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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document contains specifications of interoperability test descriptions to validate implementations of ETSI TS 103 324 [1].

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found in the ETSI docbox.

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The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 103 324 (V2.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Collective Perception Service; Release 2".

[2] ETSI TS 103 141 (V2.2.1): "Intelligent Transport Systems (ITS); Facilities layer function; Multi-Channel Operation (MCO) for Cooperative ITS (C-ITS); Release 2".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

Not applicable.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 103 324 [1] apply.

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI TS 103 324 [1] apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 103 324 [1] and the following apply:

EUT	Equipment Under Test
QE	Qualified Equipment
UC	Use Case

4 Requirements and configuration

4.1 Requirements

4.1.1 Overview

The clauses 4.1.2, 4.1.3 and 4.1.4 define mandatory and optional requirements for the implementation of the ITS-S in the role of the Equipment Under Test (EUT) and in the role of the Qualified Equipment (QE) and the network sniffer.

4.1.2 Equipment under test

The EUT in the CPS interoperability tests is an ITS-S with the following mandatory requirements:

- The EUT shall be able to send and receive CPMs as defined in ETSI TS 103 324 [1].
- The EUT's parameters as defined in ETSI TS 103 324 [1] shall be configurable by the test operator.

The EUT shall be checked if it behaves accordingly to the CPS standard ETSI TS 103 324 [1] and is interoperable with other ITS-S that have deployed the CPS.

4.1.3 Qualified equipment

The QE in the CPS interoperability tests is an ITS-S with the following mandatory requirements:

- The QE shall be able to send and receive CPMs as defined in ETSI TS 103 324 [1].
- The QE is verified to fulfil the interoperability test specification.
- The QE's parameters as defined in ETSI TS 103 324 [1] shall be configurable by the test operator.

The QE shall stimulate the EUT to change its state.

NOTE 1: The QE could be an emulated ITS-S. This reduces the overall effort in interoperability testing. Contrary to its real counterpart, an emulated device is not a physical ITS-S (such as a motorcycle or pedestrian with communication hardware), but a software which also sends CPMs which are received by the non-emulated ITS-S.

NOTE 2: In case of multiple QE in a single test case, the QE will be numbers like QE 1, QE 2, etc.

4.1.4 Network sniffer

To validate the behaviour of the EUT in certain test cases it is necessary to observe the sent and received CPMs. To enable this observation a network sniffer is required. The network sniffer does not participate actively in the communication.

Mandatory requirements:

- The Network sniffer shall be able to receive and decode CPMs as defined in ETSI TS 103 324 [1].
- The Network sniffer shall be able to support MCO as defined in ETSI TS 103 141 [2].

- The Network sniffer shall present the sniffed messages' contents to the operator in human-readable form.

NOTE: Network sniffer equipment required where there is no output on EUT's HMI.

4.2 Configurations

4.2.1 MCO configuration

Some use cases test the ability of the CPS to reduce the channel load with MCO features, as specified in ETSI TS 103 141 [2]. The following conditions shall be met to enable these tests:

- The EUT supports MCO.
- The channel shall provide a load which is defined in the corresponding use case.

NOTE: The channel load can be realized by an emulated ITS-S as described in clause 4.1.3.

4.2.2 Load Generation

To increase the CBR in the tests it is necessary to generate load on the channel. A load generator could be used to realize this load. The load generator has the following mandatory requirements:

- The load generator shall fill the channel with V2X messages which are compliant to V2X messages.
- The load generator shall encode the V2X messages with the corresponding access layer technology used in the tests.
- The load generator shall be able to increase the CBR as it would be done by N-independent ITS-S.

Alternatively, the ITS-S shall be configurable to obey the number of available resources provided, e. g. as defined in clause 5.2 of ETSI TS 103 141 [2].

4.2.3 ITS-S Type Configuration

Some use cases require the EUT to be a specific ITS-S type as the sender of the CPM. The following conditions shall be met to enable the *vehicle type* tests:

- the EUT corresponds to a Sender_ITS-S_type = vehicle;
- its heading is 35° in the WGS84 coordinate system with respect to true North;

the following conditions shall be met to enable the *trailer type* tests:

- the EUT corresponds to a Sender_ITS-S_type = trailer;
- the towing vehicle heading is 35° in the WGS84 coordinate system with respect to true North;
- the trailer's hitch point and hitch angle shall be 10 m and 310°, respectively;

and following conditions shall be met to enable the *RSU type* tests:

- EUT corresponds to a Sender_ITS-S_type = RSU;
- the reference position is selected as the actual position of EUT.

5 Requirements to be tested

5.1 Overview

The clauses below collect and enumerate the requirements that can be tested with the present interoperability test specification.

5.2 CPM interoperability requirements

Table 1

NN	Requirement	Reference	UCs
1.1	ITS-S shall encode and decode CPMs with all mandatory and optional DFs.	ETSI TS 103 324 [1]	UC1-1
1.2	ITS-S shall reconstruct received sensor information's.	ETSI TS 103 324 [1]	UC1-2
1.3	ITS-S shall reconstruct received perception regions.	ETSI TS 103 324 [1]	UC1-2 UC1-3
1.4	ITS-S shall reconstruct a received objects kinematics and attitude states.	ETSI TS 103 324 [1]	UC1-4
1.5	ITS-S shall distinguish the message assembly configuration.	ETSI TS 103 324 [1]	UC1-5
1.6	ITS-S shall correctly reconstruct the correlation matrices.	ETSI TS 103 324 [1]	UC1-6
1.7	ITS-S shall correctly interpret non-line-of-sight conditions.	ETSI TS 103 324 [1]	UC1-7
1.8	ITS-S shall reduce the number of used resources if it supports MCO and the conditions are met.	ETSI TS 103 324 [1], clause 6.1.2.1	UC1-8 UC1-9
1.9	ITS-S shall omit perceived objects with the lowest value of information if it supports MCO and the conditions are met.	ETSI TS 103 324 [1], clause 6.1.2.3	UC1-8
1.10	ITS-S shall offload objects to another channel if it supports MCO and the conditions are met.	ETSI TS 103 324 [1], clause 6.1.2.3	UC1-9

6 Interoperability test descriptions

6.1 Use-case 1-1 General CPM handling

Interoperability Test Description			
Identifier:	TC_ITS_CPS_UC1-1		
Objective:	Check that EUT can correctly encode and decode the CPM with all allowed DEs and DFs.		
Configuration:	EUT1 shall be capable of transmitting CPMs as specified in ETSI TS 103 324 [1] with all allowed DEs and DFs. EUT2 shall be capable of receiving and decoding CPMs as specified in ETSI TS 103 324 [1] with all allowed DEs and DFs. Both EUTs are configured to use the same communication channel for the transmission and reception of CPMs. The load of the communication channel shall be below 10 % CBR. EUT1 and EUT2 shall be positioned at a distance of less than 100 m in direct line of sight conditions.		
Pre-test conditions:	Neither EUT1, EUT2 nor any other ITS-S transmits CPMs.		
REQ /PICS	**Tested Requirements**	**PICS**	
	1.1		
Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	EUT1 transmits CPMs periodically with a generation event periodicity of T_GenCpm = 100 ms, using all available message fields in each generated CPM.	
2	Verify (by Receiver)	EUT2 receives the CPMs transmitted by EUT1	EUT2 forwards the decoded CPM to IF.APP or IF.CPM. All data fields of the decoded CPM are equal to the corresponding data fields in the encoded CPM by EUT1.
NOTE: EUT1 may fill the data fields with meaningful or random data, as long as the allowed ranges are obeyed. This includes *segmentationInfo* and *messageRateRange*, in the *ManagementContainer, pitchAngle, rollAngle* and *trailerDataSet* in the *OriginatingVehicleContainer* (needed only for ITS-S_Type = Vehicle or Trailer), *mapReference* in the *OriginatingRsuContainer* (needed only for ITS-S_Type = RSU), instances of *SensorInformation* each described by another *perceptionRegionShape* in the *SensorInformationContainer*, instances of *PerceptionRegion* each described by another *perceptionRegionShape, sensorIdList* and *numberOfPerceivedObjects* or p*erceivedObjectIds* in the *PerceptionRegionContainer*, and instances of *PerceivedObject* of different *ObjectClassificationDescription*, including the entire kinematic and attitude state vector with variances and correlations, as well as *mapPosition* (for PICS=RSU).			

6.2 Use-case 1-2 Sensor information handling

Interoperability Test Description	
Identifier:	TC_ITS_CPS_UC1-2
Objective:	Check that EUT2 can correctly reconstruct the sensor information transmitted by EUT1.
Configuration:	EUT1 shall be capable of transmitting CPMs as specified in ETSI TS 103 324 [1]. EUT2 shall be capable of receiving and decoding CPMs as specified in ETSI TS 103 324 [1]. Both EUTs are configured to use the same communication channel for the transmission and reception of CPMs. The load of the communication channel shall be below 10 % CBR. EUT1 and EUT2 shall be positioned at a distance of less than 100 m in direct line of sight conditions. If EUT1 is connected to sensors, it shall use the corresponding information to generate CPMs. If EUT1 is not connected to sensors, it shall use the following sensor information when generating CPMs: • Sensor information 1: – sensorType = radar (1) – perceptionRegionShape = radial – shapeReferencePoint.xCoordinate = -350 – shapeReferencePoint.yCoordinate = 150 – shapeReferencePoint.zCoordinate = 50 – range = 180 – horizontalOpeningAngleStart = 3300 – horizontalOpeningAngleEnd = 600 – verticalOpeningAngleStart = 3400 – verticalOpeningAngleEnd = 400 – perceptionRegionConfidence = 100 – shadowingApplies = false • Sensor information 2: – sensorType = lidar (2) – perceptionRegionShape = circle – shapeReferencePoint.xCoordinate = -150 – shapeReferencePoint.yCoordinate = 0 – shapeReferencePoint.zCoordinate = 150 – radius = 150 – height = 70 – perceptionRegionConfidence = 100 – shadowingApplies = false • Sensor information 3: – sensorType = localaggregation(12) – perceptionRegionShape = polygon – shapeReferencePoint.xCoordinate = 0 – shapeReferencePoint.yCoordinate = - 150 – shapeReferencePoint.zCoordinate = 50 – P1.CartesianPosition3d.xCoordinate = -10000 – P1.CartesianPosition3d.yCoordinate = -15000 – P1.CartesianPosition3d.zCoordinate = 500 – P2.CartesianPosition3d.xCoordinate = -8000 – P2.CartesianPosition3d.yCoordinate = 15000 – P2.CartesianPosition3d.zCoordinate = 500 – P3.CartesianPosition3d.xCoordinate = 13000 – P3.CartesianPosition3d.yCoordinate = 20000 – P3.CartesianPosition3d.zCoordinate = 500 – P4.CartesianPosition3d.xCoordinate = 18000 – P4.CartesianPosition3d.yCoordinate = 18000 – P4.CartesianPosition3d.zCoordinate = 500 – height = 150 – perceptionRegionConfidence = 100 – shadowingApplies = false EUT1 shall select the appropriate Sender_ITS-S_type as described in clause 4.2.3. EUT1 shall not include any perceived objects or perception regions in its CPMs. EUT2 shall be able to store the received data in an LDM.

Pre-test conditions:	The channel load sensed by EUT shall be below 10 % CBR. Neither EUT1, EUT2 nor any other ITS-S transmits CPMs.		
REQ /PICS	**Tested Requirements**		**PICS**
	1.2		
Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	EUT1 starts transmitting CPMs following the generation rules specified in ETSI TS 103 324 [1].	
2	Verify (by Receiver)	EUT2 receives the CPMs transmitted by EUT1 for at least 5 seconds and outputs the obtained data in an LDM.	EUT2 interprets the received sensor information correctly when including it in its LDM.
NOTE: To verify the result, access to the receivers LDM is needed (as data stream, HMI or similar). A comparison with the LDM of EUT1 (if available) or with the described configuration is needed for validation.			

6.3 Use-case 1-3 Perception region handling

Interoperability Test Description			
Identifier:	TC_ITS_CPS_UC1-3		
Objective:	Check that EUT2 can reconstruct the perceived regions transmitted by EUT1 correctly.		
Configuration:	EUT1 shall be capable of transmitting CPMs as specified in ETSI TS 103 324 [1]. EUT2 shall be capable of receiving and decoding CPMs as specified in ETSI TS 103 324 [1]. Both EUTs are configured to use the same communication channel for the transmission and reception of CPMs. The load of the communication channel shall be below 10 % CBR. EUT1 and EUT2 shall be positioned at a distance of less than 100 m in direct line of sight conditions. EUT1 shall include the same sensor information as specified in UC 1-2. EUT1 shall further include perception regions indicating a drop in *perceptionRegionConfidence* by 50 % in the more distant half of each included sensor information. The more distant half is defined by all points of the corresponding sensor information that are further away from the *referencePoint* than half of the distance between the *referencePoint* and the most distant point. The EUT1 has to select one of the described Sender_ITS-S_type from clause 4.2.3. EUT2 shall be able to store the received data in an LDM.		
Pre-test conditions:	The channel load sensed by EUT shall be below 10 % CBR. Neither EUT1, EUT2 nor any other ITS-S transmits CPMs.		
REQ /PICS	**Tested Requirements**		**PICS**
	1.2, 1.3		
Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	EUT1 starts transmitting CPMs following the generation rules specified in [1].	
2	Verify (by Receiver)	EUT2 receives the CPMs transmitted by EUT1 for at least 5 seconds and outputs the obtained data in an LDM.	EUT2 interprets the received data correctly by including it in its LDM.
NOTE 1: To verify the result, access to the receivers LDM is needed (as data stream, HMI or similar). A comparison with the LDM of EUT1 (if available) or with the described configuration is needed for validation. NOTE 2: The implicit definition of the perception regions is chosen to ensure the transmitting EUT1 is able to encode such situations in a way that EUT2 can decode them correctly.			

6.4 Use-case 1-4 Perceived object handling

<table>
<tr><th colspan="5">Interoperability Test Description</th></tr>
<tr><td>Identifier:</td><td colspan="4">TC_ITS_CPS_UC1-4</td></tr>
<tr><td>Objective:</td><td colspan="4">Check that EUT2 can correctly reconstruct the perceived object kinematic and attitude states transmitted by EUT1.</td></tr>
<tr><td>Configuration:</td><td colspan="4">EUT1 shall be capable of transmitting CPMs as specified in ETSI TS 103 324 [1]. EUT2 shall be capable of receiving and decoding CPMs as specified in ETSI TS 103 324 [1].
Both EUTs are configured to use the same communication channel for the transmission and reception of CPMs. The load of the communication channel shall be below 10 % CBR.
EUT1 and EUT2 shall be positioned at a distance of less than 100 m in direct line of sight conditions.
EUT1 shall include the following object in its perceived object list:
• Object 1:
– measurementDeltaTime = 1
– position.xCoordinate.value = 800
– position.xCoordinate.confidence = 1
– position.yCoordinate.value = -500
– position.yCoordinate.confidence = 1
– angles.zAngle.value = 900
– angles.zAngle.confidence = 1
– objectDimensionZ.value = 10
– objectDimensionZ.confidence = 1
– objectDimensionY.value = 20
– objectDimensionY.confidence = 1
– objectDimensionX.value = 30
– objectDimensionX.confidence = 1
EUT1 may include other objects in its perceived object list.
EUT2 shall be able to store the received data in an LDM.</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Pre-test conditions:</td><td colspan="4">The channel load sensed by EUT shall be below 10 % CBR. Neither EUT1, EUT2 nor any other ITS-S transmits CPMs.</td></tr>
<tr><td rowspan="2">REQ /PICS</td><td colspan="2">Tested Requirements</td><td colspan="2">PICS</td></tr>
<tr><td colspan="2">1.4</td><td colspan="2"></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Step</td><td>Type</td><td colspan="2">Description</td><td>Result</td></tr>
<tr><td>1</td><td>Stimulus
(by Sender)</td><td colspan="3">EUT1 starts transmitting CPMs following the generation rules specified in [1].</td></tr>
<tr><td>2</td><td>Verify
(by Receiver)</td><td colspan="2">EUT2 receives and outputs the obtained data in an LDM.</td><td>EUT2 interprets the received data correctly by including it in its LDM.</td></tr>
<tr><td colspan="5">NOTE: To verify the result, access to the receivers LDM is needed (as data stream, HMI or similar). A comparison with the LDM of EUT1 (if available) or with the described configuration is needed for validation.</td></tr>
</table>

6.5 Use-case 1-5 Message Assembly Configuration

<table>
<tr><th colspan="5">Interoperability Test Description</th></tr>
<tr><td>Identifier:</td><td colspan="4">TC_ITS_CPS_UC1-5</td></tr>
<tr><td>Objective:</td><td colspan="4">Check that EUT2 is able to distinguish the message assembly configuration chosen by the transmitter (EUT1).</td></tr>
<tr><td>Configuration:</td><td colspan="4">EUT1 shall be capable of transmitting CPMs as specified in ETSI TS 103 324 [1] with all optional DEs and DFs. EUT2 shall be capable of receiving and decoding CPMs as specified in ETSI TS 103 324 [1] with all optional DEs and DFs. Both EUTs are configured to use the same communication channel for the transmission and reception of CPMs.
The load of the communication channel shall be below 10 % CBR.
EUT1 and EUT2 shall be positioned at a distance of less than 100 m in direct line of sight conditions.
EUT1 is capable of generating CPMs with MessageAssemblyConfiguration = 0 and MessageAssemblyConfiguration = 1.
EUT1 shall have a fixed number of between 25 and 35 perceived objects in its perceived object list. The EUT transmits CPMs based on the object inclusion rules defined in ETSI TS 103 324 [1] by setting ObjectInclusionConfig to "0" and being configured to include all perceived objects in every generation event. The EUT1 shall generate CPMs with at least two perception regions. At least one object contained in the perceived object list shall be positioned within one of these perception regions. Overall EUT1 shall make use of enough optional data fields to exceed the MTU_FAC and make data segmentation into different CPMs necessary.
EUT2 is capable of implicitly determining the message assembly configuration used during the generation of received CPMs. EUT2 is capable of reporting the message assembly configuration used during the generation of received CPMs.</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Pre-test conditions:</td><td colspan="4">EUT1 generates CPMs with MessageAssemblyConfiguration = 1. EUT2 receives the CPMs transmitted by EUT1. EUT2 reports the message assembly configuration of received CPMs (=1)</td></tr>
<tr><td rowspan="2">REQ /PICS</td><td colspan="2">Tested Requirements</td><td colspan="2">PICS</td></tr>
<tr><td colspan="2">1.5</td><td colspan="2"></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Step</td><td>Type</td><td colspan="2">Description</td><td>Result</td></tr>
<tr><td>1</td><td>Stimulus
(by Sender)</td><td colspan="2">EUT1 switches to MessageAssemblyConfiguration = 0 without skipping generation events.</td><td></td></tr>
<tr><td>2</td><td>Verify
(by Receiver)</td><td colspan="2">EUT2 receives the CPMs transmitted by EUT1</td><td>EUT2 reports the change of message assembly configuration by EUT1 (=0).</td></tr>
<tr><td colspan="5">NOTE 1: Two different message assembly configurations are specified in ETSI TS 103 324 [1]. In some cases (e.g. to verify information completeness on receiver side) it is necessary to distinguish which message assembly configuration is used, though the configuration is not explicitly indicated in the generated CPM.
NOTE 2: MessageAssemblyConfiguration "1" combined with ObjectInclusionConfig "0" allows to transmit all information available at the transmitter regarding certain regions within a single CPM. This is important to increase the availability of safety functionalities at the receivers.</td></tr>
</table>

6.6 Use-case 1-6 Correlation matrix handling

Interoperability Test Description			
Identifier:	TC_ITS_CPS_UC1-6		
Objective:	Check that EUT2 can correctly reconstruct the covariance information transmitted by EUT1.		
Configuration:	EUT1 shall be capable of transmitting CPMs as specified in ETSI TS 103 324 [1]. EUT2 shall be capable of receiving and decoding CPMs as specified in ETSI TS 103 324 [1]. Both EUTs are configured to use the same communication channel for the transmission and reception of CPMs. The load of the communication channel shall be below 10 % CBR. EUT1 and EUT2 shall be positioned at a distance of less than 100 m in direct line of sight conditions. EUT1 shall include at least one object to the perceived object list. If EUT1 has access to data provided by object-detecting sensors and the data includes variances and correlations of the detected object state vector, it shall include all available components of the correlation matrix and the variances. In this case it shall transmit the covariance information using at least two instances of LowerTriangularPositiveSemidefiniteMatrix for each included object. If EUT1 has no access to data provided from object-detecting sensors or the data does not include variances and correlations of the detected object state vector, the information from **Annex B** shall be used. EUT2 shall be able to store the received data in an LDM.		
Pre-test conditions:	The channel load sensed by EUT shall be below 10 % CBR. Neither EUT1, EUT2 nor any other ITS-S transmits CPMs.		
REQ /PICS	**Tested Requirements**	**PICS**	
	1.6		
Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	EUT1 starts transmitting CPMs following the generation rules specified in [1].	
2	Verify (by Receiver)	EUT2 receives and outputs the obtained data in an LDM.	EUT2 interprets the received data correctly by including it in its LDM.
NOTE 1: To verify the result, access to the receivers LDM is needed (as data stream, HMI or similar). A comparison with the LDM of EUT1 (if available) or with the described configuration es needed for validation. NOTE 2: A visualization of the covariance matrix for at least the tuple (xPosition, yPosition) of the objects is recommended.			

6.7 Use-case 1-7 Non-line-of-sight perception

Interoperability Test Description	
Identifier:	TC_ITS_CPS_UC1-7
Objective:	Check that EUT2 can correctly interpret non-line-of-sight conditions transmitted by EUT1.
Configuration:	EUT1 shall be capable of transmitting CPMs as specified in ETSI TS 103 324 [1]. EUT2 shall be capable of receiving and decoding CPMs as specified in ETSI TS 103 324 [1]. Both EUTs are configured to use the same communication channel for the transmission and reception of CPMs. The load of the communication channel shall be below 10 % CBR. EUT1 and EUT2 shall be positioned at a distance of less than 100 m in direct line of sight conditions. EUT1 shall consider the following sensor information specifications while generating CPMs: • SIC 1: – sensorType = lidar (2) – perceptionRegionShape = radial – radialShape.shapeReferencePoint is absent – radialShape.range = 150 – radialShape.horizontalOpeningAngleStart = 3450 – radialShape.horizontalOpeningAngleEnd = 450 – perceptionRegionConfidence = 100 – shadowingApplies = false • EUT1 shall additionally consider the following perception regions while generating CPMs:PR1: – measurementDeltaTime = 1 – perceptionRegionShape = radial – radialShape.shapeReferencePoint is absent – radialShape.range = 150 – radialShape.horizontalOpeningAngleStart = 0 – radialShape.horizontalOpeningAngleEnd = 450 – perceptionRegionConfidence = 30 – shadowingApplies = false • PR2: – measurementDeltaTime = 1 – perceptionRegionShape = radial – radialShape.shapeReferencePoint is absent – radialShape.range = 150 – radialShape.horizontalOpeningAngleStart = 3550 – radialShape.horizontalOpeningAngleEnd = 450 – perceptionRegionConfidence = 100 – shadowingApplies = true EUT1 shall further consider the following perceived objects while generating CPMs: • PO1: – measurementDeltaTime = 1 – position.xCoordinate.value = 5000 – position.xCoordinate.confidence = 1 – position.yCoordinate.value = 500 – position.yCoordinate.confidence = 1 – objectDimensionX.value = 20 – objectDimensionX.confidence = 1 – objectDimensionY.value = 30 – objectDimensionY.confidence = 1 The EUT1 shall select one of the described Sender_ITS-S_type from clause 4.2.3. EUT2 shall be able to store the received data in an LDM.
Pre-test conditions:	The channel load sensed by EUT shall be below 10 % CBR. Neither EUT1, EUT2 nor any other ITS-S transmits CPMs.

REQ /PICS	Tested Requirements	PICS
	1.7	

Step	Type	Description	Result
1	Stimulus (by Sender)	EUT1 starts transmitting CPMs following the generation rules specified in ETSI TS 103 324 [1].	
2	Verify (by Receiver)	EUT2 receives the CPMs transmitted by EUT1 for at least 5 seconds and outputs the obtained data in an LDM.	EUT2 interprets the received data correctly by including it in its LDM.

NOTE: To verify the result, access to the receivers LDM is needed (as data stream, HMI or similar). A comparison with the LDM of EUT1 (if available) or with the described configuration es needed for validation.

6.8 Use-case 1-8 Resource-aware data rate adaptation

Interoperability Test Description		
Identifier:	TC_ITS_CPS_UC1-8	
Objective:	Check that EUT adapts the number of consumed communication resources according to the provided limits (e.g. by MCO ETSI TS 103 141 [2]).	
Configuration:	MCO Configuration as defined in clause 4.2.1 shall be used with additional requirements: • The EUT shall have a fixed number of between 5 and 15 perceived objects in its perceived object list. The EUT transmits CPMs based on the object inclusion rules defined in ETSI TS 103 324 [1] by setting *ObjectInclusionConfig* to "0" and being configured to include all perceived objects in every generation event. The included objects shall be described with a fixed amount of data each. • The value of information as defined in Annex E of ETSI TS 103 324 [1] shall not be equal for all perceived objects (i.e. at least two different values shall be present). • The EUT shall further include a fix number of PerceptionRegions and use *MessageAssemblyConfig* "0". • The EUT shall be configured to adapt the number of claimed communication resources as defined in normative Annex D of ETSI TS 103 324 [1]. • If the EUT has access to the state of the communication channel and can estimate the number of communication resources available to the CPS (e.g. through the use of DCC_FAC or MCO_FAC) a load generator as specified in clause 4.2.2 shall be used. EUT and the load generator shall be positioned at a distance of less than 100 m in direct line of sight conditions. • If the EUT does not have access to the state of the communication channel or cannot estimate the number of communication resources available to the CPS, the number of available resources shall be configurable.	
Pre-test conditions:	If the EUT has access to the state of the communication channel and can estimate the number of communication resources available to the CPS, the channel load shall be below 10 % CBR in the vicinity of the EUT. If the EUT does not have access to the state of the communication channel or cannot estimate the number of communication resources available to the CPS, the number of resources, as defined in clause 5.2 of ETSI TS 103 141 (V2.2.1) [2], shall be limited to resources_limit = 180 kilobits per second. As the number of available resources is high (i.e. the channel load is low), the EUT assembles CPMs containing all perceived objects.	
REQ /PICS	**Tested Requirements**	**PICS**
	1.8, 1.9	PICS_CHANNEL_LOAD_ADAPTATION=true

Step	Type	Description	Result
1	Stimulus (by Sender)	If the EUT has access to the state of the communication channel and can estimate the number of communication resources available to the CPS, the load generator increases the channel load from below 10 % CBR to above 50 %. Else, the EUT shall be provided a new limit of resources_limit = 32 kilobits per second.	
2	Verify (by Receiver)	EUT notices that the channel is either used by the load generator and/or obtains a reduced maximum number of available resources from IF.MCO, as defined in ETSI TS 103 141 [2].	EUT reduces the number of consumed channel resources to comply with the new allowed maximum data rate by omitting some of the objects with the lowest information value and/or by reducing the message rate. If the EUT has access to the state of the communication channel and can estimate the number of communication resources available to the CPS, it can additionally be verified if the new resource limit is obeyed.
NOTE 1: To verify the result a network sniffer is necessary. NOTE 2: The channel load of 50 % is selected for the test to obtain close-to-saturation conditions and ensure that the frequency and content management mechanisms specified in normative Annex D of ETSI TS 103 324 [1] come into action.			

6.9 Use-case 1-9 Resource-aware channel offloading

Interoperability Test Description	
Identifier:	TC_ITS_CPS_UC1-9
Objective:	Check that EUT1 can offload objects to other available communication channels and EUT2 can reconstruct the list of transmitted objects.
Configuration:	MCO Configuration as defined in clause 4.2.1 shall be used with additional requirements: • EUT1 shall have a fixed number of between 30 perceived objects in its perceived object list, with ascending object ids assigned to them, from 1 to 30 EUT1 transmits CPMs based on the object inclusion rules defined in ETSI TS 103 324 [1] by setting *ObjectInclusionConfig* to "0" and being configured to include all perceived objects in every generation event. The included objects shall be described with the highest possible of detail. The value of information as defined in Annex E of [1] shall not be equal for all perceived objects (i.e. at least two different values shall be present). • EUT1 shall further include a fix number of PerceptionRegions and use *MessageAssemblyConfig* "0". T_GenCpm shall be fixed to 100 ms. • EUT1 shall be able to transmit data on two different communication channels. • EUT1 shall be configured to adapt the number of claimed communication resources as defined in normative Annex D of ETSI TS 103 324 [1]. • If EUT1 has access to the state of both communication channels and can estimate the number of communication resources available to the CPS on each of them (e.g. through the use of DCC_FAC or MCO_FAC) a load generator as specified in clause 4.2.2 shall be used. EUT and the load generator shall be positioned at a distance of less than 100 m in direct line of sight conditions. • If EUT1 has access to the state of both communication channels and can estimate the number of communication resources available to the CPS on each of them, the number of available resources shall be configurable per communication channel. • EUT2 shall be able to receive CPMs as specified in [1] on both channels used by EUT1. EUT2 shall be positioned at a distance of less than 100 m in direct line of sight conditions from EUT1.
Pre-test conditions:	If EUT1 has access to the state of the communication channel and can estimate the number of communication resources available to the CPS, the load of the preferred communication channel (see ETSI TS 103 324 [1]) shall be below 10 % CBR in the vicinity of the EUT. If EUT1 does not have access to the state of the communication channels or cannot estimate the number of communication resources available to the CPS, the number of resources, as defined in clause 5.2 of ETSI TS 103 141 (V2.2.1) [2], shall be limited to resources_limit = 180 kilobits per second on each channel. As the number of available resources on the preferred communication channel is high (i.e. the channel load is low), EUT1 assembles CPMs containing all perceived objects and transmits them on the preferred communication channel.

REQ /PICS	Tested Requirements	PICS
	1.8, 1.10	PICS_CHANNEL_LOAD_ADAPTATION=true

Step	Type	Description	Result
1	Stimulus (by Sender)	If EUT1 has access to the state of the communication channels and can estimate the number of communication resources available to the CPS, the load generator increases the channel load on the preferred channel from below 10 % CBR to above 50 %. Else, EUT1 shall be provided a new resource limit on the preferred channel of *resources_limit* = 32 kilobits per second.	
2	Verify (by Receiver)	EUT1 notices that the preferred channel is either used by the load generator and/or obtains a reduced maximum number of available resources from IF.MCO, as defined in ETSI TS 103 141 [2].	EUT1 reduces the number of consumed resources on the preferred communication channel to comply with the new allowed maximum data rate by offloading some of the objects with the lowest information value to the alternative channel. If EUT1 has access to the state of the communication channels and can estimate the number of communication resources available to the CPS, it can additionally be verified if the new resource limit on the preferred channel is obeyed. EUT2 can reconstruct the list of objects provided by EUT1 by checking the object IDs.

NOTE 1: To verify the result a network sniffer is necessary.
NOTE 2: The channel load of 50 % is selected for the test to obtain close-to-saturation conditions and ensure that the frequency and content management mechanisms specified in normative Annex D of ETSI TS 103 324 [1] come into action.
NOTE 3: A message rate adaptation is discarded by the above configuration (i.e, setting a fix value for T_GenCpm) to ensure that an offloading to the alternative channel takes place.

Annex A (normative): Protocol Implementation Conformance Statements (PICS)

This annex defines the set of Protocol Implementation Conformance Statements (PICS), used in the present document. The Equipment Under Tests (EUTs) and Qualified Equipment (QE) vendors shall analyse the equipment's capability and select only relevant use-cases.

Table A.1

PICS	Description	Default Value
PICS_CHANNEL_LOAD_ADAPTATION	The EUT supports channel load adaptation	true

Annex B (normative): Covariance matrix for use case 1-6

Table B.1

0.761												
0.454	1.083											
0.592	0.776	5.109										
0.060	0.029	0.046	0.065									
0.025	0.048	-0.013	0.029	0.022								
					N/A							
0.441	-0.123	-0.511	0.019	-0,008		1.159						
0.182	0.434	0.572	0.133	0,046		1.411	2.219					
								10.930				
								3.104	4.165			
								-0.579	1.094	0.282		
								1.520	2.018	0.739	1.940	
								2.928	-2.857	-0.387	0.338	2.041

The above covariance matrix shall be used for use-case 1-6. As the matrix is symmetric, for simplicity only the covariance elements under the variance diagonal are represented. The components of the matrix are as specified in ETSI TS 103 324 [1], and the therein defined units apply:

- xPosition(0),
- yPosition(1),
- zPosition(2),
- xVelocity(3),
- yVelocity(4),
- zSpeed(5),
- xAcceleration(6),
- yAcceleration(7),
- zAcceleration(8),
- zAngle(9),
- yAngle(10),
- xAngle(11),
- zAngularVelocity(12)

EUT1 shall generate the CPMs by using two instances of LowerTriangularPositiveSemidefiniteMatrix. The components (5) and (8) shall be set as absent. The first LowerTriangularPositiveSemidefiniteMatrix shall include the components (0) to (4) and (6) to (7), while the second LowerTriangularPositiveSemidefiniteMatrix shall include the components (8) to (12).

The variances σ_i^2 (back fields in the covariance matrix) shall be transmitted by converting them into confidences for a 95 % confidence level. Given a gaussian distribution of the component (i) with value r_i the following relation applies for the (two-sided) confidence value at a confidence level of 95 %:

$$\Delta r_i = 1.96\ \sigma_i$$

The permitted confidence ranges and the corresponding standard deviation ranges can be obtained from ETSI TS 103 324 [1] and are as follows:

Component	Min Δr_i	Max Δr_i	Min σ_i	Max σ_i
xPosition(0)	0.01 m	40.94 m	0.005 m	20.888 m
yPosition(1)	0.01 m	40.94 m	0.005 m	20.888 m
zPosition(2)	0.01 m	40.94 m	0.005 m	20.888 m
xVelocity(3)	0.01 m/s	1.26 m/s	0.005 m/s	0.643 m/s
yVelocity(4)	0.01 m/s	1.26 m/s	0.005 m/s	0.643 m/s
zSpeed(5)	0.01 m/s	1.26 m/s	0.005 m/s	0.643 m/s
xAcceleration(6)	0.1 m /s²	10.0 m/s²	0.05 m /s²	5.10 m/s²
yAcceleration(7)	0.1 m /s²	10.0 m/s²	0.05 m /s²	5.10 m/s²
zAcceleration(8)	0.1 m /s²	10.0 m/s²	0.05 m /s²	5.10 m/s²
zAngle(9)	0.1°	12.5°	0.05°	6.37°
yAngle(10)	0.1°	12.5°	0.05°	6.37°
xAngle(11)	0.1°	12.5°	0.05°	6.37°
zAngularVelocity(12)	1, 2, 5, 10, 20, 50°/s		0.5, 1.0, 2.6, 5.1, 10.2, 25.5°/s	

The Pearson coefficients for the first and the second LowerTriangularPositiveSemidefiniteMatrix shall be computed from the based on the fields marked in light and dark grey in the covariance matrix, correspondingly. The computation of Pearson coefficients is defined as:

$$\rho_{ij} = \frac{\sigma_{ij}}{\sigma_i \sigma_j}$$

where σ_{ij} represents the covariance between component (i) and component (j).

History

Document history		
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