SECUR

Safety Enhancement through Connected Users on the Road

Deliverable 1.1

Accident Data Study – Accident scenarios description

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EXECUTIVE SUMMARY

The SECUR project aims to study the potential of connectivity, especially of V2X technologies, to improve the safety of different road users. With the same objective in mind this project brings together diverse and complementary stakeholders: automotive OEM and Tier1 manufacturers as well as V2X-market-stakeholders and automotive test systems providers.

The first Work Package of SECUR (WP1) is dedicated to the identification of the main accident scenarios and their parameters. The geographical scope of the accident data study is Europe. Considering that the connectivity of the vehicle is relatively recent, offering a wide range of possibilities and benefits to all the road users, the following ones were considered as opponent: Passenger Car (PC), Power Two-Wheelers (PTW), Bicyclist (BC) and Pedestrian (PD). However, in this study the ego vehicle is always a Passenger Car.

This report (D1.1) is the first WP1 deliverable out of two (D1.2). It summarizes the scientific knowledge as expressed in the current literature according to the scope of the project. Furthermore, this report provides the description of the methodology and databases used to perform the accident data study with the objective to identify the most relevant accident scenarios for the SECUR project.

Two studies were performed into the SECUR literature review to gather the needed scientific knowledge:

- study n°1: Previous European accidents data study within ADAS projects
- study n°2: V2X-safety-use cases state-of-the-art

To get an overview about the European Union (EU) accidentology, a high-level analysis was achieved. For this, three databases were used: accident data from EU (CARE), accident data from German federal statistical office (DESTATIS) and accident data from French government (BAAC).

To complete the previous studies, an in-depth accident data analysis was carried out to select and define the most relevant accident scenarios and their parameters. These data were then used to define the SECUR use cases in the WP3.

To cover the large scope of SECUR (all EU accidents and 4 types of opponents) a generic scenario catalogue was created based on the GDV accident situations and data from GIDAS. This accidentology work, define 28 accident categories for 4 types of opponents and, thus, 112 accident scenarios (combination of categories and types of opponents). The most relevant scenarios were selected based on the accidentology. The V2X and ADAS perspectives were also considered thanks to WP2 and WP3 inputs.
The following accident scenarios were studied:

N°#	Name	Road user / Opponent
1	**Oncoming**	Passenger car
2	Straight Crossing Path – Right Direction (**SCP-RD**)	Cyclist
3	Straight Crossing Path – Right Direction (**SCP-RD**)	Passenger car
4	Straight Crossing Path – Right Direction (**SCP-RD**)	Pedestrian
5	Straight Crossing Path – Left Direction (**SCP-LD**)	Pedestrian
6	Loss Of Control in CUrve (**LOC-CU**)	Single (Ego = car)
7	Straight Crossing Path – Left Direction (**SCP-LD**)	Passenger car
8	Loss Of Control in Straight Line (**LOC-SL**)	Single (Ego = car)
9	Straight Crossing Path – Left Direction (**SCP-LD**)	Cyclist
10	Rear End - Following Vehicle (**RE-FV**)	Passenger car
11	Rear End - Previous Vehicle (**RE-PV**)	Passenger car
12	Left Turn Across Path – Opposite Direction (**LTAP/OD**)	Passenger car
13	Left Turn Across Path – Opposite Direction (**LTAP/OD**)	PTW
14	Left Turn Across Path – Left Direction (**LTAP/LD**)	Passenger car
15	Left Turn Across Path – Left Direction (**LTAP/LD**)	PTW

For the analysis of each scenario, 16 relevant parameters were chosen by an expert group and are listed hereinafter: weather condition, road surface, light condition, illumination of the road, percentage of view obstruction, kind of view obstruction, topology of road/intersection, radius of curve, kind of traffic regulation, traffic density, accident cause, human failure, initial speed ego, initial speed opponent, deceleration ego and deceleration opponent. Not all parameters were analysed for each scenario: only the most relevant ones depending on the scenario type and the data needed for a use case definition.

To provide information about the EU representativeness of the study, the EU safety potential of each scenario was studied, and a comparison of the results was done on IGLAD database (only for KSI and for information purpose only).

The selected accident scenarios have a coverage of 70,6% of the whole accidentology of the SECUR Generic Scenario Catalogue.

The results of the in-depth accident data analysis for each accident scenario and by parameters are available in the deliverable D1.2.

REVISION HISTORY

Revision	Date	Description, updates and changes	Status
0.1	Jan. 2022	Creation of the report structure	Draft
1.1	31/01/2022	First draft of the report	Draft
1.2	25/03/2022	First revision of the report	In review
1.3	21/03/2022	Second revision and final version of the report	Final version
1.3	27/03/2022	Validation of the report by the Steering Board	Approved

ABBREVIATIONS

ADAS	Advanced Driver Assistance Systems
AEB-P	Autonomous Emergency Braking for Pedestrians
ARAS	Advanced Rider Assistance Systems
BC	Bicycle
BSW	Blind Spot Warning
C-ITS	Cooperative Intelligent Transport Systems
DNPW	Do Not Pass Warning
EC	European Commission
EEBL	Electronic Emergency Brake Light
ESC	Electronical Stabilization Control
EU	European Union
FCW	Forward Collision Warning
GDV	German Insurance Association (dt. Gesamtverband der Versicherer
GIDAS	German In-depth Accident Study
HLN	Hazardous Location Notification
IMA	Intersection Movement Assist
ITS	Intelligent Transport Systems
KTP	Kind of traffic participation
KSI	Killed and severely injured
LCW	Lane Change Warning
LTA	Left Turn Assist
PC	Passenger car
PD	Pedestrian
PTW	Powered Two-Wheeler
UC	Use case
V2I	Vehicle-To-Infrastructure
V2N	Vehicle-To-Network
V2P	Vehicle-To-Pedestrian
V2V	Vehicle-To-Vehicle
V2VRU	Vehicle-To-Vulnerable Road User
V2X	Vehicle-To-Everything
VRU	Vulnerable Road User

DEFINITIONS

ACCIDENT SCENARIO	Describe the basic road layout and basic motions of vehicles relative to each other participating in a road traffic accident.
USE CASE	Derived from accident scenarios by adding detailed information for example about the road layout, right-of-way and the vehicle trajectories prior to the collision. They can be derived using statistical methods such as cluster algorithms applied to the available accident data. Note: Use Cases serve as an intermediate step between the Accident Scenarios and the Test Scenarios.
TEST SCENARIO	Describe the final testing conditions.

DATABASE DESCRIPTION

Database	Country Covered	Description
CARE	Europe	“Community database on road accidents resulting in death or injury (no statistics on damage-only accidents). The major difference between CARE and most other existing international databases is the level of aggregation, i.e. CARE comprises detailed data on individual accidents as collected by the Member States" definition from [1]
IGLAD	Europe	“IGLAD was started in 2010 by European car manufacturers and is an initiative for harmonisation of global in-depth traffic accident data to improve road and vehicle safety which has grown greatly during last years. A database was developed containing accident data according to a standardised data scheme that enables comparison between datasets from different countries” definition from [1].
DESTATIS	Germany	“National road traffic accident data registered by the police is collated by The Federal Statistical Office (Destatis). Data is provided in an aggregated format mainly reporting top-level frequency statistics for road users. As the data is not available in disaggregated tables the level of analysis is limited. The Destatis data is readily used to weight GIDAS data (Hautzinger, 2004), to this extent GIDAS is used as a proxy for the national data” definition from [2].
GIDAS	Germany	“The German In-Depth Accident Study (GIDAS) is a joint venture between BASt and the Automotive Research Association (FAT). GIDAS is the largest in-depth accident study project in Germany, and it was initiated in July 1999. Approximately 2,000 accidents involving personal injury are recorded in the area of Dresden and Hannover annually. The investigation team documents all relevant information on vehicle equipment, vehicle damage, injuries of persons involved, the rescue chain, as well as the accident conditions, at the scene. Individual interviews of persons involved are followed by detailed surveying of the accident scene based on existing evidence. In addition to documentation at the scene of the accident, all information available retrospectively is collected in close collaboration with police, hospitals and rescue services. Each documented accident is reconstructed in a simulation program. The entire course of the accident is reconstructed, starting with accident lead-in phase and the reaction of the involved vehicles, to the collision and finally vehicle end position. Characteristic variables such as braking deceleration, starting speeds and collision speeds, as well as angle-changes are determined. The documentation scope obtained in GIDAS reaches up to 3,000 encoded parameters per accident” definition from [2].
BAAC	France	"The National Road traffic accidents (RTA) file, referred to as the BAAC database, gathers all the report of road accidents involving physical injury registered by police forces for any road traffic accident brought to their attention" definition from [2].
VOIESUR	France	The objective of this database is to have an intermediary level of detail between national data and in-depth data collection. The codification has been done from French police reports. About 8.500 accident cases were coded by a specialist for 1,5 years. It represents 2011 National data.
DGT	Spain	"Spanish Road Accidents database is carried out by the public organisation DGT, dependent of the Ministry of the Interior. DGT Spanish Road Accidents Database contains the entire population of accidents with casualties in Spain. Approximately 100,000 accidents take place on Spanish roads annually with 5,000 fatalities, 25,000 serious injured and 120,000 slight injured. Information contained in DGT Spanish Road Accidents Database is collected by police forces" definition from [2].
STATS19	United-Kingdom	"Road accidents on the public highway in Great Britain, reported to the police and which involve human injury or death, are recorded by police officers onto a STATS19 report form. The form collects a wide variety of information about the accident (such as time, date, location, road conditions) together with the vehicles and casualties involved and contributory factors to the accident (as interpreted by the police). The Department for Transport has overall responsibility for the design and collection system of the STATS19 data" definition from [1].
OTS	United-Kingdom	“The UK On-The-Spot (OTS) database comprises in-depth accident and injury data collected by two teams in two sampling regions: in the South and in the Midlands of England. Investigating teams are deployed to the scene of an accident, generally within 20 minutes of the accident happening, for all road traffic accidents notified to police during the periods of operation. Therefore, this data source includes damage only accidents and accidents which may not result in an injury” definition from [3].
STRADA	Sweden	“In Sweden, STRADA is an information system for road accidents with personal injuries.

		The system includes information from the police and the emergency hospitals. The police report road accidents involving at least one moving vehicle and a road user which sustained an injury" definition from [3].
ISTAT	Italy	"ISTAT is the Italian National Institute of Statistics, main supplier of official statistical information in Italy. It collects and produces information on Italian economy and society and make it available for study and decision-making purpose. ISTAT works in cooperation with the Automobile Club of Italy (ACI) to standardize the accident data, collecting Police reports." definition from [2].
ELSTAT	Greece	"Accident data is collected by the Hellenic Statistical Society (ELSTAT) and are not available to the public: CERTH (Centre for Research and Technology Hellas) is authorised to use the row data, for research purposes only. Primary data derive from administrative sources such as police and port authorities through the completion of a specially designed statistical questionnaire providing information on the place of the accident, the type of the first collision, any manoeuvres which caused the accident, specific data on the vehicles involved in the accident, data on the driver and persons injured, as well as data on the use of safety equipment. The questionnaires are then transmitted to the Section of Justice and Public Order Statistics of ELSTAT who oversees the quality control, data validation and compilation (ELSTAT, 2017)." definition from [2].
BRON/ SWOV	The Netherlands	"All road traffic crashes in the Netherlands that are recorded by the police in reports or registration sets are included in the national road crash register BRON. The registration is compiled by the Centre for Transport and Navigation (DVS) which is part of the Ministry of Infrastructure and the Environment. BRON contains a large number of characteristics of the crash and the drivers and casualties involved. Data is available from 1976. BRON contains 90% of the fatal crashes. For crashes of lesser severity, the registration is less complete. SWOV links the LBZ data (National Basic Register Hospital Care) and the BRON data of injured casualties, based on which the real number of serious road injuries is estimated. The crash data is available on the SWOV website from 1993 onward. The data of the years from 2004 onward is BRON data; the older data has been converted from the earlier system called 'Crashes and Network'" definition from [2].

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1. INTRODUCTION

1.1 THE SECUR PROJECT

Through its 2025 roadmap, the European New Car Assessment Programme (Euro NCAP) aims to encourage, by a consumer approach, ever more safety on the roads thanks to the use of new inter-vehicle communication solutions. In pursuit of Vision Zero, a functional validation protocol will be developed, and mass-produced vehicles' safety performance will be evaluated.

The SECUR project brings great importance to technological neutrality, while there was at the time a certain rivalry around the V2X (Vehicle-to-Everything) preventing a homogeneous development of connectivity solutions. This pioneering project aims to study the potential of connectivity, especially of V2X technologies, to improve the safety of different road users.

Coordinated by UTAC, the SECUR project expect to push a coherent proposal for V2X testing and assessment protocols to Euro NCAP. To this end, the industrial consortium brings together some twenty international stakeholders, from the entire automotive and V2X ecosystem – automotive OEM, Tier1 manufacturers, V2X-market-stakeholders and automotive test systems providers. They will share knowledge and collaborate through Workshops and Working Groups. First, the most common accident situations on European roads will be studied. Then, the current knowledge on V2X communication systems will be shared and studied. Thereafter, the potential of V2X systems will be studied, either alone or combined with ADAS systems. Finally, multi-technologies connected targets and protocols for evaluating these V2X systems, will be developed.

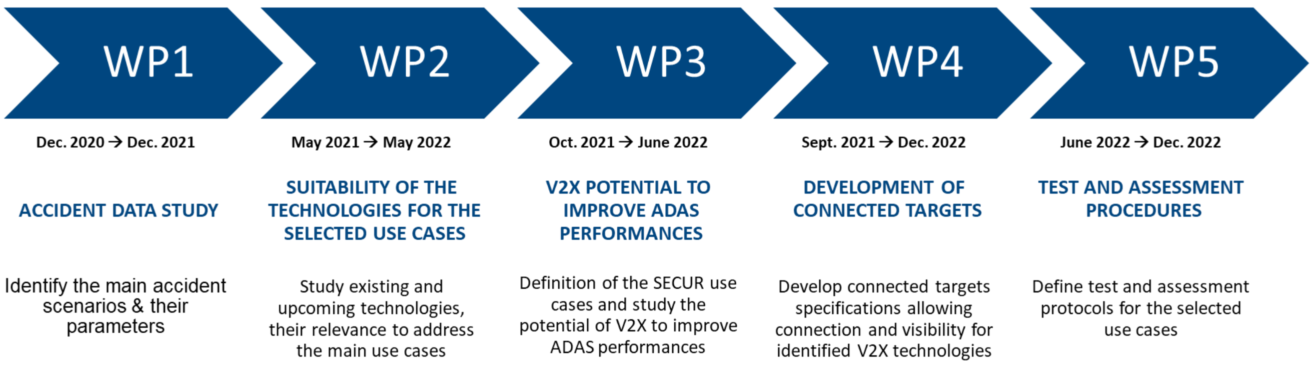


Figure 1: SECUR Project Work Packages

Figure 2: SECUR partners and contributors

1.2 OBJECTIVES AND SCOPE OF THE WP1 STUDY

The WP1 of SECUR is dedicated to the identification of the main accident scenarios and their parameters. For this, the methodology used was the following:

1) Literature review to gather and study the results of the existing V2X projects and main accident scenarios considered into previous ADAS projects.

2) High level EU accident data study on the French (BAAC), German (DESTATIS) and European (CARE) databases to complete the previous literature review.

3) SECUR Generic Scenario Catalogue: Development of a generic accident scenario catalogue for all the types of accidents and for all the main road users (passenger car, PTW, cyclist and pedestrian), for EU scope and based on GDV clustering.

4) Selection of the relevant accident scenarios and targets (pedestrian, bicyclist, passenger car, PTW…) to be considered based on the previous catalogue. The following elements were also considered for the scenario selection: V2X perspective (relevance, capability and market readiness) and ADAS perspective (limitations, effectiveness and remaining accidents in 2025).

5) In-depth EU accident data study: Deep study of a set of parameters for the selected scenarios, based of GIDAS and, with a focus on the EU potential of each scenario. The analysis outcomes are used to build SECUR use cases in the WP3.

The geographical scope of the accident data study is Europe. Considering that the connectivity of the vehicle is relatively recent, offering a wide range of possibilities and benefits to all the road users the following ones were considered as opponent: Passenger Car (PC), Power Two-Wheelers (PTW), Bicyclist (BC) and Pedestrian (PD). However, in this study the ego vehicle is always a Passenger Car.

1.3 OBJECTIVE OF THE DELIVERABLE

This report (D1.1) is the first WP1 deliverable out of two (D1.2). It summarizes the scientific knowledge as expressed in the current literature according to the scope of the project. Furthermore, this report provides the description of the methodology and databases used to perform the accident data study with the objective to identify the most relevant accident scenarios for the SECUR project.

2. Literature review

Two studies were performed into the SECUR literature review to gather the needed scientific knowledge:

- Study n°1: Previous European accidents data study within ADAS projects
- Study n°2: V2X-safety-use cases state-of-the-art

2.1 Study n°1: Previous European accidents data study within ADAS projects

2.1.1 Introduction

Within the Euro NCAP roadmaps context, different consortiums have been working on the next protocols, with the same goal: to improve road user safety by establishing testing protocols to assess active systems.

The objective of those protocols is to develop a vehicle safety assessment using tests that are based on real-world accidents and reproductible, to reduce and mitigate the consequences of road accidents.

To do so the consortium firstly focused on identify the main accident scenarios. For example, some AEB function have been first develop for car-to-car accident, then the focus has been done on VRU.

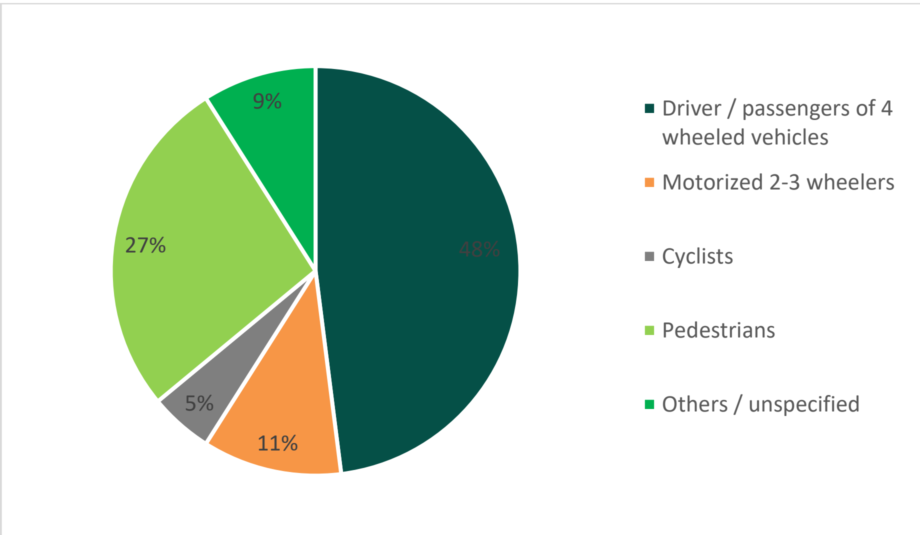


Figure 3: Distribution of death by road user type by WHO region - Europe, 2018 [4].

2.1.2 PROJECTS ON CAR-TO-CAR ACCIDENTS

2.1.2.1 ASSESS

2.1.2.1.1 Introduction

The ASSESS (Assessment of Integrated Vehicle Safety Systems for improved vehicle safety) project was developed as part of the European Commission's 7th Framework programme. It mobilised the European research community and car industry from 2009 to 2012. The overall purpose was to develop a relevant and standardised set of test and assessment methods, and associated tools for integrated vehicle safety systems, primarily focussing on available pre-crash sensing systems [3]. The first task was to define the most relevant accident scenarios involving at least one passenger car. European accident data were analysed to define most common accident situations and a more detailed analysis was carried out to provide necessary information on relevant scenario parameters such as the pre-crash vehicle kinematics in terms of speed, for example.

2.1.2.1.2 Method and databases

The European accident data study was based on in-depth data from UK (OTS – On-the-Spot) and Germany (GIDAS). In addition to these data, national accident data from Great Britain (STATS19) and Sweden (STRADA) were used to verify that the findings of the detailed data were sufficiently representative of larger populations.

The project study began with a ranking approach to balance the accidents scenarios with a lower frequency of occurrence, but which result in casualties of a higher severity, and accidents of greater frequency of occurrence but with lower injury outcomes [3].

The rankings of the accident scenarios were calculated based on the casualties in the accident and the weighting factors for considering the injury costs. The weighting prioritizes in order the number of fatalities, the number of seriously injured to the number of slight injured road users.

$$\text{Number of slightly injured road users} \times 0.011 + \text{Number of seriously injured road users} \times 0.11 + \text{Number of fatalities} \times 1$$

2.1.2.1.3 Groups of scenarios

Within the report [3], the accident scenario definition is based on those defined by SafetyNet WP5 [5].The accident situations are classified by 3-digit. Within this study, only the first digit of the accident type was used to identify the type of conflict.

Table 1: Distribution and ranking of the accident scenarios weighted based on involved road users by injury costs for injury accidents (ranking with merged Type 6 group). Weighted average is calculated by using the population size for included countries [3]

Accident scenario	GIDAS n=26,248		OTS n=10,459		STRADA n=106,397		Weighted average	
	freq	rank	freq	rank	freq	rank	freq	rank
Type 1a: Driving accident - single vehicle	28%	1	31%	2	34%	1	30%	1
Type 1b: Driving accident - multiple vehicles	10%	4	-	-	-	-	-	-
Type 2&3: Accidents with turning vehicle(s) or crossing paths in junction	27%	2	22%	3	22%	3	25%	3
Type 4: Accidents involving pedestrians	8%	5	13%	4	7%	4	10%	4
Type 5: Accidents with parked vehicles	1%	7	1%	6	1%	6	1%	5
Type 6: Accidents in longitudinal traffic, same/opposite direction	21%	3	31%	1	30%	2	26%	2
Type 7a: Other accident - single vehicle	-	-	2%	5	6%	5	-	-
Type 7b: Other accident - multiple vehicles	4%	6	-	-	-	-	-	-

Finally, four scenarios were highlighted as the most relevant by the analysis:

1. Driving accident - single vehicle loss of control
2. Accidents in longitudinal traffic (same and opposite directions)
3. Accidents with turning vehicle(s) or crossing paths in junctions
4. Accidents involving pedestrians

This ranking shows the importance of ‘accidents in longitudinal traffic’, and ‘accidents with turning vehicle(s) or crossing paths in junctions’ (rank 2 and 3). Therefore, a further analysis has been conducted to set up the parameters of test scenarios (Figure 4) for these situations.

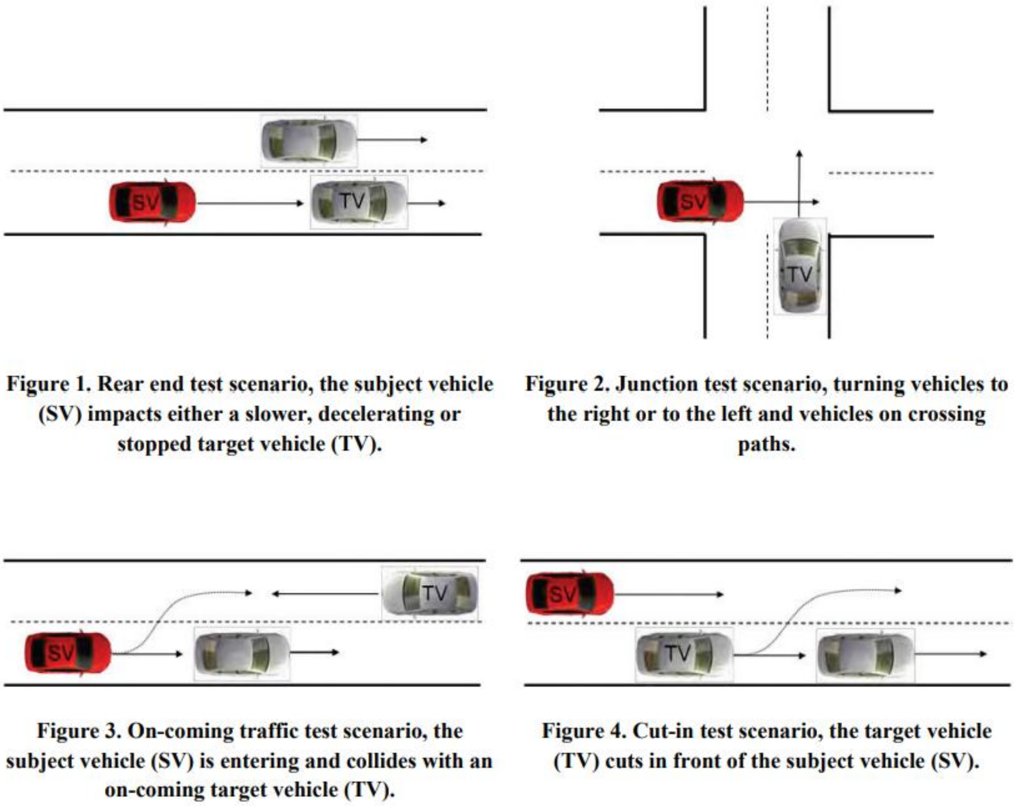


Figure 1. Rear end test scenario, the subject vehicle (SV) impacts either a slower, decelerating or stopped target vehicle (TV).

Figure 2. Junction test scenario, turning vehicles to the right or to the left and vehicles on crossing paths.

Figure 3. On-coming traffic test scenario, the subject vehicle (SV) is entering and collides with an on-coming target vehicle (TV).

Figure 4. Cut-in test scenario, the target vehicle (TV) cuts in front of the subject vehicle (SV).

Figure 4: Representation of the relevant accident scenarios for testing - Extract from [3].

This project served as basis for new ones to study the specificities of the situation, in order to help the development of technologies to improve safety. As for more information about:

- Accidents involving pedestrian, refer to 2.1.4 Projects on Car to Pedestrian accidents
- Accidents in junctions, refer to 2.1.2.2 Intersection 2020

2.1.2.2 Intersection 2020

2.1.2.2.1 Introduction

The Intersection 2020 project is a private research initiative driven by automotive industry members and led by IDIADA with the support of the BASt. It was support by the industry: Audi, BMW, Bosch, Continental, Daimler, Denso, Fiat Chrysler A., Hitachi, Honda R&D, PSA Group, Renault, Subaru, TME, Valeo, Veoneer, Volvo, ZF-TRW.
The project was initiated to develop a test procedure for Automatic Emergency Braking systems in intersection car-to-car scenarios to be transferred to Euro NCAP. It aims to address current road traffic accidents on European roads and the first work was to identify the most common accidents scenarios. [6]

2.1.2.2.2 Method and databases

Within the study the Accident Scenario is described as “basic road layout and basic motions of vehicles (here, at least four wheels each) relative to each other participating in a road traffic accident”. Use Cases are defined as “are derived from accident scenarios by adding detailed information for example about the road layout, right-of-way and the vehicle trajectories prior to the collision”.

The analysis of car-to-car accident at intersection in Europe has been conducted based on datasets from France, Germany, Spain and the United Kingdom. European databases CARE and IGLAD were also used for the analysis.

Table 2: Extract from Intersection 2020 [1] - Accident datasets considered in the project

Country / Region	High-level crash data	In-Depth Crash data
Europe	CARE	IGLAD
France	BAAC	-
Germany	DESTATIS	GIDAS
Spain	DGT	-
United Kingdom	STATS19	-

Then the most frequent accident scenarios have been studied in further details regarding technical parameters, GIDAS applying some filter to be within the scope of the project (for example, only urban and rural roads, no motorways).

2.1.2.2.3 Groups of scenarios

Finally, the overview of common car-to-car collision types at junctions in Europe shows seven important accident scenarios. Three scenarios have been defined as the most important due to their hight frequencies of severe car-to-car accidents. Most of these accidents occurred under daylight conditions.
Left Turn Across Path – Opposite Direction Conflict (LTAP-OD)

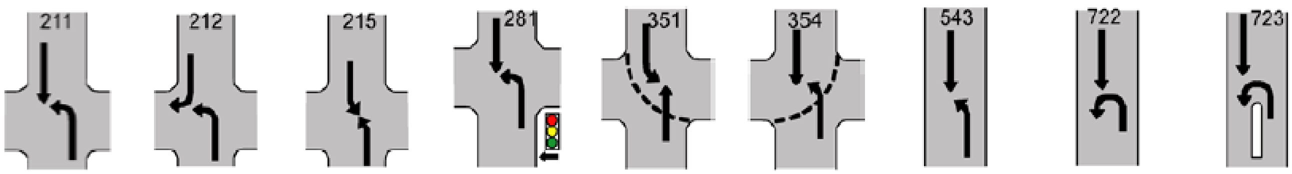


Figure 5: Extract from INTERSECTION 2020 [1] - Assignment of accident types to Accident Scenarios (LTAP-OD) based on [5].

An overview of the associated accident types showed that for KSI and ALL accidents, accident types 211 and 281 emerged most frequently and covered at least ~95% of all LTAP/OD cases. Accidents assigned to 281 differ to 211 accidents by the existence of a traffic light only.

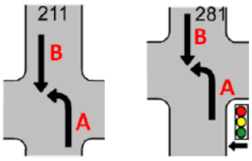


Figure 6: Extract from INTERSECTION 2020 [1] – Type of accidents from [5] selected as representative of LTAP-OD scenario.

Left Turn Across Path – Lateral Direction (LTAP-LD)

An overview of the associated accident types showed that for KSI and ALL accidents, the accident type 302 emerged most frequently and covered at least ~94% of all LTAP/LD cases. Accidents assigned to 312 differ to 302 (accounting for remaining cases) accidents by the driving of another vehicle parallel to the vehicle with right of way.

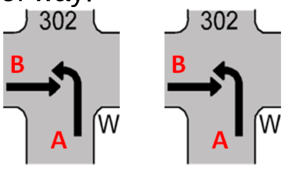


Figure 7: Extract from INTERSECTION 2020 [1] – Type of accidents from [5] selected as representative of LTAP-LD scenario.

Straight Crossing Paths

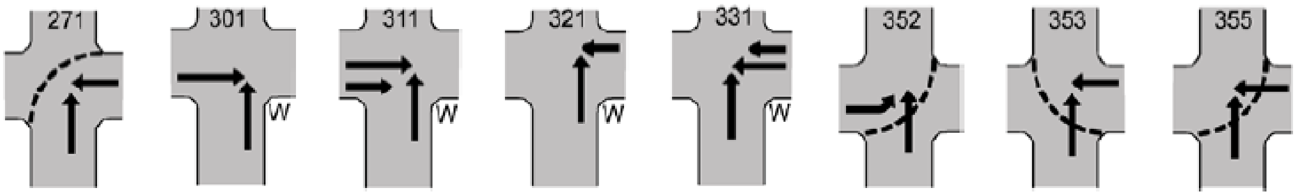


Figure 8: Extract from INTERSECTION 2020 [1] - Assignment of accident types to Accident Scenarios (SCP-RD) based on [5].

An overview of the associated accident types showed that for KSI and ALL accidents, the accident types 301 and 321 emerged most frequently and covered at least ~92% of all SCP cases. Accidents assigned to 301 differ to 321 accidents by the direction of the privileged vehicle, either approaching from left or right.

In the project Intersection 2020 the accidents were analysed from the perspective A (i.e. the causer of the accident), thus focusing on safety measures that assist the causer of the conflict.

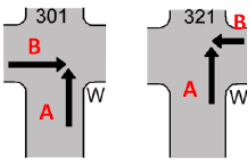


Figure 9: Extract from INTERSECTION 2020 [1] – Type of accidents from [5] selected as representative of LTAP-OD scenario.

2.1.2.3 EVADE

EVADE 2022 is a collaborative R&D project created following the INTERSECTION 2020 project (refer to paragraph 2.1.2.2) with 22 partners from the automotive industry.
The objective of the project is to establish test models for automatic emergency braking and evasion systems, such as the AES (Autonomous Emergency Steering) and the ESS (Emergency Steering Support) through digital solutions. The focus points are emergency steering manoeuvres, head-on situations and intersection crossing scenarios.

EVADE is currently on-going, the report could be reviewed with more information.

2.1.3 PROJECTS ON CAR TO MOTORCYCLE ACCIDENTS

2.1.3.1 MUSE

2.1.3.1.1 Introduction

MUSE (Motorcycle User Safety Enhancement) is a 2-year project from 2017 to 2019 that aims to improve motorcycle safety. It was initiated with the introduction of scenarios with motorcycles in the Euro NCAP Roadmap 2020/2025 at the beginning of 2017.
The objective was to provide the OEMs and TIER1s the tools to develop and evaluate their systems. By studying in a first stage the main accident scenarios and possible systems that could help to avoid them or, at least, reduce their consequences. And, at the same time, by developing the tools that allow us to improve these systems and to evaluate their performances.
The first step was to study the most common motorcycles accidents and accidents between a motorcycle and a passenger car in Europe.

2.1.3.1.2 Method and databases

The accident data study was based on Italy, France, Germany, Spain, the United-Kingdom, Greece and The Netherlands. With those 7 countries datasets covered 75.0% of the European accidents.

Two types of datasets were used:

- National datasets: ACI-STATS (Italy), BAAC ONSIR (France), DESTATIS (Germany - represented within the GIDAS weighted analysis), DGT (Spain), STATS19 (UK), ELSTAT (Greece) and SWOV/BRON (The Netherlands).
- In-depth datasets: IGLAD (used to cover Italian accidents), VOIESUR (France), GIDAS (Germany), DIANA (Spain), RAID STATS19 (GB), ELSTAT (Greece) and SWOV/BRON (The Netherlands).

First the national datasets, that contains an important sample of accidents, were studied with a cluster analysis, method approach based on prior knowledge of the UK datasets and analysis methods used to derive car-to-car and car-to-pedestrian accident scenarios [2].
In-depth databases were analysed to provide initial travel and impact speeds for the car and motorcycle by accident scenario. Whilst these datasets are very insightful due to the high number of variables recorded there is an inherent issue of a small number of analysed cases, but a good number of data samples have been returned for the more frequent accident scenarios identified in from the national dataset analysis that help form the basis for test procedures [2].

2.1.3.1.3 Group of scenarios

The outcomes of the analyses showed with the table below Table 3 the most common motorcycle accident scenarios.

Table 3: Accident Groups - Equal Weighting. Extract from MUSE D1.1 [2].

Accident Group	Weighted Percentage
Left Turn Across Path - Opposite Direction Conflict	21.41%
Left Turn Across Path - Left Direction Conflict	18.37%
Straight Crossing Path - Right Direction Conflict	13.93%
Left Turn Across Path - Same Direction Conflict	14.56%
Straight Crossing Path - Left Direction Conflict	9.59%
Follow-up Driving	5.77%
Parallel Driving	3.52%
Lane Change - Same Direction Conflict	3.20%
On Coming - Straight Driving	2.82%
Lane Change - Opposite Direction	2.02%
On Coming - Turning	1.64%
Left Turn Into Path - Right Direction Conflict	0.00%
Right Turn Into Path - Left Direction Conflict	0.35%
Reverse Across Path - Right Direction Conflict	0.20%
Reverse Crossing Path - Left Direction	0.00%
Parallel Turn - Same Direction	0.00%
Reverse Driving - Opposite Direction	0.00%
Right Turn Across Path - Right Direction	0.00%

The main scenarios are described as below, using 3-digit GIDAS code, defined by cluster analysis:

<u>Left Turn Across Path - Opposite Direction Conflict</u>

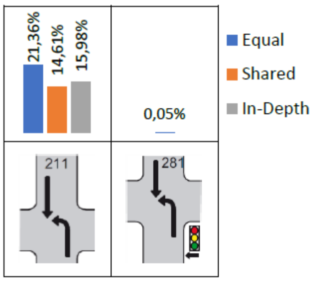


Figure 3-181: Use cases - LTAP/OD

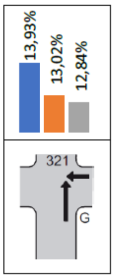
The definition of the scenario is: the passenger car is performing the left turn across the path of the oncoming PTW. [2]

Cluster:

- Speed limits are 50km/h, 80km/h and 100km/h
- Impact location is the front (both vehicles)

Figure 10: LTAP-OD results from MUSE project [2]

<u>Straight Crossing Path - Right Direction Conflict</u>



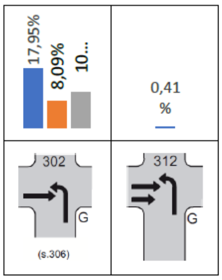
This scenario represents the passenger car failing to give way to priority traffic, traveling straight across the path of the PTW travelling from the car’s nearside PTW at a crossroads. [2]

Cluster:

- Accidents occur on urban road
- Speed limit is 50km/h
- Impact location is the front for the car and left for the PTW

Figure 11: SCP -RD results from MUSE project [2]

Left Turn Across Path - Left Direction Conflict



The car is represented as the ego vehicle performing the left turn across the path of the oncoming PTW. In a small number of cases, the PTW is overtaking or travelling parallel with a vehicle in the same direction on the offside. [2]

Cluster:

- Accidents occur on urban roads
- Speed limit is 50 km/h and 100 km/h
- Impact is on the offside for the car and front for the PTW.

