WEATHERSAFE

SAFETY ENHANCEMENT UNDER ADVERSE WEATHER CONDITIONS THROUGH IMPROVED ADAS/AD ROBUSTNESS

Deliverable 1.1/1.2

Accidentology Data Study

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EXECUTIVE SUMMARY

The "WeatherSafe" project aims to analyse the impact of adverse weather conditions (AWC) on traffic accidents in Germany and Europe, focusing on the effectiveness of Advanced Driver Assistance Systems (ADAS) and Automated Driving (AD) systems. The document encompasses a literature review, statistical and technical research, and detailed evaluations using the German in-depth accident study (GIDAS) and the Initiative for the Global Harmonisation of (in-depth) Accident Data (IGLAD). It investigates various weather conditions, accident causation, and scenarios with the intent to understand how adverse weather affects driving safety and the performance of vehicle assistance systems. Goals include understanding the definition and research around adverse weather, summarizing recent accident data, and reviewing current ADAS/AD technologies.

The introduction highlights the project's objective to analyse driving during various weather conditions. It seeks to understand the current impact of adverse weather on accidents in Germany and Europe and to assess the influence on both drivers and vehicle assistance systems.
The literature research chapter is divided into statistical and technical research. The statistical research includes data of traffic accidents in Germany and Europe, focusing on how different weather conditions impact accidents. The technical research involves the examination of ADAS/AD systems' current state and their performance under AWC. All in all, there is only limited detailed data on weather-related accidents in Europe, with Germany providing the most comprehensive information.

The GIDAS database evaluation includes the analysis of how different weather conditions like rain, snow, and wet roads affect accidents. A clear definition of AWC out of the accidentology view is established. AWC contribute to a significant proportion of accidents, highlighting the importance of considering road surface conditions and sun glare. The comparison of accidents with and without AWC gives insights into how accident locations, times, injury severity, participants and the presence of Automated Emergency Braking (AEB) systems vary with different weather conditions. This is followed by a detailed analysis of the most common accident scenarios under AWC. The most appearing AWC scenarios include mainly loss of control accidents without a direct opponent and intersection scenarios. The closer analysis of the top five AWC scenarios contains the collision speed, including acceleration and deceleration and the road surface material as well.

The IGLAD database provides an international perspective on traffic accidents, presenting data from different countries. The evaluation of the European countries in IGLAD supports the findings from the GIDAS data, showing consistent trends in AWC-related accidents across various regions.
The second last chapter maps EuroNCAP test scenarios to real-world accidents in GIDAS. It identifies gaps between existing test scenarios and actual accident types, particularly under adverse weather conditions.
The conclusion summarizes all analysed data and gives five scenario recommendations out of the accidentology view for further analysis in the project. Those recommendations should be treated with caution, as they don’t state final scenarios for the whole project. Those are only suggestions, which are made from the analysis of the statistical data.

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REVISION HISTORY

Revision	Date	Description, updates and changes	Status
1.1	10.12.2024	Implementing the methodology of mapping the current EuroNCAP scenarios in GIDAS. This methodology was developed together with Toyota and is published in December.	
1.2	13.01.2025	Addition of Co-authors on the first page.	
1.3	13.05.2026	Evaluation of the top 10 KSI scenarios. Addition of sub-chapter 4.7.3.	
			Approved

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ABBREVIATIONS

AWC	Adverse Weather Conditions
ADAS	Advanced Driver Assistance System
AD	Automated Driving
AEB	Automated Emergency Braking
DESTATIS	Statistisches Bundesamt *English: Federal Statistical Office of Germany*
ERSO	European Road Safety Observatory
ESC	Electronic Stability Control
EuroNCAP	European New Car Assessment Programme
GIDAS	German In-Depth Accident Study
GSD	Global Safety Database
IGLAD	Initiative for the Global Harmonisation of (in-depth) Accident Data
KSI	Killed and severely injured
MC	Motorcyclist
ONISR BAAC	L'Observatoire national interministériel de la sécurité routière *English: French Road Safety Observatory* Bulletin d'Analyse des Accidents de la Circulation *English: Traffic Accident Analysis Bulletin*
TME	Toyota Motor Europe
VUFO	Traffic Accident Research Unit (dt.: Verkehrsunfallforschung an der TU Dresden GmbH)

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1. Introduction

The weather conditions have a direct impact on how the sight of a vehicle driver is characterized. Weather like rain or storm could affect the driving. There are a lot of assistance systems included in modern vehicles which can help evaluate different traffic situations. But are those sensors and their connected system also affected by the weather? If they are, in which way are they affected and what consequences could result? The safe driving during any weather condition is a complex topic and leaves a lot of open questions, which should be discussed.

1.1 The WEATHERSAFE Project

The stated project is about to analyse the different parameters according driving during different AWC. The aim is to get an overview of the current impact of AWC on the current accident situation in Germany and Europe and further to analyse this data according to the influence of the driver, but also the vehicle and its' assistance systems. This project contains three big task groups, which contain different topics to examine. This paper summarizes the first step of the first task group. It contains the basic research of useful literature, listing the sources and giving a short abstract about it.

1.2 Objectives and scope of the research

The analysed literature should examine how "bad" or "adverse" weather is defined and what research is already existing. Furthermore, it is about to give a summary of the latest accident data under the aspect of different weather conditions, and it should also represent the current state of the art concerning ADAS and AD

The following bullet points unite the main goals of the literature review:

- Overview of the current accident situation (Germany, Europe)
  - Number of accidents with personal injury, by severity of injury, related to weather
  - Distribution of location, lighting, and road conditions, related to weather
  - Share of accident constellations (involved road users), related to weather
  - Overview of types of accidents, related to weather
- Technical research
  - Sensor and actor definitions
  - Simulative definition of bad weather
  - Reconstruction of accidents concerning different weather conditions
  - Simulation of weather conditions for crash tests
  - Other existing research

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2. Literature research

The following tables list the researched sources according to the different categories of chapter 1.2.

2.1 STATISTICAL RESEARCH

The literature research is split into two parts, which define the different research scopes. The first part of the list includes the statistical sources which give information about traffic accidents and weather conditions. The second list summarizes all sources which give technical information about the current state of the advanced driving assistance systems and their specifications.

The Table 1 presents sources which contain data concerning the current state of traffic accidents in relation to AWC in Europe. The listed sources analysed in the literature review in chapter 3.

Table 1 - Current traffic accident situation

#	Project / Source	Type	Year	Geographical range
[1]	European Road Safety Observatory *(abbr.: "ERSO")*	Report	Since 1990	Europe
[2]	Global Safety Database *(abbr.: GSD)*	Database	Since 2022	Worldwide
[3]	IGLAD	Database	Since 2010	Worldwide
[4]	French Road Safety Observatory *(abbr.: ONISR)*	Report	Since 1975	France
[5]	Federal Statistical Office of Germany *(abbr.: "DESTATIS", dt.: Statistisches Bundesamt)*	Report	Since 1947	Germany
[6]	GIDAS	Database	Since 1999	Germany
[7]	Swedish Traffic Accident Data Acquisition *(abbr.: "STRADA")*	Report	2018 - 2023	Sweden

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2.2 TECHNICAL RESEARCH

The following Table 2 lists the technical sources collected by the Traffic Accident Research Unit (dt.: Verkehrsunfallforschung an der TU Dresden GmbH, abbr.: VUFO). Those sources are not relevant for WP1 but can be used in further analyses of WP2 and the following accident simulation.

Table 2 - list of sources for the influence of adverse weather on ADAS/AD

#	Source	Type	Year	Geographical range
8	"AI-SEE"	Project	2021	Europe
9	Fraunhofer IEM Paderborn Project: "RoSSHAF"	Project	Since 2021	Germany
10	Technische Hochschule Ingolstadt Project: "CARISSMA-ISAFE"	Project	Since 2016	Germany
11	"ROADVIEW"	Project	Since 2019	Europe
12	"SAFE-UP"	Project	Since 2020	Europe
13	European New Car Assessment Programme *(abbr.: EuroNCAP)*	Project	Since1 996	Europe
14	Research Package VeSPA, Sub-project 4: Influences of Weather on Traffic Accidents *(Federal Roads Office of Switzerland)*	Report	2014	Switzerland
15	"The real impact of full hydroplaning on driving safety" *- Florian Spitzhüttl, Fabrice Goizet, Thomas Unger, Frederic Biesse*	Paper	2020	Germany
16	"A Survey on Intelligent Vehicle Safety Systems for Adverse Weather Conditions" *- Michael Ditze, Frank Golatowski, Nico Laum, András Várhelyi, Sven Gustafsson, Konstantina Geramani*	Paper	2009	Europe
17	"Explaining the road accident risk: Weather effects" *- Ruth Bergel-Hayat, Mohammed Debbarh, Constantinos Antoniou, George Yannis*	Paper	2013	Europe
18	"Is there a broken trend in traffic safety in Germany? Model based approach describing the relation between traffic fatalities in Germany and environmental conditions" *- Thomas Lich, Jörg Mönnich, Nora Reiter, Alexander Skiera, Thomas Schlender, Andreas Georgi*	Paper	2013	Germany
19	"Studying the effect of weather conditions on daily crash counts using a discrete time-series model" *- Tom Brijs, Dimitris Karlis, Geert Wets*	Paper	2008	Europe

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3. Literature review

The following chapters contain the analysed sources and their detailed information.

3.1 ERSO (CARE)

The annual report of the ERSO publishes the European CARE data. It can be found some data about accidents and adverse weather in the most recent report of 2022.
A deliverable named “Facts and Figures” by ERSO is giving additional information about the road surface in fatal crashes. This data is displayed in Figure 1.

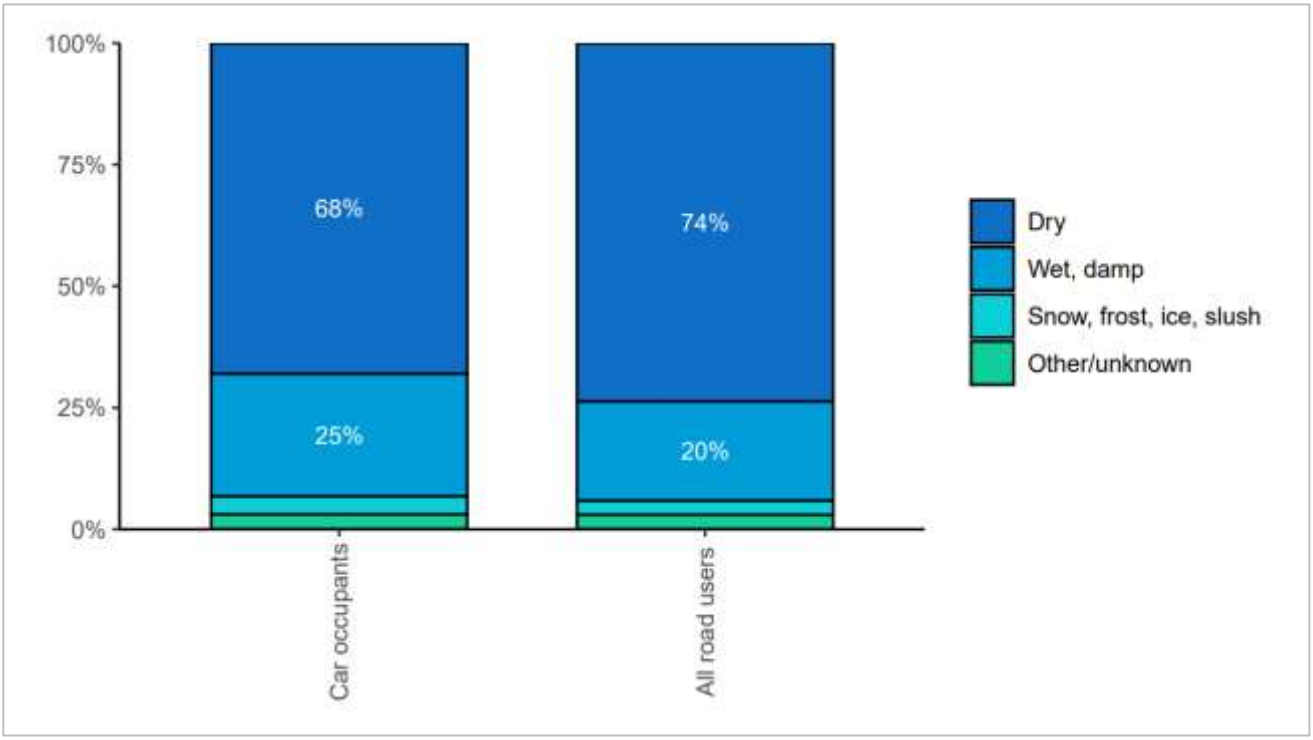

Figure 1 - Distribution of car occupant fatalities and all fatalities by surface conditions in the EU [1]

The variables in the annual report are only showing the weather conditions during the crash and not the exact causation. Table 3 displays the general information according to adverse weather given by the ERSO.

Table 3 - Variables in CARE addressing adverse weather [1]

Main category	Weather variables	Light variables	Surface variables
27 Countries of the European Union, Norway, Switzerland, Iceland	Dry/clear, rain, sleet, hail, fog, mist, smoke, snow, winds, other, unknown	Twilight, lights lit, lights unlit, no lights, none/unlit, unknown	Dry, wet/ damp, snow/ frost/ ice/ slush, other/ unknown

The following chart gives a short summary along some countries and the weather variables of the accidents in Europe.

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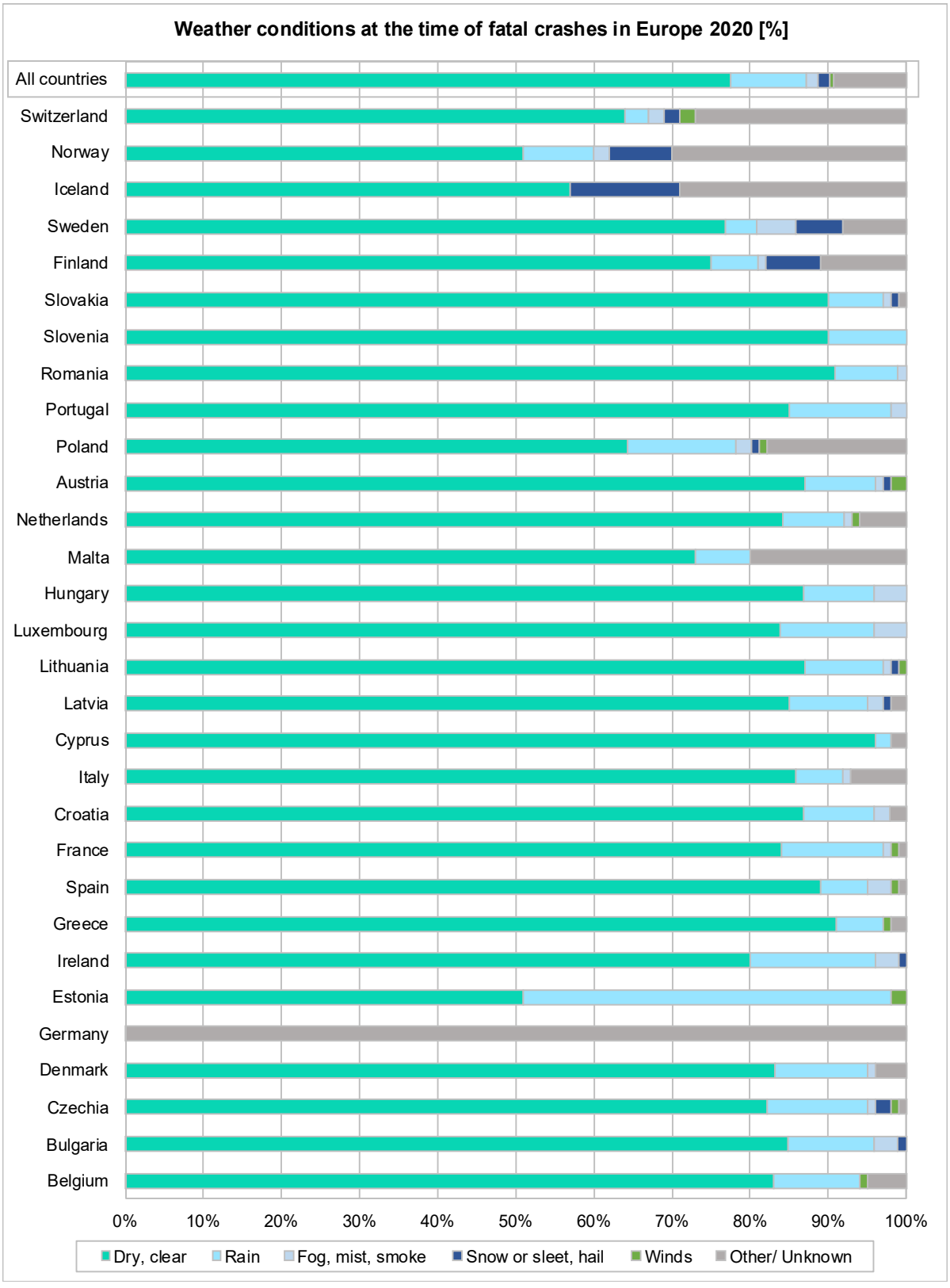

Figure 2 - Weather conditions at the time of fatal crashes in Europe 2020 [1]

Figure 2 shows that the most accidents happen during dry weather conditions with an average of 80.2 %. Rainy weather is on the second place with about 10 % and happens to appear in countries like Poland, Ireland, Czechia, France and Portugal more often than in other countries. Estonia has an outrageous percentage of fatal accidents while rainy weather, with about 47 %. Traffic accidents tend

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to happen very seldom when snowfall is occurring (1.6 %). Northern countries like Sweden or Finland have a slightly higher number of accidents concerning this weather condition.

The weather data of Europe becomes more interesting if the actual numbers of traffic accident fatalities per country are evaluated. The report of ERSO includes numbers of the traffic fatalities in Europe as well. Figure 4 shows which country has the highest fatality rate and what value the fatality rate has.

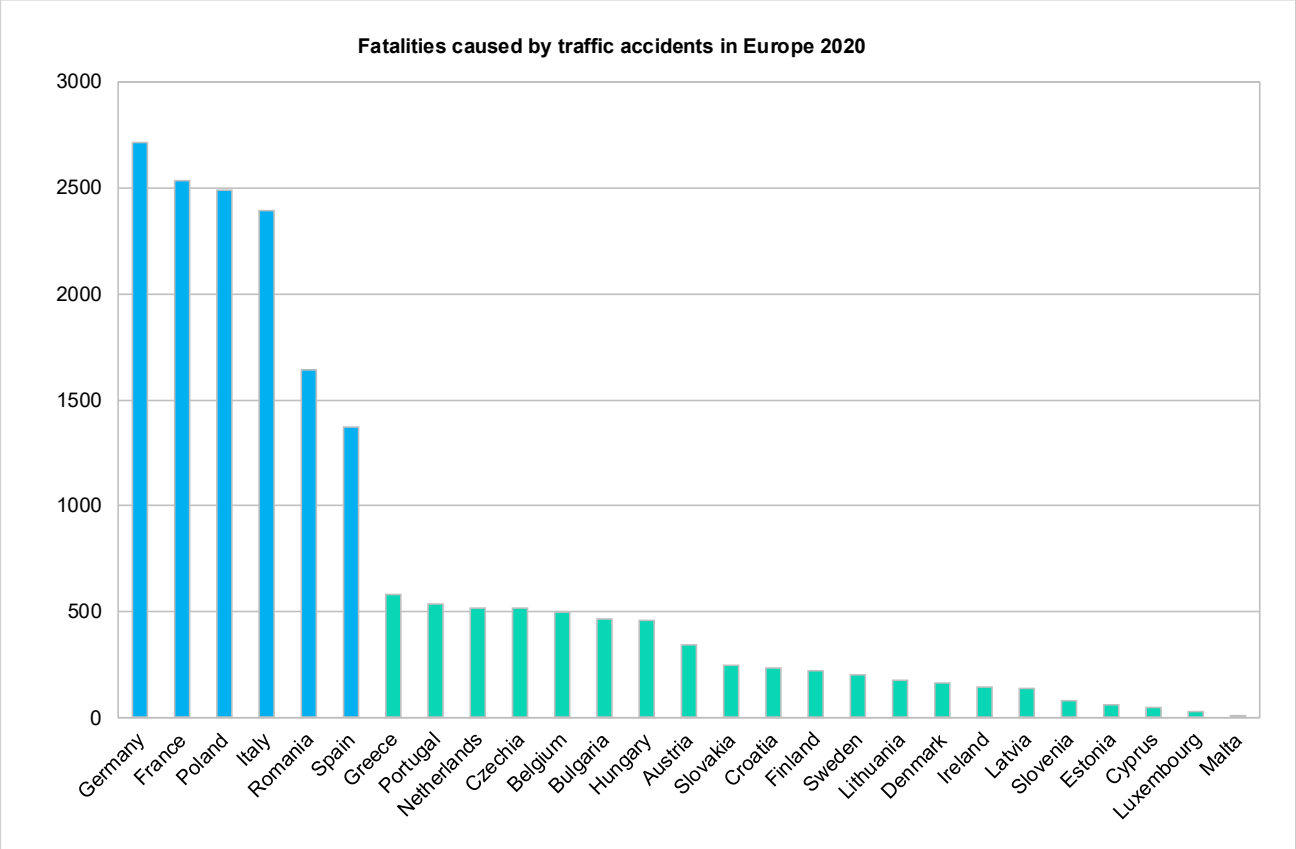

Figure 3 - Fatalities caused by traffic accidents in Europe 2020 [1]

It is undiscussable that six countries stand out negatively with their fatality rates. Germany, France, Poland, Italy, Romania and Spain reached more than 1,000 fatalities in the year 2020. On the one hand those countries are bigger in terms of their area and population than the other countries (Figure 4). Sweden is also quite big but has a smaller population rate than the named countries.
On the other hand, Poland has a lot smaller area and population than Spain but still has nearly double the fatalities.

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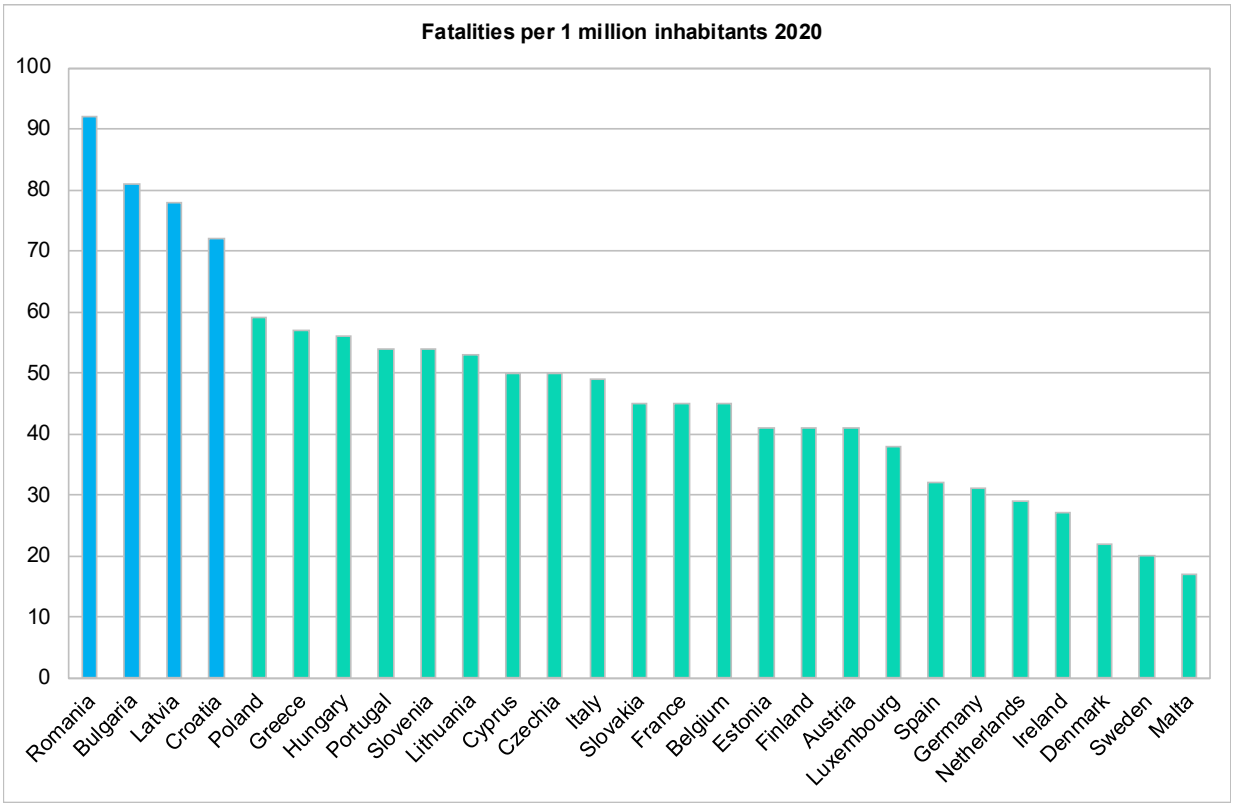

Figure 4 - Area and population of the chosen European countries [1]

Figure 5 shows the nine countries with the highest fatality rates split into the weather conditions during the traffic accidents.

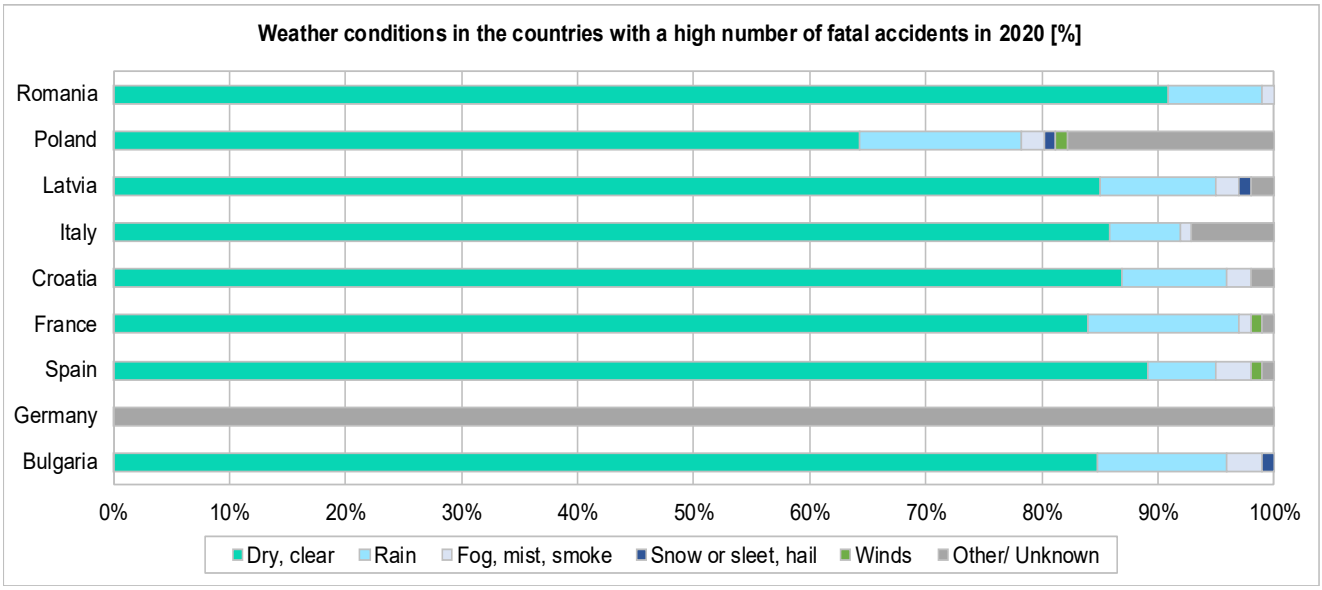

Figure 5 - Weather conditions in the countries with more than 1000 fatalities or a high fatality rate in 2020 [1]

Unfortunately, there is no data available for Germany in the ERSO report. The data of DESTATIS - which is evaluated in chapter 3.4 - is not comparable to the ERSO data. Poland, as one of the countries with the highest number of fatalities compared to its size and population, has about 64 % dry, 14 % rainy, 3 % foggy, 1 % windy, 1 % snowy and 18 % unknown weather conditions. Except of the unknown weather, dry and rainy weather conditions seem to be two of the bigger parts in the chart. Rainy weather takes up the highest percentage of adverse weather in Poland. In addition to the quite high number of fatalities, the traffic accidents during rain should be analysed more closely.

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3.2 GSD

The GSD is a summary of all existing traffic accident databases around the world. The database exists since 2022 and contains a research mask which allows to determine different variables and their existence in different databases. In addition, the GSD gives general information about the specific databases. For this project it is useful to filter weather variables and examine the results. [2]

Variables with relation to weather: “PRECIPITATION” (1); “CLOUD_FOG_WIND” (2)

Table 4 - Databases and their relation to the chosen variables [2]

Database	Match [%]
BAAC	100
BRON	100
CARE	100
CDS	100
CISS	100
CzIDAS	100
DESTATIS	100
ELSAT	100
EUSKA	100
FARS	100
GIBDD	100
GIDAS	100
HIT	100
IAAT	100
IGLAD	100
InSAFE	100

Database	Match [%]
INTACT	100
ISTAT	100
ISTAT-ACI	100
ITARDA	100
KSH	100
LAB	100
MORTH	100
NAIS	100
NPA	100
POLSAS	100
RASSI	100
ROM	100
RTMC	100
SCI	100
StatFin	100
UAG	100

Database	Match [%]
ASCZ	50 (2)
CRSS	50 (2)
ECIS	50 (2)
GES	50 (2)]
OTI	50 (2)
STAR	50 (2)
SEWIK	50 (2)
SWESTAT	50 (1)

The Table 4 above shows the matches with the selected variables. The list can be used to collect data about traffic accidents and their relation to weather conditions. This deliverable examines some of those databases which are **marked** in the tables. If there is a need of more input on the adverse weather topic, the GSD can be used to extract further information from different databases. The percentage in Table 4 is displaying which variable is found in the database. In eight out of 40 found databases there is only one variable matching. The Index behind the percentage defines what variable is matching.

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3.3 ONISR/ BAAC

The main information of a traffic accident with personal injury happening in France is collected in a file. All these files constitute the national road traffic accident file known as the “BAAC file” administered by the National Interministerial Road Safety Observatory “ONISR”. There exists a variable called “atmospheric condition” in the French database which describes the weather condition at the time of the accident. The following Figure 6 states the information about weather and traffic accidents in the year 2022 in France. [4]

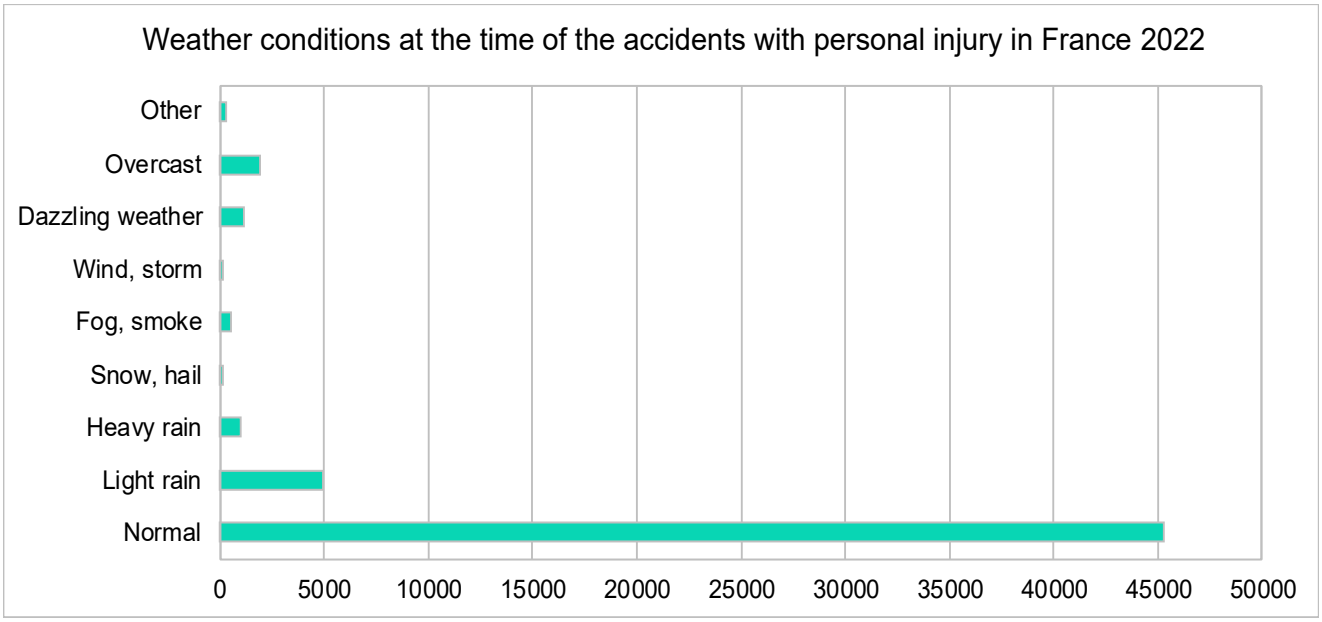

Figure 6 - Number of accidents and their weather conditions in France 2022 [4]

The French Government website gives information about the accident numbers and their characteristics. The most recent data is from the year 2022. The Figure 6 shows the weather situation during the accidents. There happen to be 50.302 accidents statistically documented in France in the year 2022. As shown in the chart the most crashes happen during “normal” weather conditions, which means e.g. dry roads or clear, sunny sky. About one-eighth of this number happens during rain.
In conclusion, the attributes “light rain”, “heavy rain” and "dazzling weather” seem to be the most important variables for further analysis. The attributes “overcast” or “normal” are less important because those weather conditions are a common crash test surrounding. As a result of expertise in traffic accident analyses, it is well known, that those weather conditions tend not to be an accident causation, expect the blinding sun, which is not examined in this data.

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3.4 DESTATIS

DESTATIS publishes a report about traffic accidents in Germany once a year. The most recent report is out of the year 2022, due to complex quality control.
There is some data about traffic accidents during adverse weather, which is listed below in Table 5 divided into the different categories. In this report the variable is the direct cause for the accident. So e.g. there are no accidents included which happen *during* rain. There are only accident numbers listed which happen *because* of rain. [5]

Table 5 - Variables in DESTATIS addressing adverse weather [5]

Main category	Variables	Further categories
Accidents with personal Injury	Weather: Fog, rain, snow, sun (blinding), wind, storm and other… Road: dirty, wet, icy, destroyed ground, lighting …	Inside/ outside cities, street categories (highways, motorways etc.)
Accidents with material damage		
Fatalities		

To represent the accident numbers of Germany, some of the variables are displayed in the following Figure 7 depending on the consequences of the accident.

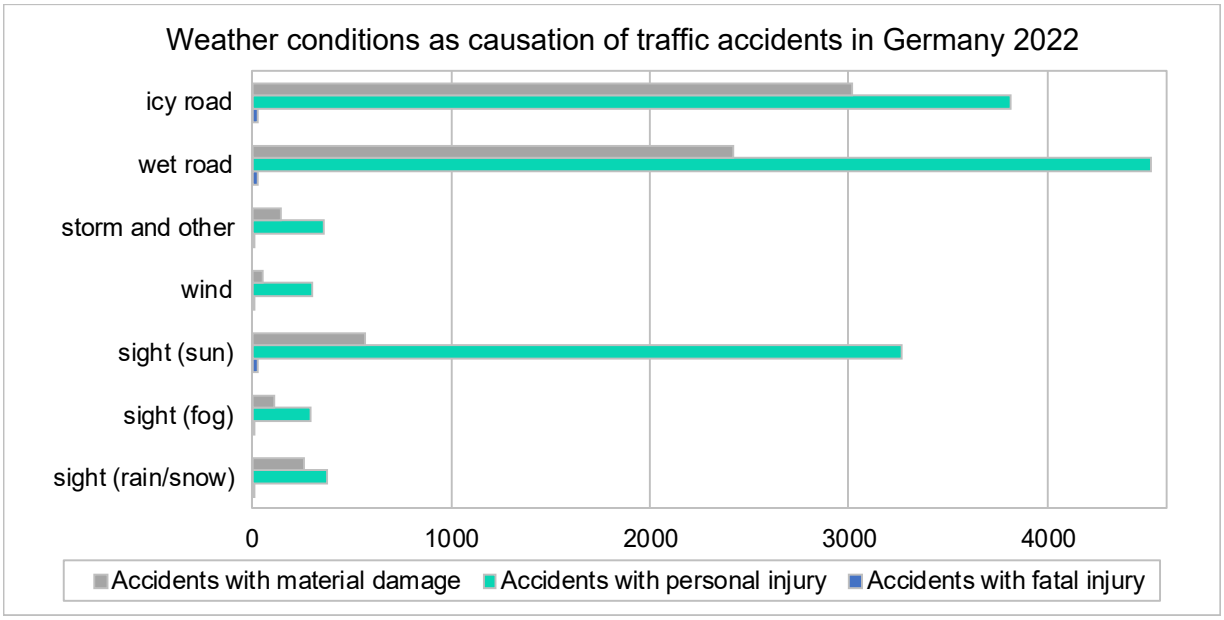

Figure 7 - Weather conditions during traffic accidents in Germany 2022 categorized in injury severity [5]

The Figure 7 shows the impact of various weather conditions on traffic accidents in Germany in 2022, categorized into accidents with material damage, personal injury and fatal injury. Wet roads caused the most accidents with personal injury, followed by icy roads. Sun glare also resulted in a significant number of accidents with personal injury and material damage. This seems to be quite interesting, as in the most countries sunny weather appears the most. It should be discussed in the following analysis to include sun or especially sun glare as adverse weather as well.
Other conditions like storm, wind, fog, and rain/snow had relatively fewer incidents in all categories. Overall, accidents with fatal injury were low across all weather conditions compared to accidents with personal injuries and material damage.

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3.5 STRADA

The Swedish accidentology data is collected and controlled by STRADA. Figure 8 represents the most recent information about adverse weather in this database. [7]

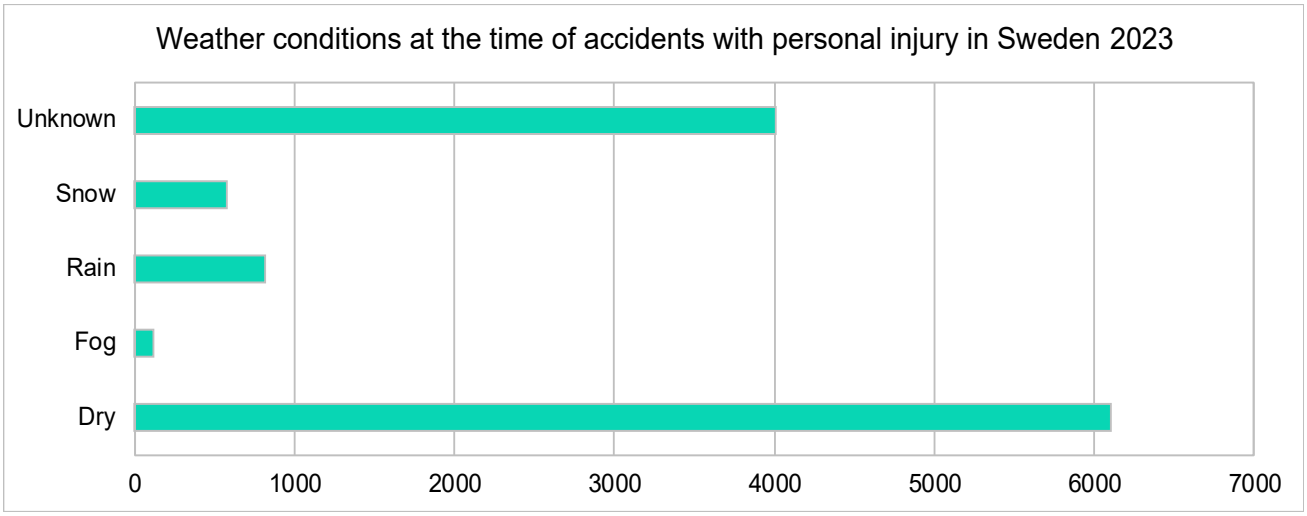

Figure 8 - Weather conditions during traffic accidents in Sweden 2023 [7]

The data shows a similar trend as the countries evaluated before. The most often appearing weather condition is the dry weather. This condition is followed by rainy and snowy weather. Rain takes up about 7 % of all documented accidents in 2023 and snow only 5 %. Due to the location of Sweden, the country shows a little higher proportion of snowy weather. Sweden has in its own statistical data also a little higher share of adverse weather in general.

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3.6 SUMMARY AND CONCLUSIONS

The following Table 6 summarizes the analysed weather conditions and gives a preliminary ranking according to their relevance. This ranking will be reanalysed after the evaluation of the GIDAS data. The table should give a first impression of the relevance of specific weather conditions in Europe. Unfortunately, most of the given information is about weather as a circumstance. Only the German statistical data includes weather as a direct accident causation.
The results of the statistical analysis show that dry/sunny weather takes up the biggest part in weather with an average percentage of 80 % in Europe. Rainy weather tends to appear the second most with around 10 %. The other three weather conditions described with snow, fog and wind tend to appear around 1 to 3 %. The relevance of the adverse weather conditions is categorized according to the percentage. For this project 10 % will be the main defined border of relevance. If the number of adverse weather accidents is above 10 % the condition is relevant and if it is below, it is not that relevant.

Table 6 - Preliminary ranking of the weather circumstances during traffic accidents in Europe

Ranking	Weather condition in Europe	Relevance	Explanation
1	Dry/sunny weather	Very relevant	Dry/sunny weather takes up the biggest part in weather with an average percentage of 80 % in Europe. Therefor the potential of glare being an adverse weather condition is quite high.
2	Rain	Very relevant	Rainy weather tends to appear the second most in Europe with about 10 %.
3	Wet or icy road surface	Very relevant	According DESTATIS wet and icy road surfaces are the third top accident causations in terms of AWC.
4	Snow	Not as relevant	Snowy weather tends to appear in about 3 % of the accidents in Europe. Icy roads tend to be one of the second most accident causations regarding AWC in Germany.
5	Winds	Not as relevant	Windy weather tends to appear in about 1 % of the accidents in Europe. But the data of DESTATIS shows, that windy and stormy weather tends to cause double of the accidents which were caused by fog.
6	Fog	Not as relevant	Foggy weather tends to appear in about 2 % of the accidents in Europe.

The described conclusions out of the statistical data will be included in the final evaluation of the preferable scenario weather circumstances and the final top five accidents scenarios. This is only a preliminary status of the AWC-relevance and after the following analysis, the final relevance is defined.

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4. The evaluation of the GIDAS-Database

Chapter 3.6 summarizes general information about GIDAS and its evaluation regarding AWC. Unless otherwise indicated all data, pictures and charts are derived from GIDAS.

4.1 THE GIDAS-DATABASE

GIDAS is known as the world leading in-depth accident research project. The accident research started in 1999 in the German cities Dresden and Hanover. Since 2023 Munich was added as well. Those three survey areas are representative for the German traffic accident situation. In GIDAS, about 2,000 traffic accidents with personal injury are documented per year. The GIDAS project is described as a cooperation between state and industry. They both finance this project. The research methods are interdisciplinary e.g. technological, medical, psychic etc. The most recent data set was published in December 2023. This data set is used for the further analyses.

