Vehicle C-ITS station 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 (C2C-CC). The industrial driven, non-commercial association was founded in 2002 by vehicle manufacturers affiliated with the idea of cooperative road traffic based on Vehicle-to-Vehicle Communications (V2V) and supported by Vehicle-to-Infrastructure Communications (V2I). The Consortium members represent worldwide major vehicle manufactures, equipment suppliers and research organisations.

Over the years, the C2C-CC has evolved to be one of the key players in preparing the initial deployment of C-ITS in Europe and the subsequent innovation phases. C2C members focus on wireless V2V communication applications based on Direct Communication 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 C2C-CC and its members work in close cooperation with the European and international standardisation organisations.

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Document information

Number:	2037	**Version:**	n.a.	**Date:**	2025-12-19
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Status:	Final				

Table 1: Document information

Changes since last release

Release	Date	Changes	Edited by	Approved
1.6.9	2025-12-19	In context of improved PTW support, changed: • RS_BSP_534 • RS_BSP_321 • RS_BSP_449 • RS_BSP_583 • RS_BSP_445 • RS_BSP_572 • RS_BSP_448 • RS_BSP_457 • RS_BSP_511 • RS_BSP_444 added: • RS_BSP_586 • RS_BSP_587 • RS_BSP_588 • RS_BSP_589	Release Management	Steering Committee
1.6.8	2025-07-11	• Improvement of maintainability through introduction of requirement hierarchies for expressing variants • Reordering of clause ‘Facility layer’	Release Management	Steering Committee
1.6.7	2024-12-13	• Coverage of vehicle type *cycle* fundamentally improved	Release Management	Steering Committee
1.6.6	2024-07-12	• Editorial changes	Release Management	Steering Committee
1.6.5	2023-12-15	• Aftermarket, devices are fully covered now • Changed attribute (i) to (#i) • Introduced new attribute (#a) (which expresses whether a requirement is relevant to allow for a communication technology agnostic implementation) • Detailed regular driving dynamics	Release Management	Steering Committee
1.6.4	2023-07-21	• Added clause on lane information	Release Management	Steering Committee
1.6.3	2022-12-16	• Minor changes	Release Management	Steering Committee
1.6.2	2022-07-22	• Minor changes, like: ○ Improved RS_BSP_534 in respect to ‘permanent extension’ ○ CCH (Control Channel) to SCH0	Release Management	Steering Committee

1.6.1	2021-12-17	• Added marking of requirements, indicating relevance for interoperability according to [CPOC] • Update of versions of referenced standards (for more details, refer to: [C2CCC Refs])	Release Management	Steering Committee

1.6.0	2021-07-23	• Detailing of:
		  ○ AT changeover and
		  ○ Position and timing
		• Major detailing of rules for creation and update of the DENM eventHistory; associated modification of Maximum Hop Limit for GBC packets
			Release Management	Steering Committee

1.5.3	2021-03-12	• Detailing of AT changeover • Disabled SCF feature	Release Management	Steering Committee
1.5.2	2020-12-16	• Further detailing of position and timing requirements • Replacement of 'C2C-CC Basic System' by 'vehicle C-ITS station'	Release Management	Steering Committee
1.5.1	2020-07-31	• Further detailing of position and timing requirements	Release Management	Steering Committee
1.5.0	2020-03-27	• Major detailing of position and timing requirements • New AT changeover requirements	Release Management	Steering Committee
1.4.0	2019-09-14	• 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
1.3.0	2018-08-31	• 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

Table 2: Changes since last release

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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 a C-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 vehicle C-ITS station (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_581**

'Cycle' is a vehicle which has at least two wheels and is propelled at least partially by the muscular energy of the persons on that vehicle, by means of pedals or hand cranks.

Definition **RS_BSP_579**

'Cycle is used' term means that a cycle is either:

1. ridden by a rider, or
2. pushed by a rider.

Note: *'cycle is used'* term excludes cases when the cycle is transported.

Definition **RS_BSP_586**

'PTW' is defined according to EU regulation [EU R168] categories L1e-B and L3e

Note: In the category L1e-B are vehicle types which can be considered as cycle or as PTW.

Definition **RS_BSP_587**

'*PTW is used'* term means that a PTW is ridden by a rider and ignition signal 15 or equivalent is on.

Note: 'PTW is used' term excludes cases when the PTW is transported or pushed.

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 vehicle C-ITS station.

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 - C-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_500**

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

Definition **RS_BSP_191**

Reference coordinate systems are defined in [EN 302 890-2].

Whereas WGS84 is assumed to use the realization G1150 or newer.

Note: This includes World Geodetic System 84 (WGS84) as coordinate system for the vehicle states specified in RS_BSP_428.

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.

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 (centred at the estimated horizontal position) described via a major axis, minor axis and orientation of the major axis relative to the north of the reference coordinate system.

Note: The reference coordinate system is defined in RS_BSP_191.

Definition **RS_BSP_578**

‘Urban roads’ are all roads within an area whose entrance and exit are guarded by town signs.

Definition **RS_BSP_429**

Information provided with a ‘confidence level’ of 95 % means that the true value is inside the confidence interval (see RS_BSP_500) or the confidence area (see RS_BSP_200) for at least 95 % of the data points in a given statistical population.

Definition **RS_BSP_511**

‘A stationary vehicle’ is defined as follows:

<car>

The vehicle is moving with a speed of <= 0,08 m/s in respect to the reference coordinate system (see also RS_BSP_191).

</car>

<ptw>

The vehicle is moving with a speed of <= 1,4 m/s in respect to the reference coordinate system (see also RS_BSP_191).

</ptw>

Definition **RS_BSP_449**

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

- has passed its initial start-up 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);
- it is located on a surface without movement in respect to the reference coordinate system, except for minimal effects like continental drift (i.e., it is not located on a moving surface like a ferry);

<car>,<ptw>

- 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).

</car>,<ptw>

<cycle>

- all the following conditions (values) apply for cycles:
  - vehicle lateral acceleration is < 1,5 m/s² (based on typical corning); AND
  - vehicle longitudinal acceleration is > - 2,0 m/s²; AND
  - vehicle longitudinal acceleration is < 2,0 m/s²; AND
  - vehicle speed is < 45 km/h AND > 10 km/h.

</cycle>

Note: This is intended to be used for confidence requirements of the vehicle state. For release 1, the vehicle is not required to detect itself whether it is under regular driving dynamics.

Note: The reference coordinate system is defined in RS_BSP_191.

Note: Valet parking using moving platforms are handled like the ferry use case. Valet parking with the vehicle operated by a driver, a local system, or remote vehicle operation (RVO) is part of regular driving dynamics as long as the requirements listed above are met.

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_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].

Definition **RS_BSP_545**

In this document the following channel definitions are used:

Channel Type	Centre frequency	Channel number	Channel spacing
G5-SCH0	5 900 MHz	180	10 MHz
G5-SCH2	5 890 MHz	178	10 MHz
G5-SCH1	5 880 MHz	176	10 MHz
G5-SCH3	5 870 MHz	174	10 MHz
G5-SCH4	5 860 MHz	172	10 MHz
G5-SCH5	5 910 MHz	182	10 MHz
G5-SCH6	5 920 MHz	184	10 MHz

Note: Former version of ETSI and C2C-CC documents named the SCH0 also ‘Control Channel (CCH)’.

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 (#i) (#a) **RS_BSP_443**

Table 3: Parameter settings

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
pAlDataRateSch0	6	Mbit/s	Default data rate for Service Channel 0 (G5-SCH0)	3	27	[EN 302 663]
pAlDataRateSch0High	12	Mbit/s	Optional higher data rate for G5-SCH0 than the default one	3	27	[EN 302 663]
pAlDataRateSch0Low	3	Mbit/s	Optional lower data rate for G5-SCH0 than the default one	3	27	[EN 302 663]
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	--
pCycleInUseDetectionDuration	2	s	Value for the cycle in use detection duration	--	--	--
pCycleInUseTimeout	300	s	Value for the cycle in use timeout	--	--	--
pDccMaxPToll	10	dBm	Value for transmission power inside protected zones	--	--	[TS 102 792]
pDenmEventHistoryGenMaxDeltaDistance	--	m	As defined in the DENM update rules of the specific Triggering Condition document	--	--	--

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
pDenmEventHistoryGenMaxDeltaHeading	--	°	As defined in the DENM update rules of the specific Triggering Condition document	--	--	--
pDenmEventHistoryGenMaxDeltaTime	--	s	As defined in the DENM update rules of the specific Triggering Condition document	--	--	--
pDenmTraceMaxLength	1 000	m	Maximum length of a trace in DENMs	--	--	--
pDenmTraceMinLength	600	m	Minimum length of a trace in DENMs	--	--	--
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	0	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	2	[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]

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
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	--	--	--
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 vehicle C-ITS station is moving	--	--	--
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	--	--	--

Parameter	Value	Unit	Description	Min. Value	Max. Value	Source Document
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	--	--	--
pSecAtRestartTime	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	--	--	--
pSecureLinkCheckInterval	10	s	Secure Link Check Interval	--	--	--
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 clause 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 vehicle C-ITS station 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 (#i) **RS_BSP_158**

A vehicle C-ITS station shall only send messages when it is mounted to the correct vehicle. See RS_BSP_583, RS_BSP_584, RS_BSP_585 for options how to verify this.

Details: RS_FEA_405

Tested by:

Requirement (#i) (#car) (#ptw) **RS_BSP_583**

A C-ITS station shall verify when it is powered, whether it is mounted to and operating in the specific vehicle to which it has been securely linked.

If such correct functioning condition cannot be verified, the vehicle C-ITS station shall be deactivated, preventing it from sending messages.

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

Note: This measure is typically taken for privately owned OEM vehicles

Details: RS_BSP_158

Tested by:

Requirement (#i) (#supervised) **RS_BSP_584**

A registered organization being responsible for supervising the correct mounting of C-ITS stations to vehicles and the operation of these C-ITS stations, shall take suited measures, to ensure that such C-ITS station is linked to its enrolment configuration over the life-time of its operation. This comprises the following measures taken:

1. technical and/or procedural life-time management is in place, i.e., the vehicle's C-ITS station and conditions of use are registered and supervised by the according organization; the C-ITS stations are revoked if/when the conditions are changed and thus no more in line with the PKI enrolment,
2. a procedure is defined and (self-)assessed to ensure the life-time management according to point 1. (above) is valid and safeguarded,
3. persistent security information (certificates, keys) is stored in confidential storage,
4. physical OBU installation is checked periodically and in case it is not present anymore the device is revoked at the PKI,
5. the C-ITS station is a remote managed, so on-demand remote misbehaviour detection and remote deactivation is possible,
6. *pSecMaxPreloadTime* shall be set to 2 weeks.

Note: Supervised C-ITS stations are installed in the factory or in a professional repair- or tuning shop.

Note: This measure is typically taken for aftermarket C-ITS stations, i.e., stations installed after factory production of the equipped vehicle.

Note: The enrolment configuration comprises the type of vehicle and the associated permissions (ITS-AID and SSPs) of the C-ITS station.

Details: RS_BSP_158

Tested by:

Requirement (#i) (#cycle) **RS_BSP_585**

A C-ITS station claiming to represent a cycle shall verify that it is mounted to a real cycle.

This verification shall be done:

- before sending the first message after start-up, and
- on a regular basis (every *pSecureLinkCheckInterval*)

and can be achieved either via:

1. secure data/property exchange with the vehicle, or
2. measures to verify the plausibility of the kinematic state for the intended station type. At least 2 different sensors need to be used to show the plausibility, e.g., GNSS and wheel ticks.

If such correct functioning condition cannot be verified, the vehicle C-ITS station shall be deactivated, preventing it from sending messages.

Note: As an example, verification method 1 can be a crypto-secured data exchange of vehicle properties.

Note: As an example, verification method 2 can be a speed signal / a wheel tick signal received by the vehicle, that is checked for plausibility via comparison with sensors integrated in the C-ITS station (e.g., GNSS/IMU).

Details: RS_BSP_158

Tested by:

Requirement **RS_BSP_168**

The vehicle C-ITS station 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 vehicle C-ITS station 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 vehicle C-ITS station shall check the distance from the originator position (in the security header, if available or from the GN header) and shall forward only messages with a distance from the originator of *pSecMaxAcceptDistance* or less.

Additionally, the vehicle C-ITS station 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 (#i) **RS_BSP_163**

The vehicle C-ITS station 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 (#i) **RS_BSP_164**

The vehicle C-ITS station shall only forward messages, that are valid according to clause 4.1 of [TS 103 097].

Details:

Tested by:

Requirement (#i) **RS_BSP_160**

The vehicle C-ITS station 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 (#i) **RS_BSP_407**

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

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

Details:

Tested by:

Requirement (#i) **RS_BSP_170**

The vehicle C-ITS station shall sign all messages, except those originated by another C-ITS station, by using digital signatures and certificates based on ECDSA-256 using the elliptic

curve NIST P-256 according to [TS 103 097] and shall use only one of the compressed formats for signatures specified in [TS 103 097].

Note: This means that the rSig parameter of the ECDSA P256 signature is not of type uncompressed.

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 clause 6.1.4.1 of [C-ITS CP].

Details:

Tested by:

Requirement (#i) **RS_BSP_178**

Authorization ticket preloading in the vehicle shall not exceed *pSecMaxPreloadTime*. All ATs in the vehicle C-ITS station shall have a validity end date below (current date + *pSecMaxPreloadTime*).

Details:

Tested by:

Requirement (#i) **RS_BSP_181**

If the vehicle C-ITS station detects a collision of the least significant 32 bit of the ‘Certificate digest’ / ‘hashedId8’ with the ‘Certificate digest’ / ‘hashedId8’ of another C-ITS station, 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 (#i) **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 %.

Note: The travel distance is understood as the length of the path followed or to be followed by the vehicle and not the straight-line distance between 2 points.

Details:

Tested by:

Requirement **RS_BSP_542**

The requirements RS_BSP_520, RS_BSP_521, RS_BSP_522, RS_BSP_523 and RS_BSP_524 shall be interpreted as exact requirements and not as minimal requirements, except if RS_BSP_181 applies, or if the AT, that is actually in use, expires.

Details:

Tested by:

Requirement **RS_BSP_543**

If one of those exceptions from RS_BSP_542 applies, they shall be treated as additional AT changeovers, that do not influence the AT change procedure according to RQs RS_BSP_520, RS_BSP_521, RS_BSP_522, RS_BSP_523 and RS_BSP_524.

Details:

Tested by:

Requirement (#i) **RS_BSP_520**

When the engine control is activated after it has been deactivated for at least *pSecAtRestartTime*, the vehicle C-ITS station shall perform an AT changeover.

Note: When the engine control is activated after it has been deactivated for less than *pSecAtRestartTime*, the vehicle C-ITS station may perform an AT changeover.

Note: Conditions for the next AT changeover are given in RS_BSP_521.

Note: Engine control is logically equivalent to the classic ignition signal 15.

Details:

Tested by:

Requirement (#i) **RS_BSP_521**

After the RS_BSP_520 has been satisfied a vehicle C-ITS station 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 (#i) **RS_BSP_522**

After the RS_BSP_521 has been satisfied, a vehicle C-ITS station 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 (#i) **RS_BSP_523**

After the RS_BSP_522 has been satisfied, a vehicle C-ITS station 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 (#i) **RS_BSP_524**

After the RS_BSP_523 has been satisfied, a vehicle C-ITS station 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:

Other (informational) **RS_BSP_525**

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

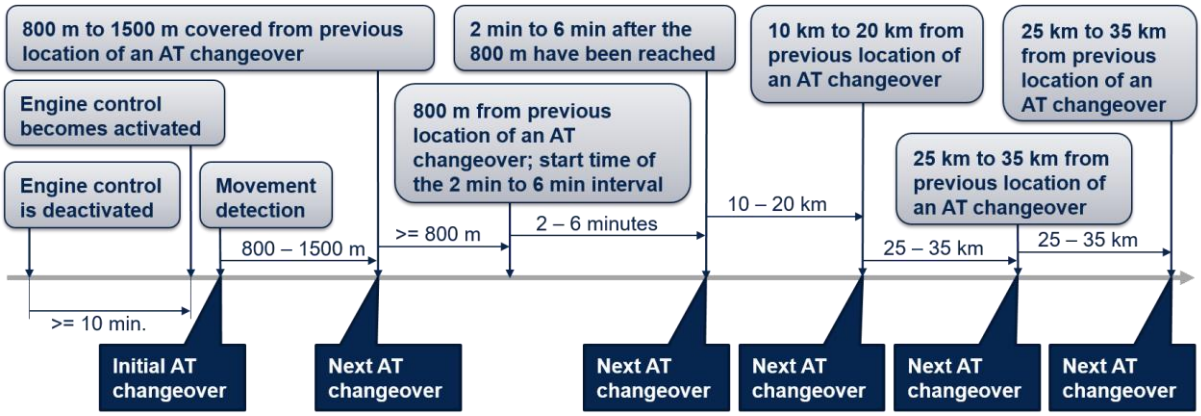

Figure 1: AT changeovers and related events over time

Requirement (#i) **RS_BSP_526**

A vehicle C-ITS station shall only sign a message when it is in possession of at least 56 valid ATs and corresponding private keys 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 (#i) **RS_BSP_527**

A vehicle C-ITS station 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 (#i) **RS_BSP_528**

A vehicle C-ITS station 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 (#i) **RS_BSP_182**

When an AT changeover happens:

- All addresses and identifiers transmitted through short-range communication shall be changed and the GBC sequence number shall be set to 0, or a different random value.
- 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 conditions are satisfied again. (Note: This implies that the triggering condition logic is restarted.)
- 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 clause 6.5 of [TS 102 940].

Details:

Tested by:

Requirement **RS_BSP_184**

Applications shall be able to block the authorization ticket change indefinitely, as long as the 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 (#i) **RS_BSP_401**

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

Details:

Tested by:

Requirement (#i) **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 (#i) **RS_BSP_190**

The vehicle states (see RS_BSP_428) shall be consistent. Therefore, heading and speed 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 (#i) **RS_BSP_540**

The vehicle C-ITS station shall use coordinate systems following RS_BSP_191 unless specified otherwise.

Details:

Tested by:

Requirement (#i) **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 (#i) **RS_BSP_192**

The vehicle C-ITS station 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 C-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 information shall continue to fulfil the corresponding requirements.

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

Details:

Tested by:

Requirement (#i) **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 used by the vehicle CITS station for the implemented use cases shall be monitored for correct performance.

Details: RS_FEA_438

Tested by:

Requirement (#i) **RS_BSP_197**

When active, a vehicle C-ITS station shall update the vehicle states (see RS_BSP_428) with a frequency of at least the *pPotiUpdateRate*.

Details:

Tested by:

Requirement (#i) **RS_BSP_431**

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

Details: RS_FEA_438

Tested by:

Requirement (#i) **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 (#i) **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).

Note: It is expected that devices stop sending specific messages e.g., in case of CAMs due to an out-of-range position confidence (see RS_BSP_535). However, there are situations when CAMs are transmitted for at least 6 min (see RS_BSP_538).

Details:

Tested by:

Requirement (#i) **RS_BSP_207**

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

Details:

Tested by:

Requirement (#i) (#car) **RS_BSP_444**

If the speed is below 1,4 m/s and the heading confidence value 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 value shall be set to ‘out of range’.

Once the speed rises above 0,08 m/s and the heading confidence value becomes less than 12,5 °, then the heading value shall be unlatched.

Details:

Tested by:

Requirement (#i) (#ptw) **RS_BSP_589**

If the speed is below 2,8 m/s and the heading confidence value becomes greater than 12,5 ° then the heading value shall be latched to the last value before this event and the heading confidence value shall be set to ‘out of range’.

Once the speed rises above 1,4 m/s and the heading confidence value becomes less than 12,5 °, then the heading value shall be unlatched.

Details:

Tested by:

Requirement **RS_BSP_445**

<car>

The vehicle C-ITS station may report a stored heading value as the initial start-up value.

</car>

<cycle>,<ptw>

The vehicle C-ITS station shall not use a stored heading value as the initial start-up value.

<cycle>,</ptw>

Details:

Tested by:

Requirement (#i) **RS_BSP_534**

The vehicle C-ITS station 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.

<cycle>,<ptw>

For vehicle C-ITS stations mounted on:

</cycle>,</ptw>

<cycle>

- a cycle – if the values are known and fixed, the width and / or the length shall be filled with the fixed values. If not, it shall be filled with unavailable.

</cycle>

<ptw>

- a PTW – the width shall be filed with a fixed value, follow the concept of [EN 302 890-2] for PTW.

</ptw>

Note: ‘without mirrors’ and ‘including permanent extensions’ is to follow the concept of [EN 302 890-2]. Alternative terms are ‘Structural width’ and ‘Overall length’.

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

Note: Handling of trailer length is defined in RS_BSP_546.

Note: The actual width of a PTW dynamically changes depending on the lean angle.

Note: The bonding box does not include the driver in cycle and PTW use cases, the rider could extend the overall width significantly.

Note: The VehicleLengthValue for PTW does not need to be defined station type specific and the general description is valid.

Details:

Tested by:

Requirement (#i) **RS_BSP_546**

If the length of an attached trailer is known to the vehicle C-ITS station, the vehicle C-ITS station shall include this length in the VehicleLengthValue in CAMs it originates and set VehicleLengthConfidenceIndication to trailerPresentWithKnownLength.

NOTE: This implies that VehicleLengthValue includes the length of a trailer if and only if VehicleLengthConfidenceIndication is set to trailerPresentWithKnownLength.

Details:

Tested by:

6.2.1 Lane information

Requirement **RS_BSP_572**

The vehicle C-ITS station should add lane information to its generated CAMs on motorways and in non-urban environments.

The vehicle C-ITS station should not add lane information to its generated CAMs while being on an urban road (see also RS_BSP_578). Motorways in such areas are not considered as urban roads.

If component lanePosition is present the following requirements (RS_BSP_573, RS_BSP_574, RS_BSP_575, RS_BSP_576 and RS_BSP_577) shall apply.

Note: Most PTW will not send out lane information.

Details: RS_FEA_440

Tested by:

Requirement **RS_BSP_573**

The updated description of the ETSI LanePosition in [TS 102 894-2 V2.1.1] shall be used.

This includes the situation of carriageways with traffic for both directions and no optical legal separation. In such cases the separation is defined as follows:

- If the total number of lanes N is even, the lanes are divided evenly between the traffic directions starting from the outside of the carriageway on both sides and the imaginary separation between traffic directions is on the border between the even number of lanes N/2;
- If the total number of lanes N is odd, the lanes are divided evenly between traffic direction starting from the outside of the carriageway on both sides and the remaining middle lane is assigned to both traffic directions as innermost lane.

Details: RS_FEA_440

Tested by:

Requirement **RS_BSP_574**

The lane information shall be provided with regards to the lane layout of the road segment at the related reference position.

Details: RS_FEA_440

Tested by:

Requirement **RS_BSP_575**

The road segments shall be determined according to the ADASIS approach as defined in clause 3.4.5.10 of [ADASIS AISBL]:

‘An ADASIS v3 Horizon Provider shall start a new Lane Model entry when the number of lanes or a lane property changes. A road segment is cut and a new Lane Model entry is started in the following situations:

- Lane connectivity changes, e.g., at an intersection, when a lane starts anew or a lane starts forming or a lane ends or a lane ends merging into another lane;
- Physical divider or lane boundary between lanes starts or ends;
- One of the lane boundary type changes.’

Note: An ‘ADASIS v3 Horizon Provider’ is the component that translates the underlying map data into the ADASIS format and broadcast it via in-vehicle networks to other components. A ‘Lane Model’ is the ADASIS representation of a lane with various attributes.

Details: RS_FEA_440

Tested by:

Requirement **RS_BSP_576**

The lane information for a position in the corresponding road segment shall be derived from map data (e.g., ADASIS) according to the following transformation algorithm:

1) Select the segment where the ego vehicle is currently driving on, by mapping the ego/reference position contained in the C-ITS Message (CAM, DENM, etc.) to the map. Exit here, if the semi-major axis length of the actual positioning accuracy ellipsis (at 95 %) is greater than 3 m;
2) Select all lanes of this segment that follows the ego's driving direction
    a. Note: this includes lanes exclusively used by one direction as well as lanes that are shared / used together with the opposite driving direction;
3) If the segment has objects of type 'fence', 'wall', 'guardrail', 'curb' or a lane marking of type 'shaded area' in between the selected lanes: Select a subset that:
    a. Contains the lane where the ego is driving on;
    b. Contains all adjacent lanes between the two closest borders. Note: a border is: either the road boarder, the opposite driving direction or a 'fence', 'wall', 'guardrail', 'curb' or a lane marking of type 'shaded area' and
    c. Continue with the selected subset of lanes. If the lane is derived directly from an absolute position and the subset consists of only one lane whose width is less than the actual lateral positioning accuracy (at 95 %), then exit (i.e., no lane information can be provided);
4) If the outer most lane is a hard shoulder assign ETSI LanePosition 14 to it (within ADASIS those lanes are describes as 'RestrictedForbidden' or 'DrivableShoulder');
5) If the inner most lane is a hard shoulder assign ETSI LanePosition 0 to it (within ADASIS those lanes are describes as 'RestrictedForbidden' or 'DrivableShoulder');
6) Initialize a counter ETSICounter with 1;
7) For all remaining lanes without an ETSI LanePosition:
    a. Take the inner most lane (with the highest ADASIS lane number) that has not been processed yet; assign the value of ETSICounter as ETSI LanePosition to it and
    b. Increment ETSICounter; Repeat step 7 for all remaining lanes;
8) Put the ETSI lane position of the currently used lane of the ego vehicle into the component LanePosition;

Where another source than ADASIS is used, the algorithm may be adapted accordingly but the implementer shall ensure that the adoption delivers to the same results.

Details: RS_FEA_440

Tested by:

Requirement **RS_BSP_577**

A vehicle C-ITS station that drives on a lane that is exclusively used by the opposite driving direction and the ability to detect it should not add lane information to its generated CAMs (e.g., during overtaking or ghost driving).

Note: This requirement is not needed in ETSI release 2 as more encoding options are available.

Details: RS_FEA_440

Tested by:

6.3 System behaviour

Requirement (#i) **RS_BSP_214**

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

<cycle>

The vehicle C-ITS station shall operate the Cooperative Awareness Service only if the status of the C-ITS station is ‘cycle in use’ as defined in RS_BSP_580. Cooperative Awareness Service may continue to operate as long as DENMs are being sent.

</cycle>

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

Note: Trailers might also send messages (CAM, DENM etc.) according to their abilities when towed.

<cycle>

Note: Cycle lane is also included in public roads.

Note: The objective is that in vehicle C-ITS stations mounted on cycles CAMs are not sent if the cycle is moved by other means, than pushing or riding, such as via car, ferry or train.

Note: Explicitly deactivated includes that the C-ITS station is not supplied with power anymore or it is heavily damaged.

</cycle>

Details:

Tested by:

Requirement (#i) (#cycle) **RS_BSP_580**

As visualized in Figure 2, the vehicle C-ITS station mounted on a cycle shall transition to the ‘cycle in use’ state from the ‘cycle not in use’ state if the cycle has been used (in accordance to RS_BSP_579) for at least *pCycleInUseDetectionDuration*. It shall transition from the ‘cycle in use’ state to the ‘cycle not in use’ state if no ‘cycle in use’ (in accordance to RS_BSP_579) was detected in the last *pCycleInUseTimeout*. If it is explicitly detected that the cycle is not used, the C-ITS station shall directly transition to ‘cycle not in use’ state from the ‘cycle in use’ state.

Note: A suitable method for detecting the usage may be e.g., cross-validate the GNSS and the wheel tick movement or recognize IMU patterns.

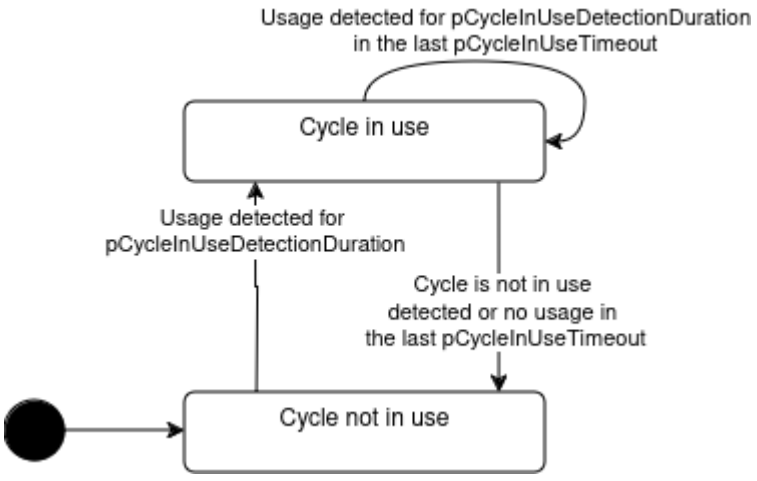

Figure 2: Cycle in use states

Details:

Tested by:

Requirement (#i) **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 (#i) **RS_BSP_501**

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

Details:

Tested by:

Requirement (#i) **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 vehicle C-ITS station 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 (#i) **RS_BSP_531**

The vehicle C-ITS station 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 (#i) **RS_BSP_433**

The vehicle C-ITS station’s access layer shall be compliant to [EN 302 571].

Details:

Tested by:

Requirement (#i) **RS_BSP_226**

The nominal RF output power shall be within the range of 17 dBm (e.i.r.p.) to 33 dBm (e.i.r.p.). The target nominal RF output power is 23 dBm (e.i.r.p.).

Note: Adjustable RF output power is required by RS_BSP_433, RS_BSP_245, RS_BSP_246.

Note: The maximum RF output power is specified by [EN 302 571].

Note: The maximum allowed total transmit power (mean e.i.r.p.) is 33 dBm with a transmit power control (TPC) range of at least 30 dB (see also: [ECID 2020/1426]).

Details:

Tested by:

Requirement (#i) (#a) **RS_BSP_225**

The vehicle C-ITS station shall use the Service Channel 0 (G5-SCH0) according to RS_BSP_545 to send messages to support Cooperative Awareness Basic Service and the priority C-ITS services in [C2CCC tc Docs].

Details:

Tested by:

Requirement (#i) (#a) **RS_BSP_434**

The vehicle C-ITS station's access layer shall be compliant with [EN 302 663].

If this is not possible, the vehicle C-ITS station's access layer shall be compliant with version 1.2.1 of [EN 302 663], in this case LLC SNAP shall be used.

Note: C-ITS stations implementing previous C2C-CC releases use LLC SNAP and do not use EtherType Protocol Discrimination (EPD) as it is stated in clause 4.3.3 of [EN 302 663] 'Logical link control'.

Details:

Tested by:

Requirement (#i) (#a) **RS_BSP_228**

The vehicle C-ITS station shall use a default transfer rate of *pAlDataRateSch0* on the G5-SCH0.

Details:

Tested by:

Other (informational) (#a) **RS_BSP_397**

According to [EN 302 663] the vehicle C-ITS station supports the *pAlDataRateSch0Low* and *pAlDataRateSch0High* transfer rates in addition to *pAlDataRateSch0*.

Note: See also RS_BSP 434 on [EN 302 663].

Requirement (#i) (#a) **RS_BSP_235**

The vehicle C-ITS station 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 vehicle C-ITS station 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 clause 8 of [TS 102 636-4-2].

The vehicle C-ITS station 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) and enhanced distributed channel access (EDCA) queue with specific transmission parameters (see [EN 302 663] Annex C.4.4).

Details:

Tested by:

Requirement (#i) (#a) **RS_BSP_436**

The vehicle C-ITS station's DCC mechanism shall comply with [TS 102 687].

Details:

Tested by:

Requirement (#i) (#a) **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 (#i) (#a) **RS_BSP_240**

The following smoothing function of Channel Busy Ratio (CBR) values shall be performed if the vehicle C-ITS station 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 vehicle C-ITS station 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 vehicle C-ITS station shall, at a minimum, be able to 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, the value shall be increased by the minimum required DENM generation rate derived from those triggering conditions.

Details:

Tested by:

Requirement (#a) **RS_BSP_245**

The vehicle C-ITS station 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 (#i) (#a) **RS_BSP_246**

The vehicle C-ITS station shall reduce its transmission power to at most *pDccMaxPToll* 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 (#i) **RS_BSP_458**

Where the vehicle C-ITS station 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 vehicle C-ITS station 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 (#i) **RS_BSP_459**

Where the vehicle C-ITS station 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 vehicle C-ITS station shall generate CAMs in accordance with clause 5.5.1 of [TS 102 792].

Details:

Tested by:

Requirement (#i) **RS_BSP_460**

Where the vehicle C-ITS station 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 C-ITS station should mitigate each time to the nearest tolling station centre position. Where several positions are given in the same area, the mobile C-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 (#i) **RS_BSP_437**

The vehicle C-ITS station's media-independent part of GeoNetworking (GN) shall be compliant with [EN 302 636-4-1].

Details:

Tested by:

Requirement (#i) **RS_BSP_250**

All default constants and parameters of the vehicle C-ITS station 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 (#i) **RS_BSP_251**

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

Details:

Tested by:

Requirement (#i) **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 vehicle C-ITS station may omit forwarding of a packet if the distance between its own location and the centre of the destination area exceeds *pGnMaxAcceptDistance*.

Details:

Tested by:

Requirement **RS_BSP_416**

For all GN packets that a vehicle C-ITS station originates, the optional parameter 'Repetition interval' shall not be set (i.e. shall be absent) in the GN-DATA.request of [EN 302 636-4-1].

Note: This implies that 'maximum repetition time' is not set neither.

Note: This implies that packet repetition is not performed at GN layer 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] are not executed.

Details:

Tested by:

Requirement (#i) **RS_BSP_414**

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

Details:

Tested by:

Requirement (#i) **RS_BSP_256**

The vehicle C-ITS station 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 (#i) **RS_BSP_257**

The vehicle C-ITS station 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 vehicle C-ITS station 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 vehicle C-ITS station shall set the LifeTime field of all GBC packets to the minimum value of ValidityDuration and RepetitionDuration, where ValidityDuration and RepetitionDuration 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_541**

If the vehicle C-ITS station is outside of the geographical area, defined in the GBC header, the GN-PDU may be passed to the upper protocol entity.

Details:
Tested by:

Requirement **RS_BSP_260**

The vehicle C-ITS station shall set the store-carry-forward (SCF) bit of the TC field of GBC packets to *pGnGbcScf*.

Note: The SCF mechanism of [EN 302 636-4-1] is considered to have some undesirable side effects. An activation of the feature might be evaluated if the standard is revised accordingly.

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 vehicle C-ITS station is not required to offload packets to another channel.

Details:
Tested by:

Requirement **RS_BSP_264**

The vehicle C-ITS station shall set the itsGnIsMobile bit of the Flags field to *pGnIsMobile*.

Details:
Tested by:

Requirement **RS_BSP_265**

The vehicle C-ITS station may set the optional GN-DATA.request parameter ‘Maximum hop limit’ for GBC packets as follows:

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

For circular destination areas with higher radius, Maximum hop limit is increased by one for any additional 250 m radius length.

Note: If that parameter is not set, the default itsGnDefaultHopLimit 10 automatically applies.

Details:

Tested by:

Requirement (#i) **RS_BSP_266**

The vehicle C-ITS station shall support multi-hop operation mode by implementing Contention-Based Forwarding (CBF) for Area and Non-Area Forwarding as detailed in Annexes D, E.3 and F.3 to [EN 302 636-4-1].

Consequently, both itsGnNonAreaForwardingAlgorithm and itsGnAreaForwardingAlgorithm shall be set to CBF (2).

Note: In [EN 302 636-4-1] Annex H, as referenced by RS_BSP_250, CBF is the default for itsGnAreaForwardingAlgorithm, but the default for itsGnNonAreaForwardingAlgorithm is GREEDY, which should not be used.

Details:

Tested by:

Requirement (#a) **RS_BSP_267**

The vehicle C-ITS station 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 vehicle C-ITS station 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 (#i) (#a) **RS_BSP_270**

All GN frames sent by the vehicle C-ITS station 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 (#i) **RS_BSP_438**

The vehicle C-ITS station's Basic Transport Protocol (BTP) shall be compliant with [EN 302 636-5-1].

Details:

Tested by:

Requirement (#i) **RS_BSP_273**

The vehicle C-ITS station shall employ BTP-B headers. Consequently, the GN common header shall use a value of *pGnBtpNh* for the NH field.

Details:

Tested by:

Requirement (#i) **RS_BSP_274**

The vehicle C-ITS station shall set the destination port info field to the value *pBtpDestPortInfo*.

Details:

Tested by:

Requirement (#i) **RS_BSP_275**

In the BTP-B header, the vehicle C-ITS station shall set the destination port to the value *pBtpCamPort* for CAMs.

Details:

Tested by:

Requirement (#i) **RS_BSP_276**

In the BTP-B header, the vehicle C-ITS station shall set the destination port to the value *pBtpDenmPort* for DENMs.

Details:

Tested by:

Requirement **RS_BSP_279**

The vehicle C-ITS station 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 (#i) **RS_BSP_280**

Where a vehicle C-ITS station 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 centre 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

6.6.1 Common

Requirement (#i) **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 (#i) **RS_BSP_537**

For all GN packets, a vehicle C-ITS station 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_447**

The vehicle C-ITS station 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:

6.6.2 Cooperative Awareness

Requirement (#i) **RS_BSP_439**

The vehicle C-ITS station’s Cooperative Awareness (CA) basic service shall be compliant with [EN 302 637-2].

Details:
Tested by:

Requirement (#i) **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 start-up 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 (#i) **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 (#i) **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 (#i) **RS_BSP_288**

Where the vehicle C-ITS station 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 (#i) **RS_BSP_289**

Where the vehicle C-ITS station 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 (#i) **RS_BSP_291**

A vehicle C-ITS station 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 (#i) **RS_BSP_292**

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

Details:

Tested by:

Requirement (#i) (#a) **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 (#i) **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 vehicle C-ITS station.

Details:

Tested by:

Requirement (#i) **RS_BSP_321**

The vehicle C-ITS station shall use a coordinate system compliant with clause 2.13 of [ISO 8855] ‘intermediate axis system’ to express LongitudinalAcceleration, LateralAcceleration, VerticalAcceleration and YawRate.

<ptw>

The vehicle C-ITS station shall set:

- the YawRateValue and YawRateConfidence to unavailable.
- the values for LongitudinalAcceleration and LateralAcceleration to zero and latched if the PTW is stationary and unlatched when it is not stationary anymore.

</ptw>

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.

Note: This is a deviation from the reference coordinate system specified in RS_BSP_191.

Details:

Tested by:

Requirement (#i) **RS_BSP_588**

The vehicle C-ITS station shall set the *value* of *Curvature* and *CurvatureCalculationMode* in accordance with [TS 102 894-2].

<ptw>

The If *curvatureValue* is set to unavailable, then also *curvatureConfidence* and the *CurvatureCalculationMode* shall be set to *unavailable*.

</ptw>

Details:

Tested by:

6.6.3 Decentralized Notification

Requirement (#i) **RS_BSP_440**

The vehicle C-ITS station's Decentralised Environmental Notification (DEN) basic service shall be compliant with [EN 302 637-3].

Details:

Tested by:

Other (informational) **RS_BSP_547**

This Release references normatively to the DEN basic service Release 1 Norm [EN 302 637-3].

The Release 2 edition of the DEN service Norm [TS 103 831] clarifies many aspects related to the usage of DENMs for V2V and I2V transmission and is suggested for clarification and further reading. The table below provides a translation between terms and message components names from both releases.

DENM Release 1 Term or message components name (from [EN 302 637-3] 1.3.1)	**DENM Release 2 Term or message components name (from [TS 103 831] V2.1.1)**
DENM relevance area	Awareness area
relevanceDistance	*awarenessDistance*
relevanceTrafficDirection	*awarenessTrafficDirection*
eventHistory	*eventZone*

Note: [TS 103 831] also refers to [TS 102 894-2] V2.1.1.

Requirement (#i) **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 (#i) **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 (#i) **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 (#i) **RS_BSP_304**

A vehicle C-ITS station 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 (#i) **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 (#i) **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 (#i) **RS_BSP_307**

Where the vehicle C-ITS station 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 (#i) **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 (#i) **RS_BSP_315**

For the priority C-ITS services, the vehicle C-ITS station 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_536**

'Keep alive forwarding' as described in clause 6.1.4.2 of [EN 302 637-3] 'DENM standard' 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 vehicle C-ITS station, the stationID shall be set to the station ID of the forwarding vehicle C-ITS station, 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 (#i) **RS_BSP_318**

The traces and path histories used by the vehicle C-ITS station shall be generated using Design Method One, as specified in Appendix A.5 to [SAE J2945/1]. The vehicle C-ITS station 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:

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

While being stationary according to RS_BSP_511, the position input shall not be updated, so that no additional Path Points are added.

Details:

Tested by:

Requirement **RS_BSP_544**

If the specific DENM use case requires the inclusion of the *eventHistory* in the updated DENM, the *eventHistory* shall be set in the following way:

At the moment the application issues the DENM update request to the DEN basic service with updated DENM *eventPosition* and *detectionTime* data elements:

- If an *eventHistory* was not yet included in the currently transmitted DENM, a new *eventHistory* shall be created with an *eventPoint* representing the current DENM *eventPosition* and *detectionTime* fields (and calculated based on the *eventPosition* and *detectionTime* of the updated DENM data elements) (see Figure 3 (b))
- Else (i.e., if an *eventHistory* is already included in the currently transmitted DENM), the following conditions shall be considered:

  (a) the difference between current time and the timestamp given by *eventDeltaTime* of the most recent *eventPoint* in the *eventHistory* does exceed the threshold *pDenmEventHistoryGenMaxDeltaTime*

(b) the distance from current position to the position of the most recent *eventPoint* in the *eventHistory* does exceed the threshold *pDenmEventHistoryGenMaxDeltaDistance* (see Figure 3 (e) and Figure 3 (f))

(c) the difference between current heading and the heading at the most recent *eventPoint* in the eventHistory does exceed the threshold *pDenmEventHistoryGenMaxDeltaHeading* (see Figure 3 (g) and Figure 3 (h))

(d) the difference between current heading and the *eventPositionHeading* of the currently transmitted DENM exceeds the threshold *pDenmEventHistoryGenMaxDeltaHeading*

- If at least one of the conditions (a), (b), (c), or (d) is fulfilled, a new *eventPoint* shall be added to the *eventHistory*. This *evenPoint* shall represent the current DENM *eventPosition*, *detectionTime* and *informationQuality* fields (and calculated based on the *eventPosition* and *detectionTime* of the updated DENM data elements)
- Else (i.e. if none of the conditions (a), (b), (c), nor (d) is fulfilled), the *eventPosition*, *eventDeltaTime* and *informationQuality* information of the most recent *eventPoint* in the *eventHistory* shall be updated and calculated based on the *eventPosition* and *detectionTime* of the updated DENM data elements (see Figure 2 (c) and Figure 2 (d)).

In all cases, an *eventPoint* shall be deleted from the *eventHistory* if its age would exceed the *validityDuration* of the DENM.

Note: The age of an *eventPoint* can be stored locally by the transmitting station to represent the time passed from the first instant the event was detected at that point

In all cases:

- the *eventPoint*s shall be ordered in the *eventHistory* in ascending order with respect to their age, with the most recent *eventPoint* in first position and
- if the maximum number of points in the *eventHistory* would be exceeded, the oldest *eventPoint* shall be deleted

Note: according to the rules described above, event history points are generated and updated in order to map, as reliably as possible, the shape of the road where the event has been detected (event area in Figure 3). Event history points get located at the entry and exit borders of the event area (Figure 3 (a)and Figure 3 (b)), reflect changes in the road heading, and their distance from each other does not exceed a threshold value. To fulfil these goals while efficiently using the available number of event history points, a DENM update does not necessarily implies creation of a new event history point: a new event history point is created only if strictly needed based on comparisons of the current vehicle position and the most recent event history point (conditions (a), (b), (c) – see Figure 3 (e) and Figure 3 (g)). Since the heading may change into one and then into the other direction, to mitigate this effect, in addition the current vehicle heading is compared with the current DENM event position heading (condition (d), see Figure 3 (c)).

Note: the age of each *eventPoint* can be calculated by the receiving station based on the *eventDeltaTime* values with respect to the updated DENM event *detectionTime*. It is up to the receiver to handle *eventPoint*s with ages that exceed the *validityDuration* after the update DENM has been generated.

Note: Requirement RS_BSP_182 affects the eventHistory.

Note: The ranges allowed by the respective data elements of an eventPoint imply limits to the values selectable for the thresholds *pDenmEventHistoryGenMaxDeltaTime*, *pDenmEventHistoryGenMaxDeltaDistance*, and *pDenmEventHistoryGenMaxDeltaHeading*.

Note: the timestamp, position, and heading of an *eventPoint* in conditions (a), (b), and (c) are not explicitly included in the transmitted DENM's *eventHistory*: the transmitting station may compute and store them locally to assess the conditions.

The Following Figure 3 depicts a sample scenario describing generation and evolution of the *eventHistory* as a vehicle detects and updates an event along an event area. The subsequent situations composing the scenario are reported in chronological order.

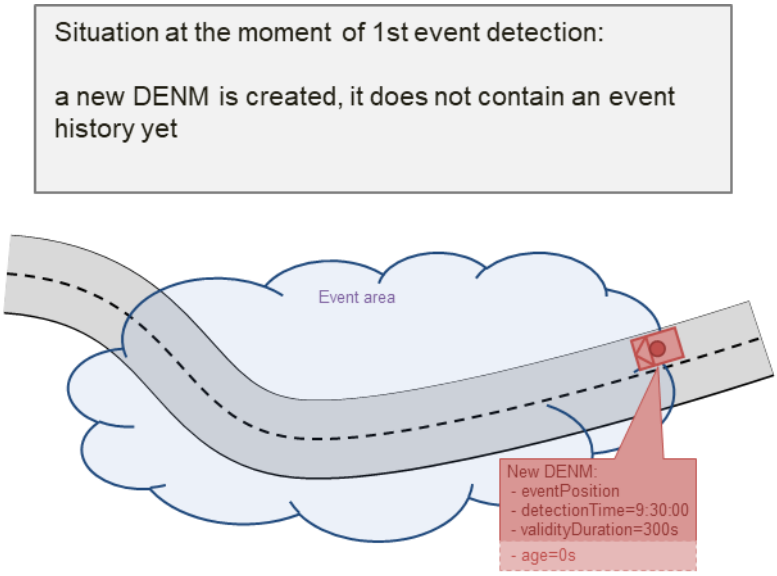

Figure 3 (a)

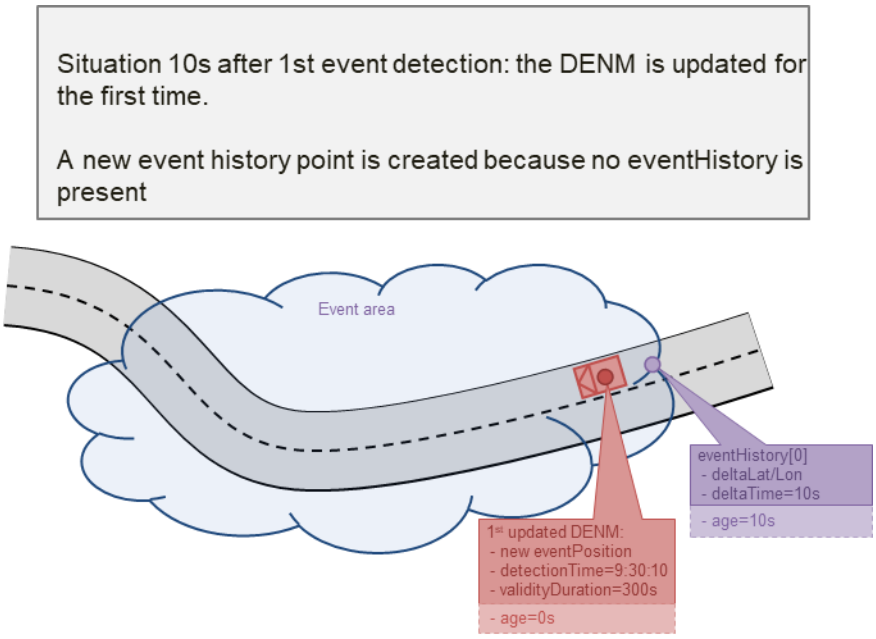

Figure 3 (b)

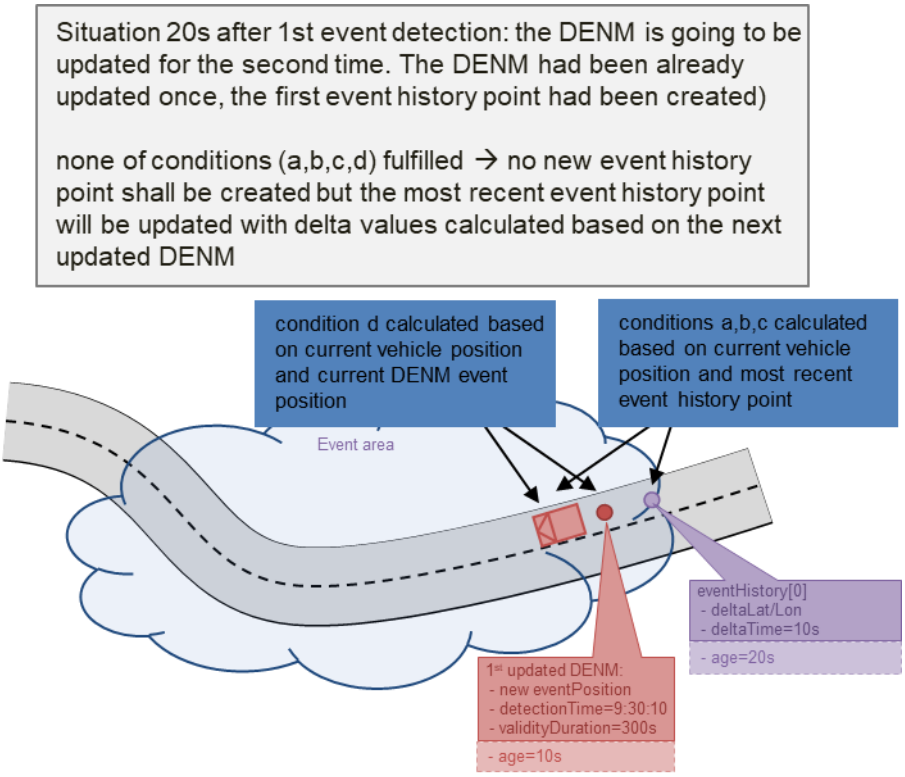

Figure 3 (c)

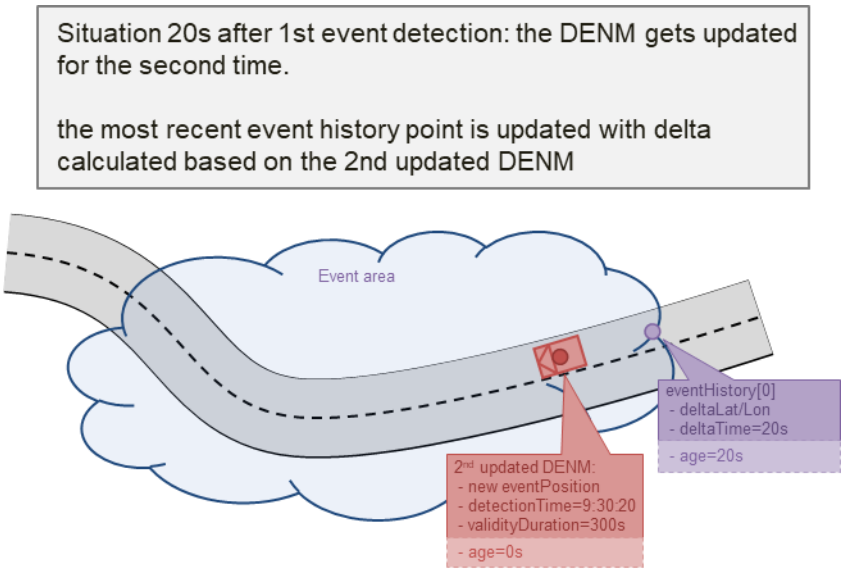

Figure 3 (d)

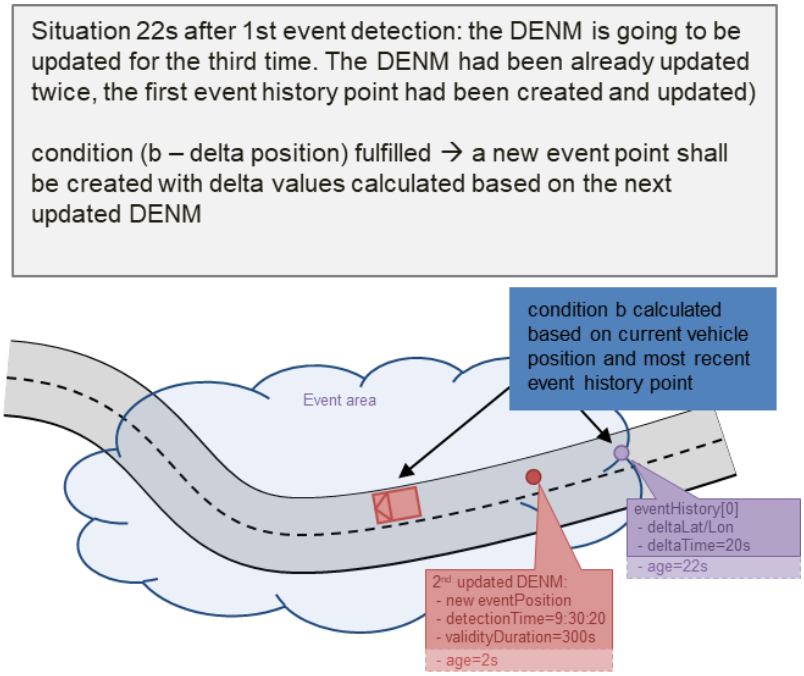

Figure 3 (e)

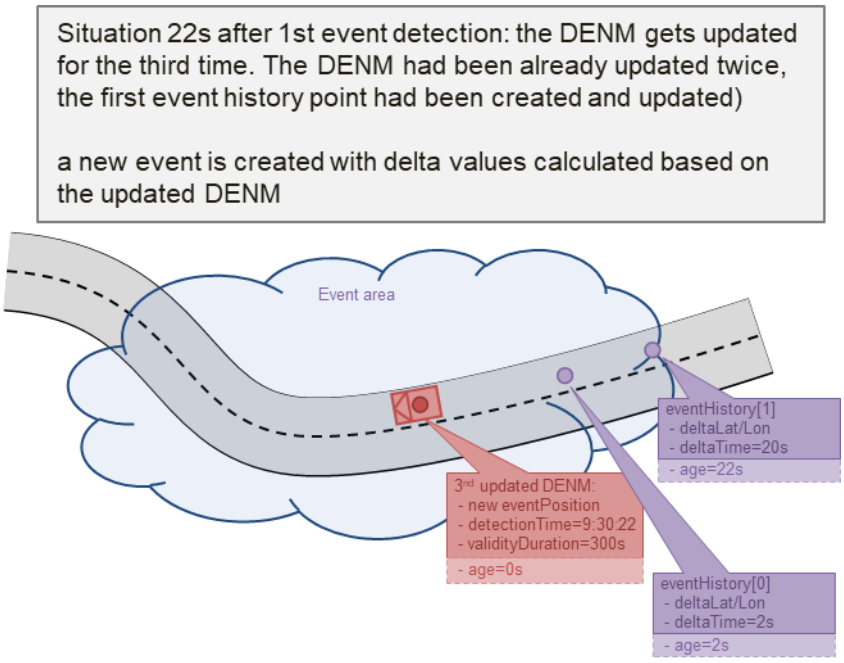

Figure 3 (f)

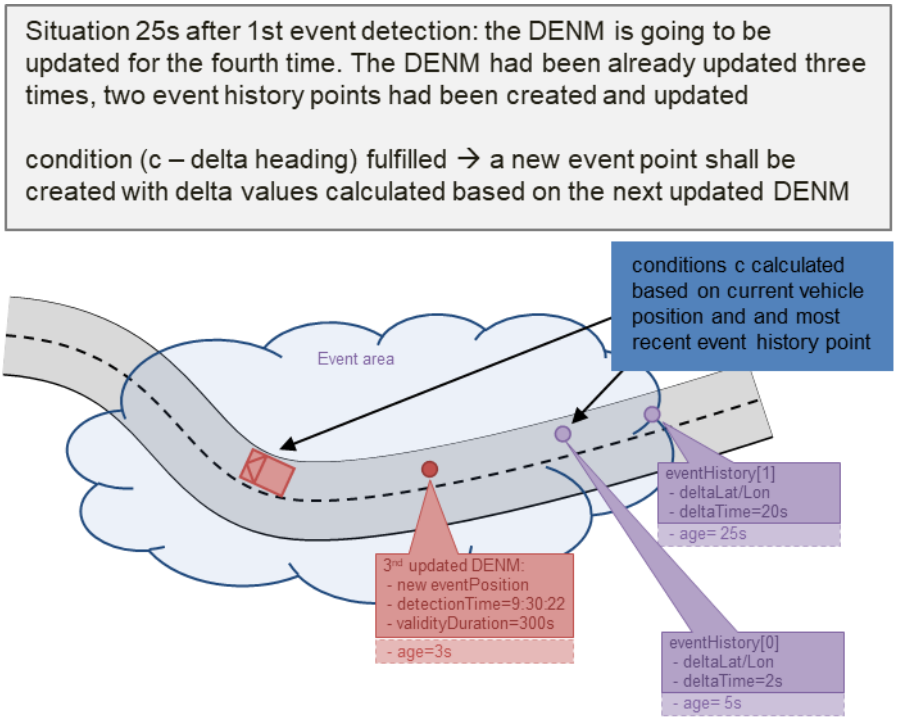

Figure 3 (g)

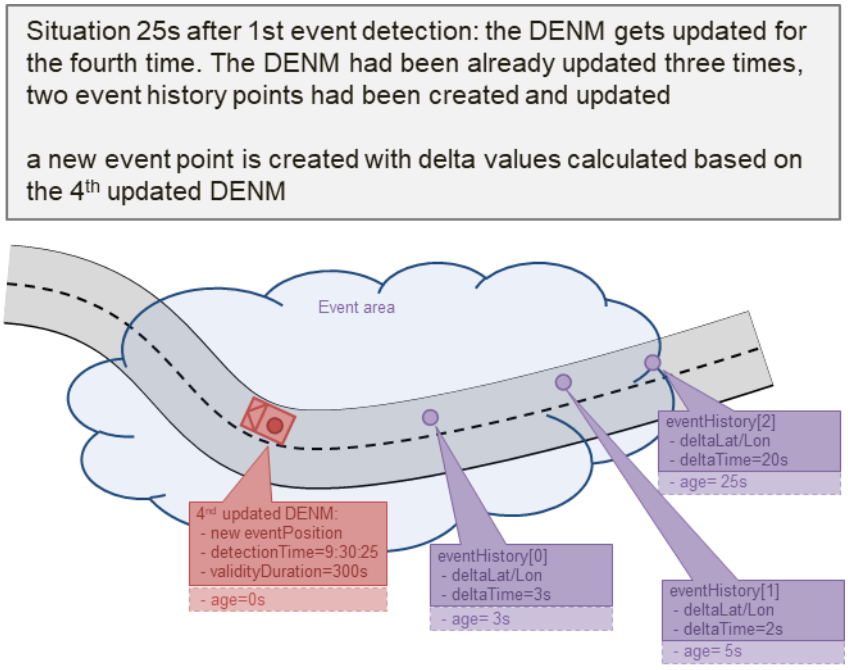

Figure 3 (h) - Generation and evolution of *eventHistory* along an event area

Details:

Tested by:

Other (informational) **RS_BSP_582**

The implementer should mandatorily interpret the DENM CC and optionally (if known to the implementation) the SCCs, as further SCC might be added in the future, which would then be unknown to earlier implementations.

Details:
Tested by:

6.7 Hardware related requirements

Requirement (#i) **RS_BSP_538**

If a C-ITS service requires information about the vehicle being stationary, the vehicle C-ITS shall be able to detect that the host vehicle is stationary in the sense of RS_BSP_511, under regular driving dynamics according to RS_BSP_449. The detection mechanism shall include sensors other than GNSS, e.g., wheel ticks.

Confidence information shall stay available (according to RS_BSP_535) while the vehicle is stationary for at least 6 min.

Note: This includes scenarios with up to 100 % sky obstruction.

<cycle>

Note: Standstill condition is currently not relevant for/not in scope of cycle use cases.

</cycle>

Details:
Tested by:

Requirement (#i) **RS_BSP_202**

The 95 % confidence information (see RS_BSP_429) 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 vehicle C-ITS station 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 information 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 information 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 (#i) **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 values of 5 m) AND
- (vertical position confidence value 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.

Note: Horizontal position confidence values are both (semi-major and semi-minor axes of the ellipse) required to be less than or equal to 5 m.

Details:

Tested by:

Requirement (#i) **RS_BSP_209**

A vehicle C-ITS station 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 ‘C’ 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 information is correct, 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, e.g., inside a tunnel; GNSS signal reflection at start and optionally at the end of the scenario. This scenario only applies for the first 250 m, or, in case it takes more than 30 s to drive the first 250 m, for the first 30 s.	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 being stationary for 30 min	as S1	as S1	C <= 0.3 m/s	any value allowed, typically *outOfRange* according to RS_BSP_4444
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	Reverse driving for at least 30 s, exceeding 1,4 m/s for at least 20 s in total, after forward driving and then being stationary for not more than 60 s.	as S1	as S1	as S1	as S1

Details:

Tested by:

Requirement (#i) **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;

<ptw>

- These values are applicable exclusively when the PTW is traveling straight without any leaning.

</ptw>

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 (#i) **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;

<ptw>

- These values are applicable exclusively when the PTW is traveling straight without any leaning.

</ptw>

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: