# Basic System Profile

## 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.

## Disclaimer

## Document information

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|---|---|---|---|---|---|
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**Table 1: Document information**

## Changes since last version

| Title: | Basic System Profile | | |
|---|---|---|---|
| Explanatory notes: | | | |
| 14/09/2019 | • Harmonization with infrastructure requirements<br>• Improvement of position and timing requirements<br>• Introduction of PTW aspects in the Profile and Triggering Condition documents | Release Management | Steering Committee |
| 31/08/2018 | • Consolidation of requirements after the split of the Basic System profile into 3 documents: Objectives (UID 2035), Features (UID 2036) and Profile (UID 2037) in the previous release.<br>• Improvement of position and timing requirements<br>• Extension of the release bundle by the Protection Profile V2X Hardware Security Module (UID 2056).<br>• Cleanup of security requirements in the Profile (UID 2037)<br>• Extraction of references into a separate document: Reference list (UID 2052)<br>• Update to new versions and cleanup of referenced standards | Release Management | Steering Committee |
| **Date** | **Changes** | **Edited by** | **Approved** |

**Table 2: Changes since last version**

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# 1 Introduction

**Other (informational)** **RS_BSP_147**

The European architecture for Cooperative Intelligent Transport System (C-ITS), outlined in [EN 302 665], defines four ITS sub-systems: vehicle, roadside, personal and central. For all of that sub-systems a common C-ITS station reference architecture is described, which offers different implementation options. Each option is further defined by one or more standards, contributed by different Standards Developing Organizations (SDOs).

For interoperability, each sub-system requires a specific set of standards, called system profile, defining in which way possible options are implemented. Thus the system profile describes external interfaces matching those of other sub-systems where communication is intended.

Interoperability again can be distinguished between two types:

- inter-sub-system interoperability i.e. sub-systems implementing the system profile can communicate/understand each other
- intra-sub-system interoperability (interoperability of components within an ITS subsystem), i.e., the sub-system consists of completely interchangeable components

Each type of interoperability provides benefits for the system, but comes with a certain effort to achieve this interoperability.

Inter-sub-system interoperability requires a precise definition of the external interfaces, but can leave room for different implementations within the sub-system, which encourages innovation and competitive differentiation.

Intra-sub-system interoperability requires a much higher degree of standardization within the sub-system, and allows customers to select among the best suppliers for each individual component within the sub-system. If intra-sub-system interoperability is not achieved, customers can only order complete sub-systems.

# 2 Scope

**Other (informational)** **RS_BSP_146**

The present document provides all requirements related to the features of a C2C-CC Basic System (see [C2CCC FEA]) to enable Inter-sub-system interoperability.

In terms of C2C-CC each requirement details a feature (which again details an objective) and provides its implementation details. Requirements itself are not further detailed by C2C-CC, thus requirements are the lowest level of specification provided by C2C-CC. As lowest layer of specification requirements are basis for testing, which follows the backward link: If all requirements of a feature are tested, the featured can be assumed as “tested” and if all features of an objective are assumed as “tested” the objective itself can be assumed as “tested”.

In some cases requirements are written in a way which let the implementation open, for example if they refer to very specific parts of a vehicle. Those requirements have to be further detailed by anybody implementing that requirement. Beside this special requirements all other requirements can be further detailed too.

# 3 Conventions to be used

## 3.1 Modal verbs terminology

**Other (informational)** **RS_BSP_152**

In this document the following verbal forms are used:

- **must:** indicates an absolute requirement of the specification due to legal issues
- **must not:** indicates an absolute prohibition of the specification due to legal issues
- **shall:** indicates an absolute requirement of the specification
- **shall not:** indicates an absolute prohibition of the specification
- **should:** indicates a recommendation. It means that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
- **should not:** indicates that something is not recommended. It means that there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
- **may:** indicates that something is permitted/possible
- **can:** indicates that something is possible/capable
- **cannot:** indicates that something is not possible/capable
- **will / will not:** indicates the inevitable behavior of the described system
- **is / is not:** indicates facts

## 3.2 Item identification

**Other (informational)** **RS_BSP_422**

Each item of this document has its unique identifier starting with "RS_BSP_" as prefix. For any review annotations, remarks and/or questions please refer to this unique ID rather than chapter or page numbers!

## 3.3 Provisions from referenced documents

**Other (informational)** **RS_BSP_153**

Unless otherwise specified in the present document, the normative requirements included in the referenced documents supporting the required functionality of the C2C-CC Basic System shall apply. The verbal forms for the definition of provisions of referenced documents are defined either inside the document, or generally by the SDO (standardization organization) or the organization providing them. For example normative requirements in ETSI documents are indicated by the verbal form “shall”.

In case of more than one option in the standard, this document specifies which one is the recommended choice to ensure interoperability and/or sufficient performance. This document supplements the standards in case where standards are open for interpretation or believed not to contain all necessary requirements to ensure interoperability and/or sufficient performance.

This document might also supplement standards in cases where, for performance reasons, it is believe that more stringent requirements than the minimum requirements in the standard shall be applied to ensure sufficient performance.

## 3.4 Requirements quality

**Other (informational)** **RS_BSP_424**

All Requirements shall have the following properties:

- **redundancy:** Requirements shall not be repeated within one requirement or in other requirements
- **clearness:** All requirements shall allow one possibility of interpretation only. Only technical terms of the glossary may be used. Furthermore, it must be clear from the requirement, what object the statement is a requirement on. Examples:
  - The <...> module shall/should/may ...
  - The <...> module's environment shall ...
  - The <...> configuration shall...
  - The function <...> shall ...
  - The hardware shall ...
- **atomicity:** Each Requirement shall only contain one requirement. A Requirement is atomic if it cannot be split up in further requirements.
- **testability:** Requirements shall be testable by analysis, review or test.
- **traceability:** The source and status of a requirement shall be visible at all times.
- **formulation:** All requirements shall be formulated so that they can be interpreted without the surrounding context (for example: "the function Xyz..." instead of "this function...").

# 4 Definitions and abbreviations

## 4.1 Abbreviations

**Table 3: Abbreviations**

**Other (informational)** **RS_BSP_150**

| | |
|---|---|
| AA | Authorization Authority |
| AT | Authorization Ticket |
| BSP | Basic System Profile |
| BTP | Basic Transport Protocol |
| C2C-CC | Car2Car Communications Consortium |
| CAM | Cooperative Awareness Message |
| CBR | Channel Busy Ratio |
| C-ITS | Cooperative Intelligent Transport System |
| CL | Channel Load |
| CS | Charging Spot |
| DCC | Decentralised Congestion Control |
| DENM | Decentralised Event Notification Message |
| DP | DCC profile |
| DPID | DCC profile identifier |
| EV | Electric Vehicle |
| GBC | GeoBroadcast |
| GN | GeoNetworking |
| GNSS | Global Navigation Satellite System |
| IEEE | Institute of Electrical and Electronics Engineers |
| ITS | Intelligent Transport System |
| ITS-AID | ITS - Application Object Identifier |
| LT | Lifetime |
| MAC | Medium Access Control |
| OEM | Original Equipment Manufacturer |
| PAI | Position Accuracy Indicator |
| PKI | Public key infrastructure |
| POI | Point of Interest |
| QPSK | Quadrature phase-shift keying |
| RCA | Root Certification Authority |
| SCF | Store Carry Forward |
| SDO | Standards Developing Organization |

| | |
|---|---|
| SHB | Single Hop Broadcast |
| SSP | Service Specific Permissions |
| TAI | Temps Atomique International |
| TAL | Trust Assurance Level |
| TC | Traffic class |
| UTC | Coordinated Universal Time |
| WG | Working Group |
| WGS | World Geodetic System |

## 4.2 Definitions

**Definition** **RS_BSP_149**

A '*C2C-CC Basic System*' is a C-ITS vehicle sub-system as outlined in [C2CCC FEA].

**Definition** **RS_BSP_193**

*'C-ITS time'* or *'time base'* means the number of elapsed International Atomic Time (TAI) milliseconds since 2004-01-01 00:00:00.000 Coordinated Universal Time (UTC)+0 as defined in [ETSI EN 302 636-4-1]. Timestamps as defined in [ETSI TS 102 894-2] follow this time format

**Definition** **RS_BSP_430**

The '*station clock' means* a clock representing Cooperative Intelligent Transport Systems (C-ITS) time (see RS_BSP_193) in a C2C-CC Basic System.

**Definition** **RS_BSP_428**

*'Vehicle states'* comprise absolute position, heading and velocity at a certain point in time.

**Definition** **RS_BSP_429**

Information provided with a 'confidence level' of 95 % means that the true value is inside the confidence interval or the confidence area for at least 95 % of the data points in a given statistical base.

**Definition** **RS_BSP_500**

A *'confidence interval'* is specified by the estimated value plus/minus the confidence value.

**Definition** **RS_BSP_211**

*'Sky obstruction'* means the fraction of half-hemisphere values that are obstructed for Galileo or other Global Navigation Satellite Systems (GNSS) satellites due to mountains, buildings, trees, etc.

**Definition** **RS_BSP_200**

For the horizontal position, a confidence area is used instead of a single confidence interval. The confidence area is specified by an ellipse (centered at the estimated horizontal position) described via a major axis, minor axis and orientation of the major axis relative to the north

direction as defined in RS_BSP_191.

**Other (informational)** **RS_BSP_450**

Definitions for *authorization tickets*, *enrolment credentials* and *authorization status repository* can be found in:

- [TS 102 940]
- [TS 102 941]
- [TS 102 731]

# 5 Parameter settings

**Definition** **RS_BSP_443**

**Table 4: Parameter settings**

| Parameter | Value | Unit | Description | Min. Value | Max. Value | Source Document |
|---|---|---|---|---|---|---|
| pAlDataRateCch | 6 | Mbit/s | Default data rate for Control Channel (CCH) | 3 | 27 | [EN 302 663] [IEEE 802.11] |
| pAlDataRateCchHigh | 12 | Mbit/s | Optional higher data rate for CCH than the default one | 3 | 27 | [IEEE 802.11] |
| pAlDataRateCchLow | 3 | Mbit/s | Optional lower data rate for CCH than the default one | 3 | 27 | [IEEE 802.11] |
| pBtpCamPort | 2001 | n/a | Well-known destination port for CAMs | 0 | 65535 | [EN 302 636-5-1] |
| pBtpDenmPort | 2002 | n/a | Well-known destination port for DENMs | 0 | 65535 | [EN 302 636-5-1] |
| pBtpDestPortInfo | 0 | n/a | Value for the destination port information | 0 | 65535 | [EN 302 636-5-1] |
| pCamGenNumber | 3 | n/a | Number of consecutive generated CAMs without time restrictions | 0 | 3 | [EN 302 637-2] |
| pCamTraceMaxLength | 500 | m | Maximal length of a trace in CAMs | -- | -- | -- |
| pCamTraceMinLength | 200 | m | Minimal length of a trace in CAMs | -- | -- | -- |
| pCamTrafficClass | 2 | n/a | Traffic class (TC) value with which CAMs are sent | 0 | 255 | -- |
| pDccCcaThresh | -85 | dBm | Minimum sensitivity of the channel | -- | -85 | [EN 302 571] |
| pDccMeasuringInterval | 100 | ms | Value for the interval in which the channel load is provided | n.a. | n.a. | [EN 302 571] |
| pDccMinSensitivity | -88 | dBm | Value for minimum receiver sensitivity | -- | -- | -- |
| pDccProbingDuration | 8 | µs | Value for the probing sample duration | n.a. | n.a. | -- |
| pDccPToll | 10 | dBm | Value for transmission power inside protected zones | <10 | =<10 (in radiusof 20m) | [TS 102 792] Version 1.2.1 |
| pDCCSensitivityMargin | 3 | dB | Value for margin of parameter pDccMinSensitivity | -- | -- | -- |
| pDenmTraceMaxLength | 1000 | m | Maximum length of a trace in DENMs | -- | -- | -- |
| pDenmTraceMinLength | 600 | m | Minimum length of a trace in DENMs | -- | -- | -- |

| | | | | | | |
|---|---|---|---|---|---|---|
| pGnAddrConfMode | ANONYMOUS (2) | n/a | Configuration method for GeoNetworking (GN) address | 0 | 2 | [EN 302 636-4-1] |
| pGnBtpNh | 2 | n/a | Value for the Next Header (NH) field of GN common header. | 0 | 3 | [EN 302 636-4-1] |
| pGnChannelOffLoad | 0 | n/a | Value for the channel offload field | 0 | 1 | [EN 302 636-4-1] |
| pGnEtherType | 0x8947 | -- | Value for the EtherType to use | -- | -- | -- |
| pGnGbcHtField | 4 | n/a | Value for the HeaderType field in cases of GeoBroadcast (GBC) | 0 | 15 | [EN 302 636-4-1] |
| pGnGbcScf | 1 | n/a | Value for the store-carry-forward field in cases of GBC | 0 | 1 | [EN 302 636-4-1] |
| pGnInterfaceType | ITS-G5 (1) | n/a | Interface type to be used by GN | 0 | 1 | [EN 302 636-4-1] |
| pGnIsMobile | 1 | n/a | Defines whether C-ITS station is mobile or not | 0 | 1 | [EN 302 636-4-1] |
| pGnMaxAreaSize | 80 | km² | Supported area to cover | 1 | 625 | [EN 302 636-4-1] |
| pGnSecurity | ENABLED D (1) | n/a | Defines use of GN security headers | 0 | 1 | [EN 302 636-4-1] |
| pGnShbHstField | 0 | n/a | Value for the HeaderSubType field in cases of Single Hop Broadcast (SHB) | 0 | 15 | [EN 302 636-4-1] |
| pGnShbHtField | 5 | n/a | Value for the HeaderType field in cases of SHB | 0 | 15 | [EN 302 636-4-1] |
| pGnShbLifeTimeBase | 1 | n/a | Value for the LifeTimeBase field in case of SHB | 0 | 3 | [EN 302 636-4-1] |
| pGnShbLifeTimeMultiplier | 1 | n/a | Value for the LifeTimeMultiplier field in cases of SHB | 0 | 63 | [EN 302 636-4-1] |
| pPotiMaxTimeDiff | 20 | ms | Maximum time difference between station clock and time base | -- | -- | -- |
| pPotiWindowTime | 120 | s | Size of Position and Time (PoTi) sliding window in seconds | 20 | 120 | -- |
| pPotiUpdateRate | 10 | Hz | Update rate for position and time information | -- | -- | -- |
| pSecCamToleranceTime | 2 | s | Maximum time deviation between time in the security header of the Cooperative Awareness Message (CAM) and station clock to accept the CAM | -- | -- | -- |
| pSecChangeBlockingMaxTime | 5 | min | Maximum time a authorization ticket change can be blocked, if C2C-CC basic system is moving | -- | -- | -- |

| | | | | | | |
|---|---|---|---|---|---|---|
| pSecECRemainingLifetimeThreshold | 12 | weeks | The minimum remaining validity duration of the Basis System Enrolment Credential in order to allow the Basic System to trigger an Enrolment Request to the EA (EC re-keying). | -- | -- | -- |
| pSecGnScc | 0 | n/a | Value for the SCC field of the GN address | 0 | 1023 | [EN 302 636-4-1] |
| pSecGnSourceAddressType | 0 | n/a | Value for the M field of the GN address (configuration type of the address) | 0 | 1 | [EN 302 636-4-1] |
| pSecMaxAcceptDistance | 6 | km | Maximum distance between sender and receiver to accept messages | -- | -- | -- |
| pSecMaxPreloadTime | 3 | month | Maximum time for preloading certificates | -- | -- | -- |
| pSecMessageToleranceTime | 10 | min | Maximum time deviation between time in security header of message (other than CAM) and station clock to accept the message | -- | -- | -- |
| pSecMinTal | 2 | TAL level | Value for minimum TAL for an C-ITS station | -- | -- | -- |
| pSecRestartBlockingTime | 10 | min | Time between consecutive restarts in which the authorization ticket shall not be changed | -- | -- | -- |
| pSecRestartDelay | 1 | min | Grace period for AT change after turning on ignition terminal | -- | -- | -- |
| pTraceAllowableError | 0,47 | m | Parameter for calculation of path history; see [SAE J2945/1] for further details | -- | -- | -- |
| pTraceDeltaPhi | 1 | ° | Parameter for calculation of path history; see [SAE J2945/1] for further details | -- | -- | -- |
| pTraceEarthMeridian | 6.378,137 | km | Earth mean radius (according to International Union of Geodesy and Geophysics (IUGG)). Used for calculation of traces; see [SAE J2945/1] for further details | -- | -- | -- |
| pTraceMaxDeltaDistance | 22,5 | m | Parameter for calculation of traces, see [SAE J2945/1] for further details. | -- | -- | -- |

# 6 Requirement specifications

## 6.1 Security

**Other (informational)** **RS_BSP_455**

The following section shall be read in the context of the European C-ITS Certificate Policy [C-ITS CP] and C-ITS Security Policy [C-ITS SP] as in general it is assumed that the C2C-CC Basic System is compliant to those policies. Therefore the requirements stated below are valid in addition to the requirements that can be found in those policies. A duplication of requirements is avoided for consistency reasons.

**Requirement** **RS_BSP_158**

A vehicle C-ITS station shall be securely linked to one specific vehicle. Where the vehicle C-ITS station is powered, it shall verify that it is operating in the vehicle with which it has been securely linked. If such correct functioning condition cannot be verified, the C-ITS station shall be deactivated, preventing it from sending messages (i.e. deactivate at least the radio transmission level of the C-ITS station).

Note: Securely linked means paired in the factory or in an authorized repair shop.

Details:

Tested by:

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**Requirement** **RS_BSP_168**

The C2C-CC Basic System shall check the timestamp in the security header against the reception time and accept only CAMs in the last time of *pSecCamToleranceTime* and other messages within the last time of *pSecMessageToleranceTime*.

Note: Due to the tolerance of the ITS station times, the C2C-CC Basic System can accept messages 2 * *pPotiMaxTimeDiff* in the future (due to clock allowed deviation).

Details:

Tested by:

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**Requirement** **RS_BSP_169**

The C2C-CC Basic System shall check the distance from the sender position — in the security header, if available — and forward only messages with a distance from the sender of *pSecMaxAcceptDistance* or less.

Details:

Tested by:

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**Requirement** **RS_BSP_163**

The verification of a message shall comprise at least cryptographic verification of the message's signature.

Details:

Tested by:

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**Requirement** **RS_BSP_164**

The C2C-CC Basic System shall forward only verified messages (see also RS_BSP_163).

Details:

Tested by:

**Requirement** **RS_BSP_160**

The C2C-CC Basic System shall use one end-to-end security header per message in accordance with [TS 103 097] and [EN 302 636-4-1].

Details:

Tested by:

**Requirement** **RS_BSP_407**

The signature shall be generated using a private key corresponding to a valid AT in accordance with clause 7.2.1 in [TS 103 097].

Note: The signature in the requirement is intended as the signature of a CAM or DENM.

Details:

Tested by:

**Requirement** **RS_BSP_170**

The C2C-CC Basic System shall sign sending messages by using digital signatures and certificates based on ECDSA-256 using the elliptic curve NIST P-256 as defined in [TS 103 097].

Note: [C-ITS CP] additionally requires implementation of the elliptic curve brainpool P256r1 to sign messages.

Note: This requirement is profiling algorithms and key length as defined in the Certificate Policy section 6.1.4.1 of [C-ITS CP].

Details:

Tested by:

**Requirement** **RS_BSP_178**

Authorization ticket preloading in the vehicle shall not exceed *pSecMaxPreloadTime*, i.e. all certificates in a vehicle shall have a validity range that spans at most *pSecMaxPreloadTime* altogether.

Details:

Tested by:

**Requirement** **RS_BSP_456**

The Basic System shall update its Enrolment Credential (EC) in advance before the expiration of its current valid EC. The Basic System shall perform the Enrolment Request when the remaining validity duration of its Enrolment Credential is less than or equal to the value of *pSecECRemainingLifetimeThreshold*.

Details:

Tested by:

**Requirement** **RS_BSP_177**

The authorization ticket used by the C2C-CC Basic System shall change every time when the vehicle's ignition is switched on except if the system gets restarted within a period of *pSecRestartBlockingTime*, the authorization ticket shall not be changed.

Details:

Tested by:

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**Requirement** **RS_BSP_409**

The authorization ticket change after turning on ignition shall be performed within a grace period of *pSecRestartDelay*.

Details:

Tested by:

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**Requirement** **RS_BSP_181**

If the C2C-CC Basic System detects a collision of the least significant 32 bit of the "Certificate digest" / "hashedId8" with the "Certificate digest" / "hashedId8" of another ITS station (or C2C-CC Basic System), it shall initiate a change of its authorization ticket if the certificate corresponding to the other "Certificate digest" / "hashedId8" is valid, if no such collision has triggered the current authorization ticket.

Details:

Tested by:

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**Requirement** **RS_BSP_182**

All addresses and identifiers transmitted through short-range communication shall be changed when the AT is changed.

Note: Identity management is defined in chapter 6.5 of [TS 102 940].

Details:

Tested by:

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**Requirement** **RS_BSP_185**

Facilities layer shall clear the own station's path history cache (used to fill into new messages) when the security entity changes its authorization ticket identity.

Details:

Tested by:

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**Requirement** **RS_BSP_184**

Applications shall be able to block the authorization ticket change indefinitely, if the vehicle does not move, i.e. PathPoint position information does not change. In other cases, applications shall only be able to block it for at most *pSecChangeBlockingMaxTime*.

Exception:

- validity of the authorization ticket expired;
- collision of "Certificate digest" / "hashedId8".

Details:

Tested by:

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**Requirement** **RS_BSP_401**

The GN Source Address shall be constructed according to chapter 6 GeoNetworking address in [EN 302 636-4-1], with field M (bit 0) to *pSecGnSourceAddressType*.

Details:

Tested by:

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**Requirement** **RS_BSP_328**

The security services in the following table be supported, but are defined by the manufacturer.

**Table 5: Manufacturer dependent security service**

| |
|---|
| Obtain and update authorization tickets |
| Obtain, update and publish enrolment credentials |
| Update local authorization status repository |

Details:

Tested by:

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**Requirement** **RS_BSP_341**

The minimal acceptable trust level for mobile ITS station implementations is *pSecMinTal*.

Details:

Tested by:

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**Requirement** **RS_BSP_342**

Each TAL is mapped to a subject assurance representation in accordance with [TS 103 097] as specified in the following table:

**Table 6: Mapping between TAL and subject assurance representations**

| TAL | Subject assurance (Hex value) |
|---|---|
| 0 | 0x00 |
| 1 | 0x20 |
| 2 | 0x40 |
| 3 | 0x60 |
| 4 | 0x80 |

Details:

Tested by:

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## 6.2 Positioning and timing

**Requirement** **RS_BSP_190**

The vehicle states (see RS_BSP_428) shall be consistent. Therefore, heading and velocity shall refer to the same moment in time as the absolute position (e.g. GenerationDeltaTime in CAMs).

Note: Any inaccuracies that might result from time-related effects should be taken into account in the accuracies of the state variables.

Details:

Tested by:

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**Requirement** **RS_BSP_191**

The C2C-CC Basic System shall use World Geodetic System 84 (WGS84) as its reference coordinate system, as specified in [TS 102 894-2].

Note: Based on the drift of the European Terrestrial Reference System (ETRS89), which is fixed to the continental plate of Europe, of 2,5 cm/year in WGS84 it needs to be noted that Vehicle C-ITS stations need to be aware what referencing system is used. When an enhanced referencing system such as a Real-time Kinematics enhanced system is used for high-precision location referencing, this shift may need to be compensated.

Details:

Tested by:

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**Requirement** **RS_BSP_198**

Altitude information shall be interpreted as height above WGS84 Ellipsoid.

Note: Alternative altitude interpretations using Geoid definitions (e.g. relative to mean sea level) shall not be used.

Details:

Tested by:

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**Requirement** **RS_BSP_192**

The C2C-CC Basic System shall interpret ‘heading’ as the direction of the horizontal velocity vector. The starting point of the velocity vector shall be the ITS vehicle reference point, as defined in B.19 ‘referencePosition’ in [EN 302 637-2].

Note: Alternative heading interpretations referring to the vehicle body orientation shall not be used.

Note: This definition implies that straight backward driving results in 180° difference between heading and vehicle body orientation.

Details:

Tested by:

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**Requirement** **RS_BSP_194**

C-ITS time shall be the basis for all timestamps in all messages transmitted by the C2C-CC Basic System.

Details:

Tested by:

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**Requirement** **RS_BSP_195**

When some sensors used for estimating vehicle states (see RS_BSP_428, e.g. GNSS and vehicle sensors) are not available, the vehicle states estimation shall be continued (e.g. by means of extrapolation). The confidence intervals of all vehicle states shall be calculated considering the actual status of the sensors used.

Details:

Tested by:

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**Requirement** **RS_BSP_197**

When active, C2C-CC Basic System shall update the vehicle states (see RS_BSP_428) with a frequency of at least the *pPotiUpdateRate*.

Details:

Tested by:

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**Requirement** **RS_BSP_431**

The accuracy estimations shall yield valid 95 % confidence values, according to definitions in RS_BSP_429 and RS_BSP_200.

Details:

Tested by:

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**Requirement** **RS_BSP_432**

Timestamps in messages shall be based on the station clock (see RSP_BSP_430).

Details:

Tested by:

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**Requirement** **RS_BSP_207**

The difference between the station clock (see RSP_BSP_430) and C-ITS time shall be estimated. If the absolute difference |Station clock time – C-ITS time| >= *pPotiMaxTimeDiff*, the vehicle C-ITS station shall not be active.

Note: A precise timestamp is not only needed for time synchronisation, but also implies that system states are valid at precisely that point in time, i.e. that the vehicle states (see RS_BSP_428 and RS_BSP_190) stay consistent.

Details:

Tested by:

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**Requirement** **RS_BSP_444**

If the speed is below 1.4 m/s and the heading confidence becomes greater than 12.5 degrees or the speed drops below 0.08 m/s (according to "new requirement out of RfC #56580"), then the heading value shall be latched to the last value before this event and the heading confidence shall be set to "out of range".

Once the speed rises above 0.08 m/s and the heading confidence becomes less than 12.5 degrees, then the heading value shall be unlatched.

Details:
Tested by:

**Requirement** **RS_BSP_445**

At system startup, the system may report a stored heading value as the initial startup value.

Details:
Tested by:

## 6.3 System behaviour

**Requirement** **RS_BSP_214**

The C2C-CC Basic System shall operate the Cooperative Awareness Basic Service when it is on public roads and under regular driving dynamics.

Note: Operation of the cooperative awareness basic service includes the transmission of CAMs if all conditions for CAM generation are fulfilled.

Details:
Tested by:

**Requirement** **RS_BSP_215**

Traces and path history data shall be generated only when position confidence and ITS time information is available as specified in RS_BSP_205 and RS_BSP_206.

Details:
Tested by:

**Requirement** **RS_BSP_216**

In some specific situations, the vehicle C-ITS station may be deactivated under a deactivation condition. This condition has to be verified by a vehicle occupant or an in-vehicle system.

Details:
Tested by:

**Requirement** **RS_BSP_501**

A vehicle occupant shall be enabled to deactivate the vehicle C-ITS station easily at any time.

Details:
Tested by:

**Requirement** **RS_BSP_242**

The C2C-CC Basic System shall handle CAM transmissions so that no outdated messages (i.e. a newer CAM is available) are transmitted even if congestion control is applied.

Details:
Tested by:

## 6.4 Access layer

**Requirement** **RS_BSP_433**

The C2C-CC Basic System's access layer shall be compliant to [EN 302 571].

Details:

Tested by:

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**Requirement** **RS_BSP_226**

RF output power of the C2C-CC Basic System shall be adjustable.

Details:

Tested by:

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**Requirement** **RS_BSP_225**

The C2C-CC Basic System shall use the control channel G5-CCH as specified in Table 3 in [EN 302 663] to send messages to support Cooperative Awareness Basic Service and the priority C-ITS services in [C2CCC tc Docs].

Details:

Tested by:

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**Requirement** **RS_BSP_434**

The C2C-CC Basic System's access layer shall be compliant with [EN 302 663], with the exception of emission limits and with the exception of clauses 4.2.1, 4.5 and 6.

Details:

Tested by:

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**Requirement** **RS_BSP_228**

The C2C-CC Basic System shall use a default transfer rate of *pAlDataRateCch* on the control channel.

Details:

Tested by:

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**Requirement** **RS_BSP_397**

The C2C-CC Basic System shall also support *pAlDataRateCchLow* and *pAlDataRateCchHigh* transfer rates on the control channel.

Note: This requirement is intended for future use cases.

Details:

Tested by:

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**Requirement** **RS_BSP_435**

The C2C-CC Basic System's access layer shall be compliant with [TS 102 724].

Details:

Tested by:

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**Requirement** **RS_BSP_235**

The C2C-CC Basic System shall support the following Decentralised Congestion Control profiles (DPs) defined in [TS 102 724]: DP0, DP1, DP2 and DP3.

These DCC profiles shall use the following DCC profile identification values:

- DP0, used only for DENMs with TC = 0;
- DP1, used for DENMs with TC = 1;
- DP2, used for CAMs with TC = *pCamTrafficClass;*
- DP3, used for forwarded DENMs and other low priority messages.

Details:

Tested by:

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**Requirement** **RS_BSP_436**

The C2C-CC Basic System's DCC mechanism shall comply with [TS 102 687].

Details:

Tested by:

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**Requirement** **RS_BSP_238**

The settings of Table A.2 in [TS 102 687] shall be used if the reactive DCC algorithm outlined in clause 5.3 of [TS 102 687] is implemented.

Note: Table A.2 in [TS 102 687] is based on CAM and Decentralised Environmental Notification Message (DENM) dissemination for priority C-ITS services with an average $T_{on}$ of 500 µs

Details:

Tested by:

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**Requirement** **RS_BSP_240**

The following smoothing function of Channel Busy Ratio (CBR) values shall be performed if the C2C-CC Basic System uses the reactive DCC algorithm outlined in clause 5.3 of [TS 102 687]:

CBR_now = (CBR(n)+CBR(n-1))/2

Note: Where ‘n’ and ‘n-1’ are the current and previous CBR sampling periods respectively.

Note: CBR assessment is a mandatory feature outlined in Clause 4.2.10 of [EN 302 571].

Details:

Tested by:

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**Requirement** **RS_BSP_241**

The C-ITS station may support information traffic shaping or selective forwarding following a best effort principle.

Note: Traffic shaping is relevant for relayed DENMs sent on DP3, as anticipated in some situations – such as severe traffic congestion or other extreme vehicular network scenarios – the DENM load might increase substantially. In such cases, the C-ITS station is allowed to forgo the forwarding of received DENMs.

Details:

Tested by:

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**Requirement** **RS_BSP_243**

The C2C-CC Basic System shall, at a minimum, be able to generate and transmit the number of messages determined by the value of the highest CAM generation rate (i.e. 10 Hz) and, if detection algorithms are used, it shall be increased by the minimum required DENM generation rate derived from those triggering conditions.

Details:

Tested by:

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**Requirement** **RS_BSP_244**

The C2C-CC Basic System shall abide by the following maximum message rates if it uses the reactive DCC algorithm outlined in clause 5.3 of [TS 102 687]:

- for the relaxed state: the sum of all messages sent on DP1, DP2 and DP3 shall not surpass $R_{max\_relaxed}$ = 16.7 messages per second. Message bursts are allowed for DP0 with $R_{Burst}$ = 20 messages per second, with a maximum duration of $T_{Burst}$ = 1 second, and may take place only every $T_{BurstPeriod}$ = 10 seconds. Thus, adding DP0 messages, the maximum message rate amounts to $R_{max\_relaxed}$ = 36.7 messages per second;
- for active states: the maximum message rate for each state is given in RS_BSP_238;
- for the restrictive state: the maximum message rate per C2C-CC Basic System station is set to 2.2 messages per second, i.e. the inverse of $T_{TX\_MAX}$ = 460 ms.

Details:

Tested by:

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**Requirement** **RS_BSP_245**

The C2C-CC Basic System shall support per-packet transmission power control.

Note: $P_{Tx}$ may depend on the current DCC state (i.e. relaxed, active or restrictive) and on the DCC profile (i.e. DP0, DP1, etc.).

Details:

Tested by:

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**Requirement** **RS_BSP_246**

The C2C-CC Basic System shall reduce its transmission power to $P_{Toll}$ = *pDccPToll* as soon as the protected zone is entered and without changing any other DCC transmission parameters as per RS_BSP_238. DP0 messages are excluded from this restriction.

Details:

Tested by:

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**Requirement** **RS_BSP_458**

Where the C2C-CC Basic System is not equipped with a CEN-DSRC radio detector as described in clause 5.2.5 of [TS 102 792], it shall maintain a list of protected zone positions as

described in clause 5.5.1 of [TS 102 792]. This list shall be composed of:

- a set of protection zones as listed in the 'latest version' (available when the vehicle is developed) of the protected zone database. The C2C-CC Basic System may include update mechanisms of the database;
- a set of protected zones as identified by the reception of CEN-DSRC mitigation CAMs as described in clauses 5.2.5 and 5.2.2.3 of [TS 102 792];
- a temporarily protected zone as identified by the reception of CEN-DSRC mitigation CAMs as described in clause 5.2.2.2 of [TS 102 792].

Details: RS_FEA_432

Tested by:

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**Requirement** **RS_BSP_459**

Where the C2C-CC Basic System is equipped with a CEN-DSRC radio detector, mitigation shall be applied as described in clause 5.2.5 of [TS 102 792] and the C2C-CC Basic System shall generate CAMs in accordance with clause 5.5.1 of [TS 102 792].

Details:

Tested by:

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**Requirement** **RS_BSP_460**

Where the C2C-CC Basic System is not equipped with a CEN-DSRC radio detector, mitigation shall be applied in accordance with [TS 102 792] on the basis of the list defined in RS_BSP_458 and received CAMs from other road users which have implemented RS_BSP_459.

Note: Clarification of clause 5.2.5 of [TS 102 792]: A mobile ITS station should mitigate each time to the nearest tolling station centre position. Where several positions are given in the same area, the mobile ITS station should respond to each centre position, possibly in a sequence. Protected zones with identical protectedZone ID may be seen as a single station. Where the protected zone database and the CEN-DSRC mitigation CAMs contain a valid protected zone with the identical protectedZone ID, mitigation shall be based only on the CEN-DSRC mitigation CAM content.

Details:

Tested by:

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## 6.5 Networking and transport layer

**Requirement** **RS_BSP_437**

The C2C-CC Basic System's media-independent part of GeoNetworking (GN) shall be compliant with [EN 302 636-4-1].

Details:

Tested by:

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**Requirement** **RS_BSP_250**

All default constants and parameters of the C2C-CC Basic System profile not defined or overwritten in the current document shall be set as specified in Annex H to [EN 302 636-4-1].

Details:
Tested by:

**Requirement** **RS_BSP_251**

GN shall be used with itsGnSecurity set to *pGnSecurity*.

Details:
Tested by:

**Requirement** **RS_BSP_252**

GN shall be used with itsGnLocalAddrConfMethod set to *pGnAddrConfMode*.

Details:
Tested by:

**Requirement** **RS_BSP_255**

GN parameter itsGnMaxGeoAreaSize shall be set to *pGnMaxAreaSize*.

Details:
Tested by:

**Requirement** **RS_BSP_416**

Packet repetition shall not be performed by GN in a vehicle C-ITS station and the corresponding steps for repetition in the packet-handling procedures described in clause 10.3 of [EN 302 636-4-1] shall not be executed.

The 'maximum repetition time' parameter of the service primitive GN-DATA.request and the GN protocol constant itsGnMinPacketRepetitionInterval do not apply to a vehicle C-ITS station.

Details:
Tested by:

**Requirement** **RS_BSP_414**

GN shall be used with its GnIfType set to *pGnInterfaceType*.

Details:
Tested by:

**Requirement** **RS_BSP_256**

The C2C-CC Basic System shall use Single Hop Broadcast (SHB) headers as defined in [EN 302 636-4-1] on all CAM packets it sends.

Consequently, the GN common header shall use a value of *pGnShbHtField* for the HT field, and a value of *pGnShbHstField* for the HST field when transmitting SHB packets.

Details:
Tested by:

**Requirement** **RS_BSP_257**

The C2C-CC Basic System shall use GBC headers as defined in [EN 302 636-4-1] on all DENM packets it sends.

Consequently, the GN common header shall use a value of *pGnGbcHtField* for the HT field when transmitting DENM packets.

For the HST field one of the following values shall be used:

- 0 for circular areas;
- 1 for rectangular areas;
- 2 for ellipsoidal areas.

Note: This profile covers the handling of SHB and GBC packets (RS_BSP_256 and RS_BSP_257, respectively). As it does not cover the handling of other GN packet types defined in [EN 302 636-4-1], it does not prevent their implementation.

Details:

Tested by:

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**Requirement** **RS_BSP_258**

The C2C-CC Basic System shall set the LifeTime field of all SHB packets in the following manner:

- set the sub-field multiplier to *pGnShbLifeTimeMultiplier* and the sub-field base to *pGnShbLifeTimeBase*.

Details:

Tested by:

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**Requirement** **RS_BSP_259**

The C2C-CC Basic System shall set the LifeTime field of all GBC packets to the minimum value of ValidityDuration and RepetitionInterval, where ValidityDuration and RepetitionInterval are defined in [C2CCC tc Docs]. The value of the LifeTime field shall not exceed the itsGnMaxPacketLifetime, as specified in Annex H to [EN 302 636-4-1].

Details:

Tested by:

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**Requirement** **RS_BSP_260**

The C2C-CC Basic System shall buffer GBC packets where no neighbours are available (store-carry-forward). Consequently, the Store Carry Forward (SCF) bit of the TC field of GBC packets shall be set to *pGnGbcScf*.

Details:

Tested by:

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**Requirement** **RS_BSP_262**

The C2C-CC Basic System is not required to offload packets to another channel. Consequently, the channel offload bit of the TC field should be set to *pGnChannelOffLoad*.

Details:

Tested by:

**Requirement** **RS_BSP_263**

The C2C-CC Basic System shall use the DCC profiles specified in RS_BSP_235. Consequently, the DCC Profile ID bits of the TC field shall use the DCC-profile identification values defined in RS_BSP_235.

Details:

Tested by:

**Requirement** **RS_BSP_264**

The C2C-CC Basic System shall set the itsGnIsMobile bit of the Flags field to *pGnIsMobile*.

Details:

Tested by:

**Requirement** **RS_BSP_265**

The C2C-CC Basic System shall set the GN Hoplimit parameter as follows:

- 0, if the destination area is a circle with radius <= 100 m;
- 1, if the destination area is a circle with radius <= 200 m;
- 2, if the destination area is a circle with radius <= 500 m;
- 3 otherwise.

Details:

Tested by:

**Requirement** **RS_BSP_266**

The C2C-CC Basic System shall support multi-hop operation mode. It shall implement the forwarding algorithm specified in Annexes D, E.3 and F.3 to [EN 302 636-4-1].

Details:

Tested by:

**Requirement** **RS_BSP_267**

When forwarding packets, the C2C-CC Basic System shall use the DCC profile DP3 as defined in [TS 102 724] and referred to in RS_BSP_235.

Details:

Tested by:

**Requirement** **RS_BSP_268**

The C2C-CC Basic System shall use duplicate packet detection on the networking and transport layer. Consequently, the algorithm specified in Annex A.2 to [EN 302 636-4-1] shall be used for detecting duplicate packets.

Details:

Tested by:

**Requirement** **RS_BSP_270**

All GN frames sent by the C2C-CC Basic System shall use the EtherType value *pGnEtherType* as listed by the Institute of Electrical and Electronics Engineers (IEEE) Registration Authority at http://standards.ieee.org/develop/regauth/ethertype/eth.txt.

Details:

Tested by:

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**Requirement** **RS_BSP_438**

The C2C-CC Basic System's Basic Transport Protocol (BTP) shall be compliant with [EN 302 636-5-1].

Details:

Tested by:

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**Requirement** **RS_BSP_273**

The C2C-CC Basic System shall employ BTP-B headers. Consequently, the GN common header shall use a value of *pGnBtpNh* for the NH field.

Details:

Tested by:

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**Requirement** **RS_BSP_274**

The C2C-CC Basic System shall set the destination port info field to the value *pBtpDestPortInfo*.

Details:

Tested by:

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**Requirement** **RS_BSP_275**

In the BTP-B header, the C2C-CC Basic System shall set the destination port to the value *pBtpCamPort* for CAMs.

Details:

Tested by:

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**Requirement** **RS_BSP_276**

In the BTP-B header, the C2C-CC Basic System shall set the destination port to the value *pBtpDenmPort* for DENMs.

Details:

Tested by:

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**Requirement** **RS_BSP_279**

The C2C-CC Basic System shall support circular, rectangular and ellipsoidal geographical areas as defined in [EN 302 931]. Each C-ITS service defined in [C2CCC tc Docs] must specify one of the above geographical area types indicated through the GN header as specified in [EN 302 636-4-1].

Details:

Tested by:

**Requirement** **RS_BSP_280**

Where a C2C-CC Basic System calculates the distance between two positions using Galileo or other GNSS coordinates (e.g. for PathDeltaPoints or in cases of circular relevance area), the great circle or a more accurately performing method shall be used.

Note: Thereby, care shall be taken to avoid large rounding errors on low-precision floating point systems; these can be avoided, e.g., with the haversine formula. In case the relevance area is an ellipse or a rectangle, then the cartesian coordinates of the area center and of the current position need to be calculated for assessing whether to hop the packet as specified in [EN 302 931]; for this purpose it is recommended to use the Local Tangent Plane method, or another method delivering the same accuracy.

Details:

Tested by:

## 6.6 Facility layer

**Requirement** **RS_BSP_439**

The C2C-CC Basic System's Cooperative Awareness (CA) basic service shall be compliant with [EN 302 637-2].

Details:

Tested by:

**Requirement** **RS_BSP_285**

The path history field in the CAM low-frequency container shall be generated in accordance with the method specified in RS_BSP_318 and shall contain a PathHistory data element covering a minimum distance of *pCamTraceMinLength* (K_PHDISTANCE_M parameter, as defined in Appendix A.5 to [SAE J2945/1]).

An exception to the minimum covered distance by PathHistory shall be made only if:

- the vehicle has not yet physically covered the distance with its current AT (e.g. after vehicle startup or right after AT change when driving); or
- the maximum number of PathPoints is used, but the overall length covered by the PathHistory still does not reach *pCamTraceMinLength*.

  Note: This may happen if the road topology contains tight curves and the distance between consecutive PathPoints is reduced.

Only in the above cases may the vehicle send PathHistory information covering a distance below *pCamTraceMinLength*.

Details:

Tested by:

**Requirement** **RS_BSP_286**

The PathHistory in CAMs shall cover at most *pCamTraceMaxLength*.

Details:

Tested by:

**Requirement** **RS_BSP_287**

The PathHistory in CAMs shall include PathDeltaTime in every PathPoint. It shall describe a list of actually travelled geographical locations leading to the current vehicle position, sorted by the time the positions were reached by the vehicle, with the first point being the closest in time to the current time.

Details:

Tested by:

**Requirement** **RS_BSP_288**

Where the C2C-CC Basic System does not move, i.e. PathPoint position information does not change, the PathDeltaTime of the first PathPoint shall still be updated with every CAM.

Details:

Tested by:

**Requirement** **RS_BSP_289**

Where the C2C-CC Basic System does not move, i.e. PathPoint position information does not change, for a duration longer than the maximum value of PathDeltaTime (specified in [TS 102 894-2]) the PathDeltaTime of the first PathPoint in the CAM shall be fixed to the maximum value.

Details:

Tested by:

**Requirement** **RS_BSP_290**

The CA basic service shall be active as long as the vehicle is on public roads and under regular driving dynamics. As long as the CA basic service is active, CAMs shall be generated in accordance with the generation rules in [EN 302 637-2].

Details:

Tested by:

**Requirement** **RS_BSP_291**

A C2C-CC Basic System shall transmit CAM messages where confidence information is available and the station clock adheres to RS_BSP_206.

Details:

Tested by:

**Requirement** **RS_BSP_292**

The TC value for CAM messages shall be set to *pCamTrafficClass*.

Details:

Tested by:

**Requirement** **RS_BSP_293**

The parameter T_GenCam_Dcc (see [EN 302 637-2]) shall be set to the value of the minimum time between two transmissions, $T_{off}$, as given by DCC mechanisms in RS_BSP_238.

Details:

Tested by:

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**Requirement** **RS_BSP_297**

The adjustable N_GenCam parameter (see [EN 302 637-2]) specified in the CAM generation frequency management shall be set to *pCamGenNumber* for the C2C-CC Basic System.

Details:

Tested by:

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**Requirement** **RS_BSP_440**

The C2C-CC Basic System's Decentralised Environmental Notification (DEN) basic service shall be compliant with [EN 302 637-3].

Details:

Tested by:

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**Requirement** **RS_BSP_301**

The DENM repetition shall be done by the DEN basic service as specified in [EN 302 637-3].

Details:

Tested by:

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**Requirement** **RS_BSP_302**

The path history field in the DEN messages shall be generated according to the method specified in RS_BSP_318 and shall contain trace-data elements covering a minimum distance of *pDenmTraceMinLength* (K_PHDISTANCE_M parameter defined in Appendix A.5 to [SAE J2945/1]).

An exception to the minimum covered distance by traces shall be made only if:

- the vehicle has not yet physically covered the distance with its current AT (e.g. after vehicle startup or right after AT change when driving); or
- the maximum number of PathPoints is used, but the overall length covered by the PathHistory still does not reach *pDenmTraceMinLength*.

Note: This may happen if the road topology contains tight curves and the distance between consecutive PathPoints is reduced.

Only in the above two cases may the vehicle send trace information covering a distance below *pDenmTraceMinLength*.

Details:

Tested by:

---

**Requirement** **RS_BSP_303**

The traces in the DENMs shall cover at most *pDenmTraceMaxLength*.

Details:

Tested by:

**Requirement** **RS_BSP_304**

A C2C-CC Basic System shall use the DENM traces as follows:

- the first trace element shall describe a time-ordered list of actually travelled geographical locations leading to the event position, as specified in RS_BSP_287.

Note: DENMs received from infrastructure stations might not follow this specification.

Details:

Tested by:

**Requirement** **RS_BSP_305**

The PathDeltaTime data elements of the PathPoints in the first DENM traces element shall be updated only if the DENM is updated.

Note: The cases in which DENM Updates are triggered are specified on a case-by-case basis in the corresponding Triggering Conditions [C2CCC tc Docs].

Details:

Tested by:

**Requirement** **RS_BSP_306**

Where the event-detecting vehicle does not move, i.e. PathPoint position information does not change, the PathDeltaTime of the first PathPoint of the first DENM traces element shall still be updated with every DEN_Update.

Note: This is only the case for stationary events where the detecting vehicle is identical to the event, e.g. a stationary vehicle warning. For dynamic events, e.g. dangerous situations or events that are not identical to the vehicle (adverse weather warnings, etc.), this is not the case.

Details:

Tested by:

**Requirement** **RS_BSP_307**

Where the C2C-CC Basic System does not move, i.e. PathPoint position information does not change, for a duration longer than the maximum value of PathDeltaTime (specified in [TS 102 894-2]), the PathDeltaTime of the first PathPoint in the first DENM trace element shall be fixed to the maximum value.

Details:

Tested by:

**Requirement** **RS_BSP_308**

Additional PathHistory elements may be present in the DENM traces. However, unlike the first element, these shall describe alternative routes to the event location. These routes may or may not be available at the time of detecting the event. In the alternative routes, the PathPoints shall be position-ordered (i.e. shortest-path routes) and shall not include the PathDeltaTime.

Details:

Tested by:

**Requirement** **RS_BSP_315**

For the priority services, the C2C-CC Basic System shall generate only DENMs as described in [C2CCC tc Docs].

Details:

Tested by:

**Requirement** **RS_BSP_313**

The data elements that constitute the content of the CAM and DENM shall be compliant with [TS 102 894-2] and use the coordinate system specified in RS_BSP_321 and RS_BSP_191.

Details:

Tested by:

**Requirement** **RS_BSP_318**

The traces and path histories used by the C2C-CC Basic System shall be generated using Design Method One, as specified in Appendix A.5 to [SAE J2945/1]. The C2C-CC Basic System shall use this generation method with the following settings:

- K_PHALLOWABLEERROR_M = *pTraceAllowableError*, where PH_ActualError < K_PHALLOWABLEERROR_M;
- maximum distance between concise path points, K_PH_CHORDLENGTHTHRESHOLD = *pTraceMaxDeltaDistance;*
- K_PH_MAXESTIMATEDRADIUS = REarthMeridian;
- K_PHSMALLDELTAPHI_R = *pTraceDeltaPhi;*
- REarthMeridian = *pTraceEarthMeridian* (according to the IUGG), used for great-circle or orthodromic distance calculation:

$$PH\_ActualChordLength = REarthMeridian * \cos^{-1}[$$
$$\cos(lat_1)\cos(lat_2)\cos(long_1 - long_2) + \sin(lat_1)\sin(lat_2)]$$

Details:

Tested by:

**Requirement** **RS_BSP_321**

The C2C-CC Basic System shall use a coordinate system compliant with section 2.13 of [ISO 8855].

Note: This means that the X and Y axes are parallel to the ground plane, the Z axis is aligned vertically upwards, the Y axis points to the left of the vehicle's forward direction, and the X axis points towards the vehicle's forward driving direction.

Details:

Tested by:

**Requirement** **RS_BSP_447**

The C2C-CC Basic System shall provide the received valid SSP and ITS-AID as part of the valid certificate to the FAC layer ([EN 302 636-5-1] annex A Parameter "permissions").

Details:

Tested by:

## 6.7 Hardware related requirements

**Requirement** **RS_BSP_202**

The 95 % confidence value (see RS_BSP_429 and RS_BSP_200) shall be valid in each scenario listed in RS_BSP_209. This implies that in a confidence value assessment test (which can be offline) a statistic averaging over all states and scenarios is not appropriate.

Instead, a sliding window containing the vehicle states (see RS_BSP_428) of the last *pPotiWindowTime* seconds shall be used as the statistical base.

Note: The proposed confidence validation mechanism using the sliding window is typically performed offline, as post-processing of collected test data. It is not required that the C2C-CC Basic System performs confidence validation online, i.e. while in safety-related context.

Note: The sliding window approach has the following advantages over separate statistics for each scenario:

- transitions between scenarios are included;
- confidence is valid ‘now’ instead of ‘over lifetime’. ‘Error bursts’ (many invalid confidence values in a short timeframe) are not allowed, thus:
  - enhancing the usefulness of the confidence value for applications;
  - requiring fast detection of accuracy degradation inside POTI;
- the precise definition of test data has no effect on confidence validation parameters; However, the test data shall contain all scenarios listed in section RS_BSP_209;
- no further statistical calculations are needed; the scenarios cover all relevant states; coverage of the relevant time will be ensured by the definition of test data in WG Conformance Assessment;
- the interval length is similar to typical (environment and driving condition) scenario lengths (e.g. city tunnel, standing at traffic light, driving manoeuvres);
  - 5 % of the interval is similar to typical short term effects (e.g. driving under a bridge).

Details:

Tested by:

**Definition** **RS_BSP_449**

A vehicle is considered to be under regular driving dynamics when it:

- has passed its initial startup phase;
- is being used as envisaged by the manufacturer;
- normal control of the vehicle is possible (e.g. it is not directly involved in an accident, road surface allows normal tyre grip);
- all the following conditions (values) apply for passenger cars:
  - vehicle lateral acceleration is < 1.9 m/s^2; AND
  - vehicle longitudinal acceleration is > -2,4 m/s^2 (deceleration); AND
  - vehicle longitudinal acceleration is < 2,5 m/s^2; AND
  - vehicle speed is <= minimum of (130 km/h, Vmax).

Note: This is intended to be used for confidence requirements of the vehicle state.

**Requirement** **RS_BSP_205**

Under optimal GNSS conditions and regular driving dynamics (as defined in RS_BSP_449), the confidence values shall be equal to or lower than the following values in at least 95 % of 3D position data points in a dataset:

- horizontal position confidence of 5 m;
- vertical position confidence of 15 m.

In other scenarios, the requirement degradations in RS_BSP_209 apply. This requirement ensures the usefulness of information sent in all C-ITS messages.

Note: Altitude Accuracy will be quantized quite roughly for CAM/DENM, e.g. “within 1/2/5/10/20/50/100/200 m”.

Details:

Tested by:

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**Requirement** **RS_BSP_206**

The station clock (see RS_BSP_430) shall be within *pPotiMaxTimeDiff* of C-ITS time, i.e. Delta t = |station clock time – C-ITS time| < *pPotiMaxTimeDiff*.

Details:

Tested by:

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**Requirement** **RS_BSP_209**

A C2C-CC Basic System shall be able to provide useful vehicle state estimations (see RS_BSP_428) also in challenging scenarios. To account for inevitable degradations, required confidence values are defined for different scenarios in the following Table 7.

‘C’ is the maximum of semiMajorConfidence and semiMinorConfidence, see also RS_BSP_200. The condition for ‘C’ shall be fulfilled in 95 % of data points in the dataset of the given scenario.

Note: One possibility to conduct these tests is a HiL testbed. Thereby, the C2C-CC (by way of the WG Conformance Assessment) could collect and administer a test database to which C2C-CC members can contribute and access data. This would allow members to test their systems across a large set of scenarios, without the need to physically collect all the data in the field, thus saving costs.

Note: The definition of “sky obstruction” is provided in RS_BSP_211.

Note: The criteria shall be met under the following slope dynamics for the analysed trace fraction:

- average slope <= 4 % and maximum slope <= 15 %

Note: As a precondition, each scenario shall be started with one minute of driving under open sky and regular driving dynamics as defined in RS_BSP_449.

Note: No C values indicate that the scenario shall be tested to ensure that the reported confidence interval is valid, but no limit is given.

**Table 7: Scenarios**

| ID | Scenario | Definition | Acceptance |
|---|---|---|---|
| **Environment under regular driving dynamics** | | | |
| S1 | Open sky | Sky is less than 20 % obstructed, with vehicle moving with regular driving dynamics, normal road conditions | C < 5 m |
| S2 | Tunnel | No GNSS satellite is visible for at least 30 s and 250 m ($v_{min}$=30 km/h); GNSS signal reflection at entrance and end of tunnel | C < 15 m |
| S3 | Parking house | No direct visible GNSS satellites, but connection by reflections, T > 60 s, $v_{max}$ < 20 km/h, minimum two 90 ° curves and s > 100 m, two ramps in the entrance and exit area | any value is allowed |
| S4 | Half open sky | Sky is 30-50 % obstructed (obstruction concentrated on one side of the car) for more than 30 s; driving conditions as S1 | C < 7 m |
| S5 | Forest | Sky is 30-50 % obstructed by objects including trees higher than the antenna, for more than 30 s. | C < 10 m |
| S6 | Mountains (valley) | Sky is 40-60 % obstructed by high mountain(s); driving conditions as S1 | C < 10 m |
| S7 | City | In a 300 s drive, the sky was 30-50 % obstructed (short periods of less than 30-50 % obstructions allowed), frequent GNSS signal reflection off buildings, including short losses of GNSS signal (i.e. fewer than 4 satellites); driving conditions as S1 | C < 14 m |
| S8 | Mild urban | Sky is 20 - 40 % obstructed, t > 60 s, s > 400 m. Driving conditions as S1, with stops, trees and/or buildings, as well as alleys | C < 10 m |
| **Driving conditions under open sky** | | | |
| S9 | Dynamic driving | Test drive with longitudinal accelerations of more than -6 m/s² and lateral accelerations of > (±) 5 m/s² | C < 7 m |
| S10 | Static | Vehicle standing still for 30 min | C < 5 m |
| S11 | Rough road | Test drive on dirt road with pot holes, v= 20-50 km/h | C < 10 m |
| S12 | Icy road | Test drive with longitudinal accelerations of more than -0,5 m/s² and lateral accelerations of > (±) 0,5 m/s², μ < 0,15, | C < 7 m |
| S13 | High speed | V= minimum of (130 km/h, Vmax) on dry road for 30 s | C < 5 m |

Details:

Tested by:

**Requirement** **RS_BSP_448**

Under optimal GNSS conditions and regular driving dynamics (as defined in RS_BSP_449),

the speed confidence values shall be equal to or lower than the following values in at least 95 % of data points in a dataset:

- 0,6 m/s for speeds between 1,4 m/s and 12,5 m/s;
- 0,3 m/s for speeds greater than 12,5 m/s.

Note: Per Confidence definition, the speed error (delta between ground truth and reported speed value) must not exceed the reported speed confidence in at least 95 % of data points in a dataset, see RS_BSP_429.

Details:

Tested by:

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**Requirement** **RS_BSP_457**

Under optimal GNSS conditions and regular driving dynamics as defined in RS_BSP_449, the heading confidence values shall be equal to or lower than the following values in at least 95 % of data points in a dataset:

- 3° for speeds between 1,4 m/s and 12,5 m/s
- 2° for speeds greater than 12,5 m/s.

Note: Per Confidence definition, the heading error (delta between ground truth and reported heading value) must not exceed the reported heading confidence in at least 95 % of data points in a dataset, see RS_BSP_429.

Details:

Tested by:

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