The GIDAS-Data gives the opportunity to evaluate data on different levels (Figure 9). The first level describes the general accident level, in which all accidents are listed and can be evaluated concerning different variables. But one accident can include more than one participant. That's why there is a second level which is called participant level, which could be used to evaluate information which can vary between the participants e.g. road surface, streetlights, blinding sun etc. The third level describes the person(s) involved in an accident. One participant can include more than one person. E.g. a passenger car can include one to five passengers regularly. The person level can be used to evaluate injury severities, personal perceptions and a lot more. GIDAS includes one more sub-level, but these analyses will not go any further than the third level in the database. The following level is described as injury level and includes more detailed information about injuries of the documented person.

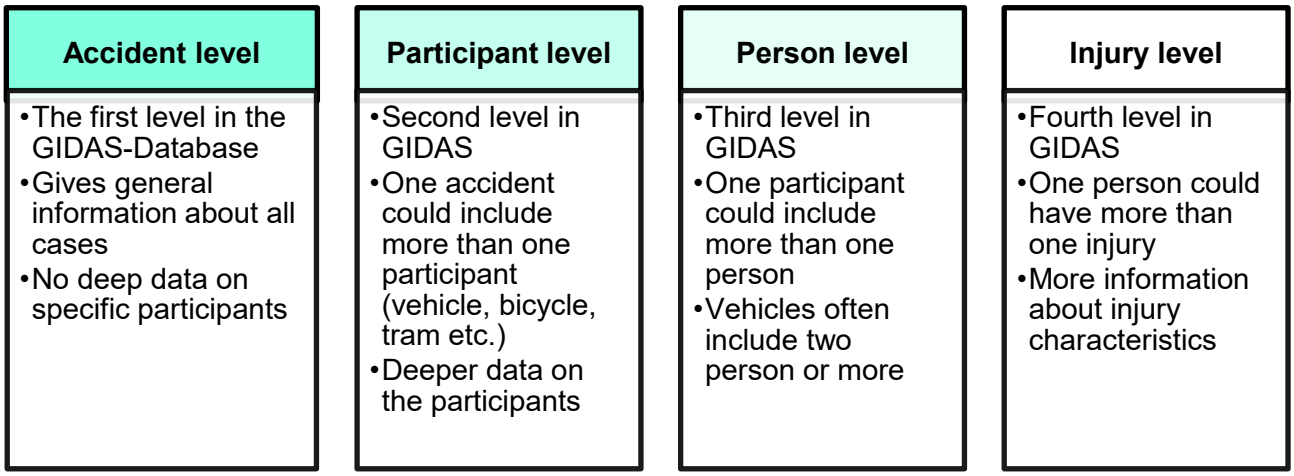

Figure 9 - Levels in the GIDAS-Database

To give an idea what is included in GIDAS, some general numbers are displayed in Figure 10. This figure shows the general classification of passenger cars in GIDAS. In 45,434 fully documented and reconstructed accidents in GIDAS are 47,158 passenger cars (M1-vehicles) involved. Those vehicles are the most relevant for this project and every analysed accident should include at least one passenger vehicle. The GIDAS-data shows, that the passenger cars take up the biggest percentage of involved vehicles in the GIDAS-Statistics with about 62 %.

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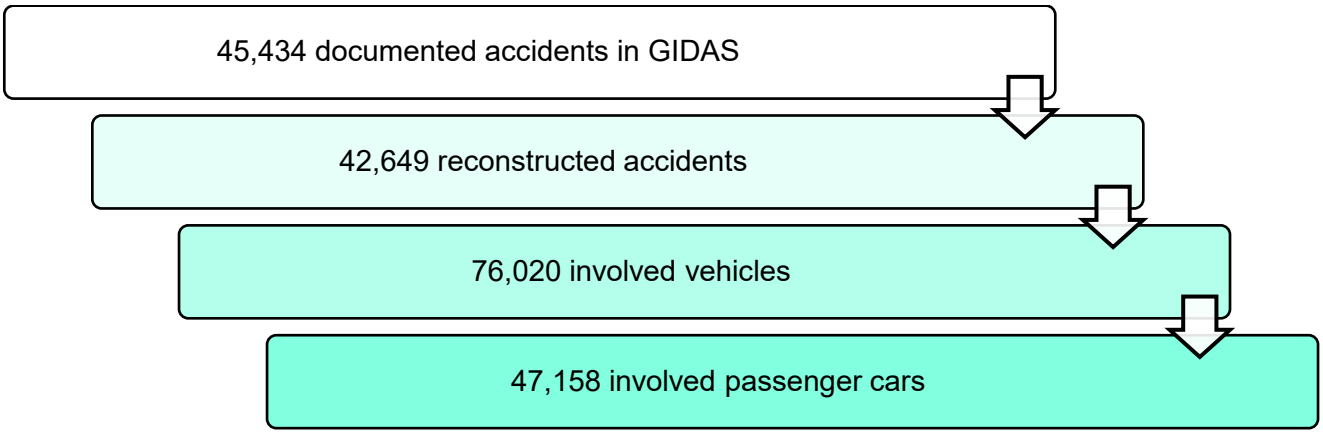

Figure 10 - General classification of passenger cars in GIDAS

4.2 THE MASTER CASE LIST

The first step in the GIDAS-Analysis is to generate a list with the relevant accidents. This means, all accidents with at least one involved passenger car should be included. The 42,649 completely documented and reconstructed accidents are filtered according to accidents with at least one involved passenger car. GIDAS includes different variables which can give access to those scenarios. To promote a better understanding of the process on filtering those scenarios, the accident type variable is explained in the following abstract.

Variable name:	UTYPA, UTYPB
Start of documentation in GIDAS:	1999
Description:	Describes accident type specified on participant
Evaluation level:	Participant level

In GIDAS the variable “UTYPA’’ and the variable “UTYPB’’ describe the accident type specified on the participant. There can be more than two participants, but in this analysis the accident triggering participants are the most interesting to look at. Those include the accident-causing participant (participant “A”) and the direct opponent (participant “B”) in the accident-causing situation. To include all scenarios with at least one passenger car involved, the type of participant “A” and “B” are variegated. In the first step the participant “A”, which is the direct trigger of the accident is defined as a passenger car. Now all scenarios with participant “A” being a passenger car and participant “B” being anything e.g. bicycle, pedestrian, truck etc. are extracted out of the data set.
In the second step, the same is going to be done the other way around with the participant “B”. Now participant “B” is defined as passenger car and participant “A” can be any kind of participant. The resulting cases are added to the list of accidents out of the first filtering step.
The last step is isolating all single accidents. In these situations, there is no direct opponent, consequently no participant “B”. Participant “A” is defined as passenger car and the resulting accidents are added to the list as well. With that procedure, all accidents including at least one passenger car can be defined.
After this analysis 32,441 accidents remain, which involve at least one passenger car. This accident list can be used to analyse different conditions in relation to AWC.

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Figure 11 shows the different accident types with participant “A” and “B”. This picture is only a snippet of accident types. The scenarios show that participant “A” is the main accident trigger and “B” the direct opponent.

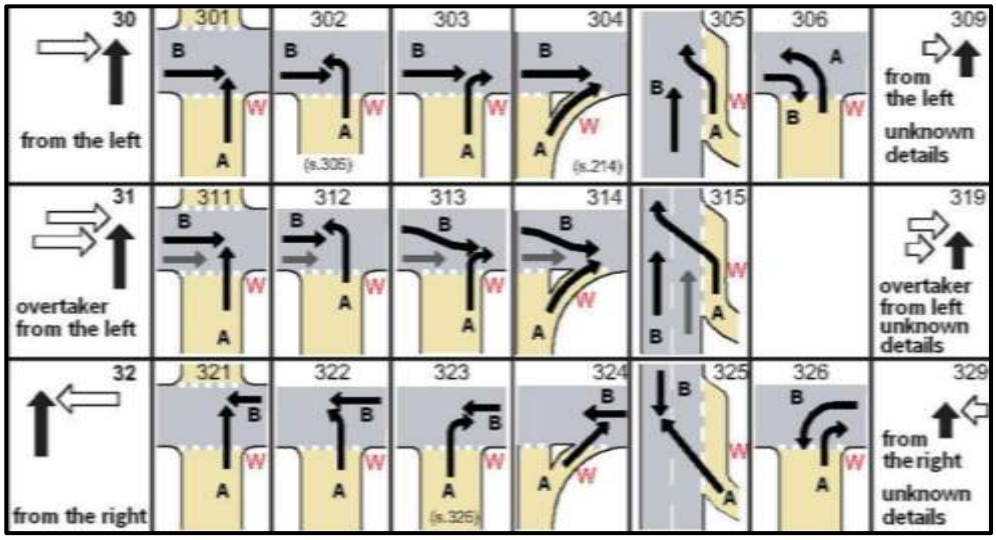

Figure 11 - Examples for different accident types in GIDAS

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Variable name:	ARTTEIL
Start of documentation in GIDAS:	1999
Description:	Describes the type of participant (vehicle, bicycle etc.)
Evaluation level:	Participant level

Figure 12 displays result of the evaluation of GIDAS concerning the distribution of participants involved in the accidents.
The variable described above includes all information concerning the participant type. It includes types like e.g. M1/N1-Vehicles, bicycles, pedestrians, trams and a lot more.
With about 47 %, the M1/N1-Vehicle happens to appear the most a participant. Bicycles are the second most appearing participants, followed by pedestrians and motorcycles. This distribution shows that the analysis of ADAS becomes more and more relevant because vehicles including those safety systems tend to have the highest percentage of participation in traffic accidents.

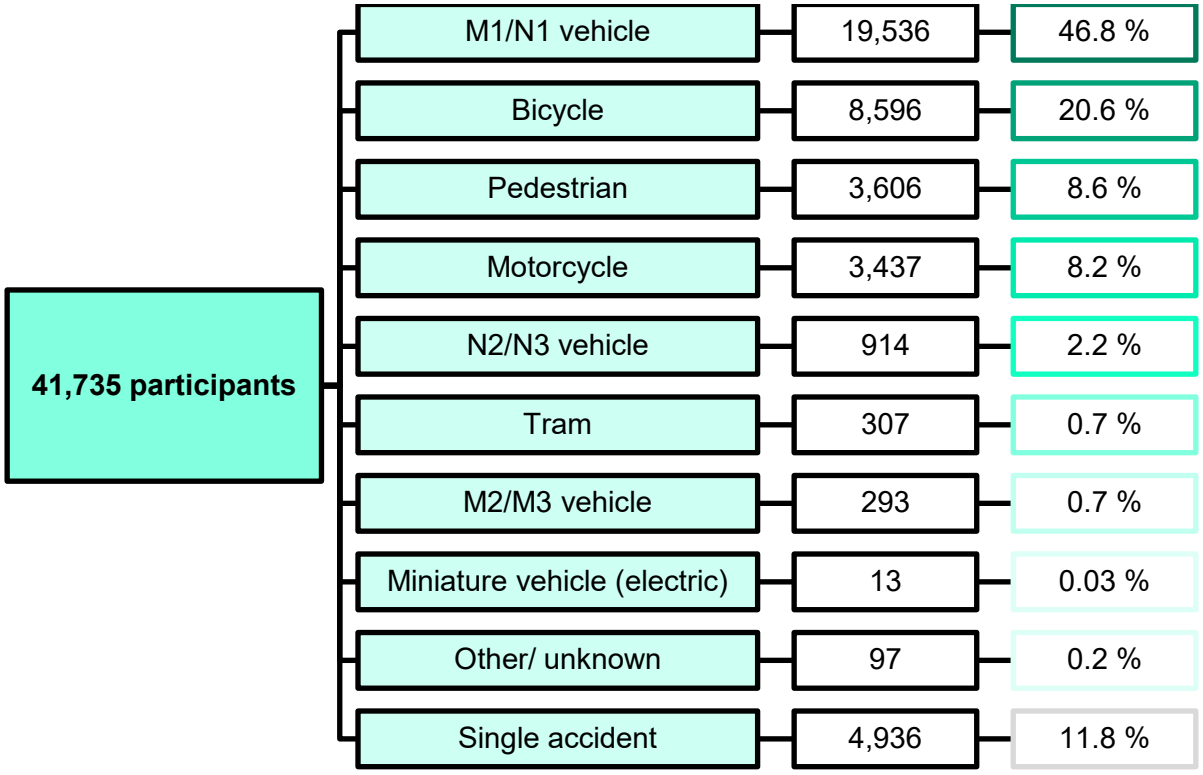

Figure 12 - Distribution of opponents of passenger car accidents

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4.3 WEATHER AS CIRCUMSTANCE IN GIDAS

4.3.1 PRECIPITATION

Variable name in GIDAS:	NIED
Start of documentation in GIDAS:	1999
Description:	Precipitation (rain, snow, hail, freezing rain)
Evaluation level:	Accident level

The precipitation is coded in GIDAS since the year 1999 and describes weather conditions like rainfall, snow, hail or freezing rain. The following chart show the accidents with at least one passenger car involved and their precipitation evaluated on accident level in the database. The number of accidents differ with the number of participants, because in the most accidents there is more than one participant involved. The evaluation on different levels is not as relevant for the weather topic. In the most cases, there is one weather condition per accident and not one per participant. Because of this conclusion most of the following weather variables are only evaluated on accident level and the results are summarized in this chapter 4.3.

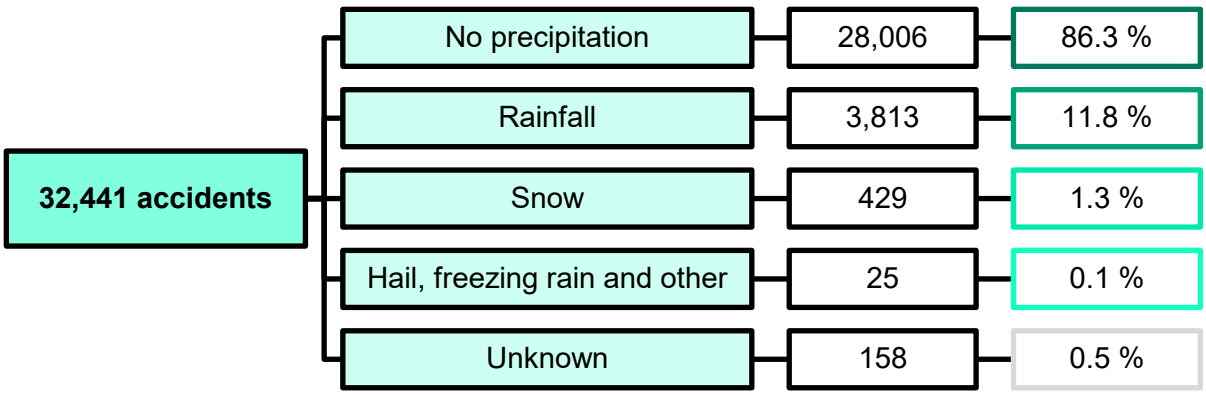

Figure 13 - Distribution of precipitation during traffic accidents with at least one vehicle

Figure 13 displays the precipitation on accident level. Overall, there are 32,441 accidents with at least one passenger car included. In 86 % of the accidents the weather is dry or clear and there is no precipitation. The general rainfall follows on the second place with about 12 %. In about 1 % of the cases snow is falling. The other precipitation attributes can be extracted from Figure 13, but they have a unsignificant percentage share.

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4.3.2 ROAD SURFACE

Variable name in GIDAS:	STROB
Start of documentation in GIDAS:	1999
Description:	Road surface condition (dry, damp, wet, icy)
Evaluation level:	Participant level

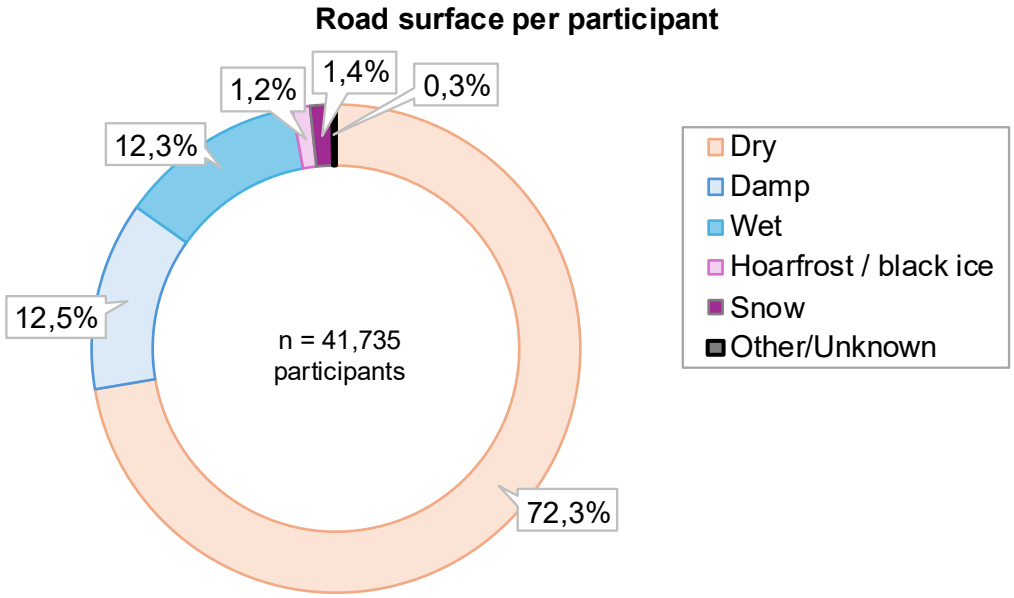

Figure 14 - Road surface distribution per participant in accidents with at least one passenger car involved

Another interesting factor to look at is, the road surface under AWC. To address those cases as adverse weather as well, GIDAS includes a road surface condition variable which can be evaluated concerning this topic. The road surface condition is coded since beginning of the documentation of traffic accidents. This variable can only be evaluated on a participant level, because e.g. different vehicles in one accident can have different road conditions. The assessment of the road surface is not based on any predefined criteria. It is subjectively determined whether, for example, the road is considered damp or wet.

Figure 14 is illustrating the distribution of road surface conditions encountered by participants. The data comprises a total of 41,735 accident opponents. The segments are color-coded to represent different road surfaces. Dry roads, which constitute the largest portion, account for 72% of the total. Damp roads make up 13 % of the total. Wet roads represent 12 %. Hoarfrost or black ice covers 2 %. Snow accounts for 1 %. Other or unknown road surfaces make up 0.3 % of the total. The chart shows that most of the accidents occur on dry roads, with progressively fewer accidents on other types of road surfaces.

Due to weather being very time sensitive, the road surface can be in a different state than the general weather condition. For example, there is a wet road surface because of rain, the rain stops, but the road is still wet, and the accident happens after the rain, but because of the wet road. Nearly 14 % of the 41,735 participants, which have an accident during dry or clear weather, happen to have damp, wet, icy or snowy roads. Those 14 % are shown in Figure 15 with 5,807 participants.

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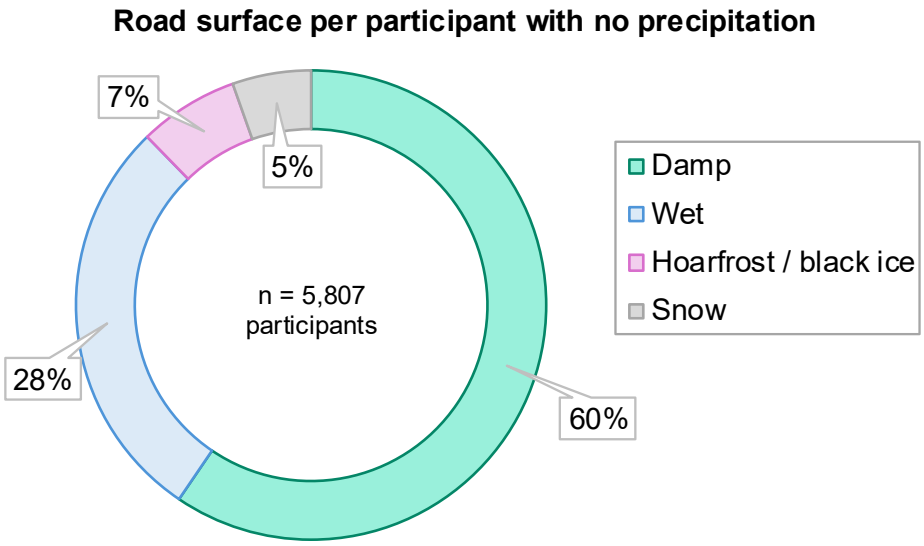

Figure 15 - Road surface per participant with no precipitation

In 60 % of the cases the road is damp and in 28 % wet. This data shows that adverse weather doesn't exactly have to be rain in the moment of the accident. Rain could cause consequences, such as a wet road, which could also lead to an accident.

4.3.3 Clouds

Variable name:	WOLK
Start of documentation in GIDAS:	1999
Description:	Cloudy weather condition (no clouds, few clouds, cloudy)
Evaluation level:	Accident level

This variable describes the cloudy weather conditions or the overcast at the time of the accident. This variable is documented in GIDAS since 1999.

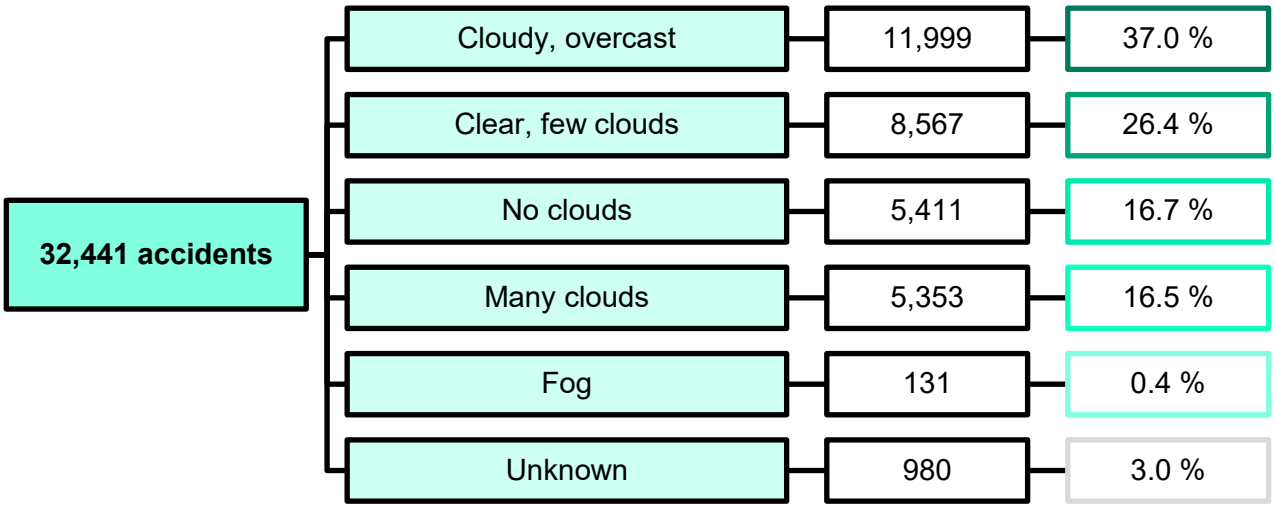

Figure 16 - Distribution of cloudy weather conditions during traffic accidents with at least one passenger car

Figure 16 shows that the cloudy weather condition, where the sky is overcast, appears the most with 37 %. The weather condition with less clouds follows with 27 %. In 17 % of the accidents the sky is completely clear.

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4.3.4 Fog

Variable name:	NEBELM
Start of documentation in GIDAS:	1999
Description:	Foggy weather condition (measured as range of sight)
Evaluation level:	Accident level

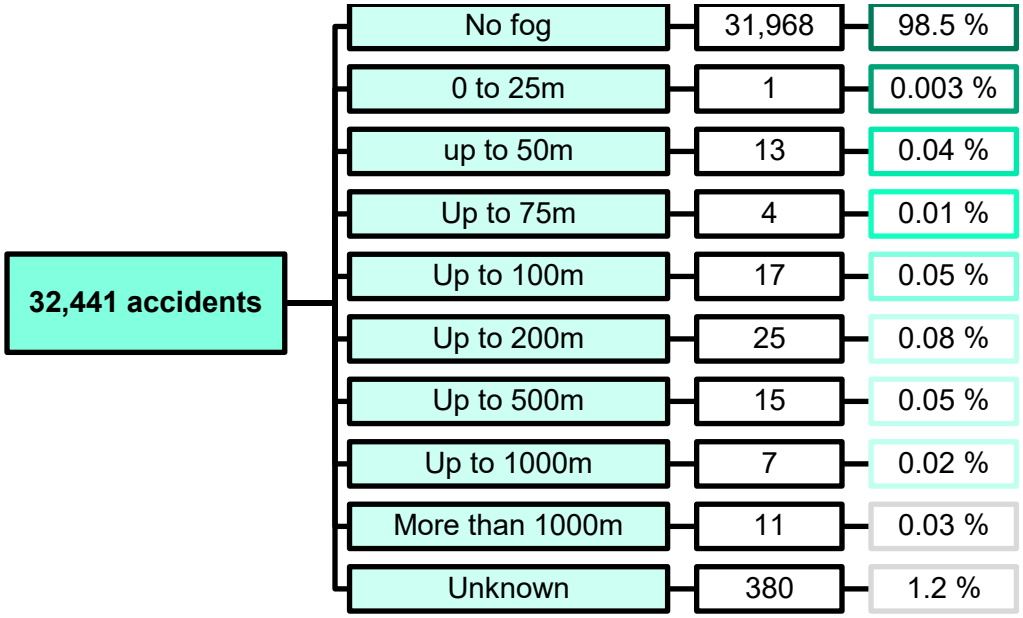

Figure 17 - Distribution of foggy weather conditions during traffic accidents with at least one passenger car

Fog as a weather condition is coded in GIDAS since 1999 as well and its distribution is displayed in Figure 17. Fog is described as the range of sight in meters.
In the most accidents (98.5 %) no fog appeared. Therefore, the foggy weather condition seems to be less interesting when evaluating an AWC at the time of the accident.

4.3.5 Wind

Variable name:	WINDE
Start of documentation in GIDAS:	2019
Description:	States if wind influenced the accident causation and how
Evaluation level:	Accident level

Since 2019 the general influence of wind on an accident is documented in GIDAS. This variable defines different wind causations, and the results are summarized. Figure 18 displays the results.

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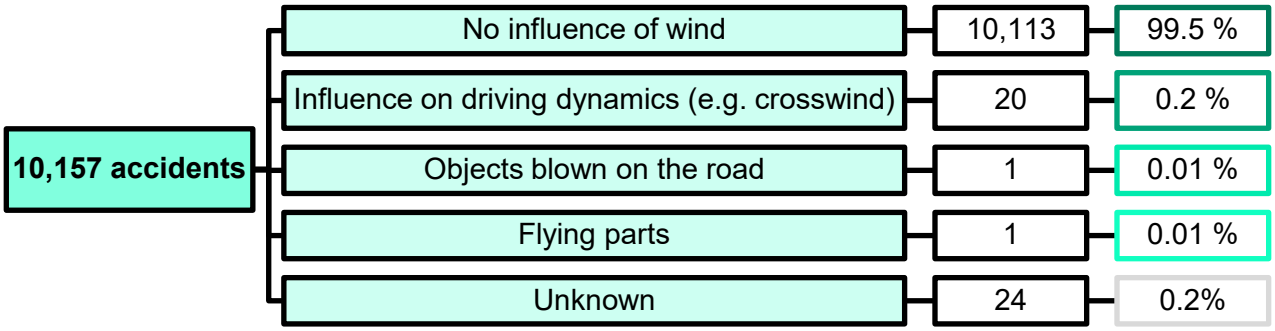

Figure 18 - Distribution of wind and its direct influence on traffic accidents with at least one passenger car

As the evaluation of this variable shows, the influence of wind as a causation of an accident can be neglected. It is important to remark that this variable is only providing evidence for the past four years. But all in all, the data shows that in 99.5 % of the accidents since 2019 wind had no influence on the accident causation.

4.3.6 GLARE

Variable name:	BLENDD
Start of documentation in GIDAS:	2005
Description:	States if driver was blinded or not and what was the cause
Evaluation level:	Participant level

There exists a variable in GIDAS since 2005 which codes the influence of glare on the accident causation as well. This variable needs to be analysed on the participant level, because if there is more than one participant, the first, the second or both participants could be blinded by the sun.

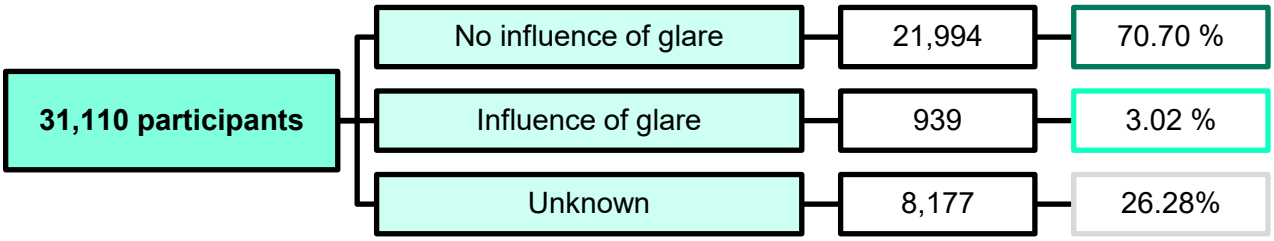

Figure 19 - Distribution of glare and its direct influence on traffic accidents with at least one passenger car

Figure 19 illustrates the influence of glare on 31,110 participants, segmented into three categories. There was no influence of glare at 21,994 participants, which represents 70.7 % of the total. The influence of glare is unknown at 8,177 participants, representing 26.3 % of the total. The chart reveals that the majority of the participants have not been influenced by glare, while a smaller proportion was affected by direct sun glare, headlights, and road illumination. For a significant portion of participants, it is unknown if glare influenced the driver.

There are 939 participants which are influenced by glare and the corresponding distribution is shown in Figure 20. Direct sun glare was a factor for 803 participants, accounting for 85 % of the 939 participants. The glare of vehicle lights influenced 129 participants, making up 14 % and road illumination was an influencing factor for 7 participants, which is about 1 %. These analysis shows that if there was a known influence of glare, sun glare is the biggest part and therefore the most relevant.

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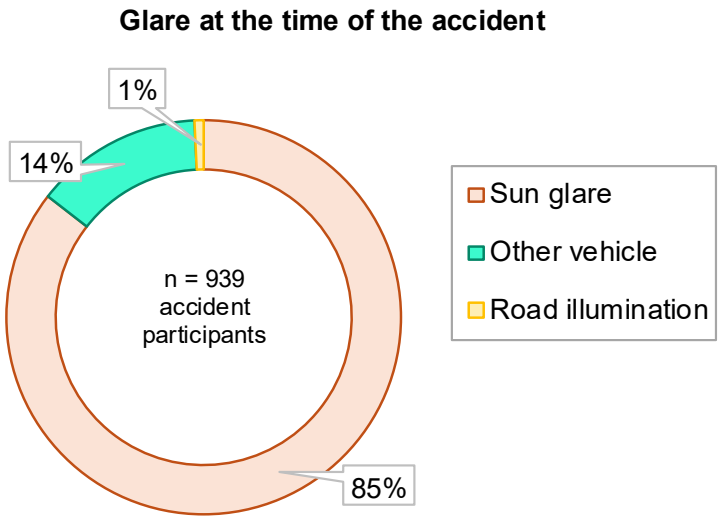

Figure 20 - Glare kinds at the time of the accidents

4.3.7 TEMPERATURE

Variable name:	TEMP
Start of documentation in GIDAS:	1999
Description:	Temperature (measured in degree Celsius)
Evaluation level:	Accident level

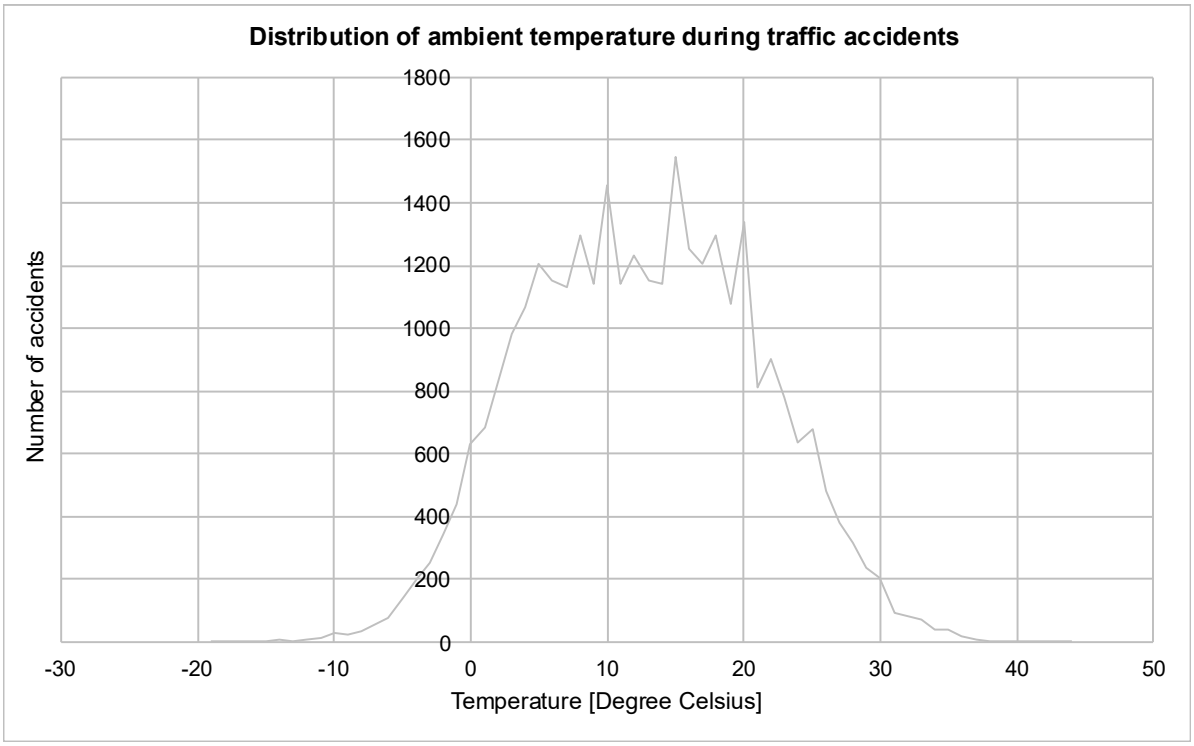

Figure 21- Distribution of ambient temperature during traffic accidents in GIDAS

The temperature is coded in GIDAS since 1999. The graph in Figure 21 shows the measured temperatures at the time of the accidents. Most of the accidents in Germany happen at a temperature between 5 and 20 degrees Celsius. The highest measured temperature is 44 and the lowest -19 degrees Celsius.

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4.4 ACCIDENT CAUSATION VARIABLES

The accident causation can be evaluated on different levels in GIDAS. The following flowchart describes the filtering steps in the database.

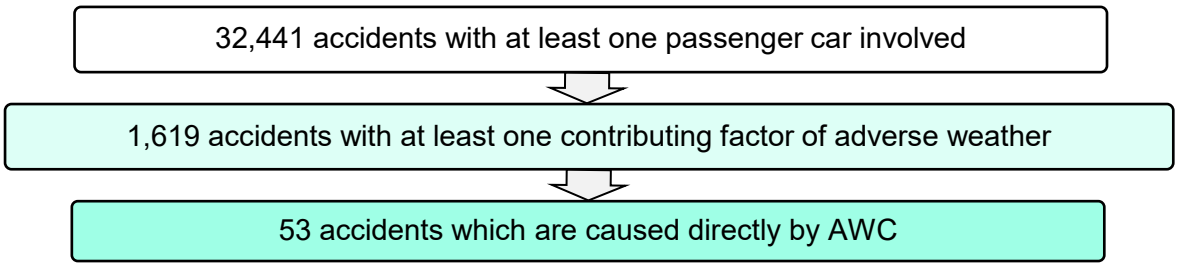

Figure 22 - Filtering steps in GIDAS

The basis are the 32,441 filtered accidents out of GIDAS which include at least one passenger car. Out of those accidents, 5 % or 1,619 accidents had at least one relation concerning adverse weather. The result shows 53 accidents which are directly caused by adverse weather. There is a variable in GIDAS which describes the exact accident causation.

Variable name:	HURSU
Start of documentation in GIDAS:	1999
Description:	Describes the main accident causation
Evaluation level:	Accident level

Figure 23 displays the accident causations of the final cases, which happened directly because of AWC.

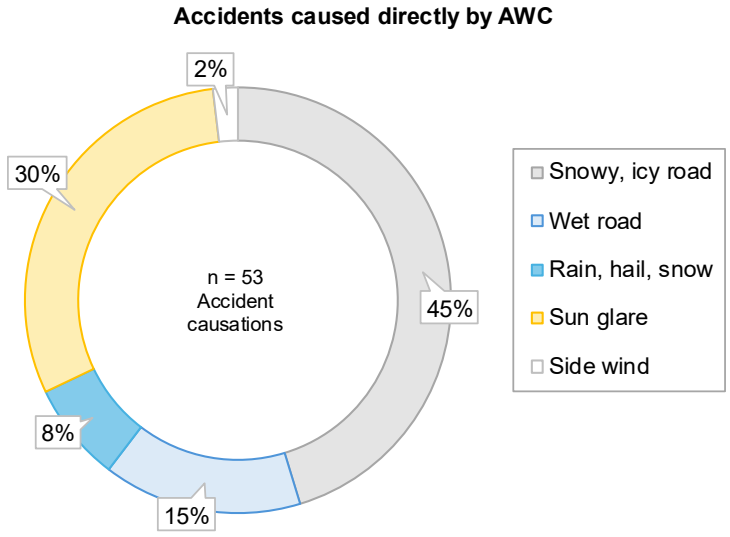

Figure 23 - Accident causations with relation to weather

Snowy or icy roads happen to be the most appearing accident causation with 45 %. This is followed by sun glare with 30 %, wet roads with 15 %, rain, hail and snow with 8 % and side wind with 2 %. The other weather conditions seem to be less relevant. Fog was never a direct accident causation in GIDAS. On the one hand, only 53 accidents and inferring from that 0.16 % of the total of 32,441 accidents are caused directly by adverse weather. On the other hand, adverse weather is a contributing factor in 5 % of those accidents.

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Variable name:	URSWIS(1-4)
Start of documentation in GIDAS:	1999
Description:	Describes all influences on the accident causation
Evaluation level:	Participant level

Resulting out of this, it becomes more interesting to take a closer look at the contributing factors with relation to AWC. GIDAS gives the possibility to code four different accident causations for each participant (URSWIS 1-4). For example, if the driver made a fault, it can be coded in the first variable (URSWIS1). But if he/she was also influenced by the sun glare and the side wind, this would be coded in two other variables (URSWIS2 and URSWIS3). The weather is here not the direct causation but a contributing factor to the accident. To evaluate those factors, the 1,619 accidents need to be analysed on a *causation level*. One accident *(accident level)* can include more than one involved participant *(participant level)* and this participant can have more than one accident causation *(causation level)*. Figure 24 shows the summary of all contributing factors of the 1,619 accidents which add up to 1,659 contributing factors. The factors are divided into road surface (wet, icy or dirty) and weather conditions in general (rain, snow, fog, wind, storm etc.).

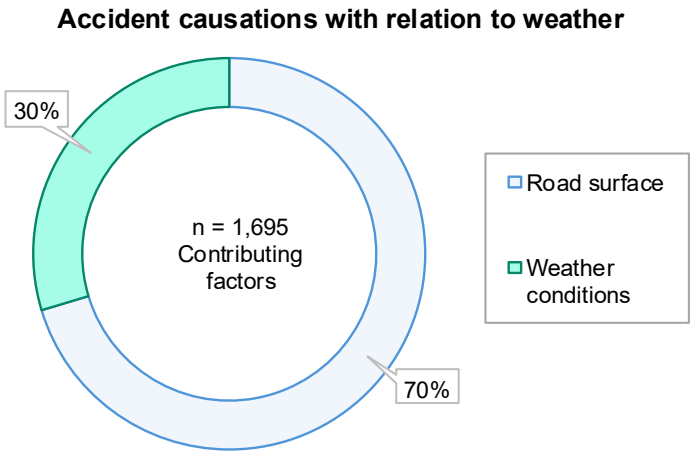

Figure 24 - Contributing factors on accident causations with relation to weather

The road surface seems to have a higher number of contributing factors than the weather conditions with 70 %. The following Figure 25 and Figure 26 describe the weather conditions and the road surface as contributing factors more nearly.

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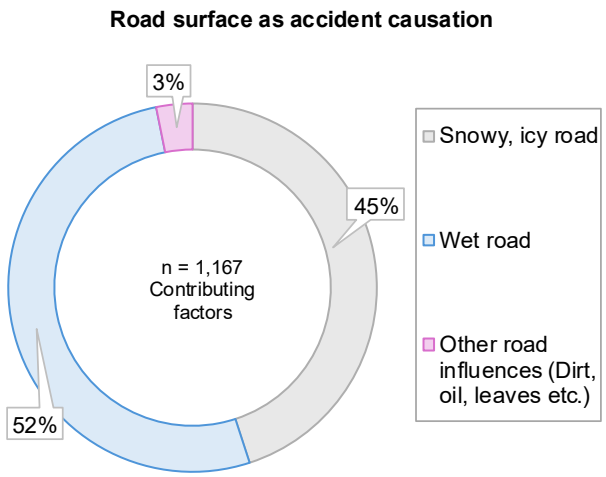

Figure 25 - Road surface as contributing factor

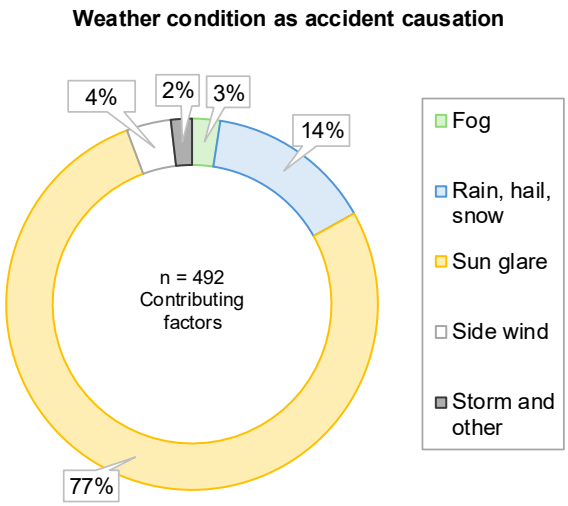

Figure 26 - AWC as contributing factor

The road surface is in 52 % of the corresponding accidents wet and in 45 % icy or snowy. Regarding the weather conditions, sun glare influenced the most accidents with 77 % and followed by rain, hail or snow with 14 %. Fog, side wind and storm tend to have a very small influence on accidents.

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4.5 ADVERSE WEATHER DEFINITION

To collect all accidents which happen during or because of AWC in the scope of the project, a new variable named “AWC” is created. This variable defines if there is any relation to the relevant AWC in the accident.
The results of the GIDAS-Analyses show, that ***not all*** analysed weather conditions seem to be relevant for the further steps. The following Table 7 displays the AWC which were defined as relevant by VUFO and the explanation for those classifications.