Figure 12: LTAP -LD results from MUSE project [2]

Follow-up Driving

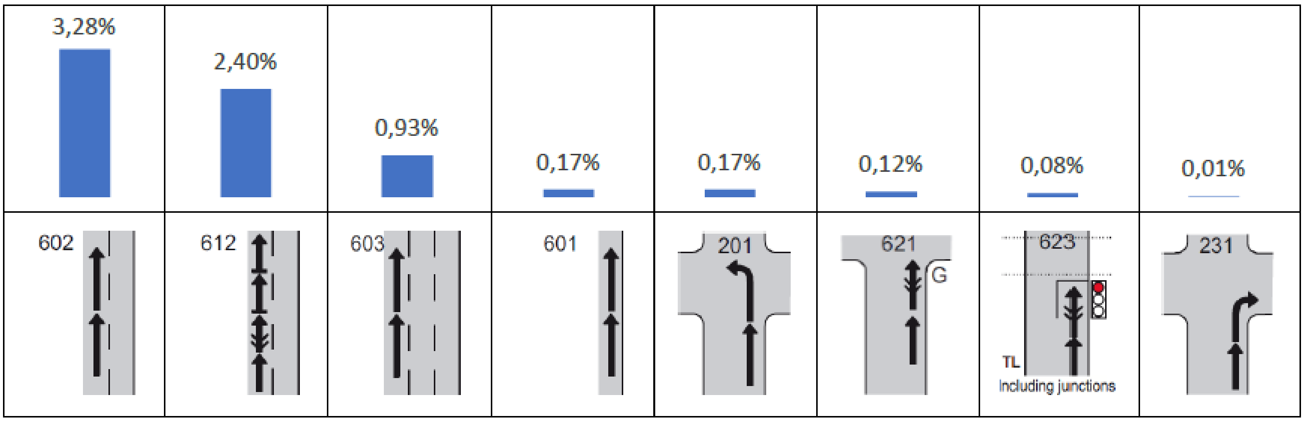


Figure 13: Follow-up driving results from MUSE project [2]

In this scenario the car is represented as the ego vehicle travelling straight ahead and impacting the rear of the PTW whilst it is also travelling straight ahead, slowing, stationary or turning. [2]

Cluster:

- Accidents occur mainly on urban roads, out of junction and on single carriage way roads.
- Speed limits are 50km/h and 100 km/h

Straight Crossing Path - Left Direction Conflict

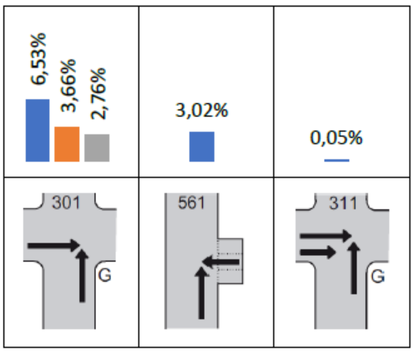


Figure 14: SCP- LD cluster results from MUSE project [2]

In this scenario the car is represented as the ego-vehicle, failing to give way to priority traffic, traveling straight across the path of the PTW travelling from the car's nearside at a crossroads or parking space. [2]

Cluster:

- Accidents on urban roads
- Speed limits of 50km/h, 80km/h and 100km/h
-Impact location is the front (both vehicles)

Based on observation from initial speeds, the car is approaching the junction at low or moderate speed due to the priority.

Left Turn Across Path - Same Direction Conflict

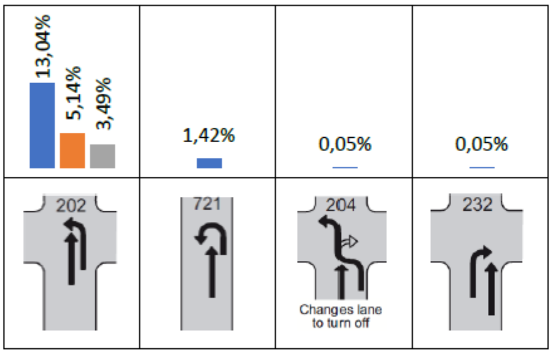


Figure 3-186: Use Cases - LTAP/SD

Figure 15: LTAP - SD cluster results from MUSE project [2]

In this scenario the car is represented as the ego-vehicle performing the left turn across the path of the approaching PTW from behind the car. [2]
In this study, it is considered similar to Right Turn Across Path – Same Direction Conflict.
Cluster:

- Accidents occur in urban area
- Speed limit is 50 km/h
- Impact location is front, front left or offside for the car and front for PTW.
- Speeds shows that the PTW is travelling at much higher speed that the car (turning at 10-28 km/h)

2.1.3.1.4 Conclusion

The main conclusions from the accident data study from MUSE project about accidents between a motorcycle and a passenger car are that more accidents occur at junctions.

In order, the most common at junction are the accident group:

- Left Turn Across Path – Opposite Direction (Figure 10: LTAP-OD results from MUSE project
- Straight Crossing Path – Right Direction (Figure 11)
- Left Turn Across Path – Left Direction (Figure 12)
- Straight Crossing Path – Left Direction (Figure 14)

The next most frequent accident type is front to rear where the car is the rear impacting vehicle against a slower moving or stationary motorcycle (Figure 13). Within the remaining accident scenarios, the configurations are mostly head-on and lane change conflicts.

2.1.4 Projects on Car to Pedestrian Accidents

2.1.4.1 <u>AsPeCSS</u>

2.1.4.1.1 Introduction

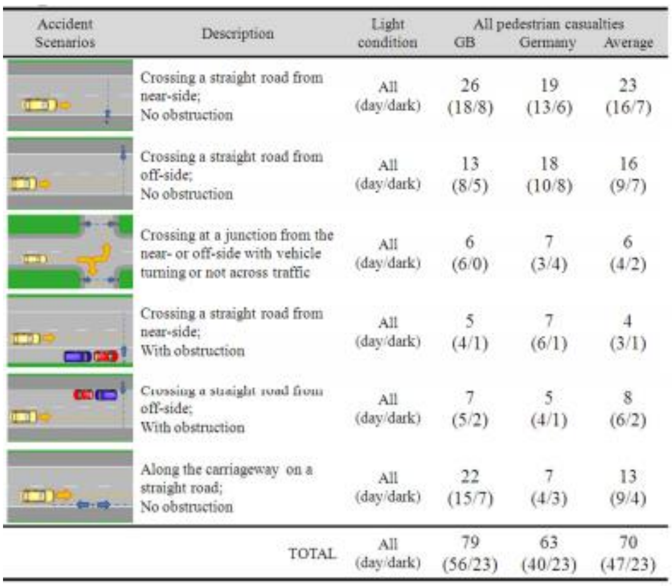
The AsPeCSS (Assessment methodologies for forward looking integrated Pedestrian and further extension to Cyclist Safety Systems) was led by the European research community and car industry from 2011 to 2014.
The overall objective is to contribute towards improving the protection of vulnerable road users, in particular pedestrians and cyclists, through the development of harmonised test and assessment procedures for forward-looking integrated pedestrian safety systems.

2.1.4.1.2 Method and database

Following a first overview of the main accident scenarios through a literature review, an accident data study was performed based on accident datasets from Germany (Destatis and GIDAS), UK (STATS19) and France (ONSIR).

An Accident Scenario was defined as "a crash configuration (general motion of the vehicle and pedestrian) together with key surrounding conditions (e.g. road layout, view of pedestrian obstruction of not, dark or light)".

2.1.4.1.3 Group of scenarios



Accident Scenarios	Description	Light condition	All pedestrian casualties GB	Germany	Average
	Crossing a straight road from near-side; No obstruction	All (day/dark)	26 (18/8)	19 (13/6)	23 (16/7)
	Crossing a straight road from off-side; No obstruction	All (day/dark)	13 (8/5)	18 (10/8)	16 (9/7)
	Crossing at a junction from the near- or off-side with vehicle turning or not across traffic	All (day/dark)	6 (6/0)	7 (3/4)	6 (4/2)
	Crossing a straight road from near-side; With obstruction	All (day/dark)	5 (4/1)	7 (6/1)	4 (3/1)
	Crossing a straight road from off-side; With obstruction	All (day/dark)	7 (5/2)	5 (4/1)	8 (6/2)
	Along the carriageway on a straight road; No obstruction	All (day/dark)	22 (15/7)	7 (4/3)	13 (9/4)
	TOTAL	All (day/dark)	79 (56/23)	63 (40/23)	70 (47/23)

Figure 16: AsPeCSS Accident Scenarios of car-to-pedestrian crashes in day and dark light [7]

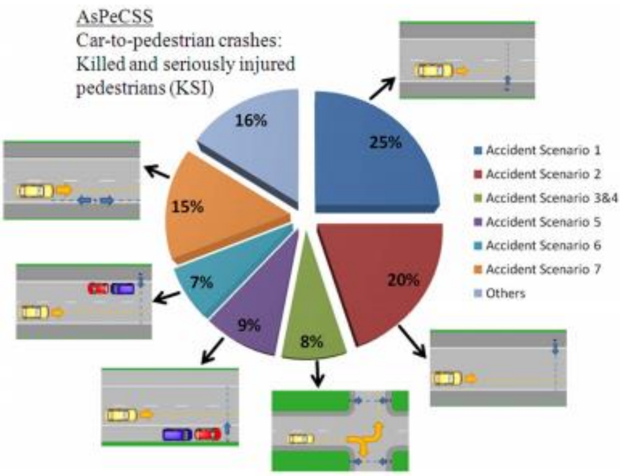


Figure 17: AsPeCSS Accident Scenarios - Overview of killed and seriously injured (KSI) pedestrians in crashes with cars [7]

To sum-up, the three highest weigthed scenarios are scenario 1, 2 and 7.

2.1.4.2 PROSPECT

2.1.4.2.1 Introduction

The project PROSPECT (PROactive Safety for PEdestrians and CyclisTs) started in May 2015 when the first generation of Autonomous Emergency Braking Systems that avoid and mitigate VRU accidents were in the market. The context of Euro NCAP in terms of VRU was roadmaps: for AEB-Pedestrian systems in 2016, AEB-Cyclist systems in 2018, then more complex scenarios in 2020.
Indeed, accidents involving Vulnerable Road Users remain a significant issue for road safety, accounting for 30% of pedestrian and motorcyclists of road fatalities in the European Union (World Health Organization, 2015).
In this context PROSPECT aims to significantly improve the effectiveness of active VRU safety systems compared to those available on the market by:

(1) expending scope of scenarios addressed by the systems and
(2) improve overall system performance based on sensors fusion and VRU modelling.

The project focuses on two groups with large shares of fatalities: cyclist and pedestrian.
Partners from 9 EU countries:

- Vehicle manufacturer: Audi, BMW, Volvo, TME, Daimler
- Tier-1 supplier: Bosch, Continental
- SMEs: 4activeSystems
- Research centres and Test laboratories: Applus IDIADA, BASt, VTI, TNO, IFSTTAR
- Academia: University of Nottingham, University of Budapest, University of Amsterdam, Chalmers.

2.1.4.2.2 Method and databases

The methodology applied for the study of the relevant VRU scenarios is described as:

- Macro statistical and in-depth accident analysis
    - National statistics from specific countries
    - Detailed understanding from GIDAS & IGLAD
    - CARE analysis for weighting to EU level

- Definition of traffic conditions and user expectations
    - Naturalistic urban observations with large number of VRUs
    - Hotspots monitoring in different EU cities

Then, for Germany, national statistics were provided by DESTATIS and used to derive a weighting of the accidents regarding severity and frequency.
The national database gives an important sample of accident for the study but a limited amount of information about the accident scenarios. The details about the accidents were added from GIDAS, based on reconstructed accidents between 2000 and 2013. Finally, 83.1 % (representing 3.550 cases) of all accidents between passenger cars and cyclists were analysed in further details within the project. [8]

and the following parameters were studied:

- Obstruction [yes/no]
- Daytime [day/night/dawn].
- Age of cyclist [0-90 years].
- Initial and collision velocity of the cyclist [0-55 kph].
- Initial and collision velocity of the passenger car [0-80 kph].

All the use cases were then weighted, based on the same method from ASSESS project [3], by applying weighting factors using injury cost (more detail and exact formula in the report [8]. The result shows a ranking of the accidents in terms of frequency and level of injury.

2.1.4.2.3 Group of scenarios

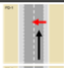
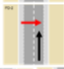
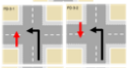
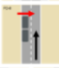
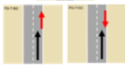
Accident Scenarios	ID	Description	Light condition	Fatalities	KSI	All
	1	Crossing a straight road from near-side; No obstruction	All (day/dark)	23 (9/14)	23 (14/9)	19 (13/6)
	2	Crossing a straight road from off-side; No obstruction	All (day/dark)	39 (6/33)	22 (10/12)	16 (9/7)
	3a, 3b	Crossing at a junction from the near (a)- or off-side(b); vehicle turning across traffic	All (day/dark)	5 (3/2)	11 (5/6)	11 (5/6)
	4a, 4b	Crossing at a junction from the near (a)- or off-side (b); vehicle not turning across traffic	All (day/dark)	1 (0.5/0.5)	4 (2/2)	5 (3/2)
	5	Crossing a straight road from near-side; With obstruction	All (day/dark)	6 (4/2)	10 (8/2)	8 (6/2)
	6	Crossing a straight road from off-side; With obstruction	All (day/dark)	3 (1/2)	7 (5/2)	5 (4/1)
	7	Along the carriageway on a straight road; No obstruction	All (day/dark)	6 (2/4)	3 (2/1)	6 (4/2)
No picture by now	8	Driving backwards	All (day/dark)	6 (5/1)	6 (5/1)	7 (6/1)
	0	Others	All (day/dark)	11 (6/5)	14 (10/4)	23 (17/6)
Urban only		TOTAL	All (day/dark)	100 (36/64)	100 (61/39)	100 (67/33)

Table 3.1: Overview of accident scenarios

The accident scenarios ID 1 to 7 are the same as already defined by the AsPeCSS project. Then accident scenario ID 8 describes crashes in which a pedestrian was injured by a reversing vehicle.
In summary, accident scenarios 1 and 2 were found to be the two highest weighted scenarios for car-to-pedestrian crash configurations in Germany (sum of weights concerning Killed and Seriously Injured people (KSI) is 45 % and concerning fatalities is 62 %). Those scenarios represent a pedestrian crossing, respectively from near-side and off-side, while the vehicle is travelling on a straight road, without any obstruction [8]

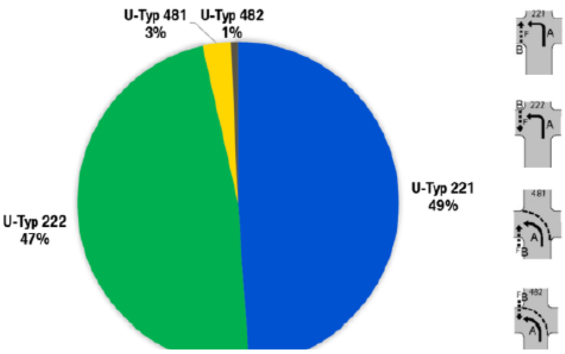


Figure 18: GIDAS U-type and traffic regulation for left-turning scenarios - GIDAS analysis from PROSPECT [8].

The third more critical situations are left-turning scenarios (use cases 3a and 3b).
In 98 % of the accidents, the vehicle has to wait for the pedestrian, which is shown in Figure 4.2. The pedestrian has the right of way in most of the cases.
GDV code: 221,222, 481,482

2.1.5 PROJECTS ON CAR TO BICYCLE ACCIDENTS

2.1.5.1 CATS

2.1.5.1.1 Introduction

Among the Vulnerable Road Users (without PTW), cyclists represent the second most important within the fatalities after the pedestrians. Therefore, following the development of active systems for pedestrian safety and the integration in Euro NCAP assessment of AEB – Autonomous Emergency Braking- testing with pedestrians, Euro NCAP decided to include these testing for cyclist as well from 2018.
Within this context, CATS was conducted from 2014 to 2016.

The objective of the CATS consortium was to develop a testing system for Cyclist-AEB:

- Preparing the introduction of a Cyclist-AEB protocol for consumer tests.
- Proposing a test setup (incl. hardware) and test protocol for Cyclist-AEB systems based on technical/scientific considerations.
- Base the tests on analysis of most relevant cyclist accident scenarios in EU countries.

2.1.5.1.2 Method and databases

Within the project, the objective of the WP1 “accident analysis” is to analyse car-to-cyclist accident in Europe Union. The data has been collected from 8 countries: Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom.
The project focuses on car-to-cyclist accidents. Cyclists include bicycle users and bicycle defined in the scope is referring to a legal definition of it, which will include e-bikes, but not motorized 2 wheelers such as mopeds, scooters or speed pedelecs.
The relevant accidents for this study are the ones that can be addressed by any safety systems on the passenger car. Therefore, only accidents involving a collision between one bicycle and one M1 vehicle (passenger car) are selected (not for example, single sided cyclist accidents).

#	Country	Source	Killed		Seriously injured		Period
			Definition	*n*	*Definition*	*n*	
1	France	LAB [7]	Fatal	72	Severely injured	620	2011
2	Germany	GIDAS based PCM [9]	Fatal	11	AIS2+	360	1999-2012
3	Italy	Fiat internal [10]	Fatal	23	AIS2+	17	2003-2014
4	Netherlands	BRON [11]	Fatal	902	Seriously injured	10854	2000-2013
5	Sweden	STA/STRADA [12]	Fatal	104	AIS2+	435	2005-2014 K 2010-2014 SI
6	UK	STATS19 [14]	Fatal	116	Seriously injured	2699	2008-2010

Figure 19: Overview of the accident databases for CATS scenarios selection.

Each accident scenario is defined by the combination of the orientation of the bicycle with respect to the car and the driving manoeuvre and direction of both the car and the bicycle. [9]

For all accident scenarios describe in the study, the following boundary conditions hold:

- Definitions are based on EU main land traffic directions and position on road.
- The bicycle can be located either on the road or a bicycle lane.
- Crossing is not limited to intersections.

The selection of accident scenarios was derived from previously performed literature studies. While working on the accident statistics for the different countries it was however noted that the table did not cover all possible scenarios and others were possible and to some extend also found within certain databases.
Therefore, an extensive check based on German GIDAS based PCM data is performed to determine whether the chosen accident scenarios would cover all relevant accident scenarios for seriously injured and fatal car-to-cyclist collisions. This is done by mapping accidents derived from GIDAS based PCM into a matrix. The matrix is chosen in a manner, that it reflects 100%Group of scenarios. [9]

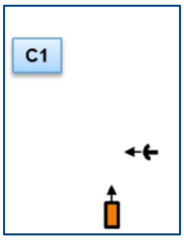
2.1.5.1.3 Group of scenarios

CATS scenarios are clustered from the perspective of the car, regardless if the car or the bicycle is causer of the conflict situation (i.e. participant A). The main accidents scenarios between M1 vehicle and cyclist have been classified in 4 main categories:

- Crossing
- Turning
- Longitudinal/Oncoming
- Remaining/Others

These categories include different scenarios defined as below. Pictogram are extracts from CATS report.

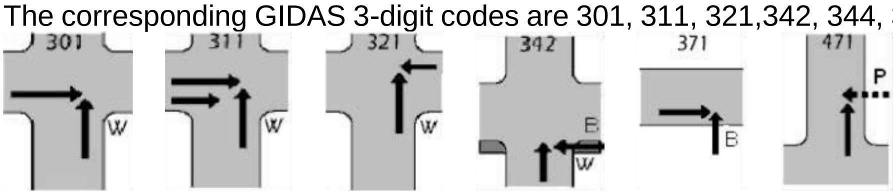
<u>Crossing</u>

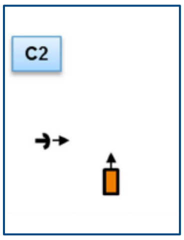


The description of the scenario is:
• Car driving straight
• Cyclist crossing the vehicle path from the right

This scenario cover 25% of the fatalities and 29 % of the seriously injured.

The corresponding GIDAS 3-digit codes are 301, 311, 321,342, 344, 371, 471.

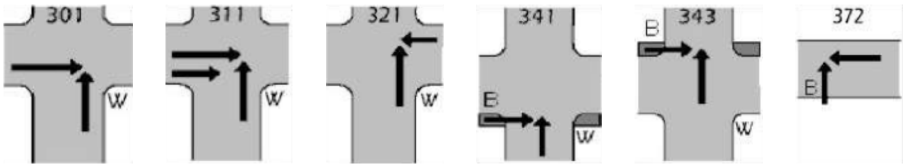




The description of the scenario is:
• Car driving straight
• Cyclist crossing the vehicle path from the left

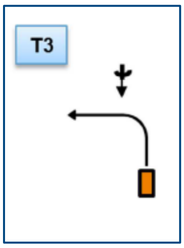
This scenario cover 29% of the fatalities and 28 % of the seriously injured.

The corresponding GIDAS 3-digit codes are 301, 311, 321, 341, 343, 372.



Turning

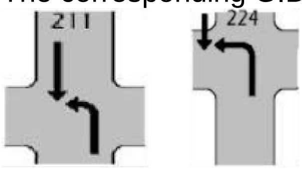
Turning scenarios category doesn’t account within the most common scenarios with 0-4% of the fatalities depending on the country.
Only one scenario was determined as relevant without the outcomes of the project.



The description of the scenario is:
• Car turning to the left, crossing the (straight) bicycle path
• Cyclist coming from the opposite direction, riding straight

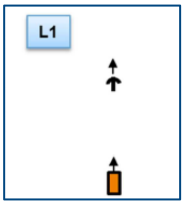
This scenario cover 29% of the fatalities and 28 % of the seriously injured.

The corresponding GIDAS 3-digit codes are 211, 224.



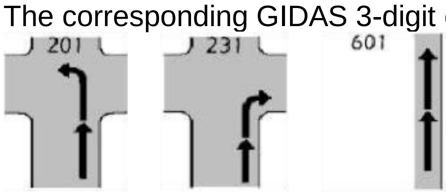
Longitudinal/Oncoming

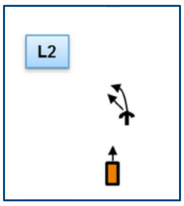
L: Car and cyclist driving in the same direction
This scenario cover 24% of the fatalities and 7% of the seriously injured.



The description of the scenario is:
• Cyclist is riding straight and hit by the car from the rear.

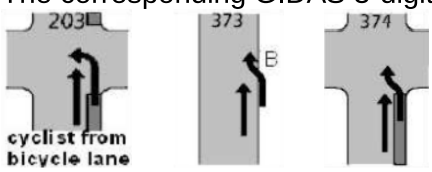
The corresponding GIDAS 3-digit codes are 201, 231, 601.

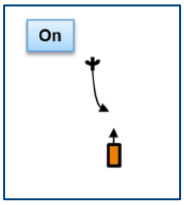




The description of the scenario is:
• Cyclist is swerving to the left in front of the car and hit by the car from the rear

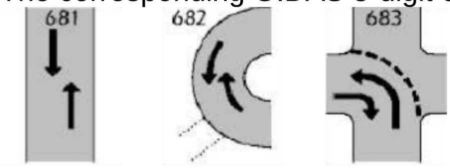
The corresponding GIDAS 3-digit codes are 203, 373, 374.





For oncoming scenarios, description is:
•Car driving straight, possibly driving towards the far roadside in a passing manoeuvre
•Cyclist coming in the opposite (on-coming) direction riding straight

This scenario cover 8% of the fatalities and 6% of the seriously injured.
The corresponding GIDAS 3-digit codes are 681, 682, 683.



2.1.5.2 PROSPECT

2.1.5.2.1 Introduction

Refer to paragraph 2.1.4.2.1.

2.1.5.2.2 Method and databases

Refer to paragraph 2.1.4.2.2.

2.1.5.2.3 Group of scenarios

Car-to-cyclist turning scenarios
The turning scenarios consist of the following cases:

- Vehicle turns to left and oncoming traffic.
- Vehicle turns to left and traffic in same direction.
- Vehicle turns to right and oncoming traffic.
- Vehicle turns to right and traffic in same direction.

The GDV code corresponding and considered in the analysis are:

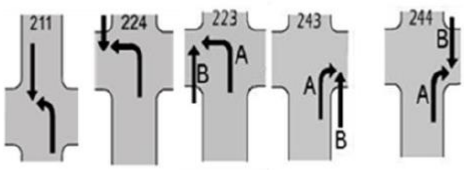


Figure 3.1: Turning scenarios

To be noted that within the project, these scenarios have been defined in different PROSPECT_UTYP cases, and further analyse, depending on the traffic signalisation for example.

Car-to-cyclist crossing scenarios

The crossing scenarios consist of different cases:

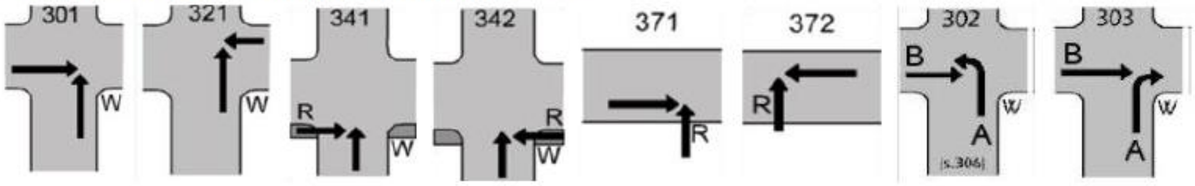


Figure 3.2: Car-to-cyclist crossing scenarios

Other situations

In UTYP 5xx, door-opening situations as well as rear-end accidents can be found.

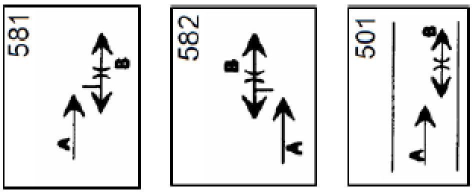


Figure 3.3: Door-opening and rear-end situations

Longitudinal situations

In UTYP 6xx situations, rear-end accidents as well as oncoming traffic accidents can be found.

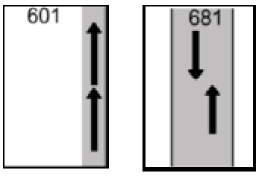


Figure 3.4: Longitudinal situations

Longitudinal cases -> refer to CATS project (paragraph 2.1.5.1).

2.1.6 CONCLUSION

The following table summarize the previous literature review and the most addressed accident scenarios by road users.

Table 4: Review of the main accident scenarios by road users.

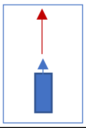
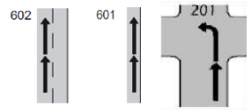
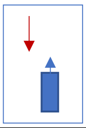
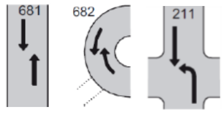
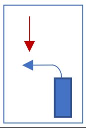
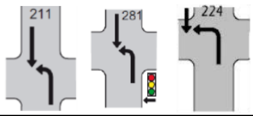
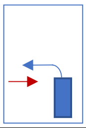
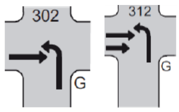
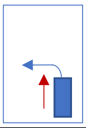
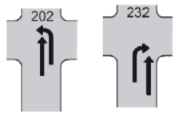
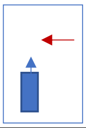
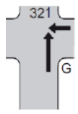
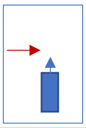
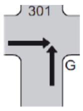
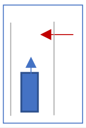
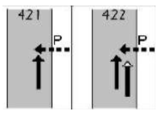
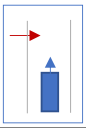
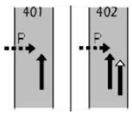
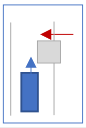
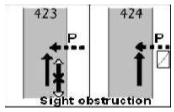
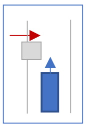
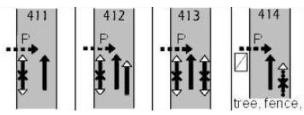
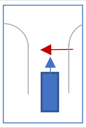
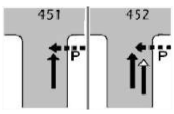
Scenarios	Car to Car	Car to PTW	Car to Bicycle	Car to Pedestrian
(A) Driving accidents - Loss of control	x			
(B) Accident in longitudinal traffic (same and opposite directions)	x		x	
(B) On Coming - Lane Change - parallel Driving		x		
(B) - 1) Follow-up Driving		x	x	
(B) - 2) On Coming			x	
(C) Accident with turning vehicle(s) or crossing paths in junctions	x			
(C) - 1) Left Turn Across Path-Opposite Direction (LTAP-OD)	x	x	x	
(C) - 2) Left Turn Across Path-Left Direction (LTAP-LD)	x	x	x	
(C) - 3) Left Turn Across Path-Same Direction (LTAP-SD)		x		
(C) - 4) Straight Crossing Paths (SCP)	x			
(C) - 4a) Straight Crossing Paths - Right Direction (SCP - RD)		x	x	
(C) - 4b) Straight Crossing Paths - Left Direction (SCP - LD)		x	x	
(D) Accidents involving pedestrians and bicycles				x
(D) - 1) Crossing scenarios				x
(D) - 1a) Crossing a straight road from near-side; no obstruction			x	x
(D) - 1b) Crossing a straight road from off-side; no obstruction			x	x
(D) - 1c) Crossing a straight road from near-side; with obstruction				x
(D) - 1d) Crossing a straight road from off-side; with obstruction				x
(D) - 1e) Crossing at junction road from near-side; no/with obstruction			x	
(D) - 1f) Crossing at junction from off-side; no/with obstruction			x	
(D) - 2) Along the carriageway on a straight road.				x
(D) - 3) Turning Scenarios				
(D) - 3a) Left Turning Scenarios; near-side			x	x
(D) - 3b) Left Turning Scenarios; off-side			x	x
(D) - 3c) Right Turning Scenarios; near-side			x	
(D) - 3d) Right Turning Scenarios; off-side			x	
(E) - Door opening and rear-end situations	Running-up from behind		x	

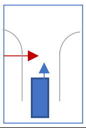
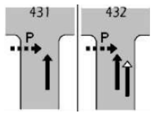
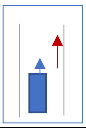
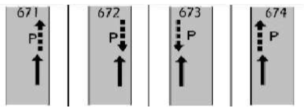
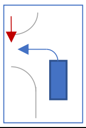
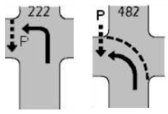
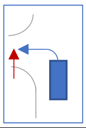
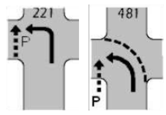
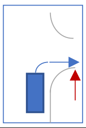
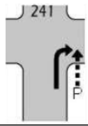
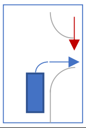
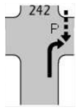
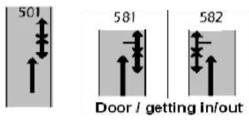
Table 5: Review of the main accident scenarios by project.

Project	Road Users	Most relevant scenarios (1)	%(2)
ASSESS	Car to Car Car to Pedestrian	(A) Driving accidents - Loss of control (B) Accident in longitudinal traffic (same and opposite directions) (C) Accident with turning vehicle(s) or crossing paths in junctions (D) Accidents involving pedestrians	30% 26% 25% 10%
INTERSECTION 2020	Car to Car	(C) - 1) LTAP-OD (C) - 2) LTAP-LD (C) - 3) SCP	27% 20% 36%
MUSE	Car to PTW	(C) - 1) LTAP-OD (C) - 4a) SCP - RD (C) - 2) LTAP-LD (B) - 1) Follow-up Driving (C) - 4b) SCP - LD (C) - 3) LTAP-SD (B) On Coming - Lane Change - parallel Driving	21% 14% 18% 6% 10% 15% 12% (∑,1-3%)
AsPeCSS	Car to Pedestrian	(D) - 1a) Crossing a straight road from near-side; no obstruction (D) - 1b) Crossing a straight road from off-side; no obstruction (D) - 2) Along the carriageway on a straight road.	25% 20% 15%
PROSPECT	Car to Pedestrian	(D) - 1a) Crossing a straight road from near-side; no obstruction (D) - 1b) Crossing a straight road from off-side; no obstruction (D) - 3b) Left Turning Scenarios; off-side (D) - 3a) Left Turning Scenarios; near-side (D) - 1c) Crossing a straight road from near-side; with obstruction (D) - 1d) Crossing a straight road from off-side; with obstruction (D) - 2) Along the carriageway on a straight road.	23% 39% 5% 6% 3% 6%
PROSPECT	Car to Bicyclist	(C) - 1) LTAP-OD (D) - 3b) Left Turning Scenarios; off-side (D) - 3a) Left Turning Scenarios; near-side (D) - 3d) Right Turning Scenarios; off-side (D) - 3c) Right Turning Scenarios; near-side (C) - 4b) SCP - LD (C) - 4a) SCP - RD (C) - 2) LTAP-LD (D) - 1a) Crossing a straight road from near-side; no obstruction (D) - 1b) Crossing a straight road from off-side; no obstruction (D) - 1e) Crossing at junction road from near-side; no obstruction (D) - 1f) Crossing at junction from off-side; no obstruction (E) - Door opening and rear-end situations (B) Accident in longitudinal traffic (same and opposite directions)	5.2% 1.5% 3.0% 2.4% 5.6% 8.7% 9.2% 5.5% 9.5% 4.5%
CATS	Car to Bicyclist	(C) - 4a) SCP-RD (C) - 4b) SCP-LD (C) - 1) LTAP-OD (B) - 1) Follow-up Driving (B) - 2) Oncoming	18-31% 11-40% 0-4% 10-49% 0-14%

(1) The column lists the most relevant scenarios highlighted by the relative story.
(2) The percentage written is not to be taken as absolute value but as an indication of the proportion of the accidents scenario within the most relevant written in (1).

Table 6: Representation and example of accident situations by scenarios.

Scenarios	Representation	Example from GDV code
(A) Driving accidents - Loss of control	Loss of control single vehicle	
(B) Accident in logitudinal traffic (same and opposite directions)		
(B) On Coming - Lane Change - parallel Driving		
(B) - 1) Follow-up Driving		
(B) - 2) On Coming		
(C) Accident with turning vehicle(s) or crossing paths in junctions		
(C) - 1) Left Turn Across Path-Opposite Direction (LTAP-OD)		
(C) - 2) Left Turn Across Path-Left Direction (LTAP-LD)		
(C) - 3) Left Turn Across Path-Same Direction (LTAP-SD)		
(C) - 4) Straight Crossing Paths (SCP)		
(C) - 4a) Straight Crossing Paths - Right Direction (SCP - RD)		
(C) - 4b) Straight Crossing Paths - Left Direction (SCP - LD)		
(D) Accidents involving pedestrians		
(D) - 1) Crossing scenarios		
(D) - 1a) Crossing a straight road from near-side; no obstruction		
(D) - 1b) Crossing a straight road from off-side; no obstruction		
(D) - 1c) Crossing a straight road from near-side; with obstruction		
(D) - 1d) Crossing a straight road from off-side; with obstruction		
(D) - 1e) Crossing at junction road from near-side; no obstruction		

Scenarios	Representation	Example from GDV code
(D) - 1f) Crossing at junction from off-side; no obstruction		
(D) - 2) Along the carriageway on a straight road.		
(D) - 3) Turning Scenarios		
(D) - 3a) Left Turning Scenarios; near-side		
(D) - 3b) Left Turning Scenarios; off-side		
(D) - 3c) Right Turning Scenarios; near-side		
(D) - 3d) Right Turning Scenarios; off-side		
(E) - Door opening and rear-end situations		

2.2 Study n°2: V2X-Safety-Use cases State-of-the-art

2.2.1 Introduction

In this chapter the existing safety use cases of other studies will be analysed. For giving an overview about the state of the art of V2X (Vehicle-to-Everything) safety use cases, the following source list (Table 7) got collected in a first step of the literature research.

Table 7: Sources list V2X safety use cases

#	Project / Source	Type	Year	Geographical range
1	MUSE – Deliverable 5.1	Deliverable	2018	Europe
2	5GAA	Paper	2019	Global
3	5GAA	Report	2020	Global
4	5GCAR	Deliverable	2019	Europe, US, China
5	5GCroCo	Deliverable + Presentation	2020	Europe
6	5G Carmen	Deliverable	2019	Europe
7	C2CCC	Paper	2019	Europe
8	CMC - Consortium	Report	2020	Germany
9	ASPECSS	Report	2014	Europe
10	C-ITS Platform	Report	2016	Europe
11	Convex	Deliverable	2017	Europe
12	PAC V2X	Deliverable	2017	Europe
13	Sim TD	Deliverable	2009	Germany

In the following chapters, the single sources are analysed and described more in detail.

2.2.2 Source 1 – MUSE Deliverable 5.1 (2018) [10]

The Motorbike Users Safety Enhancement (MUSE) was a project by UTAC with the aim to improve the safety of powered two-wheelers.

The report starts with a presentation of the current state of the art of Advanced Driver Assistance Systems (ADAS) in cars in the categories of comfort and security and a short overview of these systems which can address the safety of riders. Followed by a summary of Advanced Rider Assistance Systems (ARAS) in powered two-wheelers and a short overview of projects about active safety for Powered Two-Wheelers (PTW). The last part is about Intelligent Transport Systems (ITS), the Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication with a short overview of projects and programs about ITS.

The presented applications of V2V systems are Intersection Movement Assist, Left Turn Assist, Emergency Electronic Brake Light, Forward Collision Warning, Blind Spot Warning + Lane Change Warning, Do Not Pass Warning, Vehicle Turning Right in Front of Bus Warning, Car Breakdown Warning, Approaching Emergency Vehicle, Slow Vehicle Warning, Post-Crash-Warning, Obstacle Warning, Motorcycle Warning, Traffic Information and Recommended Itinerary, Transparent Leasing.

Furthermore the listed V2I applications are Traffic regulation warning (Red Light Violation Warning, Curve Speed Warning, Stop Sign Gap Assist, Stop Sign Violation Warning, Railroad Crossing Violation Warning, Green Light Optimized Speed Advisory), Setback warning (Reduced Speed Zone Warning, Oversize Vehicle Warning, In-vehicle Signage, Road Works Warning), Information (Spot Weather Information Warning), Other (Insurance and Financial Services, Dealer Management, Point of Interest Notification, Fleet Management).

“The main objective in MUSE is to improve safety of motorcyclists”. “V2V and V2I safety applications […] could play a role to address accident and safety of riders, but only if cars and motorcycles are equipped with ITS devices in order to communicate together” [10, p. 37].

In Table 8 the use cases and the addressed communication types of this project are shown.

Table 8: Use cases - MUSE Deliverable 5.1

#	Use cases	Type
1	- Motorcycle Users Safety - V2V possible Applications • Intersection Movement Assist • Left Turn Assist • Emergency Electronic Brake Light - V2I possible Applications • Traffic regulation warning • Setback warning • Other	V2V, V2I

[10]

2.2.3 Source 2 – 5GAA Paper (2019) [11]

The 5G Automotive Association (further 5GAA) is an organization to link automotive, technology and telecommunication industries.

This white paper describes the 5GAA methodology used to create solution agnostic use cases (UC) descriptions in order to facilitate the selection of the most suitable technology to realize a UC. Then a few UCs were used to illustrate the methodology. Summarized, this paper presents an example set of V2X UC descriptions, the service level requirements and the corresponding framework for the description of solution-independent UCs and service level requirements.

In Table 9 the use cases and the addressed communication types of this paper are shown.

Table 9: Use cases – 5GAA Paper

#	Use cases	Type
2	- Cross Traffic Left Turn Assist - Intersection Movement Assist - Emergency Break Warning - Lane Change Warning - Hazard Location Warning - Other Use Cases that address UC grouping	V2V

[11]

2.2.4 Source 3 – 5GAA Report (2020) [12]

This report builds on the white paper in chapter 2.2.2. It describes advanced UCs that have challenging requirements for future communication systems, especially 5G, and are applicable to both driven and autonomous vehicles. In total, 31 UCs are described. Examples for these UCs are "Tele-Operated Driving", "Cooperative Maneuver of Autonomous Vehicles for Emergency Situations", "Continuous Traffic Flow via Green Lights Coordination" and the "Obstructed View Assist", to name a few. In case of "Tele-Operated Driving", the challenging requirements are information about road conditions, traffic signs, traffic information, lane designations and geometry, vehicle location, speed, trajectory and maneuver instructions (steering wheel, acceleration and brake pedal inputs). In case of "Obstructed View Assist", the location of the vehicle, the location of the surveillance camera, and the video stream are required.

In Table 10 the use cases and the addressed communication types of this report are shown.

Table 10: Use cases – 5GAA Report

#	Use cases	Type
3	- Cooperative Traffic Gap - Interactive Vulnerable Road User (VRU) Crossing - Vehicle Operations Management - Infrastructure-Based Tele-Operated Driving - Other Use Cases that address UC grouping	V2V

[12]

2.2.5 Source 4 – 5GCAR Deliverable (2019) [13]

The Fifth Generation Communication Automotive Research and innovation (further 5GCAR) is a project funded by the European Commission (EC) in the scope of Horizon 2020.

"The overall goal of the 5GCAR project is to contribute to the specification of 5G to become a true enabler of V2X applications that today are not realizable due to the limitations of current communication networks" [13, p. 4]. Five use case classes are introduced that has been identified as relevant classes.

Those are:

1. Cooperative maneuver
2. Cooperative perception
3. Cooperative safety
4. Autonomous navigation
5. Remote driving

In each UC class, one relevant and representative UC is selected:

1. Lane merge (Cooperative maneuver)
2. See-through (Cooperative perception)
3. Network assisted vulnerable pedestrian protection (Cooperative safety)
4. High-definition local map acquisition (Autonomous navigation)
5. Remote driving for automated parking (Remote driving)

After the definition of the UCs and UC Classes, the requirement labels and definitions were specified. The requirements have been divided into automotive requirements, network requirements and qualitative or non-functional requirements.

In Table 11 the use cases and the addressed communication types of this project are shown.

Table 11: Use cases – 5GCAR Deliverable

#	Use cases	Type
4	- Use Case Classes • Cooperative Manoeuvre • Cooperative Perception • Cooperative Safety - Use cases • Lane Merge • See-through • Network Assisted VRU Protection	V2X, V2I

[13]

2.2.6 Source 5 – 5GCroCo Deliverable and Presentation (2020) [14]

The Fifth Generation Cross-Border Control (further 5GCroCo) is a research and innovation project in the scope of Horizon 2020 (funded by EC). They act cross-border between France, Germany and Luxembourg.

“5GCroCo intends to specify, develop, trial and demonstrate future automotive use cases that require seamless availability of 5G telecommunication features at operator and country borders” [14, p. 4]. This paper presents three UCs that have been identified to be representative for the automated driving application.

1. Tele-Operated Driving
2. High-Definition map generation and distribution for autonomous driving
3. Anticipated Cooperative Collision Avoidance

These three UCs are specified in detail together with the requirements that are imposed by them. In particular, the test cases are specifying what has to be tested and measured and where it will be tested.

In Table 12 the use cases and the addressed communication types of this study are shown.

Table 12: Use cases – 5GCroCo Deliverable

#	Use cases	Type
5	- Use cases: • Tele-Operated Driving • High-Definition Map Generation and Distribution for Autonomous Driving • Anticipated Cooperative Collision Avoidance	V2X, V2N

[14]

2.2.7 Source 6 – 5G Carmen Deliverable (2019) [15]

The 5G for Connected and Automated Road Mobility in the European Union (further 5G Carmen) is a project (as part of the Horizon 2020) funded by the EC. It investigates the 5G based possibilities for connected driving on a corridor between Germany (Munich), Austria (Innsbruck) and Italy (Bologna).

"The deliverable reports on the 5G-CARMEN use cases and the associated functional and system requirements" [15, p. 8]. The deliverable includes a report on previous tasks, such as analysis of existing and past projects with key deliverables and guidelines, as input for 5G-CARMEN developments. It provides an overall description for use cases, possible networking approaches and related information flows. The 5G-CARMEN use cases are:

1. Cooperative Maneuver
2. Situation Awareness
3. Green Driving
4. Video Streaming

The report shows a high-level data flow representation of these use cases, highlighting the kind of networking approach.

In Table 13 the use cases and the addressed communication types of this project are shown.

Table 13: Use cases – 5G Carmen Deliverable

#	Use cases	Type
6	- Cooperative Manoeuvring - Cooperative Lane Merging - Situation Awareness - Video Streaming	V2V, V2I, V2N

[15]

2.2.8 Source 7 – C2CCC Paper (2019) [16]

The Car To Car Communication Consortium (further C2CCC) is a consortium of European and international vehicle manufacturers and other partners for researching and developing Cooperative Intelligent Transport Systems (C-ITS).

"This white paper provides the Car-2-Car Communication Consortium with guidance about activities that are needed or have to be prioritized for preparing the future Cooperative Intelligent Transport Systems (C-ITS) deployment […]" [16, p. 6]. For this purpose, UCs are presented, the associated technological requirements are shown, and a detailed description of the application-related services is provided.

In Table 14 the use cases and the addressed communication types of this study are shown.

Table 14: Use cases – C2CCC Paper

#	Use cases	Type
7	- Electronic Emergency Break Light Warning - Emergency Vehicle Approaching Warning - Adverse Weather Conditions - Pre-Crash Sensing Warning - Probe Vehicle Data - Road Work Warning (Short / Long term) - Slow or stationary Vehicle Warning - Red Light Violation Protection - Traffic Jam Ahead Warning - Co-operative Glare Reduction - Traffic Signal Priority Request - (Advanced) Intersection Collision Warning - (Improved) Vulnerable Road User Protection - (Optimized) Traffic Light Information - (Automated) Green Light Optimum Speed Advisory - Green Wave Information - In-Vehicle Signage - Motorcycle Approaching Information / Warning - Advanced Pre-Crash Sensing Warning - Cooperative Adaptive Cruise Control - Overtaking Vehicle Warning - Target Driving Area Reservation - Cooperative Merging Assistance / Lane Change / Overtaking	V2X

[16]

2.2.9 Source 8 – CMC Report (2020) [17]

The Connected Motorcycle Consortium (further CMC) addresses the safety of PTW. They work at the aim to make PTW fit for the connected traffic future.

This report shows an analysis of PTW accidents. In order to evaluate future C-ITS for PTW, it is important to know the PTW accident situation in detail. Therefore, the German PTW accident situation was analysed with the following filter criteria:

1. Completely reconstructed and coded accidents
2. Accidents since 2005
3. Minimum one L3e (Regulation (EU) No. 168/2013) vehicle was involved (no moped)
4. Exclusion of unknown accident types

19 applications were selected for the accident analysis, that could have an impact on the accident scenario with focus on collision accidents. The paper mentions nine of them and the calculated potential of these for PTW safety. The UCs identified are the "Motorcycle Approach Indication / Warning", "Intersection Movement Assist" (IMA), "Forward Collision Warning" (FCW), "Blind Spot Warning" (BSW), "Lane Change Warning" (LCW), "Left Turn Assist" (LTA), "Electronic Emergency Brake Light" (EEBL) and the "Hazardous Location Notification" (HLN).

The potential of the C-ITS applications in the combination of IMA, LTA, BSW / LCW, FCW, Do Not Pass Warning (DNPW) in dependence of the regarded injury severity is the following:

- All injured: 23%
- All KSI: 20%
- All fatal: 25%

In Table 15 the use cases and the addressed communication types of this study are shown.

Table 15: Use cases – CMC Consortium Report

#	Use cases	Type
8	- Motorcycle Approach Indication / Warning - Do Not Pass Warning - Intersection Movement Assist - Forward Collision Warning - Blind Spot Warning - Lane Change Warning - Left Turn Assist - Electronic Emergency Brake Light - Hazardous Location Notification	V2VRU (PTW)

[17]

2.2.10 Source 9 – AsPeCSS Report (2014) [18]

The Assessment methodologies for forward looking Integrated Pedestrian and further extension to Cyclist Safety (further AsPeCSS) is a project to improve the safety of VRU, especially pedestrian and cyclists.

"The overall purpose of the AsPeCSS project was to contribute towards improving the protection of vulnerable road users, in particular pedestrians and also cyclists, by developing harmonized test and assessment procedures for forward-looking integrated pedestrian safety systems" [18, p. 2]. The report starts with an accident analysis and test scenarios were then derived through different factors. The accident scenarios "Crossing a straight from near-side and off-side" and "Along the carriageway on a straight road" were found as the highest weighted scenarios for car-to-pedestrian crash configurations. The preliminary test scenarios for car-to-bicyclist scenarios are "City Crossing" (car and bicycle moving straight forward), "City turning left/right" (car turning off the road with bicyclist moving straight forward) and "Inter-Urban Longitudinal" (car travelling straight forward hitting the bicyclist driving straight forward from behind). Also test targets, test tools and test procedures used in

Autonomous Emergency Braking for Pedestrians (AEB-P) testing is shown. Furthermore, pedestrian impactor testing and simulation was studied.

In Table 16 the use cases and the addressed communication types of this report are shown.

Table 16: Use cases – AsPeCSS Report

#	Use cases	Type
9	- Proposed preliminary test scenarios: • City Crossing • City Turning Left • City Turning Right • Inter-Urban Longitudinal	V2VRU

[18]

2.2.11 Source 10 – C-ITS Platform Report (2016) [19]

The C-ITS Platform is a consortium of about 120 member experts to reconcile different aspects of technical and legal issues to ensure the interoperability of C-ITS in different countries.

This paper shows the main technical issues (frequencies, hybrid communications, security and access to in-vehicle data and resources) and legal issues (liability, data protection and privacy) of C-ITS. Three UCs were determined:

- Intersection Collision Warning
- Regulatory Speed Limits Notification
- Probe Vehicle Data Collection

The report also covers standardization, cost benefit analysis, business models, public acceptance, international cooperation, road safety and other implementation topics. In addition, policy recommendations and proposals for action will be developed for both the EC and other relevant actors along the C-ITS value chain.

In Table 17 the use cases and the addressed communication types of this report are shown.

Table 17: Use cases – C-ITS Platform Report

#	Use cases	Type
10	- Three proposed use cases: • Intersection Collision Warning • Regulatory Speed Limits Notification • Probe Vehicle Data Collection	V2V, V2I

[19]

2.2.12 Source 11 – ConVeX Deliverable (2017) [20]

The Connected Vehicle to Everything (further ConVeX) is a project by the German Ministry of

Transportation and Digital Infrastructure with the aim to develop a test scenario for V2X.

The document describes V2X UCs, requirements and performance evaluation criteria with which traffic scenarios, deployment environment and vehicle characteristics (density, speed, lanes) are derived. Based on the selected UCs and traffic scenarios, the set of requirements to be used and met by the implementation technology is defined. This includes requirements on:

1. Communication links / protocols
2. Intra-car-connectivity (sensors / actors)
3. Applications (messaging, processing, Human-Machine-Interface)
4. General features to be supported by the selected UCs

Additionally, the test measurements and logs that have to be collected along with the collection methodology are described. 12 UCs are proposed, covering the areas of traffic safety, traffic efficiency and comfort: “Follow Me Information”, “Cloud Based Sensor Sharing”, “Blind Spot / Lane Change Warning”, “Do Not Pass Warning”, “Emergency Electronic Brake Lights”, “Intersection Movement Assist”, “Left Turn Assist”, “VRU Warning”, “Shockwave Damping”, “In-Vehicle Information”, “Road Works Warning”, “Network Availability Prediction”.

In Table 18 the UCs and the addressed communication types of this study are shown.

Table 18: Use cases – Convex Deliverable

#	Use cases	Type
11	- 12 selected use cases: • Follow Me Information • Cloud Based Sensor Sharing • Blind Spot / Lane Change Warning • Do Not Pass Warning • Emergency Electronic Brake Lights • Intersection Movement Assist • Left Turn Assist • Vulnerable Road User Warning • Shockwave Damping • In-Vehicle Information • Road Works Warning • Network Availability Prediction	V2V, V2I, V2N, Vehicle-To-Pedestrian (V2P)

[20]

2.2.13 Source 12 – PAC V2X Deliverable (2017) [21]

The Perception Augmented by V2X Cooperation (further PAC V2X) is a French project with the aim to augment the perception of connected vehicles in complex traffic situations.

The document describes the purpose of the PAC V2X project. “The […] purpose is to augment the vehicles perception of their environment via a cooperation between the infrastructure and the vehicles themselves” [21, p. 5]. Five services, divided into a total of eight UCs, are considered during this project:

1. Intersection Crossing Assist

   a. Traffic Light Violation Warning
   b. Traffic Scheduling Assist
2. Lane Merging Assist
   a. Motorway Access Assist
   b. Active Roadwork Warning
3. Lane Change Assist
   a. Motorway Tolling Assist
   b. Overtaking with Limited Perception
4. Wrong Way Driving
   a. Motorway Access via an Exit Warning
5. Contextual Speed Adaptation
   a. Speed Limit Adaptation

"This document provides the general specifications of services, applications and use cases which will be developed during the PAC V2X project. It provides the functional and operational requirements of the applications with the objective to support the specified services" [21, p. 6].

In Table 19 the use cases and the addressed communication types of this project are shown.

Table 19: Use cases – PAC V2X Deliverable

#	Use cases	Type
12	- 8 selected uses cases: • Traffic Light Violation Warning • Traffic Scheduling Assist • Motorway Access Assist • Active Roadwork Warning • Motorway Tolling Assist • Overtaking with Limited Perception • Motorway Access via an Exit Warning • Speed Limit Adaptation	V2X, V2I

[21]

2.2.14 Source 13 – simTD Deliverable (2009) [22]

The Safe Intelligent Mobility in the test area Germany (further simTD) is a project initialized by the German Ministry of Education and Research. It is a predecessor project of the C2CCC (see also chapter 2.2.8).

Source 13 consists of a total of three reports written by the sim TD Consortium. "[The] document presents a comprehensive collection of V2X based functions that serves as the basis for the selection of the functions to be realized in simTD. […] As a result, 32 functions together with 72 use cases are described and merged into an extended V2X function list" [22, p. 2].

After the description of the functions follows a report about the analysis of the efficiency of selected simTD-systems, based on real accident data from the GIDAS database. Three use cases have been analyzed for their specific areas of action: Electronic Brake Light, Cross Traffic Assistant and Traffic Sign Assistant for Right of Way Regulations [23].

In the last report, the main road safety impacts of simTD were identified. For this purpose, the

Electronic Brake Light, the Cross Traffic Assistant and the Traffic Sign Assistant for Right of Way Regulations were investigated. The benefit effects are determined under the premise, that these systems can unfold their full effectiveness through a correspondingly high equipment rate [24].

In Table 20 the use cases and the addressed communication types of this study are shown.

Table 20: Use cases – simTD Deliverable

#	Use cases	Type
13	- 32 functions - 76 use cases - Safety relevant use case: • Provision of traffic weather data • Identification of planned and not planned traffic events • Road information in the surrounding of a road work scene • Priorization of emergency vehicles • Pre-crash warning • Warning of: ○ Broken vehicles ○ Slow vehicles ○ Road work ○ Obstacles on the road ○ Traffic jam ○ Weather danger ○ Emergency vehicles (stationary or coming) • Collision warning • Emergency brake assistant • Electronical brake light • Pre-crash data transfer • Adaptive cruise control • Cross traffic assistant • Left turn assistant • Right turn assistant • Lane change assistant • Merge assistant • Warning / acting VRU safety system	V2V, V2I

[22]

2.2.15 Conclusion

Taking the analysed information sources into account, it can be summarized, that most of the researched reports and projects addresses various fields of communication types. The most studied fields in vehicle safety development with V2X are mainly vehicle-to-vehicle communication and vehicle-to-infrastructure communication.

Most of the existing projects investigate the possibilities and implementability of the following V2X based safety systems:

- Forward Collision Warning
- Blind Spot Warning
- Lane Change Warning
- Left Turn Assist
- Electronic Emergency Brake Light

3. High level accident data analyses

3.1 Introduction

To get an overview about the basis accidentology in the European Union (EU), a high-level analysis was done. In the next subchapters, the methodology, the used databases and the results of the high-level analyses are shown in detail.

3.2 Methodology and Databases

For the high-level analyses, three databases have been used:

- Accident data from EU (CARE)
- Accident data from German federal statistical office (DESTATIS)
- Accident data from French government (BAAC)

Because of not existing data for the accident year 2020 in the moment of the implementation of the high-level analyses, the data will be extrapolated to the accident year 2020 based on the known data. The data of the various databases are known for different years:

- CARE data from 2012 and 2018
- DESTATIS data from 2012 and 2019
- BAAC data from 2011 and 2019

Thus, it is possible to compare the analyses of the various databases in a common accident year. But keep in mind, that the analysed data are only estimations. As we worked with linear estimation numbers the covid situation had no impact on our study.

The results of all the analyses can be found in the next chapter.

3.3 Results and Analyses

In this chapter of the deliverable the high-level analyses will be shown and the main results will be written down. In the scope of the high-level analyses, the following parameters got analysed:

- Overview accident numbers
- Fatalities by kind of traffic participation
- Development of the fatalities by kind of traffic participation
- Fatalities at junctions (only CARE and DESTATIS)
- Fatalities by weather condition (only CARE)
- Accident location
- Kind of participation of injured people
- Injury severity

In the last part of the chapter a conclusion of all the analyses can be found.

3.3.1 European Union

At first it is about to take a view on the overview of the base accident numbers of all road users in the EU (Figure 20). At this, the analysed CARE data contains the EU28 countries and Iceland, Liechtenstein, Norway and Switzerland.

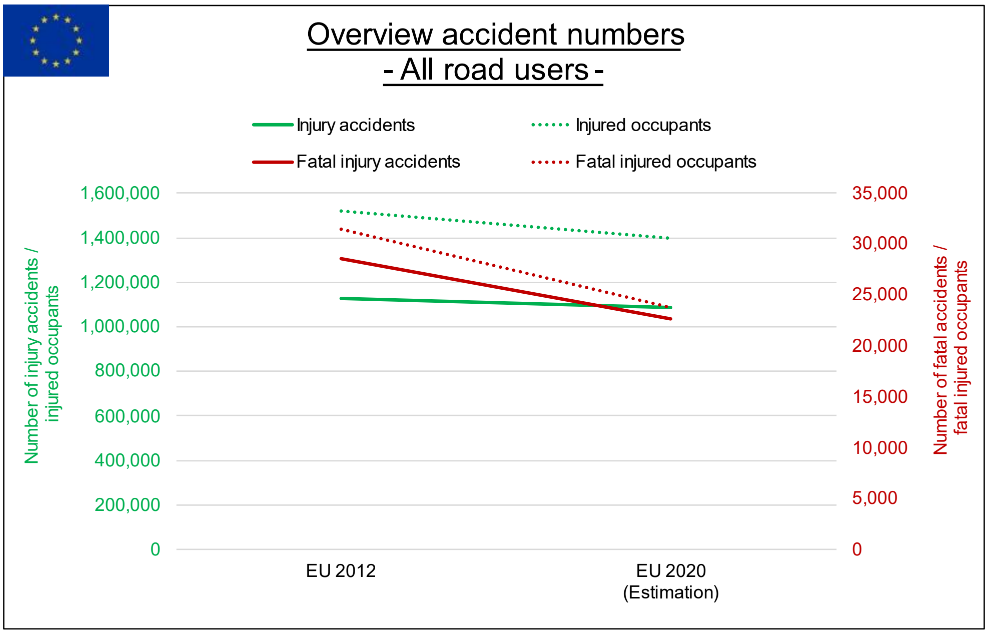


Figure 20: Overview accident numbers – EU [25]

It can be stated that all the analysed numbers decreased between 2012 and 2020. The decrease rate of the numbers of the fatal accidents as well as the numbers of the fatally injured occupants is much higher than the decrease rate of the numbers of accidents with injured occupants and injured occupants in total.

At the next analysis the main focus shall be only on fatalities. In Figure 21, the kind of traffic participation (KTP) can be seen for all fatalities in accidents in the EU.

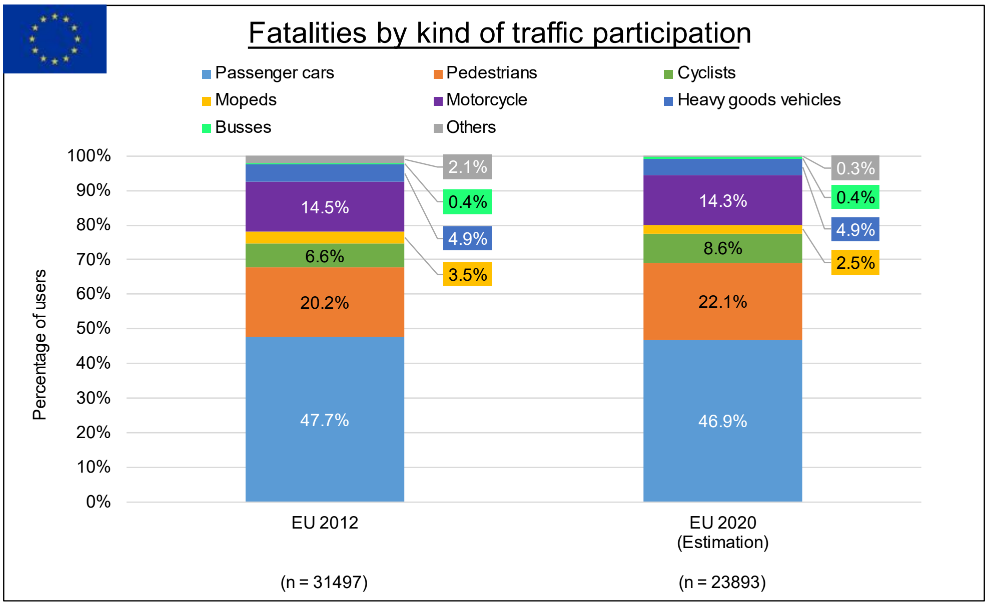


Figure 21: Fatalities by kind of traffic participation – EU [25]

Most of the fatalities died as occupants in passenger cars. The percentage of killed pedestrians and cyclists are the only kinds of road use, which increased in the regarded time slot.

In Figure 22 the decreasing rate of fatalities is analysed.

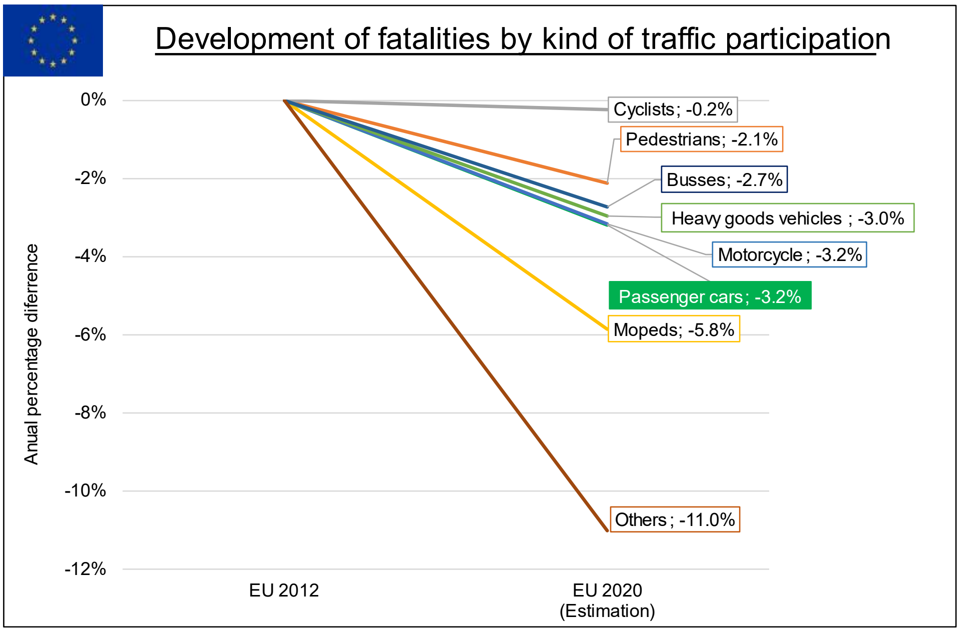


Figure 22: Development of fatalities by kind of traffic participation – EU [25]

This analysis shows that the decreasing rate of killed cyclists and pedestrians is the lowest of all kinds of road use. Fatal injured occupants of passenger cars had a decreasing rate of 3.2%.

The next analysis will provide information about the road type, where people died in traffic accidents (Figure 23).

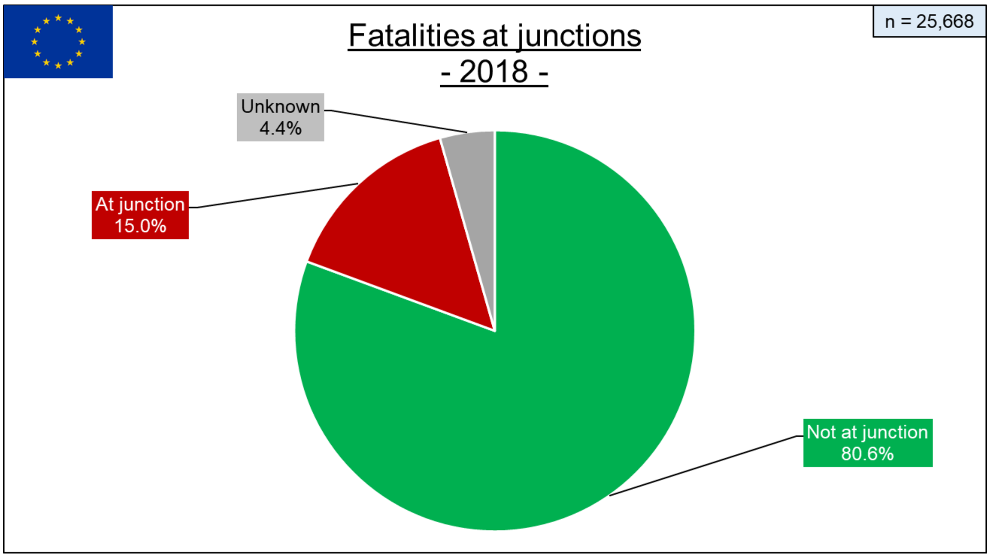


Figure 23: Fatalities by road type – EU [25]

About 15 in 100 fatalities died in an accident at a junction.

In Figure 24 the weather conditions are analysed for all fatalities in accidents in the EU.

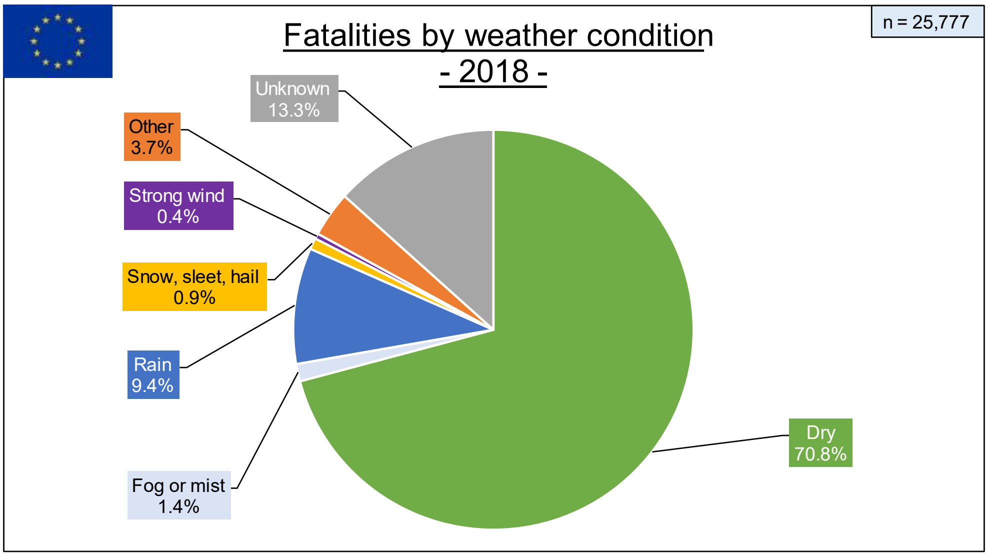


Figure 24: Fatalities by weather condition – EU [25]

Most of the people died in accidents at dry weather conditions. About one in ten fatalities was killed in an accident in rain, snow, sleet or hail.

In the following chart the accident site of all injured people in the EU is analysed (Figure 25). At this, the accident site is divided into accidents in urban area, rural area and on motorways.

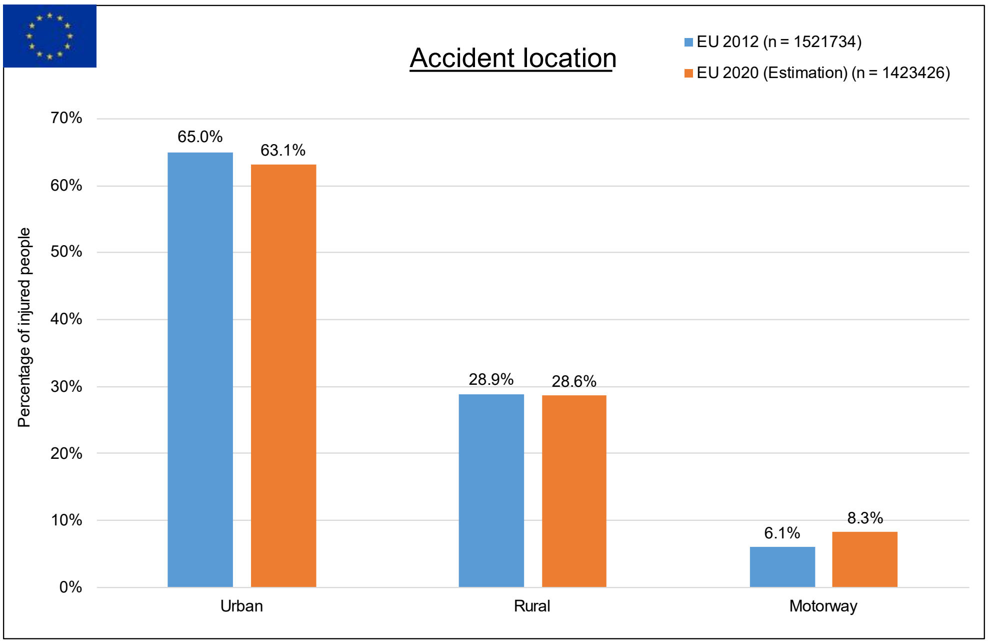


Figure 25: Accident site – EU [25]

Most of the people got injured in an accident in urban area. About one third of the injured people had an accident in rural area. The percentage of injured people in accidents on motorways increased since 2012 in favour of accidents in urban area.

Figure 26 and Figure 27 show the kind of participation of injured people in dependence to the accident site for the years 2012 in comparison with the estimation of the year 2020.

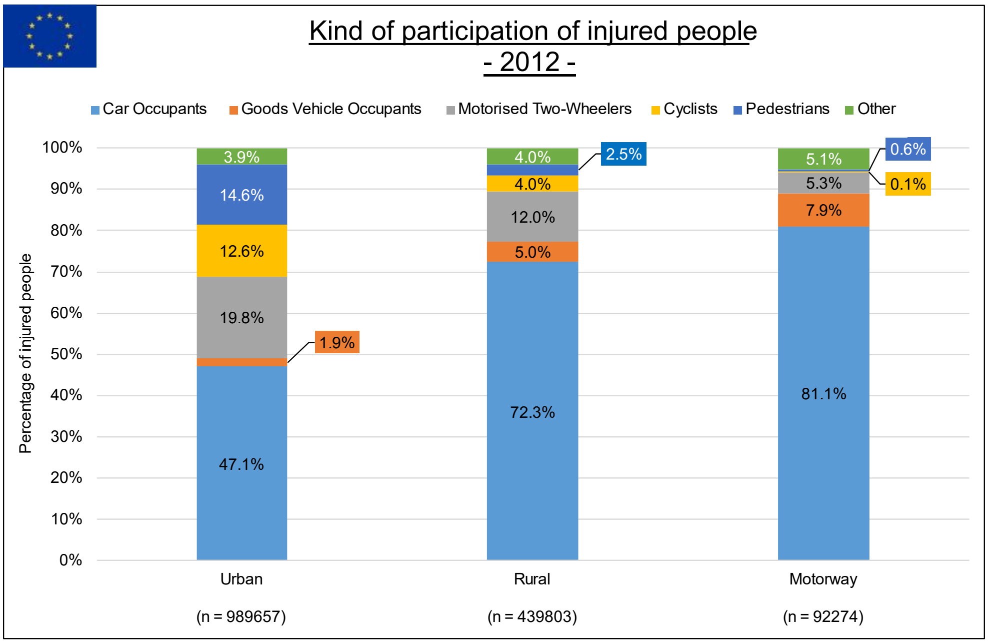


Figure 26: Kind of participation of injured people 2012 – EU [25]

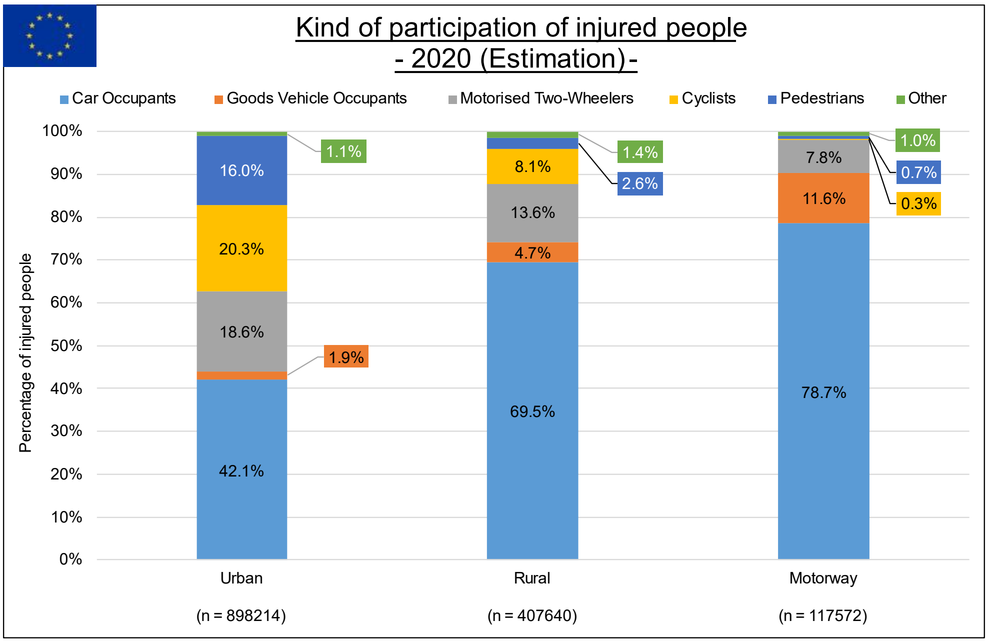


Figure 27: Kind of participation of injured people 2020 – EU [25]

The percentage of injured cyclists increased massively in accidents in urban area as well as in accidents in rural area. There is also an increase of the percentage of injured pedestrians in urban are. On motorways the increase of the percentage of injured occupants of heavy good vehicles is noticeable in the comparison of 2012 and 2020.

In a further analysis the injury severity of all injured people in traffic accidents shall be shown in dependence of the accident site (Figure 28).

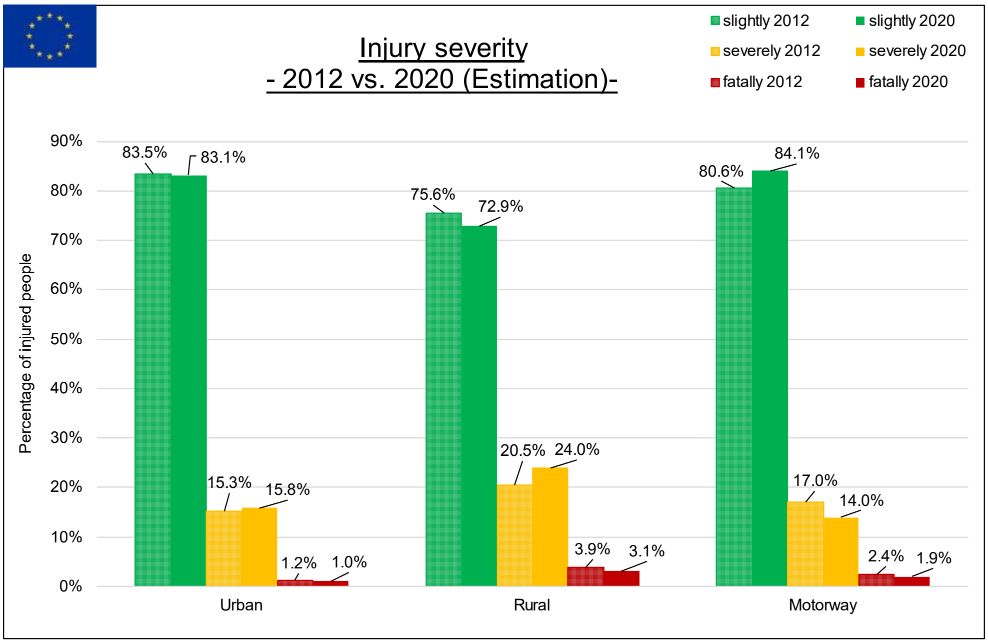


Figure 28: Injury severity – EU [25]

The highest percentage of all killed and severely injured people can be found in accidents in rural area. There is a noticeable increase of severely injured people in accidents in rural area between 2012 and 2020.

As an additional information, Figure 29 shows the same analysis as done in Figure 28, but for injured occupants of passenger cars only.

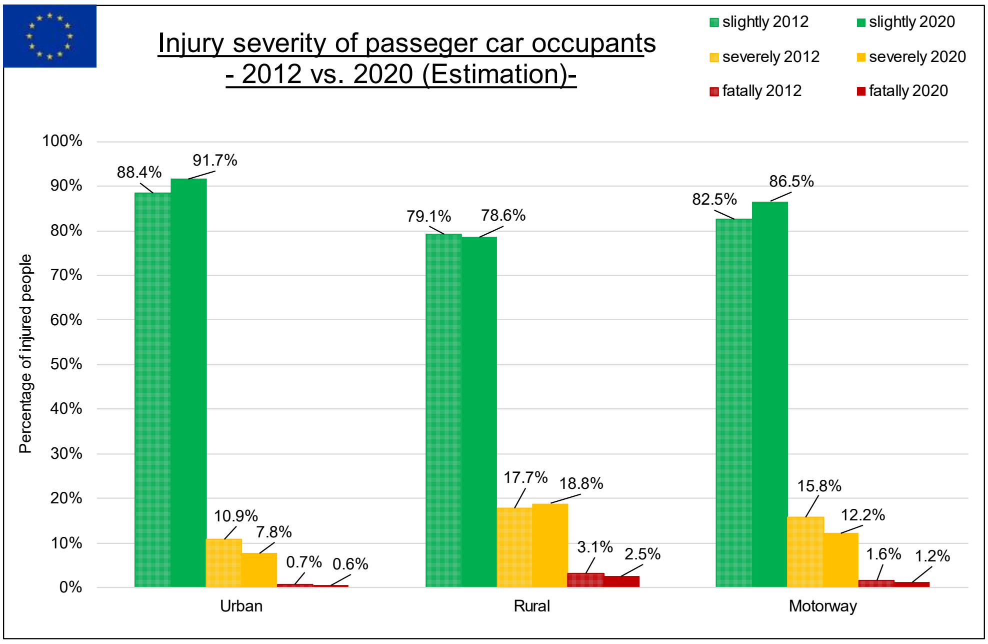


Figure 29: Injury severity of passenger car occupants – EU [25]

It is noticeable that the percentage of killed and severely injured passenger car occupants is a little lower than in consideration of all injured road users.

3.3.2 GERMANY

In this chapter only accidents on German roads got analysed. At the beginning, Figure 30 gives an overview about the base accident numbers.

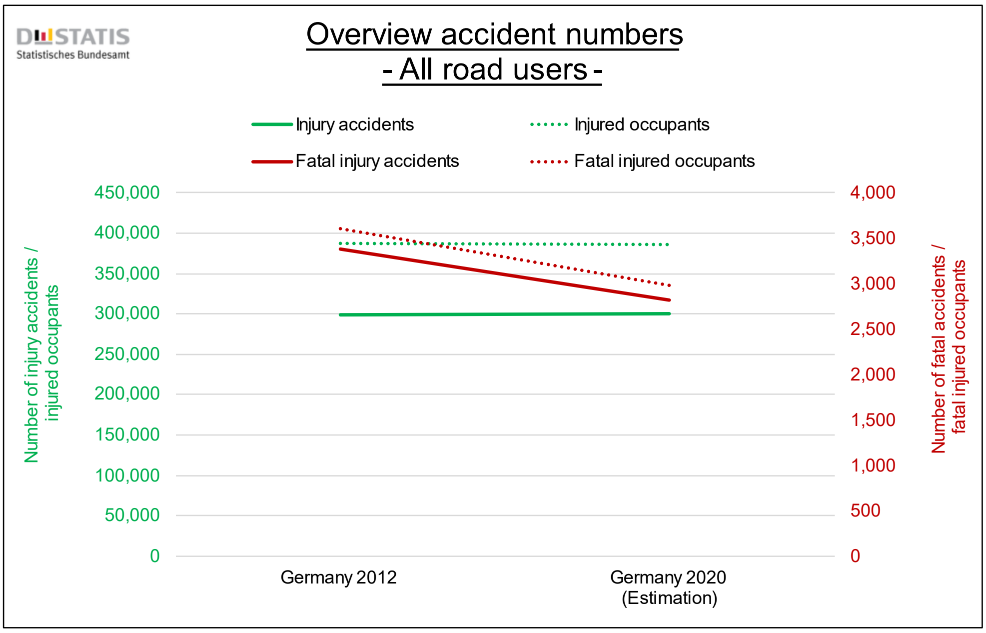


Figure 30: Overview accident numbers – Germany [26]

In Germany, the number of accidents with injured people and the number of injured people did not change recognizable between 2012 and 2020. The numbers of fatal accidents decreased in the regarded time range as well as the number of fatalities.

The KTP be seen in Figure 31 as a comparison between the year 2012 and the estimation of the year 2020.

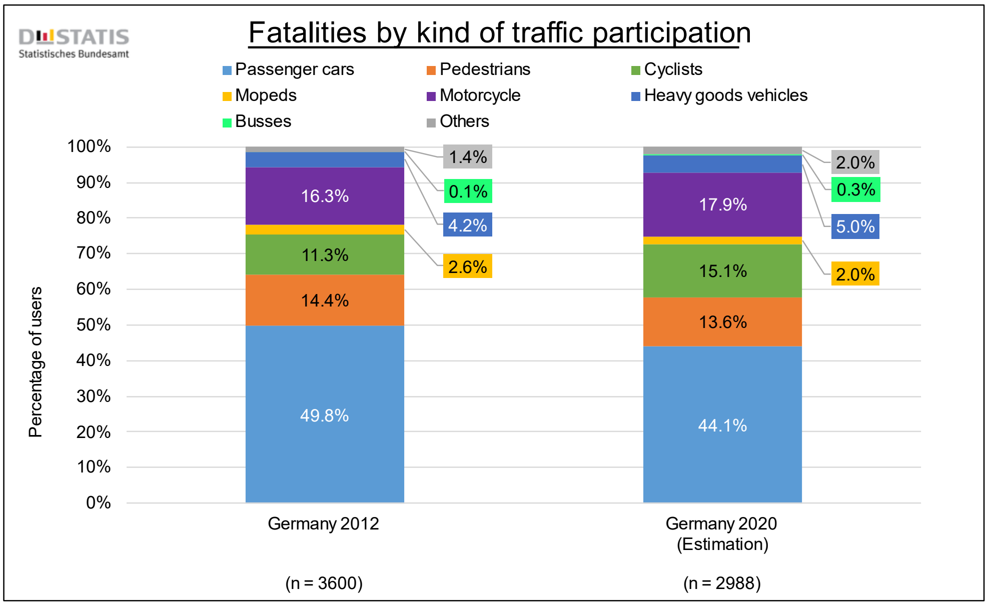


Figure 31: Fatalities by kind of traffic participation – Germany [26]

The percentage of killed cyclists and motorcyclists increased noticeable in the regarded time slot.

Figure 32 contains the results of analysing the development of the fatalities in Germany depending on the KTP.

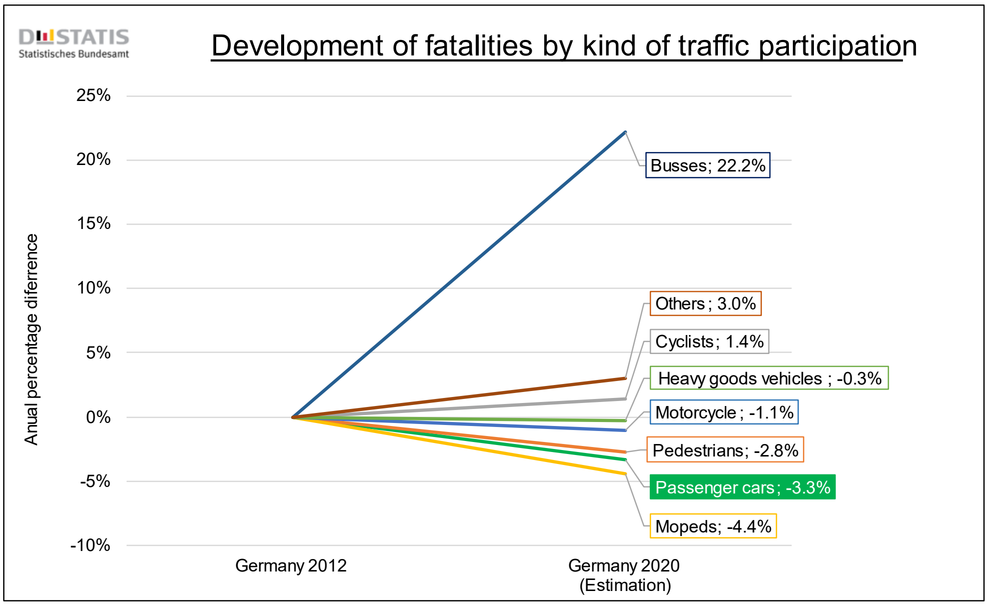


Figure 32: Development of fatalities by kind of traffic participation – Germany [26]

Most of the kinds of road use show a decrease rate of fatalities between 2012 and 2020. Killed cyclists had an increase rate of 1.4%.
At the really high increase rate of fatal bus occupants, it has to be mentioned, that the base of this KTP are 3 fatalities in 2012 and 7 fatalities in the year 2019. Thus, there are 8 fatalities calculated for the year 2020. That is a really small number of fatalities and probably a too small base for a visualization like this.

In the next analysis, the fatalities are shown regarding the road type, on which they had their traffic accident (Figure 33).

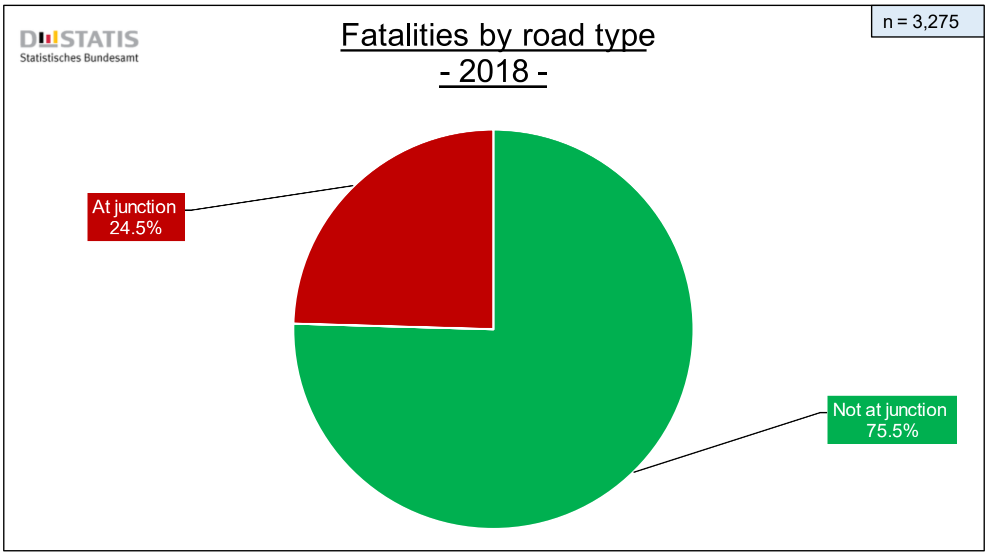


Figure 33: Fatalities by road type – Germany [26]

Every fourth fatality had an accident at a junction.

The next analyses are all in dependence to the accident site. At first, Figure 34 shows the percentages of the injured people divided in the several accident sites at all.

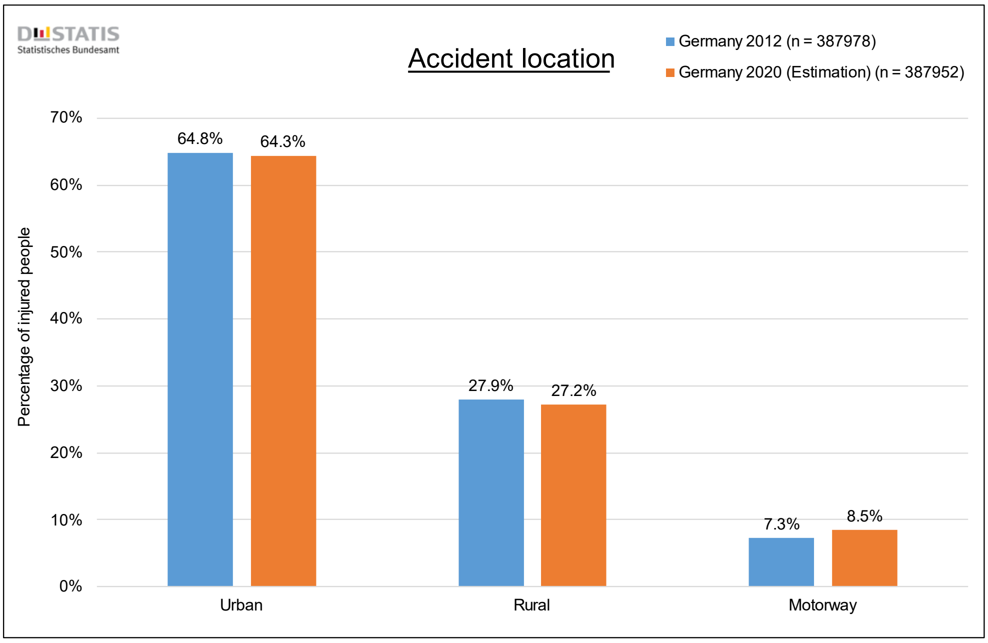


Figure 34: Accident site – Germany [26]

Most of the people got injured in an accident in urban area. A little more than one fourth of the injured people had an accident in rural area. The percentage of injured people in accidents on motorways increased since 2012 in favour of accidents in urban and rural area.

Figure 35 and Figure 36 show the kind of participation of injured people in dependence to the accident site for the years 2012 in comparison with the estimation of the year 2020.

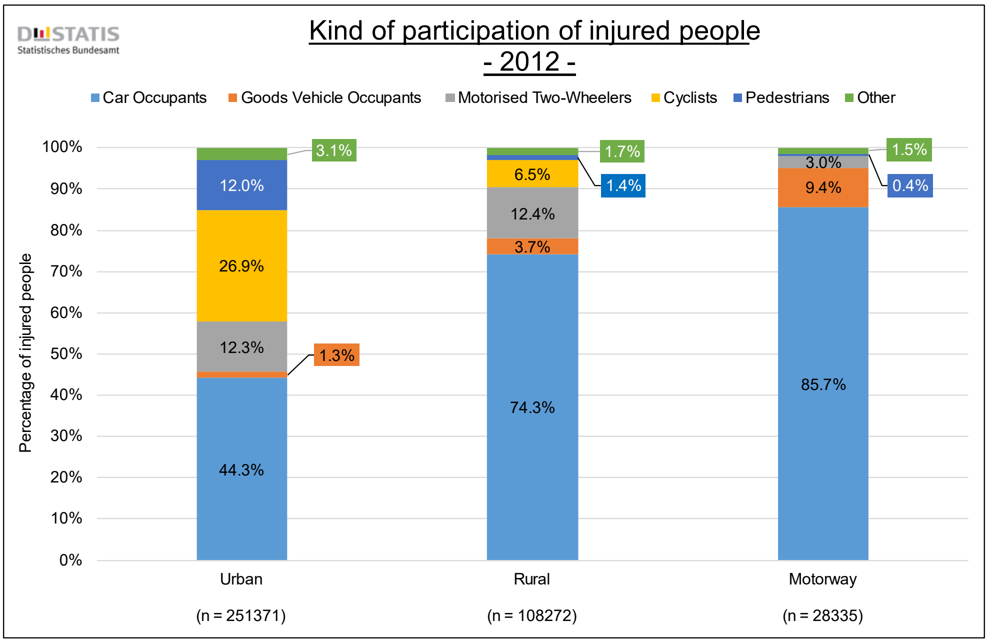


Figure 35: Kind of participation at injured people 2012 – Germany [26]

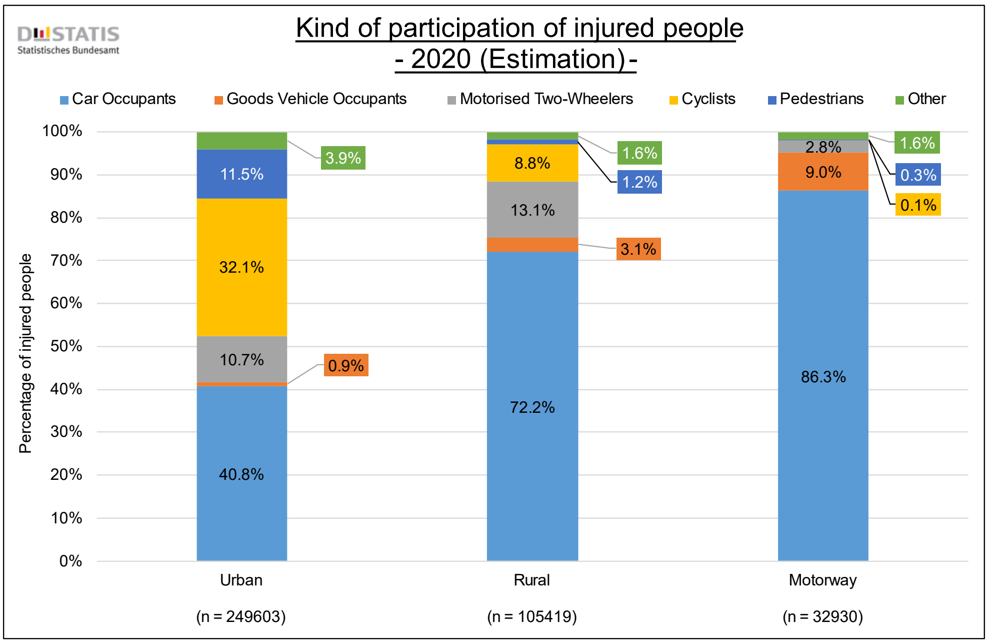


Figure 36: Kind of participation at injured people 2020 – Germany [26]

The percentage of injured cyclists increased between 2012 and 2020 in urban area as well as in rural area. But in urban area the increase is much more noticeable.

As last analyses of the German accidents, the injury severity of all injured road users (Figure 37) shall be shown in the comparison of the injury severity of injured occupants in passenger cars only (Figure 38).

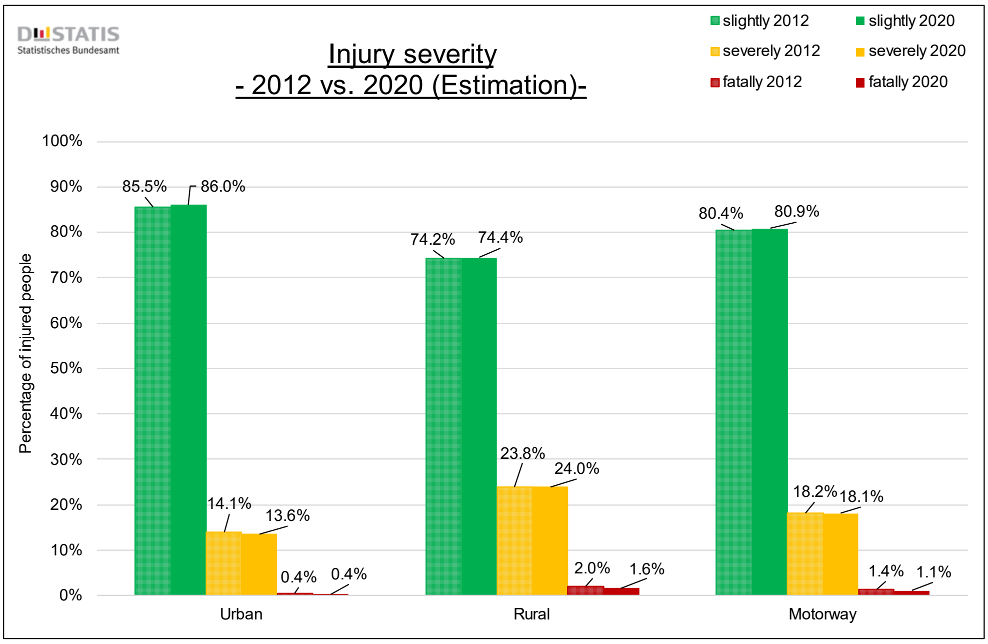


Figure 37: Injury severity – Germany [26]

The highest percentage of all killed and severely injured people can be found in accidents in rural area.

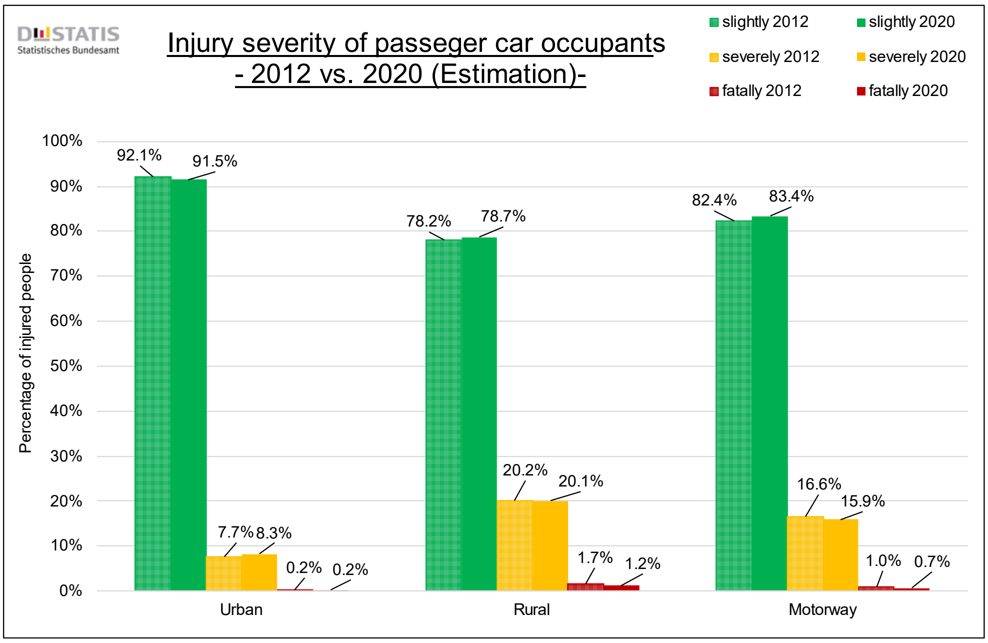


Figure 38: Injury severity of passenger car occupants – Germany [26]

It is noticeable that the percentage of killed and severely injured passenger car occupants is a little lower than in consideration of all injured road users at all. This fact is most noticeable in the consideration of accidents in urban area.

3.3.3 France

As a last database in the scope of this high-level analyses, the official traffic accident data of France shall be analysed. The most basic analysis is shown in Figure 39. It shows an overview of the accident numbers of all injured and fatally injured road users in France.

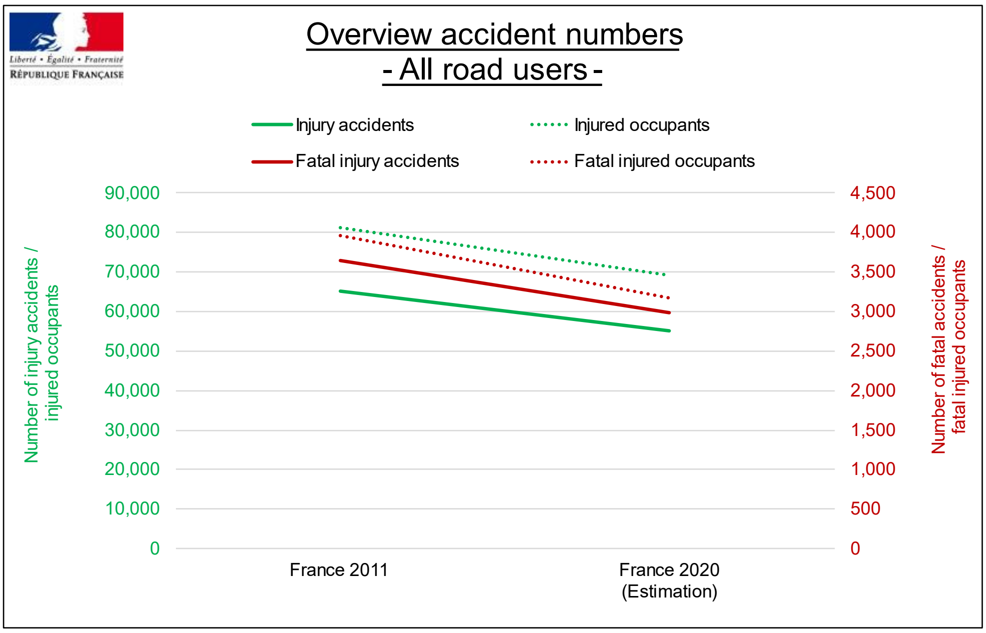


Figure 39: Overview accident numbers – France [27]

The chart shows a high decrease rate of accidents with injured and fatally injured occupants as well as a similar high decrease rate of injured and fatally injured occupants.

In Figure 40, the distribution of the road traffic fatalities in dependence of the KTP in France is shown.

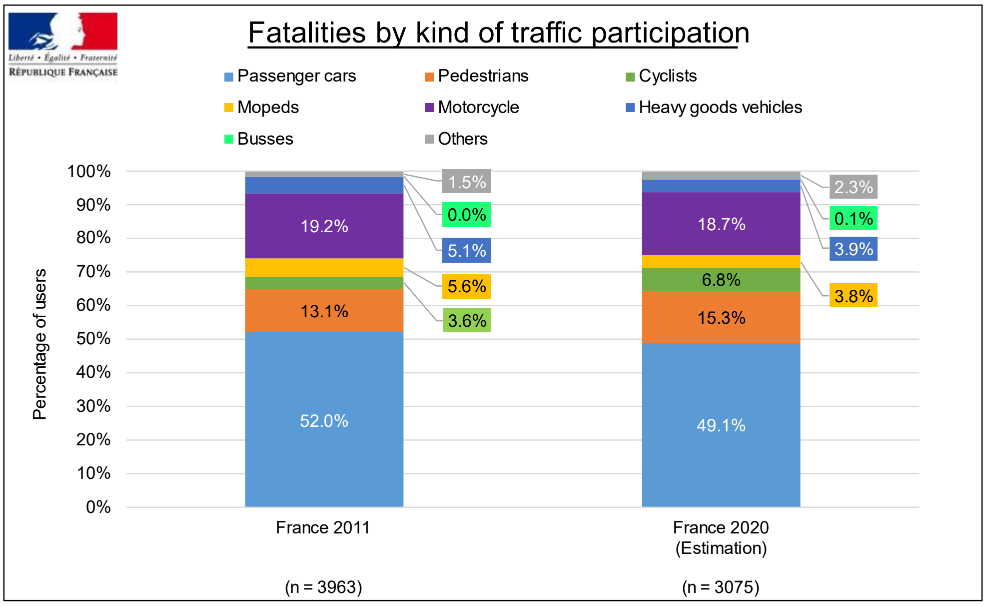


Figure 40: Fatalities by kind of traffic participation – France [27]

The percentage of killed pedestrians and cyclists increased noticeable in the comparison of the year 2012 and the estimation of the year 2020.

In addition to this analysis, the development of the fatalities in dependence to their KTP can be viewed in Figure 41.

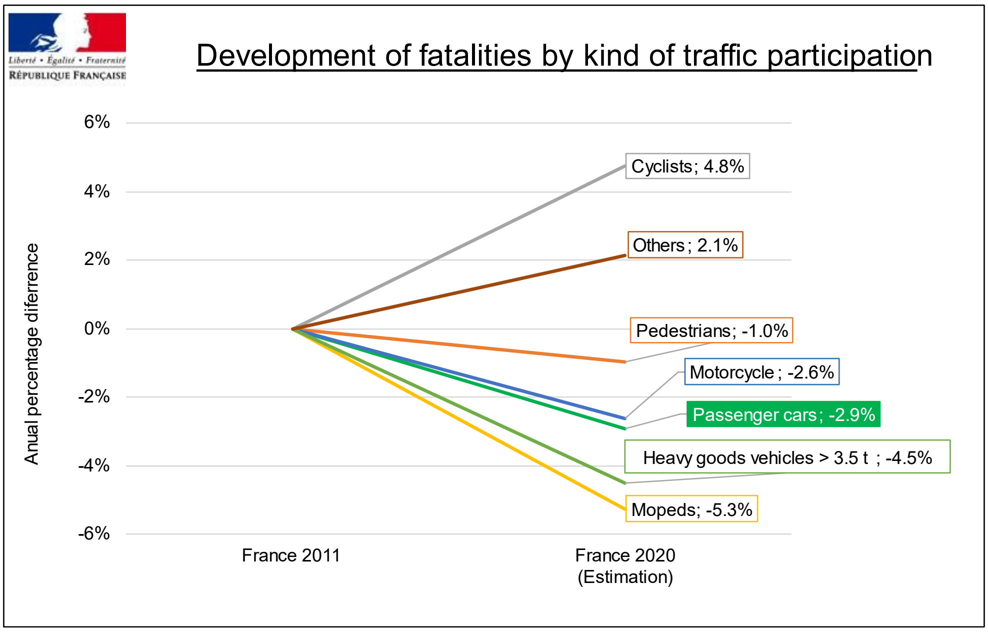


Figure 41: Development of fatalities by kind of traffic participation– France [27]

The number of killed cyclists had an increase of nearly 5%.

The next analyses are all in dependence to the accident site. At first, Figure 42 shows the percentages of the injured people divided in the several accident sites at all.

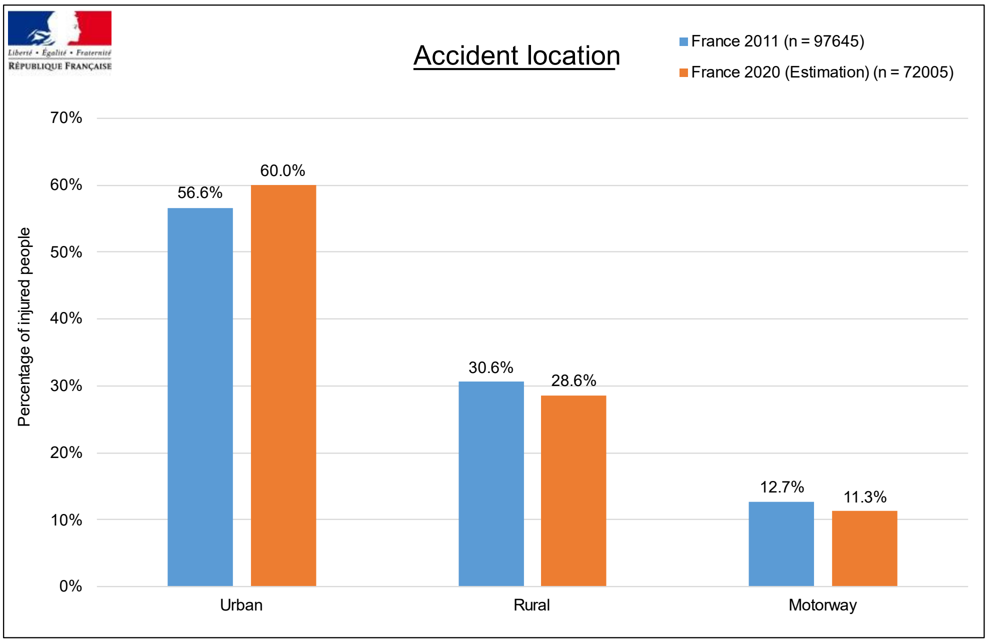


Figure 42: Accident site – France [27]

Most of the injured people had a traffic accident in urban area. The percentage of injured people in accidents on motorways and in rural area decreased at the expense of injured people in accident in urban area.

Figure 43 and Figure 44 show the kind of participation of injured people in dependence to the accident site for the years 2011 in comparison with the estimation of the year 2020.

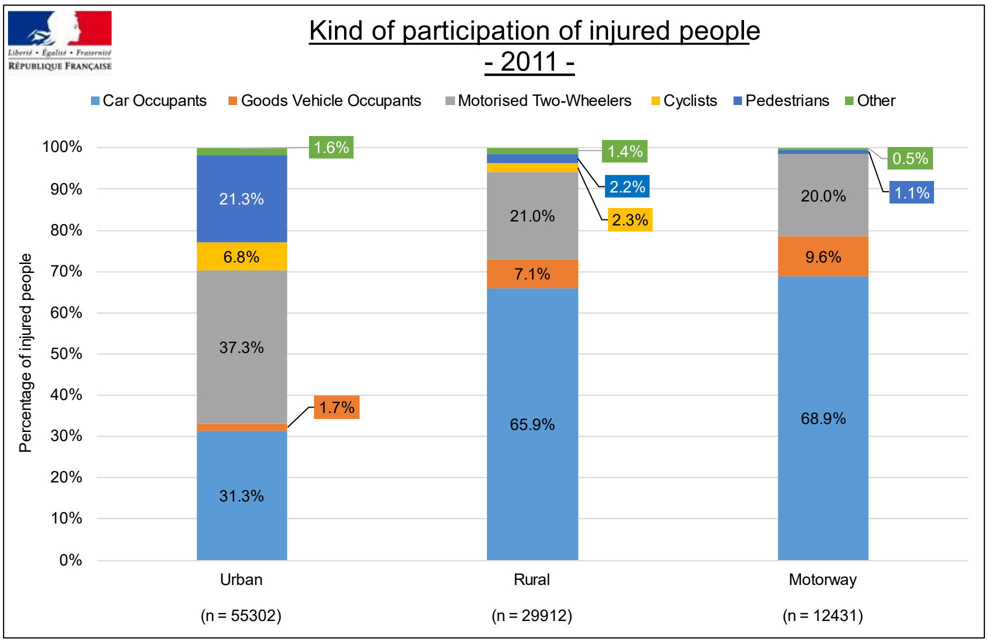


Figure 43: Kind of participation at injured people 2011 – France [27]

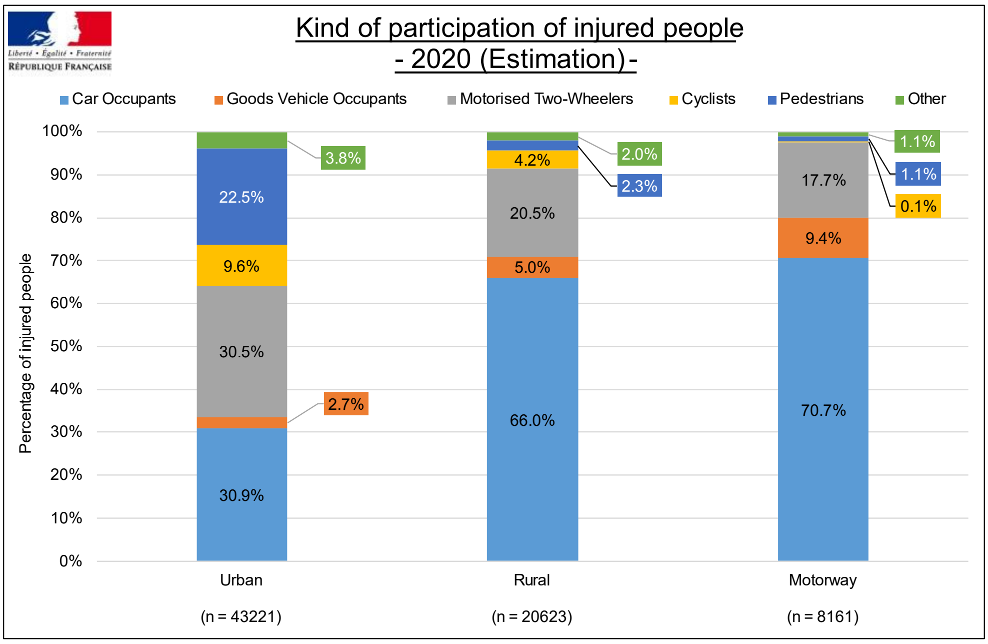


Figure 44: Kind of participation at injured people 2020 – France [27]

It is noticeable, that the percentage of injured cyclists increased mainly in urban area, but also in rural area between 2011 and 2020. The percentage of injured motorcyclists in urban area decreased by nearly 7 percentage points.

As last analyses of the accidents in France, the injury severity of all injured road users (Figure 45) shall be shown in the comparison of the injury severity of injured occupants in passenger cars only (Figure 46).

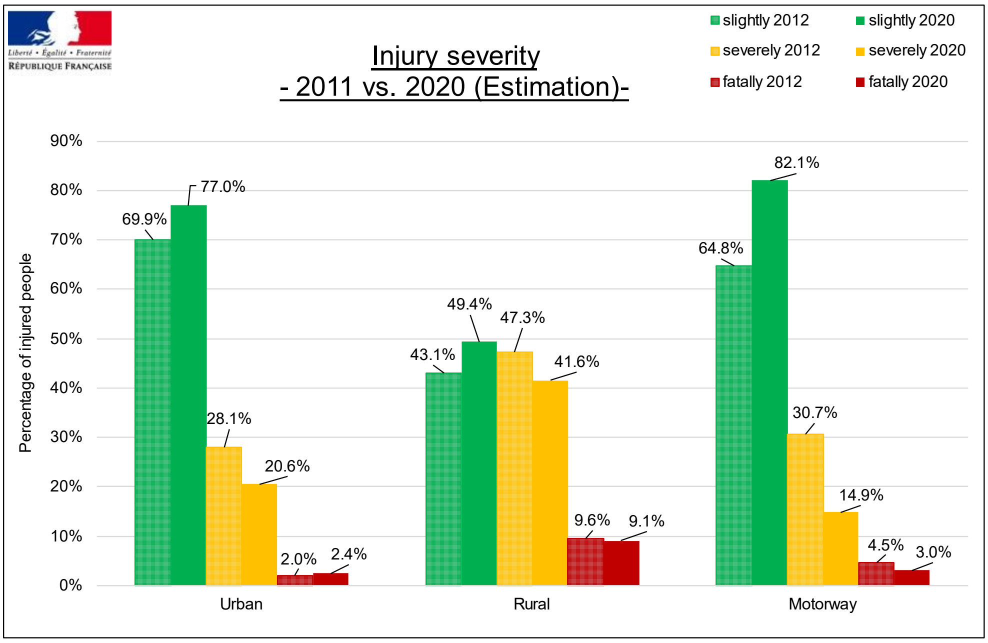


Figure 45: Injury severity – France [27]

Conspicuous is the really high percentage of killed and severely injured people at all. This percentage is the highest in rural accidents. In the comparison of the year 2011 and the estimation of the year 2020, a positive trend can be determined.

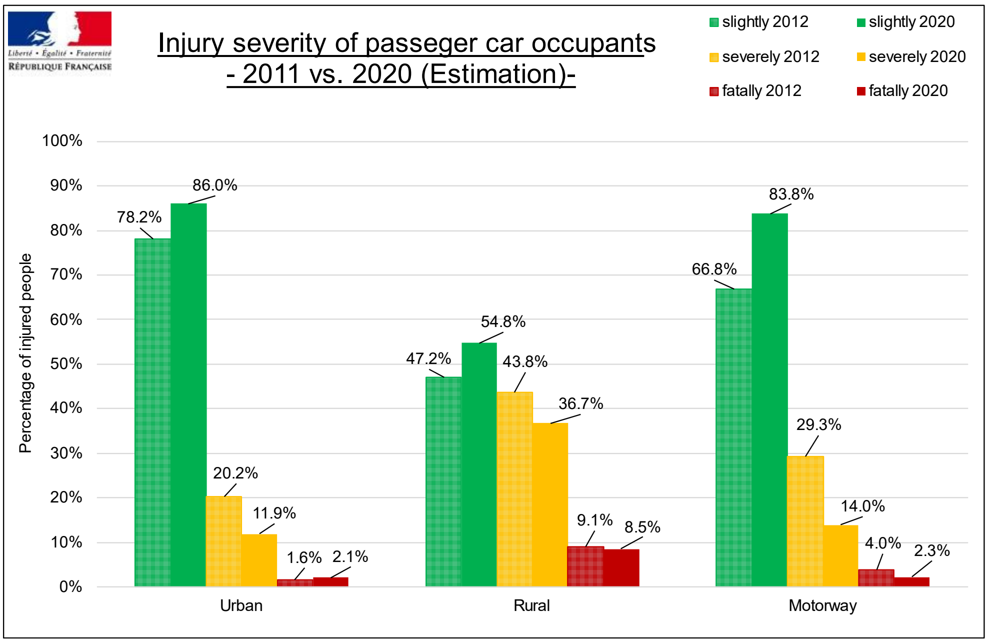


Figure 46: Injury severity of passenger car occupants – France [27]

The percentage of killed and severely injured occupants in passenger cars in accidents on motorways is comparable with the same at accidents of all road users. In urban area, the percentage of severely injured passenger car occupants is much lower than the same percentage at all injured road users in urban accidents.

3.4 Conclusion

In all areas (EU, Germany and France), the numbers of fatal accidents and fatalities in traffic accidents decreased in the last years. In France, the numbers of accidents with injured people and the number of injured occupants decreased, too.

The percentage of killed pedestrians in Germany and France is less than in the entirety of the EU. However, the percentage of killed motorcyclists in Germany and France is higher than in the EU. The percentage of killed cyclists is comparatively high in Germany.

In all the regarded regions, the decreasing rate of fatalities in passenger cars is comparable and levels out at about 3% in the viewed time slot. In France, a very high increasing rate of killed cyclists is noticeable.

In all regions, the most injured people had an accident in urban area. In both Germany and the EU, the percentage of injured people in accidents on motorways is increasing. In France it is the other way around.

In all areas (EU, Germany and France) and all accident sites (urban, rural and motorway) the percentage of injured cyclist increased in the regarded time range. In France, there is a comparatively high percentage of injured powered two-wheelers, especially in urban area.

In all regions, the highest percentage of killed and severely injured people can be found in accidents in rural area. In France, a comparatively high percentage of fatalities in rural area is noticeable. When considering only the injured occupants of passenger cars, there are less killed and severely injured people than in the consideration of all kinds of road use. In France, also the fatal injured occupants of passenger cars have a comparatively percentage.

4. In-depth accident data analyses - Methodology

4.1 Introduction

The focus of the data study is to complete the previous literature review work to select and define the SECUR use cases and their parameters. For this, the first step was to develop a scenario catalogue, which covers all the situations of traffic accidents, the driver of a passenger car can slip in. Thus, it is possible to determine the most relevant scenario and gives a base to develop a test environment for a useful V2X-System via an in-depth accident study of the most relevant scenarios.

4.2 Database

For the development of the SECUR scenario catalogue, the data of the German In-depth Accident Study (GIDAS) were used because these data allow detailed analyses of traffic accidents. GIDAS is a collaborative project of the Federal Highway Research Institute of Germany (BASt) and The Research Association of Automotive Technology of Germany (FAT). It started in 1999 including data of research areas Dresden and Hannover. In these areas about 2,000 accidents per year are investigated and recorded to the GIDAS database. Each case is encoded with about 3,400 variables. Following the documentation, each accident is reconstructed by an experienced engineer. The structure of the GIDAS project is shown in Figure 47.

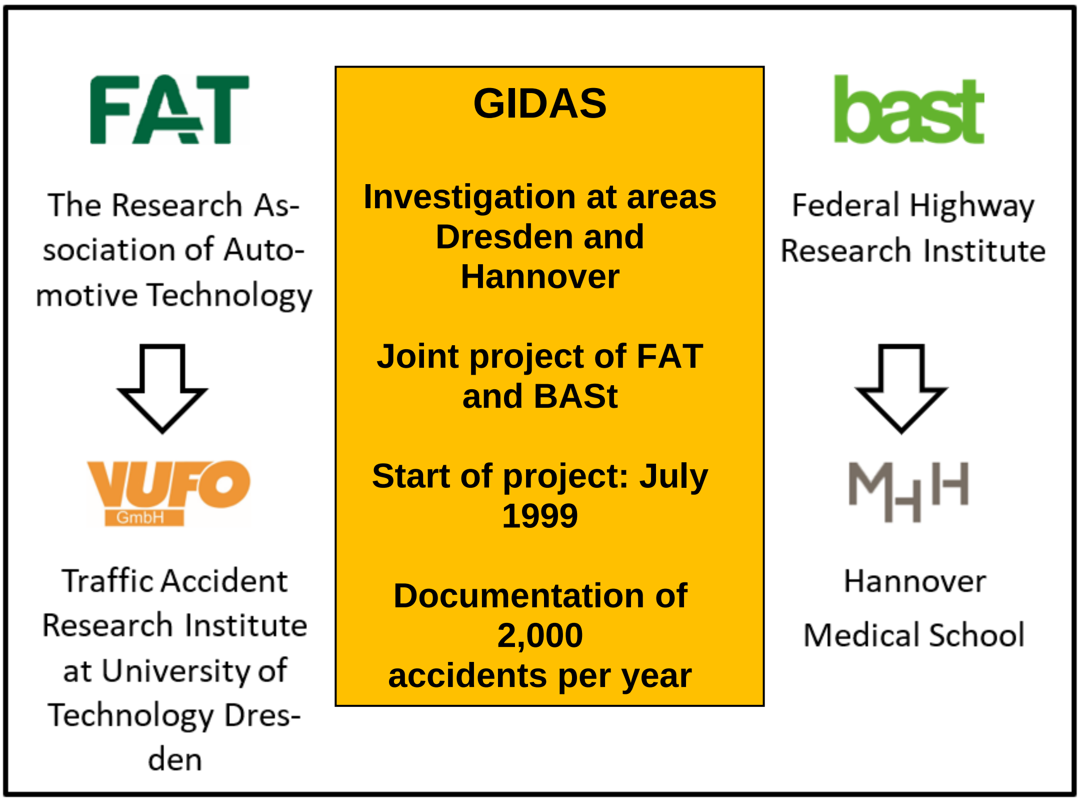


Figure 47: Structure of the GIDAS project

The GIDAS database is adapted for representative statements about German traffic accident scenario due to high number of recorded accidents, the fact that research areas represent topographically German average and investigation follows an exact sampling plan. For further details please take a look to the website of the GIDAS project (www.gidas.org).

4.3 Master Dataset

For making beneficial analyses it was necessary to create at first a target-oriented master dataset. A master dataset is a filtered version of the whole GIDAS dataset. In consultation with the WG1 members, the decision was found, to apply the following filter criteria:

- Only completely coded and reconstructed accidents
- The ego vehicle had to be a passenger car
- The ego vehicle had to be equipped with an Electronical Stabilization Control (ESC)

Just before starting the in-depth analyses, the WG1 members decided, that they want to have analysed quite modern vehicles only. The first idea was to eliminate all the skidding accidents. This idea was not realized, because it could be possible, that a V2X system could be developed, which is able to warn against slippery road conditions. Thus, it would have been not helpful to get no information about the actual numbers of skidding accidents. Finally, the decision was done to consider only vehicles equipped with an ESC. This also leads to quite modern vehicles in the master dataset and the information about the percentage of skidding accidents got preserved.

For all the analyses the GIDAS database with a status of June 2021 was used.

4.4 SECUR Category Catalogue

The category catalogue in the scope of SECUR shall group all possible accident situations into well summarized categories. The following KTP as opponents where considered:

- Passenger Car (all M1/N1 vehicle according to the ECE vehicle classes)
- Powered Two-wheeler (PTW; including e-bikes being able to drive faster than 25 kph)
- Bicyclist (including e-bikes up to 25 kph))
- Pedestrian
- Others (contains busses, trams, heavy goods vehicles and micro vehicles)

The ego vehicle is always a passenger car.

To find all possible accident situations, several sources were considered as the MUSE project and the scenario catalogue of Continental. Additional scenarios were defined by accidentology experts of the WG1. The result category list is shown in Table 21.

Table 21: SECUR Category catalogue complete

Category	
Category 1	Left Turn Across Path - Opposite Direction
Category 2	Left Turn Across Path - Same Direction
Category 3	Left Turn Across Path - Right Direction
Category 4	Left Turn Across Path - Left Direction
Category 5	Right Turn Across Path - Opposite Direction
Category 6	Right Turn Across Path - Same Direction
Category 7	Right Turn Across Path - Right Direction
Category 8	Right Turn Across Path - Left Direction
Category 9	Oncoming
Category 10	Straight Crossing Path - Same Direction - Turning
Category 11	Rear End - Following Vehicle
Category 12	Straight Crossing Path - Same Direction - Lane Change
Category 13	Straight Crossing Path - Right Direction
Category 14	Straight Crossing Path - Left Direction
Category 15	Rear End - Previous Vehicle
Category 16	Parallel Driving
Category 17	Lane Change - Same Direction
Category 18	Lane Change - Opposite Direction
Category 19	Reverse
Category 20	Loss Of Control in Straight Line
Category 21	Loss Of Control in Curve
Category 22	Loss Of Control at Turning
Category 23	Rail Vehicle
Category 24	Animals / Objects
Category 25	Break Down
Category 26	Inability (falling asleep, dizzy spell, other physical disability w/o alcohol)
Category 27	Sudden Vehicle Damage
Category 28	Dooring

The categories are content-related based on the accident type. The used accident type was catalogued by the German Insurance Association (GDV – dt. Gesamtverband der Versicherer) in the year 1997. The accident type is defined as the accident-causing situation.

In most of the accident types, a participant A and a participant B are existing. **In those accident types, the ego vehicle can be causer (participant A) or non-causer (participant B).** Therefore, a safety measure will not only assist the causer of the crash but both participants. E.g., the potential benefit of a car fitted with a warning system regardless of the role that the car has in the conflict. This allows a holistic view of the accidents. For car vs car accidents, two scenarios are derived, one from each perspective A and B. Thus, each accident can potentially be addressed from two sides. E.g., a crossing accident will result in a scenario crossing from right for one car and crossing from left for the other car. This increases the potential benefit of a safety measure as it might assist the causer and the non-causer of a conflict.

All the percentages of the concerned occupants in the single categories are based on the total number of occupants in GIDAS in dependence to their injury severity. At this, on the one hand injured occupants are all the occupants regardless of their injury severity. On the other hand, the killed and severely injured (KSI) occupants only have been considered. These base numbers are shown in dependence to the injury severity of the occupants in GIDAS are shown in Table 22.

Table 22: Base numbers in GIDAS in dependence to the injury severity

Total number of... (in GIDAS)	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured occupants	13,140	1,248	3,575	1,121	245	19,329
KSI occupants	2,091	421	690	497	21	3,720

In the following subchapters, the accident type based contents are shown in detail. There you can find the accident types, which are assigned to the particular category, the numbers of all the concerned occupants and their percentages of the total occupant numbers in GIDAS (Table 22).

In the chapter 4.4.29, the accident types, which have been excluded from the category catalogue, are shown and the reasons for excluding them are described.

For every category a pictogram was created. In these pictograms, the ego vehicle is consistently coloured in blue and the opponent vehicle or causing problem in red.

4.4.1 Category 1 – Left Turn Across Path – Opposite Direction (LTAP-OD)

The *LTAP-OD* scenario contains a left turning passenger car, which had a conflict with a participant coming from the opposite direction as shown in Figure 48.

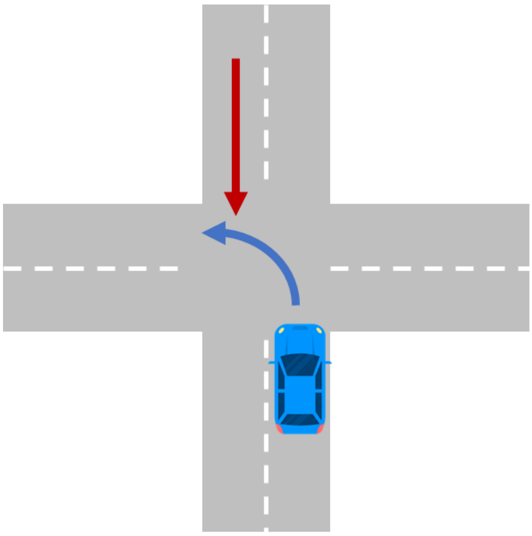


Figure 48: Pictogram – LTAP-OD

Ego vehicle as participant A

In Figure 49 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

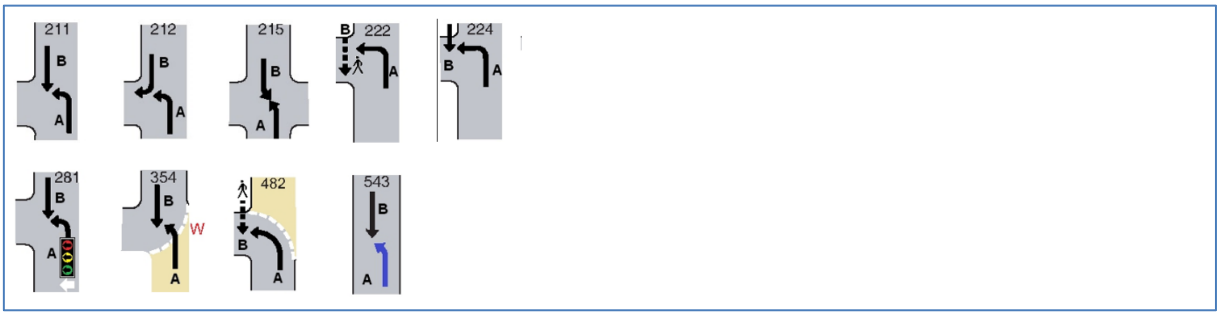


Figure 49: Accident types - participant A – LTAP-OD

Ego vehicle as participant B

In Figure 50 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

Figure 50: Accident types - participant B - LTAP-OD

Results for the whole category

In Table 23 the numbers of the whole *LTAP-OD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 23: Numbers and percentages in total - LTAP-OD

Category 1	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	828	188	267	96	16	1.395
	6,3%	15,1%	7,5%	8,6%	6,5%	7,2%
KSI	123	87	56	34	1	301
	5,9%	20,7%	8,1%	6,8%	4,8%	8,1%

Results for the single accident types

In Table 24 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 24: Numbers and percentages of accident types - LTAP-OD

Category 1	Accident type										Total
	211	212	215	222	224	281	351	354	482	543	
Injured	1022	8	3	95	161	93	6	2	1	4	1395
	5,3%	0,0%	0,0%	0,5%	0,8%	0,5%	0,0%	0,0%	0,0%	0,0%	7,2%
KSI	222	1	0	33	33	10	0	0	0	2	301
	6,0%	0,0%	0,0%	0,9%	0,9%	0,3%	0,0%	0,0%	0,0%	0,1%	8,1%

For accident type 215, which is existing in both groups ego as participant A and ego as participant B, the occupants got counted only once.

4.4.2 Category 2 – Left Turn Across Path – Same Direction (LTAP-SD)

The *LTAP-SD* scenario contains a left turning passenger car, which had a conflict with a participant driving in the same direction as shown in Figure 51.

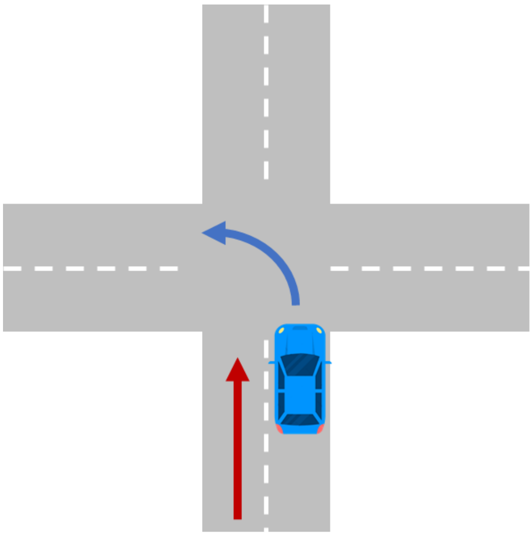


Figure 51: Pictogram – LTAP-SD

Ego vehicle as participant A

In Figure 52 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

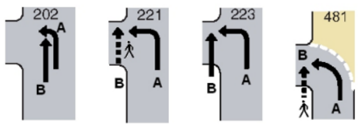


Figure 52: Accident types - participant A – LTAP-SD

Ego vehicle as participant B

In Figure 53 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

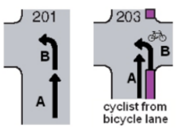


Figure 53: Accident types - participant B - LTAP-SD

Results for the whole category

In Table 25 the numbers of the whole LTAP-SD are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

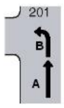
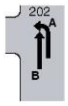
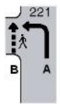
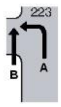
Table 25: Numbers and percentages in total - LTAP-SD

Category 2	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	311	78	83	75	6	553
	2,4%	6,3%	2,3%	6,7%	2,4%	2,9%
KSI	36	30	17	30	2	115
	1,7%	7,1%	2,5%	6,0%	9,5%	3,1%

Results for the single accident types

In Table 26 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 26: Numbers and percentages of accident types - LTAP-SD

Category 2	Accident type						Total
	201	202	203	221	223	481	
							
Injured	221	184	0	73	73	2	553
	1,1%	1,0%	0,0%	0,4%	0,4%	0,0%	2,9%
KSI	25	45	0	30	15	0	115
	0,7%	1,2%	0,0%	0,8%	0,4%	0,0%	3,1%

4.4.3 Category 3 – Left Turn Across Path – Right Direction (LTAP-RD)

The *LTAP-RD* scenario contains a left turning passenger car, which had a conflict with a participant coming from the right direction as shown in Figure 54.

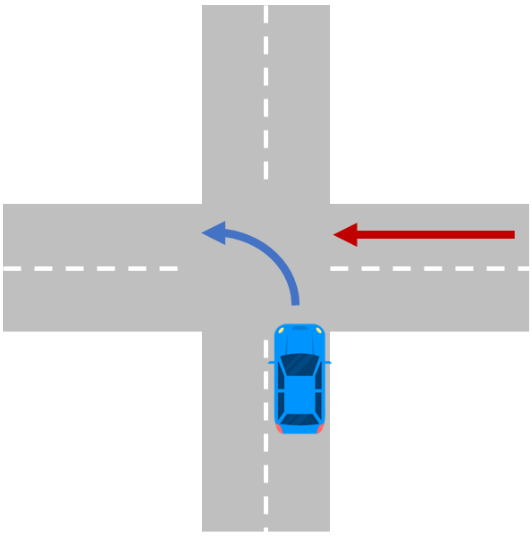


Figure 54: Pictogram – LTAP-RD

Ego vehicle as participant A

In Figure 55 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

Figure 55: Accident types - participant A - LTAP-RD

Ego vehicle as participant B

In Figure 56 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

Figure 56: Accident types - participant B - LTAP-RD

Results for the whole category

In Table 27 the numbers of the whole *LTAP-RD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 27: Numbers and percentages in total - LTAP-RD

Category 3	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	87	41	44	-	11	183
	0,7%	3,3%	1,2%	0,0%	4,5%	0,9%
KSI	6	10	7	-	-	23
	0,3%	2,4%	1,0%	0,0%	0,0%	0,6%

Results for the single accident types

In Table 28 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 28: Numbers and percentages of accident types - LTAP-RD

Category 3	Accident type					Total
	213	214	322	332	352	
Injured	0	0	168	9	6	183
	0,0%	0,0%	0,9%	0,0%	0,0%	0,9%
KSI	0	0	23	0	0	23
	0,0%	0,0%	0,6%	0,0%	0,0%	0,6%

4.4.4 Category 4 – Left Turn Across Path – Left Direction (LTAP-LD)

The *LTAP-LD* scenario contains a left turning passenger car, which had a conflict with a participant coming from the left direction as shown in Figure 57.

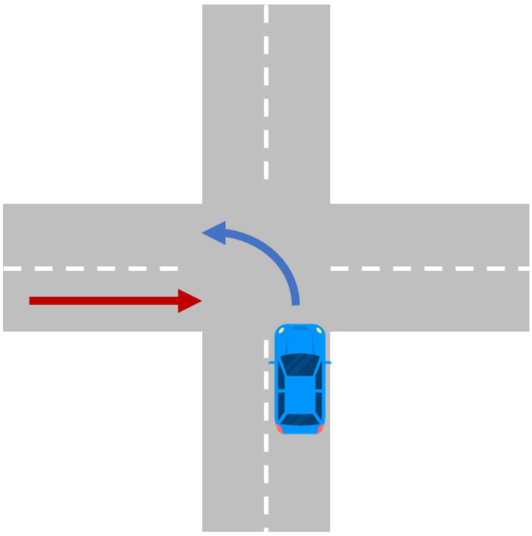


Figure 57: Pictogram – LTAP-LD

Ego vehicle as participant A

In Figure 58 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

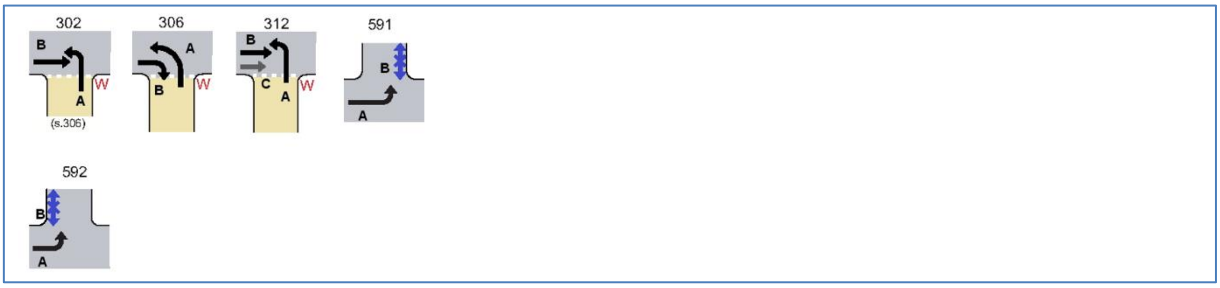


Figure 58: Accident types - participant A - LTAP-LD

Ego vehicle as participant B

In Figure 59 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

Figure 59: Accident types - participant B - LTAP-LD

Results for the whole category

In Table 29 the numbers of the whole *LTAP-LD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 29: Numbers and percentages in total - LTAP-LD

Category 4	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	583	218	92	-	13	906
	4,4%	17,5%	2,6%	0,0%	5,3%	4,7%
KSI	86	82	20	-	-	188
	4,1%	19,5%	2,9%	0,0%	0,0%	5,1%

Results for the single accident types

In Table 30 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 30: Numbers and percentages of accident types - LTAP-LD

Category 4	Accident type									Total
	261	286	302	306	312	326	591	592	683	
Injured	27	0	810	4	55	6	0	0	4	906
	0,1%	0,0%	4,2%	0,0%	0,3%	0,0%	0,0%	0,0%	0,0%	4,7%
KSI	5	0	168	1	14	0	0	0	0	188
	0,1%	0,0%	4,5%	0,0%	0,4%	0,0%	0,0%	0,0%	0,0%	5,1%

4.4.5 Category 5 – Right Turn Across Path – Opposite Direction (RTAP-OD)

The *RTAP-OD* scenario contains a right turning passenger car, which had a conflict with a participant coming from the opposite direction as shown in Figure 60.

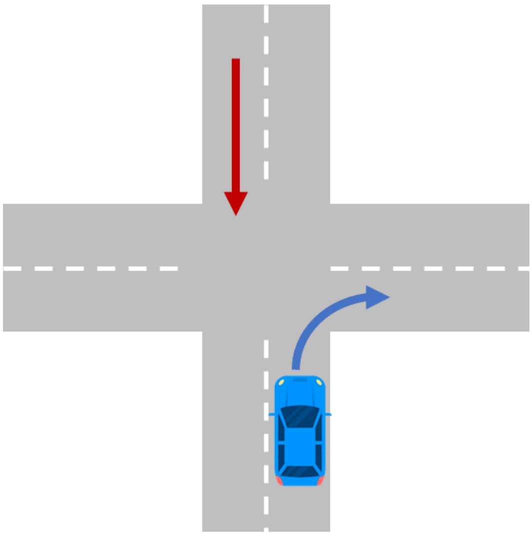


Figure 60: Pictogram – RTAP-OD

Ego vehicle as participant A

In Figure 61 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

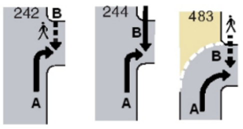


Figure 61: Accident types - participant A – RTAP-OD

Ego vehicle as participant B

In Figure 62 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

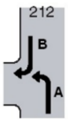


Figure 62: Accident types - participant B - RTAP-OD

Results for the whole category

In Table 31 the numbers of the whole *RTAP-OD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

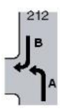
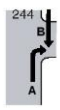
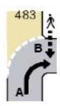
Table 31: Numbers and percentages in total - RTAP-OD

Category 5	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	5	-	160	30	1	196
	0,0%	0,0%	4,5%	2,7%	0,4%	1,0%
KSI	-	-	23	8	1	32
	0,0%	0,0%	3,3%	1,6%	4,8%	0,9%

Results for the single accident types

In Table 32 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 32: Numbers and percentages of accident types - RTAP-OD

Category 5	Accident type				Total
	212 	242 	244 	483 	
Injured	4	30	162	0	196
	0,0%	0,2%	0,8%	0,0%	1,0%
KSI	0	8	24	0	32
	0,0%	0,2%	0,6%	0,0%	0,9%

4.4.6 CATEGORY 6 – RIGHT TURN ACROSS PATH – SAME DIRECTION (RTAP-SD)

The *RTAP-SD* scenario contains a right turning passenger car, which had a conflict with a participant driving in the same direction as shown in Figure 63.

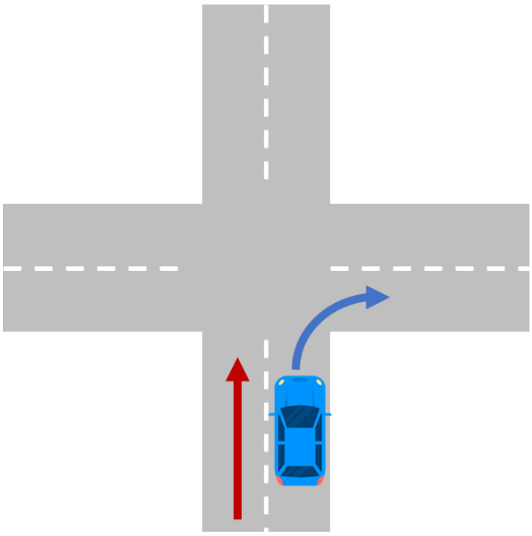


Figure 63: Pictogram – RTAP-SD

Ego vehicle as participant A

In Figure 64 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

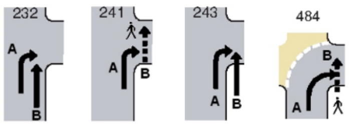


Figure 64: Accident types - participant A - RTAP-SD

Ego vehicle as participant B

In Figure 65 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

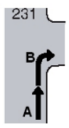


Figure 65: Accident types - participant B - RTAP-SD

Results for the whole category

In Table 33 the numbers of the whole *RTAP-SD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 33: Numbers and percentages in total - RTAP-SD

Category 6	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	119	30	338	31	8	526
	0,9%	2,4%	9,5%	2,8%	3,3%	2,7%
KSI	8	5	35	11	-	59
	0,4%	1,2%	5,1%	2,2%	0,0%	1,6%

Results for the single accident types

In Table 34 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 34: Numbers and percentages of accident types - RTAP-SD

Category 6	Accident type					Total
	231	232	241	243	484	
Injured	129	69	32	295	1	526
	0,7%	0,4%	0,2%	1,5%	0,0%	2,7%
KSI	8	8	11	32	0	59
	0,2%	0,2%	0,3%	0,9%	0,0%	1,6%

4.4.7 Category 7 – Right Turn Across Path – Right Direction (RTAP-RD)

The *RTAP-RD* scenario contains a right turning passenger car, which had a conflict with a participant coming from the right direction as shown in Figure 66.

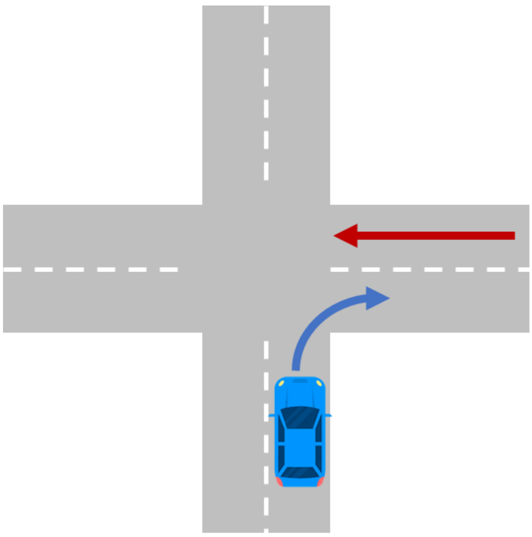


Figure 66: Pictogram – RTAP-RD

<u>*Ego vehicle as participant A*</u>

In Figure 67 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

Figure 67: Accident types - participant A - RTAP-RD

<u>*Ego vehicle as participant B*</u>

In Figure 68 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

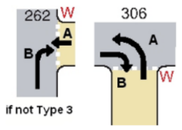


Figure 68: Accident types - participant B - RTAP-RD

Results for the whole category

In Table 35 the numbers of the whole *RTAP-RD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 35: Numbers and percentages in total - RTAP-RD

Category 7	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	32	6	29	1	5	73
	0,2%	0,5%	0,8%	0,1%	2,0%	0,4%
KSI	6	1	3	-	-	10
	0,3%	0,2%	0,4%	0,0%	0,0%	0,3%

Results for the single accident types

In Table 36 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 36: Numbers and percentages of accident types - RTAP-RD

Category 7	Accident type										Total
	262	286	306	323	326	333	334	593	594	683	
Injured	5	3	7	39	4	8	0	3	0	4	73
	0,0%	0,0%	0,0%	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,4%
KSI	0	1	2	4	0	3	0	0	0	0	10
	0,0%	0,0%	0,1%	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,3%

4.4.8 Category 8 – Right Turn Across Path – Left Direction (RTAP-LD)

The *RTAP-LD* scenario contains a right turning passenger car, which had a conflict with a participant coming from the left direction as shown in Figure 69.

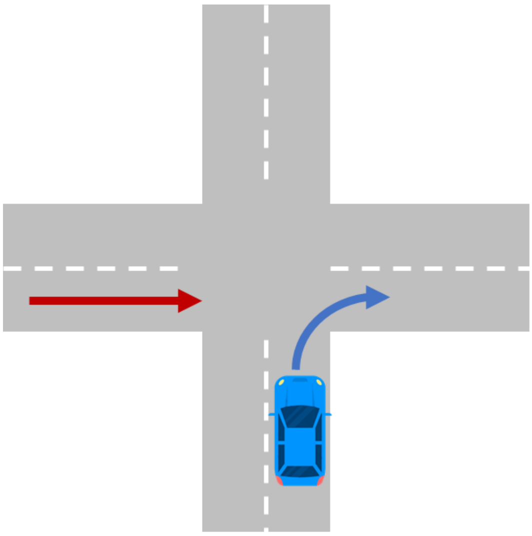


Figure 69: Pictogram – RTAP-LD

Ego vehicle as participant A

In Figure 70 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

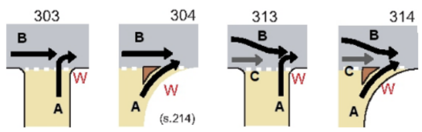


Figure 70: Accident types - participant A - RTAP-LD

There is no accident type for this category, where the ego vehicle was participant B.

Results for the whole category

In Table 37 the numbers of the whole *RTAP-LD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

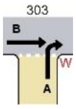
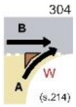
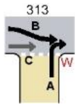
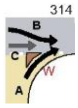
Table 37: Numbers and percentages in total - RTAP-LD

Category 8	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	62	42	101	-	21	226
	0,5%	3,4%	2,8%	0,0%	8,6%	1,2%
KSI	5	8	16	-	2	31
	0,2%	1,9%	2,3%	0,0%	9,5%	0,8%

Results for the single accident types

In Table 38 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 38: Numbers and percentages of accident types - RTAP-LD

Category 8	Accident type				Total
	303 	304 	313 	314 	
Injured	202	23	1	0	226
	1,0%	0,1%	0,0%	0,0%	1,2%
KSI	27	4	0	0	31
	0,7%	0,1%	0,0%	0,0%	0,8%

4.4.9 Category 9 – Oncoming

The *Oncoming* scenario contains a straight driving passenger car, which had a conflict with an oncoming participant as shown in Figure 71.

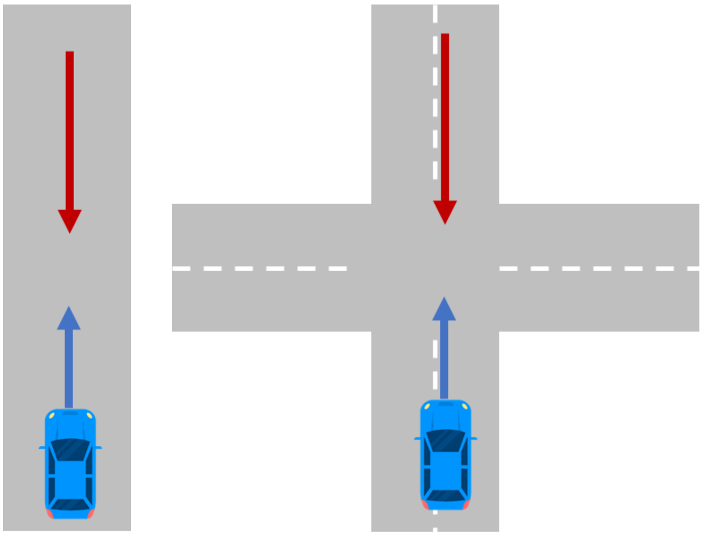


Figure 71: Pictogram – Oncoming

<u>*Ego vehicle as participant A*</u>

In Figure 72 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

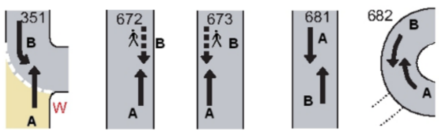


Figure 72: Accident types - participant A - Oncoming

<u>*Ego vehicle as participant B*</u>

In Figure 73 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

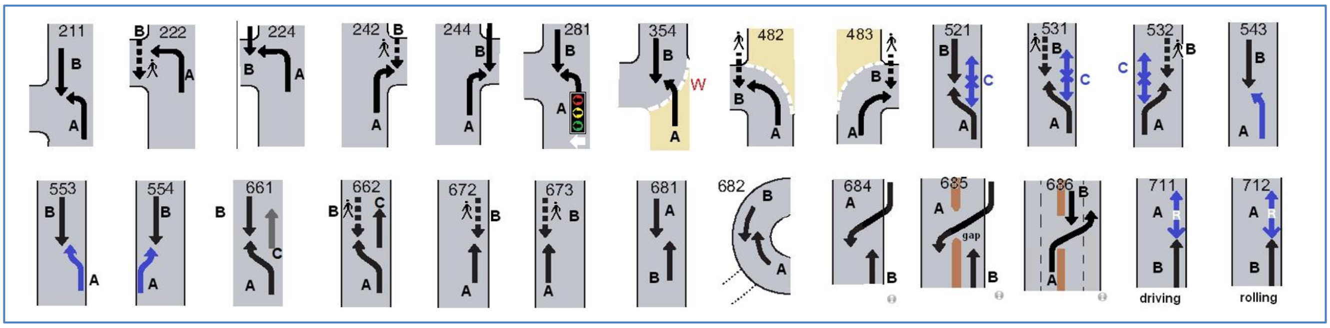


Figure 73: Accident types - participant B – Oncoming

Please notice, that the accident types, where participant B have to be a pedestrian, are only shown in the list for reasons of completeness. For these accident types no occupant is counted in the scope of SECUR.

Results for the whole category

In Table 39 the numbers of the whole *Oncoming* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 39: Numbers and percentages in total - Oncoming

Category 9	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	1.326	49	76	15	19	1.485
	10,1%	3,9%	2,1%	1,3%	7,8%	7,7%
KSI	332	24	14	4	3	377
	15,9%	5,7%	2,0%	0,8%	14,3%	10,1%

Results for the single accident types

In the following tables (Table 40 to Table 42) the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 40: Numbers and percentages of accident types - Oncoming (1)

Category 9	Accident type										
	211	222	224	242	244	281	351	354	482	483	521
Injured	739	0	1	0	0	90	30	2	0	0	25
	3,8%	0,0%	0,0%	0,0%	0,0%	0,5%	0,2%	0,0%	0,0%	0,0%	0,1%
KSI	130	0	0	0	0	10	2	0	0	0	5
	3,5%	0,0%	0,0%	0,0%	0,0%	0,3%	0,1%	0,0%	0,0%	0,0%	0,1%

Table 41: Numbers and percentages of accident types - Oncoming (2)

Category 9	Accident type										
	531	532	543	553	554	661	662	672	673	681	682
Injured	0	0	4	0	0	85	0	9	6	257	226
	0,0%	0,0%	0,0%	0,0%	0,0%	0,4%	0,0%	0,0%	0,0%	1,3%	1,2%
KSI	0	0	2	0	0	35	0	4	0	96	93
	0,0%	0,0%	0,1%	0,0%	0,0%	0,9%	0,0%	0,1%	0,0%	2,6%	2,5%

Table 42: Numbers and percentages of accident types - Oncoming (3)

Category 9	Accident type					Total
	684	685	686	711 driving	712 rolling	
Injured	0	0	0	11	0	1485
	0,0%	0,0%	0,0%	0,1%	0,0%	7,7%
KSI	0	0	0	0	0	377
	0,0%	0,0%	0,0%	0,0%	0,0%	10,1%

4.4.10 Category 10 – Straight Crossing Path – Same Direction – Turning (SCP-SDT)

The *SCP-SDT* scenario contains a left straight driving passenger car, which had a conflict with a participant driving in the same direction with the aim of turning off as shown in Figure 74.

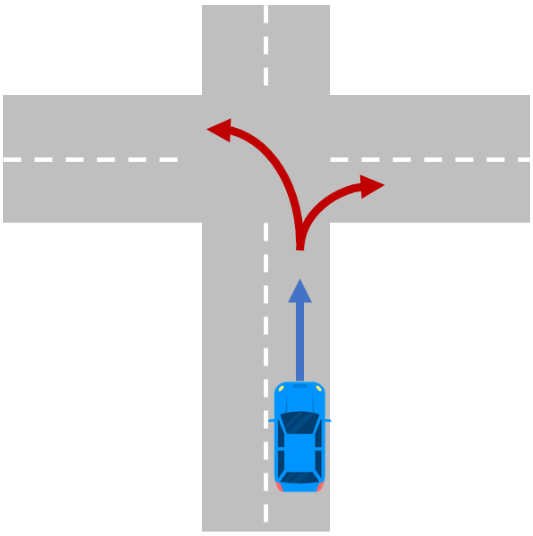


Figure 74: Pictogram – SCP-SDT

<u>*Ego vehicle as participant A*</u>

In Figure 75 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

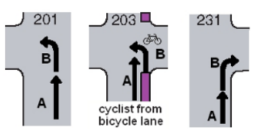


Figure 75: Accident types - participant A – SCP-SDT

<u>*Ego vehicle as participant B*</u>

In Figure 76 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

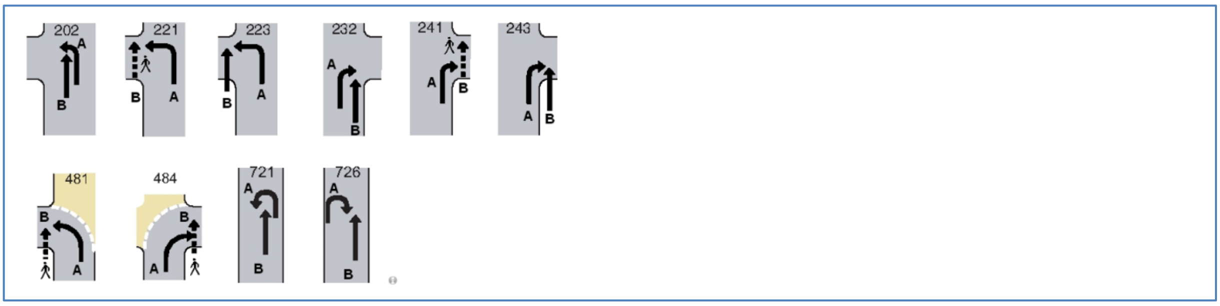


Figure 76: Accident types - participant B - SCP-SDT

Please notice, that the accident types, where participant B have to be a pedestrian, are only shown in the list for reasons of completeness. For these accident types no occupant is counted in the scope of SECUR.

Results for the whole category

In Table 43 the numbers of the whole *SCP-SDT* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 43: Numbers and percentages in total - SCP-SDT

Category 10	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	446	31	35	-	4	516
	3,4%	2,5%	1,0%	0,0%	1,6%	2,7%
KSI	47	6	6	-	-	59
	2,2%	1,4%	0,9%	0,0%	0,0%	1,6%

Results for the single accident types

In the following tables (Table 44 and Table 45) the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 44: Numbers and percentages of accident types - SCP-SDT (1)

Category 10	Accident type										
	201	202	203	221	223	231	232	233	241	243	481
Injured	195	120	9	0	0	101	18	0	0	1	0
	1,0%	0,6%	0,0%	0,0%	0,0%	0,5%	0,1%	0,0%	0,0%	0,0%	0,0%
KSI	11	21	3	0	0	6	3	0	0	0	0
	0,3%	0,6%	0,1%	0,0%	0,0%	0,2%	0,1%	0,0%	0,0%	0,0%	0,0%

Table 45: Numbers and percentages of accident types - SCP-SDT (2)

Category 10	Accident type			Total
	484	721	726	
Injured	0	72	0	516
	0,0%	0,4%	0,0%	2,7%
KSI	0	15	0	59
	0,0%	0,4%	0,0%	1,6%

4.4.11 Category 11 – Rear End – Following Vehicle (RE-FV)

The *RE-FV* scenario contains a passenger car, which had a rear end conflict with another participant driving ahead as shown in Figure 77.

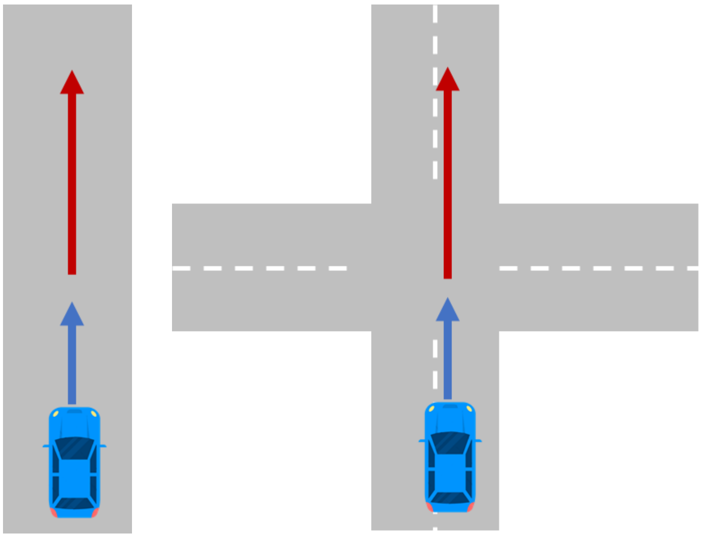


Figure 77: Pictogram – RE-FV

Ego vehicle as participant A

In Figure 78 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

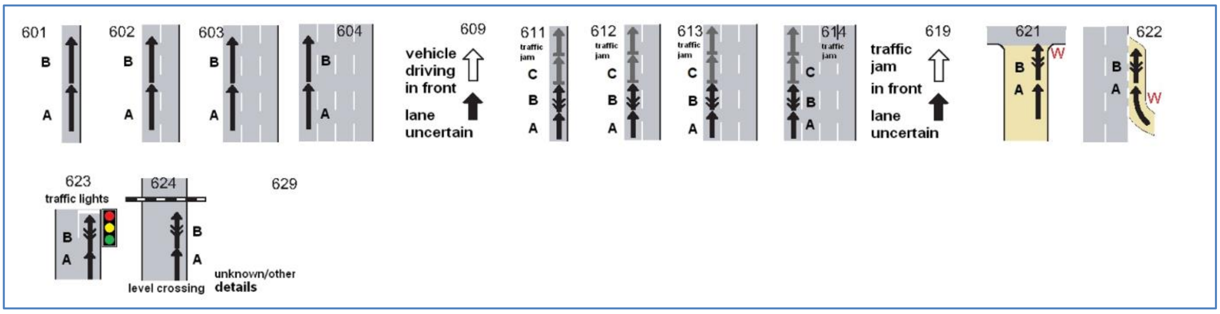


Figure 78: Accident types - participant A – RE-FV

There is no accident type for this category, where the ego vehicle was participant B.

Results for the whole category

In Table 46 the numbers of the whole *RE-FV* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 46: Numbers and percentages in total - RE-FV

Category 11	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	2.051	50	18	-	7	2.126
	15,6%	4,0%	0,5%	0,0%	2,9%	11,0%
KSI	164	12	7	-	1	184
	7,8%	2,9%	1,0%	0,0%	4,8%	4,9%

Results for the single accident types

In the following tables (Table 47 and Table 48) the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 47: Numbers and percentages of accident types - RE-FV (1)

Category 11	Accident type										
	601	602	603	604	609	611	612	613	614	619	621
Injured	425	138	68	11	10	593	207	96	10	8	128
	2,2%	0,7%	0,4%	0,1%	0,1%	3,1%	1,1%	0,5%	0,1%	0,0%	0,7%
KSI	58	12	10	3	1	47	11	20	0	0	4
	1,6%	0,3%	0,3%	0,1%	0,0%	1,3%	0,3%	0,5%	0,0%	0,0%	0,1%

Table 48: Numbers and percentages of accident types - RE-FV (2)

Category 11	Accident type				Total
	622	623	624	629	
Injured	52	364	1	15	2126
	0,3%	1,9%	0,0%	0,1%	11,0%
KSI	0	18	0	0	184
	0,0%	0,5%	0,0%	0,0%	4,9%

4.4.12 Category 12 – Straight Crossing Path – Same Direction – Lane Change (SCP-SDLC)

The *SCP-SDLC* scenario contains a passenger car going straight, which had a conflict with a participant going into the same direction and changing lane as shown in Figure 79.

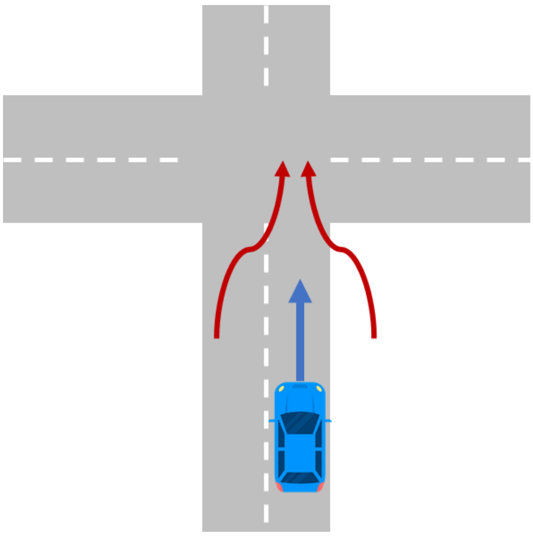


Figure 79: Pictogram – SCP-SDLC

<u>*Ego vehicle as participant A*</u>

In Figure 80 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

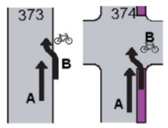


Figure 80: Accident types - participant A – SCP-SDLC

Ego vehicle as participant B

In Figure 81 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

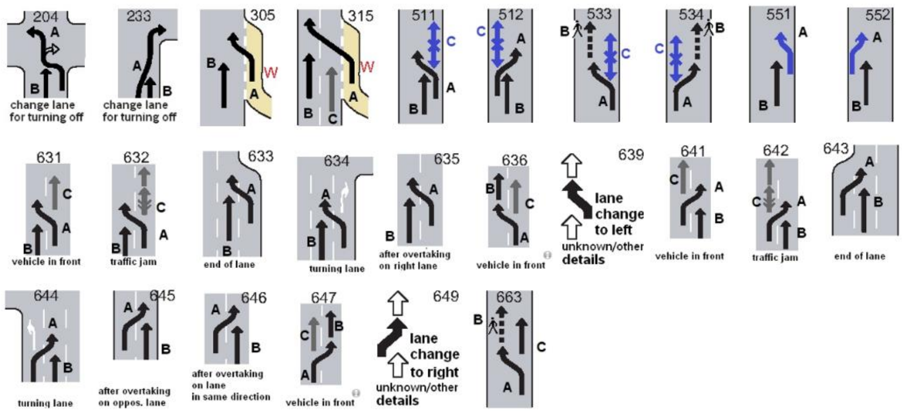


Figure 81: Accident types - participant B - SCP-SDLC

Please notice, that the accident types, where participant B have to be a pedestrian, are only shown in the list for reasons of completeness. For these accident types no occupant is counted in the scope of SECUR.

Results for the whole category

In Table 49 the numbers of the whole *SCP-SDLC* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 49: Numbers and percentages in total - SCP-SDLC

Category 12	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	312	17	28	-	6	363
	2,4%	1,4%	0,8%	0,0%	2,4%	1,9%
KSI	48	4	8	-	-	60
	2,3%	1,0%	1,2%	0,0%	0,0%	1,6%

Results for the single accident types

In the following tables (Table 50 to Table 52) the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 50: Numbers and percentages of accident types - SCP-SDLC (1)

Category 12	Accident type										
	204	233	305	315	373	374	511	512	533	534	551
Injured	3	1	26	4	10	8	6	0	0	0	50
	0,0%	0,0%	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,3%
KSI	1	1	2	0	1	3	2	0	0	0	5
	0,0%	0,0%	0,1%	0,0%	0,0%	0,1%	0,1%	0,0%	0,0%	0,0%	0,1%

Table 51: Numbers and percentages of accident types - SCP-SDLC (2)

Category 12	Accident type										
	552	631	632	633	634	635	636	639	641	642	643
Injured	0	117	20	13	15	8	0	8	11	1	5
	0,0%	0,6%	0,1%	0,1%	0,1%	0,0%	0,0%	0,0%	0,1%	0,0%	0,0%
KSI	0	26	7	1	4	0	0	0	1	0	0
	0,0%	0,7%	0,2%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

Table 52: Numbers and percentages of accident types - SCP-SDLC (3)

Category 12							Total
	644	645	646	647	649	663	
Injured	12	6	20	0	19	0	363
	0,1%	0,0%	0,1%	0,0%	0,1%	0,0%	1,9%
KSI	2	1	1	0	2	0	60
	0,1%	0,0%	0,0%	0,0%	0,1%	0,0%	1,6%

4.4.13 Category 13 – Straight Crossing Path – Right Direction (SCP-RD)

The *SCP-RD* scenario contains a straight driving passenger car, which had a conflict with a participant coming from the right direction as shown in Figure 82.

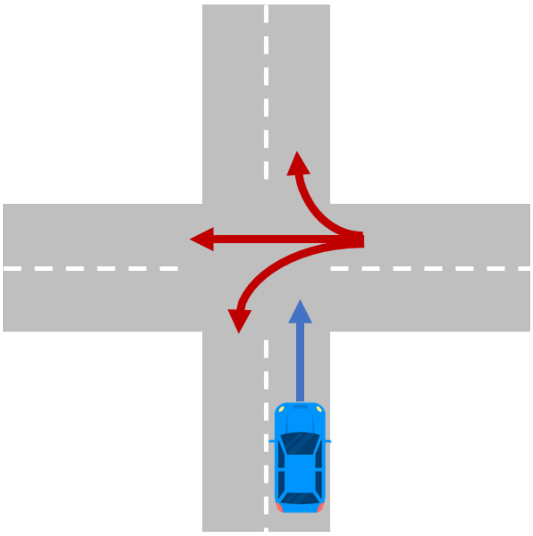


Figure 82: Pictogram – SCP-RD

<u>Ego vehicle as participant A</u>

In Figure 83 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

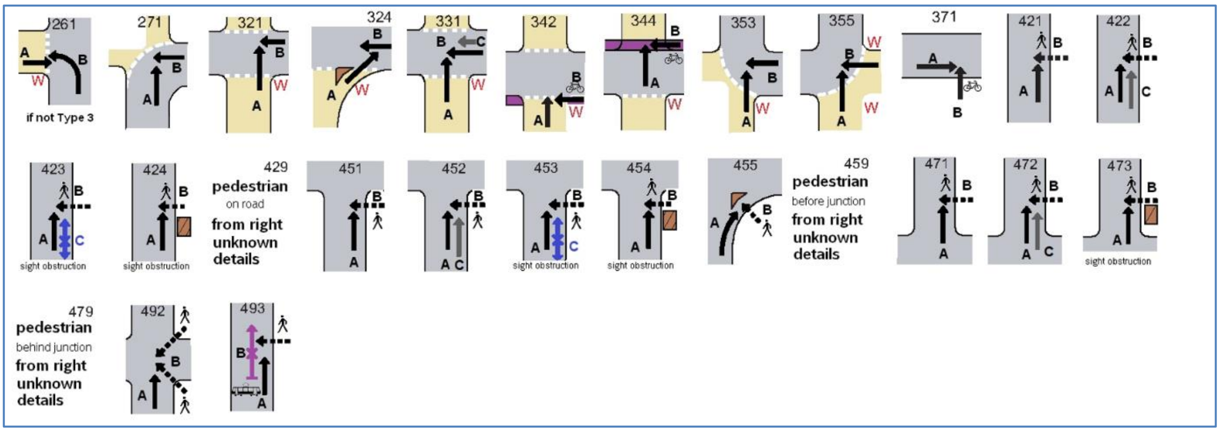


Figure 83: Accident types - participant A – SCP-RD

<u>Ego vehicle as participant B</u>

In Figure 84 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

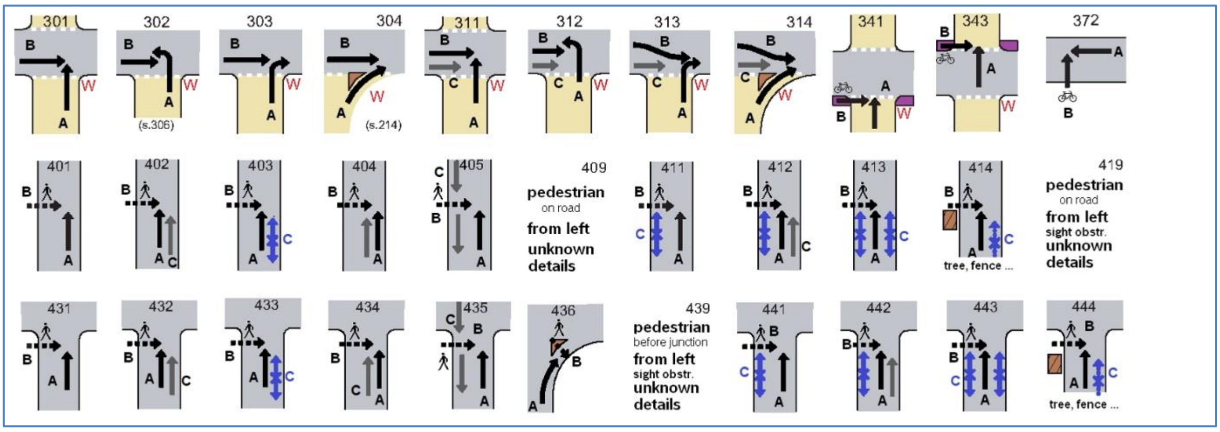


Figure 84: Accident types - participant B - SCP-RD

Please notice, that the accident types, where participant B have to be a pedestrian, are only shown in the list for reasons of completeness. For these accident types no occupant is counted in the scope of SECUR.

Results for the whole category

In Table 53 the numbers of the whole *SCP-RD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 53: Numbers and percentages in total - SCP-RD

Category 13	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	1.598	101	1.162	497	15	3.373
	12,2%	8,1%	32,5%	44,3%	6,1%	17,5%
KSI	233	40	248	214	-	735
	11,1%	9,5%	35,9%	43,1%	0,0%	19,8%

Results for the single accident types

In the following tables (Table 54 to Table 60) the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 54: Numbers and percentages of accident types - SCP-RD (1)

Category 13	Accident type										
	261	271	301	302	303	304	311	312	313	314	321
Injured	23	35	454	440	73	13	24	25	1	0	793
	0,1%	0,2%	2,3%	2,3%	0,4%	0,1%	0,1%	0,1%	0,0%	0,0%	4,1%
KSI	3	9	92	82	8	2	7	2	0	0	144
	0,1%	0,2%	2,5%	2,2%	0,2%	0,1%	0,2%	0,1%	0,0%	0,0%	3,9%

Table 55: Numbers and percentages of accident types - SCP-RD (2)

Category 13	Accident type										
	324	331	341	342	343	344	353	355	371	372	401
Injured	3	7	1	807	1	31	6	2	117	1	0
	0,0%	0,0%	0,0%	4,2%	0,0%	0,2%	0,0%	0,0%	0,6%	0,0%	0,0%
KSI	0	4	0	121	1	4	2	0	39	0	0
	0,0%	0,1%	0,0%	3,3%	0,0%	0,1%	0,1%	0,0%	1,0%	0,0%	0,0%

Table 56: Numbers and percentages of accident types - SCP-RD (3)

Category 13	Accident type										
	402	403	404	405	409	411	412	413	414	419	421
Injured	0	0	0	0	0	0	0	0	0	0	148
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,8%
KSI	0	0	0	0	0	0	0	0	0	0	61
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	1,6%

Table 57: Numbers and percentages of accident types - SCP-RD (4)

Category 13	Accident type										
	422	423	424	429	431	432	433	434	435	436	439
Injured	30	69	36	1	0	0	0	0	0	0	0
	0,2%	0,4%	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
KSI	19	26	16	0	0	0	0	0	0	0	0
	0,5%	0,7%	0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

Table 58: Numbers and percentages of accident types - SCP-RD (5)

Category 13	Accident type										
	441	442	443	444	449	451	452	453	454	455	459
Injured	0	0	0	0	0	71	25	13	15	5	0
	0,0%	0,0%	0,0%	0,0%	0,0%	0,4%	0,1%	0,1%	0,1%	0,0%	0,0%
KSI	0	0	0	0	0	30	11	6	6	2	0
	0,0%	0,0%	0,0%	0,0%	0,0%	0,8%	0,3%	0,2%	0,2%	0,1%	0,0%

Table 59: Numbers and percentages of accident types - SCP-RD (6)

Category 13	Accident type										
	461	462	463	464	465	469	471	472	473	479	491
					sight obstruction	pedestrian behind junction from left unknown details			sight obstruction	pedestrian behind junction from right unknown details	
Injured	0	0	0	0	0	0	58	10	8	0	0
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,3%	0,1%	0,0%	0,0%	0,0%
KSI	0	0	0	0	0	0	25	5	3	0	0
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,7%	0,1%	0,1%	0,0%	0,0%

Table 60: Numbers and percentages of accident types - SCP-RD (7)

Category 13	Accident type						Total
	492	493	494	561	571	714	
						backing out	
Injured	3	5	0	4	9	6	3373
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	17,5%
KSI	2	2	0	1	0	0	735
	0,1%	0,1%	0,0%	0,0%	0,0%	0,0%	19,8%

4.4.14 Category 14 – Straight Crossing Path – Left Direction (SCP-LD)

The *SCP-LD* scenario contains a straight driving passenger car, which had a conflict with a participant coming from the left direction as shown in Figure 85.

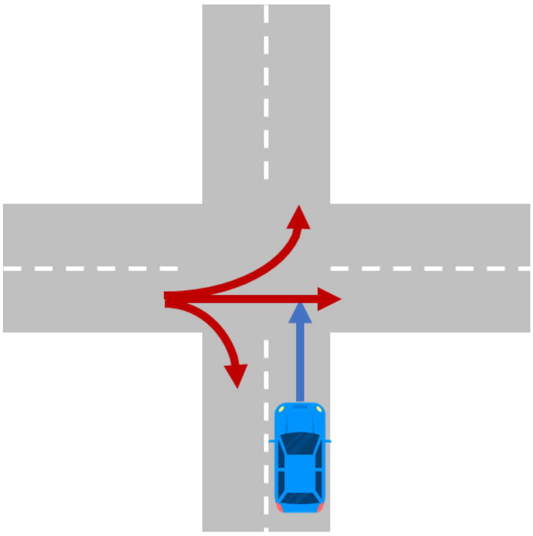


Figure 85: Pictogram – SCP-LD

<u>*Ego vehicle as participant A*</u>

In Figure 86 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

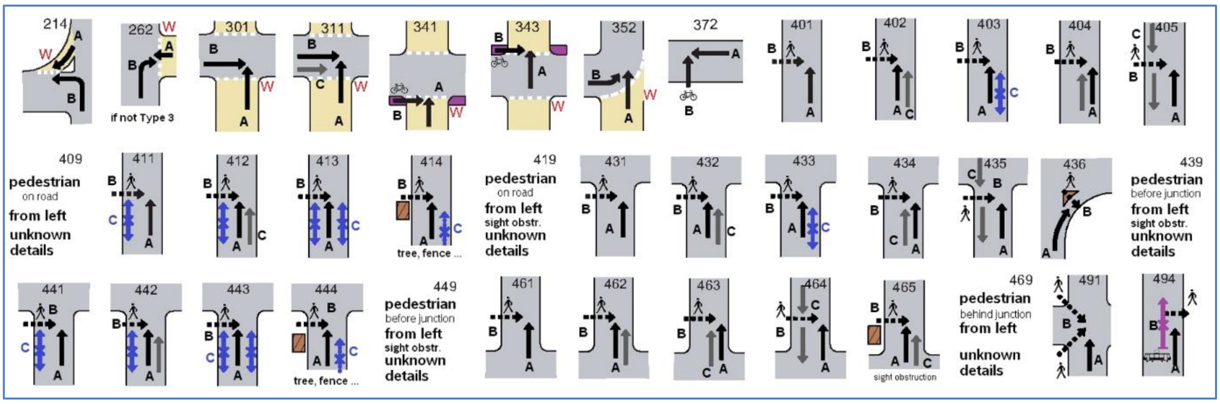


Figure 86: Accident types - participant A - SCP-LD

Ego vehicle as participant B

In Figure 87 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

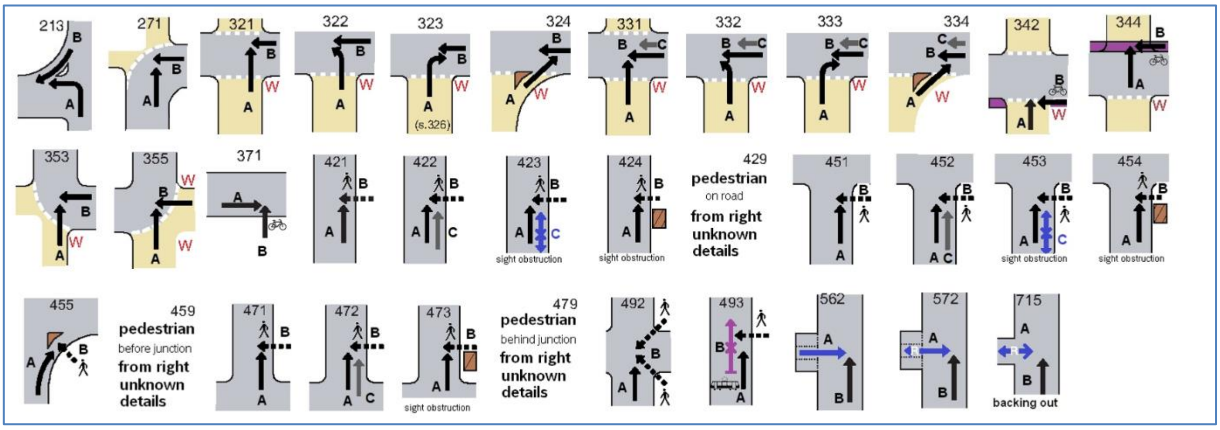


Figure 87: Accident types - participant B - SCP-LD

Please notice, that the accident types, where participant B have to be a pedestrian, are only shown in the list for reasons of completeness. For these accident types no occupant is counted in the scope of SECUR.

Results for the whole category

In Table 61 the numbers of the whole *SCP-LD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 61: Numbers and percentages in total - SCP-LD

Category 14	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	1.230	89	747	360	42	2.468
	9,4%	7,1%	20,9%	32,1%	17,1%	12,8%
KSI	179	29	167	194	6	575
	8,6%	6,9%	24,2%	39,0%	28,6%	15,5%

Results for the single accident types

In the following tables (Table 62 to Table 68) the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 62: Numbers and percentages of accident types - SCP-LD (1)

Category 14	Accident type										
	213	214	262 (if not Type 3)	271	301	311	321	322	323 (s.326)	324	331
Injured	0	3	5	37	521	24	860	100	15	0	12
	0,0%	0,0%	0,0%	0,2%	2,7%	0,1%	4,4%	0,5%	0,1%	0,0%	0,1%
KSI	0	0	0	7	92	6	149	13	1	0	5
	0,0%	0,0%	0,0%	0,2%	2,5%	0,2%	4,0%	0,3%	0,0%	0,0%	0,1%

Table 63: Numbers and percentages of accident types - SCP-LD (2)

Category 14	Accident type										
	332	333	334	341	342	343	344	352	353	355	371
Injured	3	7	0	375	7	22	0	21	3	11	0
	0,0%	0,0%	0,0%	1,9%	0,0%	0,1%	0,0%	0,1%	0,0%	0,1%	0,0%
KSI	1	1	0	72	1	4	0	4	0	2	0
	0,0%	0,0%	0,0%	1,9%	0,0%	0,1%	0,0%	0,1%	0,0%	0,1%	0,0%

Table 64: Numbers and percentages of accident types - SCP-LD (3)

Category 14	Accident type										
	372	401	402	403	404	405	409 (pedestrian on road from left unknown details)	411	412	413	414 (tree, fence ...)
Injured	66	101	4	2	6	13	1	63	2	4	3
	0,3%	0,5%	0,0%	0,0%	0,0%	0,1%	0,0%	0,3%	0,0%	0,0%	0,0%
KSI	19	57	1	1	4	9	0	32	1	1	0
	0,5%	1,5%	0,0%	0,0%	0,1%	0,2%	0,0%	0,9%	0,0%	0,0%	0,0%

Table 65: Numbers and percentages of accident types - SCP-LD (4)

Category 14	Accident type										
	419 (pedestrian on road from left sight obstr. unknown details)	421	422	423 (sight obstruction)	424 (sight obstruction)	429 (pedestrian on road from right unknown details)	431	432	433	434	435
Injured	0	0	0	0	0	0	49	6	1	5	0
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,3%	0,0%	0,0%	0,0%	0,0%
KSI	0	0	0	0	0	0	22	5	0	5	0
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,6%	0,1%	0,0%	0,1%	0,0%

Table 66: Numbers and percentages of accident types - SCP-LD (5)

Category 14	Accident type										
	436	439	441	442	443	444	449	451	452	453	454
		pedestrian before junction from left sight obstr. unknown details				tree, fence ...	pedestrian before junction from left sight obstr. unknown details			sight obstruction	sight obstruction
Injured	1	0	14	4	1	3	1	0	0	0	0
	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
KSI	0	0	7	3	1	2	0	0	0	0	0
	0,0%	0,0%	0,2%	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%

Table 67: Numbers and percentages of accident types - SCP-LD (6)

Category 14	Accident type										
	455	459	461	462	463	464	465	469	471	472	473
		pedestrian before junction from right unknown details					sight obstruction	pedestrian behind junction from left unknown details			sight obstruction
Injured	0	0	49	2	4	9	1	0	0	0	0
	0,0%	0,0%	0,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
KSI	0	0	24	2	3	6	1	0	0	0	0
	0,0%	0,0%	0,6%	0,1%	0,1%	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%

Table 68: Numbers and percentages of accident types - SCP-LD (7)

Category 14	Accident type								Total
	479	491	492	493	494	562	572	715	
	pedestrian behind junction from right unknown details							backing out	
Injured	0	4	0	0	13	2	3	5	2468
	0,0%	0,0%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%	12,8%
KSI	0	1	0	0	6	0	0	4	575
	0,0%	0,0%	0,0%	0,0%	0,2%	0,0%	0,0%	0,1%	15,5%

4.4.15 Category 15 – Rear End –Previous Vehicle (RE-PV)

The *RE-PV* scenario contains a passenger car, which had a rear end conflict with a following participant as shown in Figure 88.

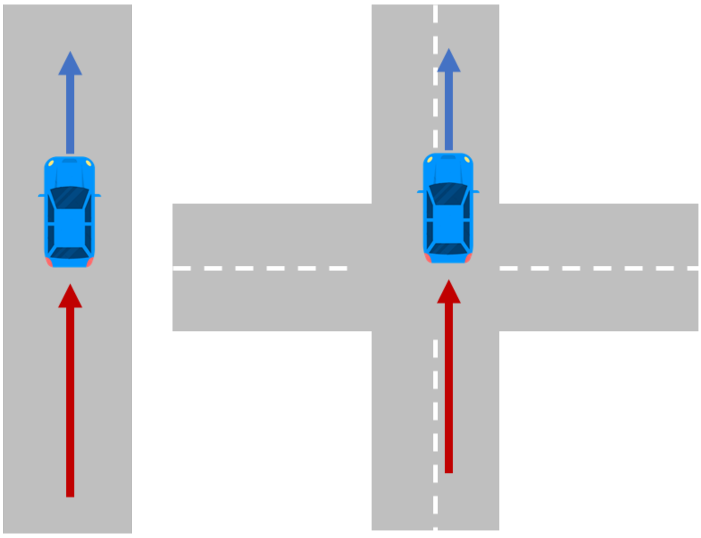


Figure 88: Pictogram – RE-PV

Ego vehicle as participant B

In Figure 89 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

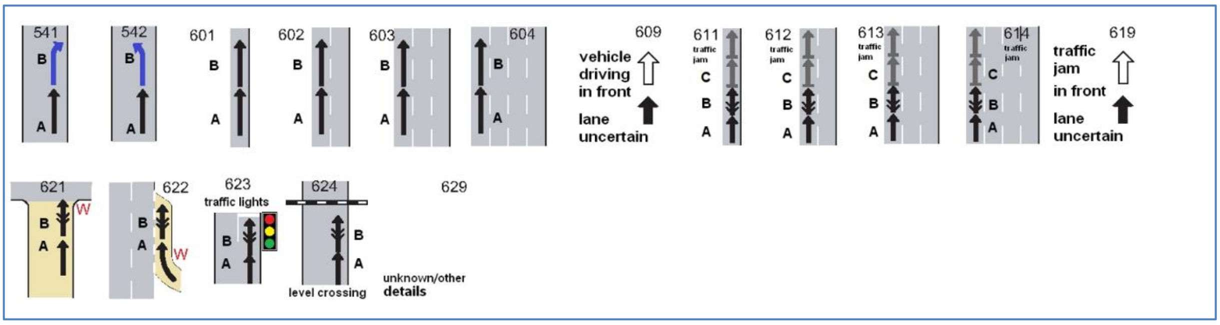


Figure 89: Accident types - participant B – RE-PV

There is no accident type for this category, where the ego vehicle was participant A.

Results for the whole category

In Table 69 the numbers of the whole *RE-PV* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 69: Numbers and percentages in total - RE-PV

Category 15	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	2.382	175	30	-	10	2.597
	18,1%	14,0%	0,8%	0,0%	4,1%	13,4%
KSI	154	39	6	-	2	201
	7,4%	9,3%	0,9%	0,0%	9,5%	5,4%

Results for the single accident types

In the following tables (Table 70 and Table 71) the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 70: Numbers and percentages of accident types - RE-PV (1)

Category 15	Accident type										
	541	542	601	602	603	604	609 vehicle driving in front lane uncertain	611 traffic jam	612 traffic jam	613 traffic jam	614 traffic jam
Injured	12	2	454	157	69	11	9	691	279	132	10
	0,1%	0,0%	2,3%	0,8%	0,4%	0,1%	0,0%	3,6%	1,4%	0,7%	0,1%
KSI	0	0	41	14	5	1	0	59	17	24	0
	0,0%	0,0%	1,1%	0,4%	0,1%	0,0%	0,0%	1,6%	0,5%	0,6%	0,0%

Table 71: Numbers and percentages of accident types - RE-PV (2)

Category 15	Accident type						Total
	619 traffic jam in front lane uncertain	621	622	623 traffic lights	624 level crossing	629 unknown/other details	
Injured	7	164	67	507	3	23	2597
	0,0%	0,8%	0,3%	2,6%	0,0%	0,1%	13,4%
KSI	0	7	6	26	1	0	201
	0,0%	0,2%	0,2%	0,7%	0,0%	0,0%	5,4%

4.4.16 Category 16 – Parallel Driving (PD)

The *PD* scenario contains a passenger car, which had a conflict with a parallel driving participant as shown in Figure 90.

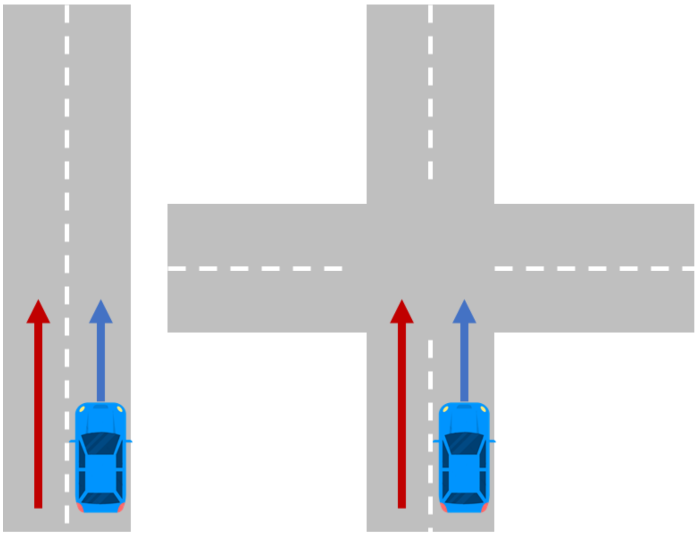


Figure 90: Pictogram – PD

<u>*Ego vehicle as participant A or B*</u>

In Figure 91 the accident types for all the situations, where the ego vehicle participated as participant A or participant B, are shown.

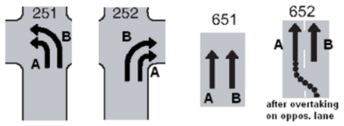


Figure 91: Accident types - participant A or B - PD

<u>*Results for the whole category*</u>

In Table 72 the numbers of the whole *PD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

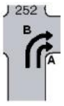
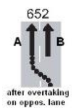
Table 72: Numbers and percentages in total - PD

Category 16	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	65	22	47	-	4	138
	0,5%	1,8%	1,3%	0,0%	1,6%	0,7%
KSI	10	3	12	-	-	25
	0,5%	0,7%	1,7%	0,0%	0,0%	0,7%

<u>*Results for the single accident types*</u>

In Table 73 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 73: Numbers and percentages of accident types - PD

Category 16	Accident type				Total
	251 	252 	651 	652 	
Injured	8	11	86	33	138
	0,0%	0,1%	0,4%	0,2%	0,7%
KSI	1	0	14	10	25
	0,0%	0,0%	0,4%	0,3%	0,7%

4.4.17 Category 17 – Lane Change – Same Direction (LC-SD)

The *LC-SD* scenario contains a lane changing passenger car, which had a conflict with a participant driving in the same direction as shown in Figure 92.

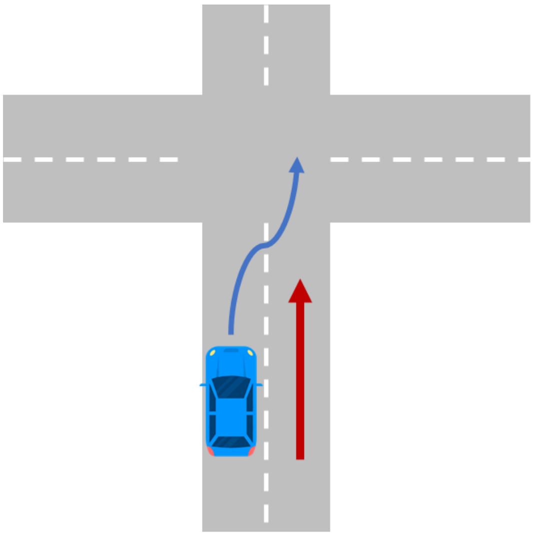


Figure 92: Pictogram – LC-SD

<u>Ego vehicle as participant A</u>

In Figure 93 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

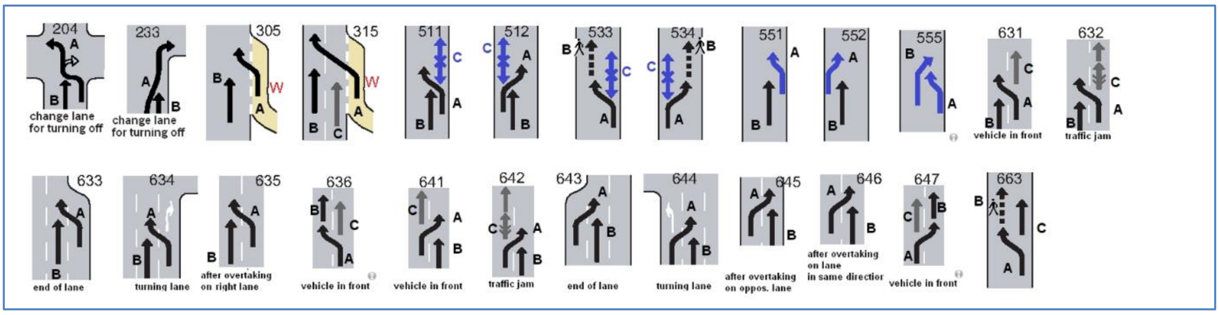


Figure 93: Accident types - participant A – LC-SD

<u>Ego vehicle as participant B</u>

In Figure 94 the accident types for all the situations, where the ego vehicle participated as participant B, are shown.

Figure 94: Accident types - participant B - LC-SD

Please notice, that the accident types, where participant B have to be a cyclist, are only shown in the list for reasons of completeness. For these accident types no occupant is counted in the scope of SECUR.

<u>Results for the whole category</u>

In Table 74 the numbers of the whole *LC-SD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 74: Numbers and percentages in total - LC-SD

Category 17	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	274	81	40	1	34	430
	2,1%	6,5%	1,1%	0,1%	13,9%	2,2%
KSI	50	32	5	-	-	87
	2,4%	7,6%	0,7%	0,0%	0,0%	2,3%

<u>*Results for the single accident types*</u>

In the following tables (Table 75 to Table 77) the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 75: Numbers and percentages of accident types - LC-SD (1)

Category 17	Accident type										
	204	233	305	315	373	374	511	512	533	534	551
Injured	2	1	25	2	0	2	6	0	0	0	114
	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,6%
KSI	1	1	4	0	0	0	0	0	0	0	11
	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,3%

Table 76: Numbers and percentages of accident types - LC-SD (2)

Category 17	Accident type										
	552	555	631	632	633	634	635	636	637	641	642
Injured	3	0	112	18	11	17	16	0	0	15	7
	0,0%	0,0%	0,6%	0,1%	0,1%	0,1%	0,1%	0,0%	0,0%	0,1%	0,0%
KSI	1	0	31	3	3	1	7	0	0	3	0
	0,0%	0,0%	0,8%	0,1%	0,1%	0,0%	0,2%	0,0%	0,0%	0,1%	0,0%

Table 77: Numbers and percentages of accident types - LC-SD (3)

Category 17	Accident type						Total
	643	644	645	646	647	663	
Injured	6	15	16	41	0	1	430
	0,0%	0,1%	0,1%	0,2%	0,0%	0,0%	2,2%
KSI	0	2	8	11	0	0	87
	0,0%	0,1%	0,2%	0,3%	0,0%	0,0%	2,3%

4.4.18 Category 18 – Lane Change – Opposite Direction (LC-OD)

The *LC-OD* scenario contains a lane changing passenger car, which had a conflict with a participant coming from the opposite direction as shown in Figure 95.

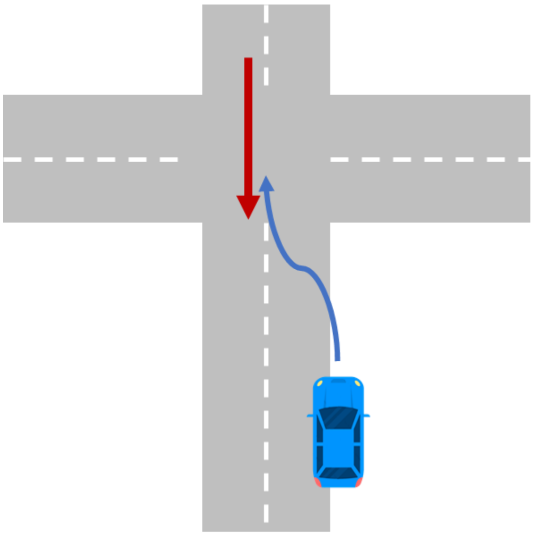


Figure 95: Pictogram – LC-OD

Ego vehicle as participant A

In Figure 96 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

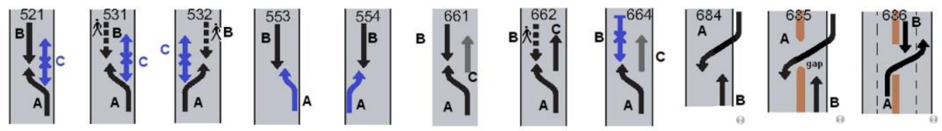


Figure 96: Accident types - participant A - LC-OD

There is no accident type for this category, where the ego vehicle was participant B.

Results for the whole category

In Table 78 the numbers of the whole *LC-OD* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 78: Numbers and percentages in total - LC-OD

Category 18	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	109	8	7	-	15	139
	0,8%	0,6%	0,2%	0,0%	6,1%	0,7%
KSI	39	5	-	-	1	45
	1,9%	1,2%	0,0%	0,0%	4,8%	1,2%

Results for the single accident types

In Table 79 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 79: Numbers and percentages of accident types - LC-OD

Category 18	Accident type											Total
	521	531	532	553	554	661	662	664	684	685	686	
Injured	20	0	0	1	9	108	0	1	0	0	0	139
	0,1%	0,0%	0,0%	0,0%	0,0%	0,6%	0,0%	0,0%	0,0%	0,0%	0,0%	0,7%
KSI	2	0	0	0	0	43	0	0	0	0	0	45
	0,1%	0,0%	0,0%	0,0%	0,0%	1,2%	0,0%	0,0%	0,0%	0,0%	0,0%	1,2%

4.4.19 Category 19 – Reverse

The *Reverse* scenario contains a reversing passenger car, which had a conflict with another participant as shown in Figure 97.

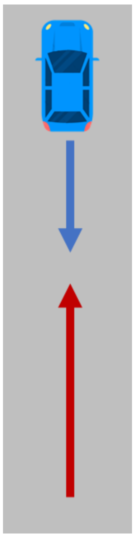


Figure 97: Pictogram – Reverse

Ego vehicle as participant A

In Figure 98 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

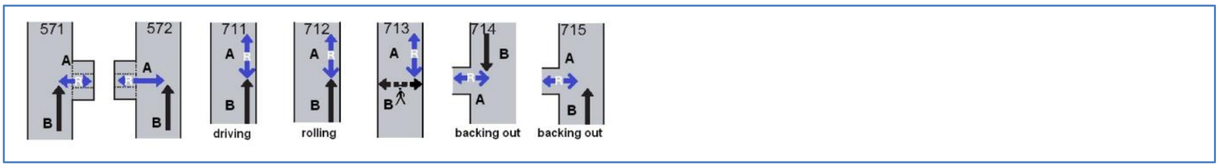


Figure 98: Accident types - participant A - Reverse

Results for the whole category

In Table 80 the numbers of the whole *Reverse* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

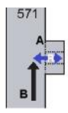
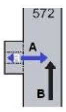
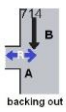
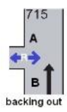
Table 80: Numbers and percentages in total - Reverse

Category 19	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	31	18	75	14	1	139
	0,2%	1,4%	2,1%	1,2%	0,4%	0,7%
KSI	5	4	8	2	-	19
	0,2%	1,0%	1,2%	0,4%	0,0%	0,5%

Results for the single accident types

In Table 81 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 81: Numbers and percentages of accident types - Reverse

Category 19	Accident type							Total
	571	572	711	712	713	714	715	
								
Injured	48	11	21	6	0	30	23	139
	0,2%	0,1%	0,1%	0,0%	0,0%	0,2%	0,1%	0,7%
KSI	9	0	2	0	0	2	6	19
	0,2%	0,0%	0,1%	0,0%	0,0%	0,1%	0,2%	0,5%

4.4.20 Category 20 – Loss Of Control in Straight Line (LOC-SL)

The *LOC-SL* scenario contains a passenger car losing control without the influence of a curve as shown in Figure 99.

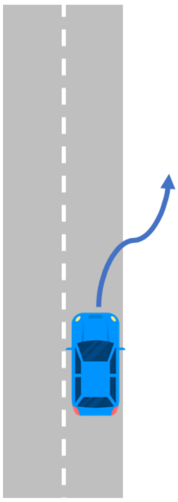


Figure 99: Pictogram – LOC-SL

Ego vehicle as participant A

In Figure 100 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

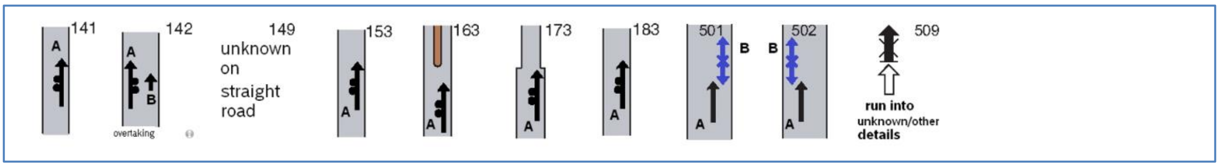


Figure 100: Accident types - participant A – LOC-SL

There is no accident type for this category, where the ego vehicle was participant B.

Results for the whole category

In Table 82 the numbers of the whole *LOC-SL* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 82: Numbers and percentages in total - LOC-SL

Category 20		Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured		393	-	-	-	-	393
		3,0%	0,0%	0,0%	0,0%	0,0%	2,0%
KSI		174	-	-	-	-	174
		8,3%	0,0%	0,0%	0,0%	0,0%	4,7%

Results for the single accident types

In Table 83 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 83: Numbers and percentages of accident types - LOC-SL

Category 20	Accident type										Total
	141	142	149	153	163	173	183	501	502	509	
Injured	280	0	0	4	10	4	1	82	12	0	393
	1,4%	0,0%	0,0%	0,0%	0,1%	0,0%	0,0%	0,4%	0,1%	0,0%	2,0%
KSI	146	0	0	3	6	1	0	17	1	0	174
	3,9%	0,0%	0,0%	0,1%	0,2%	0,0%	0,0%	0,5%	0,0%	0,0%	4,7%

4.4.21 Category 21 – Loss Of Control in Curve (LOC-CU)

The *LOC-CU* scenario contains a passenger car losing control with the influence of a curve as shown in Figure 101.

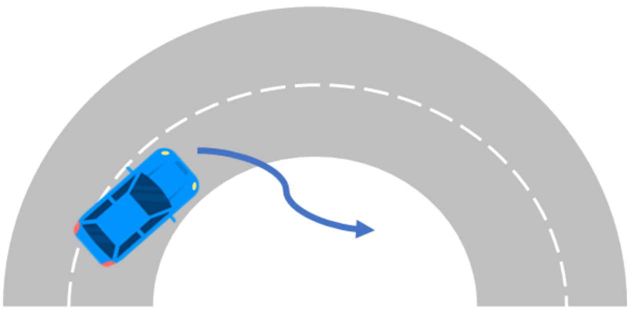


Figure 101: Pictogram – LOC-CU

Ego vehicle as participant A

In Figure 102 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

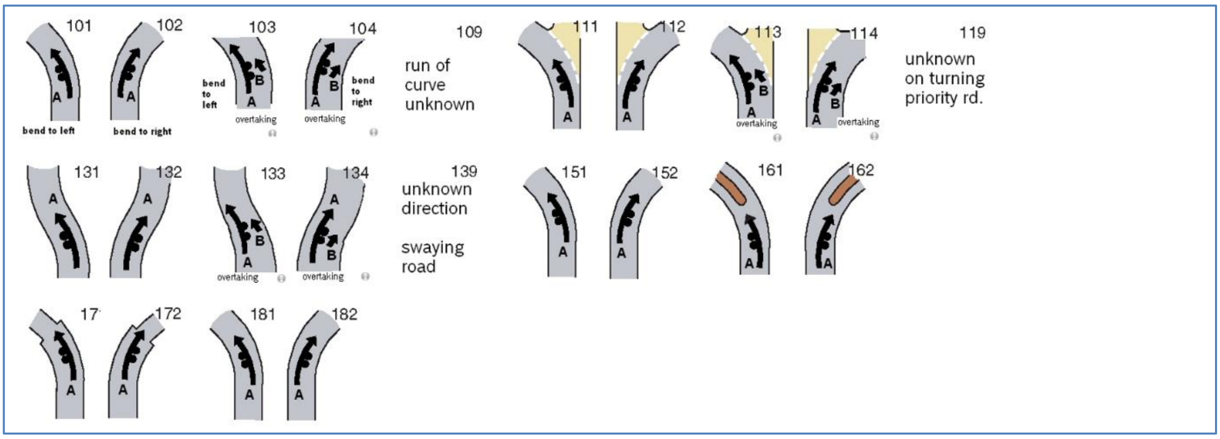


Figure 102: Accident types - participant A - LOC-CU

There is no accident type for this category, where the ego vehicle was participant B.

Results for the whole category

In Table 84 the numbers of the whole *LOC-CU* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 84: Numbers and percentages in total - LOC-CU

Category 21	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	493	-	-	-	-	493
	3,8%	0,0%	0,0%	0,0%	0,0%	2,6%
KSI	190	-	-	-	-	190
	9,1%	0,0%	0,0%	0,0%	0,0%	5,1%

Results for the single accident types

In the following tables (Table 85 and Table 86) the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 85: Numbers and percentages of accident types - LOC-CU (1)

Category 21	Accident type										
	101	102	103	104	109	111	112	113	114	119	131
Injured	217	197	0	0	0	5	2	0	0	0	5
	1,1%	1,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
KSI	91	72	0	0	0	0	0	0	0	0	1
	2,4%	1,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

Table 86: Numbers and percentages of accident types - LOC-CU (2)

Category 21	Accident type												Total
	132	133	134	139 unknown direction swaying road	151	152	161	162	171	172	181	182	
Injured	11	0	0	0	24	22	0	7	2	0	1	0	493
	0,1%	0,0%	0,0%	0,0%	0,1%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	2,6%
KSI	5	0	0	0	8	12	0	1	0	0	0	0	190
	0,1%	0,0%	0,0%	0,0%	0,2%	0,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	5,1%

4.4.22 Category 22 – Loss Of Control at Turning (LOC-TU)

The *LOC-TU* scenario contains a passenger car losing control with the influence of a turning procedure as shown in Figure 103.

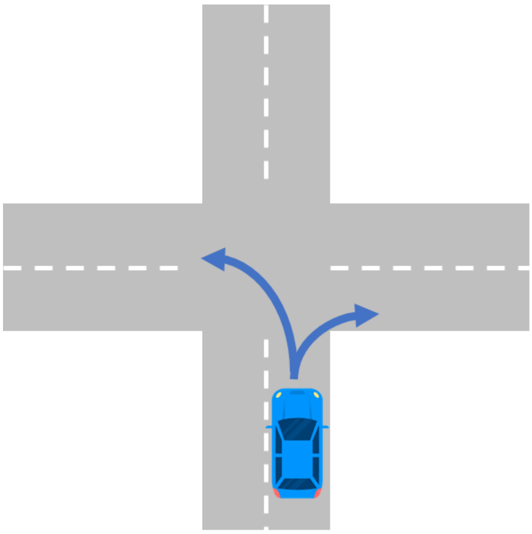


Figure 103: Pictogram – LOC-TU

__Ego vehicle as participant A__

In Figure 104 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

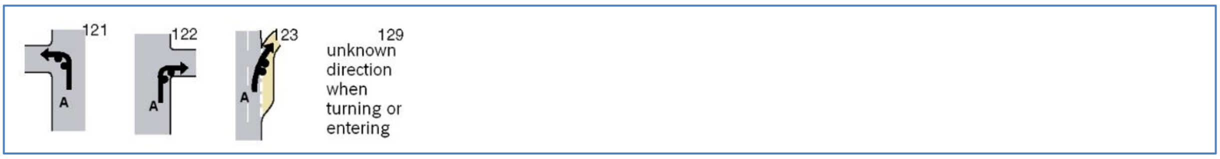


Figure 104: Accident types - participant A - LOC-TU

There is no accident type for this category, where the ego vehicle was participant B.

__Results for the whole category__

In Table 87 the numbers of the whole *LOC-TU* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

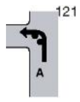
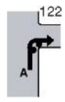
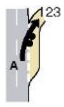
Table 87: Numbers and percentages in total - LOC-TU

Category 22		Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured		62	-	-	-	-	62
		0,5%	0,0%	0,0%	0,0%	0,0%	0,3%
KSI		19	-	-	-	-	19
		0,9%	0,0%	0,0%	0,0%	0,0%	0,5%

Results for the single accident types

In Table 88 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 88: Numbers and percentages of accident types - LOC-TU

Category 22	Accident type				Total
	121	122	123	129	
				129 unknown direction when turning or entering	
Injured	28	23	11	0	62
	0,1%	0,1%	0,1%	0,0%	0,3%
KSI	13	4	2	0	19
	0,3%	0,1%	0,1%	0,0%	0,5%

4.4.23 Category 23 – Rail Vehicle

The *Rail Vehicle* scenario contains a passenger car, which had a conflict with a rail vehicle as shown in Figure 105.

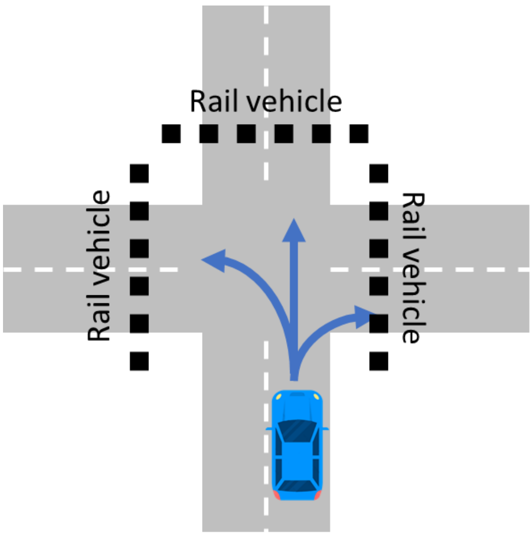


Figure 105: Pictogram – Rail Vehicle

Ego vehicle as participant A

In Figure 106 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

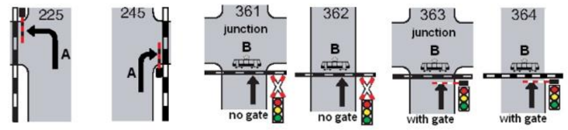


Figure 106: Accident types - participant A - Rail Vehicle

There is no accident type for this category, where the ego vehicle was participant B.

<u>Results for the whole category</u>

In Table 89 the numbers of the whole *Rail Vehicle* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

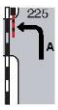
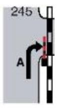
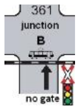
Table 89: Numbers and percentages in total - Rail Vehicle

Category 23	**Passenger Car**	**Powered Two-Wheeler**	**Bicycle**	**Pedestrian**	**Other kind of participation**	**Total**
Injured	26	-	-	-	6	32
	0,2%	0,0%	0,0%	0,0%	2,4%	0,2%
KSI	5	-	-	-	2	7
	0,2%	0,0%	0,0%	0,0%	9,5%	0,2%

<u>Results for the single accident types</u>

In Table 90 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 90: Numbers and percentages of accident types - Rail Vehicle

Category 23	**Accident type**						**Total**
	225 	245 	361 	362 	363 	364 	
Injured	0	0	0	0	0	0	0
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
KSI	0	0	0	0	0	0	0
	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

4.4.24 Category 24 – Animals / Objects

The *Animals / Objects* scenario contains a passenger car, which had a conflict with an animal or an object which is on the road as shown in Figure 107.

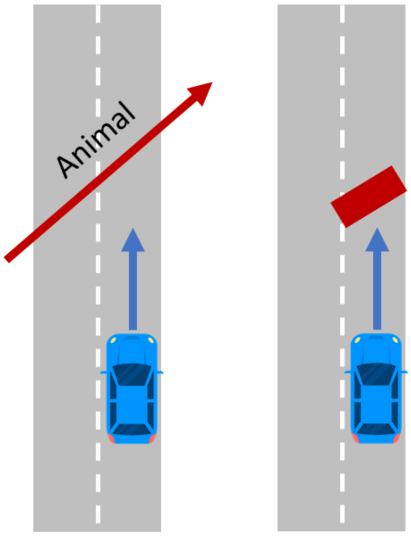


Figure 107: Pictogram – Animals / Objects

Ego vehicle as participant A

In Figure 108 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

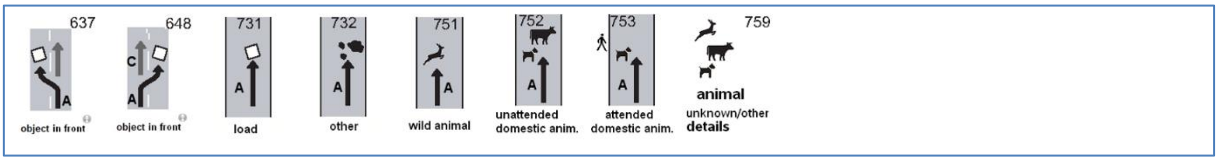


Figure 108: Accident types - participant A - Animals / Objects

There is no accident type for this category, where the ego vehicle was participant B.

Results for the whole category

In Table 91 the numbers of the whole *Animals / Objects* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 91: Numbers and percentages in total - Animals / Objects

Category 24	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	45	-	-	-	-	45
	0,3%	0,0%	0,0%	0,0%	0,0%	0,2%
KSI	17	-	-	-	-	17
	0,8%	0,0%	0,0%	0,0%	0,0%	0,5%

Results for the single accident types

In Table 92 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 92: Numbers and percentages of accident types - Animals / Objects

Category 24	Accident type								Total
	637 object in front	648 object in front	731 load	732 other	751 wild animal	752 unattended domestic anim.	753 attended domestic anim.	759 animal unknown/other details	
Injured	0	0	8	7	26	2	0	2	45
	0,0%	0,0%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%	0,2%
KSI	0	0	0	2	13	1	0	1	17
	0,0%	0,0%	0,0%	0,1%	0,3%	0,0%	0,0%	0,0%	0,5%

4.4.25 Category 25 – Brake Down

The *Brake Down* scenario contains a passenger car, which had a conflict with a braking Passenger Car in front of it as shown in Figure 109.

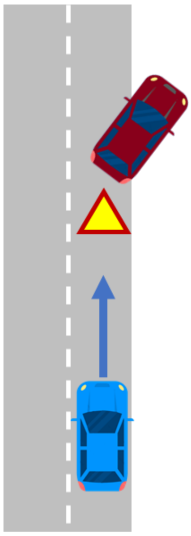


Figure 109: Pictogram – Brake Down

Ego vehicle as participant A

In Figure 110 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

Figure 110: Accident types - participant A - Brake Down

There is no accident type for this category, where the ego vehicle was participant B.

Results for the whole category

In Table 93 the numbers of the whole *Brake Down* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 93: Numbers and percentages in total - Brake Down

Category 25	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	16	-	-	-	-	16
	0,1%	0,0%	0,0%	0,0%	0,0%	0,1%
KSI	4	-	-	-	-	4
	0,2%	0,0%	0,0%	0,0%	0,0%	0,1%

Results for the single accident types

In Table 94 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 94: Numbers and percentages of accident types - Brake Down

Category 25	Accident type			Total
	741 accident	742 break down	749 break down unknown/other details	
Injured	11	5	0	16
	0,1%	0,0%	0,0%	0,1%
KSI	3	1	0	4
	0,1%	0,0%	0,0%	0,1%

4.4.26 Category 26 – Inability

The *Inability* scenario contains a passenger car with a driver falling asleep or having a medical problem as shown in Figure 111.

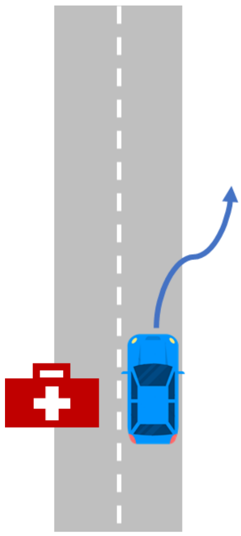


Figure 111: Pictogram – Inability

Ego vehicle as participant A

In Figure 112 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

Figure 112: Accident types - participant A - Inability

There is no accident type for this category, where the ego vehicle was participant B.

Results for the whole category

In Table 95 the numbers of the whole *Inability* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 95: Numbers and percentages in total - Inability

Category 26		Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured		233	-	-	-	-	233
		1,8%	0,0%	0,0%	0,0%	0,0%	1,2%
KSI		147	-	-	-	-	147
		7,0%	0,0%	0,0%	0,0%	0,0%	4,0%

Results for the single accident types

In Table 96 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 96: Numbers and percentages of accident types - Inability

Category 26	Accident type			Total
	761 	762 	763 	
Injured	80	56	97	233
	0,4%	0,3%	0,5%	1,2%
KSI	49	33	65	147
	1,3%	0,9%	1,7%	4,0%

4.4.27 Category 27 – Sudden Vehicle Damage

The *Sudden Vehicle Damage* scenario contains a passenger car, which had a conflict because of a technical problem at his vehicle as shown in Figure 113.

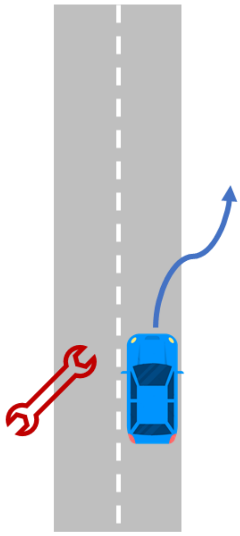


Figure 113: Pictogram – Sudden Vehicle Damage

Ego vehicle as participant A

In Figure 114 the accident types for all the situations, where the ego vehicle participated as participant A, are shown.

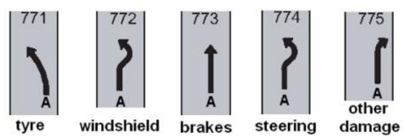


Figure 114: Accident types - participant A - Sudden Vehicle Damage

There is no accident type for this category, where the ego vehicle was participant B.

Results for the whole category

In Table 97 the numbers of the whole *Sudden Vehicle Damage* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

Table 97: Numbers and percentages in total - Sudden Vehicle Damage

Category 27	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	19	-	-	-	-	19
	0,1%	0,0%	0,0%	0,0%	0,0%	0,1%
KSI	4	-	-	-	-	4
	0,2%	0,0%	0,0%	0,0%	0,0%	0,1%

Results for the single accident types

In Table 98 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 98: Numbers and percentages of accident types - Sudden Vehicle Damage

Category 27	Accident type					Total
	771 tyre	772 windshield	773 brakes	774 steering	775 other damage	
Injured	12	1	2	3	1	19
	0,1%	0,0%	0,0%	0,0%	0,0%	0,1%
KSI	3	0	1	0	0	4
	0,1%	0,0%	0,0%	0,0%	0,0%	0,1%

4.4.28 Category 28 – Dooring

The *Dooring* scenario contains a passenger car opening his door or having a conflict with another participant opening his door as shown in Figure 115.

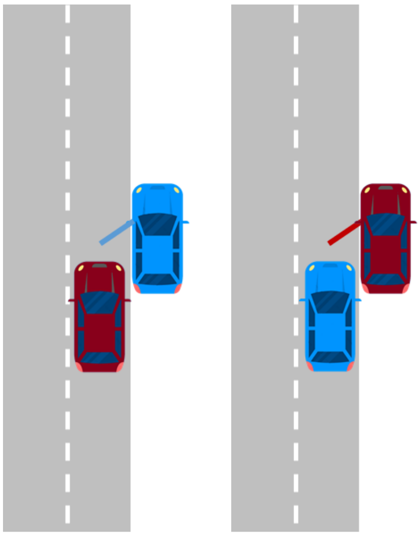


Figure 115: Pictogram – Dooring

Ego vehicle as participant A

In Figure 116 the accident types for all the situations, where the ego vehicle participated as participant A or participant B, are shown.

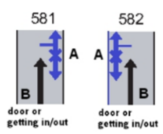


Figure 116: Accident types - participant A or B - Dooring

Results for the whole category

In Table 99 the numbers of the whole *Dooring* are shown in dependence to the kind of participation. Additionally, their percentages of the total occupant numbers in GIDAS (Table 22) are presented.

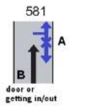
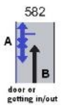
Table 99: Numbers and percentages in total - Dooring

Category 28	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation	Total
Injured	2	4	196	1	1	204
	0,0%	0,3%	5,5%	0,1%	0,4%	1,1%
KSI	-	-	32	-	-	32
	0,0%	0,0%	4,6%	0,0%	0,0%	0,9%

Results for the single accident types

In Table 100 the numbers of the single accident types are shown in combination with their percentages of the total occupant numbers in GIDAS (Table 22).

Table 100: Numbers and percentages of accident types - Dooring

Category 28	Accident type		Total
	581 	582 	
Injured	179	25	204
	0,9%	0,1%	1,1%
KSI	29	3	32
	0,8%	0,1%	0,9%

4.4.29 Excluded accident types

At assigning the accident types to the different categories, the categories in Figure 117 could have been assigned to at least two categories (e.g. because the moving direction of one participant was not known).

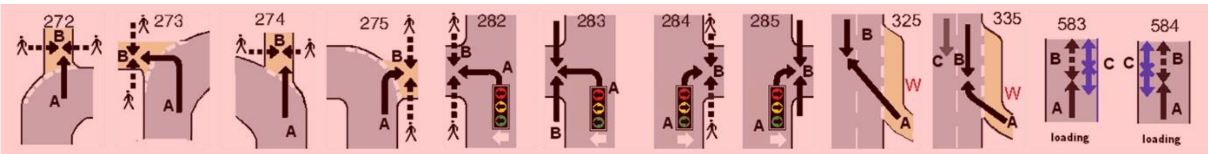


Figure 117: Excluded accident types

A short analysis showed that the number of accidents in these accident types in GIDAS is very small. Thus, the decision was made to exclude these accident types from all the categories.

4.5 Category selection

The next step was about extracting the most relevant categories. For an overview of the numbers of all categories, the numbers of injured and KSI occupants is shown in Figure 118.

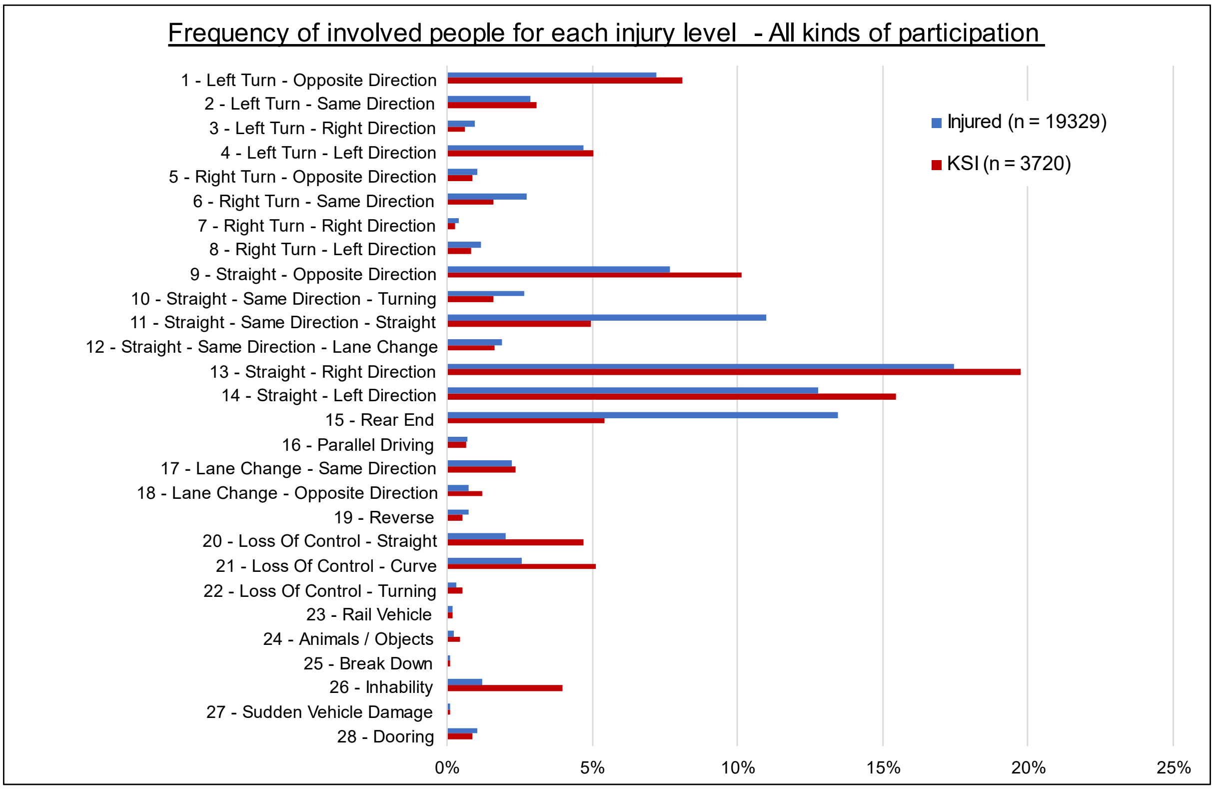


Figure 118: Overview injured and KSI occupants in all categories

The decision was made, to take the numbers of KSI occupants as a basis for this work step. In Table 101 all the categories are shown summarized and sorted by the number of KSI occupants. The ten most relevant categories are green marked in Table 101.

Table 101: Categories sorted by number of KSI

Ranking KSI	Category		Injured	KSI
1	Category 13	13 - Straight Crossing Path - Right Direction	3,373	735
2	Category 14	14 - Straight Crossing Path - Left Direction	2,468	575
3	Category 9	9 - Oncoming	1,485	377
4	Category 1	1 - Left Turn Across Path - Opposite Direction	1,395	301
5	Category 15	15 - Rear End - Previous Vehicle	2,597	201
6	Category 21	21 - Loss Of Control in Curve	493	190
7	Category 4	4 - Left Turn Across Path - Left Direction	906	188
8	Category 11	11 - Rear End - Following Vehicle	2,126	184
9	Category 20	20 - Loss Of Control in Straight Line	393	174
10	Category 26	26 - Inability	233	147
11	Category 2	2 - Left Turn Across Path - Same Direction	553	115
12	Category 17	17 - Lane Change - Same Direction	430	87
13	Category 12	12 - Straight Crossing Path - Same Direction -	363	60
14	Category 6	6 - Right Turn Across Path - Same Direction	526	59
15	Category 10	10 - Straight Crossing Path - Same Direction -	516	59
16	Category 18	18 - Lane Change - Opposite Direction	139	45
17	Category 5	5 - Right Turn Across Path - Opposite Directio	196	32
18	Category 28	28 - Dooring	204	32
19	Category 8	8 - Right Turn Across Path - Left Direction	226	31
20	Category 16	16 - Parallel Driving	138	25
21	Category 3	3 - Left Turn Across Path - Right Direction	183	23
22	Category 19	19 - Reverse	139	19
23	Category 22	22 - Loss Of Control at Turning	62	19
24	Category 24	24 - Animals / Objects	45	17
25	Category 7	7 - Right Turn Across Path - Right Direction	73	10
26	Category 23	23 - Rail Vehicle	32	7
27	Category 25	25 - Break Down	16	4
28	Category 27	27 - Sudden Vehicle Damage	19	4
Total			19,329	3,720

To complete the accidentology, the WG2 and WG3 provided the V2X and ADAS perspective to define and come to the most relevant accident categories. The following factors were considered for the scenario selection: V2X availability, V2X relevance and ADAS effectiveness with regards to each category with and the expected remaining accidents in 2025. The WG2 and WG3 inputs were provided by answering questions such as:

- How V2X could bring benefits to each scenario?
- Which ADAS are involved?
- What vehicle behaviour is expected?
- Is V2X relevant for each scenario?
- Is it realistic to consider each scenario from a V2X perspective for 2025?
- What are the V2X function behind each scenario?
- What are the V2X messages available and useful in each scenario?
- Is the scenario already covered by Euro NCAP?
- Will ADAS performances be sufficient in 2025 to handle each scenario?

The top 10 first accident categories were all defined as relevant from a V2X perspective, with the exception of the category Inability. For this category, it was agreed that V2X has no added value, neither in terms of safety, nor in proving extra information to the ego vehicle. This case may fall into another category if several participants are involved.
V2X will bring safety benefits standalone but also with ADAS fusion. Indeed, V2X is one of the keys to improve the ADAS performances and cope with their boundaries. It was defined that V2X

technologies are or will be ready for 2025 regarding those accident scenarios at least with V2X warnings and V2X as a new sensor.

The OSCCAR project [28] was also considered to validate the expected remaining accidents in 2025 considering the ADAS performances and penetration rate improvement. The previous relevant categories of the catalogue are highlighted in this project as still relevant in 2025 even with the ADAS performances improvements.

Because of the similarity of the categories 20 and 21 (LOC in Straight Line / LOC in Curve) they got combined to one category "Loss Of Control". Another special case is the category 26 (Inability). This category contains all the situations, where the driver of the ego vehicle had a physical problem like falling asleep or a dizzy spell and all other physical disabilities. Problems going along with the consumption of alcohol are **not** part of category 26. This category got removed because of V2X systems cannot help in case of inability. Thus, the following nine categories were analysed in the scope of the GIDAS in-depth analyses:

1. Category 13 – SCP-RD
2. Category 14 – SCP-LD
3. Category 9 – Oncoming
4. Category 1 – LTAP-OD
5. Category 15 – RE-PV
6. Category 20 / 21 – LOC-SL/CU
7. Category 4 – LTAP-LD
8. Category 11 – RE-FV

These nine categories represent 78.9% of all injured occupants and 78.7% of all the KSI occupants in GIDAS. The coverage of the Top 9 for the different kinds of road usage can be viewed in Table 102.

Table 102: Coverage of the Top 9

	Injured	KSI
Passenger car occupants	82.8%	78.2%
Motorcyclists	69.7%	74.3%
Cyclists	66.9%	75.1%
Pedestrians	86.4%	89.7%
Total	78.8%	78.6%

All in all, the coverage of the categories, which can be found in the in-depth analyses, is very high.

4.6 EU Safety potential

The safety potential in the scope of SECUR is the estimation of a number of occupants, which could be prevented by a system, which is able to eliminate completely the occurrence of all accidents of a category. Thus, the estimation of the safety potential is category based and will be shown for all the categories regarded in chapter 4.5.

For the estimation, the sum of the numbers of all the slightly, severely and fatally injured occupants in all the cases in each individual category as a percentage of all slightly, severely and fatally injured occupants in GIDAS got calculated in dependence to the KTP. This percentages got applicated to the numbers of slightly, severely and fatally injured occupants in the EU, based on the CARE database.

Please note, that the following calculations are an estimation only. It is not possible to say, that the estimated numbers for the EU safety potential reflect the actual numbers of slightly, severely and fatally injured occupants.

4.6.1 Category 13 – Straight Cross Path – Right Direction

In Figure 119 you can find the estimated safety potential for the category 13.

EU27 - Likely Target Group Estimation for 2020 (Accident year 2018)			Category 13 SAFETY POTENTIAL n	%
CASUALTIES	Car Occupants	slightly	43.399	6,7%
		severely	3.979	4,2%
		fatally	25	0,2%
	Goods Vehicle Occupants	slightly	395	1,0%
		severely	0	0,0%
		fatally	0	0,0%
	Motorised Two-Wheelers	slightly	2.805	1,6%
		severely	1.074	1,9%
		fatally	0	0,0%
	Cyclists	slightly	14.677	9,2%
		severely	4.215	7,7%
		fatally	216	10,6%
	Pedestrians	slightly	10.752	9,8%
		severely	3.931	9,6%
		fatally	363	7,1%
	Other	slightly	134	1,0%
		severely	0	0,0%
		fatally	0	0,0%
	TOTAL	**slightly**	**72.162**	6,9%
		severely	**13.200**	5,4%
		fatally	**604**	2,7%

Legend
< 1.0%
1.0%...4.9%
≥ 5.0%

Figure 119: EU Safety potential - Category 13

If it would be possible to develop a system, which could prevent all the category 13 related accidents, 10.6% of the fatally injured cyclists could be saved, for example. With such a system it would be possible to save 6.9% of all the slightly injured occupants.

4.6.2 Category 14 – Straight Cross Path – Left Direction

In Figure 120 you can find the estimated safety potential for the category 14.

EU27 - Likely Target Group Estimation for 2020 (Accident year 2018)			Category 14 SAFETY POTENTIAL n	%
CASUALTIES	Car Occupants	slightly	33.416	5,1%
		severely	3.036	3,2%
		fatally	50	0,5%
	Goods Vehicle Occupants	slightly	297	0,7%
		severely	39	0,5%
		fatally	0	0,0%
	Motorised Two-Wheelers	slightly	2.759	1,6%
		severely	779	1,4%
		fatally	0	0,0%
	Cyclists	slightly	9.314	5,9%
		severely	2.928	5,3%
		fatally	24	1,2%
	Pedestrians	slightly	6.307	5,8%
		severely	3.501	8,5%
		fatally	419	8,2%
	Other	slightly	401	3,1%
		severely	92	3,3%
		fatally	0	0,0%
	TOTAL	**slightly**	**52.493**	4,9%
		severely	**10.375**	4,2%
		fatally	**493**	2,1%

Legend
< 1.0%
1.0%...4.9%
≥ 5.0%

Figure 120: EU Safety potential - Category 14

If it would be possible to develop a system, which could prevent all the category 14 related accidents, 8.5% of the severely injured pedestrians could be saved, for example. With such a system it would be possible to save 4.9% of all the slightly injured occupants.

4.6.3 Category 9 – Oncoming

In Figure 121you can find the estimated safety potential for the category 9.

EU27 - Likely Target Group Estimation for 2020 (Accident year 2018)			Category 9 SAFETY POTENTIAL n	%
CASUALTIES	Car Occupants	slightly	31.603	4,9%
		severely	5.472	5,8%
		fatally	326	3,1%
	Goods Vehicle Occupants	slightly	692	1,7%
		severely	118	1,6%
		fatally	0	0,0%
	Motorised Two-Wheelers	slightly	1.150	0,7%
		severely	618	1,1%
		fatally	34	0,8%
	Cyclists	slightly	996	0,6%
		severely	247	0,5%
		fatally	0	0,0%
	Pedestrians	slightly	418	0,4%
		severely	59	0,1%
		fatally	28	0,5%
	Other	slightly	109	0,8%
		severely	0	0,0%
		fatally	0	0,0%
	TOTAL	**slightly**	**34.968**	2,9%
		severely	**6.513**	2,8%
		fatally	**388**	1,8%

Legend
< 1.0%
1.0%...4.9%
≥ 5.0%

Figure 121: EU Safety potential - Category 9

If it would be possible to develop a system, which could prevent all the category 9 related accidents, 5.9% of the severely injured passenger car occupants could be saved, for example. With such a system it would be possible to save 2.9% of all the slightly injured occupants.

4.6.4 Category 1 – Left Turn Across Path – Opposite Direction

In Figure 122 you can find the estimated safety potential for the category 1.

EU27 - Likely Target Group Estimation for 2020 (Accident year 2018)			Category 1 SAFETY POTENTIAL n	Category 1 SAFETY POTENTIAL %
CASUALTIES	Car Occupants	slightly	22.415	3,5%
		severely	2.076	2,2%
		fatally	50	0,5%
	Goods Vehicle Occupants	slightly	198	0,5%
		severely	0	0,0%
		fatally	0	0,0%
	Motorised Two-Wheelers	slightly	4.644	2,7%
		severely	2.230	3,9%
		fatally	136	3,1%
	Cyclists	slightly	3.388	2,1%
		severely	970	1,8%
		fatally	24	1,2%
	Pedestrians	slightly	2.356	2,2%
		severely	665	1,6%
		fatally	0	0,0%
	Other	slightly	158	1,2%
		severely	18	0,7%
		fatally	0	0,0%
	TOTAL	**slightly**	**33.159**	2,8%
		severely	**5.958**	2,2%
		fatally	**210**	0,8%

Legend
< 1.0%
1.0%...4.9%
≥ 5.0%

Figure 122: EU Safety potential - Category 1

If it would be possible to develop a system, which could prevent all the category 1 related accidents, 3.9% of the severely injured motorcyclists could be saved, for example. With such a system it would be possible to save 2.8% of all the slightly injured occupants.

4.6.5 Category 15 – Rear End – Previous Vehicle

In Figure 123 you can find the estimated safety potential for the category 15.

EU27 - Likely Target Group Estimation for 2020 (Accident year 2018)			Category 15 SAFETY POTENTIAL n	%
CASUALTIES	Car Occupants	slightly	70.838	10,9%
		severely	2.607	2,8%
		fatally	50	0,5%
	Goods Vehicle Occupants	slightly	99	0,2%
		severely	39	0,5%
		fatally	53	4,3%
	Motorised Two-Wheelers	slightly	6.254	3,7%
		severely	1.048	1,9%
		fatally	0	0,0%
	Cyclists	slightly	385	0,2%
		severely	106	0,2%
		fatally	0	0,0%
	Pedestrians	slightly	0	0,0%
		severely	0	0,0%
		fatally	0	0,0%
	Other	slightly	85	0,6%
		severely	0	0,0%
		fatally	0	0,0%
	TOTAL	**slightly**	**77.661**	6,2%
		severely	**3.800**	1,5%
		fatally	**103**	0,4%

< 1.0%
1.0%...4.9%
≥ 5.0%

Figure 123: EU Safety potential - Category 15

If it would be possible to develop a system, which could prevent all the category 15 related accidents, 10.9% of the slightly injured passenger car occupants could be saved, for example. With such a system it would be possible to save 6.2% of all the slightly injured occupants.

4.6.6 Category 20 / 21 – Loss Of Control – Straight Line / Curve

In Figure 124 you can find the estimated safety potential for the category 20 / 21.

EU27 - Likely Target Group Estimation for 2020 (Accident year 2018)			Category 20 / 21 SAFETY POTENTIAL	
			n	%
CASUALTIES	Car Occupants	slightly	16.597	2,6%
		severely	5.712	6,1%
		fatally	778	7,4%
	Goods Vehicle Occupants	slightly	0	0,0%
		severely	0	0,0%
		fatally	0	0,0%
	Motorised Two-Wheelers	slightly	0	0,0%
		severely	0	0,0%
		fatally	0	0,0%
	Cyclists	slightly	0	0,0%
		severely	0	0,0%
		fatally	0	0,0%
	Pedestrians	slightly	0	0,0%
		severely	0	0,0%
		fatally	0	0,0%
	Other	slightly	0	0,0%
		severely	0	0,0%
		fatally	0	0,0%
	TOTAL	**slightly**	**16.597**	1,4%
		severely	**5.712**	2,5%
		fatally	**778**	3,7%

Legend
< 1.0%
1.0%...4.9%
≥ 5.0%

Figure 124: EU Safety potential - Category 20 / 21

If it would be possible to develop a system, which could prevent all the category 20 / 21 related accidents, 7.4% of the fatally injured passenger car occupants could be saved, for example. With such a system it would be possible to save 3.7% of all the fatally injured occupants.

4.6.7 CATEGORY 4– LEFT TURN ACROSS PATH – LEFT DIRECTION

In Figure 125 you can find the estimated safety potential for the category 4.

EU27 - Likely Target Group Estimation for 2020 (Accident year 2018)			Category 4 SAFETY POTENTIAL n	%
CASUALTIES	Car Occupants	slightly	15.802	2,4%
		severely	1.458	1,6%
		fatally	25	0,2%
	Goods Vehicle Occupants	slightly	0	0,0%
		severely	0	0,0%
		fatally	0	0,0%
	Motorised Two-Wheelers	slightly	6.254	3,7%
		severely	2.149	3,8%
		fatally	68	1,6%
	Cyclists	slightly	1.156	0,7%
		severely	353	0,6%
		fatally	0	0,0%
	Pedestrians	slightly	0	0,0%
		severely	0	0,0%
		fatally	0	0,0%
	Other	slightly	158	1,2%
		severely	0	0,0%
		fatally	0	0,0%
	TOTAL	**slightly**	**23.370**	1,9%
		severely	**3.960**	1,4%
		fatally	**93**	0,4%

< 1.0%
1.0%...4.9%
≥ 5.0%

Figure 125: EU Safety potential - Category 4

If it would be possible to develop a system, which could prevent all the category 4 related accidents, 3.8% of the severely injured motorcyclists could be saved, for example. With such a system it would be possible to save 1.9% of all the slightly injured occupants.

4.6.8 Category 11– Rear End – Following Vehicle

In Figure 126 you can find the estimated safety potential for the category 11.

EU27 - Likely Target Group Estimation for 2020 (Accident year 2018)			Category 11 SAFETY POTENTIAL n	%
CASUALTIES	Car Occupants	slightly	59.996	9,2%
		severely	2.710	2,9%
		fatally	151	1,4%
	Goods Vehicle Occupants	slightly	494	1,2%
		severely	0	0,0%
		fatally	0	0,0%
	Motorised Two-Wheelers	slightly	1.747	1,0%
		severely	269	0,5%
		fatally	68	1,6%
	Cyclists	slightly	177	0,1%
		severely	106	0,2%
		fatally	24	1,2%
	Pedestrians	slightly	0	0,0%
		severely	0	0,0%
		fatally	0	0,0%
	Other	slightly	12	0,1%
		severely	18	0,7%
		fatally	0	0,0%
	TOTAL	**slightly**	**62.426**	5,1%
		severely	**3.103**	1,3%
		fatally	**242**	1,1%

< 1.0%
1.0%...4.9%
≥ 5.0%

Figure 126: EU Safety potential - Category 11

If it would be possible to develop a system, which could prevent all the category 11 related accidents, 9.2% of the slightly injured passenger car occupants could be saved, for example. With such a system it would be possible to save 5.1% of all the slightly injured occupants.

4.7 GIDAS In-depth analyses

In this chapter the methodology of the GIDAS in-depth analyses is described. Thereby, detailed information about the scenario selection and the parameters to be analysed can be found.

4.7.1 Scenario selection

Analysing all the 28 categories in combination with all 4 KTP would have meant to analyse 112 combinations of categories and KTP. These combinations of categories and KTP are called “Scenario”. With taking the nine most relevant categories like described in chapter 4.5 (which led to 36 scenarios), only 12% of the KSI cases were lost.

In some of these nine categories, not all the KTP of the injured people are relevant. Thus, the decision was made to analyse the 15 most relevant scenarios, only. At this, the relevance is again based on the number of KSI. With these 15 scenarios, 70.6% of all the KSI accidents are covered. These scenarios were already identified by WG2 and WG3 as relevant and realistic from a V2X and ADAS perspective. The 15 relevant scenarios are shown red marked in Table 103.

Table 103: Top 9 categories combined with kind of road usage – List of scenarios

				Total	Passenger Car	Powered Two-Wheeler	Bicycle	Pedestrian	Other kind of participation
Ranking KSI	Category			KSI	KSI	KSI	KSI	KSI	KSI
1	Category 13	SCP-RD	Straight Crossing Path - Right Direction	735	233	40	248	214	0
2	Category 14	SCP-LD	Straight Crossing Path - Left Direction	575	179	29	167	194	6
3	Category 9	Oncoming	Oncoming	377	332	24	14	4	3
4	Category 1	LTAP-OD	Left Turn Across Path - Opposite Direction	301	123	87	56	34	1
5	Category 15	RE-PV	Rear End - Previous Vehicle	201	154	39	6	0	2
6	Category 21	LOC-CU	Loss Of Control in Curve	190	190	0	0	0	0
7	Category 4	LTAP-LD	Left Turn Across Path - Left Direction	188	86	82	20	0	0
8	Category 11	RE-FV	Rear End - Following Vehicle	184	164	12	7	0	1
9	Category 20	LOC-SL	Loss Of Control in Straight Line	174	174	0	0	0	0

The following 15 scenarios were analysed in the scope of the GIDAS in-depth analyses. Thereby, the categories “LOC-SL” (ranking number 8) and “LOC-CU” (ranking number 6) were analysed combined (ranking number 6).

At this, the following abbreviations were used:

- BC for bicycle
- PC for passenger car
- PD for pedestrian
- PTW for powered two-wheeler

GIDAS in-depth analyses:

Scenario 1	Oncoming-PC	Oncoming – Passenger Car
Scenario 2	SCP-RD-BC	Straight Cross Path – Right Direction – Bicycle
Scenario 3	SCP-RD-PC	Straight Cross Path – Right Direction – Passenger Car
Scenario 4	SCP-RD-PD	Straight Cross Path – Right Direction – Pedestrian
Scenario 5	SCP-LD-PD	Straight Cross Path – Left Direction – Pedestrian
Scenario 6	LOC-Single	Loss Of Control – Single Vehicle
Scenario 7	SCP-LD-PC	Straight Cross Path – Left Direction – Passenger Car
Scenario 8	Combined as „Loss Of Control“ (Scenario number 6)	
Scenario 9	SCP-LD-BC	Straight Cross Path – Left Direction – Bicycle
Scenario 10	RE-FV-PC	Rear End – Following Vehicle – Passenger Car
Scenario 11	RE-PV-PC	Rear End – Previous Vehicle – Passenger Car
Scenario 12	LTAP-OD-PC	Left Turn Across Path – Other Direction – Passenger Car
Scenario 13	LTAP-OD-PTW	Left Turn Across Path – Other Direction – Powered Two-wheeler
Scenario 14	LTAP-LD-PC	Left Turn Across Path – Left Direction – Passenger Car
Scenario 15	LTAP-LD-PTW	Left Turn Across Path – Left Direction – Powered Two-wheeler

4.7.2 Analysed Parameters

For the analyses of the scenarios, 16 relevant parameters were chosen by an expert group in the scope of SECUR.

- weather condition
- road surface
- light condition
- illumination of the road
- percentage of view obstruction
- kind of view obstruction
- topology of road / intersection
- radius of curve
- kind of traffic regulation
- traffic density
- accident cause
- human failure
- initial speed ego
- initial speed opponent
- deceleration ego
- deceleration opponent

Not all parameters had to be analysed for each scenario. In Table 104 the parameter set can be found for each scenario.

Table 104: Parameter set for each scenario

SECUR Scenario n°	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
SECUR Category name	Oncoming	SCP-RD	SCP-RD	SCP-RD	SCP-LD	LOC-CU	SCP-LD	LOC-SL	SCP-LD	RE-FV	RE_PV	LTAP-OD	LTAP-OD	LTAP-LD	LTAP-LD
SECUR Category n°	9	13	13	13	14	21	14	20	14	11	15	1	1	4	4
Opponent / Parameter	PC	BC	PC	PD	PD	Single	PC	Single	BC	PC	PC	PC	PTW	PC	PTW
Weather condition	x	x	x	x	x	o	x	o	x	x	x	x	x	x	x
Road surface (dry, wet, icy, …)						o		o							
Light condition (day / night)	x	x	x	x	x		x		x	x	x	x	x	x	x
Illumination of the road		x	x	x	x		x		x			x	x	x	x
Percentage of view obstruction	x	x	x	x	x		x		x	x	x	x	x	x	x
Kind of view obstruction	x	x	x	x	x		x		x	x	x	x	x	x	x
Topology of road / intersection	x	x	x	x	x		x		x	x	x	x	x	x	x
Radius of curve (mean)						o									
Kind of traffic regulation		x	x	x	x		x		x			x	x	x	x
Traffic density	x	x	x	x	x	o	x	o	x	x	x	x	x	x	x
Accident cause	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Human failure	x					x		x							
Initial speed Ego	x	x	x	x	x	o	x	o	x	x	x	x	x	x	x
Initial speed Opponent	x	x	x				x		x	x	x	x	x	x	x
Deceleration Ego										x	x				
Deceleration Opponent										x	x				

Weather conditions

The first parameter, which was analysed for all scenarios, is the weather condition. It describes, if there was any precipitation during the accident and if so, the type of precipitation, for example rainfall, hail, or snow.

Road surface

The parameter for the road surface was only analysed for the loss of control scenarios. With the help of this parameter the state of the road surface at the time of the accident is characterised. Conditions like dry, damp, wet or hoarfrost are possible. The grip of the road can be estimated from this parameter.

Light condition

The light condition was examined for most of the scenarios. It describes if the accident happened during daylight, darkness, or dawn/twilight.

Illumination of the road

For the accidents that happened during the darkness or dawn/twilight, the parameter illumination of the road was also analysed. This parameter contains information whether the scene of the accident was covered by street lighting and if so, whether it was switched on or off.

Percentage of view obstruction

To quantify the number of accidents, where a view obstruction was present, the parameter percentage of view obstruction was used.

Kind of view obstruction

For the accidents where a view obstruction was present, the type of the view obstruction is described in detail. This can be other cars, structural circumstances or problems on the own vehicle like an icy windscreen. For a lot of cases the kind of view obstruction is unknown due to the fact, that this variable is only implemented in GIDAS since 2009. Additionally, the actual viewing conditions prior to the accident often cannot be traced exactly, because of the time difference between the accident and the arrival of the survey team.

Topology of the road / intersection

The topology of road / intersection describes the road or intersection, where the accident happened. This parameter shows the available driving lanes. Because of a better clarity, in the results the Top 5 of the kinds of topology are shown, only.

Radius of curve

For the loss of control scenarios, the parameter radius of curve was used to describe the mean radius of the curve. For this parameter there is a high percentage of “unknown“, because it is often not possible to realize a curve measurement (e.g. too high traffic density or too dangerous accident site). The radius is measured at the inner side of the curve.

Kind of traffic regulation

For accidents on intersections, the parameter kind of traffic regulation was used to give an information about the traffic control. This can be for example traffic lights or right has right-of-way. This variable has a high percentage of “unknown“ since it has been implemented in GIDAS only since 2005. For each type of traffic regulation, it was additionally analysed if the ego participant was the main causer of the accident.

Traffic density

The traffic density was studied for all scenarios. This can be light traffic, dense traffic or a traffic jam.

Accident cause

The parameter accident cause was also analysed for all scenarios. This parameter describes the main cause of the accident. The possible causations are clustered in groups like ability to drive, speed, or right of way priority, but are also described more detailed. Because of a better clarity, in the results the Top 5 of the accident causes are shown, only.

Human failure

For some scenarios, the human failure parameter was studied. This parameter describes if a human failure of the ego-participant influenced the accident. Thereby, a human failure is something like problems at seeing or hearing, distraction or wrong estimation of situations. It is collected during the interview and describes only the point of view of the participant. This parameter also has a high percentage of “unknown“, because the information has been implemented in the GIDAS scheme in the year 2008.

Initial speed

The initial speed is the speed driven prior to the first critical situation in the accident. It was analysed for the ego vehicle and the opponent vehicle, if the opponent was a bicycle, a powered two-wheeler or a passenger car. For accidents with pedestrians, only the speed of the ego vehicle was analysed.

Deceleration

For scenarios, where the colliding participants drove in the same direction, the deceleration of the ego and the opponent vehicle were studied. The unit of this parameter is m/s^2. It describes the mean deceleration prior to the crash and has a positive sign if the participant decelerates.

5. IGLAD accident data analyses

5.1 Introduction

Additionally, to the study in GIDAS a study in IGLAD was conducted with the aim to classify, if the in-depth analyses with GIDAS are representative for the accident numbers in the EU.

5.2 Database

IGLAD is an in-depth accident database which contains accident data from different countries. The countries and their data providers are shown in Figure 127. In contrast to the GIDAS database, the data in IGLAD are not representative for the occurrence of accidents in the countries where the data originates from. That is caused by some data providers who only record and provide fatal accidents. Therefore, the results of the analysis are only given as an additional information.

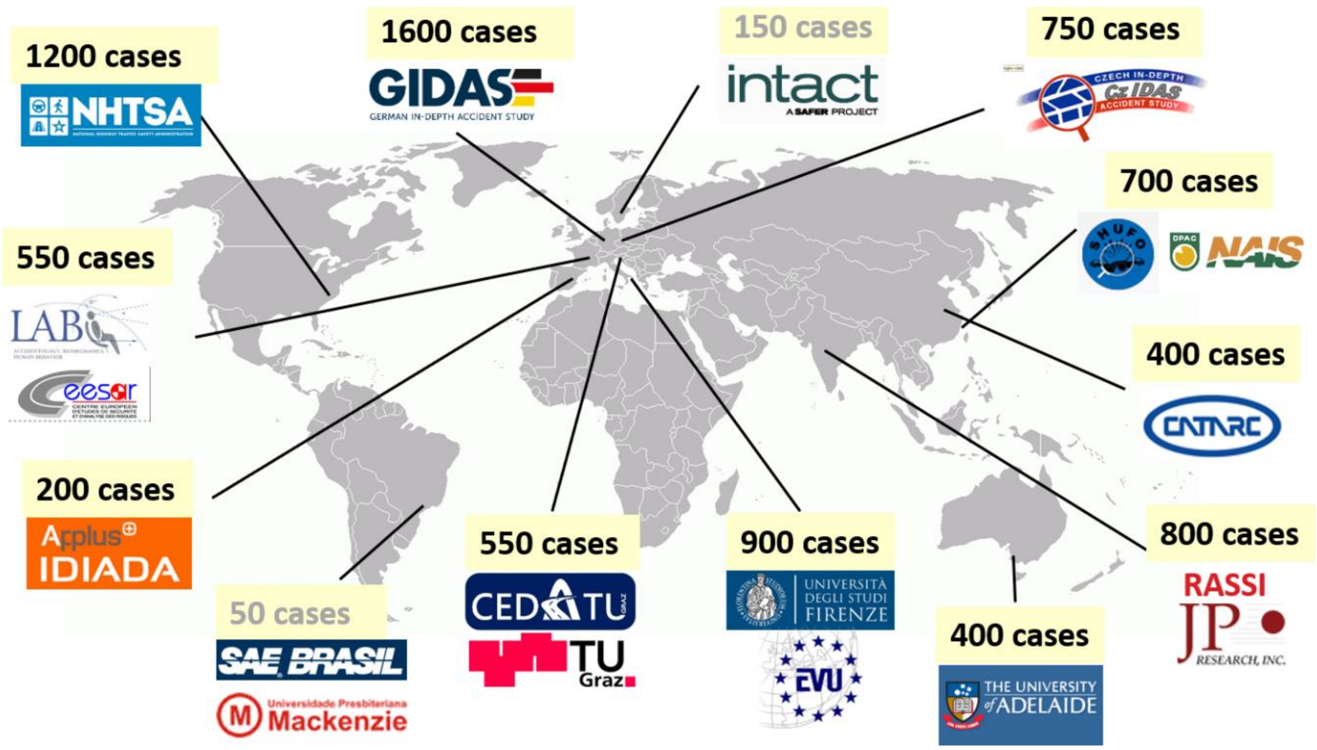


Figure 127: Data providers and the number of provided cases for IGLAD [29]

5.3 Comparison of Categories

The frequency of occurrence of people with KSI in the categories in IGLAD was analysed. Therefore, accidents from all European countries were studied except for Germany since the data are already included in the GIDAS database. In Figure 128 the frequency of involved KSI occupants for each scenario is shown.

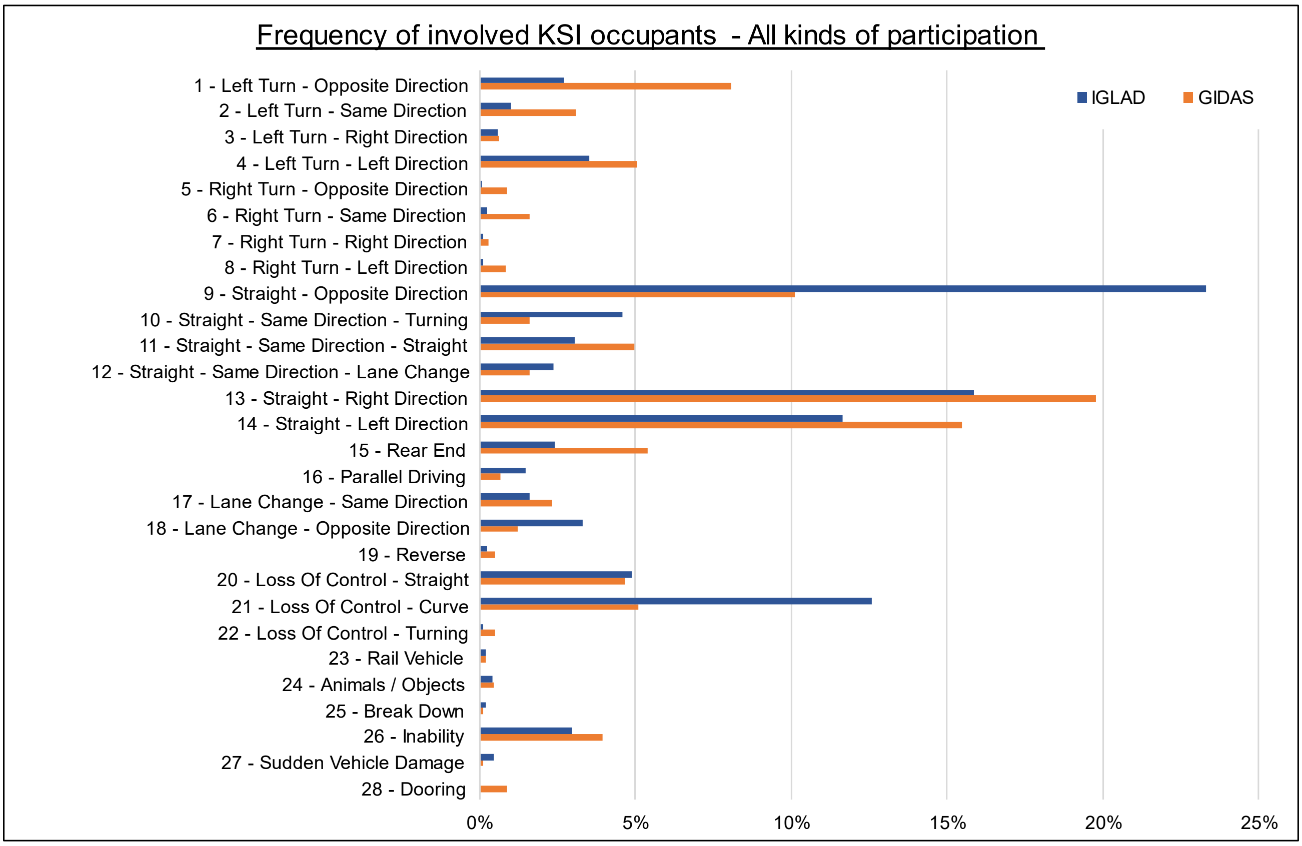


Figure 128 Frequency of involved KSI occupants [30] [31]

While comparing the data of GIDAS and IGLAD, it sticks out, that in the IGLAD database the frequency of KSI occupants in category 9 and category 21 is much higher than in GIDAS. The reason for that could be, that in IGLAD the filter of existing ESC at the ego vehicle was not used due to very bad coding quality of this criterium in IGLAD. In category 1, category 13 and category 14, KSI occupants appear more frequently in GIDAS than in IGLAD.

The ranking of the categories sorted by the number of KSI occupants is shown in Figure 129 for GIDAS data and in Figure 130 for IGLAD data.

Ranking KSI		Category	GIDAS	IGLAD
1	Category 13	13 - Straight - Right Direction	19.8%	15.8%
2	Category 14	14 - Straight - Left Direction	15.5%	11.7%
3	Category 9	9 - Straight - Opposite Direction	10.1%	23.3%
4	Category 1	1 - Left Turn - Opposite Direction	8.1%	2.7%
5	Category 15	15 - Rear End	5.4%	2.4%
6	Category 21	21 - Loss Of Control - Curve	5.1%	12.6%
7	Category 4	4 - Left Turn - Left Direction	5.1%	3.5%
8	Category 11	11 - Straight - Same Direction - Straight	4.9%	3.1%
9	Category 20	20 - Loss Of Control - Straight	4.7%	4.9%
10	Category 26	26 - Inability	4.0%	2.9%
11	Category 2	2 - Left Turn - Same Direction	3.1%	1.0%
12	Category 17	17 - Lane Change - Same Direction	2.3%	1.6%
13	Category 12	12 - Straight - Same Direction - Lane Change	1.6%	2.4%
14	Category 10	10 - Straight - Same Direction - Turning	1.6%	4.6%
15	Category 6	6 - Right Turn - Same Direction	1.6%	0.2%
16	Category 18	18 - Lane Change - Opposite Direction	1.2%	3.3%
17	Category 5	5 - Right Turn - Opposite Direction	0.9%	0.1%
18	Category 28	28 - Dooring	0.9%	0.0%
19	Category 8	8 - Right Turn - Left Direction	0.8%	0.1%
20	Category 16	16 - Parallel Driving	0.7%	1.5%
21	Category 3	3 - Left Turn - Right Direction	0.6%	0.6%
22	Category 19	19 - Reverse	0.5%	0.2%
23	Category 22	22 - Loss Of Control - Turning	0.5%	0.1%
24	Category 24	24 - Animals / Objects	0.5%	0.4%
25	Category 7	7 - Right Turn - Right Direction	0.3%	0.1%
26	Category 23	23 - Rail Vehicle	0.2%	0.2%
27	Category 27	27 - Sudden Vehicle Damage	0.1%	0.5%
28	Category 25	25 - Break Down	0.1%	0.2%

Figure 129: Top 10 categories in GIDAS [30] [31]

Ranking KSI		Category	GIDAS	IGLAD
1	Category 9	9 - Straight - Opposite Direction	10.1%	23.3%
2	Category 13	13 - Straight - Right Direction	19.8%	15.8%
3	Category 21	21 - Loss Of Control - Curve	5.1%	12.6%
4	Category 14	14 - Straight - Left Direction	15.5%	11.7%
5	Category 20	20 - Loss Of Control - Straight	4.7%	4.9%
6	Category 10	10 - Straight - Same Direction - Turning	1.6%	4.6%
7	Category 4	4 - Left Turn - Left Direction	5.1%	3.5%
8	Category 18	18 - Lane Change - Opposite Direction	1.2%	3.3%
9	Category 11	11 - Straight - Same Direction - Straight	4.9%	3.1%
10	Category 26	26 - Inability	4.0%	2.9%
11	Category 1	1 - Left Turn - Opposite Direction	8.1%	2.7%
12	Category 15	15 - Rear End	5.4%	2.4%
13	Category 12	12 - Straight - Same Direction - Lane Change	1.6%	2.4%
14	Category 17	17 - Lane Change - Same Direction	2.3%	1.6%
15	Category 16	16 - Parallel Driving	0.7%	1.5%
16	Category 2	2 - Left Turn - Same Direction	3.1%	1.0%
17	Category 3	3 - Left Turn - Right Direction	0.6%	0.6%
18	Category 27	27 - Sudden Vehicle Damage	0.1%	0.5%
19	Category 24	24 - Animals / Objects	0.5%	0.4%
20	Category 6	6 - Right Turn - Same Direction	1.6%	0.2%
21	Category 19	19 - Reverse	0.5%	0.2%
22	Category 23	23 - Rail Vehicle	0.2%	0.2%
23	Category 25	25 - Break Down	0.1%	0.2%
24	Category 8	8 - Right Turn - Left Direction	0.8%	0.1%
25	Category 22	22 - Loss Of Control - Turning	0.5%	0.1%
26	Category 7	7 - Right Turn - Right Direction	0.3%	0.1%
27	Category 5	5 - Right Turn - Opposite Direction	0.9%	0.1%
28	Category 28	28 - Dooring	0.9%	0.0%

Figure 130 Top 10 categories in IGLAD [30] [31]

5.4 CONCLUSION

Differences in the top 10 selected categories are that category 1 and category 15 are in the top 10 in GIDAS but not in the top 10 in IGLAD. But they are in ranked 11th and 12th closely to the top 10. Category 10 and category 18 are in the top 10 in IGLAD but not in the top 10 in GIDAS. They are ranked 14th and 16th. The analysis of the IGLAD data affirms the selected categories which were selected on the basis of the GIDAS data.

CONCLUSION

The literature review performed during the project provided on the one hand knowledge of the main safety V2X use cases already considered by EU V2X projects and on the other hand of the main accidents considered into past ADAS projects with their importance within the accidentology. This literature review was completed by the high-level analysis based on national databases.

To cover the large scope of SECUR (all EU accidents and 4 types of opponents) a EU generic scenario catalogue was created based on the GDV accident situations clustering and data from GIDAS. This accidentology work results in 28 accident categories for 4 types of opponents and, thus, 112 accident scenarios (combination of categories and types of opponents). The most relevant scenarios were selected from this accidentology work and considering the V2X perspective (relevance, capability and market readiness) and ADAS perspective (limitations, effectiveness and remaining accidents in 2025). According to SECUR scope and confirmed by the distribution of accidents in the SECUR EU Generic Scenario Catalogue, the road users targeted are the following ones: Passenger Car, PTW, Bicyclist and Pedestrian.

The following accident scenarios were selected and investigated in the In-depth EU accident data study based on GIDAS:

N°#	Name	Road user / Opponent
1	**Oncoming**	Passenger car
2	Straight Crossing Path – Right Direction (**SCP-RD**)	Cyclist
3	Straight Crossing Path – Right Direction (**SCP-RD**)	Passenger car
4	Straight Crossing Path – Right Direction (**SCP-RD**)	Pedestrian
5	Straight Crossing Path – Left Direction (**SCP-LD**)	Pedestrian
6	Loss Of Control in CUrve (**LOC-CU**)	Single (Ego = car)
7	Straight Crossing Path – Left Direction (**SCP-LD**)	Passenger car
8	Loss Of Control in Straight Line (**LOC-SL**)	Single (Ego = car)
9	Straight Crossing Path – Left Direction (**SCP-LD**)	Cyclist
10	Rear End - Following Vehicle (**RE-FV**)	Passenger car
11	Rear End - Previous Vehicle (**RE-PV**)	Passenger car
12	Left Turn Across Path – Opposite Direction (**LTAP/OD**)	Passenger car
13	Left Turn Across Path – Opposite Direction (**LTAP/OD**)	PTW
14	Left Turn Across Path – Left Direction (**LTAP/LD**)	Passenger car
15	Left Turn Across Path – Left Direction (**LTAP/LD**)	PTW

For the analysis of each scenario, a set of 16 relevant parameters were chosen by an expert group and are listed hereinafter: weather condition, road surface, light condition, illumination of the road, percentage of view obstruction, kind of view obstruction, topology of road/intersection, radius of curve, kind of traffic regulation, traffic density, accident cause, human failure, initial speed ego, initial speed opponent, deceleration ego and deceleration opponent. Among this set, only specific parameters were analysed for each scenario, depending on the scenario type and the data needed for a use case definition

To provide information about the EU representativeness of the study, the EU safety potential of each scenario was studied, and a comparison of the results was done on IGLAD database (only for KSI and for information purpose only).

Among the whole SECUR EU Generic Scenario Catalogue, the accident scenarios selected as a basis for the development of the use cases of the project cover 70,6% of all accidents in the EU.

For each accident scenario considered into the In-depth EU accident data study, the results by parameters are available in the deliverable D1.2.

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Partners

Contributors

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