

Triggering Conditions and Data Quality Exchange of IRCs

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). Today, the Consortium comprises 73 members, with 12 vehicle manufacturers, 33 equipment suppliers and 28 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 well as other road users. As a key contributor, the CAR 2 CAR Communication Consortium works in close cooperation with the European and international standardisation organisations such as ETSI and CEN.

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1 Introduction

1.1 Abstract

Other (informational)

RS_tcIRC_8

This document describes the triggering conditions for a critical driving situation where the Impact Reduction Containers (IRCs) of potential collision opponents shall be exchanged.

Other (informational)

RS_tcIRC_138

The triggering conditions are divided into the following two C-ITS services:

- exchange of IRCs – request IRC
- exchange of IRCs – response IRC

2 Definitions and abbreviations

2.1 Abbreviations

Other (informational)

RS_tcIRC_119

ABS	Anti-lock Braking System
ASN.1	Abstract Syntax Notation One
ASR	Anti-Slide Regulation
AT	Authorization Ticket
AUT	Automatic Transmission
CAM	Cooperative Awareness Message
C2C-CC	CAR 2 CAR Communication Consortium
CDD	Common Data Dictionary
DEN	Decentralized Environmental Notification
DENM	DEN Message
ECE	Economic Commission for Europe
ETSI	European Telecommunications Standards Institute
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IRC	Impact Reduction Container
ITS	Intelligent Transport System
ITS-S	ITS Station
TC	Triggering Conditions
TTC	Time To Collision
V2V	Vehicle to Vehicle

Table 3: Abbreviations

2.2 Definitions

Definition

RS_tcIRC_642

‘*Vehicle speed*’ is the length of the velocity-vector of the reference position point.

3 Triggering conditions

3.1 Exchange of IRCs

3.1.1 Exchange of IRCs - request IRC

3.1.1.1 Description of C-ITS service

Other (informational)**RS_tcIRC_140**

This section describes the triggering of V2V messages for a critical driving situation where a crash between two vehicles is highly likely or unavoidable. This phase is called PreCrash phase.

Other (informational)**RS_tcIRC_11**

In general, a request of an IRC is distinguished from a response to an IRC. In the request sending case, the ego vehicle is recognizing a potential collision and is therefore sending its own IRC, to get the IRC of the collision opponent in response.

Other (informational)**RS_tcIRC_141**

The following C-ITS services are related to this service, because they share similar triggering conditions:

- 'exchange of IRCs — response IRC';

Requirement**RS_tcIRC_10**

A DENM signal shall be sent to the stack only if the triggering conditions described in this section are evaluated as valid. Such a signal prompts the stack to generate a new DENM. If the triggering conditions are not met, a DENM signal shall not be generated.

Tested by:

3.1.1.2 Triggering conditions

3.1.1.2.1 Preconditions

Requirement**RS_tcIRC_157**

No specific preconditions apply to this C-ITS service.

Tested by:

3.1.1.2.2 Service-specific conditions

Requirement**RS_tcIRC_13**

If both the following conditions are satisfied, the triggering conditions for this C-ITS service are fulfilled and the generation of a DENM shall be triggered:

- 1) the 'time to collision' (TTC) calculated by an on-board measurement device algorithm is < 1.5 s. The acceptable tolerance for the calculated TTC value is 10 %;
- 2) the relative speed between two potential collision opponents exceeds 20 km/h.

Tested by:

3.1.1.2.3 Information quality

Requirement **RS_tcIRC_14**

The value of the data element *informationQuality* in the DENM depends on how the event is detected. The *informationQuality* value shall be set in accordance with the following table (highest possible value shall be used):

Table 4: Information quality of ‘exchange of IRCs — request IRC’

Event detection	Value of InformationQuality
No TRCO-compliant implementation	unknown(0)
Otherwise	1

Tested by:

3.1.1.3 Termination conditions

Requirement **RS_tcIRC_15**

A termination of the C-ITS service shall not be considered.

Tested by:

3.1.1.3.1 Cancellation

Requirement **RS_tcIRC_16**

A cancellation DENM shall not be used for this C-ITS service.

Tested by:

3.1.1.3.2 Negation

Requirement **RS_tcIRC_17**

A negation DENM shall not be used for this C-ITS service.

Tested by:

3.1.1.4 Update

Requirement **RS_tcIRC_18**

An update DENM shall not be used for this C-ITS service.

Tested by:

3.1.1.5 Repetition duration and repetition interval

Requirement **RS_tcIRC_19**

New DENMs shall be repeated for a *repetitionDuration* of 300 ms (100 ms three times in a row) with a *repetitionInterval* of 100 ms. Therefore, the interface parameters *Repetition*

duration and *Repetition interval* between the application and the DEN basic service shall be set in accordance with the above values.

Note: As it is not guaranteed that a sent IRC will reach the receiver (e.g. because of channel load, temporarily out of range, etc.), the sender sends the IRC three times in a row. This is equivalent to a *repetitionDuration* of 300 ms.

Note: The estimated duration for transmitting (application to application) an IRC (repetition not included) over automotive WLAN is 200 - 300 ms. If only the third attempt is received (worst case), in both cases (request and response), the information will be available for both vehicles after 1 second ($2 * (300 \text{ ms} + 100 \text{ ms} (@10 \text{ Hz}) + 100 \text{ ms} (@10 \text{ Hz}))$). Therefore, the trigger parameter $TTC < 1.5 \text{ s}$ is sufficient. Sending the IRC three times in a row is considered a good compromise between channel load and ensuring successful transmission.

Note: Only the first DENM will be sent without Decentralized Congestion Control (DCC) constraints. The second and third DENMs may be affected by DCC (based on current channel load).

Note: Where two DENMs with the same *causeCode* originate from the same C-ITS station, the case shall be managed by the receiving C-ITS station.

Tested by:

3.1.1.6 Traffic class

Requirement

RS_tcIRC_20

New DENMs shall be set to *traffic class 0*.

Tested by:

3.1.1.7 Message parameters

3.1.1.7.1 DENM

Requirement

RS_tcIRC_21

The following table specifies the data elements of the DENM that shall be set.

Table 5: DENM data elements of ‘exchange of IRCs — request IRC’

Data field	Value
Management container	
<i>actionID</i>	Identifier of a DENM. Shall be set in accordance with [TS 102 894-2].
<i>detectionTime</i>	<i>Timestamp</i> ts-timestamp at which the event is detected by the originating C-ITS station. Shall be set in accordance with [TS 102 894-2].
<i>referenceTime</i>	<i>Timestamp</i> ts-timestamp at which a new DENM is generated. Shall be set in accordance with [TS 102 894-2].
<i>termination</i>	Shall not be set, because neither negation nor cancellation are to be used in this C-ITS service.
<i>eventPosition</i>	<i>ReferencePosition</i> . Shall be set in accordance with [TS 102 894-2].

<i>relevanceDistance</i>	lessThan100m(1) Note: This shall also cover the worst case scenario of driving at nearly 250 km/h towards a dangerous end of queue ($s = v \cdot t = 69.4 \text{ m/s} \cdot 1.5 \text{ s} = 104.2 \text{ m}$).
<i>relevanceTrafficDirection</i>	allTrafficDirections(0)
<i>validityDuration</i>	2 s Note: Shall be larger than TTC.
<i>stationType</i>	The type of the originating C-ITS station. Shall be set in accordance with [TS 102 894-2].
Situation container	
<i>informationQuality</i>	See RS_tcIRC_14.
<i>causeCode</i>	collisionRisk(97)
<i>subCauseCode</i>	unavailable(0)
Location container	
<i>eventSpeed</i>	Speed of the originating C-ITS station. Shall be set in accordance with [TS 102 894-2].
<i>eventPositionHeading</i>	Heading of the originating C-ITS station. Shall be set in accordance with [TS 102 894-2].
<i>traces</i>	<i>PathHistory</i> of the originating C-ITS station. Shall be set in accordance with [TS 102 894-2].
<i>roadType</i>	Shall be set in accordance with [TS 102 894-2]. If the information about the urban/non-urban status cannot be determined, the data element shall be omitted.
Alacarte container: ImpactReductionContainer	
<i>heightLonCarrLeft</i>	Height of left longitudinal carrier of the vehicle from base to top. Shall be set in accordance with [TS 102 894-2].
<i>heightLonCarrRight</i>	Height of right longitudinal carrier of the vehicle from base to top. Shall be set in accordance with [TS 102 894-2].
<i>posLonCarrLeft</i>	Longitudinal distance from the centre of vehicle front bumper to the front of the left longitudinal carrier of vehicle. Shall be set in accordance with [TS 102 894-2].
<i>posLonCarrRight</i>	Longitudinal distance from the centre of vehicle front bumper to the front of the right longitudinal carrier of vehicle. Shall be set in accordance with [TS 102 894-2].
<i>positionOfPillars</i>	Vehicle pillars refer to the vertical or near vertical support of vehicle, designated respectively as A, B, C or D. Shall be set in accordance with [TS 102 894-2].
<i>posCentMass</i>	Perpendicular distance from the centre of mass of an empty load vehicle to the front line of the vehicle bounding box. Shall be set in accordance with [TS 102 894-2].

<i>wheelBaseVehicle</i>	Perpendicular distance between front and rear axle of the wheel base of vehicle. Shall be set in accordance with [TS 102 894-2].
<i>turningRadius</i>	The smallest circular turn (i.e. U-turn) that the vehicle is capable of making. Shall be set in accordance with [TS 102 894-2].
<i>posFrontAx</i>	Perpendicular distance between the vehicle front line of the bounding box and the front wheel axle. Shall be set in accordance with [TS 102 894-2].
<i>positionOfOccupants</i>	BitString that indicates whether a passenger seat is occupied or whether the occupation status is detectable or not. Shall be set in accordance with [TS 102 894-2].
<i>vehicleMass</i>	Mass of an empty loaded vehicle. Shall be set in accordance with [TS 102 894-2].
<i>requestResponseIndication</i>	request(0)

Tested by:

3.1.1.7.2 CAM

Requirement

RS_tcIRC_22

CAM adaption shall not be used for this C-ITS service.

Tested by:

3.1.1.8 Network and transport layer

Requirement

RS_tcIRC_23

The interface parameter *DENM destination area* between the DEN basic service and the networking and transport layer shall be equal to a circular shape with radius equal to *relevanceDistance*.

Tested by:

3.1.1.9 Security layer

Requirement

RS_tcIRC_25

If the triggering conditions as described in section 3.1.1.2 apply, an AT change shall be blocked as long as the *validityDuration* has not expired (see RS_tcIRC_21). Corresponding new DENMs shall be sent with the same AT.

Tested by:

3.1.1.10 Scenarios

Other (informational)

RS_tcIRC_144

This section has an informational character and is not part of the requirement specification.

Other (informational)

RS_tcIRC_142

The following list encompasses scenarios which are regarded as relevant or irrelevant considering the present C-ITS service:

Table 6: Exchange of IRC — request IRC scenarios

Count	Description	Status
	tbd.	
	tbd.	

3.1.2 Exchange of IRCs - response IRC

3.1.2.1 Description of C-ITS service

Other (informational)

RS_tcIRC_148

This section describes the triggering of V2V messages after having received an IRC from a potential collision opponent.

Other (informational)

RS_tcIRC_149

In general, a request of an IRC is distinguished from a response to an IRC. In the response sending case, the vehicle has received an IRC of a potential opponent and is therefore sending its own IRC, to provide the requesting vehicle the information it was requesting.

Other (informational)

RS_tcIRC_150

The following C-ITS services are related to this service, because they share similar triggering conditions:

- 'exchange of IRCs — request IRC'.

Requirement

RS_tcIRC_27

A DENM signal shall be sent to the stack only if the triggering conditions described in this section are evaluated as valid. Such a signal prompts the stack to generate a new DENM. If the triggering conditions are not met, a DENM signal shall not be generated.

Tested by:

3.1.2.2 Triggering conditions

3.1.2.2.1 Preconditions

Requirement

RS_tcIRC_28

The following preconditions shall be satisfied when this use case is triggered:

1. an IRC as described in RS_tcIRC_21 has been received.

Tested by:

3.1.2.2.2 Service-specific conditions

Requirement

RS_tcIRC_29

If the precondition in RS_tcIRC_28 and both the following conditions are satisfied, the

triggering conditions for this C-ITS service are fulfilled and the generation of a DENM shall be triggered:

- 1) *requestResponseIndication* in the received IRC is set to request(0);
- 2) the perpendicular distance between the requesting vehicle (event position in the IRC) and the ego vehicle (reference position as defined in CAM) is less than 100 m.

Note: When an IRC is received, the receiver has to check that it was actually requested before responding with its own IRC. This can be done on the basis of the *requestResponseIndication*. To avoid unnecessary load on the transmission channel from multiple transmitted IRCs, only vehicles in the immediate vicinity (within 100 m) respond to the request.

Tested by:

3.1.2.2.3 Information quality

Requirement

RS_tcIRC_30

The value of the data element *informationQuality* in the DENM depends on how the event is detected. The *informationQuality* value shall be set in accordance with the following table (highest possible value shall be used):

Table 7: Information quality of ‘exchange of IRCs — response IRC’

Event detection	Value of InformationQuality
No TRCO-compliant implementation	unknown(0)
Otherwise	1

Tested by:

3.1.2.3 Termination conditions

Requirement

RS_tcIRC_31

A termination of the C-ITS service shall not be considered.

Tested by:

3.1.2.3.1 Cancellation

Requirement

RS_tcIRC_32

A cancellation DENM shall not be used for this C-ITS service.

Tested by:

3.1.2.3.2 Negation

Requirement

RS_tcIRC_33

A negation DENM shall not be used for this C-ITS service.

Tested by:

3.1.2.4 Update

Requirement

RS_tcIRC_34

An update DENM shall not be used for this C-ITS service.

Tested by:

3.1.2.5 Repetition duration and repetition interval

Requirement

RS_tcIRC_35

New DENMs shall be repeated for a *repetitionDuration* of 300 ms (100 ms three times in a row) with a *repetitionInterval* of 100 ms. Therefore the interface parameters *Repetition duration* and *Repetition interval* between the application and the DEN basic service shall be set in accordance with the above values.

Note: As it is not guaranteed that a sent IRC will reach the receiver (e.g. because of channel load, temporarily out of range, etc.), the sender sends the IRC three times in a row. This is equivalent to a *repetitionDuration* of 300 ms.

Note: The estimated duration for transmitting (application to application) an IRC (repetition not included) over automotive WLAN is 200 - 300 ms. If only the third attempt is received (worst case), in both cases (request and response), the information will be available for both vehicles after 1 second (2 * (300 ms + 100 ms (@10 Hz) + 100 ms (@10 Hz))). Therefore, the trigger parameter TTC < 1.5 s is sufficient. Sending the IRC three times in a row is considered a good compromise between channel load and ensuring successful transmission.

Note: Only the first DENM will be sent without DCC constraints. The second and third DENMs may be affected by DCC (based on current channel load).

Note: Where two DENMs with the same *causeCode* originate from the same C-ITS station, the case shall be managed by the receiving C-ITS station.

Tested by:

3.1.2.6 Traffic class

Requirement

RS_tcIRC_36

New DENMs shall be set to *traffic class* 0.

Tested by:

3.1.2.7 Message parameters

3.1.2.7.1 DENM

Requirement

RS_tcIRC_37

The following table specifies the data elements of the DENM that shall be set.

Table 8: DENM data elements of 'exchange of IRCs — response IRC'

Data field	Value
Management container	
<i>actionID</i>	Identifier of a DENM. Shall be set in accordance with [TS 102 894-2].

<i>detectionTime</i>	<i>Timestamp</i> ts-timestamp at which the event is detected by the originating C-ITS station. Shall be set in accordance with [TS 102 894-2].
<i>referenceTime</i>	<i>Timestamp</i> ts-timestamp at which a new DENM is generated. Shall be set in accordance with [TS 102 894-2].
<i>termination</i>	Shall not be set, because neither negation nor cancellation are to be used in this C-ITS service.
<i>eventPosition</i>	<i>ReferencePosition</i> . Shall be set in accordance with [TS 102 894-2].
<i>relevanceDistance</i>	lessThan100m(1)
<i>relevanceTrafficDirection</i>	allTrafficDirections(0)
<i>validityDuration</i>	2 s
<i>stationType</i>	The type of the originating C-ITS station. Shall be set in accordance with
Situation container	
<i>informationQuality</i>	See RS_tcIRC_30.
<i>causeCode</i>	collisionRisk(97)
<i>subCauseCode</i>	unavailable(0)
Location container	
<i>eventSpeed</i>	Speed of the originating C-ITS station. Shall be set in accordance with [TS 102 894-2].
<i>eventPositionHeading</i>	Heading of the originating C-ITS station. Shall be set in accordance with [TS 102 894-2].
<i>traces</i>	<i>PathHistory</i> of the originating C-ITS station. Shall be set in accordance with [TS 102 894-2].
<i>roadType</i>	Shall be set in accordance with [TS 102 894-2]. If the information about the urban/non-urban status cannot be determined, the data element shall be omitted.
Alacarte container: ImpactReductionContainer	
<i>heightLonCarrLeft</i>	Height of left longitudinal carrier of the vehicle from base to top. Shall be set in accordance with [TS 102 894-2].
<i>heightLonCarrRight</i>	Height of right longitudinal carrier of the vehicle from base to top. Shall be set in accordance with [TS 102 894-2].
<i>posLonCarrLeft</i>	Longitudinal distance from the centre of vehicle front bumper to the front of the left longitudinal carrier of vehicle. Shall be set in accordance with [TS 102 894-2].
<i>posLonCarrRight</i>	Longitudinal distance from the centre of vehicle front bumper to the front of the right longitudinal carrier of vehicle. Shall be set in accordance with [TS 102 894-2].

<i>positionOfPillars</i>	Vehicle pillars refer to the vertical or near vertical support of vehicle, designated respectively as A, B, C or D. Shall be set in accordance with [TS 102 894-2].
<i>posCentMass</i>	Perpendicular distance from the centre of mass of an empty load vehicle to the front line of the vehicle bounding box. Shall be set in accordance with [TS 102 894-2].
<i>wheelBaseVehicle</i>	Perpendicular distance between front and rear axle of the wheel base of vehicle. Shall be set in accordance with [TS 102 894-2].
<i>turningRadius</i>	The smallest circular turn (i.e. U-turn) that the vehicle is capable of making. Shall be set in accordance with [TS 102 894-2].
<i>posFrontAx</i>	Perpendicular distance between the vehicle front line of the bounding box and the front wheel axle. Shall be set in accordance with [TS 102 894-2].
<i>positionOfOccupants</i>	BitString that indicates whether a passenger seat is occupied or whether the occupation status is detectable. Shall be set in accordance with [TS 102 894-2].
<i>vehicleMass</i>	Mass of an empty load vehicle. Shall be set in accordance with [TS 102 894-2].
<i>requestResponseIndication</i>	response(1)

Tested by:

3.1.2.7.2 CAM

Requirement

RS_tcIRC_38

CAM adaption shall not be used for this C-ITS service.

Tested by:

3.1.2.8 Network and transport layer

Requirement

RS_tcIRC_39

The interface parameter *DENM destination area* between the DEN basic service and the networking and transport layer shall be equal to a circular shape with radius equal to *relevanceDistance*.

Tested by:

3.1.2.9 Security layer

Requirement

RS_tcIRC_115

If the triggering conditions as described in section 3.1.2.2 apply, an AT change shall be blocked as long as the *validityDuration* has not expired (see RS_tcIRC_37).

Tested by:

3.1.2.10 Scenarios

Other (informational)

RS_tcIRC_152

This section has an informational character and is not part of the requirement specification.

Other (informational)

RS_tcIRC_151

The following list encompasses scenarios which are regarded as relevant or irrelevant considering the present C-ITS service:

Table 9: Exchange of IRC — response IRC scenarios

Count	Description	Status
	tbd.	
	tbd.	