ETSI TS 103 925 V2.1.1 (2024-11)

TECHNICAL SPECIFICATION

**Intelligent Transport Systems (ITS);
Testing;
Vulnerable Road Users (VRU) awareness;
Interoperability tests specification;
Release 2**

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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).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1   Scope

The present document contains specifications of interoperability test descriptions to validate implementations of ETSI TS 103 300-3 [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 at ETSI docbox.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

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

[1]   ETSI TS 103 300-3: "Intelligent Transport Systems (ITS); Vulnerable Road Users (VRU) awareness; Part 3: Specification of VRU awareness basic service; Release 2".

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

[3]   ETSI TS 103 831: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Decentralized Environmental Notification Service; 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 103 300-3 [1] apply.

3.2   Symbols

For the purposes of the present document, the symbols given in ETSI TS 103 300-3 [1] apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 103 300-3 [1] and the following apply:

CL   Cluster Leader
EUT   Equipment Under Test
QE   Qualified Equipment

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 VAM interoperability tests is an ITS-S with the following mandatory requirements:

- The EUT shall be able to send and receive VAMs [1]).

- The EUT's parameters as defined in ETSI TS 103 300-3 [1] shall be configurable by the test operator.

The EUT shall be checked if it behaves accordingly to the VRU standard [1]) and is interoperable with other VRUs.

 NOTE: In all test cases only one EUT is present.

4.1.3 Qualified equipment

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

- The QE shall be able to send and receive VAMs [1].

- The QE is verified to fulfil the interoperability test specification.

- The QE's parameters as defined in ETSI TS 103 300-3 [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 VAMs 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 send and received VAMs. 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 VAMs [1].

- 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   VRU basic configuration

The parameters used in the following tests are the default parameters as described in ETSI TS 103 300-3 [1], clause 8 unless stated otherwise. For compatibility, these shall be synchronized between the ITS-S.

To participate in the test with the present configuration, ITS-S shall be configured as following if it is not explicitly defined in the use-case description:

- ITS-S is configured as equipment type VRU-St.

- All ITS-Ss, independent of their role as QE or EUT are configured to send and receive VAMs as defined by ETSI TS 103 300-3 [1], clause 6. Clustering is enabled unless stated otherwise in the use-case description.

- The parameter *numCreateCluster* is set to 2 to simplify testing unless stated otherwise.

NOTE: All QEs used during the tests could be emulated except from QEs which takes an active role CPMs and has to be perceived from the QEs sensors.

4.2.2   Stations operate under cluster join conditions

Some use cases test the ability to create or join a VRU cluster or avoiding doing so. In these use cases, at least two stations shall interact in a way that the (configurable) "clustering conditions" are met during the test.

The clustering conditions that shall be fulfilled include that an ITS-S A:

- is in within the bounding box;

- not more than *maxClusterDistance* away;

- and moves in the same direction with a velocity difference not more than *maxClusterVelocityDifference* of an ITS-S B, which is the designated Cluster Leader (CL).

Additionally, there are no more than *maxClusterSize* - 1 ITS-S already in this cluster. This configuration allows, depending on the initial state of ITS-B and probably further ITS-S (cluster is already created or not), to test cluster joining and cluster creating use cases.
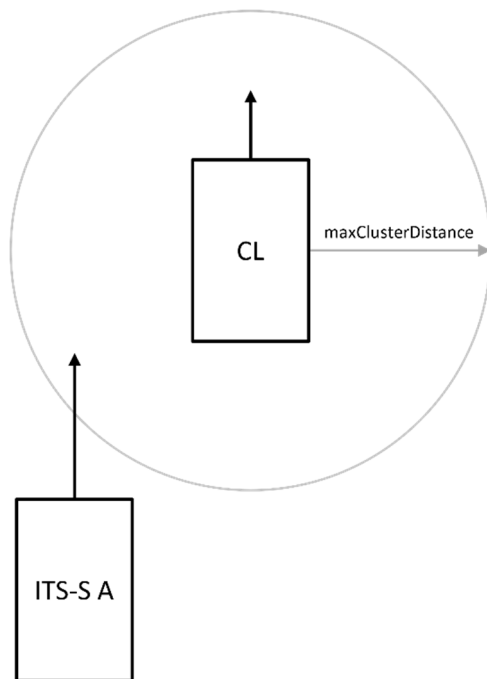
Figure 1: Cluster join conditions behaviour

4.2.3   Station operate under cluster leave conditions

Some use cases test the ability to leave or disband a VRU cluster or refrain from doing so. Analogous to clause 4.2.2, at least two stations shall interact in a way that the previously defined clustering conditions are not met anymore.

At least one of the clustering conditions stated in clause 4.2.2 shall be violated which can be achieved by:

- moving out the bounding box;

- moving away from the cluster leader more than *maxClusterDistance*;

- or exceeding a velocity difference of more than *maxClusterVelocityDifference* from it.

Figure 2: Cluster leave conditions behaviour

5   Requirements to be tested

5.1   Overview

The clauses below collect and enumerate the requirements that can be tested with the present document.

5.2   VAM interoperability requirements

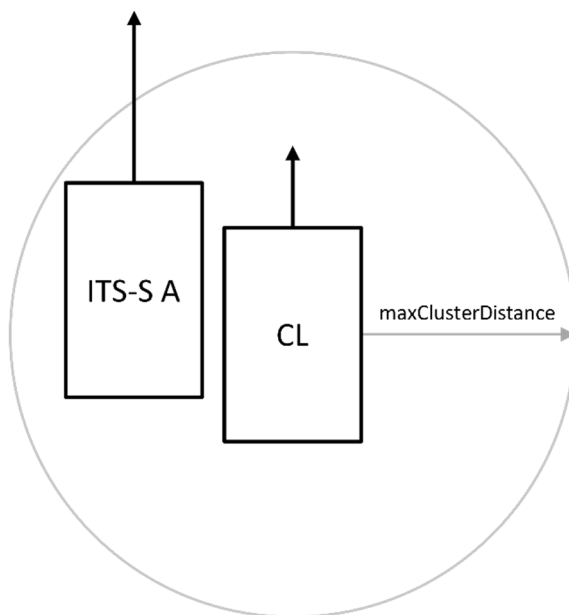| NN	Requirement	Reference	UCs
1.1	ITS-S may be configurable to activate and deactivate clustering	ETSI TS 103 300-3 [1], clause 5.4.1	UC1-1 UC1-2 UC1-4
1.2	ITS-S shall be part of maximum one cluster	ETSI TS 103 300-3 [1], clauses 5.4.1 and 5.4.2.2	UC1-3 UC1-4 UC1-10 UC1-11
1.3	ITS-S shall be only part of a cluster when acting as a VRU	ETSI TS 103 300-3 [1], clause 5.4.2.2	UC1-4
1.4	ITS-S shall initiate clusters with a bounding box only containing the creating ITS-S	ETSI TS 103 300-3 [1], clause 5.4.2.2	UC1-4
1.5	ITS-S shall start sending individual VAMs when leaving a cluster	ETSI TS 103 300-3 [1], clauses 5.4.2.2, 5.4.2.6 and 7.3.5	UC1-6 UC1-10 UC1-11 UC1-12 UC1-16
1.6	ITS-S shall stop sending individual VAMs when entering cluster	ETSI TS 103 300-3 [1], clauses 5.4.2.2, 5.4.3, and 7.3.5	UC1-5 UC1-15
1.7	ITS-S shall cancel joining a cluster if conditions are not met anymore	ETSI TS 103 300-3 [1], clauses 5.4.2.2 and 7.3.5	UC1-7
1.8	ITS-S acting as cluster leader shall track of the properties of its cluster	ETSI TS 103 300-3 [1], clauses 5.4.2.2, 5.4.3 and 7.3.5	UC1-8 UC1-9 UC1-14
1.9	ITS-S shall join a cluster if cluster conditions are met	ETSI TS 103 300-3 [1], clauses 5.4.2.4 and 7.3.5	UC1-3 UC1-5
1.10	ITS-S shall leave a cluster if cluster conditions are not met anymore	ETSI TS 103 300-3 [1], clauses 5.4.2.2, 5.4.2.4 and 7.3.5	UC1-10
1.11	ITS-S shall indicate joining cluster with ID 0 if in cluster bounding box of received C-ITS message other than VAM	ETSI TS 103 300-3 [1], clauses 5.4.2.2 and 7.3.5	UC1-15
1.12	ITS-S shall indicate leaving cluster with ID 0 if not anymore in cluster bounding box of received C-ITS message other than VAM	ETSI TS 103 300-3 [1], clauses 5.4.2.2 and 7.3.5	UC1-16
1.13	ITS-S shall indicate the correct cluster ID when joining or leaving clusters	ETSI TS 103 300-3 [1], clause 5.4.2.2	UC1-7 UC1-10 UC1-13
1.14	ITS-S shall disband a cluster if join condition for a larger cluster are fulfilled	ETSI TS 103 300-3 [1], clause 5.4.2.4	UC1-3
1.15	ITS-S may increase communicated safe distance when DENM with adverse weather conditions received and applicable	ETSI TS 103 300-3 [1], clause 6.6.3	UC1-17
1.16	ITS-S shall leave a cluster if a new vehicle's or VRU vehicle's distance falls below the ITS-S's configured safe distance	ETSI TS 103 300-3 [1], clause 7.3.5	UC1-12
1.17	ITS-S may indicate a violation of its safe distance	ETSI TS 103 300-3 [1], clause 7.3.6	UC1-12
1.18	ITS-S may indicate a trajectory interception	ETSI TS 103 300-3 [1], clause 7.3.6	UC1-18

6 Interoperability test descriptions
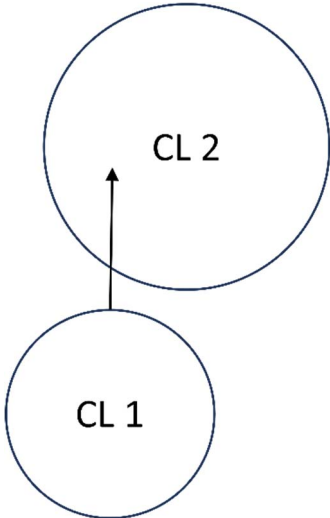
6.1 Use-case 1-1 Cluster deactivation

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-1
Objective:	Check that EUT can deactivate the clustering
Configuration:	Participants: QE 1, QE 2, EUT QE 1 and QE 2 (can be emulated) already fulfil cluster join conditions (see clause 4.2.2). QE 1 is configured with *numCreateCluster* = 2, QE 2 is configured with *numCreateCluster* >= 4. EUT is configured so that cluster joining is disabled. EUT fulfils cluster join conditions with QE as defined in clause 4.2.2.
Pre-test conditions:	QE 1 and QE 2 has organized a cluster. QE 1 acts as a cluster leader for QE 2.

REQ /PICS	Tested Requirements		PICS
	1.1		EUT: PICS_CLUSTERING_ENABLED=false QE: PICS_CLUSTERING_ENABLED=true

Step	Type	Description	Result
1	Stimulus (by Sender)	QE 1 sends VAM containing DF *ClusterInformationContainer*	
2	Verify (by Receiver)	EUT validates received VAM	EUT does not send DF *clusterJoinInfo* in the following VAMs

6.2 Use-case 1-2 Cluster activation

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-2
Objective:	Check that EUT can activate the clustering
Configuration:	Participants: QE 1, QE 2, EUT QE 1 and QE 2 (can be emulated) already fulfil cluster join conditions (see clause 4.2.2). QE 1 is configured with *numCreateCluster* = 2, QE 2 is configured with *numCreateCluster* >= 4. EUT is configured so that cluster joining is enabled. EUT fulfils cluster join conditions with QE as defined in clause 4.2.2. The *timeClusterJoinNotification* parameter is set to 3 s.
Pre-test conditions:	QE 1 is cluster leader containing QE 2. EUT does not send cluster information container before test start.

REQ /PICS	Tested Requirements		PICS
	1.1		EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true

Step	Type	Description	Result
1	Stimulus (by Sender)	QE sends VAM containing cluster information container	
2	Verify (by Receiver)	EUT validates received VAM	EUT sends DF *clusterJoinInfo* in the following VAMs for 3 s.

6.3 Use-case 1-3 Cluster leader break cluster up

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-3
Objective:	Check that EUT disbands a cluster if a larger, compatible cluster is available
Configuration:	Participants: QE 1, QE 2, QE 3 & QE 4, EUT QE 1 is fulfilling cluster join conditions (see clause 4.2.2) of EUT. QE 1 is configured with *numCreateCluster* >= 6, EUT is configured with *numCreateCluster* = 2. EUT's *timeClusterBreakupWarning* and *timeClusterJoinNotification* are set to 3 s. QE 3 and QE 4 are fulfilling cluster join conditions (see clause 4.2.2) of QE 2. QE 2 is configured with numCreateCluster = 2, QE 3 & QE 4 have set numCreateCluster >= 6. QE 2 to QE 4 form Cluster 2 (CL 2). Cluster 1 and Cluster 2 start apart from each other (not fulfilling each other's clustering conditions). Cluster 1 moves into Cluster 2's range and bounding box, consequently, EUT is fulfilling cluster join conditions of cluster 2. CL 2 CL 1
Pre-test conditions:	EUT is cluster leader of a cluster CL 1 with QE 1. QE 2, QE 3 and QE 4 define another cluster CL 2.

REQ /PICS	Tested Requirements	PICS
	1.2, 1.9, 1.14	EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true

Step	Type	Description	Result
1	Stimulus (by Sender)	EUT fulfils cluster join conditions for the cluster of QE 2, QE 3 and QE 4 (cluster 2). QE 2 sends VAM containing information (i.e. size, bounding box) about its cluster.	
2	Verify (by Receiver)	EUT validates received VAM and disbands cluster.	EUT sends DF *clusterBreakupInfo* in the following VAMs for 3 s.
3	Verify (by Receiver)	EUT joins cluster with QE 2, QE 3 and QE 4.	EUT sends DF *clusterJoinInfo* in the following VAMs for 3 s.

6.4 Use-Case 1-4 Creating a cluster

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-4
Objective:	Check that EUT successfully creates a cluster when compatible stations are close
Configuration:	Participants: QE 1, EUT QE 1 is configured with *numCreateCluster* >= 3, EUT is configured with *numCreateCluster* = 2 QE 1 fulfils cluster join conditions of EUT (see clause 4.2.2)

Pre-test conditions:			
REQ /PICS	**Tested Requirements**		**PICS**
	1.1, 1.2, 1.3, 1.4		EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true
Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	QE fulfils cluster join conditions of EUT and sends VAM
2	Verify (by Receiver)	EUT validates received VAM and creates a cluster initially containing only EUT	EUT sends the following VAMs containing DF *clusterInformationContainer* with DE *clusterCardinalitySize*=1 and DE *boundingBoxShape* comprising only EUT 1

6.5   Use-Case 1-5 Stop sending VAMs after cluster joining

Interoperability Test Description
Identifier:	TC_ITS_VRU_UC1-5
Objective:	Check that EUT stops sending individual VAMs after joining a cluster
Configuration:	Participants: QE 1, QE 2 EUT QE 1 is configured with *numCreateCluster* = 2, QE 2 with *numCreateCluster* >= 4. EUT's *timeClusterJoinNotification* is set to 3 s. QE 2 initially fulfils cluster join conditions (see clause 4.2.2) of QE 1. During the test, EUT moves into the range of the created cluster to also fulfil the cluster join conditions.
Pre-test conditions:	QE 1 is cluster leader with QE 2 as member
REQ /PICS	**Tested Requirements**	**PICS**
	1.6, 1.9	EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true
Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	EUT moves into the cluster's bounding box to fulfil the cluster join conditions of QE 1. Consequently, QE 1 sends VAMs containing cluster join container
2	Verify (by Receiver)	EUT validates received VAM	EUT sends VAMs containing DF *clusterJoinInfo* with *clusterId* of QE 1's cluster After 3 s, EUT stops sending individual VAMs

6.6   Use-Case 1-6 Cluster Breakup triggered by leader

Interoperability Test Description
Identifier:	TC_ITS_VRU_UC1-6
Objective:	Check that EUT sends individual VAMs after a cluster breakup is triggered by the cluster leader.
Configuration:	Participants: QE 1, EUT QE 1 is configured with *numCreateCluster* = 1, EUT is configured with *numCreateCluster* >= 2 EUT fulfils cluster create conditions (see clause 4.2.2) QE can be configured to deactivate clustering and consequently send DF *ClusterBreakupInfo*

Pre-test conditions:	QE is cluster leader, EUT is member of cluster and does not send individual VAMs.		
REQ /PICS	**Tested Requirements**		**PICS**
	1.5		EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true PICS_CLUSTER_CHANGE_CONFIGURATION=true
Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	QE disables clustering per configuration. Consequently, DF *ClusterBreakupInfo* is included in VAMs sent by QE.	
2	Verify (by Receiver)	EUT validates received VAM	EUT starts sending individual VAMs

6.7   Use-Case 1-7 Failed joining a cluster

Interoperability Test Description			
Identifier:	TC_ITS_VRU_UC1-7		
Objective:	Check that EUT sends cluster leave notifications when it fails to join a cluster.		
Configuration:	Participants: QE 1, QE 2, EUT. EUT's *timeClusterJoinNotification* is set to 10 s. EUT's *timeClusterLeaveNotification* is set to 1 s. QE 2 fulfils cluster join conditions of QE 1 (see clause 4.2.2).		
Pre-test conditions:	QE1 is cluster leader containing QE 2.		
REQ /PICS	**Tested Requirements**		**PICS**
	1.7, 1.13		EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true
Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	EUT fulfils joining conditions of QE 1's cluster. QE sends VAM with cluster information container.	
2	Verify (by Receiver)	EUT validates received VAM with cluster information container of QE 1	EUT sends DF *clusterJoinInfo* with corresponding *clusterId*
3	Stimulus (by Sender)	Within max. 10 s, EUT does not fulfil cluster conditions anymore (e.g. by leaving the bounding box of the cluster leader, see also clause 4.2.3)	
4	Verify (by Receiver)	EUT validates received VAM	EUT sends DF *clusterLeaveInfo* with *clusterId* belonging to QE 1 for 1 s. After that, EUT continues sending individual VAMs without any cluster information.
NOTE: *timeClusterJoinNotification* is set to a non-standard value for ease of testing. If required, *timeClusterJoinNotification* can be set even higher.			

6.8 Use-Case 1-8 Increase cluster after successful cluster joining

Interoperability Test Description			
Identifier:	TC_ITS_VRU_UC1-8		
Objective:	Check that EUT increases the cluster size and bounding box and correctly indicates all contained profile types after a new ITS-S has joined the cluster.		
Configuration:	Participants: QE 1, QE 2, QE 3, EUT. EUT, QE 1/QE 2 have the same profile type. QE 3 has a different profile type (e.g. EUT, QE 1 and QE 2 are configured with the bicycle profile and QE 3 with the pedestrian profile). QE 1 and QE 2 fulfil cluster join conditions (see clause 4.2.2) of EUT. QE 3 is outside of cluster join conditions in the beginning of the test.		
Pre-test conditions:	EUT is a cluster leader containing QE 1 and QE 2.		
REQ /PICS	**Tested Requirements**		**PICS**
	1.8		EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true

Step	Type	Description	Result
1	Stimulus (by Sender)	QE 3 fulfils cluster join conditions of EUT (see clause 4.2.2) and sends VAM containing DF *clusterJoinInfo*.	
2	Verify (by Receiver)	EUT validates received VAM of QE 3 containing cluster join information and verifies that QE 3 is fulfilling cluster join conditions.	EUT increases the value of the DE *clusterCardinalitySize* to 3. EUT increases the transmitted bounding box to include QE 3. EUT correctly indicates profile types of all members in its sent VAMs.

6.9 Use-Case 1-9 Cluster leader does not change cluster properties on aborted cluster joining attempt

Interoperability Test Description			
Identifier:	TC_ITS_VRU_UC1-9		
Objective:	Check that EUT does not increase the cluster size and bounding box and correctly indicates all contained profile types when a new ITS-S fails to join the cluster.		
Configuration:	Participants: QE 1, QE 2, EUT. EUT and QE 1 have the same profile type. QE 2 has a different profile type (e.g. EUT and QE 1 are configured with the bicycle profile and QE 3 with the pedestrian profile). QE 1 fulfils cluster join conditions (see clause 4.2.2) of EUT. QE 1's and EUT's *timeClusterJoinNotification* is set to 3 s. EUT shall be configured to not add new ITS-S to its cluster before *timeClusterJoinNotification*.		
Pre-test conditions:	EUT is leader of a cluster containing QE 1.		
REQ /PICS	**Tested Requirements**		**PICS**
	1.8		EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true

Step	Type	Description	Result
1	Stimulus (by Sender)	QE 2 fulfils cluster join conditions (see clause 4.2.2) and sends VAMs containing DF *clusterJoinInfo* no longer than 3 s. Within 3 s, QE 2 does not fulfil cluster join conditions anymore and sends VAMs containing DF *clusterLeaveInfo*.	
2	Verify (by Receiver)	EUT validates received VAMs of QE 2.	EUT does not increase the value of the DE *clusterCardinalitySize.* EUT does not increase the transmitted bounding box to include QE 2. EUT does not adapt profile type in its sent VAMs.
NOTE:	For ease of testing, *timeClusterJoinNotification* can be increased. However, it shall then be ensured that the time for adding new ITS-S to the cluster at EUT is delayed to that amount as well.		

6.10   Use-Case 1-10 Leave VAM cluster

Interoperability Test Description			
Identifier:	TC_ITS_VRU_UC1-10		
Objective:	Check that EUT leaves the cluster if the cluster conditions are not fulfilled anymore.		
Configuration:	Participants: QE 1, EUT. EUT's *timeClusterLeaveNotification* is set to 1 s. At the beginning of the test, EUT fulfils cluster join conditions (see clause 4.2.2.) of QE 1.		
Pre-test conditions:	EUT is part of a cluster with QE 1 as cluster leader.		
REQ /PICS	**Tested Requirements**		**PICS**
	1.2, 1.5, 1.10, 1.13		EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true

Step	Type	Description	Result
1	Stimulus (by Sender)	QE 1 sends VAM. EUT does not fulfil cluster conditions of QE 1's cluster anymore (see clause 4.2.3).	
2	Verify (by Receiver)	EUT validates received VAM.	EUT starts sending individual VAMs. EUT sends DF *clusterLeaveInfo* with the *clusterId* belonging to QE 1 in the VAMs for 1 s.

6.11   Use-Case 1-11 Leave cluster in case of connection loss

Interoperability Test Description			
Identifier:	TC_ITS_VRU_UC1-11		
Objective:	Check that EUT is leaving the cluster if the connection with the cluster leader is lost		
Configuration:	Participants: QE 1, EUT. EUT fulfils cluster join conditions (see clause 4.2.2) of QE 1. EUT's *timeClusterContinuity* is set to 2 s. EUT's *timeClusterLeaveNotification* is set to 1 s.		
Pre-test conditions:	EUT is a part of a cluster with QE 1 as cluster leader, QE is sending VAMs with cluster information container.		
REQ /PICS	**Tested Requirements**		**PICS**
	1.2, 1.5, 1.10		EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true

Step	Type	Description	Result
1	Stimulus (by Sender)	Connection between QE 1 and EUT is cut off (e.g. by turning off QE 1)	
2	Verify (by Receiver)	EUT does not receive any message from QE 1 for 2 s.	EUT starts sending individual VAMs. EUT sends DF *clusterLeaveInfo* in the VAMs for the duration of 1 s.
NOTE:		It shall be assured that QE 1 has no chance to send DF *clusterBreakupInfo* when turned off. If not possible, the sending of VAMs should be suppressed otherwise.	

6.12   Use-Case 1-12 Leave cluster on Safe Distance Violation

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-12
Objective:	Check that EUT leaves the cluster indicating "SafetyCondition" when its *minimumSafeLateralDistance*,, *minimumSafeLongitudinalDistance* and *minimumSafeVerticalDistance* are violated
Configuration:	Participants: QE 1, QE 2, EUT EUT's *timeClusterLeaveNotification* is set to 1 s. EUT's *minimumSafeLateralDistance* is set to max (2 m, A (see note)). EUT's *minimumSafeLongitudinalDistance* is set to the longitudinal distance ego-VRU could travel in T_GenVamMax** seconds. EUT's *minimumSafeVerticalDistance* is set to 5 m. QE 2 is parked in front of EUT with a lateral distance of 0 m and longitudinal distance of 25 m on the same plane. QE 1 stands next to EUT with a lateral distance of > 2 m. EUT and QE 1 start moving with approx. 3 m/s together towards QE 2, QE 1 always keeps the lateral distance of > 2 m. * A = the lateral distance ego-VRU could travel in *T_GenVamMax*** seconds (see [1], clause 8). ** The recommended value for T_GenVamMax is 5 000 ms (see [1], clause 8).
Pre-test conditions:	EUT is part of a cluster with QE 1 as cluster leader.
REQ /PICS	**Tested Requirements** / **PICS**

REQ /PICS	Tested Requirements	PICS
	1.5, 1.16, 1.17	EUT: PICS_CLUSTERING_ENABLED=true PICS_SDI_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true

Step	Type	Description	Result
1	Stimulus (by Sender)	QE 1 and EUT come closer than 15 m to QE 2. QE 1 and QE 2 send VAMs indicating their position.	
2	Verify (by Receiver)	EUT validates received VAM	EUT starts sending individual VAMs with DE *safeDistanceIndicator* = FALSE for QE's ID EUT sends cluster leave information with DE *ClusterLeaveReason* "SafetyCondition (8)" in the VAMs for 1 s
NOTE:	A = the lateral distance ego-VRU could travel in T_GenVamMax seconds.		

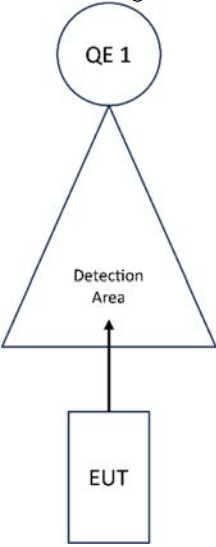# 6.13   Use-Case 1-13 Leave cluster after cluster ID change

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-13
Objective:	Check that EUT leaves the cluster if the cluster leader has changed the cluster ID
Configuration:	Participants: QE 1, EUT. EUT fulfils cluster join conditions (see clause 4.2.2) of QE 1. EUT's *timeClusterIdPersist* is set to 3 s.
Pre-test conditions:	EUT is part of a cluster with QE 1 as cluster leader

REQ /PICS	Tested Requirements	PICS
	1.13	EUT: PICS_CLUSTERING_ENABLED=true QE 1: PICS_CLUSTERING_ENABLED=true PICS_CLUSTER_ID_CHANGE=true

Step	Type	Description	Result
1	Stimulus (by Sender)	QE changes cluster ID and sends VAM with DE *clusterId* set to the new ID.	
2	Verify (by Receiver)	EUT validates received VAM	EUT sends DF clusterLeaveInfo with the old OR the new *clusterId* in its VAMs within 3 s (both are valid). After 3 s, EUT sends the new *clusterId*.

6.14   Use-Case 1-14 Decrease of cluster size after a cluster leaving

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-14
Objective:	Check that EUT decreases the cluster size and bounding box and correctly indicates all contained profile types after a cluster member has leaved the cluster.
Configuration:	Participants: QE 1, QE 2, QE 3, EUT. QE 1 and QE 2 are configured with *numCreateCluster* >= 4, EUT is configured with *numCreateCluster* = 2. QE 1 and QE 2 fulfil cluster join conditions (see clause 4.2.2) of EUT. EUT, QE 1/QE 2 have the same profile type. QE 3 has a different profile type (e.g. EUT, QE 1 and QE 2 are configured with the bicycle profile and QE 3 with the pedestrian profile).
Pre-test conditions:	EUT is cluster leader containing QE 1 and QE 2.

REQ /PICS	Tested Requirements	PICS
	1.8	EUT: PICS_CLUSTERING_ENABLED=true QE: PICS_CLUSTERING_ENABLED=true

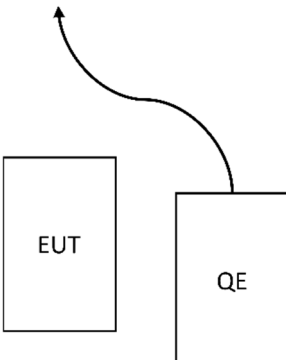| Step	Type	Description	Result
1	Stimulus (by Sender)	QE 2 does not fulfil cluster conditions (see clause 4.2.3) anymore and sends VAM containing DF *clusterLeaveInfo*	
2	Verify (by Receiver)	EUT validates received VAM	EUT decreases the value of the DE *clusterCardinalitySize* to 2. EUT decreases the transmitted bounding box to only include EUT and QE 1. EUT correctly indicates profile types of all members in its sent VAMs.

6.15 Use-Case 1-15 Stop sending VAM if ITS-S is part of CPM

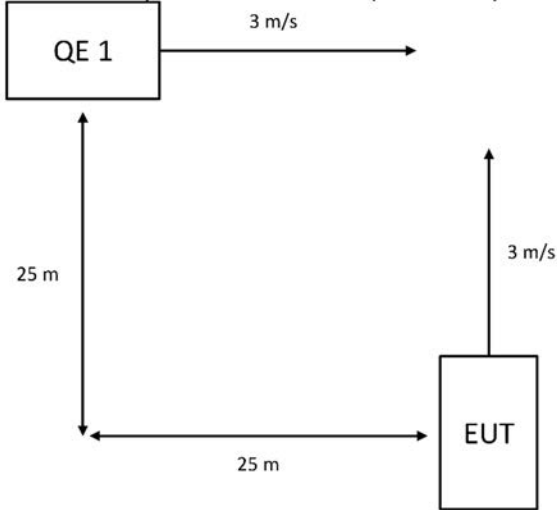| Interoperability Test Description			
Identifier:	TC_ITS_VRU_UC1-15		
Objective:	Check that EUT stops sending individual VAMs if it detects that it is already part of a CPM [2]		
Configuration:	Participants: QE 1, EUT. EUT's *timeClusterJoinNotification* is set to 3 s. QE 1 sends CPMs [2] with detected objects. EUT starts outside of QE 1's sensor detection area to be excluded from QE 1's sent CPMs [2]. During the test, EUT will move into the detection range to find itself in the sent CPMs [2].		
Pre-test conditions:			
REQ /PICS	**Tested Requirements**		**PICS**
	1.6, 1.11		EUT: PICS_CLUSTERING_ENABLED=true PICS_RECV_CPS=true QE: PICS_CLUSTERING_ENABLED=true PICS_SEND_CPS=true
Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	EUT enters detection area of QE 1. QE 1 sends CPM containing EUT as a perceived object.	
2	Verify (by Receiver)	EUT validates received CPM	EUT sends VAMs containing DE *clusterJoinInfo* with ID 0 for 3 s. After that, EUT stops sending individual VAMs
NOTE: The QE could not be emulated in this test.			

6.16   Use-Case 1-16 Start sending VAM if ITS-S is not a part of CPM anymore

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-16
Objective:	Check that EUT sends a cluster leave information and start sending individual VAMs if it is not a part of a CPM [2] anymore.
Configuration:	Participants: QE 1, EUT. EUT's *timeClusterLeaveNotification* is set to 1 s. QE 1 sends CPMs [2] with detected objects. EUT starts inside of QE 1's sensor detection area to be included from QE 1's sent CPMs [2]. During the test, EUT will move out of the detection range. QE 1 EUT
Pre-test conditions:	EUT is a part of a CPM sent by QE 1.

REQ /PICS	Tested Requirements		PICS

	1.5, 1.12		EUT: PICS_CLUSTERING_ENABLED=true
			        PICS_RECV_CPS=true
			
			QE: PICS_CLUSTERING_ENABLED=true
			        PICS_SEND_CPS=true

Step	Type	Description	Result
1	Stimulus (by Sender)	EUT leaves sensor detection area of QE 1. QE 1 sends CPM not containing EUT anymore.	
2	Verify (by Receiver)	EUT validates received CPM	EUT starts sending individual VAMs. EUT sends DF *clusterLeaveInfo* with DE *clusterId*=0 in the VAMs for 1 s.
NOTE: The QE could not be emulated in this test.			

6.17 Use-Case 1-17 Increased safe distance after adverse weather warning

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-17
Objective:	Check that EUT increases the safe distance in case it receives a DENM [3] with adverse weather conditions
Configuration:	Participants: QE 1, QE 2 (optional, see note), EUT. EUT is configured to send *safeDistanceIndication* and *timeToCollision.* QE slowly moves in front of EUT so that EUT indicates a *timeToCollision* with QE 1.

Pre-test conditions:	

REQ /PICS	**Tested Requirements**	**PICS**
	1.15	QE 1 or QE 2: PICS_SEND_DENM_AWC=true EUT: PICS_RECV_DEN_AWC=true

Step	**Type**	**Description**	**Result**
1	Stimulus (by Sender)	QE 1 (or QE 2, see note) sends DENM indicating adverse weather conditions. QE 1 moves in front of EUT while sending VAMs.	
2	Verify (by Receiver)	EUT validates received DENM and VAM	EUT increases the value of DE *timeToCollision* in its VAMs as compared to before
NOTE:	The adverse weather warning can also be sent by a third party, QE 2.This presents a contrast to the calculation of time-to-collision as outlined in the CDD, which does not accommodate for variations in weather conditions.		

6.18 Use-Case 1-18 Trajectory interception probability

Interoperability Test Description	
Identifier:	TC_ITS_VRU_UC1-18
Objective:	Check that EUT sends VAMs with an increasing trajectory interception probability
Configuration:	Participants: QE 1, EUT QE 1 stands perpendicular to EUT with 25 m of longitudinal and lateral offset. QE 1 and EUT start moving towards a common intersection point with approximately. 3 m/s. QE 1 or EUT pass the intersection point closely in front of the other.
Pre-test conditions:	

REQ /PICS	Tested Requirements		PICS
	1.18		EUT: PICS_TII_ENABLED=true

Step	Type	Description	Result
1	Stimulus (by Sender)	QE 1 slowly crosses EUTs pathway while sending VAMs indicating its position.	
2	Verify (by Receiver)	EUT validates received VAM	EUT's sends VAMs with an increased DE *TrajectoryInterceptionProbability* compared to before

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 (EUT) and Qualified Equipment (QE) vendors shall analyse the equipment's capability and select only relevant use-cases.

PICS	Description	Default Value
PICS_CLUSTERING_ENABLED	The ITS-S supports clustering and has it enabled	true
PICS_CLUSTER_CHANGE_CONFIGURATION	The ITS-S supports changing the clustering support during the runtime of the service	true
PICS_RECV_CPS	The ITS-S supports receiving CPM according to [2]	true
PICS_SEND_CPS	The ITS-S supports sending CPM according to [2]	true
PICS_CLUSTER_ID_CHANGE	The ITS-S supports changing the ID of the cluster during the runtime of the service	true
PICS_RECV_DEN_AWC	The ITS-S supports receiving DENMs [3] with adverse weather conditions	true
PICS_SDI_ENABLED	The ITS-S supports *safeDistanceIndication* according to [1] and has it enabled	true
PICS_TII_ENABLED	The ITS-S supports *trajectoryInterceptionIndication* according to [1] and has it enabled	true

History

Document history		
V2.1.1	November 2024	Publication