passengers (G3.3) People or pets inside the vehicle obstruct the driver's view.	The driver can not see out of the rear window because a tall passenger seated in the middle of the back seat obstructs the view.	
	Dirty/blocked visor (G3.4) The helmet visor is difficult to see through due to mud splashes, rain, or similar		
Equipment failure (I1)	**Temporary obstruction (G4.1)** Temporary obstruction makes it difficult for the driver to reach one or more items/controls in the driver environment.	The driver finds it difficult to reach the brake pedal because he did not adjust the seat before starting to drive.	**Temporary access limitations (G4)** Temporary problems for the driver to reach or find items/controls in the driver environment.

Equipment failure (I1) **Inadequate design of driver environment (P1)**	**None defined**		**Incorrect ITS-information (G5)** Information given by an ITS-device (e.g. navigation, speed-information) is ambiguous, incorrect or missing.

PERMANENT HMI PROBLEMS (H)

Permanent HMI problems include permanent, or long-term, problems with human-machine-interfaces related to the vehicle.

ANTECEDENTS			CONSEQUENTS)
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
Inadequate design of driver environment (P1)	**Weak light (H1.1)** The light inside the vehicle is too weak.	The driver has difficulty seeing the speedometer as the illumination of the dashboard is too weak.	**Permanent illumination problems (H1)** The light, on e.g. the dashboard, is too strong (causing glare) or too weak.
Inadequate design of driver environment (P1)	**Low sound signal (H2.1)** The signals from different driver support systems inside the vehicle are too low.	The driver has difficulty hearing the warning signal of the speed warning device as the signal is too low.	**Permanent sound problems (H2)** The sound signals inside the vehicle are too high (causing startle) or too low.
Inadequate design of driver environment (P1)	**Scratched / miscoloured visor (H3.1)** The helmet visor is difficult to see through due to scratches, miscolouring's, etc.		**Permanent sight obstruction (H3)** The view is permanently obstructed by parts of the vehicle.

VEHICLE EQUIPMENT FAILURE (I)

Vehicle equipment failure includes failures of the vehicle or any equipment or system related to it.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
Inadequate vehicle maintenance (O1) **Inadequate design of communication devices (P2)** **Inadequate construction of vehicle parts and/or structures (P3)**	**Cold tires (I1.1)** **PTW tires are cold and thus have reduced friction**		**Equipment failure (I1)** Some piece of equipment (e.g. tyres, steering, brake system or lighting) does not perform as intended or does not work at all (because it has broken).

WEATHER CONDITIONS (J)

Weather conditions include reduced visibility and stability due to environmental factors.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
None defined	**Low sun (J1.1)** Low sun facing the driver makes it difficult to see.	The driver cannot see the brake lights on the car in front as the low sun is shining directly in his eyes.	**Reduced visibility (J1)** The visibility is reduced due to low sun, fog, darkness etc.
	Low contrast (J1.2) Pedestrian or other traffic object is difficult to distinguish from background due to low contrast (/ is difficult to distinguish from background	Pedestrian wearing dark clothes at night,	
None defined	**Non defined**		**Strong side wind (J2)** The stability of the vehicle is affected by strong side wind

OBSTRUCTION OF VIEW DUE TO OBJECT (K)

Obstruction to view due to objects includes all temporary and permanent objects, in the traffic environment, obstructing the drivers' view.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
None defined	**Partial obstruction of view (K1.1)** Low acuity due to PARTIAL obstruction of view.	Low fence or row of parked cars partially obscure bicyclist/pedestrian	**Temporary obstruction of view (K1)** Objects (e.g. driven or parked vehicles, gatherings of people) in the traffic environment cause temporary obstruction of view.
Inadequate information design (Q1) **Inadequate road design (Q2)**	**None defined**		**Permanent obstruction of view (K2)** Objects (e.g. buildings, fences, signs, vegetation) in the traffic environment cause permanent obstruction of view.

