CMC

Crossing

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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Disclaimer

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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 crossing 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]

2. Crossing

2.1 Summary

Crossing traffic accident types according to the German In-Depth Accident Study (GIDAS) database describe a conflict between a road user (Participant A) who is obligated to wait (“W” in Figure 1) and a road user (Participant B) entitled to the right of way.

This type of accident with PTW participation happens most often in urban areas (67%), at junctions (53%), with the traffic regulation "Right of way" (73%). In addition, this scenario may occur at junctions and crossings of roads, field or cycle paths, railway crossings as well as property exits or parking lots. Due to right of way violations, the scenario ends in a collision.

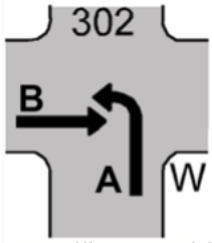

Figure 1: Crossing traffic – Accident type 302 [3]

[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

2.2 Background

According to the German In-Depth Accident Study (GIDAS) database, the accident type 302 is the most common accident type within the crossing traffic scenario shown in Figure 2.

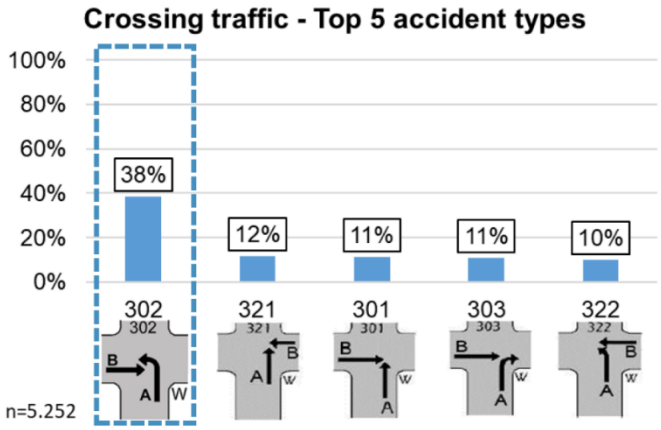

Figure 2: Selection of crossing traffic accident type[3]

2.3 Objective/ Desired Behaviour

Ideally, Participant A should receive an advisory notification about the oncoming Participant B. In 62% of the analysed cases (GIDAS accident type 302), a TTC calculation earlier than TTC = 2.6 s is possible and gives Participant A time to decelerate and let Participant B pass.[4] If Participant A would start accelerating anyway, an active intervention combined with an earliest possible warning would mitigate the situation.

2.4 Expected Benefits

According to the GIDAS data base, crossing traffic is the most frequent scenario in which PTWs become the victim of an accident as shown in Figure 3.

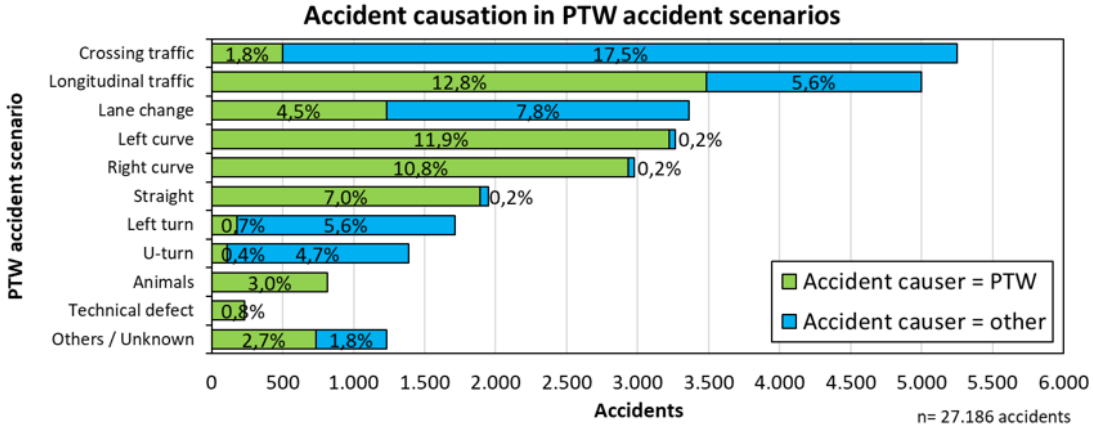

Figure 3: Accident causation in the PTW scenarios based on the GIDAS database [5]

[3] Gesamtverband der Deutschen Versicherungswirtschaft e.V. (GDV), Unfallforschung der Versicherer; Unfalltypenkatalog, Leitfaden zur Bestimmung des Unfalltyps

[4] GIDAS-PCM 2020-1, https://www.vufo.de/gidas-pcm/

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

Applications which prevent or mitigate crossing accident scenarios have high potential to save lives and reduce injuries.

2.5 Actors and Relations

2.5.1 ADAS only

In our example Participant A is a car which is about to enter the intersection to turn left. Participant A is obligated to wait. The car is equipped with on-board ADAS, such as camera and radar. Participant B is a PTW which is entering the intersection from the left side from the perspective of Participant A. Participant B is entitled to the right of way. The car is providing an active intervention such as Autonomous Emergency Braking (AEB) which will be accompanied by a warning.

2.5.2 ADAS + C - ITS

Participant A is a car which is about to enter the intersection to turn left. Participant A is obligated to wait. The car is equipped with on-board ADAS and C-ITS Technology, that enables direct communication between the participants (V2X – Communication). Therefore, the car is receiving and processing the V2X messages sent by the participants. The car is providing an active intervention such as Autonomous Emergency Braking (AEB) based on on-board sensors, which will be accompanied by a warning. Participant B is a PTW which is entering the intersection from the left side from the perspective of Participant A. Participant B is entitled to the right of way. The PTW is equipped with a V2X communication unit and the PTW is sending a Cooperative Awareness Message (CAM) regularly.

2.6 Traffic Situations

As described above, the use case focuses on a conflict which arises in perpendicular traffic. While the motivation to address this use case comes from the accident type 302, with a left-turning Participant A, the use case covers situations with other planned trajectories of Participant A (e.g., going straight or turning right) as well. The basic conflict remains the same. Still, the descriptions will focus on the accident type 302 situation. The following chapters explain possible situations more in detail.

2.6.1 Road Types

For accident type 302, different road type situations are explained, in order to cover the variety of real traffic crossing scenarios:
1-1: T – Junction: Participant A is waiting on a perpendicular street to the main carriageway and intends to turn left into the main carriageway. Participant B is travelling on the main carriageway heading towards the junction.
1-2: Crossing: Participant A is on a perpendicular road to Participant B, waiting to turn left onto the same road, but onto the opposite lane of Participant B. Participant B is travelling towards the crossing.
1-3: Property Exit: Participant A intends to enter the main carriageway from a property exit (which means Participant A enters the carriageway at a point which is not defined as a junction

on a digital map). Participant B is travelling perpendicular to Participant A and is approaching the property exit.

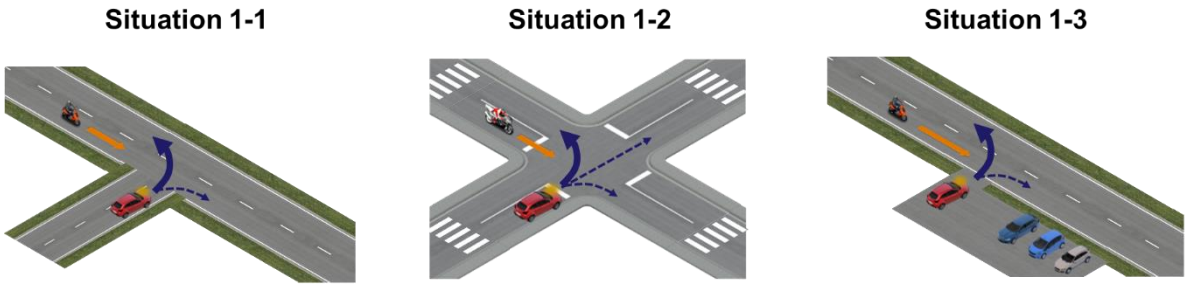

Figure 4: Road type situations for crossing without visual obstruction

2.6.2 Line-of-Sight Visibility

According to the GIDAS database, every third Participant A (32,3%) had a view obstruction in the accident type 302.[6] Therefore, two different situations will be addressed.
2-1 No obstruction: Both Participants A and B are generally visible to each other while approaching the potential conflict zone.
2-2 With obstruction: Due to any kind of obstacle, such as a building or another road user, Participant A and Participant B have limited or no view towards each other until Participant A arrives at the junction.

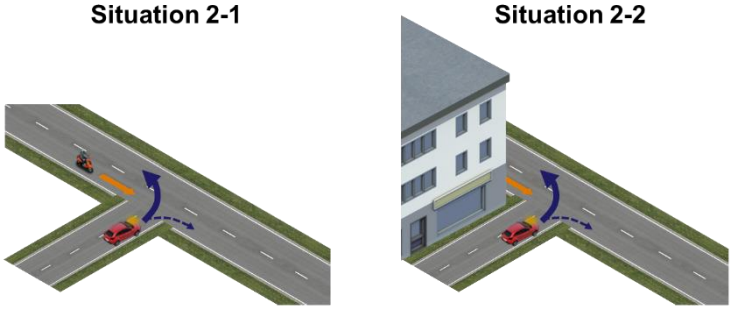

Figure 5: Road type situations for crossing without (left) and with view obstruction (right)

2.7 Use Case Scenarios

Scenario 1:
The starting situation of scenario 1:
Participant B (PTW) is on a right-of-way road following Participant C (here: blue car). Participant A (here: red car) is coming from the perpendicular road. The red car giving right of way cannot see Participant B, because it is hidden behind Participant C. Buildings or vegetation may further hinder the view. The main challenge of this scenario is a view obstruction due to a non-permanent obstacle, such as a car in this example.

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

The following figures will make use of dashed arrows to indicate potential driving directions of a vehicle that is currently stopped and solid arrows for actual driving directions/ trajectories of a vehicle in motion.

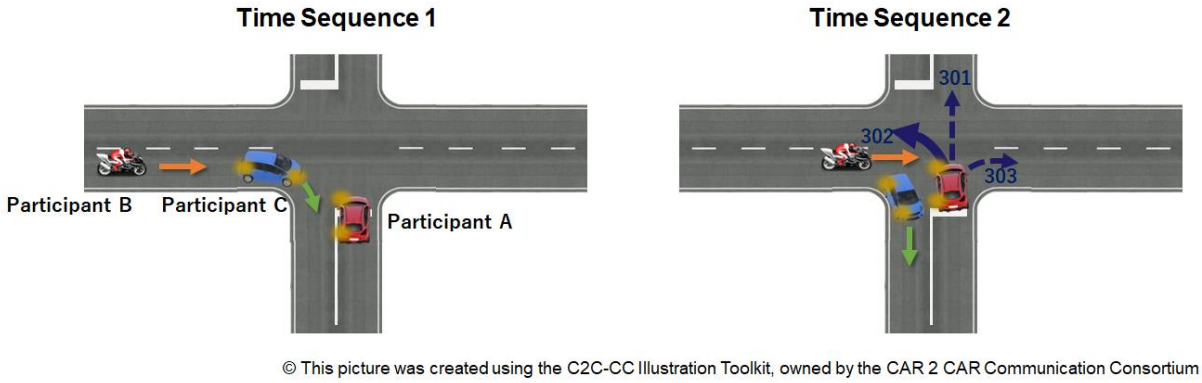

Figure 6: Scenario 1 - Participant A and Participant B cannot see each other due to view obstruction caused by Participant C (based on accident types 301, 302, 303 in the GIDAS database).

Special characteristics of scenario 1:

Since Participant C indicates its right turn (turn signal), the waiting Participant A presumably receives the signal to drive off. Participant C as perceived by Participant A will not cross the direction of travel of Participant A. Participant B is not visible for Participant A. For this reason, Participant A could already (early and thus causing a collision with Participant B) proceed with the planned driving manoeuver, i.e., drive off/turn off.

Participant C turning right can also cause the distance between Participants B and C to be reduced due to the speed reduction associated with the turning manoeuver, thus creating an even more unfavourable angle of view. In addition, a right-turning Participant C may entice Participant B to drive up closer in the lane further to the left at the same time, further worsening the already poor view from Participant A towards Participant B.

From the Participant B point of view: In addition, in this situation, it is possible that Participant B will continue to drive straight past Participant C while the vehicle is still turning to the right. In doing so, Participant B assumes that Participant A has noticed him and is therefore waiting. It is also possible that Participant B has not yet noticed Participant A. Often fatal misunderstandings, or a mixture of lack of perception and misinterpretation cause these types of the situations.

Scenario 2:

The starting situation of scenario 2:

Participant A wants to turn left. Participant C, who is approaching from the left and has the right of way, crosses the intersection (here: blue car) and thereby obscures Participant B that drives past the stationary vehicles and has the right of way to cross the intersection.

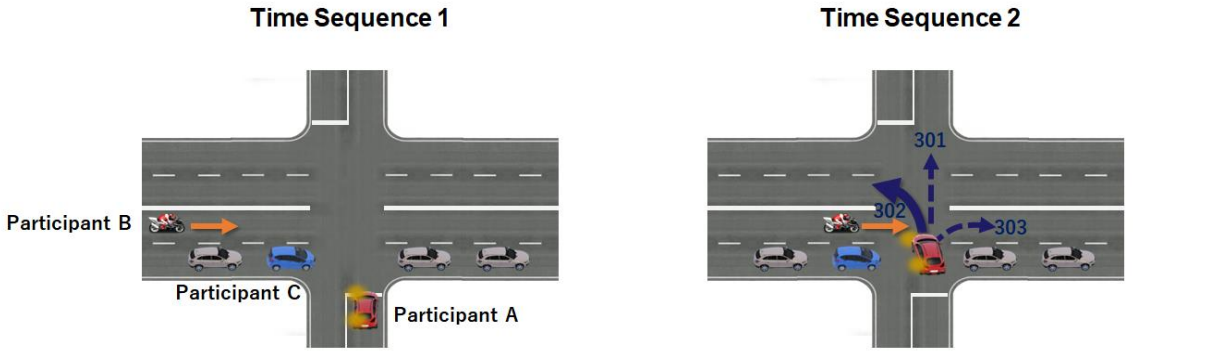

Figure 7: Scenario 2 - Participant A wants to enter the intersection, Participant C (here: grey car) keeps small distance to the vehicle ahead (here: blue car) and thereby obscures Participant B that just wants to drive past the stationary vehicles (based on accident types 301, 302, 303 in the GIDAS data base).

Special characteristics of scenario 2:

Participant C is standing with other participants in the right lane of a four-lane road with two lanes per driving direction in the crossing area. In the right lane, there is almost no distance between the participants, which makes it even more difficult for Participant A to get a direct sight on Participant B. A fast start and left-turn of Participant A to get into the free opposite lane makes a collision with Participant B possible, which passes the standing participants in the free left lane and cannot see Participant A or can see it only very late.

Scenario 3:

The starting situation of scenario 3:

Participant A wants to turn left. Participant C, who is approaching from the left and has the right of way, crosses the intersection and attracts participant A's attention while Participant B is approaching the intersection from the right.

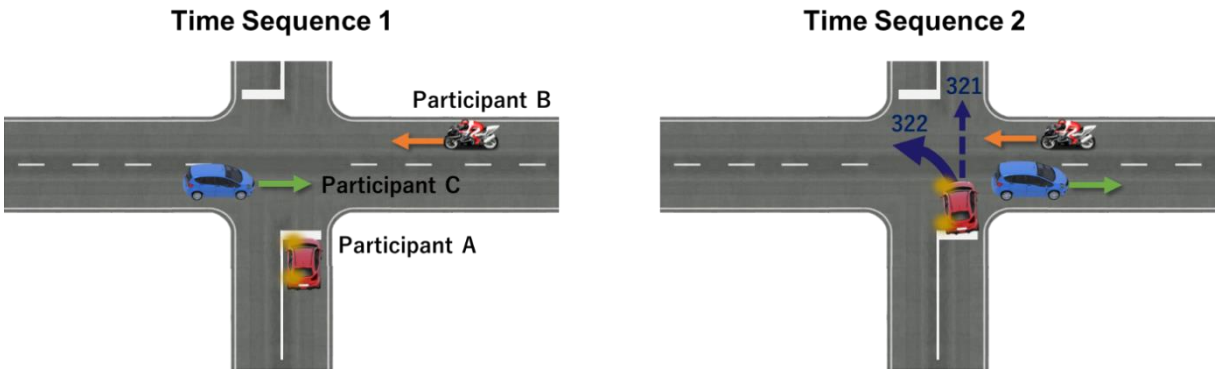

Figure 8: Scenario 3 - Participant A wants to turn left, Participant C approaches from the left and attracts Participant A's attention, therefore Participant A does not recognize Participant B approaching from the right side (based on accident types 321, 322 in the GIDAS data base).

Special characteristic of scenario 3:

Participant A could potentially see Participant B, but is distracted by Participant C. It is a matter of attention allocation or insufficient situation awareness, which means an insufficient analysis of the traffic situation. Therefore, Participant A begins to enter the intersection without recognising Participant B.

In this scenario we observe the frequently occurring case of distraction and in addition in the final phase of the scenario an obstructed view on Participant B (here: the narrow PTW). In general, when turning left or crossing a junction, distraction and overlooking other vehicles is always a danger (both, due to attention allocation or view obstruction). Such situations can even get worse in poor lighting conditions (e.g., sun glare, light-dark fields on forest roads).

2.8 Alert Principle

2.8.1 ADAS only

Assuming that on-board sensors might recognize the other Participant in cross traffic rather late, an active intervention (AEB) seems the most likely possibility for accident avoidance or mitigation. This application should primarily run in Participant A's vehicle, which fails to give way to Participant B.

2.8.2 ADAS + C-ITS

An advisory V2X notification should increase situation awareness and direct the attention towards other traffic participants entering the junction. Consequently, it should be avoided that Participant B is not recognised by Participant A. Therefore, Participant A should be assisted in appropriately judging the remaining time for safely entering the junction. Information on direction of Participant B could increase the acceptance of the application. If the advisory information is not considered, an active intervention of an on-board based AEB system in the passenger car combined with a warning would mitigate the situation.

3. Supplemental Information

https://www.utacceram.com/images/utac/metiers/muse/reports/d1-1-accident-data-study.pdf

Situations like these are described by the ifz in its brochure "Gefährliche Begegnungen".

Helpful for riders of PTW, but also for drivers of passenger cars:
https://ifz.de/wordpress/wp-content/uploads/2015/02/Gefaehrliche_Begegnungen-www.pdf

Abbreviations

5GAA	5G Automotive Association
ACEM	European Association of Motorcycle Manufacturers
AEB	Autonomous Emergency Braking
C2C-CC	CAR 2 CAR Communication Consortium
CAM	Cooperative Awareness Message
CMC	Connected Motorcycle Consortium
C-ITS	Cooperative Intelligent Transport Systems
DENM	Decentralized Environmental Notification Message
ETSI	European Telecommunications Standards Institute
EU	European Union
GIDAS	German In-Depth Accident Study
GNSS	Global Navigation Satellite System
HMI	Human-Machine Interface
ITS	Intelligent Transport Systems
MAI	Motorcycle Approach Indication
MAW	Motorcycle Approach Warning
OEM	Original Equipment Manufacturer
PTW	Powered Two Wheeler
RSU	Road Side Unit
R&D	Research and Development
V2V	Vehicle-to-Vehicle
V2I	Vehicle-to-Infrastructure
V2X	Vehicle-to-everything
VRU	Vulnerable Road Users