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 61 members, with 11 vehicle manufacturers, 31 equipment suppliers and 29 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 works in close cooperation with the European and international standardisation organisations such as ETSI and CEN.

Disclaimer

Document information

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Table 1: Document information

Changes since last version

Title:	Basic System Profile		
Explanatory notes:			
31/07/2020	• Further detailing of position and timing requirements	Release Management	Steering Committee
27/03/2020	• Major detailing of position and timing requirements • New AT changeover requirements	Release Management	Steering Committee
14/09/2019	• Harmonization with infrastructure requirements • Improvement of position and timing requirements • 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. • Improvement of position and timing requirements • Extension of the release bundle by the Protection Profile V2X Hardware Security Module (UID 2056). • Cleanup of security requirements in the Profile (UID 2037) • Extraction of references into a separate document: Reference list (UID 2052) • 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 these 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 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 are the requirements the 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 to be ‘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 these special requirements, all other requirements can be further detailed, too.

3 Conventions used

Other (informational) **RS_BSP_152**

Conventions used in this and other C2C-CC specification documents can be found in [C2CCC ConV].

4 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 [EN 302 636-4-1]. Timestamps as defined in [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_206**

'Clock validity' – The station clock (see RS_BSP_430) is valid if it is within *pPotiMaxTimeDiff* to C-ITS time, i.e. Delta t = |station clock time – ITS time| < *pPotiMaxTimeDiff*.

Definition **RS_BSP_428**

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

Definition **RS_BSP_535**

*'*Confidence information' is available when all of the following conditions are true:

- PosConfidenceEllipse.semiMajorConfidence is not set to 'unavailable';
- PosConfidenceEllipse.semiMinorConfidence is not set to 'unavailable';
- PosConfidenceEllipse.semiMajorOrientation is not set to 'unavailable';
- AltitudeConfidence is not set to 'unavailable';
- SpeedConfidence is not set to 'unavailable';
- HeadingConfidence is not set to 'unavailable';
- PosConfidenceEllipse.semiMajorConfidence and PosConfidenceEllipse.semiMinorConfidence are not both set to 'outOfRange'.

Note: This implies that a mixture of 'unavailable' and other values is not allowed.

Note: 'outOfRange' is allowed for values other than semiMajorConfidence and semiMinorConfidence at the same time.

Note: Heading confidence is treated also according to RS_BSP_444.

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 population.

Definition **RS_BSP_511**

'*A stationary vehicle****'*** is defined as follows: The vehicle is moving with a speed of <= 8 cm/s. This state shall be determined by internal vehicle sensors (e.g. wheel ticks).

NOTE: While being stationary, speed is expected to be 0 and heading is expected not to change (see RS_BSP_444). However, position may change, e.g. due to better sensor data becoming available.

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 tire 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, legal Vmax of the vehicle).

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

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 hemisphere values that are obstructed for Galileo or other Global Navigation Satellite Systems (GNSS) satellites due to mountains, buildings, trees, etc.

Definition **RS_BSP_533**

'Open sky conditions' are given when the sky is less than 20 % obstructed.

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.

Definition **RS_BSP_510**

'Priority C-ITS services' refer to C-ITS services that contribute to road safety or traffic efficiency and which are specified in [C2CCC tc Docs].

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 3: 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	2 001	n/a	Well-known destination port for CAMs	0	65 535	[EN 302 636-5-1]
pBtpDenmPort	2 002	n/a	Well-known destination port for DENMs	0	65 535	[EN 302 636-5-1]
pBtpDestPortInfo	0	n/a	Value for the destination port information	0	65 535	[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	--	--	--
pCamTraceMaxPoints	23	n/a	Maximum allowed number of trace points in CAMs	n/a	n/a	[EN 302 637-2]
pCamTrafficClass	2	n/a	Traffic class (TC) value with which CAMs are sent	0	255	--
pDccPToll	10	dBm	Value for transmission power inside protected zones	<10	=< 10 (in radiusof 20 m)	[TS 102 792] Version 1.2.1
pDenmTraceMaxLength	1 000	m	Maximum length of a trace in DENMs	--	--	--
pDenmTraceMinLength	600	m	Minimum length of a trace in DENMs	--	--	--