STATE OF ROAD (L)

State of the road includes problems with the road itself and its surface as well as the friction between the surface and tyres.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
Inadequate road maintenance (O2) **Inadequate road design (Q2)**	**None defined**		**Insufficient guidance (L1)** The road guidance (painted lane markings, cat's eyes, roadside reflectors etc.) is insufficient.
Equipment failure (I1) **Inadequate road maintenance (O2)** **Inadequate road design (Q2)**	**Low noise tarmac in rain (L2.1)** Low noise tarmac, that has become wet, can make the road surface very slippery due to very small rubber particles (the noise damping stuff) surfacing from cracks in the tarmac.	The driver finds a road with low noise tarmac very slippery after a light drizzle.	**Reduced friction (L2)** The friction is reduced due to ice, snow, oil, gravel etc. on the road or due to bad tyres on the vehicle.
Inadequate road maintenance (O2) **Inadequate road design (Q2)**	**None defined**		**Road surface degradation (L3)** The road surface has degraded (e.g. have potholes or deep ruts). Does not include problems resulting in reduced friction!
Inadequate road maintenance (O2)	**Animals (L4.1)** Animals, dead or alive, are on the road.	The driver's progression is hindered by a dead badger lying in the middle of the road or wild dears crossing the road.	**Object on road (L4)** The road is partly, or completely, blocked by objects other than vehicles (e.g. stones, exploded tires, lost cargo, animals).
Inadequate road design (Q2)	**None defined**		**Inadequate road geometry (L5)** The road geometry (e.g. curves, camber, road shoulder) is inadequate.

COMMUNICATION (M)

Communication includes failures to transmit correct information from other road users or from the traffic environment to the driver.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
	Insufficient transmission (M1.1) Another road user fails to communicate expected/relevant signals/information	Not using indicator before turning Vehicle lacks functioning brake lights (they do not light up when braking)	**Insufficient / inappropriate transmission from other road users (M1)** Other road users fail to transmit information or the information transmitted is ambiguous, incorrect or inappropriate.
	Inappropriate transmission (M1.2) The communication from another road user deepens a conflict rather than resolves it	Driver one at an intersection signals to driver two that s/he can go, but does not realise a third vehicle with priority over both driver one and two is approaching	
Inadequate information design (Q1)	**None defined**		**Inadequate transmission from road environment (M2)** The road environment fails to transmit information to the driver and/or the vehicle (e.g. traffic lights or transmitters to ITS systems are out of order, warning signs or signals are missing) or the information transmitted is ambiguous or incorrect.

ORGANISATION (N)

Organisation includes structures in social- or working life which might impede the private- or professional driver's driving performance.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
None defined	**Being late (N1.1)** Being late for a professional or private appointment makes the private driver experience time pressure.	The private driver experiences time pressure as he is late for work, nursery pick-up, a party or some other professional or private appointment.	**Time pressure (N1)** Private or professional obligations resulting in time pressure.
	Inadequate time schedule (N1.2) Working under tight time margins for pick-ups and deliveries makes the professional driver feel pressured to exceed the legal speed limit and/or the legal number of working hours.	The professional bus driver experiences time pressure as his time table is very tight.	
None defined	**Night shift (N2.1)** Working night shift forces the private driver to drive home during the circadian morning dip.	The private driver is driving home early in the morning after having worked at a hospital all night.	**Irregular working hours (N2)** Irregular working hours makes it difficult to follow the circadian rhythm.
	Scheduled night driving (N2.2) Night driving makes it hard for the professional driver to follow the circadian rhythm.	The professional truck driver drives all night in order to deliver his goods on time.	
None defined	**Heavy physical activity for private drivers (N3.1)** Heavy physical activity precedes the private driver's drive.	The private driver drives home after a heavy days work in the forest or after having participated in an important football match.	**Heavy physical activity before drive (N3)** Heavy physical activity or work before the private or professional driver's drive.
	Heavy physical work for professional drivers (N3.2) Heavy physical work precedes the professional driver's drive.	The professional driver drives after having performed heavy physical work in order to load his truck.	
None defined	**None defined**		**Inadequate training (N4)** Insufficient training to acquire the skills and knowledge needed for the task.

MAINTENANCE (O)

Maintenance includes maintenance of the vehicle as well as the traffic environment.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
None defined	**None defined**		**Inadequate vehicle maintenance (O1)** The vehicle, or parts of it (e.g. tyres, steering, brake system, lighting), has been inadequately or incorrectly maintained.
None defined	**None defined**		**Inadequate road maintenance (O2)** The road, or parts of it, has been inadequately or incorrectly maintained.

VEHICLE DESIGN (P)

Vehicle design includes problems with the design of one or more parts of the vehicle.

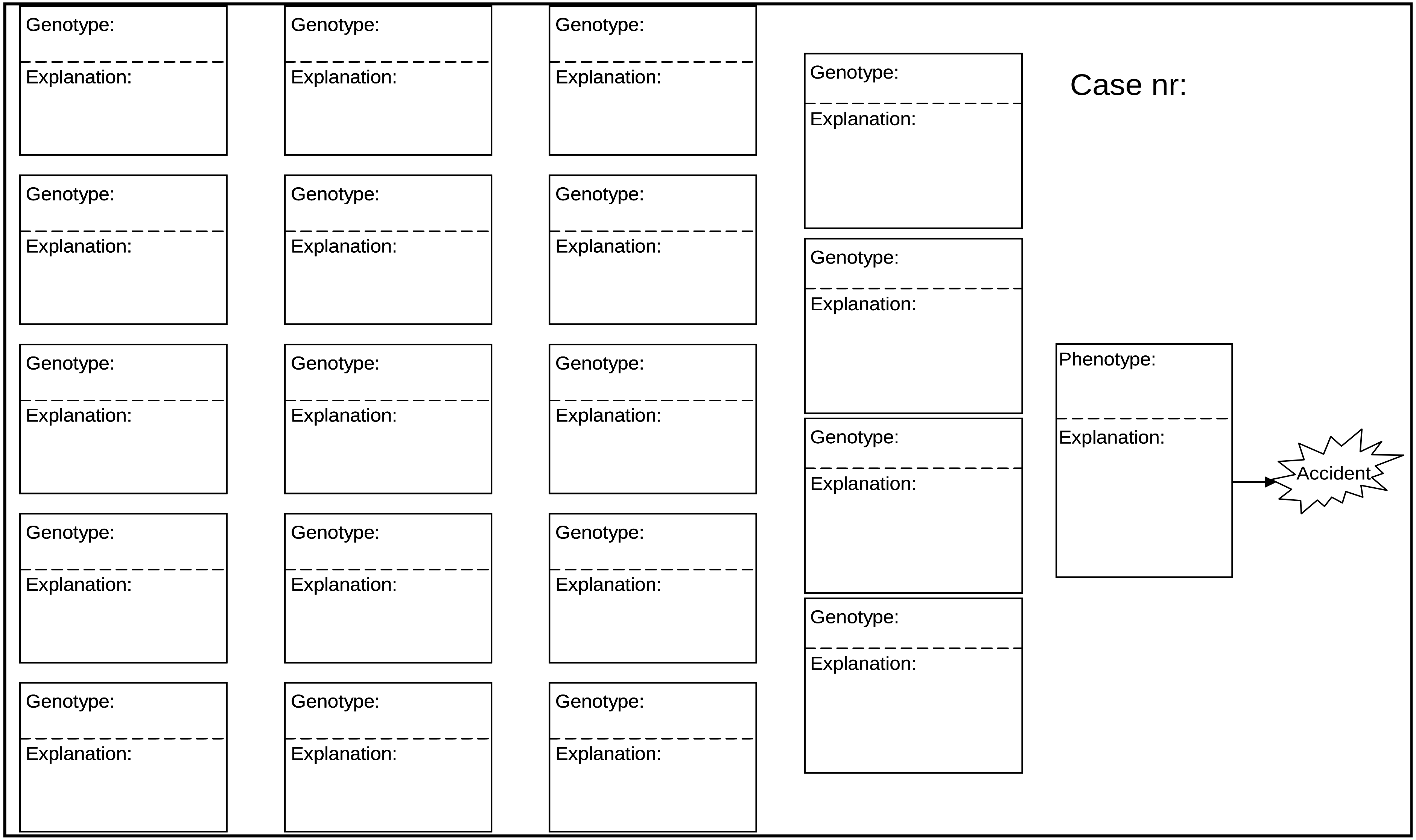
ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
None defined	**None defined**		**Inadequate design of driver environment (P1)** One or more parts of the driver environment are inadequately designed from an HMI or ergonomic point of view (e.g. ITS-system is very distracting, driver's seat is hard to adjust, pillar obstructs the view).
None defined	**None defined**		**Inadequate design of communication devices (P2)** One or more of the communication devices (e.g. indicators, brake lights, reverse lights) are inadequately designed.
None defined	**None defined**		**Inadequate construction of vehicle parts and/or structures (P3)** The vehicle has been insufficiently built or the construction has been insufficiently considered resulting in suboptimal performance (e.g. poor road friction, large steering radius, limited braking power, insufficient head light) or complete equipment failure (e.g. balks breaking, seats becoming loose, head lights failing).
None defined	**Load (P4.1)** Heavy load makes the vehicle behave unpredictably.	The driver experiences the car behaving unusually (e.g. under steering) when the boot is heavily loaded.	**Unpredictable system characteristics (P4)** The characteristics of the vehicle become unpredictable under certain circumstances (e.g. a vehicle that is normally under-steered might become over-steered when taking sharp curves in high speed).

ROAD DESIGN (Q)

Road design includes problems with the design of road information or the road itself.

ANTECEDENTS			CONSEQUENTS
GENERAL Genotypes	**SPECIFIC Genotypes (with definitions)**	**Examples for SPECIFIC Genotypes**	**GENERAL Genotypes (with definitions)**
None defined	**None defined**		**Inadequate information design (Q1)** The design of the traffic guidance or control is inadequate (e.g. road signs are too many, ambiguous or inappropriately placed, traffic lights are inappropriately timed or inappropriately placed; lines on the tarmac supporting stop/give way signs or traffic lights are inappropriately placed).
None defined	**None defined**		**Inadequate road design (Q2)** The planning and/or the construction of the road are inadequate (e.g. inadequate road surface, curve, camber, road shoulder, vertical/ horizontal alignment or inadequately placed guard rails).

Appendix B: DREAM Analysis Linking Template



Comments:

Precipitating Event

precipitate
verb |priˈsipəˌtāt| [with obj.]
• (**precipitate someone/something into**) send someone or something suddenly into a particular state or condition: *they were precipitated into a conflict for which they were quite unprepared.*

ORIGIN early 16th cent.: from Latin ***praecipitat- 'thrown headlong,'*** from the verb ***praecipitare***, from ***praeceps***, ***praecip(it)- 'headlong,'*** from ***pare 'before'*** + ***caput 'head.'*** The original sense of the verb was ***'hurl down, send violently'***; hence ***'cause to move rapidly,'*** which gave rise to sense 1 (early 17th cent).

Description: This is the state of environment or action that began the sequence. This is a vehicle kinematic measure that does not include driver state. This is the critical event which made the crash or near-crash possible, and is independent of who caused the conflict.

If two events occur simultaneously, choose the event that imparted the greatest effect on the crash or near-crash. If more than one sequential event contributed to the crash or near-crash, determination of which is the precipitating event depends upon whether the driver had enough time or vehicular control to avoid the latter event. If the driver avoids one event and immediately encounters another potentially harmful event (with no time or ability to avoid the latter), then the precipitating event is the first.

If start of precipitating event is not visible, an approximation based on velocities, directions etc. has to be made. In cases where the precipitating factor is not an event with start and end time, but a state of environment (e.g. object in roadway), the start time is set to when it is detectable by the driver.

In the case of a conflict with a conflict partner in constant motion, the precipitating event starts when any partner enters the other partner's lane. However, in case one of the partners stops before entering the other's lane, the precipitating event starts when the move into the conflicting lane is first initialized.

Categories:

This vehicle loss of control

1. This Vehicle Lost Control - Blow-Out or Flat Tire
   Driver of subject vehicle loses some amount of vehicular control due to tire "air out"
   - *Precipitating event starts at tire blow-out or first sign of loss of control*

2. This Vehicle Lost Control - Stalled Engine
   Driver of subject vehicle loses some amount of vehicular control due to loss of engine power
   - *Precipitating event starts as engine stalls*

3. This Vehicle Lost Control - Disabling Vehicle Failure
   Driver of subject vehicle loses some amount of vehicular control due to a mechanical malfunction of a component (other than stalled engine), which prevents the vehicle from being drivable
   - *Precipitating event starts at first sign of failure*

4. This Vehicle Lost Control - Minor Vehicle Failure
   Driver of subject vehicle loses some amount of vehicular control due to a mechanical abnormality (other than stalled engine), but vehicle is still drivable
   - *Precipitating event starts at first sign of failure*

5. This Vehicle Lost Control - Poor Road Conditions
   Driver of subject vehicle loses some amount of vehicular control due to poor environmental or structural conditions of the roadway surface
   - *Precipitating event starts at first sign of loss of control*

6. This Vehicle Lost Control - Excessive Speed
   Driver of subject vehicle loses some amount of vehicular control due to traveling too fast for the driving conditions
   - *Precipitating event starts at first sign of loss of control*

7. This Vehicle Lost Control - Other Cause
   Driver of subject vehicle loses some amount of vehicular control, and the loss of control was due to some recognized reason not described in previous categories
   - *Precipitating event starts at first sign of loss of control*

8. This Vehicle Lost Control - Unknown Cause
   Driver of subject vehicle loses some amount of vehicular control, but the cause (ex. vehicular or environmental cause) is unknown
   - *Precipitating event starts at first sign of loss of control*

This vehicle travelling

9. Subject over Left Lane Line
   Subject vehicle departs its lane to the left and is entering or has entered adjoining lane or shoulder (note: for cases not included in categories "Subject lane change - left behind vehicle/left in front of vehicle/left, sideswipe threat/left, other")--in general, this would be a vehicle departing its lane to the left into a lane with opposing travel
   - *Precipitating events starts when wheels cross lane line*

10. Subject over Right Lane Line
    Subject vehicle departs its lane to the right and is entering or has entered adjoining lane or shoulder (note: for cases not included in categories "Subject lane change - right behind vehicle/right in front of vehicle/right, sideswipe threat/right, other")--in general, this would be a vehicle departing its lane to the right into a lane with opposing travel
    - *Precipitating events starts when wheels cross lane line*

11. Subject over Left Edge of Road
    Subject vehicle departs the roadway beyond the left side shoulder area or onto a median (first harmful or potentially harmful event occurs off of roadway)
    - *Precipitating events starts when wheels cross road edge line, wheels cross edge of road if no line is present, or wheels touch curb in case of side walk or median*

12. Subject over Right Edge of Road
    Subject vehicle departs the roadway beyond the right side shoulder area or onto a median (first harmful or potentially harmful event occurs off of roadway)
    - *Precipitating events starts when wheels cross road edge line, wheels cross edge of road if no line is present, or wheels touch curb in case of side walk or median*

13. Subject Vehicle: End Departure
    Subject vehicle departs the end of a roadway
    - *Precipitating events starts when wheels cross road edge line, wheels cross edge of road if no line is present, or wheels touch curb in case of side walk or median*

Subject in intersection

14. Subject in Intersection - Turning Left
    Subject vehicle attempts a left turn from its roadway to another roadway, driveway, or ramp.
    - *Precipitating event starts at acceleration start of subject vehicle after minimum velocity or when vehicle enters intersection*

15. Subject in Intersection - Turning Right
    Subject vehicle attempts a right turn from its roadway to another roadway, driveway, or ramp.
    - *Precipitating event starts at acceleration start of subject vehicle after minimum velocity or when vehicle enters intersection*

16. Subject in Intersection - Passing Through
    Subject vehicle is proceeding through an intersection without planning to make a turn.
    - *Precipitating event starts at acceleration start of subject vehicle after minimum velocity or when vehicle enters intersection*

Other vehicle in lane

17. Subject Ahead, Stopped on Roadway More than 2 Seconds
Subject vehicle has been stopped on the roadway for more than 2 seconds when crash or near-crash occurs (from behind), and is the lead vehicle in the event
    - *Precipitating event starts when conflict partner starts approaching subject vehicle*

18. Subject Ahead, Slowed and Stopped 2 Seconds or Less
Subject vehicle is decelerating to a stop or has just stopped (has been stopped for 2 seconds or less) when crash or near-crash occurs, and is the lead vehicle in the event
    - *Precipitating event starts when subject initiates the deceleration, either by releasing accelerator pedal or pressing brake pedal if accelerator pedal is not depressed*

19. Subject Lane Change - Left Behind Vehicle
Subject vehicle departs its lane to the left and is entering or has entered adjoining lane behind a leading vehicle in that lane (traveling in the same direction), contacting or nearly contacting the rear portion of that lead vehicle
    - *Precipitating events starts when wheels cross lane line*

20. Subject Lane Change - Right Behind Vehicle
Subject vehicle departs its lane to the right and is entering or has entered adjoining lane behind a leading vehicle in that lane (traveling in the same direction), contacting or nearly contacting the rear portion of that lead vehicle
    - *Precipitating events starts when wheels cross lane line*

21. Subject Lane Change - Left in Front of Vehicle
Subject vehicle departs its lane to the left and is entering or has entered adjoining lane in front of another vehicle in that lane (traveling in the same direction), contacting or nearly contacting the front portion of that following vehicle
    - *Precipitating events starts when wheels cross lane line*

22. Subject Lane Change - Right in Front of Vehicle
Subject vehicle departs its lane to the right and is entering or has entered adjoining lane in front of another vehicle in that lane (traveling in the same direction), contacting or nearly contacting the front portion of that following vehicle
    - *Precipitating events starts when wheels cross lane line*

23. Subject Lane Change - Left, Sideswipe Threat
Subject vehicle is traveling in the adjacent right lane, beside and in the same direction as other vehicle, and crosses left lane line (i.e., other vehicle's right lane line), resulting in contact or near-contact between the left side of this vehicle and the right side of the other vehicle
    - *Precipitating events starts when wheels cross lane line*

24. Subject Lane Change - Right, Sideswipe Threat
Subject vehicle is traveling in the adjacent left lane, beside and in the same direction as other vehicle, and crosses right lane line (i.e., other vehicle's left lane line), resulting in contact or near-contact between the right side of this vehicle and the left side of the other vehicle
    - *Precipitating events starts when wheels cross lane line*

25. Subject Lane Change - Left, Other
Subject vehicle is traveling in the adjacent right lane, in the same direction as other vehicle, and crosses left lane line (i.e., other vehicle's right lane line) in a manner not described in other categories
    - *Precipitating events starts when wheels cross lane line*

26. Subject Lane Change - Right, Other
Subject vehicle is traveling in the adjacent left lane, in the same direction as other vehicle, and crosses right lane line (i.e., other vehicle's left lane line) in a manner not described in other categories
    - *Precipitating events starts when wheels cross lane line*

27. Subject Ahead, Decelerating
Subject vehicle is decelerating, traveling in the same lane ahead of (and in same direction as) other vehicle involved in the crash or near-crash
    - *Precipitating event starts when subject initiates the deceleration, either by releasing accelerator pedal or pressing brake pedal if accelerator pedal is not depressed*

28. Subject Ahead, at a Slower Constant Speed

Subject vehicle is traveling at a lower constant speed in the same lane ahead of (and in the same direction as) other vehicle involved in the crash or near-crash

- *Precipitating event starts when conflict partner starts approaching subject vehicle*

29. Other Vehicle Ahead - Stopped on Roadway More than 2 Seconds
A vehicle (not in motion) is ahead in subject vehicle's lane, and has been stopped for more than 2 seconds when the crash or near-crash occurs
    - *Precipitating event starts when other vehicle is visible*

30. Other Vehicle Ahead - Slowed and Stopped 2 Seconds or Less
A vehicle is decelerating to a stop or has just stopped ahead in subject vehicle's lane (has been stopped for 2 seconds or less) when crash or near-crash occurs
    - *Precipitating event starts at activation of brake light of target vehicle, or start of deceleration of target*

31. Other Vehicle Ahead, at a Slower Constant Speed
Other vehicle is traveling at a lower constant speed ahead of (and in the same lane and direction) as subject vehicle
    - *Precipitating event starts at activation of brake light of POV ahead or negative longitudinal acceleration of POV in same lane*

32. Other Vehicle Ahead, Decelerating
Other vehicle is decelerating, traveling ahead of (and in same lane and direction) as subject vehicle
    - *Precipitating event starts at activation of brake light of target vehicle, or start of deceleration of target*

33. Other Vehicle Ahead, Accelerating
Other vehicle is accelerating or traveling at a higher speed, ahead of (and in same lane and direction) as subject vehicle

34. Other Vehicle - Traveling in Opposite Direction
Other vehicle is in subject vehicle's travel lane and traveling head-on in the opposite direction of subject vehicle
    - *Precipitating event starts when other vehicle is visible*

35. Other Vehicle - Backing
Other vehicle is in the process of backing up while in subject vehicle's travel lane or path of travel (other than cases described in other categories in which a vehicle backing and is completely or partially in the subject vehicle lane)
    - *Precipitating events starts when other vehicle starts approaching subject vehicle*

Another vehicle encroaching into this vehicle's lane

36. Other Vehicle Lane Change - Left in Front of Subject
Other vehicle is traveling in the adjacent lane, ahead of and in the same direction as subject vehicle, and crosses subject vehicle's left lane line (i.e., other vehicle crosses its right lane line), resulting in contact or near-contact between the front of subject vehicle and rear of the other vehicle
    - *Precipitating events starts when wheels cross lane line*

37. Other Vehicle Lane Change - Left Behind Subject
Other vehicle is traveling in the adjacent lane, behind and in the same direction as subject vehicle, and crosses subject vehicle's left lane line (i.e., other vehicle crosses its right lane line), resulting in contact or near-contact between the rear of subject vehicle and front of the other vehicle
    - *Precipitating events starts when wheels cross lane line*

38. Other Vehicle Lane Change - Left, Sideswipe Threat
Other vehicle is traveling in the adjacent left lane, beside and in the same direction as subject vehicle, and crosses subject vehicle's left lane line (i.e., other vehicle crosses its right lane line), resulting in contact or near-contact between the left side of subject vehicle and the right side of the other vehicle
    - *Precipitating events starts when wheels cross lane line*

39. Other Vehicle Lane Change - Left Other
Other vehicle is traveling in an adjacent lane, in the same direction as subject vehicle, and crosses subject vehicle's left lane line in a manner not described in other categories
    - *Precipitating events starts when wheels cross lane line*

40. Other Vehicle Lane Change - Right in Front of Subject
Other vehicle is traveling in the adjacent lane, ahead of and in the same direction as subject vehicle, and crosses subject vehicle's right lane line (i.e., other vehicle crosses its left lane line), resulting in contact or near-contact between the front of subject vehicle and rear of the other vehicle
    - *Precipitating events starts when wheels cross lane line*

41. Other Vehicle Lane Change - Right Behind Subject
Other vehicle is traveling in the adjacent lane, behind and in the same direction as subject vehicle, and crosses subject vehicle's right lane line (i.e., other vehicle crosses its left lane line), resulting in contact or near-contact between the rear of subject vehicle and front of the other vehicle
    - *Precipitating events starts when wheels cross lane line*

42. Other Vehicle Lane Change - Right, Sideswipe Threat
Other vehicle is traveling in the adjacent right lane, beside and in the same direction as subject vehicle, and crosses subject vehicle's right lane line (i.e., other vehicle crosses its left lane line), resulting in contact or near-contact between the right side of subject vehicle and the left side of the other vehicle
    - *Precipitating events starts when wheels cross lane line*

43. Other Vehicle Lane Change - Right Other
Other vehicle is traveling in an adjacent lane, in the same direction as subject vehicle, and crosses subject vehicle's right lane line in a manner not described in other categories
    - *Precipitating events starts when wheels cross lane line*

44. Other Vehicle Oncoming - Over Left Line
Other vehicle crosses subject vehicle's left lane line while traveling in the opposite direction from subject vehicle
    - *Precipitating events starts when wheels cross lane line*

45. Other Vehicle Oncoming - Over Right Line
Other vehicle crosses subject vehicle's right lane line while traveling in the opposite direction from subject vehicle
    - *Precipitating events starts when wheels cross lane line*

46. Other Vehicle from Parallel or Diagonal Parking Lane
Other vehicle crosses subject vehicle's lane line while departing some type of parking lane
    - *Precipitating events starts when wheels cross lane line*

Other vehicle entering intersection

47. Other Vehicle Entering Intersection - Turning same Direction
Other vehicle is turning from another roadway onto subject vehicle's roadway and attempts to travel in the same direction as subject vehicle, crossing subject vehicle's lane line
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

48. Other vehicle entering intersection - straight across path
Other vehicle is continuing straight through the intersection and attempts to cross over subject vehicle's roadway, crossing subject vehicle's lane line
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

49. Other vehicle entering intersection - turning onto opposite direction
Other vehicle is entering an intersection from another roadway and is turning or attempting to turn onto subject vehicle's roadway in the opposite travel direction of subject vehicle, crossing subject vehicle's lane line
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

50. Other vehicle entering intersection - left turn across path
Other vehicle is entering an intersection and is making a left turn across the path of the subject vehicle (could have originally been traveling in either the same direction (in an adjacent lane) or opposite direction (in an oncoming lane) as the subject vehicle)
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

51. Other vehicle entering intersection - right turn across path
Other vehicle is entering an intersection and is making a right turn across the path of the subject vehicle (could have originally been traveling in either the same direction (in an adjacent lane) or opposite direction (in an oncoming lane) as the subject vehicle.

- *Precipitating events starts when other vehicle enters subject vehicle's lane*

52. Other vehicle entering intersection - intended path unknown
Other vehicle enters an intersection, crossing subject vehicle's lane line, but the other vehicle's travel direction could not be determined
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

Other vehicle from driveway or entrance to highway

53. Other vehicle from driveway - turning into same direction
Other vehicle is turning from a driveway (a roadway providing access from some property adjacent to the trafficway) onto subject vehicle's roadway and attempts to travel in the same direction as subject vehicle, crossing subject vehicle's lane line
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

54. Other vehicle from driveway - straight across path
Other vehicle is turning from a driveway (a roadway providing access from some property adjacent to the trafficway) onto subject vehicle's roadway and attempts to travel in the same direction as subject vehicle, crossing subject vehicle's lane line
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

55. Other vehicle from driveway - turning into opposite direction
Other vehicle is entering subject vehicle's roadway from a driveway (a roadway providing access from some property adjacent to the trafficway) and is attempting to turn into the opposite travel direction of subject vehicle, crossing subject vehicle's lane line
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

56. Other vehicle from driveway - intended path unknown
Other vehicle is entering subject vehicle's roadway from a driveway (a roadway providing access from some property adjacent to the trafficway) , crossing subject vehicle's lane line, but details about its intended path are unknown
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

57. Other vehicle from entrance to limited access highway
Other vehicle is attempting to enter (merge) onto the limited access highway (via an entrance ramp) which is being travelled by subject vehicle, crossing subject vehicle's lane line
    - *Precipitating events starts when other vehicle enters subject vehicle's lane*

Pedestrian, bicyclist, or other non-motorist

58. Pedestrian in roadway
A pedestrian is present somewhere on the roadway (not necessarily walking)
    - *Precipitating event starts when pedestrian is visible*

59. Pedestrian approaching roadway
A pedestrian is within the trafficway and moving toward the roadway or attempting to enter the roadway, but is not on the roadway
    - *Precipitating event starts when pedestrian initiates walk towards roadway or when he/she steps out into roadway*

60. Pedestrian in unknown location
The presence or action of a pedestrian is a critical factor in the crash or near-crash, but the location and/or action of the pedestrian is unknown

61. Bicyclist/other non-motorist in roadway
A bicyclist (person riding a pedal-powered conveyance such as a bicycle or tricycle) or other non-motorist (person riding on or in a conveyance not pedal-powered or motorized such as a baby carriage, skateboard, roller blades, etc.) is present somewhere on the roadway
    - *Precipitating event starts when bicyclist/other non-motorist is visible*

62. Bicyclist/other non-motorist approaching roadway
A bicyclist (person riding a pedal-powered conveyance such as a bicycle or tricycle) or other non-motorist (person riding on or in a conveyance not pedal-powered or motorized such as a baby carriage, skateboard, roller blades,

etc.) is within the trafficway and moving toward the roadway or attempting to enter the roadway, but is not on the roadway

- *Precipitating event starts when road-user initiates motion towards roadway or when he/she moves into roadway*

63. Bicyclist/other non-motorist in unknown location
The presence or action of a bicyclist (person riding a pedal-powered conveyance such as a bicycle or tricycle) or other non-motorist (person riding on or in a conveyance not pedal-powered or motorized such as a baby carriage, skateboard, roller blades, etc.) is a critical factor in the crash or near-crash, but the location and/or action of the bicyclist/non-motorist is unknown

Object or animal

64. Animal in roadway
A live animal (stationary or moving) is present somewhere on the roadway
    - *Precipitating event starts when animal is visible*

65. Animal approaching roadway
A live animal is within the trafficway and moving toward the roadway or attempting to enter the roadway, but is not on the roadway
    - *Precipitating event starts when animal initiates move towards roadway or when it enters roadway*

66. Animal in unknown location
The presence or action of a live animal is a critical factor in the crash or near-crash, but the location and/or action of the animal is unknown

67. Object in roadway
An inanimate object (either fixed or nonfixed) is present somewhere on the roadway
    - *Precipitating event starts when object is visible*

68. Object approaching roadway
An inanimate object (either fixed or nonfixed) is present somewhere on the roadway
    - *Precipitating event starts when object starts moving towards roadway or when it enters roadway*

69. Object in unknown location
The presence or movement of an inanimate object (wither fixed or nonfixed) is a critical factor in the crash or near-crash, but the location and/or specific movement of the object is unknown

70. This vehicle accelerating
This vehicle initiating approach to conflicting road user
71. Other
72. Unknown