

Document Information

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3.1 Intersection Movement Assist (IMA)

3.1.1 General description

The Intersection Movement Assist (IMA) application warns the driver of a vehicle or PTW when it is not safe to enter an intersection or a roundabout due to high probability of collision with other vehicles. The 'Time-To-Collision' is calculated and a warning is only issued when a collision is likely to occur.

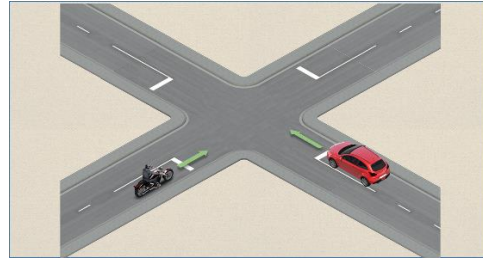
3.1.2 Use case description

The IMA will operate on intersections, including parking lot entrances, roundabouts and other kinds of junctions where vehicles might cross encounter zones. If a warning is to be provided, considerations should be taken into account in order to avoid distractions but still operate the proper operation of this safety application.

For simplicity, only a 4-way crossing intersection and a 2-way roundabout are used here to illustrate the different situations in which IMA can operate.

Straight crossing paths

- Case 1: A car has the right of way.
- Case 2: No one has the right of way (uncommon in Europe), e.g. stop signs on each corner.

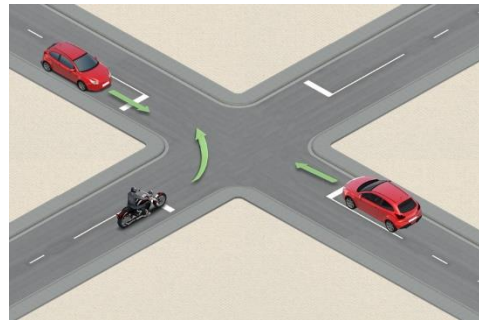


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Figure 1: IMA - Straight crossing paths

Left turn into crossing

- Case 1: A car is driving in the same final-direction of a PTW. They'll be on the same path after the turn of the PTW.
- Case 2: A car is driving in the opposite to the final-direction of a PTW. The PTW will need to cross the path in front of the car in order to turn.

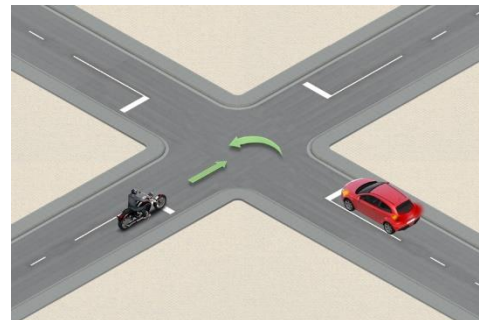


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Figure 2: IMA – Left turn into crossing

Other vehicle turning left from the right

- A car is willing to turn left but the PTW is going straight. This scenario is similar to the “Left Turn Assist” scenario but from a different angle.

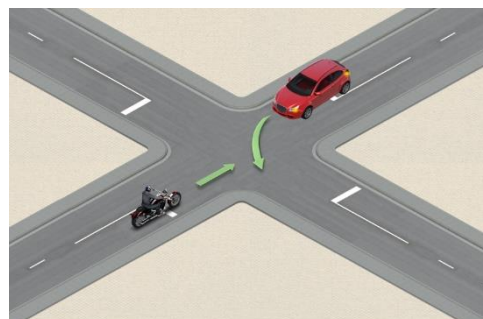


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Figure 3: IMA – Other vehicle turning left from the right

Other vehicle turning left ahead

- A car is willing to turn left but a PTW is going straight. This scenario is the “Left Turn Assist” scenario for the car. IMA is taking over this scenario and issuing a warning on the ego vehicle (the PTW) in case the other vehicle (the car) doesn't stop appropriately before entering the intersection.



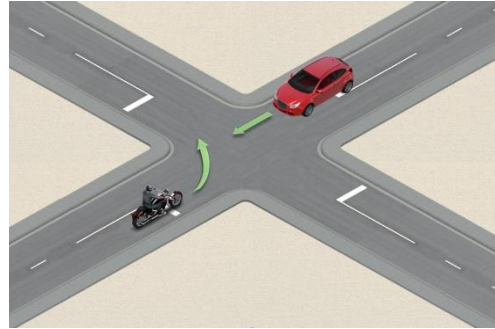
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Figure 4: IMA – Other vehicle turning left ahead

Left Turn Assist (LTA)

The whole LTA application is included in the IMA application in the form of a single use case. IMA consequently replaces LTA entirely and adds a new level of robustness by issuing warnings instead of indications (TTC is calculated and a warning is only issued when a collision is likely to occur).

