CMC

Longitudinal traffic

CMC has developed specifications related to the incorporation of powered two-wheelers in Cooperative Intelligent Transport Systems, with the ultimate goal of enhancing rider safety. The CMC Specifications consist of multiple documents, and this document represents the use case description.

Document Information

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1. Preamble

Powered Two Wheelers (PTWs) have different characteristics compared to other road users. Significant characteristics of PTWs are a basically smaller size and different driving dynamics compared to other types of vehicles, which may end up in a variety of dangerous situations as described below:

- Hidden behind another participant or object
- Delay of detection by other road users such as car drivers
- Hidden in the blind spot
- Speed and distance are easily misjudged
- Filtering through narrow space

This document describes important longitudinal use cases with conflict potential for Advanced Driver Assistance Systems (ADAS) based on on-board sensor systems such as camera or radar, and Cooperative Intelligent Transport Systems (C-ITS) technologies taking PTW-specific characteristics into consideration.

The basic criterion to decide whether a conflict situation is arising or not, is the Time-To-Collision (TTC). TTC defines what time is left before the conflict emerges. For the TTC calculation a path prediction is used assuming constant speed and trajectory for each participant at every point in time. If these paths cross and would lead to a collision, a TTC can be calculated. For the following analyses, the German In-Depth Accident Study (GIDAS) was used and weighted to the German motorcycle accident statistics 2019.[1,2]

[1] GIDAS dataset from 30.06.20 weighted to Germany 2019, https://www.gidas.org/start.html

[2] The methodology for the creating of the dataset can be found in chapter 3.3 of the document "CMC Basic Specification Assessment of C-ITS application potential" , https://www.cmc-info.net/assessment.html

2. Longitudinal traffic

2.1 Summary

Longitudinal traffic accident types according to the German In-Depth Accident Study (GIDAS) database are described as a conflict between a road user (Participant A) that is following or approaching another road user (Participant B) who is either driving or stuck in traffic.
In this report, four accident types are addressed, while the two accident types 601 & 602 and 611 & 612 were each combined and analysed together.
The combination of accident type 601 & 602 with PTW participation happens most often in urban areas (62%) and on straight roads (70%) without specific traffic regulation. Same holds true for the combination of accident type 611 & 612 with PTW participation (mostly in urban areas (60%) and on straight roads (72%) without specific traffic regulation).

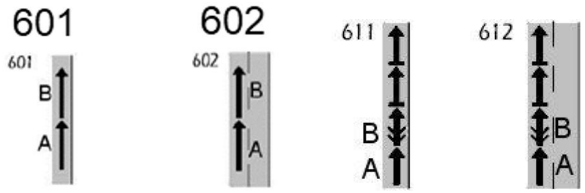


Figure 1: Longitudinal traffic – Accident type combination 601 & 602 and 611 & 612 [3]

2.2 Background

Within the longitudinal accident scenario, there exist more precise accident types as shown in Figure 2. Which use case to concentrate on has been decided from the frequency of the specific use case, i.e., accident type 601 which counts for 19.7% of all the longitudinal traffic accident types and accident type 611 which counts for 14.3% of all the longitudinal traffic accident types.

In addition, accident type 602 was combined with accident type 601 and analysed together because accident type 602 is similar to accident type 601. The only difference is in the number of lanes. In a similar manner, accident type 612 was combined with accident type 611 and analysed together.

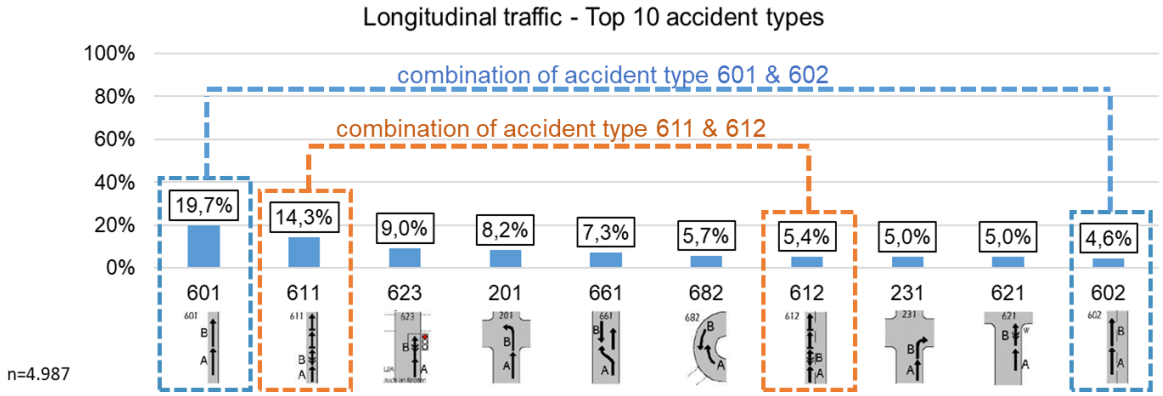


Figure 2: Selection and combination of longitudinal traffic accident type 601 & 602 and 611 & 612: Selection and combination of longitudinal traffic accident type 601 & 602 and 611 & 612

2.3 Objective/ Desired Behaviour

Typically, the most efficient avoidance manoeuvre would be braking or swerving of Participant A to avoid a rear-end crash with the lead vehicle ahead (Participant B). As view obstruction plays a neglectable role with this accident type, the desired effect of an assistance system would be to direct Participant A's attention towards the upcoming threat ahead. Assuming a warning cascade a rather unobtrusive advisory notification could be shown in the beginning, followed by an imminent crash warning (i.e., Forward Collision Warning, FCW), which aims at triggering an avoidance manoeuvre of the driver/ rider. A last resort solution to the scenario would be an autonomous emergency braking of Participant A's vehicle.

2.4 Expected Benefits

To pursue the goal "improving motorcycle rider safety and comfort", CMC has studied the most frequent Powered Two-Wheeler (PTW) accident scenarios in the GIDAS (German In-Depth Accident Study) database (Figure 3). Out of those accident scenarios, the longitudinal traffic scenario is found to be 18.4% of the total of PTW accidents. This is the second frequent accident scenario among all PTW accident scenarios. In addition, when the accident causer is a PTW, the longitudinal traffic scenario is actually the most frequent scenario.
CMC performed a study for longitudinal traffic accident scenarios as explained in this report, using the GIDAS database.

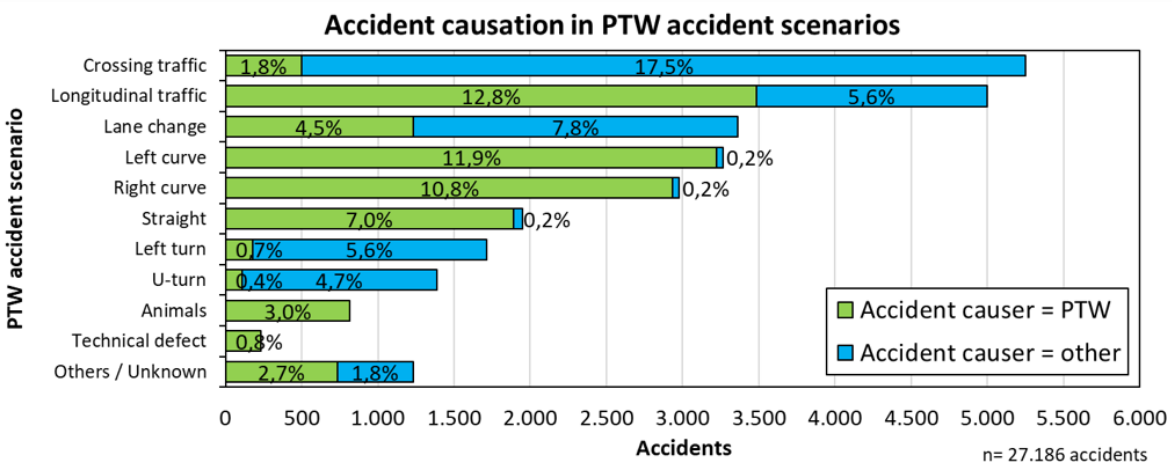


Figure 3: Accident causation in the PTW scenarios

2.5 Actors and Relations

2.5.1 ADAS only

In the majority of cases analysed in the GIDAS database, Participant A is a Powered Two-Wheeler. The PTW would be equipped with on-board sensors such as radar or camera(s) capable of detecting the obstacle ahead (Participant B). Based on this information a Forward Collision Warning (FCW) could be triggered, which should trigger an imminent avoidance manoeuvre (typically braking) if necessary. If no action is observed, an autonomous emergency braking (MAEB) would theoretically be possible.

2.5.2 ADAS + C-ITS

In the majority of cases analysed in the GIDAS database, Participant A is a Powered Two-Wheeler. The PTW as well as the other traffic participant would be equipped with on-board sensors such as radar or camera(s) as well as C-ITS technology sending a Cooperative Awareness Message (CAM) regularly (both participants act as sender and receiver of V2X messages). Based on the exchanged C-ITS messages, an earlier and more reliable rider notification can be displayed to the rider. This would be followed by a Forward Collision Warning (FCW) which aims at triggering an imminent avoidance manoeuvre (typically braking) if necessary. If no action is observed, an autonomous emergency braking (MAEB) would theoretically be possible.

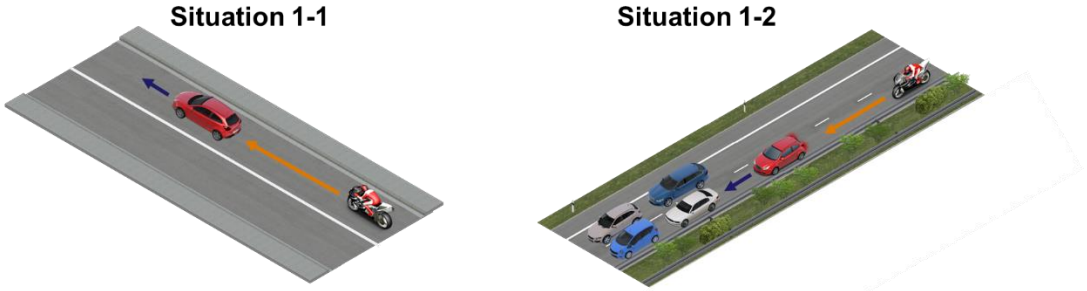
2.6 Traffic Situations

As described above, the use case focuses on a conflict which arises in longitudinal traffic. The motivation to address this use case comes from the accident type 601. The following sub chapters explain possible situations more in detail.

2.6.1 Road type

Situation 1-1: Longitudinal traffic at single lane road: Participant B (red car) is driving on a single lane road in the urban area. Participant A (PTW) approaches from behind with a higher speed.

Situation 1-2: Participant A (red car) is driving in a rural area on a two-lane road, approaching a traffic jam and reducing his speed. Involved Participant A (PTW) is approaching from behind at a higher speed.



2.6.2 Line-of-Sight Visibility

View obstruction plays a minor role and is therefore not discussed separately.

2.7 Use Case Scenarios

Scenario 1:

The longitudinal traffic accident types 601 & 602 describe a conflict between a road user (Participant A) and a road user (Participant B) who is driving in front (Figure 4).

At the longitudinal traffic accident type 601, Participant A and Participant B are using a single lane road. On the other hand, at the longitudinal traffic accident type 602, Participant A and Participant B are using a two-lane road.

Figure 4: Longitudinal traffic accident types 601 & 602

Scenario 2:

The longitudinal traffic accident types 611 & 612 describe a conflict between a road user (Participant A) and a road user (Participant B) who is driving in front, in a traffic congestion (Figure 5).

At the longitudinal traffic accident type 611, Participant A and Participant B are using a single lane road. At the longitudinal traffic accident type 612, Participant A and Participant B are using a two-lane road.

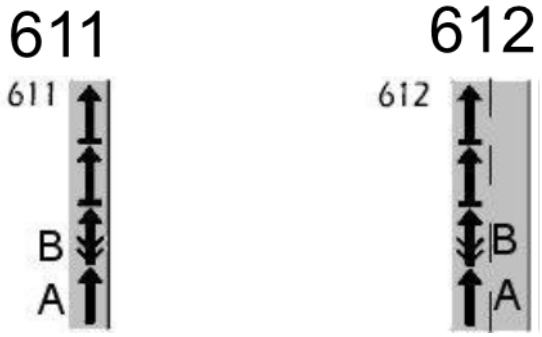


Figure 5: Longitudinal traffic accident types 611 & 612

2.8 Display / Alert Principle

2.8.1 ADAS only

Participant A would most probably receive some kind of Forward Collision Warning (FCW). It should trigger an immediate response (typically braking). To convey the criticality, the warning would most probably rely on a warning design, which decreases the rider response time and directs the rider's attention towards the forward roadway. If Participant A fails to react, an autonomous emergency braking could be a possibility to avoid that kind of accident. This intervention would go along with a notification to the rider indicating that the PTW will reduce the velocity automatically.

2.8.2 ADAS + C-ITS

In addition to the alert principles described above, a combination of on-board sensors and C-ITS technology could provide earlier advisory notifications to Participant A, e.g., based on differential speed between Participants A and B. The intention would be to direct Participant A's attention towards the forward roadway, where the slower or stationary Participant B is already visible. The notification should therefore be capable of providing the directional information "potential conflict in front of you". This might lead to an earlier and smoother deceleration and avoid the triggering of an imminent crash warning (FCW) or an autonomous emergency braking, which would still be available as the criticality of the situation increases when no avoiding response by Participant A is observed.

3. Abbreviations

ADAS	Advanced Driver Assistance Systems
C2C-CC	CAR 2 CAR Communication Consortium
CAM	Cooperative Awareness Message
CMC	Connected Motorcycle Consortium
C-ITS	Cooperative Intelligent Transport Systems
FCS	Forward Collision Warning
GIDAS	German In-Depth Accident Study
MAEB	Motorcycle Autonomous Emergency Braking
PTW	Powered Two Wheeler
TTC	Time-To-Collision