Table 7 - Definition of AWC in GIDAS

Ranking	Weather condition/ contributing factor in GIDAS	Relevance	Explanation
1	Precipitation (rain, snow, hail)	Very relevant	In about 12.0 % of the accidents the weather is rainy, in 1.3 % it was snowy and in 0.1 % appeared hail. *(n = 32,441)*
2	Road surface (wet, damp, icy, dry)	Very relevant	14 % of the participants had an accident on a wet, damp or icy road, even if there is no precipitation at the time of the accident. *(n = 41,735)*
3	Sun glare	Relevant	In about 30 % of the accident causations sun glare was the reason. *(n = 53)* In 77 % it is a contributing factor as well. *(n = 1,659)*
4	Fog	Not relevant	In 98,5 % of the accidents no fog appears. *(n = 32,441)*
5	Clouds	Not relevant	There are clouds in about 80 % of the accidents. This condition is not defined as an accident causation in any accident. *(n = 32,441)*
6	Temperature	Not relevant	The most accidents happened at a temperature between 5 and 20 degrees Celsius. The temperature doesn’t seem to have an influence as well. *(n = 32,441)*
7	Wind/ storm/ other conditions	Not relevant	Wind is coded in GIDAS since 2019, so there is not a lot of comparable information. In 99.5 % of those accidents, there is no influence of wind described. Other causations like road impurities because of leaves or side winds can be neglected due to their insignificant high percentage.

Out of the limitation of several parameters result **9,902 accidents** which happened during or because of adverse weather. In total there were 32,441 accidents and **30.5 %** of those are related to relevant AWC. In the following chapters the accidents are classified regarding their accident types and the final top five scenarios are determined.
The discarded parameters could still be evaluated more nearly in the future. Those are recommendations which result based on the analysis to narrow the scope.

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4.6 COMPARISON OF ACCIDENTS WITH AND WITHOUT AWC

4.6.1 ACCIDENT OPPONENTS IN GENERAL

The opponents were evaluated in the Chapter 4.2 already. Now, a comparison between the participants with and without AWC is given in Figure 27 below.

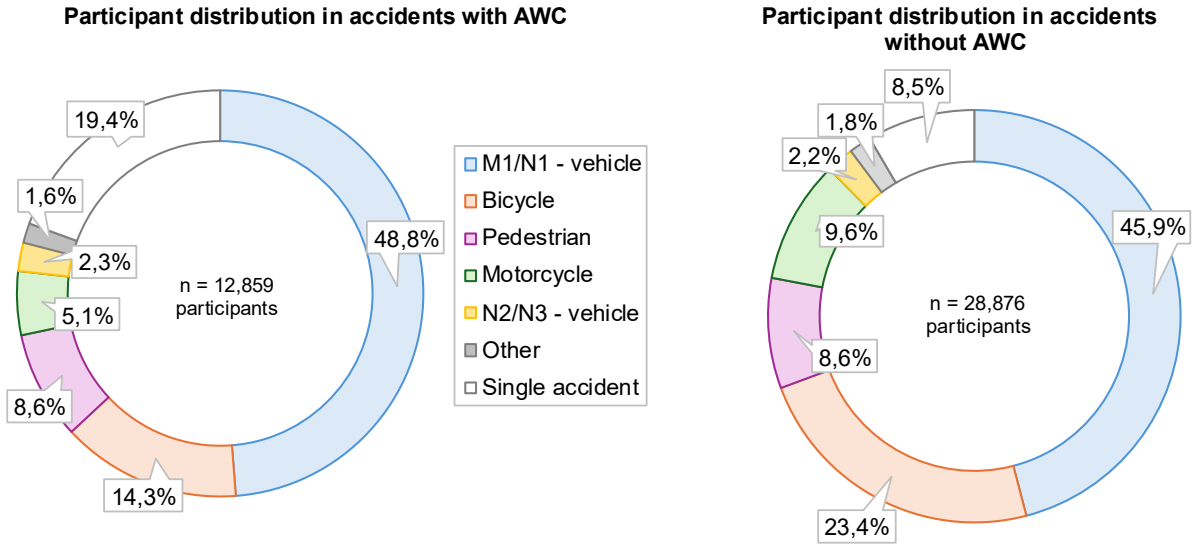

Figure 27 - Comparison of opponent distribution in accidents with and without AWC

For accidents with AWC, M1/N1-vehicles constitute 48.8% of the participants, bicycles 14.3%, pedestrians 8.6%, motorcycles 5.1%, N2/N3-vehicles 2.3%, other types 1.6%, and single accidents 19.4%, with a total of 12,859 participants. In contrast, for accidents without AWC, M1/N1-vehicles make up 45.9%, bicycles 23.4%, pedestrians 8.6%, motorcycles 9.6%, N2/N3-vehicles 2.2%, other types 1.8%, and single accidents 8.5%, totalling 28,878 participants. The notable differences are a higher percentage of bicycle and motorcycle involvement in accidents without AWC, while single accidents are significantly more frequent with AWC. Pedestrian involvement remains consistent in both scenarios. Overall, accidents without AWC involve a greater proportion of bicycles and motorcycles, whereas accidents with AWC show a higher incidence of single accidents.

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4.6.2 LOCATION

Variable name:	ORTSL
Start of documentation in GIDAS:	1999
Description:	Location (urban, rural, motorway)
Evaluation level:	Accident level

To analyse where the accidents happened and how these change with AWC, the variable “ORTSL” is evaluated. It is coded in three different categories: “urban”, “rural (without motorway” and “motorway”. The results of the valuation are displayed in Figure 28.

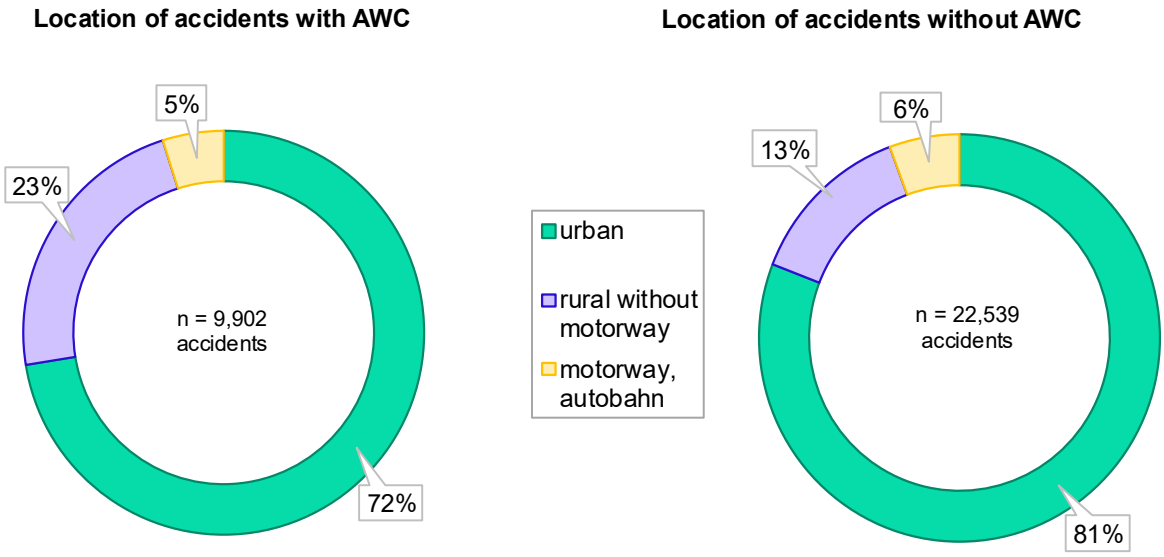

Figure 28 - Location of accidents with and without AWC

The largest category is describing the accidents happening on urban roads with between 72 % and 81 % in both charts displayed. The charts are divided into the accidents case list with and without AWC. The biggest difference is shown in the rural roads or the roads on the countryside. This percentage rises with adverse weather. So only 13 % of the cases without AWC happen on rural roads out of cities. 23 % of the accidents with adverse weather happen on rural roads, which are 10 % more. The number of accidents on motorways is nearly the same in both groups. The resulting conclusion is that adverse weather has an influence on the location of accidents. There tend to happen more accidents on the countryside and out of cities or villages during AWC.

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4.6.3 ACCIDENT TIME

Variable name:	TZEIT
Start of documentation in GIDAS:	1999
Description:	Describes time of the day
Evaluation level:	Accident level

The accident time is coded in GIDAS since the beginning of the documentation. This variable describes three parameters: “day “, “night” and “twilight/dawn”. Accidents with AWC are compared with the accidents without AWC to see if the time of the accidents has an additional influence on the accidentology.

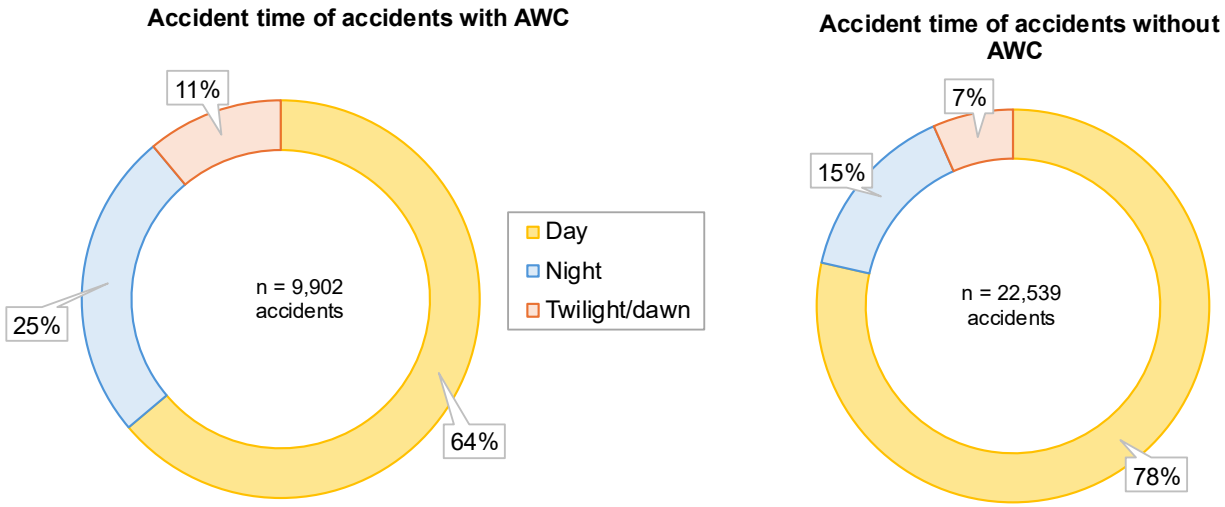

Figure 29 - Distribution of accident time with and without AWC

Regarding to the Figure 29 displayed above, two main statements can be made. In comparison to accidents without AWC, a higher percentage of AWC-accidents happened at twilight/dawn or at night. This means in numbers that there are 10 % more accidents with AWC happened at night and 4 % more accidents with AWC happened at dawn.
Regarding the higher percentage of AWC-accidents happening at a time with less illumination, the analysis of the road illumination could be interesting.

Streetlights are defined in GIDAS by the variable described in the table below.

Variable name:	STRABEL
Start of documentation in GIDAS:	1999
Description:	Availability of streetlights at the time of the accidents
Evaluation level:	Participant level

This variable defines the existence and illumination of streetlights at the time of the accident. The evaluation results are displayed in the same way as before, but the number are described on participant level, because one of the participants could have been driving on a road with streetlights while the other one could have been driving on an unilluminated road. The following two charts display the accidents with AWC split into participants in accidents at night and participants in accidents at dawn. There are about 14 % of the general number of 9,902 AWC-accidents happening at dawn and about 32 % happening at night. To evaluate how much glare potential could come from streetlights, the distribution of the streetlight illumination is analysed.

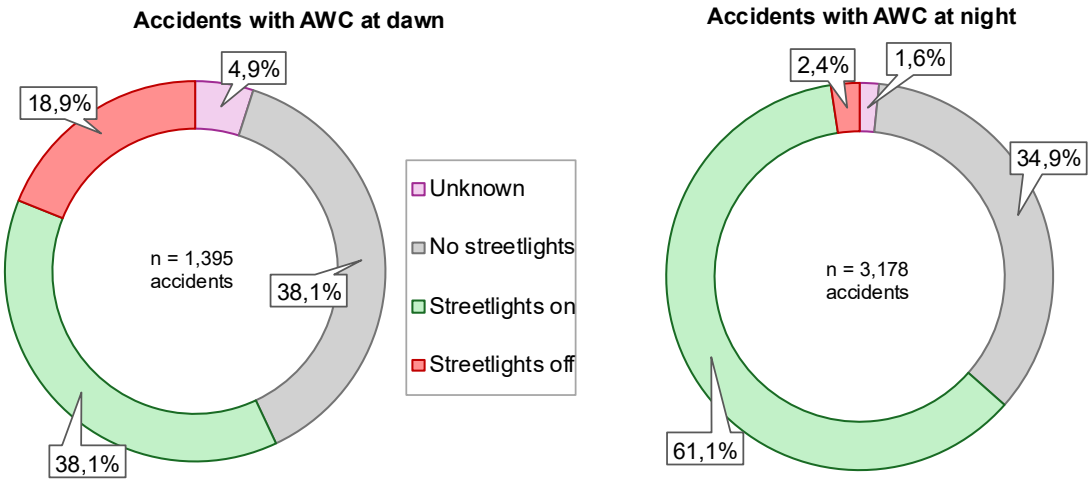

Figure 30 - Distribution of streetlights in dawn- and night-accidents with AWC

The charts in Figure 30 compare accidents with AWC at dawn and at night, categorized by streetlight status. At dawn, 38.1 % of the participants have been driving on a road with no streetlights, 38.0 % on a road with streetlights on, 18.9 % on a road with streetlights off, and 4.9 % with unknown streetlight status.
At night, 34.9 % of the participants have been driving on a road with no streetlights, 61.1 % on a road with streetlights on, 2.4 % on a road with streetlights off, and 1.6 % with unknown streetlight status.
Thus, more participants in accidents at night had switched on streetlights, while dawn saw a higher proportion with switched off streetlights or no streetlights. Those results are reasonable as there is a higher probability of the streetlights being switched off at dawn than at night. The proportion of streetlights turned off at dawn is taken up by streetlights turned on at night. So, there is a higher probability of a car being blinded by streetlights at night than at dawn. But as evaluated earlier in 4.3.6, the road illumination has an insignificant influence on blinding participants. The percentage of the category with no streetlights nearly stays the same with 38.1 % and 34.9 %.

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4.6.4 INJURY CATEGORIES

Variable name:	PVERL
Start of documentation in GIDAS:	1999
Description:	Injury severity on person level
Evaluation level:	Person level

The injury categories are coded in GIDAS since 1999 and define how severe the injury/ injuries per person is(are). The variable divides into “not injured”, “slightly injured”, “seriously injured”, “killed” and “unknown”. Accordingly, the following two charts compare the injury categories of people who had an accident with and without AWC.

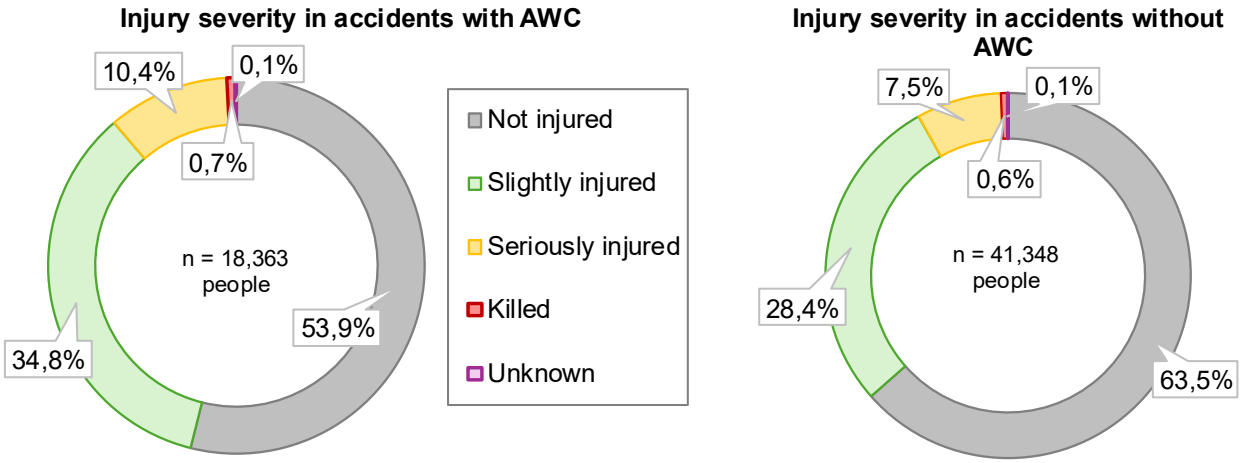

Figure 31 - Injury severity categories in accidents with and without AWC

The chart on the left side in Figure 31 displays the distribution of the injury severity of people in accidents with AWC. The right side shows the injury severity of people in accidents without AWC. The evaluation of this variable is made on person level. That means, it could have been an accident with two participants, in which one participant includes two persons. The biggest difference is recognizable in the numbers of the slightly and seriously injured people. There are about 6 % more people slightly injured and about 3 % more people seriously injured during accidents with adverse weather. The number of killed people nearly stays the same. All in all, the proportion of the killed and severely injured (abbr.: KSI) is about 3 % higher with AWC.

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4.6.5 EMERGENCY BRAKE ASSISTANT

Variable name:	AEBLANG, AEBQUER, AEBFGRF
Start of documentation in GIDAS:	2014
Description:	Describes availability of emergency brake systems
Evaluation level:	Participant level

To code if the vehicle includes a system for AEB, three variables in GIDAS describe the existence of different AEB-Systems. The first variable “AEBLANG” defines whether the vehicle is equipped with an emergency braking or steering system designed to prevent rear-end collisions. The second variable “AEBQUER” states if the vehicle is equipped with an AEB-System designed to prevent accidents with crossing vehicles. And the third variable “AEBFGRF” includes the information whether the vehicle is equipped with an AEB-System designed to prevent accidents involving pedestrians or cyclists. The variables are coded since 2014 and the percentages in the charts below are in relation to the participants of the accidents since this year.

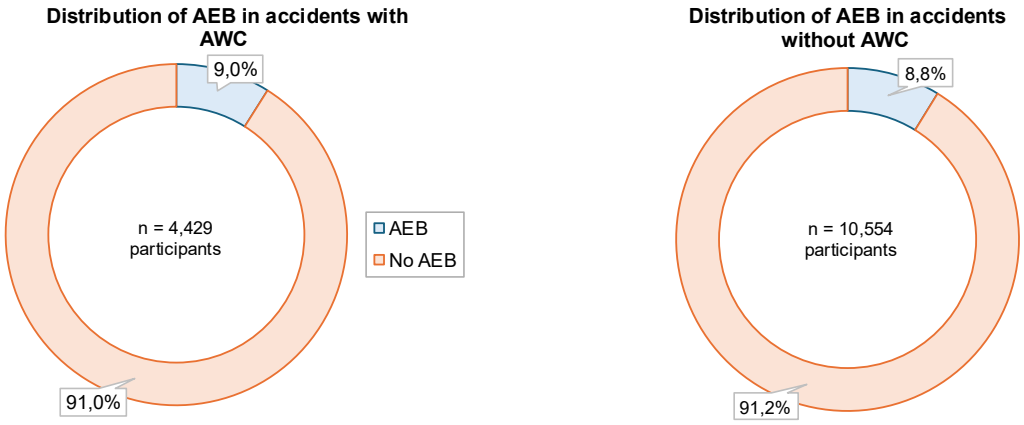

Figure 32 - AEB-System availability in accidents with and without AWC

The two charts in Figure 32 are illustrating the distribution of AEB at participants in accidents with and without AWC. The first chart shows that out of 4,429 participants, 91 % were not equipped with an AEB, while 9 % were equipped with at least one AEB. The main difference to the right chart is the number of participants, as there are a lot more participants having an accident during good or not adverse weather conditions. The distribution of AEB’s nearly stays the same.

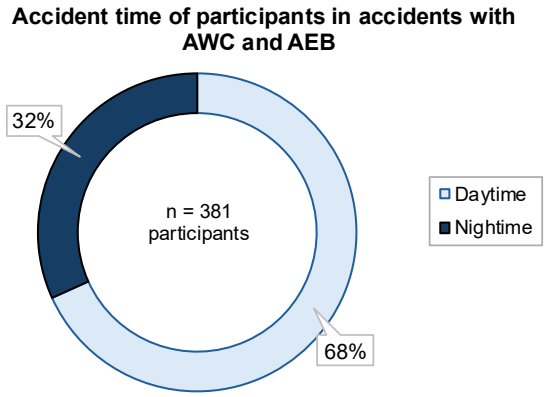

Figure 33 - Accident time of participants in accidents with AWC and AEB

Figure 33 shows the day and nighttime distribution of the 381 participants which had an accident during AWC and drove a vehicle which was equipped with at least one AEB. 68 % had their accidents during daytime, while 32 % had their accidents during nighttime. This distribution reflects similar percentages as the general distribution of accident time in Figure 29.
Thus, the main conclusion is that only about 9 % of all participants include an AEB.

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4.7 ACCIDENT SCENARIO DESCRIPTION

4.7.1 ACCIDENT SCENARIOS IN GENERAL

Variable name:	UTYP
Start of documentation in GIDAS:	1999
Description:	Describes accident type in general per accident
Evaluation level:	Accident level

To determine which scenarios are most relevant for further steps in the simulation, the general scenario distribution should be analysed. To give a general overview about the accident scenarios, the charts in Figure 34 shows the distribution of accident scenario categories, comparing accidents with AWC to those without AWC.

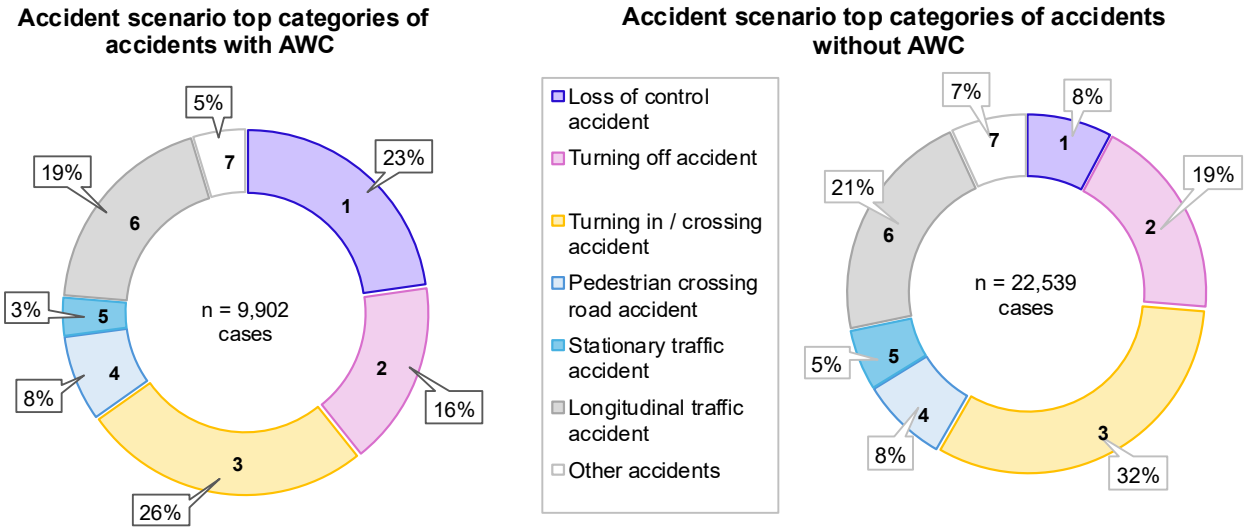

Figure 34 - Accident scenario top categories with and without AWC

Both charts are divided into seven sections, each representing a different type of accident scenario. The first chart, representing scenarios in accidents with AWC, shows the following proportions: loss of control accidents (23 %), turning off accidents (16 %), turning in/crossing accidents (26 %), pedestrian crossing road accidents (3%), stationary traffic accidents (8 %), longitudinal traffic accidents (19 %), and other accidents (5 %), with a total of 9,902 accidents. The second chart, representing scenarios in accidents without AWC, shows the same categories in a different distribution with a total of 22,539 accidents. Comparing the two charts, the introduction of AWC appears to increase the proportion of loss of control accidents significantly while reducing the proportions of turning off accidents, turning in/crossing accidents, pedestrian crossing road accidents, and other accidents. The proportions of stationary traffic accidents and longitudinal traffic accidents show little to no significant change.

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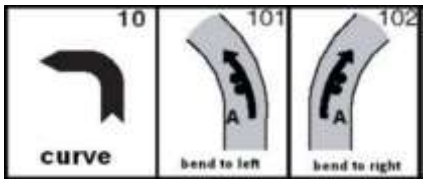
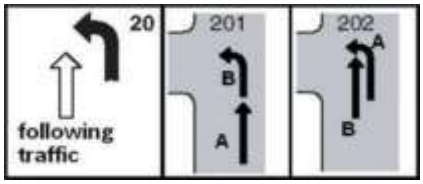
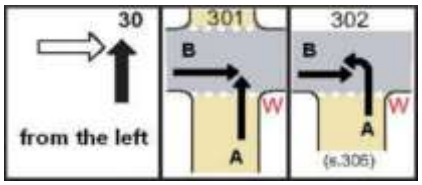
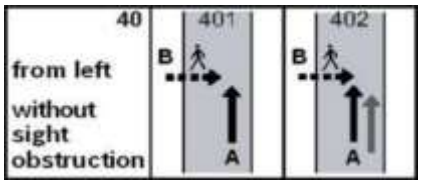
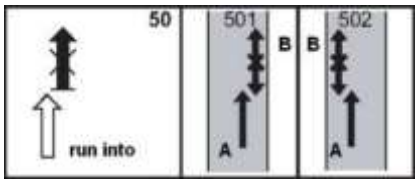
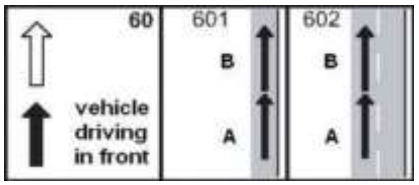
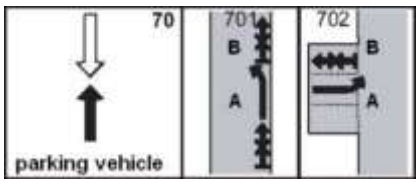
The following Table 8 describes the scenario top categories more nearly. The first column includes the category and some sub-categories of accident types. The second column includes the name of the category, and some scenarios are given as example sin the last column.

Table 8 - Description of the top scenario categories in general

Scenario category	Definition	Scenario examples
1 *(101,102, etc.)*	Loss of control accident	
2 *(201, 202, etc.)*	Turning off accident	
3 *(301, 302, etc.)*	Turning in / crossing accident	
4 *(401,402, etc.)*	Pedestrian crossing road accident	
5 *(501,502, etc.)*	Stationary traffic accident	
6 *(601, 602, etc.)*	Longitudinal traffic accident	
7 *(701, 702, etc.)*	Other accidents	

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4.7.2 ANALYSIS OF THE ACCIDENT SCENARIOS

The accident scenarios with the highest number of accidents are the most relevant for further investigations. In the end, the top five accident scenarios shall be analysed. To narrow down the scope of the analysis the top ten accident scenarios are displayed in Table 9. The data shows that most relevant differences happen to appear in the first five accident types. Between the number of accidents at fifth and the sixth place is a gap of about 100 accidents.

Table 9 - Comparison of the top 10 accident scenarios with and without AWC

Top 10 accident scenarios with AWC		**Top 10 accident scenarios without AWC**	
Accident type	Number of accidents	Accident type	Number of accidents
102	707	342	1512
141	591	211	1381
321	580	321	1370
211	557	302	1059
101	555	301	971
302	475	611	914
301	362	601	729
611	343	141	594
342	315	341	525
623	303	623	517

Table 10 shows the top five scenarios of the accidents with at least one passenger car involved divided into those with AWC and without AWC.

Table 10 - Comparison of top 5 scenarios with and without AWC

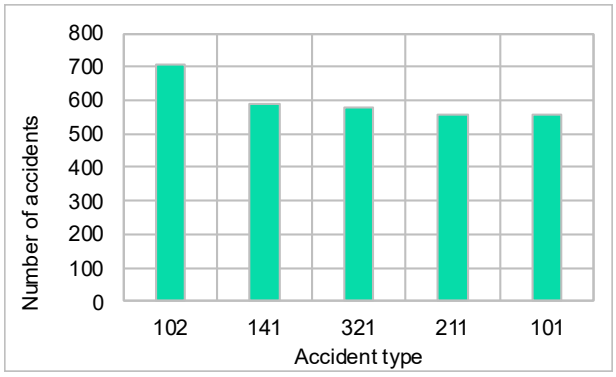
<table>
<tr><th>Top five accident scenarios with AWC</th><th>Top five accident scenarios without AWC</th></tr>
<tr><td>

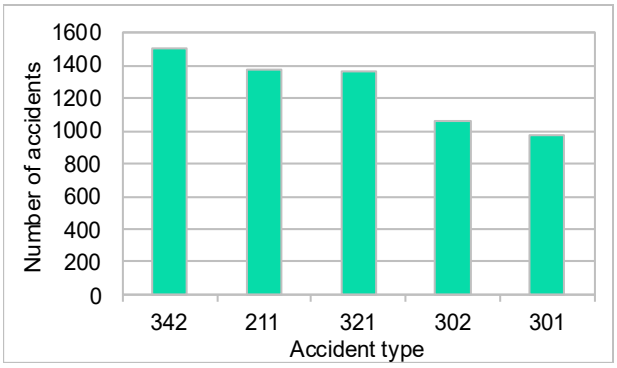
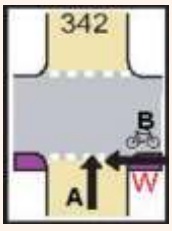
Figure 35 - Top 5 accident scenarios with AWC</td><td>

Figure 36 - Top 5 accident scenarios without AWC</td></tr>
<tr><td>
</td><td>- loss of control accident
- curve bend to right</td><td>
</td><td>- turning in/ crossing accident
- starting to cross the priority road
- cyclist comes from the right sidewalk</td></tr>
</table>

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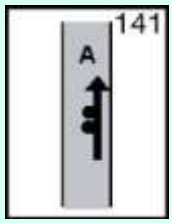
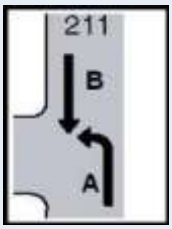
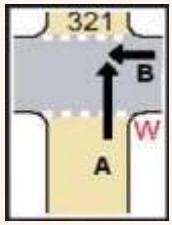
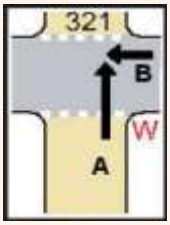
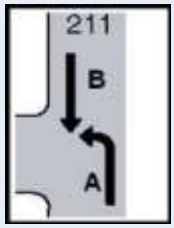
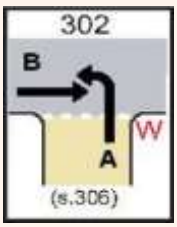
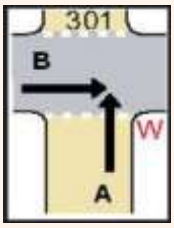
	- loss of control accident - on straight road		- turning off accident - turning left on an intersection - no priority road
	- turning in/ crossing accident - crossing the priority road - opponent comes from the right side		- turning in/ crossing accident - crossing the priority road - opponent comes from the right side
	- turning off accident - turning left on an intersection - no priority road		- turning in/ crossing accident - turning in on the priority road - opponent comes from the left side
	- loss of control accident - curve bend to left		- turning in/ crossing accident - crossing the priority road - opponent comes from the left side

The most appearing accident scenarios during or because of adverse weather are “loss of control”-accidents. Those accidents take up the first, second and fourth place. This implicates that most of the accidents which can be related to adverse weather happen without a direct opponent because of loss of control.

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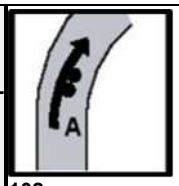
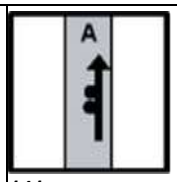
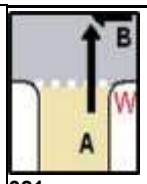
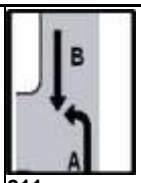
The following Table 11 summarizes the detailed weather conditions during the top five AWC accident scenarios. Road surface and the combination of precipitation and road surface seem to have a quite similar and high share in all scenarios. Those are always followed by sun glare and combinations of those three. All in all, rain/snow and wet/icy roads seem to have the most significant influence.
One special difference can be found in the proportion of sun glare as a contributing factor within the intersection accident scenarios “321” and “211”. The share of sun glare is a lot higher than with the loss of control accidents “102”, ”141” and “101”. In the scenario ”211”, seven percent more accidents happened with sun glare as contributing factor than in scenario “321”. The reason here could be the opponents coming from the front and therefor blinding sun from the front being a worse influence than in the other scenario.

Table 11 - Detailed weather conditions during the top five AWC scenarios

Top 5 AWC-Scenarios	 **102**	 **141**	 **321**	 **211**	 **101**
Number of scenarios	N = 707	N = 591	N = 580	N = 557	N = 555
Road surface	54.9 %	44.3 %	46.2 %	37.9 %	50.8 %
Road surface + Precipitation	42.6 %	50.4 %	37.1 %	40.2 %	45.6 %
Sun Glare	1.1 %	1.7 %	14.0 %	20.5 %	2.0 %
Sun Glare + Road Surface	0.1 %	0.5 %	1.7 %	0.5 %	0.4 %
Precipitation	0.0 %	0.3 %	0.9 %	0.4 %	0.2 %
Road Surface + Fog	1.0 %	1.9 %	0.0 %	0.5 %	0.9 %
Precipitation +Road Surface + Fog	0.3 %	0.3 %	0.0 %	0.0 %	0.2 %
Precipitation + Sun Glare + Road surface	0.0 %	0.5 %	0.2 %	0 %	0.0 %

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4.7.3 TOP 10 SCENARIOS WITH KILLED OR SEVERELY INJURED PEOPLE

The following Table 12 displays the top 10 accident scenarios with AWC on the left and the top 10 accident scenarios with AWC and KSI (abbr.: Killed or severely injured) on the right. When looking at the top five accident scenarios the general content of accident types “102”, “141”, “101”, “321” and “211” stays the same. There is a change in the distribution of the accidents type numbers. When looking at KSI only accident scenarios, the loss of control accident scenarios become a little more relevant and spread across the top three. Additionally, accidents with crossing pedestrians from left “401” and with crossing pedestrians from right “421” appear in the top 10 scenarios with AWC and KSI.

Table 12 - Top 10 accident scenarios with relation to AWC and at least one killed or severely injured person

Top 10 accident scenarios with AWC		**Top 10 accident scenarios with AWC and KSI only**	
Accident type	Number of accidents	Accident type	Number of accidents
102	707	102	286
141	591	141	234
321	580	101	219
211	557	321	147
101	555	211	135
302	475	302	117
301	362	301	92
611	343	401	63
342	315	421	54
623	303	342	54

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4.8 SCENARIO PARAMETERS

This chapter evaluates the top five scenario categories regarding different parameters which are representative for EuroNCAP test scenarios. Those scenarios include the loss of control accidents scenarios with the accident types “101”, “102” and “141” and the intersection accidents with the accident types “211” and “321”.

4.8.1 COLLISION SPEED

Variable name:	VK
Start of documentation in GIDAS:	1999
Description:	Describes the collision speed of the participant
Evaluation level:	Event level

The following Figure 37 and Figure 38 display the collision speed of the first collision (event) of the participant “A” and “B” of the filtered accidents. This variable is evaluated on event level, because one participant can have more than one event like a sliding situation or even a collision in an accident. For this analysis, the first and accident triggering collision is most relevant. Therefor the following evaluation is only representative for the first collision in the examined accidents. The chart in Figure 37 shows the collision speeds for loss of control accidents involving 1,853 participants.

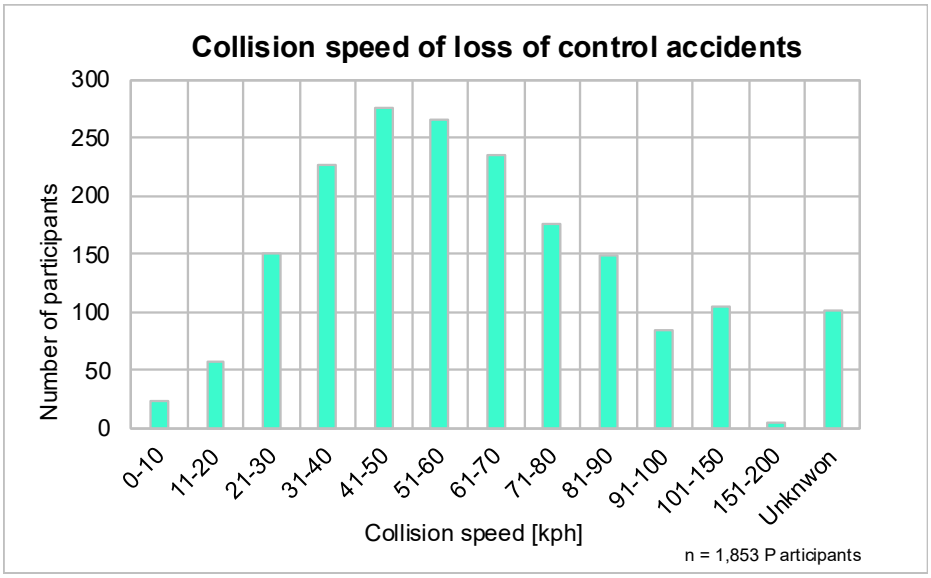

Figure 37 - Collision speed of loss of control accidents with AWC

The chart in Figure 39 displays the collision speeds for loss of control accidents involving 1,853 participants. The distribution of collision speeds is shown in various ranges from 0-10 kph to 151-200 kph, with an additional category for unknown speeds. The most accidents occurred within the 41-50 kph and 51-60 kph ranges, each accounting for nearly 300 participants. The 31-40 kph and 61-70 kph ranges also saw significant numbers, with each range involving over 200 participants. There are fewer accidents at both lower (0-10 kph, 11-20 kph) and higher speeds (101-150 kph), with the least in the 151-200 kph range. A notable number of accidents have unknown collision speeds, suggesting incomplete data for some incidents. The chart indicates that loss of control accidents most frequently occur at moderate speeds between 31-70 kph.

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Figure 38 illustrates the collision speeds for intersection accidents involving 1,761 participants. The collision speeds are categorized into ranges from 0-10 km/h to 91-100 km/h, along with an additional category for unknown speeds.

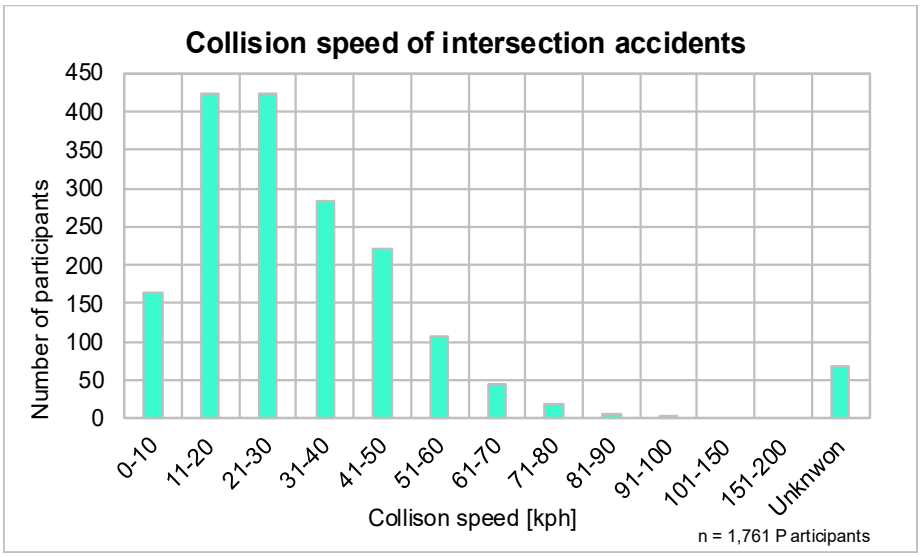

Figure 38 - Collision speed of intersection accidents with AWC

The highest number of accidents occurred in the 11-20 kph and 21-30 kph ranges, each involving around 400 participants. The 31-40 kph and 41-50 kph ranges also had significant numbers, with approximately 300 and 200 participants respectively. Fewer accidents were observed at both lower (0-10 kph) and higher speeds (51-60 kph and above), with a sharp decline in accidents beyond 50 kph. There is a notable number of accidents with unknown collision speeds.

The main difference between this chart and the previous one (collision speed of loss of control accidents) is the distribution of collision speeds. Intersection accidents predominantly occur at lower speeds (11-30 kph), whereas loss of control accidents are more frequent at moderate speeds (31-70 kph). This suggests that intersection accidents tend to happen at lower speeds compared to loss of control accidents, which often occur at higher speeds

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4.8.2 ACCELERATION AND DECELERATION

Variable name:	BV
Start of documentation in GIDAS:	1999
Description:	States if an acceleration or deceleration happened and how high it was
Evaluation level:	Event level

The acceleration and deceleration of a vehicle is coded in the variable of the braking deceleration. This variable is evaluated on event level as well, because every event within an accident can include different accelerations or decelerations. This analysis is looking at the first accident triggering collision of the accident as described in chapter 4.8.1 before. This variable is a numeric number which can be negative or positive. If it is positive, the number describes acceleration and if it is negative, it was a deceleration.

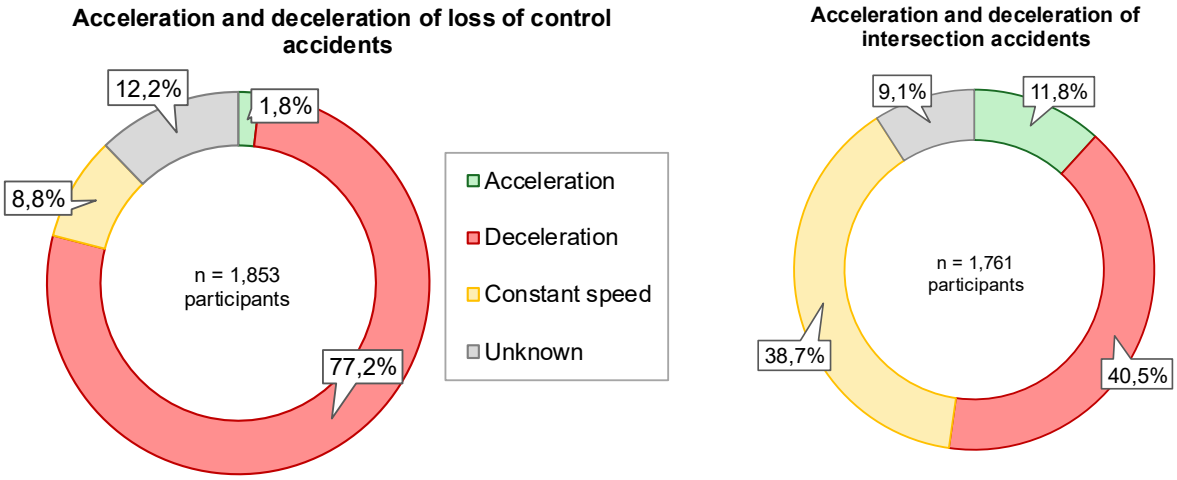

Figure 39 - Distribution of acceleration and deceleration in the top five accident scenarios with AWC

The two charts in Figure 39 illustrate the distribution of acceleration and deceleration phases in loss of control accidents and intersection AWC-accidents. In loss of control accidents, 77.2 % of the participants decelerated in the event of the first collision, 12.2 % were at constant speed, 8.8 % were in unknown phases, and only 1.8 % were accelerating, with a total of 1,853 participants.
On the other hand, for intersection accidents, 40.5 % of participants were decelerating in the event of the first collision, 38.7 % were at constant speed, 11.8 % were accelerating, and 9.1 % were in unknown phases, with a total of 1,781 participants.

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The main differences between the two types of accidents are that deceleration is significantly higher in loss of control accidents compared to intersection accidents, while constant speed and acceleration phases are more prevalent in intersection accidents. The proportion of unknown phases is similar between the two types of accidents, with only a slight difference. These comparisons highlight the different dynamics involved in each type of accident, particularly the deceleration in loss of control scenarios and a more balanced distribution of phases in intersection accidents. The following Table 13 includes the main braking deceleration numbers.

Table 13 - Braking deceleration numbers

	Loss of control accidents	Intersection accidents
Acceleration	b_v = [- 0.1 … - 5.9 m/s^2] Distribution evenly	b_v = [- 0.4 … - 4.4 m/s^2] Mainly around: b_v = [-1.5 … -2.0 m/s^2]
Deceleration	b_v = [0.1 … 12 m/s^2] Mainly around: b_v = [3.0 … 4.0 m/s^2]	b_v = [0.3 … 9.0 m/s^2] Mainly around: b_v = [5.0 … 6.0 m/s^2]

4.8.3 ROAD SURFACE MATERIAL

Variable name:	STRDECK
Start of documentation in GIDAS:	1999
Description:	States which kind of material the road at the time of the accident was made of
Evaluation level:	Participant level

The following two charts illustrate the distribution of road surface materials involved in two types of AWC-accidents: loss of control and intersection accidents.

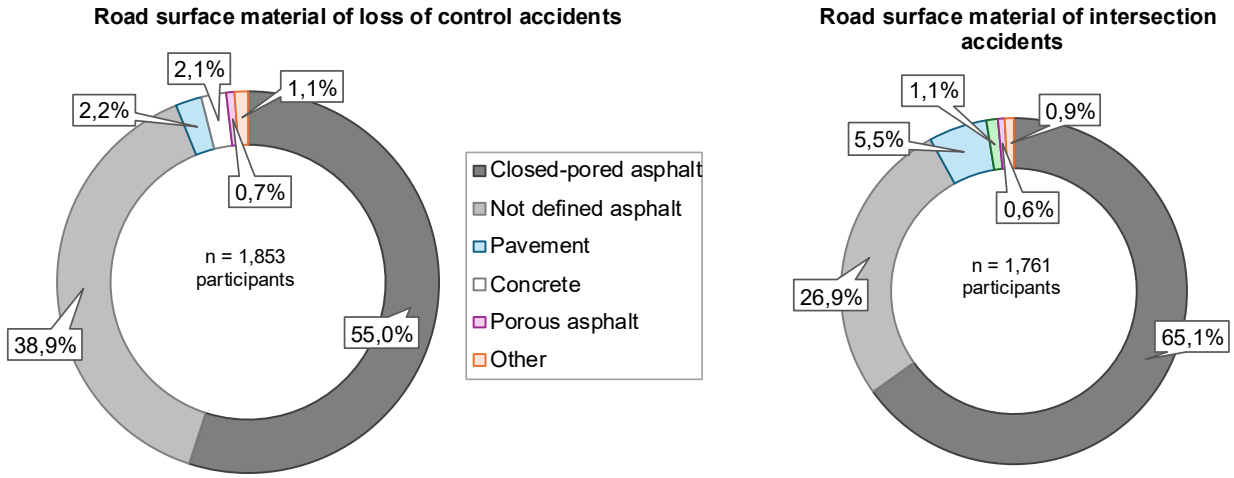

Figure 40 - Distribution of road surface material in-between the different AWC scenario categories

In the first chart in Figure 40, which covers loss of control accidents with 1,853 participants, the majority (55.0 %) occurred on closed-pored asphalt, followed by 38.9 % on not defined asphalt, 2.2 % on pavement, 2.1 % on concrete, 1.1 % on porous asphalt, and 0.7 % on other surfaces. The second chart depicts intersection accidents involving 1,781 participants, with 65.1 % of these accidents happening on closed-pored asphalt, 26.9 % on not defined asphalt, 5.5 % on pavement, 1.1 % on concrete, 0.9 % on porous asphalt, and 0.6 % on other surfaces. These charts highlight the predominance of closed-pored asphalt in both types of accidents, with a notably higher percentage in intersection accidents compared to loss of control accidents.

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5. Evaluation of the IGLAD-Database

As an addition to the national GIDAS database it would be interesting to take a look at the database IGLAD. The following chapters describe this database in general and give a superficial analysis of the data, to compare if the results are similar to the analysed European, statistical data in chapter 3.1.

5.1 General information about IGLAD

The IGLAD database is a comprehensive repository of road accident data aimed at enhancing traffic safety.

“The project was initiated by Daimler AG, ACEA and different research institutes and announced as a working group at the FIA Mobility Group in October 2010. The goal of the group was to define a common in-depth accident data standard and provide a yearly data set that is created from international partners that are part of the consortium. The non-profit project is completely self-funded and offers its data to interested parties to be used for research purposes charging a moderate membership fee. In January 2023 IGLAD has entered its fifth phase and continues to deliver comparable world-wide in-depth accident data for another 3 years.’’ [3]



Figure 41 - Merged data in IGLAD and its contributors around the world [3]

“The consortium currently consists of 20 members complemented by the chair and the administrator from SAFER Vehicle and Traffic Safety Centre at Chalmers, Sweden. The project celebrated its 10th yearly data release in June 2023. The complete merged dataset includes 10,555 cases provided by 14 data providers located in 12 different countries: Australia, Austria, Brazil, China, Czech Republic, France, Germany, India, Italy, USA, Spain, and Sweden. New countries, data providers, and members are expected to join the project soon. The goal is to cover as many regions/ countries of the world as possible.’’ [3]

The database compiles detailed information on road accidents, including vehicle types, collision circumstances, road conditions, and injury outcomes. This data is harmonized according to agreed standards to ensure consistency and reliability. By providing a large, standardized dataset, IGLAD supports research and development in vehicle safety technologies, informs policymaking, and fosters international collaboration on traffic safety initiatives.

5.2 EVALUATION OF THE DATA

To compare the IGLAD-data to the general European statistics, all European countries in IGLAD are analysed in IGLAD concerning the AWC. These are Austria, Czech Republic, France, Germany, Italy, Spain, and Sweden. Therefor accidents with AWC are defined as in the GIDAS-analysis (4.5). Accidents with wet or icy roads, rainy, snowy, stormy weather conditions or accidents with influence of illumination by sun and other light sources are defined as adverse weather accidents.

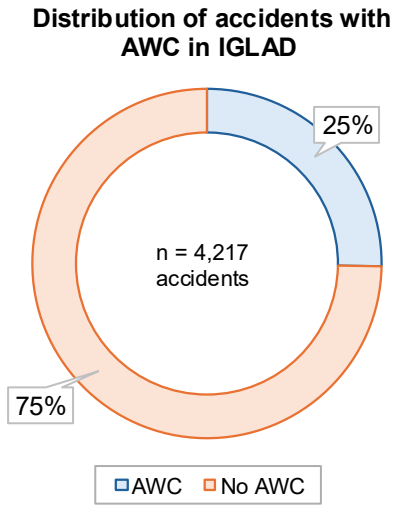

Figure 42 - Distribution of AWC in IGLAD

The Figure 42 is showing the distribution of AWC in IGLAD accidents in general. It indicates that out of 4,217 accidents, 75 % did not have AWC, while 25 % had AWC. The proportion of AWC-accidents with 25 % is a little less than the 30 % in GIDAS.
Despite this the closer look into IGLAD and the included countries shows a more similar sharing.

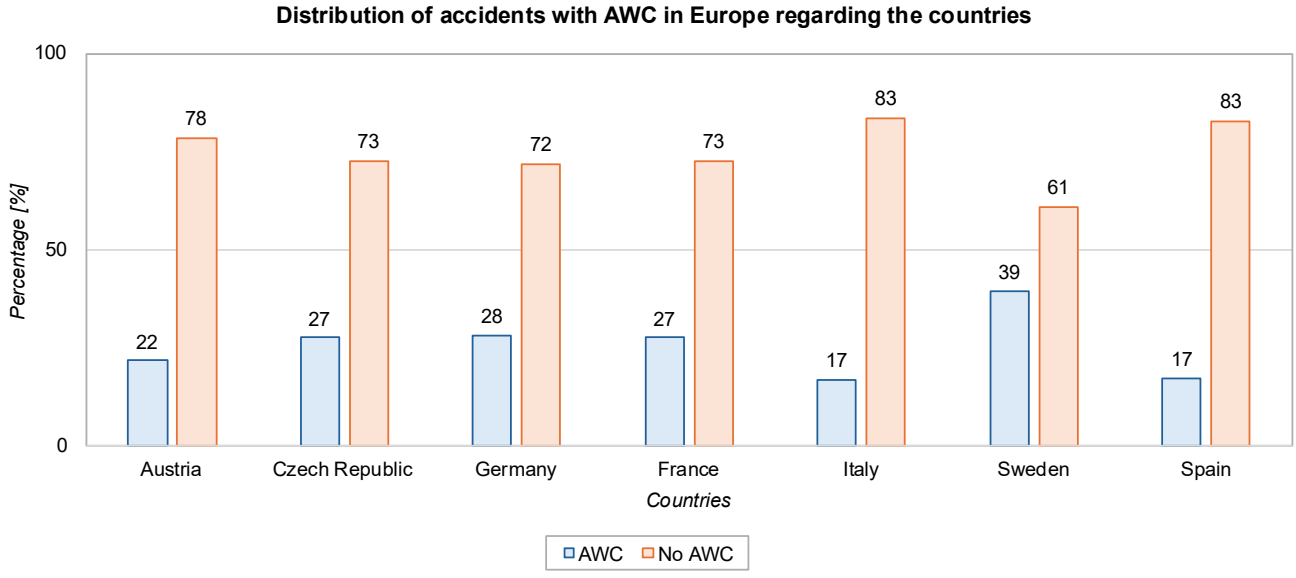

Figure 43 - Distribution of AWC per European country in IGLAD

Figure 43 illustrates the spread of AWC in various European countries. Each country is represented with two bars: one for the accidents with AWC and one for the accidents without AWC. The percentages of accidents with AWC range from 17 % in Italy and Spain to 39 % in Sweden. Other countries include Austria (22 % AWC), Czech Republic (27 % AWC), Germany (28 % AWC), and France (27 % AWC).

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6. EuroNCAP scenarios in GIDAS

The EuroNCAP is an organization that evaluates the safety of vehicles sold in Europe. Founded in 1997 by the Transport Research Laboratory for the UK Department for Transport, EuroNCAP conducts rigorous crash tests and other safety assessments to provide consumers with independent safety ratings. The program's assessments cover areas such as adult occupant protection, child occupant protection, pedestrian protection, and safety assist technologies. Over the years, EuroNCAP's stringent testing standards have significantly influenced car manufacturers to enhance vehicle safety features, leading to safer cars on European roads. [8] [9]

6.1 General information about EuroNCAP

The EuroNCAP test scenarios aim to evaluate different systems. When it comes to a situation addressing an AEB with at least one passenger car involved, they are divided into four sub-groups:

- car-to-car
- car-to-motorcycle
- car-to-bicycle
- car-to-pedestrian

Among these four sub-groups, further test scenarios are described, shown in the Table 14 below:

Table 14 - List of all EuroNCAP scenarios [8] [9]

Category	Scenario	Description
Car-to-Car scenarios	CCRs	- vehicle crashes into another stationary vehicle from behind
	CCRm	- vehicle crashes into another driving vehicle from behind
	CCRb	- vehicle drives behind a vehicle - the first decelerates and the one from behind crashes
	CCFtap	- a collision in which a vehicle turns across the path of an oncoming vehicle
	CCCscp	- two vehicles cross an intersection and collide
	CCFho	- two vehicles crash frontal into each other - one vehicle overtakes another and crashes into the oncoming traffic
Car-to-motorcyclist scenarios	CMRs	- vehicle crashes into motorcyclist (abbr.: MC) from behind - MC is standing
	CMRb	- vehicle crashes into MC from behind while MC is braking
	CMFtap	- vehicle turns left at an intersection - MC comes from the front and crashes
Car-to-bicyclist scenarios	CBFA	- a collision in which a vehicle travels forwards towards a bicyclist crossing its path from the far side (no braking)
	CBNA	- a collision in which a vehicle travels forward towards a bicyclist crossing its path from the nearside - cyclist could also come from behind an obstruction (no braking)
	CBLA	- bicyclist is moving in front of a driving vehicle - vehicle crashes into bike from behind
	CBTA	- vehicle turns left at intersection - vehicle crashes into cyclist which comes from the front - vehicle can also turn right and collides with bike which comes from the footpath

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Car-to-Pedestrian scenarios	CPNA	- a collision in which a vehicle travels forward towards an adult pedestrian crossing its path walking from the nearside
	CPFA	- a collision in which a vehicle travels forward towards an adult pedestrian crossing its path running from the far side
	CPNCO	- a collision in which a vehicle travels forward towards a child pedestrian crossing its path running from behind an obstruction from the nearside
	CPLA	- a collision in which a vehicle travels forward towards an adult pedestrian walking in the same direction in front of the vehicle
	CPTA	- a collision where the vehicle is turning at an intersection and crashes into a crossing pedestrian from far side or nearside
	CPRA/CPRC	- vehicles reverses into standing or moving adult or child pedestrian

6.2 THE EURONCAP MAPPING IN GIDAS

The mapping of the EuroNCAP scenarios into GIDAS is developed together with Toyota Motor Europe (abbr.: TME). The mapping was published by TME and VUFO at the Carhs event “Euro NCAP UpDate” on the 10th of December 2024. The following sub-chapters 6.2.1, 6.2.2 and 6.2.3 include the detailed description of the EuroNCAP mapping and gives information about the results of matching the EuroNCAP scenarios into GIDAS. As mentioned in chapter 6.2.2 before, the mapping focuses on AEB testing scenarios. Therefor not all EuroNCAP scenarios are described.

6.2.1 METHODOLOGY OF THE EURONCAP MAPPING

The methodology bases on the existing EuroNCAP scenarios, thus it is split into the following scenario groups:

- car-to-car
- car-to-motorcycle
- car-to-bicycle
- car-to-pedestrian

For the mapping in GIDAS, the first collision got considered. As in every EuroNCAP scenario, the so-called ego-vehicle is a passenger car. The ego-vehicle is the vehicle which sustains the frontal impact in the accident. It is only made for accidents with exactly two participants. The overlap of the ego-vehicle was not implemented to the mapping. For all accident types without a further specification, the ego-vehicle is participant A (GIDAS variable UTYPA). In most of the scenarios a speed tolerance between 5 and 10 kph have been chosen to account for tolerances that may happen during the reconstruction of the accident and which is also part of the EuroNCAP protocols.
For all the scenario groups, the EuroNCAP characteristics are described in **black**. The **turquoise** characteristics describe the chosen specification in GIDAS (GIDAS variables in capital letters). All the used characteristics in GIDAS have been defined in close coordination with TME.
After filtering the scenarios in GIDAS, the resulting EuroNCAP scenarios in GIDAS are analysed in the following sub-chapter 6.2.2 and 6.2.3.

Car-to-car EuroNCAP scenarios:
The following Table 15 depicts the car-to-car EuroNCAP scenarios which were described in the previous main chapter (6.1). Those six scenarios are filtered according to their characteristics.
The high tolerances of the ego vehicle speed at CCRs and CCRm are based on different EuroNCAP protocols.

*Table 15 - Car-to-car EuroNCAP scenarios and their characterization in **GIDAS***

	CCRs	CCRm	CCRb	CCFtap	CCCscp	Head-On
Accident type	UTYP: 201; 231; 541; 542; 601; 602; 603; 604; 611; 612; 613; 614; 621; 622; 623; 624			UTYP: 211; 281; 354 Ego as B: 351	UTYP: 271; 301; 311; 321; 331; 353; 355; 561; 562	UTYP: 661; 681
Target kind	Vehicle (KLASSECE = 1)					
Ego vehicle speed [kph]	10 - 80 (5 ≤ V0 ≤ 130)	30 - 80 (25 ≤ V0 ≤ 130)	50 (V0 ≤ 60)	10; 15; 20 (5 ≤ V0 ≤ 25)	20 - 60 (10 ≤ V0 ≤ 70)	50 - 70 (40 ≤ V0 ≤ 80)
Target vehicle speed [kph]	V0 = 0	V0 > 0 & Target driving speed < Ego vehicle driving speed & SEQART IS NOT 4	Braking vehicle (SEQART = 4 & V0 > 0)	30; 45; 60 (25 ≤ V0 ≤ 70)	20 - 60 (10 ≤ V0 ≤ 70)	50 - 70 (40 ≤ V0 ≤ 80)
Weather condition	Sunny/Cloudy (NIED = 2)					
Ego road surface condition	Dry (STROB = 3)					
Time of the day/ Light conditions	Daylight (TZEIT = 3)					
Ego VDI1	12	12	12	01; 11; 12	01; 11; 12	12
Target VDI2	03	03	03	01; 02; 04	02; 04	01
Other					No obstruction ego (SICHTBV = 0; 2)	

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Car-to-motorcycle EuroNCAP scenarios:
The next Table 16 describes the five recent EuroNCAP car-to-motorcycle scenarios which were analysed in GIDAS as well. The methodology is similar to the one in Table 15.

*Table 16 - Car-to-motorcycle EuroNCAP scenarios and their characterization in **GIDAS***

Scenario	CMRs	CMRb	CMFtap
Accident type	UTYP: 201; 231; 541; 542; 601; 602; 603; 604; 611; 612; 613; 614; 621; 622; 623; 624		UTYP: 211; 281; 354 Ego as B: 351
Target kind	Motorcycle (FART = 11)		
Ego vehicle speed [kph]	10 - 60 (5 ≤ V0 ≤ 70)	50 (V0 ≤ 60)	10; 15; 20 (5 ≤ V0 ≤ 25)
Target vehicle speed [kph]	V0 = 0	50 (SEQART = 4)	30; 45; 60 (20 ≤ V0 ≤ 70)
Weather condition	Sunny/Cloudy (NIED = 2)		
Ego road surface condition	Dry (STROB = 3)		
Time of the day/ Light conditions	Daylight (TZEIT = 3)		
Ego VDI2	01		

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Car-to-Bicycle EuroNCAP scenarios:
The next Table 17 describes the five recent EuroNCAP car-to-motorcycle scenarios which were analysed in GIDAS as well. The methodology is similar to the one in Table 15 and Table 16.

*Table 17 - Car-to-bicycle EuroNCAP scenarios and their characterization in **GIDAS***

Scenario	CBFA	CBNA	CBLA	CBTA
Accident type	UTYP: 301; 341; 343; 372 Ego as B: 321; 353; 355	UTYP: 321; 342; 344; 353; 355; 371 Ego as B: 301	UTYP: 201; 231; 541; 542; 601, 602; 603; 604; 611; 612, 613; 614; 621; 622; 623; 624	UTYP: 211; 224; 244; 281; 283; 285; 354 Ego as B: 351
Target kind	Bicycle (FART = 10)			
Ego vehicle speed [kph]	10 - 60 (5 ≤ V0 ≤ 70)	10 - 60 (5 ≤ V0 ≤ 70)	25 - 60 (10 ≤ V0 ≤ 70)	10; 15; 20 (5 ≤ V0 ≤ 25)
Target vehicle speed [kph]	20 (15 ≤ V0 ≤ 25)	10; 15 (5 ≤ V0 ≤ 20)	15; 20 (10 ≤ V0 ≤ 25)	15 (10 ≤ V0 ≤ 20)
Target age	Adult (ALTER1 ≥ 18)			
Cycle Direction (Ego VDI1)	08; 09; 10; 11; 12	12; 01;02; 03; 04	11; 12; 01	08; 09; 10; 11; 12; 01; 02; 03; 04
Weather condition	Sunny/Cloudy (NIED = 2)			
Ego road surface condition	Dry (STROB = 3)			
Time of the day/ Light conditions	Daylight (TZEIT = 3)			
Ego VDI2	01			
Other	No obstruction (SICHTBV = 0; 2)			

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Car-to-pedestrian EuroNCAP scenarios:
This Table 18 describes the six recent EuroNCAP car-to-pedestrian scenarios which were analysed in GIDAS. The methodology is similar to the one in the three tables before.

*Table 18 - Car-to-Pedestrian EuroNCAP scenarios and their characterization in **GIDAS***

Scenario	CPNA	CPFA	CPNCO	CPLA	CPTA		CPRA / CPRC
Accident type	UTYP: 421; 451; 471	UTYP: 401; 402; 403; 431; 432; 433; 461; 462	UTYP: 423; 424; 453; 454; 473	UTYP: 671; 674	UTYP: 221; 222; 241; 242; 273; 275; 282; 284; 481; 482; 483; 484		UTYP: 713
Target kind	Adult (ALTER1 ≥ 18)		Child (ALTER1 < 8)	Adult (ALTER1 ≥ 18)			Adult or child (ALTER1 ≥ 18; < 8)
Ego vehicle speed [kph]	10 - 60 (5 ≤ V0 ≤ 70)			20 - 80 (10 ≤ V0 ≤ 90)	10; 15; 20 (5 ≤ V0 ≤ 25)	10 (5 ≤ V0 ≤ 25)	4; 8 (V0 ≤ 10)
Target walking speed [kph]	5 (FGVKOL = 3; 4; 5)	8 (FGVKOL = 6)	5 (FGVKOL = 3; 4; 5)				0; 5 (FGVKOL = 2; 3; 4; 5)
Weather condition	Sunny/Cloudy (NIED = 2)						
Ego road surface condition	Dry (STROB = 3)						
Time of the day/ Light conditions	Day/ Night (TZEIT = 3; 4)				Day (TZEIT = 3)		
Ego VDI2	01						03
Pedestrian direction to the car	Nearside (FGRI = 02; 03; 04)	Farside (FGRI = 08; 09; 10)	Nearside (FGRI = 02; 03; 04)	Backside (FGRI = 05; 06; 07)	Farside (FGRI = 08; 09; 10)	Nearside (FGRI = 02; 03; 04)	Standing or Nearside (FGRI = 02; 03; 04; 98)
Other	No obstruction for Ego (SICHTBV = 0; 2)		Obstruction for Ego (SICHTBV = 1; 3; 4; 8)				

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6.2.2 FINDINGS OF THE EURONCAP MAPPING

The general mapping results of the existing EuroNCAP scenarios in GIDAS are summarized in the next charts. The evaluation of the scenarios is done on participant level, because in one accident different participants could have different scenarios. Figure 44 shows that only 1.3 % of all participants of accidents with AWC fit into a EuroNCAP scenario. All other participants can't be assigned to an already existing testing scenario.

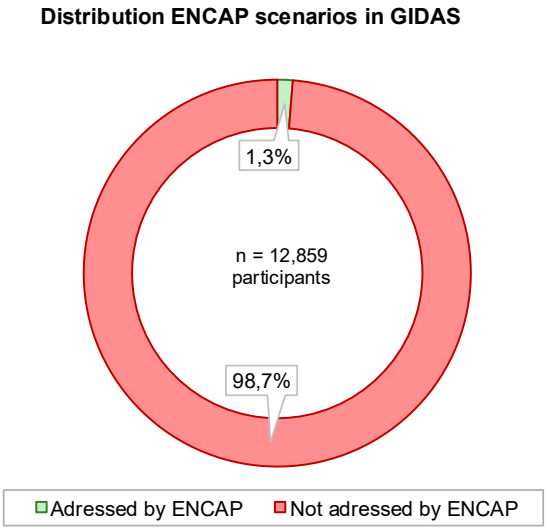

Figure 44 - EuroNCAP scenario distribution in GIDAS with AWC

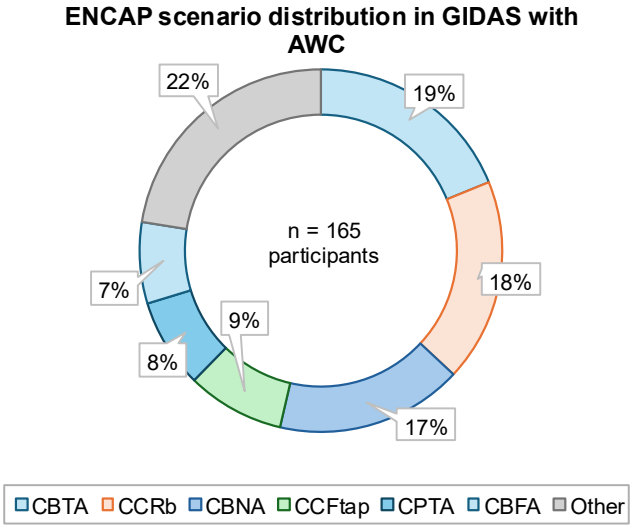

Figure 45 - EuroNCAP scenario distribution in GIDAS with AWC in detail

Figure 45 presents the distribution of the 1.3 % of participants which address different EuroNCAP scenarios. Each segment represents a specific EuroNCAP scenario and is color-coded and labeled with its corresponding percentage. The total number of participants (n = 165) is indicated in the centre of the chart. The legend matches each scenario abbreviation with its respective colour in the chart.
The CBTA category accounts for 19% of the total, while CCRb represents 18%. The CBNA category follows closely with 17%, and CCFtap makes up 9%. The CPTA and CBFA categories constitute 8% and 7%, respectively. Lastly, the "Other" category comprises 22% of the total. Each category is displayed in a distinct colour, as indicated in the legend below the chart.

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Figure 46 shows the top ten accident type distribution of the 98.7 % of participants in AWC accidents who do not match with an existing EuroNCAP scenario.

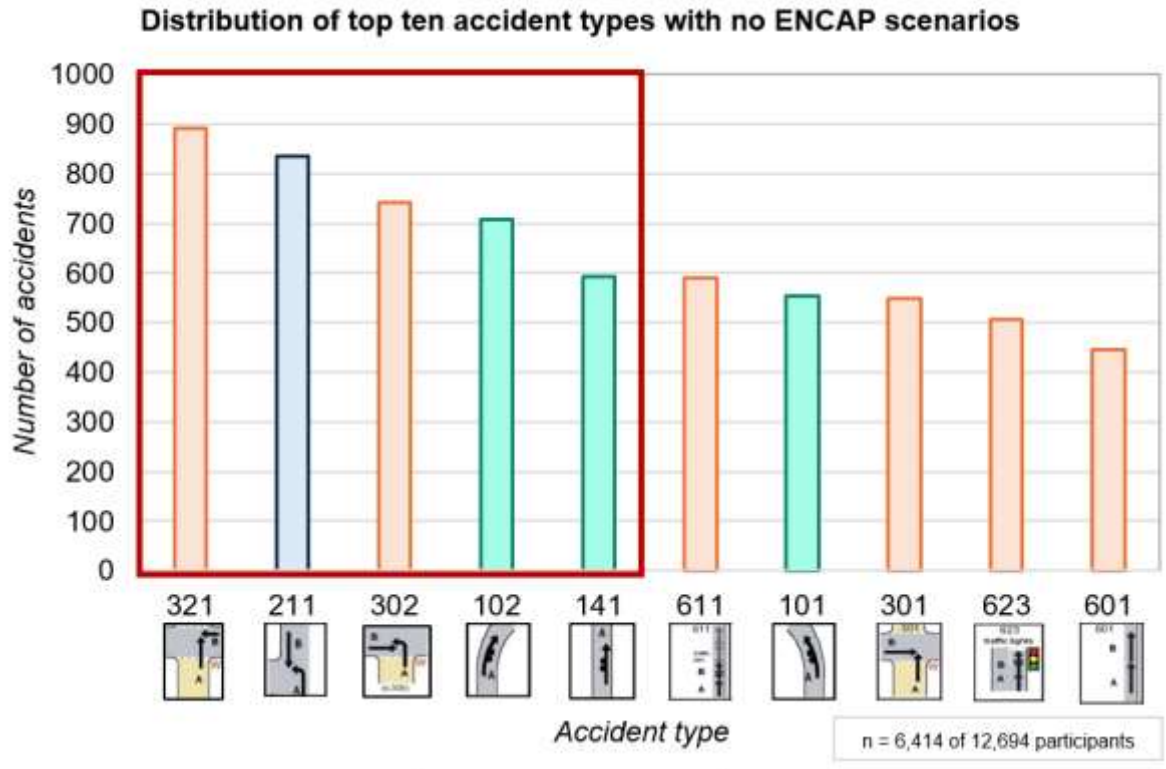

Figure 46 - Distribution of AWC-accident types with no EuroNCAP scenarios

The chart highlights the variability in the number of participants for different accident types. The accident types can be found on the x-axis and the number of participants on the y-axis.
Figure 46 shows the distribution of accident types with no EuroNCAP scenario among 12,694 participants. The x-axis represents the accident types labelled numerically (e.g., 321, 211, 302, etc.), while the y-axis indicates the number of participants, ranging from 0 to 1000.

The accident types are divided into two groups: those within a red-bordered section (321, 211, 302, 102, and 141) and those outside it (611, 101, 301, 623, and 601). The participants within the red border are the most frequent, with the numbers ranging between approximately 600 and 900. Specifically, accident type 321 and 211 have the highest numbers of accidents, close to 900, followed by types 302, 102, and 141 with slightly fewer accidents. Outside the red-bordered section, the number of accidents decreases, with values falling between roughly 400 and 600. Accident types 611, 101, and 301 have slightly higher counts than types 623 and 601, which appear to have the lowest participant counts on the chart.

The accident types show a different distribution to the analysis in chapter 4.7.2, because the analysis of the accident types here is made on participant level. Loss of control scenarios contain only one participant. Intersection scenarios contain more than one participant and therefor the intersection scenarios are weighing more in this evaluation on participant level.

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6.2.3 WEATHER DISTRIBUTION REGARDING EURONCAP

The share of different weather factors is displayed in the two charts below. Those include weather conditions as direct accident causations as well as weather as contributing factors such as weather as circumstance in the AWC-accidents. The following charts display those weather conditions in two different categories. Figure 47 displays the AWC of 165 participants, which address a EuroNCAP scenario. Figure 48 shows the AWC of 12,694 participants, which address no EuroNCAP scenario.

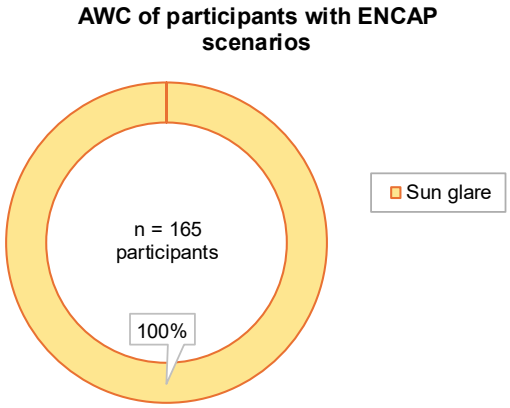

Figure 47 - AWC of participants addressing an EuroNCAP scenarios

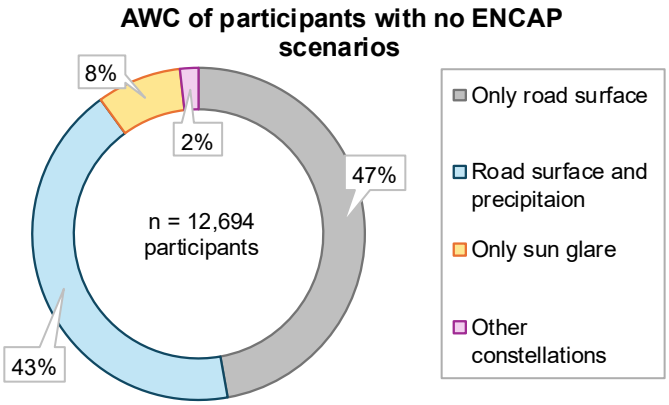

Figure 48 - AWC of participants addressing no EuroNCAP scenarios

100 % of the participants in Figure 47 are attributed to sun glare.
47 % of the participants in Figure 48 are due to adverse road surface conditions, 43 % to road surface conditions and precipitation, 8 % to only sun glare, and 2 % to other constellations.
The relevance of analysing road surface and precipitation in different combinations in the future is underlined by the data of the right chart. Sun glare should be included into the existing scenarios due to an excessive occurrence in the accidents, which address a EuroNCAP scenarios as well.

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7. Final conclusions

The following abstract summarizes the main statements and conclusions made of the statistical analysis and the evaluation of the GIDAS and IGLAD database.

7.1 STATISTICAL RESEARCH - HIGH LEVEL

The representative data for Europe is filtered out of the ERSO-Report. The most recent and evaluable data is out of the year 2020.There is no exact information on the cause of the accidents, but there is data about the general weather conditions at the time of the accidents. Additionally to the report, certain European countries and their traffic accident data is compared.

- The bigger the country and the higher the population rate, the higher the traffic accident fatality rate. Germany, France, Spain, Italy, Poland, and Romania have the highest fatality rates with over 1500 fatalities. The other European countries were quite beneath 1500 fatalities in the year 2020.
- Dry/ clear weather takes the highest percentage with an average of 80.2 % in Europe. Rainy weather conditions take the second place with an average percentage of 10 %, followed by snowy weather with about 1.6 % and foggy or smoky conditions with an average of 1.5 %.
- The ERSO as well as most of European countries describe weather as a circumstance at the time of the accident. Only Germany (DESTATIS) presents detailed information about weather being a direct accident cause.
- There is very less data about Poland. Together with France and Germany this country contributes to one of countries with quite high fatalities.
- In general, the adverse weather accident data is quite thin. There is not a lot of detailed, statistical information regarding weather influences on the accidentology in the European countries.

7.2 STATISTICAL RESEARCH - GIDAS AND IGLAD

The Chapter 3.6 provides a detailed evaluation of the GIDAS database to analyse traffic accidents involving passenger cars under AWC. The evaluation is categorized into multiple levels including accident level, participant level, person level to ensure comprehensive analysis. The main conclusions are listed below:

- An initial filtering resulted in 32,441 accidents involving at least one passenger car out of a total of 42,434 documented accidents.
- Different adverse AWC such as precipitation, road surface conditions, cloudiness, fog, wind, sun glare, and temperature are carefully examined to understand their implications on traffic accidents.
- Precipitation analyses shows that around 86 % of accidents occur without any form of precipitation, with rain being the predominant form of precipitation in 12 % of the *accidents*.
- Road surface conditions are critical irrespective of the weather; about 14 % of the accidents on wet or icy roads happen even during dry weather. This highlights the importance of analysing road surface conditions separately from precipitation.
- The data on fog demonstrates that it is a rare factor in traffic accidents, influencing less than 0.3 % of accidents.

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- Similarly, the impact of wind on accident causation is negligible in 99.5% of the *accidents* since its start of documentation in 2019.
- Sun glare, on the other hand, has been documented since 2005, influencing about 30 % of the accident causations, indicating its notable impact under certain circumstances.
- Analyses of temperature data show that most accidents occur when temperatures range between 5 to 20 degrees Celsius.
- Further, the analysis explores accident causation variables, identifying direct causes of accidents due to AWC. Snowy or icy roads are the leading direct cause, followed by sun glare and wet roads, though direct weather causation accounts for only a minuscule portion (0.16 %) of total accidents.
- Contributing factors such as road surface and various weather conditions are also considered, with road surface conditions standing out as the most significant factor.
- To streamline the analyses, the document defines AWC as conditions involving precipitation, sun glare, and specific road surface conditions while excluding fog, general cloudiness, temperature range variances, and wind impacts. This focused definition results in identifying 30.5 %, or 9,902, of the total of accidents as AWC-related.
- Comparisons between accidents with and without AWC reveal significant insights. The participant distribution shows that accidents with AWC tend to be single accidents more often. Also, there are less vehicle to bicycle accidents happening with AWC.
- Accidents involving AWC show a higher occurrence in rural areas and during nighttime or twilight periods compared to non-AWC accidents.
- In terms of injury severity, AWC-related accidents show a higher incidence of slight injuries and KSI, marking an increase of 3 % in KSI, compared to non-AWC accidents.
- Additionally, the presence of AEB systems shows that roughly 10 % of the vehicles involved in accidents had such systems, with no substantial variation between AWC and non-AWC accidents.
- Accident scenarios are classified and analysed to identify the most common patterns. General accident scenarios include accident types such as loss of control, turning off, turning in/crossing, pedestrian crossing, stationary traffic, and longitudinal traffic accidents. The analyses identify the top five accident scenarios with AWC, predominantly involving loss of control, further illuminating the specific challenges presented by AWC.
- Those scenarios are further analysed regarding the collision speed and the road surface. The main results show that the collisions speed range and the deceleration phases are quite higher with loss of control accidents. Intersection accident scenarios tend to happen more at constant speed or while accelerating.

This extensive evaluation highlights the critical aspects of how various weather conditions influence traffic accidents and the importance of considering both direct and contributing factors to develop more effective safety measures and ADAS/AD systems.

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Chapter 5 of this WeatherSafe deliverable dives into the evaluation of the IGLAD database to enhance traffic safety by compiling a comprehensive repository of road accident data from around the world, with contributions from 7 European countries, which have been considered for this project. This database includes detailed, standardized accident data aimed at supporting research, vehicle safety technology development, and informing policymaking. The chapter explores the general information about IGLAD, highlighting its goals and expansion over time. An analysis of IGLAD data concerning AWC is presented, comparing it with previously gathered data from GIDAS for a comprehensive understanding. The main results are presented in the following statements:

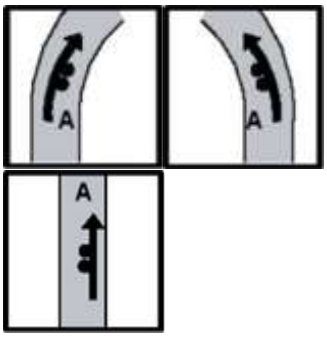
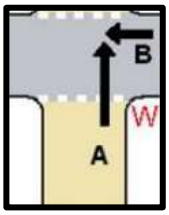
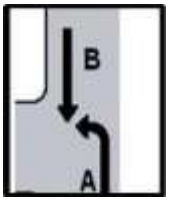
- The evaluation reveals that out of 4,217 accidents in Europe in the IGLAD database, 75 % did not involve AWC, whereas 25 % did, showcasing a significant portion affected by adverse weather.
- Country-specific analysis showed variations, with Italy and Spain having the lowest proportion of AWC-related accidents at 17 %, while Sweden had the highest at 39 %. Other countries like Austria, Czech Republic, Germany, and France had AWC percentages ranging from 22 % to 28 %, aligning with broader European trends.
- Those percentages confirm the statements out of the general statistical research of Europe and the in-depth analyses. Sweden has in its own statistical data also a little higher share of adverse weather in general.

7.3 OUTLOOK

The findings of the EuroNCAP mapping with GIDAS reveal that only 1.3 % of the participants in GIDAS which had an AWC address an existing EuroNCAP scenario. This indicates a significant gap between real-world accidents under AWC and the scenarios tested by EuroNCAP. The predominant EuroNCAP scenarios identified included CCRb, CBTA, CCRs, CBNA, CCCscp, and CCFtap, which collectively made up a small portion of the total of participants. Most of the accident types did not align with the existing EuroNCAP test scenarios, with common accident types involving loss of control and various intersection-related accidents.
A detailed analysis of participants with and without EuroNCAP testing scenarios was also presented, showing the distribution of AWC across different types of accidents. For participants that address EuroNCAP scenarios, 100 % were attributed to sun glare. Conversely, accidents not addressing a EuroNCAP scenario had a more diverse range of contributing factors, including road surface conditions (47 %), a combination of road surface and precipitation (43 %), only sun glare (8 %), and other minor contributing factors (2 %).

Based on these findings, VUFO proposes various scenarios in the following Table 19. These combinations need to be evaluated for their feasibility in the ongoing project, after which it will be decided whether one or more of these scenarios are suitable as EuroNCAP test scenarios. The suggestions are derived from the assessment of accident data in GIDAS and do not represent a final draft, they are merely recommendations for further analysis.

Table 19 - Recommendation of future EuroNCAP test scenarios

Scenario(s)	Description	Weather conditions which could be tested
	➢ Most accidents with AWC tend to happen as loss of control accidents ➢ Bend or straight road ➢ More accidents on bend road ➢ No direct opponent ➢ Driver loses control over vehicle	Main conditions: ➢ Wet road on its own ➢ Rainfall (with obviously wet road) Secondary conditions: ➢ Sun glare (bright light source) ➢ Sun glare with wet road (additional light source through reflecting road) Additional (optional) parameters: ➢ Participant A: Passenger car ➢ Participant B: none ➢ Collision speed: 30 to 70 kph ➢ Road material: closed-pored asphalt ➢ Deceleration around: b_v = [3.0 … 4.0 m/s^2]
	➢ A lot of accidents happen as intersection accidents ➢ Opponent B is driving on the priority road ➢ Initiator A is coming from the side road and crossing the trajectory of B	Main conditions: ➢ Wet road on its own ➢ Rainfall (with obviously wet road) Secondary conditions: ➢ Sun glare (bright light source) ➢ Sun glare with wet road (additional light source through reflecting road) Additional (optional) parameters: ➢ Participant A: Passenger car ➢ Participant B: Passenger car ➢ Collision speed: 10 to 40 kph ➢ Road material: closed-pored asphalt ➢ Deceleration around: b_v = [5.0 … 6.0 m/s^2] or constant speed
	➢ Both roads are equally prior ➢ Opponent B is coming from the front ➢ Initiator A is turning left	Main conditions: ➢ Wet road on its own ➢ Rainfall (with obviously wet road) ➢ Sun glare (bright light source) ➢ Sun glare with wet road (additional light source through reflecting road) Additional (optional) parameters: ➢ Participant A: Passenger car ➢ Participant B: Passenger car ➢ Collision speed: 10 to 40 kph ➢ Road material: closed-pored asphalt ➢ Deceleration around: b_v = [5.0 … 6.0 m/s^2] or constant speed

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The recommended weather conditions for testing were selected based on accident data in GIDAS. The usefulness of these conditions should also be analysed more deeply according ADAS/AD in the future. The impact of weather conditions on sensors and automated systems should be included in the scenario evaluation as well. However, this has not been considered in these analyses.

This deliverable underscores the complexity and variety of real-world traffic accidents under AWC and highlight the necessity for more comprehensive and inclusive testing scenarios to improve vehicle safety assessments and mitigate accident risks effectively.
With the data and insights from WeatherSafe, future research can better focus on creating accurate simulations and improving the efficacy of ADAS and AD systems in AWC. This will involve continued evaluation, particularly focusing on high-risk factors such as rain, road surface and sun glare. Expanding databases and including more diverse geographical data will also enhance the reliability of conclusions, ultimately contributing to safer driving environments under all weather conditions.

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