For details about this use case, see the LTA chapter in Application Specification.



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Figure 5: IMA - LTA

Roundabout

- Case 1: A PTW is about to enter a roundabout at which a car is currently driving.



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Figure 6: IMA – PTW entering roundabout

- Case 2: A car is about to enter a roundabout at which a PTW is currently riding.



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Figure 7: IMA – PTW inside roundabout

The scenarios below correspond to different use cases, all involving a PTW (ego vehicle) and another vehicle, both equipped with C-ITS system and driving into an intersection.

3.1.2.1 Scenario description: PTW transmit CAM

For all the aforementioned use cases, the time sequence of the scenario develops into three steps as follows:

Time sequence 1

The ego vehicle (PTW) is approaching an intersection or inside a roundabout and sending Cooperative Awareness Message (CAM) regularly. A car is driving into the same intersection or roundabout, coming from a different direction and fails to see the coming PTW which has the right of way. At the same time, the car is receiving and processing the CAM sent by the PTW.

Time sequence 2

After all preconditions and triggering conditions on the car have met, a warning is issued to the car driver, who is then able to stop before entering the intersection or roundabout, letting the PTW pass.

Time sequence 3

The PTW is able to go through the intersection or exit the roundabout without receiving a warning if the car reacted on time and stopped before entering the intersection or roundabout. If not, the PTW rider does also receive a warning.

3.1.2.2 Scenario description: PTW receive CAM

For all the aforementioned use cases, the time sequence of the scenario develops into three steps as follows:

Time sequence 1

The ego vehicle (PTW) is approaching an intersection or a roundabout and is periodically receiving and processing a CAM coming from a car which is approaching the same intersection from a different direction, or is already inside the roundabout. The rider fails to see the car, which has the right of way.

Time sequence 2

After processing the received CAM, a warning is issued to the rider so that they are able to stop before entering the intersection, letting the car pass. For issuing this warning, the system must first recognize the most probable riding maneuver of the involved vehicles and detect a possible collision between the two; for this detection, a Point-of-Collision is calculated, i.e. where the vehicles could collide if they maintain the same driving conditions (speed, direction, acceleration, etc.).

Time sequence 3

The car is able to go through the intersection or exit the roundabout without receiving a warning if the PTW reacted on time and stopped before entering the intersection or roundabout. If not, the car driver should also receive a warning.

3.1.3 Technical description

3.1.3.1 PTW transmit CAM

CAM is transmitted periodically.

For detailed information about CAM, please refer to the following standard: ETSI EN 302 637-2 V1.4.1 (2019-04)¹.

3.1.3.2 PTW receive CAM

3.1.3.2.1 State flow

The function state flow from Service-In to Service-Out of PTW receive CAM is indicated in the following figure.

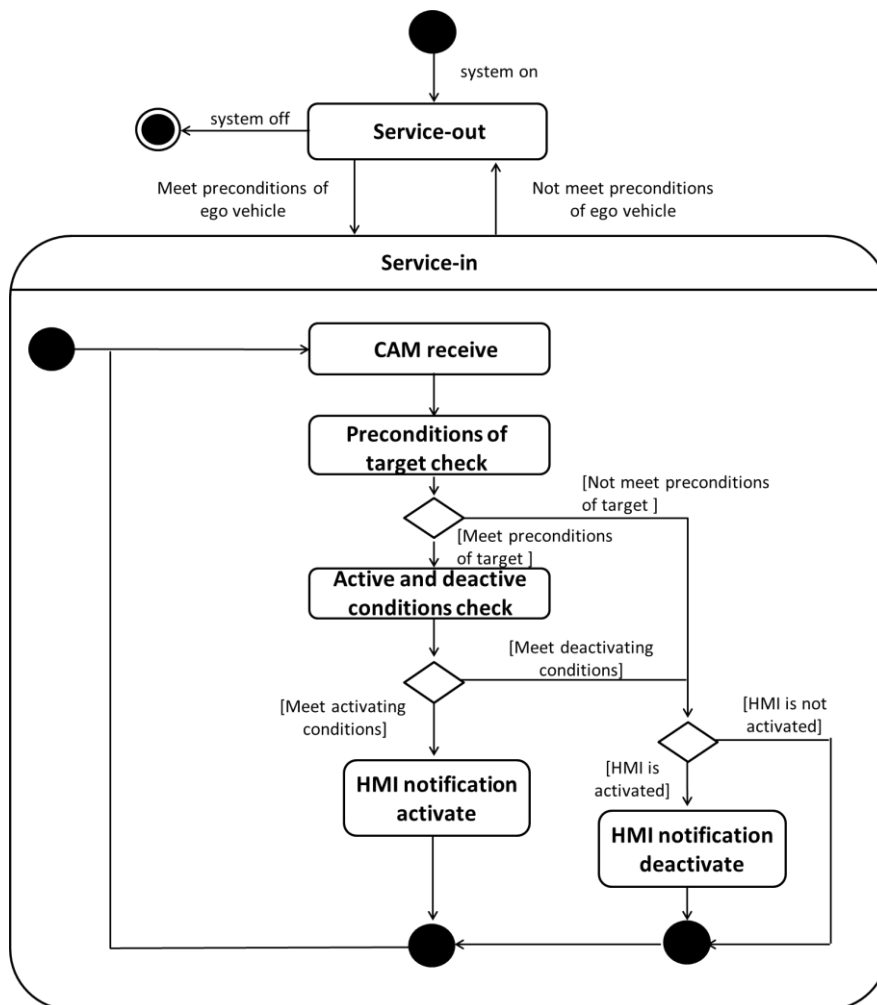


Figure 8: State Flow of IMA (PTW receive CAM)

¹ ETSI EN 302 637-2, V1.4.1 (2019-04)
https://www.etsi.org/deliver/etsi_en/302600_302699/30263702/01.04.01_60/en_30263702v010401p.pdf, accessed on 12.11.2020)

3.1.3.2.2 Preconditions

All of the following preconditions (PC_1 to PC_9) shall be satisfied every time before PTW receive CAM use case is activated:

Table 1: Preconditions of ego vehicle (PTW receive CAM)

#	Item	Condition
PC_1	Ego vehicle	PTW
PC_2	Speed range	Up to 100km/h
PC_3	Location	Crossing/Intersection/Junction/Roundabout (<200m between PTW and intersection/roundabout)
PC_4	Road type	Non-priority road
PC_5	Time	-
PC_6	Weather	-
PC_7	Other conditions	-
PC_8	Out of scope	-
PC_9	Acceleration	Not decreasing as for stopping before entering the intersection when riding on a non-priority road

All of the preconditions of target (PC_10 and PC_11) shall be satisfied before active and deactivate condition check.

Table 2: Preconditions of target (PTW receive CAM)

#	Item	Condition
PC_10	Other vehicle	Other vehicle is approaching the same intersection or roundabout from a different direction
PC_11	Distance between ego vehicle and other vehicle	< 300m

3.1.3.2.3 Activation and deactivation requirements

The activation and deactivation requirements of PTW receive CAM of IMA are stated below. All activating conditions must be satisfied to trigger to warning.

Table 3: Activating conditions of IMA (PTW receive CAM)

#	Activating conditions
AC_1	The next riding maneuver of the ego vehicle is assessed by at least reading out the state of the turn signal and other appropriate conditions found to be on collision course with the other vehicle, i.e. their paths cross in the near future.
AC_2	A TTC between 2.5s and 6.5s is calculated.

Table 4: Deactivating conditions of IMA (PTW receive CAM)

#	Deactivating conditions
DC_1	There is no calculated Point-of-Collision any more for 1 second or more.
DC_2	If the PTW is inside the roundabout: the car is detected to be approaching to the roundabout with an initial speed and positive deceleration as for stopping or sufficiently slowing down before entering. If the PTW is outside the roundabout: the PTW is detected to be approaching the roundabout with an initial speed and positive deceleration as for stopping or sufficiently slowing down before entering.

In addition to Table 3, other activation conditions may need to be considered, but have prerequisites, such as higher accuracy in positioning and/or a map to enable a path prediction.

To deactivate the warning, all deactivating conditions must be satisfied.

Abbreviations

Please refer to the abbreviations in Preamble document.