Triggering Conditions and Data Quality Pre-Crash Information

CAR 2 CAR Communication Consortium

About the C2C-CC

Enhancing road safety and traffic efficiency by means of Cooperative Intelligent Transport Systems and Services (C-ITS) is the dedicated goal of the CAR 2 CAR Communication Consortium. The industrial driven, non-commercial association was founded in 2002 by vehicle manufacturers affiliated with the idea of cooperative road traffic based on Vehicle-to-Vehicle Communications (V2V) and supported by Vehicle-to-Infrastructure Communications (V2I). The Consortium members represent worldwide major vehicle manufactures, equipment suppliers and research organisations.

Over the years, the CAR 2 CAR Communication Consortium has evolved to be one of the key players in preparing the initial deployment of C-ITS in Europe and the subsequent innovation phases. CAR 2 CAR members focus on wireless V2V communication applications based on ITS-G5 and concentrate all efforts on creating standards to ensure the interoperability of cooperative systems, spanning all vehicle classes across borders and brands. As a key contributor, the CAR 2 CAR Communication Consortium and its members work in close cooperation with the European and international standardisation organisations.

Disclaimer

Document information

Number:	2066	**Version:**	n.a.	**Date:**	2021-07-23
Title:	Triggering Conditions and Data Quality Pre-Crash Information			**Document Type:**	RS
Release	1.6.0				
Release Status:	Public				
Status:	Final				

Table 1: Document information

Changes since last version

Title:	Triggering Conditions and Data Quality Pre-Crash Information		
Date	**Changes**	**Edited by**	**Approved**
2021-07-23	Minor editorial changes	Release Management	Steering Committee
2021-03-12	No changes	Release Management	Steering Committee
2020-12-16	Minor editorial changes	Release Management	Steering Committee
2020-07-31	Minor corrections	Release Management	Steering Committee
2020-03-27	No changes	Release Management	Steering Committee
2019-09-13	Initial Version	Release Management	Steering Committee

Table 2: Changes since last version

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1 Introduction

Other (informational) **RS_tcPci_024**

This document describes the triggering conditions for the exchange of Pre-Crash Information, when a vehicle detects a critical situation (e.g. an obstacle) ahead.

2 Triggering conditions

2.1 Exchange of Pre-Crash Information

2.1.1 Description of Use Case

Other (informational) **RS_tcPci_001**

This use case describes the process for DENMs to be sent by a vehicle, when a critical situation ahead is detected, e.g. when the ego vehicle approaches a slower or stationary vehicle. In cases where a collision is likely, dedicated information is shared with all vehicles in the immediate surrounding. For example, this information contains measured values about the relative distance and speed between the ego and the critical object. Each receiving vehicle may activate its Pre-Crash measures when it assumes itself to be under risk and the situation is considered as sufficiently critical. Nevertheless, the behavior of the receiving vehicle(s) is out of scope of this document and not specified.

Other (informational) **RS_tcPci_002**

This use case requires data elements which are not yet part of latest version of [EN 302 637-3]. It is intended to update the EN accordingly and mass deployment of this use case shall be delayed until the [EN 302 637-3] is finally updated. In consequence this use case description shall be considered as part of standardization process, where the required data elements will be identified and verified.

The required extension (ASN.1 only) of the existing DENM specification is fully specified in ‘C2CCC_RS_2067_Pre-CrashInformation_AsnExtension’.

Other (informational) **RS_tcPci_003**

This use case uses a new *subCauseCode* of an already existing *CauseCode*. The new *subCauseCode* is not yet specified in ETSI and should be introduced during the change process.

2.1.2 Relations to other Use Cases

Other (informational) **RS_tcPci_004**

This use case can be active in parallel with one or more of the following use cases, since they share their operational scope:

- Exchange of IRCs - Request IRC
- Exchange of IRCs - Response IRC
- Dangerous Situations - Electronic Emergency Brake Light
- Dangerous Situations - Automatic Brake Intervention
- Dangerous Situations - Reversible Occupant Restraint System Intervention

This use case and *Exchange of IRCs* shares their triggering conditions and have similar thresholds for triggering the use case. Due to the low TTC value of less than 1.5 s, a detection of dangerous situation use case, e.g. caused by a hard braking maneuver, is considered as likely, too.