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
pDenmTraceMaxPoints	40	n/a	Maximum allowed number of trace points in DENMs	n/a	n/a	[EN 302 637-3]
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	--	--	--
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]
pGnMaxAcceptDistance	10	km	Maximum distance between forwarder and centre of the destination area of a packet	--	--	--
pGnSecurity	ENABLED (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 C-ITS time	--	--	--

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
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	--	--	--
pSecCamPastToleranceTime	2	s	Maximum absolute time difference between the time in the security header of the Cooperative Awareness Message (CAM) and station clock to accept the CAM	--	--	--
pSecChangeBlockingMaxTime	5	min	Maximum time an 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	1 023	[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	10	km	Maximum distance between originator and receiver to accept messages	--	--	--
pSecMinAcceptDistance	6	km	The lower bound of *pSecMaxAcceptDistance*	--	--	--
pSecMaxPreloadTime	3	month	Maximum time for preloading certificates	--	--	--
pSecMessageFutureToleranceTime	220	ms	Maximum absolute time difference between timestamp in security header and station clock to accept messages from the future	--	--	--
pSecMessagePastToleranceTime	10	min	Maximum absolute time difference between the time in security header of message (other than CAM) and station clock to accept the message	--	--	--
pSecRestartBlockingTime	10	min	Time between consecutive restarts in which the authorization ticket shall not be changed	--	--	--

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
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 chapter 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 reasons of consistency.

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:

Requirement **RS_BSP_168**

The C2C-CC Basic System shall check the *generationTime* in the security header against the reception time and accept only CAMs in the last time of *pSecCamPastToleranceTime* and other messages within the last time of *pSecMessagePastToleranceTime*. Message types shall be differentiated using the indicated ITS-AID in the security header.

Details:

Tested by:

Requirement **RS_BSP_532**

The C2C-CC Basic System shall check the *generationTime* in the security header against the reception time and accept only messages from up to *pSecMessageFutureToleranceTime* in the future.

Details:

Tested by:

Requirement **RS_BSP_169**

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

Additionally, the C2C-CC Basic System may also forgo forwarding messages with a distance between *pSecMinAcceptDistance* and *pSecMaxAcceptDistance*.

Note: 6 km = 6 hops x 1 000 m.

Details:

Tested by:

Requirement **RS_BSP_163**

The C2C-CC Basic System shall be able to verify message signatures using any of the following algorithms: ECDSA_nistP256_with_SHA 256, ECDSA_brainpoolP256r1_with_SHA 256 and ECDSA_brainpoolP384r1_with_SHA 384.

Details:

Tested by:

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 CAM and DENM Security Profiles according to [TS 103 097] and the Geonetworking secured header format according to [EN 302 636-4-1] for ITS-G5 transmissions.

Details: RS_FEA_439

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 chapter 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*. All ATs in C-ITS station shall have a validity end date below (current date + *pSecMaxPreloadTime*).

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_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. This only applies if all of the following conditions are valid:

- the certificate corresponding to the other 'Certificate digest' / 'hashedId8' is valid;
- the message used to provide the certificate has a valid signature;
- the change to the current AT has not been triggered by a collision.

Details:

Tested by:

Requirement **RS_BSP_519**

All distances in the requirements from RS_BSP_520 to RS_BSP_525 shall be travel distances with a relative uncertainty of less than 5 %.

Details:

Tested by:

Requirement **RS_BSP_520**

When the engine control is activated after it has been deactivated for at least 10 min, a vehicle C-ITS-S shall not send any C-ITS message while being stationary.

As soon as the vehicle is no longer stationary, the vehicle C-ITS station shall perform an AT changeover and start to transmit C-ITS messages.

Details:

Tested by:

Requirement **RS_BSP_521**

After the RS_BSP_520 has been satisfied a C-ITS-S shall perform the AT changeover after the vehicle has driven a distance equal to a current random value in the range of [800 m; 1 500 m].

Details:

Tested by:

Requirement **RS_BSP_522**

After the RS_BSP_521 has been satisfied, a C-ITS-S shall perform the AT changeover after the vehicle has driven at least 800 m from the location of that AT changeover plus an additional

time interval equal to a current random value in the range [120 s; 360 s].

Details:

Tested by:

Requirement **RS_BSP_523**

After the RS_BSP_522 has been satisfied, a C-ITS-S shall perform the AT changeover after the vehicle has driven a random distance in the range of [10 000 m; 20 000 m] with respect to the location of the last AT changeover.

Details:

Tested by:

Requirement **RS_BSP_524**

After the RS_BSP_523 has been satisfied, a C-ITS-S shall perform further AT changeovers every time the vehicle has driven a random distance in the range of [25 000 m; 35 000 m] from the location of the last AT changeover.

Details:

Tested by: y

Other (informational) **RS_BSP_525**

The following image provides a summary of the described changeover procedure.

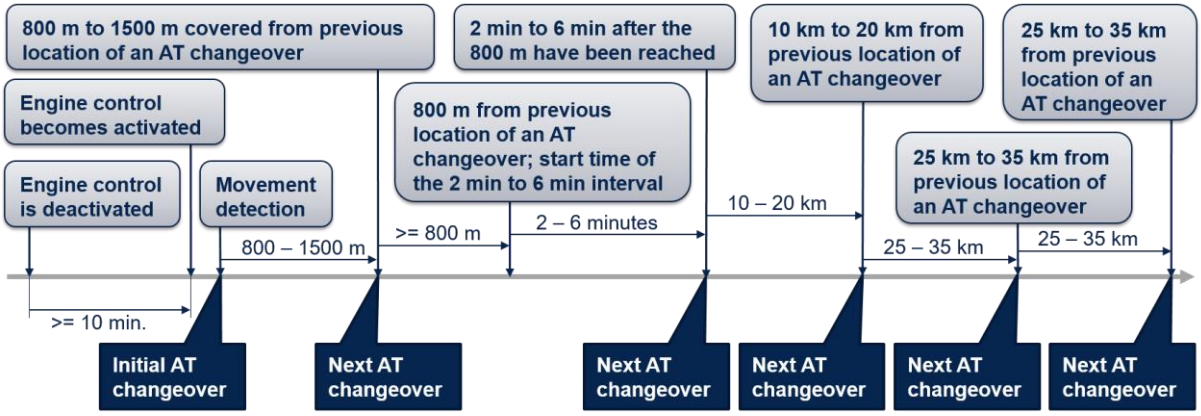

Figure 1: AT changeovers and related events over time

Requirement **RS_BSP_526**

A C-ITS-S shall only sign a message when it is in possession of at least 56 ATs and their private keys that are valid at the point in time of signing that message.

Note: If this requirement cannot be met due to connectivity or CCMS service availability problems, the C-ITS station might operate in degraded mode, as defined by the single OEM.

Details:

Tested by:

Requirement **RS_BSP_527**

A C-ITS-S shall select the next AT randomly with equal probability and without replacement, from the available and valid ATs of RS_BSP_526.

Note: this means that after use of one AT, that this AT is not immediately available but can be kept for later selection see RS_BSP_528.

Details:

Tested by:

Requirement **RS_BSP_528**

A C-ITS-S shall re-start the random selection procedure of RS_BSP_527 when all ATs have been selected an equal number of times.

Note: this means that all valid ATs are available again for the procedure of RS_BSP_527.

Details:

Tested by:

Requirement **RS_BSP_182**

When a AT changeover happens:

- All addresses and identifiers transmitted through short-range communication shall be changed.
- The internal storage used for generation of *Traces* and *EventHistory* of the DENMs shall be erased.
- All active DENM transmissions shall be stopped. DENM transmission can be restarted after the AT changeover has been done and if the triggering condition is still active.
- The internal storage used for generation of the *PathHistory* of CAMs shall be erased.

Note: Erasing of data is done to ensure that no old data is transmitted in messages after the AT changeover.

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

Details:

Tested by:

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*.

Exceptions:

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

Details:

Tested by:

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:

Requirement **RS_BSP_328**

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

Table 4: Manufacturer dependent security service

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

Details:

Tested by:

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:

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:

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:

Requirement **RS_BSP_192**

The C2C-CC Basic System shall interpret ‘heading’ as the orientation of the horizontal velocity vector with regards to the WGS84 north as defined in A.35 DE_HeadingValue in [TS 102 894-2].

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:

Requirement **RS_BSP_195**

When information from some sensors used for estimating vehicle states (see RS_BSP_428, e.g. GNSS or vehicle sensors) is not available, the vehicle states estimation shall be continued (e.g. by means of extrapolation). The confidence intervals shall continue to fulfil the corresponding requirements.

Note: The corresponding requirements are e.g: RS_BSP_429, RS_BSP_200, RS_BSP_207 and RS_BSP_202.

Details:

Tested by:

Requirement **RS_BSP_514**

Any requirement related to host vehicle dynamics refer to the actual vehicle dynamics, and not to measurements reported by the related sensors, unless otherwise stated.

Thus, sensor outputs shall be monitored for correct performance.

Details: RS_FEA_438

Tested by:

Requirement **RS_BSP_197**

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

Details:

Tested by:

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: RS_FEA_438

Tested by:

Requirement **RS_BSP_432**

Timestamps in messages generated by vehicle C-ITS stations shall be based on the station

clock (see RS_BSP_430).

Details:

Tested by:

Requirement **RS_BSP_516**

If the clock has been valid within the last 7 d and if a full system reset has not been performed, the station clock shall become valid (see RS_BSP_206) within 1 min after an external synchronisation signal is available.

Otherwise the clock shall become valid within 15 min after an external synchronisation signal is available.

Note: ‘7 d’ shall point out the assumption, that a vehicle is used at least once a week. Besides this, the number ‘7’ does not have a certain technical background.

Details:

Tested by:

Requirement **RS_BSP_517**

After the station clock has become valid (see RS_BSP_516), it shall remain valid as long as an external synchronisation signal is available (see RS_BSP_516).

Details:

Tested by:

Requirement **RS_BSP_518**

After the station clock has become valid (see RS_BSP_516), it shall remain valid for at least 6 min when no external time synchronisation signals are available.

Note: 15 min are recommended to augment existing and to support future use cases (15 min = 18 ms drift in case of 20 ppm).

Details:

Tested by:

Requirement **RS_BSP_207**

If the station clock is not valid (see RS_BSP_206) the C-ITS station shall not be active.

Details:

Tested by:

Requirement **RS_BSP_444**

If the speed is below 1,4 m/s and the heading confidence becomes greater than 12,5 ° or the speed drops below 0,08 m/s (according to RS_BSP_511), 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 °, then the heading value shall be unlatched.

Details:

Tested by:

Requirement **RS_BSP_445**

At system startup, the vehicle C-ITS station may report a stored heading value as the initial startup value.

Details:

Tested by:

Requirement **RS_BSP_534**

The C2C-CC Basic System shall set the VehicleWidth in CAMs it originates to the ceiled value of the width without mirrors and the VehicleLengthValue to the ceiled value of the length including permanent extensions.

Note: ‘without mirrors’ and ‘including permanent extensions’ is to follow the concept of [EN 302 890-2].

Note: ‘ceiled values’ is to ensure that distance calculations including the vehicle shape are ‘on the safe side”.

Details:

Tested by:

6.3 System behaviour

Requirement **RS_BSP_214**

The vehicle C-ITS station shall operate the Cooperative Awareness Basic Service when it is participating in public traffic, unless the C-ITS station is explicitly deactivated.

Note: ‘Participating in public traffic’ includes ‘being on public roads under regular driving dynamics’, but is not limited to public roads only.

Details:

Tested by:

Requirement **RS_BSP_215**

Traces and path history data shall be generated only when position confidence information (see RS_BSP_535) is available and the station clock adheres to RS_BSP_206.

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_404**

For all CAMs and DENMs that originate from a vehicle C-ITS station, the time interval given by the moment in time when the message is sent from the originating station minus the moment

in time the information in the message refers to, shall be in the range of 0 ms to +100 ms plus additional delays due to DCC mechanisms.

Note: The moment in time the information refers to is represented by a timestamp in the message. This timestamp is represented in a CAM by the *GenerationDeltaTime* and in a DENM by the *DetectionTime.*

Note: The moment in time when the message is sent and the moment in time the information in the message refers to may be measured by different station clocks. Therefore, the allowed time difference between the station clock and C-ITS time in accordance to RS_BSP_206 shall be taken into account when determining the time interval.

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:

Requirement **RS_BSP_531**

The C2C-CC Basic System shall only operate the Decentralized Environmental Notification Basic Service if also operating the Cooperative Awareness Basic Service.

Note: Operation of the Cooperative Awareness Basic Service is defined in RS_BSP_214.

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:

Requirement **RS_BSP_226**

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

Details:

Tested by:

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:

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:

Requirement **RS_BSP_228**

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

Details:

Tested by:

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:

Requirement **RS_BSP_435**

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

Details:

Tested by:

Requirement **RS_BSP_235**

The C2C-CC Basic System shall set traffic classes (TC) according to the requirements of C2C-CC triggering conditions [C2CCC tc Docs] for DENM packets it originates and RS_BSP_292 for CAM packets it originates.

The C2C-CC Basic System shall set access categories (AC) of ETSI ITS-G5 of packets it originates according to the mapping based on traffic classes (TC) as defined in [TS 102 636-4-2].

The C2C-CC Basic System shall set access categories (AC) of ETSI ITS-G5 of packets it forwards according to RS_BSP_267.

Note: Each AC is mapped to a user priority (UP)(see [IEEE 802.1D]) and enhanced distributed channel access (EDCA) queue with specific transmission parameters (see [EN 302 663]).

Details:

Tested by:

Requirement **RS_BSP_436**

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

Details:

Tested by:

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. Additional bursts are allowed for TC ID 0 messages with R_{Burst} = 20 messages/s, with a maximum duration of T_{Burst} = 1 s. The time period in between these bursts should be at least $T_{BurstPeriod}$ = 10 s. The limits given in [EN 302 571] still apply (see also RS_BSP_433).

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:

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:

Requirement **RS_BSP_241**

The C2C-CC Basic System may implement a filtering of received messages that also affects GeoBroadcast forwarding in situations of high message loads.

Note: In some situations – such as severe traffic congestion or other extreme vehicular network scenarios – the DENM load might increase substantially. Information traffic shaping or selective forwarding is allowed to exclude some DENMs from forwarding in such situations.

Details:

Tested by:

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:

Requirement **RS_BSP_245**

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

Note: PTx may depend on the current DCC state (i.e. relaxed, active or restrictive) and on the traffic class (i.e. TC ID 0, TC ID 1, etc.).

Details:

Tested by:

Requirement **RS_BSP_246**

The C2C-CC Basic System shall reduce its transmission power to PToll = pDccPToll as soon as the protected zone is entered and without changing any other DCC transmission parameters as per RS_BSP_238. TC ID 0 messages are excluded from this restriction.

Details:

Tested by:

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:

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:

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:

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:

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_515**

The C2C-CC Basic System may omit forwarding of a packet if the distance between its own location and the center of the destination area exceeds *pGnMaxAcceptDistance*.

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) packet transport type as defined in [EN 302 636-4-1] on all CAM packets it originates.

Details:

Tested by:

Requirement **RS_BSP_257**

The C2C-CC Basic System shall use the GBC packet transport type as defined in [EN 302 636-4-1] on all DENM packets it originates.

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:

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
- set the sub-field base to *pGnShbLifeTimeBase*.

Details:

Tested by:

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:

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:

Requirement **RS_BSP_262**

The channel offload bit of the TC field shall be set to *pGnChannelOffLoad*.

Note: This requirement is intended to enable future use of according features.

Note: The C2C-CC Basic System is not required to offload packets to another channel.

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 may set the optional GN-DATA.request parameter 'Maximum hop limit' for GBC packets 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.

Note: If that parameter is not set, the default *itsGnDefaultHopLimit* 10 automatically applies (RS_BSP_437, RS_BSP_250).

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**

The C2C-CC Basic System shall forward packets using background access category (AC_BK), see [TS 102 636-4-2].

Note: In case of forwarded packets, the TC indicated in the GN Common Header is preserved and not used for DCC queue assignment. The media dependent part of the network layer is defining the access category to be used by the access layer.

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:

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:

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:

Requirement **RS_BSP_274**

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

Details:

Tested by:

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:

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:

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] specifies 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]). The parameter vMaxPHistPoints is set to *pCamTraceMaxPoints*.

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*.

Note: Depending on the use case the length of the path history may exceed the minimum length of *pCamTraceMinLength* but not exceed *pCamTraceMaxLength*.

Details:

Tested by:

Requirement **RS_BSP_286**

The PathHistory in CAMs originated by vehicle C-ITS stations shall cover at most *pCamTraceMaxLength*.

Note: Following RS_BSP_285 and its parameters, this is automatically given.

Details:

Tested by:

Requirement **RS_BSP_512**

The PathHistory in CAMs originated by vehicle C-ITS stations shall consist of at most *pCamTraceMaxPoints* path points.

Note: Regardless of the value of *pCamTraceMaxPoints*, the system is expected to be able to process the PathHistory in received CAMs with up to 23 path points (see RS_BSP_439). Handling of the PathHistory in received CAMs with more than 23 path points is considered optional.

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_291**

A C2C-CC Basic System shall transmit CAMs when position confidence information (see RS_BSP_535) is available and the station clock adheres to RS_BSP_206.

Details:

Tested by:

Requirement **RS_BSP_292**

The TC ID 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:

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:

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:

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:

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]). The parameter vMaxPHistPoints is set to *pDenmTraceMaxPoints*.

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*.

Note: Depending on the use case the length of the path history may exceed the minimum length of *pDenmTraceMinLength* but not exceed *pDenmTraceMaxLength.*

Details:

Tested by:

Requirement **RS_BSP_303**

The traces in the DENMs originated by vehicle C-ITS stations shall cover at most *pDenmTraceMaxLength*.

Note: Following RS_BSP_302 and its parameters, this is automatically given.

Details:

Tested by:

Requirement **RS_BSP_513**

The traces in the DENMs originated by vehicle C-ITS stations shall consist of at most *pDenmTraceMaxPoints* path points.

Note: Regardless of the value of *pDenmTraceMaxPoints*, the system is expected to be able to process traces in received DENMs with up to 40 path points (see RS_BSP_440).

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 C-ITS services, the C2C-CC Basic System shall generate DENMs only as described in the triggering conditions provided with this release [C2CCC tc Docs].

Note: This requirement is not intended to restrict innovation but aims to ensure forward and backward compatibility.

Note: In case of modifications of the triggering conditions (e.g. for particular vehicle classes) temporary deviations due to release cycles are acceptable.

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_536**

'Keep alive forwarding' as described in chapter 6.1.4.2 of the DENM standard [EN 302 637-3] shall not be used.

Note: This forwarding does not have a security mechanism and therefore should not be used.

Note: The statement 'For the forwarding ITS-S, the stationID shall be set to the station ID of the forwarding ITS-S, if the DENM is forwarded.' in Annex B item B.1 of [EN 302 637-3] does not apply for GN forwarding.

Details:

Tested by:

Requirement **RS_BSP_537**

For all GN packets, a C2C-CC Basic System originates, the time interval given by the moment in time when the message is sent from the originating station minus the moment in time the source position vector refers to, shall be in the range of 0 ms to +100 ms plus additional delays due to DCC mechanisms.

Note: The moment in time when the message is sent and the moment in time the source position vector refers to may be measured by different station clocks. Therefore, the allowed time difference between the station clock and C-ITS time in accordance to RS_BSP_206 shall be taken into account when determining the time interval.

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:

- Instead of the maximum value 15 in step number 9, the parameter vMaxPHistPoints shall apply;
- K_PHALLOWABLEERROR_M = *pTraceAllowableError*, where PH_ActualError < K_PHALLOWABLEERROR_M;
- K_PH_CHORDLENGTHTHRESHOLD = *pTraceMaxDeltaDistance*, maximum distance between two successive concise path points.*;*
- 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 chapter 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. Therefore, the statistical population shall be a sliding window consisting of all the vehicle states (see RS_BSP_428) over the last *pPotiWindowTime* seconds instead of one large dataset containing all scenarios.

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.

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 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:

Requirement **RS_BSP_205**

Under open sky conditions (as defined in RS_BSP_533) and regular driving dynamics (as defined in RS_BSP_449), the confidence values shall be equal to or lower than the following values with at least 95 % probability:

- (horizontal position confidence of 5 m) AND
- (vertical position confidence of 20 m).

Note: 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: The relation between position confidence values and position error (delta between ground truth and reported position) is given by RS_BSP_431.

Details:

Tested by:

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 5.

'C' for horizontal position is the maximum of *semiMajorConfidence* and *semiMinorConfidence*, see also RS_BSP_200. The condition for 'C' shall be fulfilled with at least 95 % probability in the given scenario.

Note: To enable proper statistics, it is recommended to include multiple realisations of a scenario summing up to at least 100 s of each scenario. Example: 3 tunnels of 35 s each, can be multiple drives through the same tunnel.

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: At the beginning of every scenario, the vehicle C-ITS station system shall be in a properly initialized state without significant degradation due to prior operational conditions. This can be assumed if the requirements from another scenario with more stringent confidence requirements are fulfilled for 60 s prior to the start of the scenario. Scenario S2 and S3 shall never be part of the last 60 s prior to the start of a scenario. Scenario S2 (Tunnel) shall never follow S7.

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.

Note: In the scenarios it is assumed that the vehicle is not moved (towed/pushed/..) by an external force.

Note: The values in the scenario table are currently checked for passenger cars only.

Table 5: Scenarios

ID	Scenario	Definition	Acceptance			
			Horizontal position (C = PositionConfidence)	**Vertical position** (C = PositionConfidence)	**Horizontal Speed** (C = SpeedConfidence)	**Horizontal Heading** (C = HeadingConfidence)
Environment under regular driving dynamics						
S1	Open sky	Open sky conditions (as defined in RS_BSP_533), with vehicle moving with regular driving dynamics, normal road conditions	C <= 5 m	see RS_BSP_205	see RS_BSP_448	see RS_BSP_457
S2	Tunnel	Sky is 100 % obstructed 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	any value is allowed	C <= 0.6 m/s (for parts of the scenario with v >= 1.4 m/s, otherwise any value allowed)	12 degrees (for parts of the scenario with v >= 1.4 m/s, otherwise any value allowed)
S3	Parking house	Sky is 100 % obstructed (Note: GNSS reception due to reflections may occur), 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	as S2	any value allowed	any value allowed

ID	Scenario	Definition	Acceptance			
			Horizontal position (C = PositionConfidence)	**Vertical position** (C = PositionConfidence)	**Horizontal Speed** (C = SpeedConfidence)	**Horizontal Heading** (C = HeadingConfidence)
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	as S2	as S2	6 ° (for parts of the scenario with v >= 1,4 m/s, otherwise any value allowed)
S5	Forest	Sky is 30-50 % obstructed by objects including trees higher than the antenna, for more than 30 s.	C <= 10 m	as S2	as S2	as S4
S6	Mountains (valley)	Sky is 40-60 % obstructed by high mountain(s); driving conditions as S1	C <= 10 m	as S2	as S2	as S4
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	as S2	as S2	as S2
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	as S2	as S2	as S4
Driving conditions under open sky						

ID	Scenario	Definition	Acceptance			
			Horizontal position (C = PositionConfidence)	**Vertical position** (C = PositionConfidence)	**Horizontal Speed** (C = SpeedConfidence)	**Horizontal Heading** (C = HeadingConfidence)
S9	Dynamic driving	Test drive with longitudinal accelerations of more than -6 m/s² and lateral accelerations of > +/-5 m/s²	C <= 7 m	as S1	C <= 1,2 m/s (for parts of the scenario with v >= 1,4 m/s, otherwise any value allowed)	as S4
S10	Static	Vehicle standing still for 30 min	as S1	as S1	C <= 0.3 m/s	any value allowed, typically *outOfRange* according to RS_BSP_444
S11	Rough road	Test drive on unpaved road (e.g. gravel road or dirt road) with pot holes, v= 20-50 km/h	C <= 10 m	as S1	As S9	as S4
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	as S1	any value allowed	any value allowed
S13	High speed	V= minimum of (130 km/h, legal Vmax of the vehicle) on dry road for 30 s	as S1	as S1	as S1	as S1

ID	Scenario	Definition	Acceptance			
			Horizontal position (C = PositionConfidence)	**Vertical position** (C = PositionConfidence)	**Horizontal Speed** (C = SpeedConfidence)	**Horizontal Heading** (C = HeadingConfidence)
S14	Reverse driving	After forward driving followed by a standstill of not more than 60 s, reverse driving for at least 30 s, exceeding 1,4 m/s for at least 20 s in total	as S1	as S1	as S1	as S1

Details:

Tested by:

Requirement **RS_BSP_448**

Under open sky conditions (as defined in RS_BSP_533) and regular driving dynamics (as defined in RS_BSP_449), the speed confidence values shall be equal to or lower than the following values with at least 95 % probability:

- 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: 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: The relation between speed confidence value and speed error (delta between ground truth and reported speed) is given by RS_BSP_431.

Details:

Tested by:

Requirement **RS_BSP_457**

Under open sky conditions (as defined in RS_BSP_533) and regular driving dynamics (as defined in RS_BSP_449), the heading confidence values shall be equal to or lower than the following values with at least 95 % probability:

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

Note: 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: The relation between heading confidence value and heading error (delta between ground truth and reported heading) is given by RS_BSP_431.

Details:

Tested by:

Requirement **RS_BSP_529**

The curvature error (delta between ground truth and reported *curvatureValue*) shall not exceed the reported *curvatureConfidence* in at least 95 % of data points.

Details:

Tested by:

Requirement **RS_BSP_530**

Under open sky conditions (as defined in RS_BSP_533) and regular driving dynamics (as defined in RS_BSP_449), latest 4 s after reaching a constant radius, the reported *curvatureConfidence* values shall be equal to or better than the following values with at least 95 % probability:

- ‘onePerMeter-0-01 (4)’ for true radii between 100 and 500 m, true speed at least 12,5 m/s
- ‘onePerMeter-0-002 (3)’ for true radii between 500 and 2 500 m, true speed at least 12,5 m/s

NOTE: A constant radius can be assumed if the change of yaw rate is less than 0,5 °/s^2, see 6.3.6-V2V-BSMTX-DATAACC-046 of [SAE J2945/1].

Details:
Tested by: