CMC

Left Turn

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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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 left turn 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]

Left Turn

2.1 Summary

The left turn scenario is described by two or more road users in an oncoming traffic situation, with one of the participants intending to turn left. This type of accident with PTW participation happens most often in urban areas (79%) and at crossings (43%), with the traffic regulation "Right of way" (51%).[1]

The one trying to turn may misjudge the speed and distance of or does not even recognise the one coming straight at all. Due to right of way violations, the scenario ends in a collision.

[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

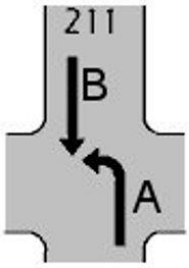

Figure 1: Left Turn – Accident type 211 [3]

2.2 Background

According to the German In-Depth Accident Study database (GIDAS) the "accident type 211" is the most frequent accident scenario within the category of left turn accidents. Due to this dominance, the chapter will focus on descriptions of the accident type 211, but is valid for some of the other accident types as well.

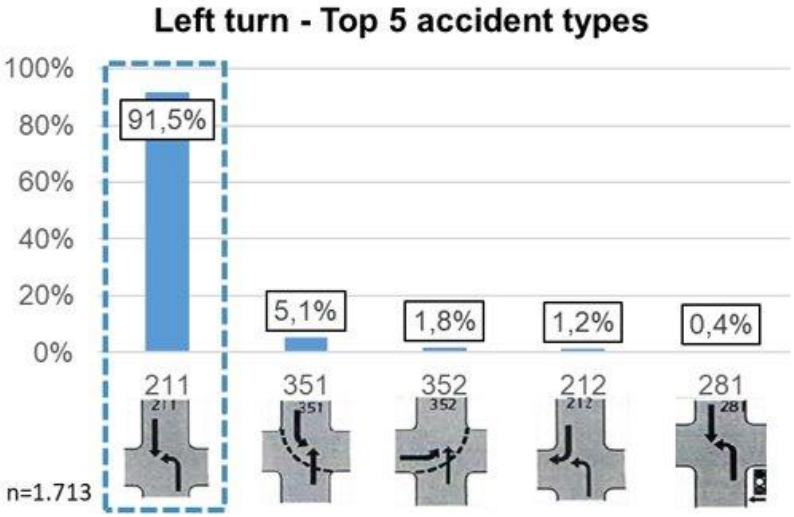

Figure 2: Left Turn - Top 5 accident types [3]

2.3 Objective/ Desired Behaviour

The left-turning vehicle as main accident causer will be addressed. According to the GIDAS database the median differential speed between the two vehicles involved is 92 km/h. Furthermore, in 50% of all analysed cases, a TTC[4] calculation was not possible earlier than TTC = 1.5 sec. Given these boundary conditions, an active intervention would have the highest expected safety benefit, followed by a warning with the aim of increasing driver/ rider situation awareness and stop turning (for research from the passenger car domain see also e.g., Neukum, 2011; Winner, Hakuli, Lotz & Singer, 2015). Providing an advisory notification will likely not prevent the accident due to the limited time resulting from the accident configuration.

[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/

2.4 Expected Benefits

The described left turn use case is based on analysis of the accident type 211. According to the GIDAS database this accident type is one of the most common accidents involving a PTW and another vehicle as main causer.

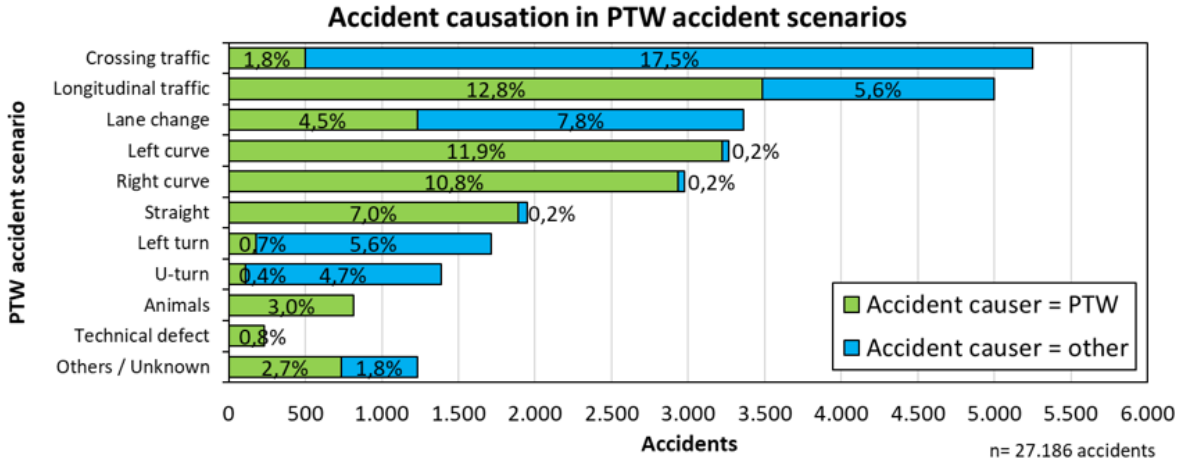

Figure 3: *Accident causation in the PTW scenarios based on the GIDAS database* [5]

In 35 percent of those involved in the accident type 211 are seriously injured. Furthermore, 3 percent of this accident type even results in fatalities. Applications which prevent or mitigate Left Turn accidents have high potential to save lives or reduce injuries.

2.5 Actors and Relations

2.5.1 ADAS only

In our example Participant A is a car which is about to turn left and is obligated to wait. The car is equipped with on-board ADAS, such as camera and radar. Participant B is a PTW which is running straight and 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

In our example Participant A is a car which is about to turn left. 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 other 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 running straight and entitled to the right of way. The PTW is equipped with a V2X communication unit and is sending a Cooperative Awareness Message (CAM) regularly.

[5] GIDAS, 2019

2.6 Traffic Situations

As described above, the use case focuses on a conflict which arises in left turning traffic. The motivation to address this use case comes from the accident type 211, with a left-turning Participant A. The following chapters explain possible situations more in detail.

2.6.1 Road type

1-1: Left turn at Crossing: Participant A is turning left at a crossing while Participant B is coming from the opposite direction.
1-2: Left turn at T-junction: Participant A is turning left at a T-junction while Participant B is coming from the opposite direction.
1-3: Left turn at Property exit: Participant A is turning to the property exit while Participant B is coming from the opposite direction.

Figure 4: Road type situations for left turn scenarios

2.6.2 Line-of-Sight Visibility

According to the GIDAS database, nearly 18% of Participant A had a view obstruction within the accident type 211. Possible view obstructions are waiting, starting or driving vehicles. 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 another road user, Participant A and Participant B have limited or no visibility towards each other until Participant A turns left.

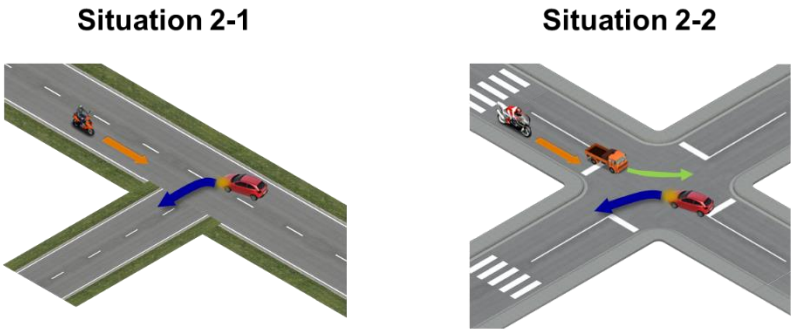

Figure 5: Road type situations for left turn without (left) and with view obstruction (right)

2.7 Use Case Scenarios

Scenario 1:

The starting situation of scenario 1:

Participant B (PTW) is running straight and is entitled by the right-of-way. Participant A (red car), driving on the same priority road but in the opposite direction, is about to turn left at the intersection (left turn indicator on), but the oncoming PTW is covered by the blue car (Participant C) from Participant A's point of view. The main challenge is the view obstruction due to a non-permanent obstacle(s) (here: car(s)).

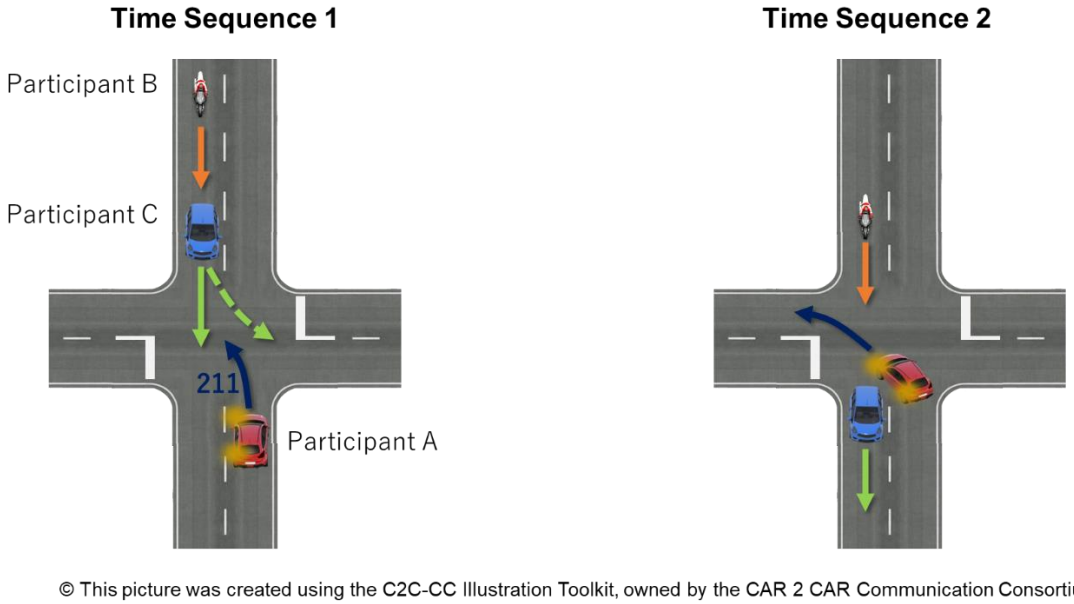

Figure 6: Scenario 1 - Participant A and Participant B cannot see each other due to the view obstruction caused by Participant C (based on accident type 211). The dashed arrow indicates a possible alternative trajectory of Participant C. Time Sequence 2 is exemplarily indicating Participant C going straight.

Special characteristics of scenario 1:

As soon as Participant C has passed the intersection, the waiting Participant A presumably feels safe to drive off, as Participant B is only visible quite late for Participant A. This manoeuvre causes a potential conflict with Participant B.

If Participant C is turning left, the distance between Participants B and C could further be reduced due to the speed reduction associated with the turning manoeuvre, thus creating an even more critical situation. In addition, a left-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.

Scenario 2:

The starting situation of scenario 2:

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

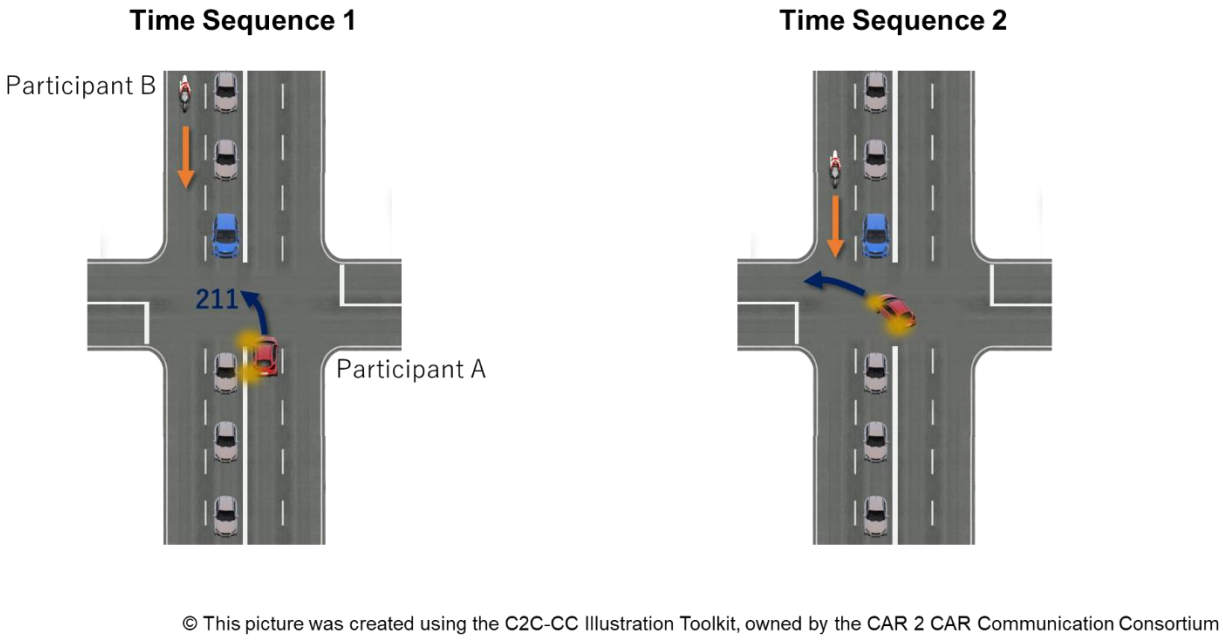

Figure 7: Scenario 2 - Participant A is about to turn left, Participant C (here: grey car) keeps small distance to the vehicle ahead (here: blue car) and thereby obscures Participant B that wants to drive past the stationary vehicles (based on accident type 211)

Special characteristics of scenario 2:

Participant C is standing with other participants in the left lane of a four-lane road with two lanes per direction (as seen from the driver's point of view). In the left lane, there is almost no distance between the vehicles, 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 vehicles in the free right lane and cannot see Participant A or can see Participant A only very late.

2.8 Display / Alert Principle

2.8.1 ADAS only

Due to the rather short available time (TTC = 1.5 sec) an active intervention by AEB functions seems the most likely possibility for accident avoidance or mitigation. Additionally, an imminent warning should contain an auditory tone and visual feedback. The visual feedback can contain a generic warning icon, but also a PTW-specific warning icon, which can increase acceptance, but is not expected to create a reaction time benefit.

2.8.2 ADAS + C-ITS

Due to the rather short available time (TTC = 1.5 sec) an imminent crash warning should trigger immediate reaction (i.e. braking). Therefore, the warning should contain an auditory tone in addition to any visual feedback. The visual feedback can contain a generic warning icon but could benefit from a PTW-specific warning icon in case of view obstruction (e.g., PTW obscured by a truck). Consequently, it should be avoided that Participant A overlooks Participant B or receives assistance to recognise the obscured vehicle (here: PTW) and avoid the collision. Automated Brake Activation based on on-board sensors and a Cooperative Awareness Message would mitigate the situation.

Supplemental Information

Neukum, A. (2011). Wenn das Fahrzeug mehr sieht als der Fahrer – Konsequenzen für die Gestaltung der Fahrer-Fahrzeug Schnittstelle. Paper presented at the Ko-FAS Zwischenpräsentation, Aschaffenburg, Germany

Winner, H., Hakuli, S., Lotz., L. & Singer, C. (Hrsg.). (2015). Handbuch Fahrerassistenzsysteme: Grundlagen, Komponenten und Systeme für aktive Sicherheit und Komfort. Springer Vieweg: Wiesbaden. S. 906.

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