Note: When this use case is active, the parallel activation of one of the Dangerous Situation use cases is still possible. Both use cases can and should be active in parallel, but depending on the DCC restrictions they may compete for message transmission. This is caused by the high update rate for these DENMs (10 Hz each).

2.1.3 Triggering Conditions

2.1.3.1 Preconditions

Requirement **RS_tcPci_005**

The on-board sensors that are used for the criticality evaluation are operational and are not reporting errors (e.g. electrical issues) or functional limitations (e.g. blindness).

Tested by:

2.1.3.2 Use Case Specific Conditions

Requirement **RS_tcPci_006**

The use case shall be triggered if the host vehicle has identified a critical object - using its on-board sensors - based on one of the following conditions:

a) An object that likely is a vehicle and is located ahead of the host vehicle based on the vehicles' estimated paths and dimensions.
b) The detected object is critical, because it is triggering the FCW system
c) The detected object is critical, because it is triggering the AEB system

Additionally, both of the following conditions need to apply to the critical object:

d) The computed Time To Collision (TTC) with the identified object is smaller than 1,5 s
e) The relative speed between the identified object and the host vehicle is smaller than -10 km/h

Note: relative speed is measured in the host vehicle coordinate system and thus negative when the object is closing in.

Tested by:

Requirement **RS_tcPci_007**

The computation of the TTC shall include the ego velocity, ego acceleration, object velocity and relative distance between the ego and the critical object.

Tested by:

Requirement **RS_tcPci_008**

The use case shall not be triggered again as long as a previously detected use case is not terminated. In the case of a change of the critical object, the previous detection shall be terminated and the use case shall be triggered again immediately (with a new DENM and thus new ActionID).

Tested by:

2.1.3.3 Information Quality

Requirement **RS_tcPci_009**

The value of the data element *informationQuality* in the DENM depends on the way the event is detected. The *informationQuality* value shall be set based on the following table (if multiple

conditions apply, the highest value shall be selected):

Event detection	Value of InformationQuality
No TRCO-compliant implementation	unknown(0)
Conditions a) and d) and e) are fulfilled	1
Conditions b) and d) and e) are fulfilled	2
Conditions c) and d) and e) are fulfilled	3

Table 3: Information quality of 'Exchange of Pre-Crash Information'

Tested by:

2.1.4 Termination Conditions

Requirement **RS_tcPci_010**

This use case is terminated by a cancellation of the originating vehicle C-ITS station. At the termination of the use case, update DENM request shall be terminated.

Tested by:

2.1.4.1 Cancellation

Requirement **RS_tcPci_011**

Once at least one of the following conditions is fulfilled continuously for more than 200 ms, the generation of a cancellation DENM shall be triggered:

1. No critical object is detected anymore.
2. The computed TTC with the critical object is greater than 2 s.
3. The relative speed between the host vehicle and the critical object is greater than -5 km/h.
4. The detected critical object has changed, i.e. another vehicle is now considered as the critical object.

Note: Different criticality thresholds are used for the cancellation such that toggling of the use case activation can be prevented.

Note: Repetition shall not be used for the cancellation. The critical situation is over, no more update DENMs will be sent and therefore, there is no harm in case the cancellation message is lost.

Tested by:

Requirement **RS_tcPci_012**

When a cancellation DENM is triggered, all data elements in the management container of the cancellation DENM shall be updated.

Tested by:

2.1.4.2 Negation

Requirement **RS_tcPci_013**

A negation DENM shall not be used for this use case.

Tested by:

2.1.5 Update

Requirement **RS_tcPci_014**

The generated DENM shall be updated every 100 ms, as long as the use case is not terminated.

For each updated DENM, all data elements within the DENM shall be updated.

Tested by:

2.1.6 Repetition Duration and Repetition Interval

Requirement **RS_tcPci_015**

A repetition of the DENM shall not be used for this use case.

Tested by:

2.1.7 State Diagram

Other (informational) **RS_tcPci_016**

The following diagram provides an overview of the envisioned operational behavior based on the previous requirements:

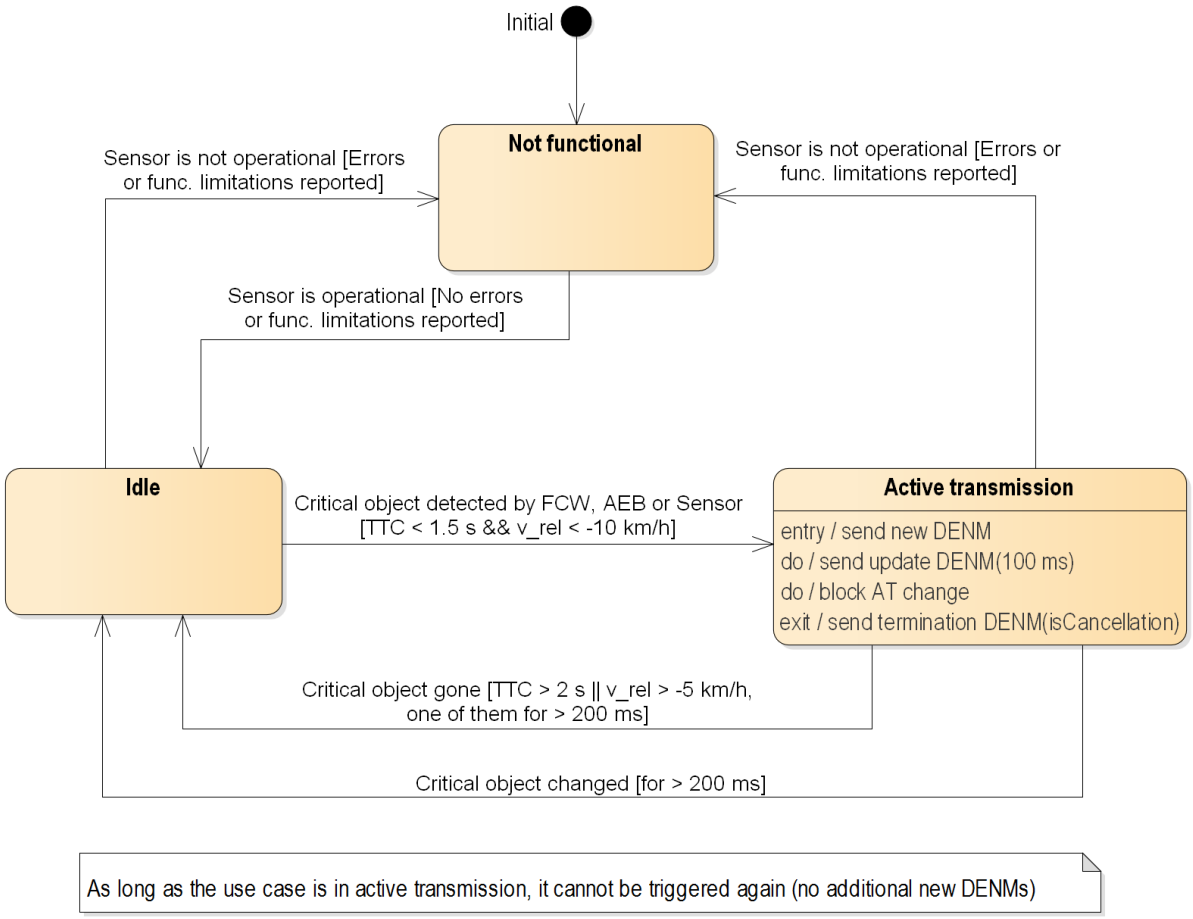

Figure 1: State diagram of the envisioned operational behaviour.

2.1.8 Traffic class

Requirement **RS_tcPci_017**

For new, update and cancellation DENMs, the traffic class shall be set to 0.

Tested by:

2.1.9 Message Parameter

2.1.9.1 DENM

Requirement **RS_tcPci_018**

Table 4 specifies the data elements of the DENM that shall be set.

Data Field	Value
Management Container	

actionID	Identifier of a DENM. Shall be set according to [TS 102 894-2].
detectionTime	*TimestampIts*-Timestamp at which the event is detected by the originating vehicle C-ITS station. Shall be set according to [TS 102 894-2].
referenceTime	*TimestampIts*-Timestamp at which a new, update or cancellation DENM is generated. Shall be set according to [TS 102 894-2].
termination	Shall not be set in case of new or update DENM. Shall be set to isCancellation (0) in case of a cancellation DENM.
eventPosition	*ReferencePosition*. Shall be set according to [TS 102 894-2].
relevanceDistance	lessThan100m(1) Note: This shall also cover the worst case scenario of driving with nearly 250 km/h towards a dangerous end of queue (s = v x t = 69,4 m/s x 1,5 s = 104,2 m). Note: Per the GeoNetworking specification, applications in stations outside of the relevanceDistance to the event will not receive this message.
relevanceTrafficDirection	allTrafficDirections(0)
validityDuration	2 s Note: Value shall be larger than TTC.
stationType	The type of the originating vehicle C-ITS station. Shall be set according to [TS 102 894-2].
Situation Container	
informationQuality	See RS_tcPci_009.
causeCode	collisionRisk(97)
subCauseCode	preCrashInformation(5) Note: This subCauseCode is not yet defined in [EN 302 637-3].
Location Container	
eventSpeed	Speed of the originating vehicle C-ITS station. Shall be set according to [TS 102 894-2].
eventPositionHeading	Heading of the originating vehicle C-ITS station. Shall be set according to [TS 102 894-2].
traces	The data element shall not be populated for this use case. A minimum of data (e.g. one trace with zero elements) may be necessary to fulfill the ASN.1 requirements. Note: The trace is omitted since it seems not to be useable for relevance assessment by receiving stations. Receiving stations can still use the trace given in the sender's CAM.
roadType	Shall be set according to [TS 102 894-2]. Otherwise, if the information about the urban/non-urban status cannot be determined, the data element shall be omitted.
Alacarte Container: PreCrashContainer	

perceivedObject	A customized data field of a PerceivedObject of a CPM as described in [TR 103 562]. This data element contains all the relative information of the perceived object.
PerceivedObject:: objectID	A constant identifier of the object. Shall be set according to [TR 103 562].
PerceivedObject:: timeOfMeasurement	Relative time, describing the moment in time when the provided measurement data was generated by the on-board sensor. The relative value shall be provided in relation to the DE *detectionTime.*
PerceivedObject:: xDistance	X-component (host vehicle reference frame) of the relative distance between the host vehicle reference point and the reference point of the measurement as measured by the on-board sensor. The measurement delay (measurement time to detection time) shall be less than 100 ms.
PerceivedObject:: yDistance	Y-component (host vehicle reference frame) of the relative distance between the host vehicle reference point and reference point of the measurement as measured by the on-board sensor. The measurement delay (measurement time to detection time) shall be less than 100 ms.
PerceivedObject:: xSpeed	X-component (host vehicle reference frame) of the relative speed between the host vehicle and the object as measured by the on-board sensor. The measurement delay (measurement time to detection time) shall be less than 100 ms.
PerceivedObject:: ySpeed	Y-component (host vehicle reference frame) of the relative speed between the host vehicle and the object as measured by the on-board sensor. The measurement delay (measurement time to detection time) shall be less than 100 ms.
PerceivedObject:: yawAngle	The yaw angle represents the relative angle measured between the host vehicle orientation and the vector perpendicular to the perceived object side (planarObjectDimension1), see also Figure 2. Shall be set according to [TR 103 562]. The measurement delay (measurement time to detection time) shall be less than 100 ms. This data element shall be optional.
PerceivedObject:: planarObjectDimension1	Perceived width of the side of the object on which the reference point of the measurement is located. The measurement delay (measurement time to detection time) shall be less than 100 ms. Note: This width might be shorter or longer than the real object width due to sensor vision limitations (e.g. obstructions).

objectStationId	The stationID of the object for which the values are provided. Shall be set according to [TS 102 894-2]. This data element shall be optional. Note: The stationID of the object may change during the use case, when the object changes its AT.
timeToCollision	The calculated (or measured) time to collision towards the object, determined by the host vehicle. This data element shall be optional.
hostVehicleOrientation	Absolute orientation of the host vehicle body in the world coordinate system. Shall be set according to [TR 103 562].
impactSection	Indication of the object's section where the impact will most likely occur. When the target object is likely to be a vehicle, than this data element should be made available, otherwise (every other type of object) the data element shall not be provided. Note: It is permissible to derive the required object dimensions and orientation from models to provide a best guess.

Table 4: DENM data elements of 'Exchange of Pre-Crash Information'

Tested by:

2.1.9.2 Details on the reference point of the measurement

Other (informational) **RS_tcPci_019**

For the Pre-Crash Information it is assumed that the reference point of the measurement is always located in the middle of the side for which also the perceived object width is given.

The following graphic gives an overview of the different distance and direction data elements and their relations to each other.

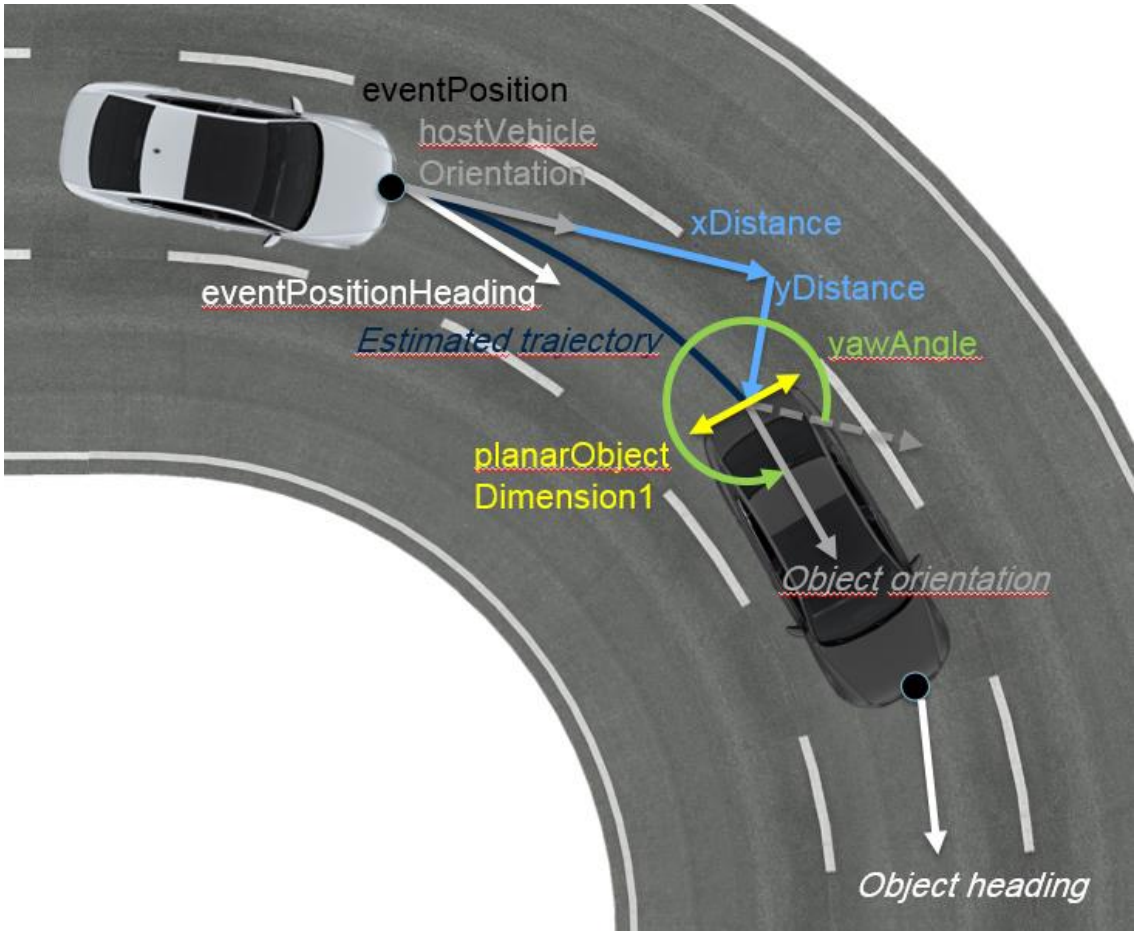

Figure 2: Representation of the measurement point for PCI and related quantities. Values written in italic are depicted to support a better understanding, but they are not part of the DENM; Note: The shown y-distance is of negative value in the vehicle coordinate system according to [ISO 8855].

2.1.9.3 CAM

Requirement **RS_tcPci_020**

CAM adaption shall not be used for this use case.

Tested by:

2.1.10 Networking and Transport Layer

Requirement **RS_tcPci_021**

The facility layer's interface parameter *Destination area* shall be equal to a circular shape with radius equal to *relevanceDistance*.

Tested by:

2.1.11 Security Layer

Requirement **RS_tcPci_022**

An AT change shall be blocked in the following cases:

1. While the use case is active
2. As long as the *validityDuration* of the cancellation DENM is not expired.

Corresponding new, update and cancellation DENMs shall be sent with the same AT.

Tested by: