5th Cooperative Mobility Services Plugtests event;

ETSI

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Foreword

Major TC ITS standards have been recently published, enabling ITS component vendors to design implementations compliant with stable specifications. Ongoing EU projects, like for instance DRIVE-C2X, are using TC ITS standards to develop cooperative system frameworks, as well as to use the cooperative systems in field operational tests to assess the benefit of this technology.

ETSI STF have already produced conformance test specifications and are currently developing a conformance test platform for the assessment of the cooperative systems component compliancy.

ETSI experience with other similar communication technologies (e.g. mobile communicaton systems) shows that compliant systems are not necessarily interoperabable. Furthermore, the tests carried out during the interoperability event are using pragmatical test methods, which are perfectly matching the test needs for prototype ITS implementations.

Conformance testing aims to assess standard compliancy of implementations by checking individual requirements of a single protocol layer against a protocol simulator. But interoperability testing aims to test the interoperability of complete implementations in real conditions, thus exercising the complete system in communication operation to verify their correct behaviour.

1 Scope

This document forms the guidelines to lead the technical organization of the 5th Cooperative Mobility Services Plugtests event. This document is intended to be upgraded for future interoperability events.

This document describes:

• The testbed architecture showing which ITS systems and components are involved and how they are going to interwork

• The configurations used during test sessions, including the parameter values of the different layers (PHY, MAC, NWT, …)

• The interoperability test descriptions, which are describing the scenarios, which the participants will follow to perform the tests.

2 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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2.1 Normative references

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

[1] IEEE 802.11-2012: IEEE Standard for Information technology— Telecommunications and information exchange between systems— Local and metropolitan area networks— Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY).

[2] SAE J2735 (2016-03): "Dedicated Short Range Communications (DSRC) Message Set Dictionary™".

[3] ETSI TS 103 301 V1.1.1 (2016-11): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services".

[4] ETSI EN 302 636-4-1 (V1.2.1): "Intelligent Transport System (ITS); Vehicular communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to multipoint communications; Sub-part 1: Media independent functionalities".

[5] ETSI EN 302 637-2 (V1.3.2): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[6] ETSI EN 302 637-3 (V1.2.2): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".

[7] ETSI EG 202 798 (V1.1.1): "Intelligent Transport Systems (ITS); Testing; Framework for conformance and interoperability testing".

[8] ETSI TS 101 556-1 (V1.1.1): "Intelligent Transport Systems (ITS); Infrastructure to Vehicle Communication; Electric Vehicle Charging Spot Notification Specification"

[9] ETSI TS 102 894-2 (V1.2.2): " Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary"

[10] IETF RFC 7252: "The Constrained Application Protocol (CoAP)"

[11] IETF RFC 7641: "Observing Resources in the Constrained Application Protocol (CoAP)"

[12] IETF RFC 7400: "6LoWPAN-GHC: Generic Header Compression for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)"

[13] IETF RFC 7388: "Definition of Managed Objects for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)"

[14] IETF RFC 7428: "Transmission of IPv6 Packets over ITU-T G.9959 Networks"

3 Definitions and Abbreviations Vehicle equipped with OBU

3.1 Definitions

Host Vehicle Vehicle equipped with an OBU

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CAM Cooperative Awareness Message

CoAP Constrained Application Protocol

CPS Central Position Server

DENM Decentralized Environmental Notification Message

EUT Equipment Under Test

EVCSN Electrical Vehicle Charging Spot Notification Message

GPSD Daemon that receives data from a GPS receiver. It provides a unified interface to receivers of different types, and allows concurrent access by multiple applications

GN GeoNetworking

GN6 IPv6 over GeoNetworking

GVL Geographical Virtual Link

HV Host Vehicle

IoT Internet of Things

ITS-S ITS Station. Can be either RSU or OBU.

MAC Media Access Control layer of the access layers

OBU On Board Unit

PHY The Physical layer of the access layers

RIS ITS Roadside Station

RSU Road Side Unit

RWW Road Works Warning

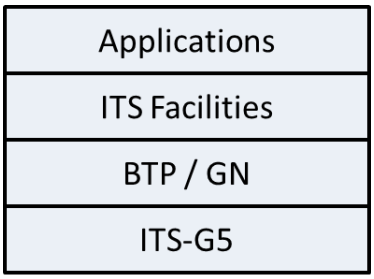
TVL	Topological Virtual Link
VIS	ITS Vehicle Station

4 Configuration

To be updated. Will contain the configuration values to be referenced in the use cases

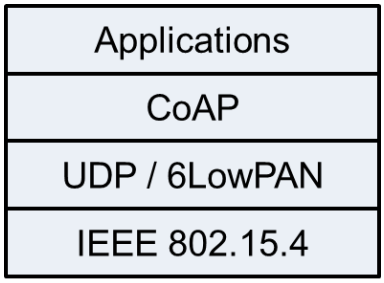
4.1 Protocol stacks in the devices

4.1.1 ITS Station

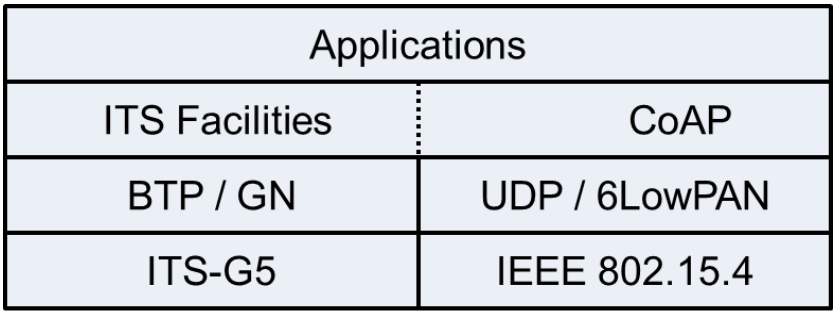


4.1.2 IoT stack

Applications are using either the GET or the OBSERVE methods of COAP. Sensors are playing the role of servers and answer requests from the ITS-S



4.1.3 ITS Station with IoT stack



4.2 Common Rules for GN

Unless specified otherwise in the test description, the messages used in the present test specification shall respect the following common characteristics:

- Maximum repetition time: until the end of the test scenario
- Repetition interval: 1000ms
- Header Type (HT): GEOBROADCAST
- HopLimit: 1
- GeoArea
    - Circular or rectangular
    - Lat/Long: RSU position
    - Distance a/Distance b: 5000 m
    - Azimuth: 0

4.3 Common Rules for DEN messages

Unless specified otherwise in the test description, the DEN messages used in the present test specification shall respect the following common characteristics:

- detectionTime and validityDuration: at reception of the DENMs the event shall be valid, i.e. the detectionTime is in the past and the validityDuration is sufficiently long enough (validityDuration of 1.5 hours is recommended)
- termination: Negation is forbidden. Only cancelation of the own actionID is allowed
- eventPosition:
    - the positionConfidenceEllipse shall be set as follows:

```
positionConfidenceEllipse ::= {
  semiMajorConfidence 100,
  semiMinorConfidence 100,
  semiMajorOrientation 0
}
```

    - altitude shall be set to `0`
- relevanceDistance: `lessThan200m(2)`
- relevanceTrafficDirection: `upstreamTraffic(1)`

For the IoT test, the following triggering considerations will apply when using the polling mode:

- First time the sensor reports a change of condition, if relevant, the application requests an AppDENM_trigger, with a new actionID and Sequence number set to an unused value.

- At next polling events, if the information remains identical, the application requests an AppDENM_update, passing the same actionID. This remains valid until the sensor reports a change of condition.

Timing and period setting of the DENM is independent from the polling period.

4.4 Common rules for IVI messages

Unless specified otherwise in the test description, the IVI messages used in the present test specification shall respect the following common characteristics:

- serviceProviderId:

```
serviceProviderId {
   countryCode '1100 0000 01'B,
   issuerIdentifier event specific value
  }
```

- iviStatus: `new (0)`

- validTo: `end of current day`

4.5 Common rules for SPaT messages

Unless specified otherwise in the test description, the SPAT messages used in the present test specification shall respect the following common characteristics:

The IntersectionState object has two fields that are mandatory for Europe in ISO 19091.

- moy – minutes of the year (0 … 60*24*365)

- timestamp – milliseconds of the minute (0.000 … 60.000)

The fields shall be updated every time a SPaT message is transmitted. At the receiving side it can therefore be used for the following purposes:

- To check if there has been a transit delay or a large difference in clock time between sender and receiver.

- To discard older messages that have arrived via a different path (e.g. via the mobile data network).

4.6 Common rules for Access

All messages defined in the present document shall be sent on the channel type G5-CCH with the channel number 180, see EN 302 663 V1.2.1.

5 ITS Test Scenarios

5.1 UC1

5.1.1 Road Works Warning

5.1.1.1 Overview

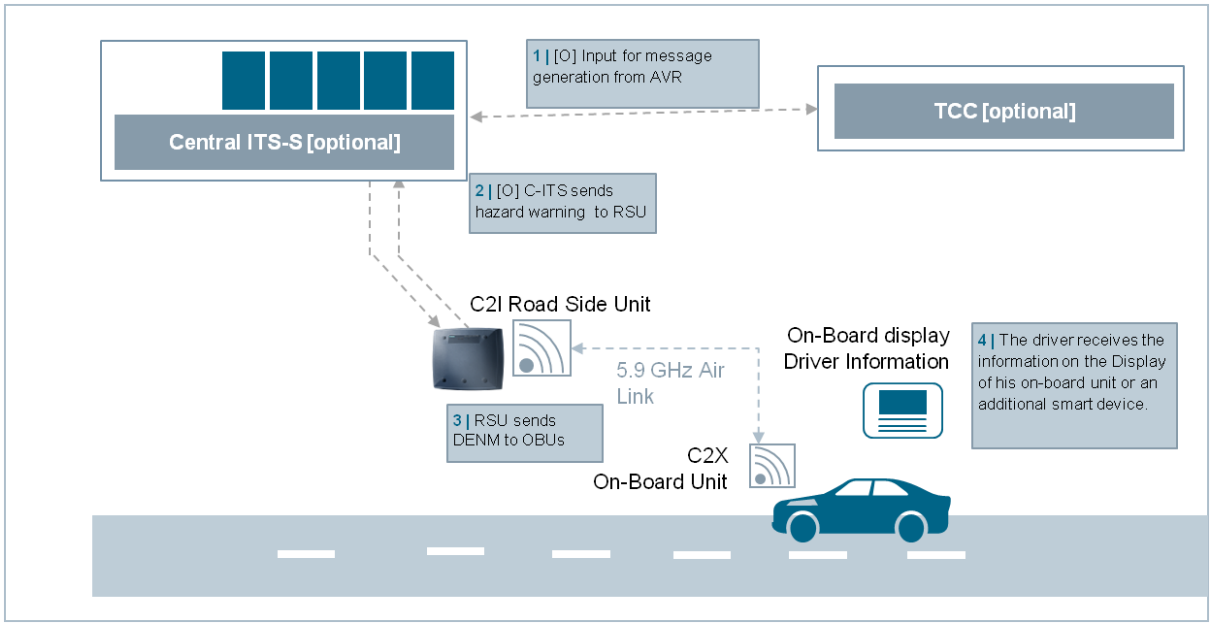


Figure 1:

The objective of this test is to verify the interoperability of ITS OBUs and RSUs in the context of Road Works Warning (RWW). In particular it is determined whether an OBU is able to process RWW specific DENMs which are sent by RSUs. Optionally the DENM content can be defined by a Traffic Control Center (TCC).

The equipment involved:

- Traffic Control Center: Optional
- Central ITS-S: Optional
- RSU: Mandatory
- HV: Mandatory
- HMI: Mandatory

Pre-conditions:

- HV is outside the relevance area
- RSU broadcasts RWW DENMs (pre-configured or via TCC)

Test Sequence:

- HV enters the use case zone on the test track
- HV receives and processes the DENMs
- HV determines that the received DENMs are relevant
- HMI notifies the driver

5.1.1.2 Test Setup

The figure below shows the test setup.

```
D3 {
 management {
  eventPosition POS3,
 },
 situation {
  eventType {
   causeCode roadworks(3),
   subCauseCode 0
  },
  eventHistory EventHistory3
 },
 location {
  traces Trace3
 },
 alacarte {
  roadWorks {
   closedLanes {
    hardShoulderStatus closed(1),
    drivingLaneStatus '0100'B
   },
   speedLimit 30,
   trafficFlowRule passToLeft(3),
   referenceDenms { D1, D2 }
  }
 }
}
```

```
D2 {
 management {
  eventPosition POS2,
 },
 situation {
  eventType {
   causeCode roadworks(3),
   subCauseCode 0
  },
  eventHistory EventHistory2
 },
 location {
  traces Trace2
 },
 alacarte {
  roadWorks {
   closedLanes {
    hardShoulderStatus availableForDriving(2),
    drivingLaneStatus '0011'B
   },
   speedLimit 30,
   trafficFlowRule passToRight(2),
   referenceDenms { D1, D3 }
  }
 }
}
```

```
D1 {
 management {
  eventPosition POS1,
 },
 situation {
  eventType {
   causeCode roadworks(3),
   subCauseCode 0
  },
  eventHistory EventHistory1
 },
 location {
  traces Trace1
 },
 alacarte {
  roadWorks {
   closedLanes {
    hardShoulderStatus availableForDriving(2),
    drivingLaneStatus '0001'B
   },
   speedLimit 30,
   startingPointSpeedLimit POS0,
   trafficFlowRule passToRight(2),
   referenceDenms { D2, D3 }
  }
 }
}
```

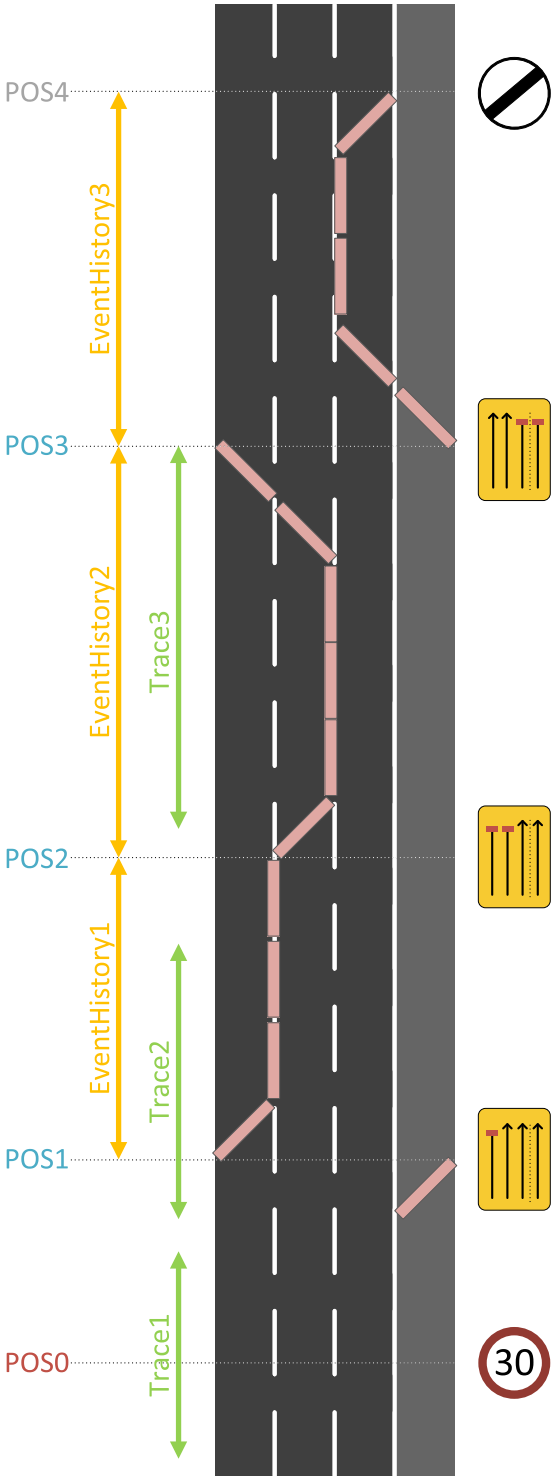
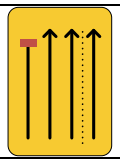
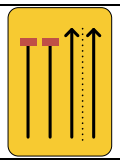
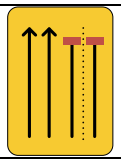
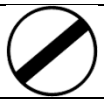


Figure 2: UC1 Test Setup

5.1.1.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC01_01			
Objective:	Process RWW Information			
Configuration:	See Figure 2			
Pre-test conditions:	• HV is outside the relevance area • A single RSU broadcasts RWW DENMs D1, D2 and D3 (pre-configured or via TCC) • HV receives RWW DENMs D1, D2 and D3			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters the use case zone on the test track	
	2	stimulus	HV enters the Relevance Area and synchronizes to the trace of D1	
	3	verify	HMI displays the speed limit before **POS0**	
	4	verify	HMI displays the closed lane information before **POS1**	
	5	stimulus	HV synchronizes to the trace of D2	
	6	verify	HMI displays the closed lane information before **POS2**	
	7	stimulus	HV synchronizes to the trace of D3	
	8	verify	HMI displays the closed lane information before **POS3**	
	9	stimulus	HV passes **POS4**	
	10	verify	HMI shows no more closed lane information and end of speed limitation	

5.2 UC2

5.2.1 Distribution of Road Hazard Signals

5.2.1.1 Overview

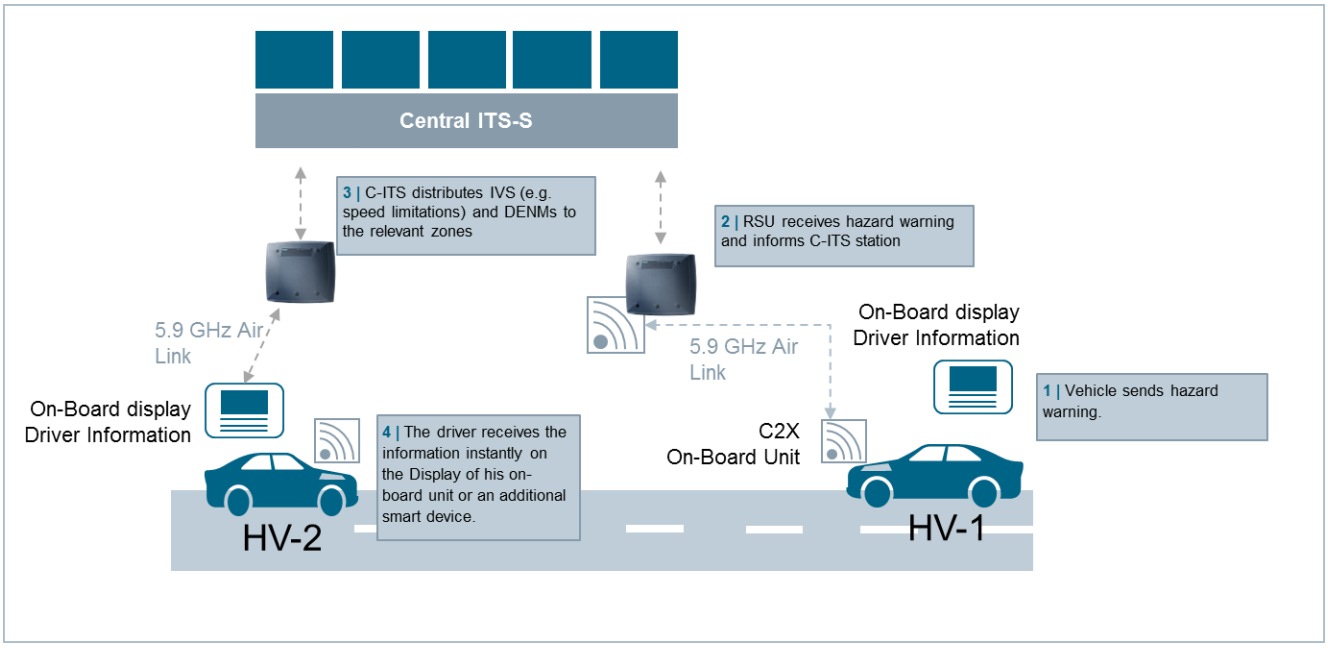


Figure 3:

The objective of this test is to verify the distribution of Road Hazard Signals via Central ITS-S. In particular it is determined whether RSUs are able to transmit and receive DENM information to/from Central ITS-S. The equipment involved:

- Central ITS-S: Mandatory
- RSU-1: Mandatory
- RSU-2: Mandatory
- HV-1: Mandatory
- HV-2: Mandatory
- HMI (HV-2): Mandatory

Pre-conditions:

- RSU-1 and RSU-2 are not in direct communication range
- HV-1 and HV-2 are not in direct communication range
- HV-1 detects dangerous situation
- HV-1 broadcasts Road Hazard DENM

Test Sequence:

- RSU-1 receives Road Hazard DENM
- RSU-1transmits Road Hazard DENM to Central ITS-S
- Central ITS-S dispatches the Road Hazard DENM to RSU-2

- RSU-2 broadcasts Road Hazard DENM
- HV-2 receives and processes the DENM
- HV-2 determines that the received DENM is relevant
- HMI notifies the driver

5.2.1.2 Test Setup

The figure below shows the test setup.

```
D1 {
 management {
  eventPosition POS1,
  relevanceDistance lessThan100m(1),
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode CAUSE_CODE,
   subCauseCode SUB_CAUSE_CODE
  }
}
```

```
D2 {
 management {
  eventPosition POS1,
  relevanceDistance lessThan10km(6),
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode CAUSE_CODE,
   subCauseCode SUB_CAUSE_CODE
  }
}
```

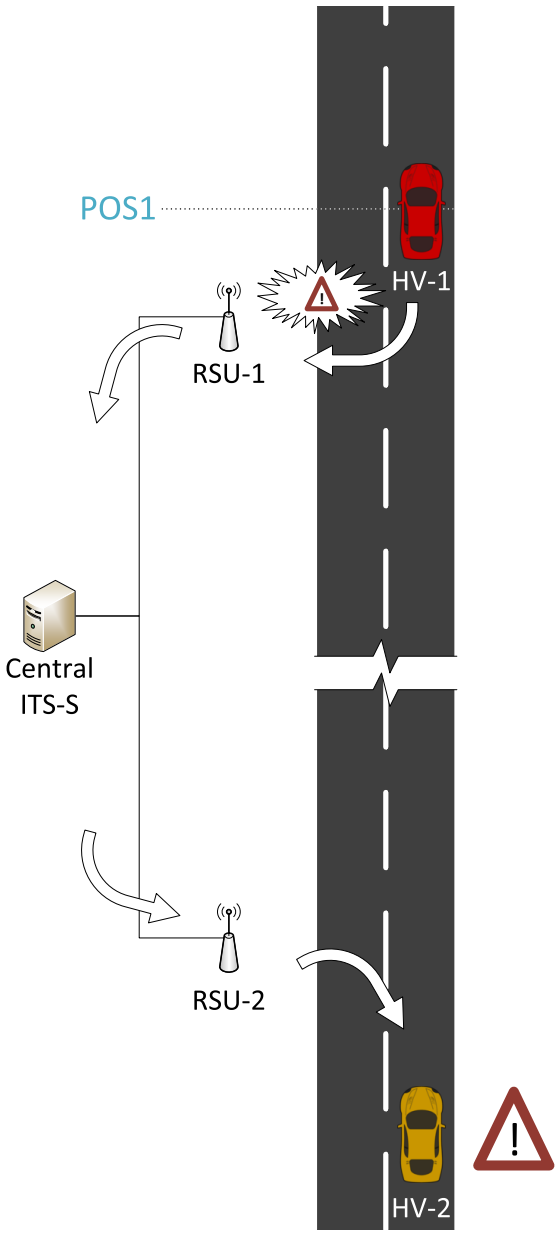


Figure 4: UC2 Test Setup

5.2.1.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC02_01			
Objective:				
Configuration:	See Figure 4			
Pre-test conditions:	• RSU-1 and RSU-2 are not in direct communication range • HV-1 and HV-2 are not in direct communication range			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV-1 detects dangerous situation (Note 1)	
	2	verify	HV-1 broadcasts D1	
	3	verify	RSU-1 transmits D1 to Central ITS-S	
	4	verify	Central ITS-S dispatches D1 to RSU-2	
	5	verify	RSU-2 broadcasts D2	
	6	verify	HMI(HV-2) displays Road Hazard information	
Note 1: HV-1 can detect the dangerous situation by the means of an IoT stack or any other means, see TD_IOT_UC02_01				

5.3 UC3

5.3.1 Time To Green / Traffic Sign Violation

5.3.1.1 Overview

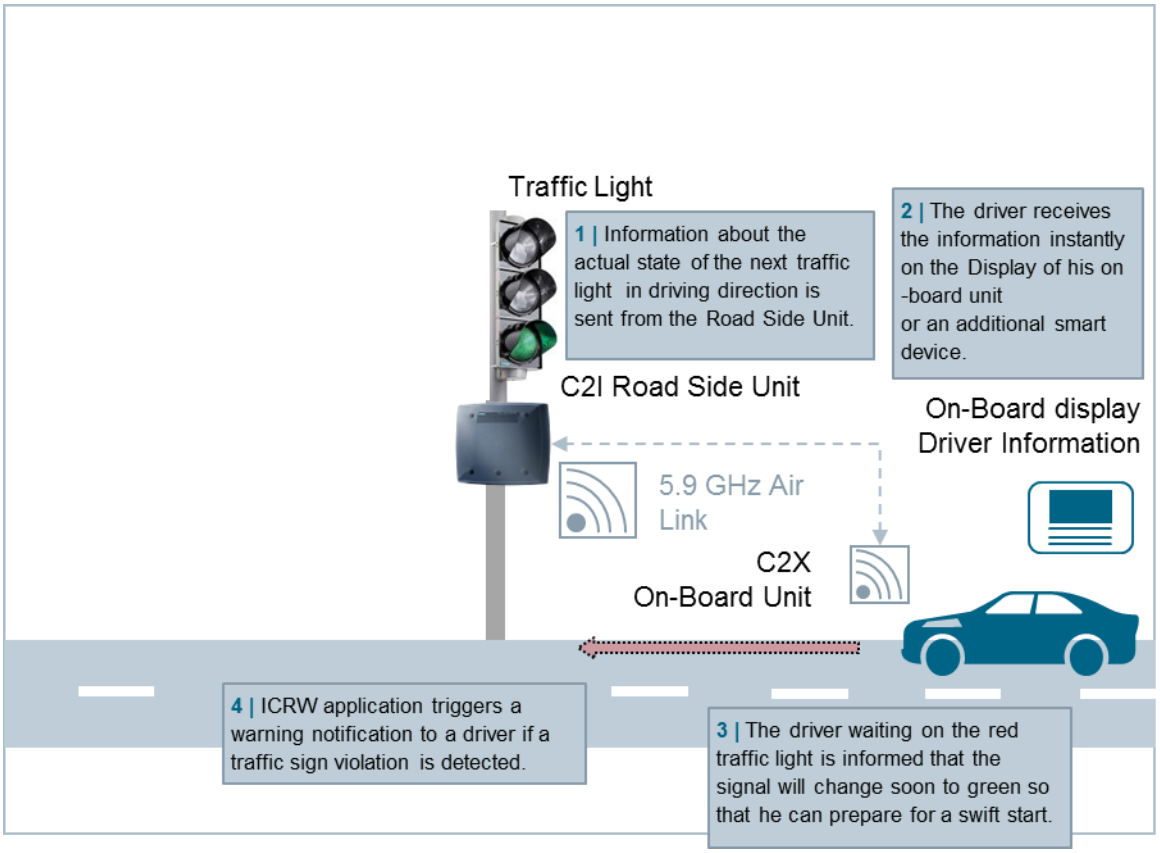


Figure 5:

The objective of this test is to verify the interoperability of ITS OBUs and RSUs in the context of Traffic Light Signalling. In particular it is determined whether an OBU is able to process MAPEM describing intersection and Signalling specific SPATEMs which are sent by RSUs. Optionally the MAPEM and SPATEM content can be defined by a Traffic Control Center (TCC).

The equipment involved:

- Traffic Control Center: Optional
- Central ITS-S: Optional
- RSU: Mandatory
- HV: Mandatory
- HMI: Mandatory

Pre-conditions:

- HV is inside the relevance area
- HV is stopped at the stop-line (alternatively: driving towards the stop-line)
- RSU broadcasts MAPEM and SPATEMs for the intersection (pre-configured or via TCC)

Test Sequence:

- HV enters the use case zone on the test track
- HV receives and processes the MAPEM and SPATEMs
- HMI notifies the driver of the relevant signal states

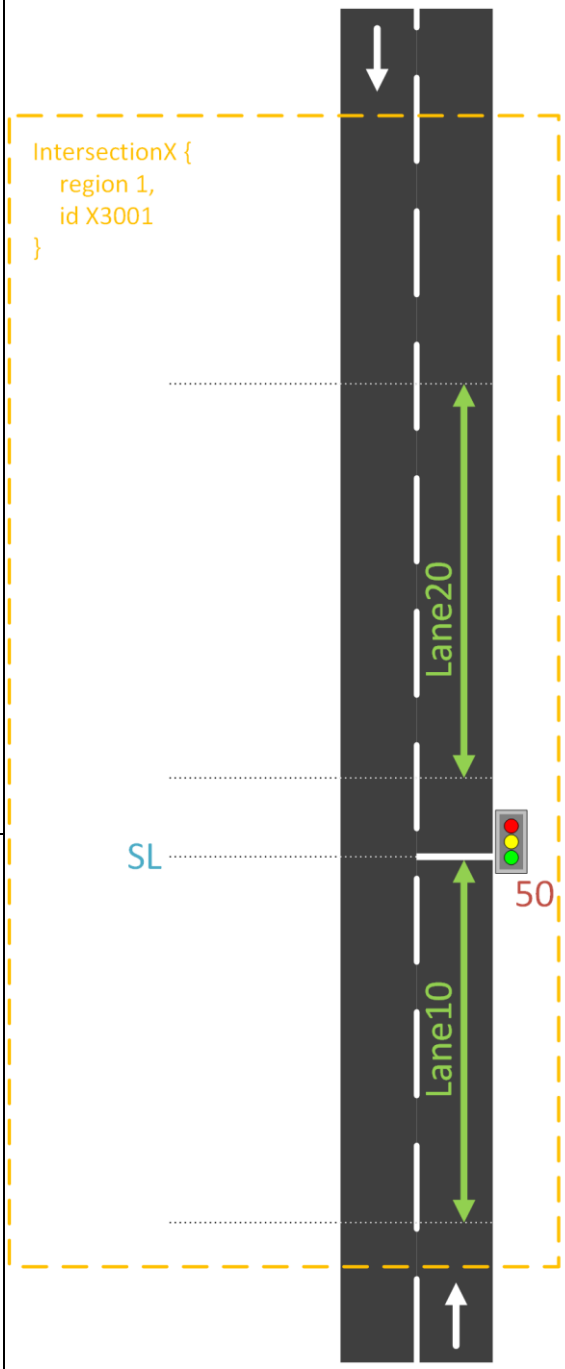
5.3.1.2 Test Setup

The figure below shows the test setup.

Note: SPATEMs described in the present document make use of the following notation for time references fields of type TimeMark: **[CurrentPhaseStartTime + XXs].** The interpretation shall be the following: Add XX seconds to the exact time at which the currently active phase started. This notation provides an abstract way to describe time references in this document, and those fields should however be instantiated as TimeMark values in actual messages. As reminder, TimeMark values are encoded in units of $1/10^{th}$ second from current hour (UTC time), e.g. 9:34:23.11 AM (UTC+2) shall be encoded as 20631 (34 * 60 + 23) * 10 + 1).

```
MAP1 {
 intersections {
  {
   id IntersectionX,
   refPoint refPoint,
   laneSet {
    {
     laneID 10,
     ingressApproach 1,
     laneAttributes ::= {
      directionalUse '10'B,
      sharedWith '0000000000'B,
      laneType := { vehicle '00000000'B }
     },
     nodeList ::= {
      nodes Lane10
     },
     connectsTo {
      {
       connectingLane {
        lane 20
       },
       signalGroup 50
      }
     }
    },
    {
     laneID 20,
     egressApproach 2,
     laneAttributes ::= {
      directionalUse '01'B,
      sharedWith '0000000000'B,
      laneType := { vehicle '00000000'B }
     },
     nodeList ::= {
      nodes Lane20
     }
    }
   }
  }
 }
}
```

```
SPAT1 {
 intersections {
  {
   id IntersectionX,
   status '0000'H,
   states {
    {
     signalGroup 50,
     state-time-speed {
      {
       eventState permissive-Movement-Allowed,
       timing {
        minEndTime [CurrentPhaseStartTime + 30s]
       }
      },
      {
       eventState permissive-Clearance,
       timing {
        startTime [CurrentPhaseStartTime + 30s],
        minEndTime [CurrentPhaseStartTime + 40s]
       }
      }
     }
    }
   }
  }
 }
}
```



```
SPAT2 {
 intersections {
  {
   id IntersectionX,
   status '0000'H,
   states {
    {
     signalGroup 50,
     state-time-speed {
      {
       eventState permissive-Clearance,
       timing {
        minEndTime [CurrentTime + 10s]
       }
      },
      {
       eventState stop-And-Remain,
       timing {
        startTime [CurrentTime + 10s],
        minEndTime [CurrentTime + 30s]
       }
      }
     }
    }
   }
  }
 }
}
```

```
SPAT3 {
 intersections {
  {
   id IntersectionX,
   status '0000'H,
   states {
    {
     signalGroup 50,
     state-time-speed {
      {
       eventState stop-And-Remain,
       timing {
        minEndTime [CurrentPhaseStartTime + 20s]
       }
      },
      {
       eventState permissive-Movement-Allowed,
       timing {
        startTime [CurrentPhaseStartTime + 20s],
        minEndTime [CurrentPhaseStartTime + 50s]
       }
      }
     }
    }
   }
  }
 }
}
```

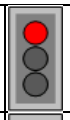
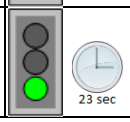
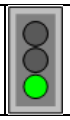
Figure 6: UC3 Test Setup

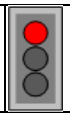
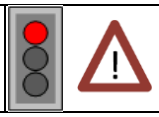
SPAT messages SPAT1, SPAT2 and SPAT3 are sent in a loop with the following timing:

SPATEM	Repetition Duration	Repetition Interval
SPAT1	30s	1s
SPAT2	10s	1s
SPAT3	20s	1s

Figure 7: SPATEM timing for UC3

5.3.1.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC03_01			
Objective:	Process Signalling information and indicate Time To Green			
Configuration:	See Figure 6			
Pre-test conditions:	• RSU broadcasts IntersectionX MAPEM MAP1 (pre-configured or via TCC) • RSU broadcasts sequentially SPATEMs SPAT1 (30s), SPAT2 (10s) and SPAT3 (20s) • HV receives MAPEM MAP1 • HV approaches the stop-line **SL**			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV receives SPATEM SPAT3	
	2	verify	HMI indicates that current traffic light status is 'red'	
	3	verify	HMI indicates timing information to next green light	
	4	stimulus	HV receives SPATEM SPAT1	
	5	verify	HMI indicates that current traffic light status is 'green'	

Interoperability Test Description				
Identifier:	TD_ITS_UC03_02			
Objective:	Process Signalling information and indicate Traffic Sign Violation			
Configuration:	See Figure 6			
Pre-test conditions:	• RSU broadcasts IntersectionX MAPEM MAP1 (pre-configured or via TCC) • RSU broadcasts alternatively SPATEMs SPAT1 (30s), SPAT2 (10s) and SPAT3 (20s) • HV receives MAPEM MAP1 • HV approaches the stop-line **SL**			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV receives SPATEM SPAT3	
	2	verify	HMI indicates that current traffic light status is 'red'	
	3	stimulus	HV drives over stop-line	
	4	verify	HMI indicates Traffic Sign Violation	

5.4 UC4

5.4.1 Vehicle Data Aggregation

5.4.1.1 Overview

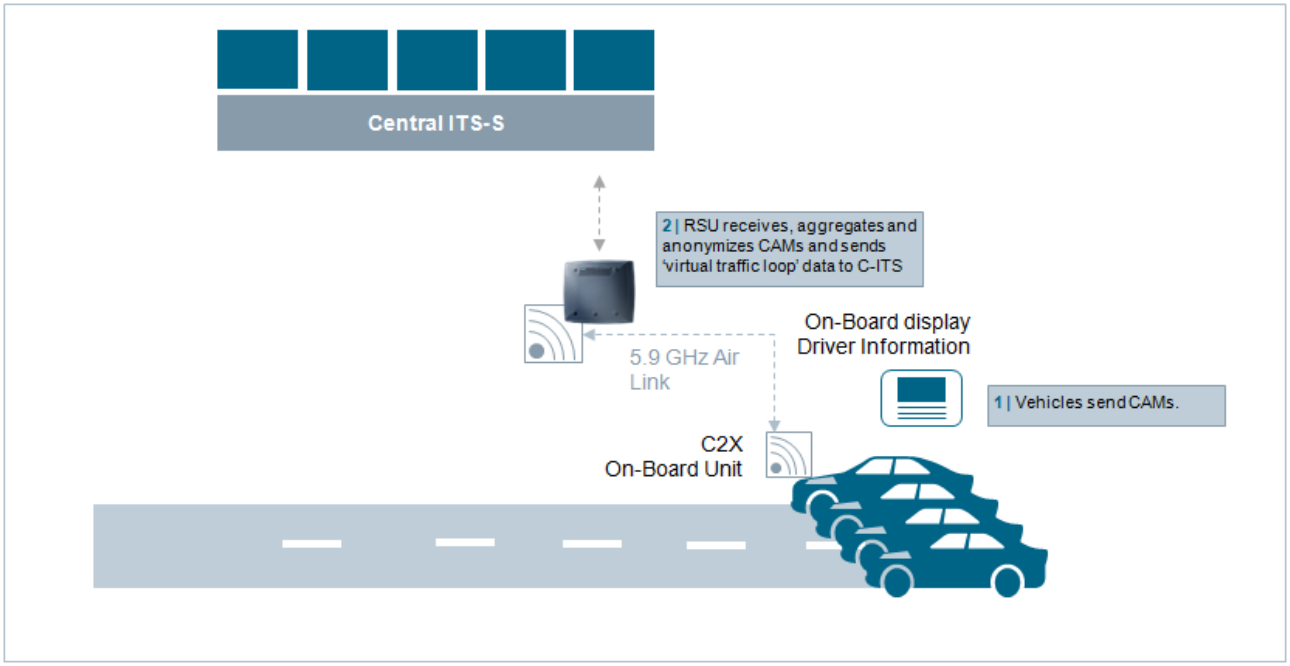


Figure 8:

5.4.1.2 Test Setup

As shown in clause 5.4.1.1 Overview.

5.4.1.3 Test Procedure

No specific requirements on the test procedure.

5.5 UC5

5.5.1 In-Vehicle Signage

5.5.1.1 Overview

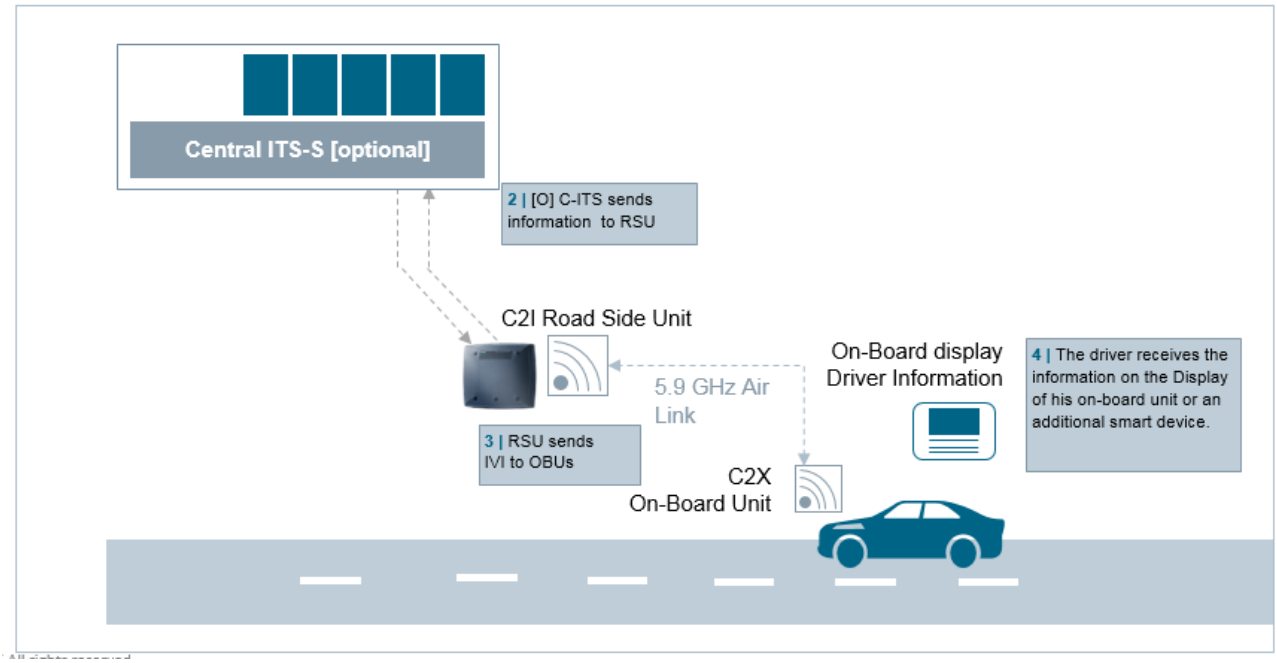


Figure 9:

The objective of this test is to verify the interoperability of ITS OBUs and RSUs in the context of In-Vehicle Signage. In particular it is determined whether an OBU is able to process IVI messages describing current road signalling which are sent by RSUs. Optionally the IVI message content can be defined by a Traffic Control Center (TCC).

The equipment involved:

- Traffic Control Center: Optional
- Central ITS-S: Optional
- RSU: Mandatory
- HV: Mandatory
- HMI: Mandatory

Pre-conditions:

- HV approaches the relevance area
- RSU broadcasts IVI messages

Test Sequence:

- HV enters the relevance area
- HV receives and processes the IVI messages
- HMI notifies the driver of the current road signalling information

5.5.1.2 Test Setup

The figure below shows the test setup.

```
IVI1 {
 optional {
  {
   glc : {
    referencePosition POS1,
    parts {
     {
      zoneId 1,
      zone segment : {
       line deltaPositions : Trace1
      }
     },
     {
      zoneId 2,
      zone segment : {
       line deltaPositions : Trace2
      }
     }
    }
   },
   giv : {
    {
     detectionZoneIds {1},
     relevanceZoneIds {2},
     direction sameDirection=0,
     minimumAwarenessTime 4,
     iviType regulatoryMessages=1,
     roadSignCodes {
      {
       code iso14823 : {
        pictogramCode {
         serviceCategoryCode
          trafficSignPictogram : regulatory=1,
         pictogramCategoryCode {
          nature 5,
          serialNumber 57
         }
        },
        attributes {
         spe : {
          spm SpeedLimit,
          unit kmperh=0
         }
        }
       }
      }
     }
    },
    {
     detectionZoneIds {1},
     relevanceZoneIds {2},
     direction sameDirection=0,
     minimumAwarenessTime 15,
     iviType regulatoryMessages=1,
     vehicleCharacteristics {
      {
       train {
        equalTo {
         euVehicleCategoryCode : euVehicleCategoryN : n2,
         euVehicleCategoryCode : euVehicleCategoryN : n3
        },
        ranges {
         {
          comparisonOperator greaterThan=0,
          limits vehicleWeightLimits : {
           vehicleMaxLadenWeight 0,
           vehicleTrainMaximumWeight 750,
           vehicleWeightUnladen 0
          }
         }
        }
       }
      }
     },
     roadSignCodes {
      {
       code iso14823 : {
        pictogramCode {
         serviceCategoryCode
          trafficSignPictogram : regulatory=1,
         pictogramCategoryCode {
          nature 5,
          serialNumber 44
         }
        }
       }
      }
     }
    }
   }
  }
 }
}
```

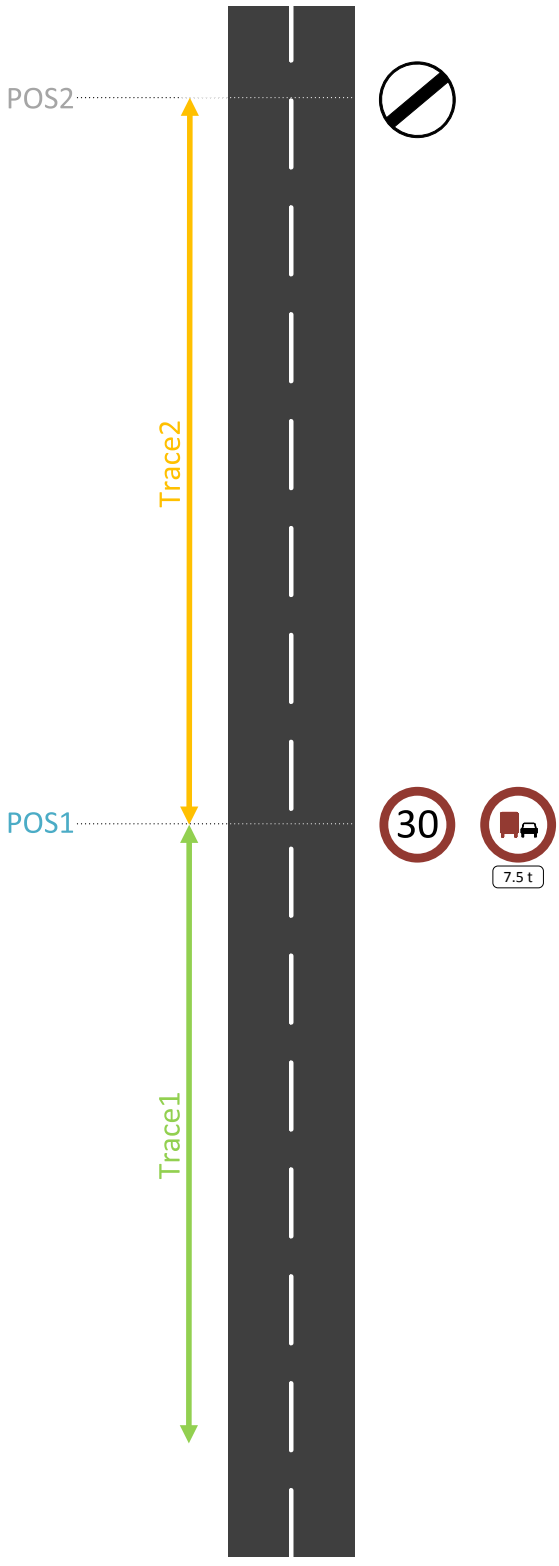
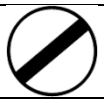


Figure 10: UC5 Test Setup

5.5.1.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC05_01			
Objective:	Process In-Vehicle Signalling information			
Configuration:	See Figure 10			
Pre-test conditions:	• RSU broadcasts IVI message IVI1 (pre-configured or via TCC) • HV receives IVI message IVI1 • HV approaches relevance zone			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters relevance zone at **POS1**	
	2	verify	HMI display current road signalling information: • Overtaking forbidden for trucks above 7.5t • Speed limitation **SpeedLimit**	
	3	stimulus	HV exits relevance zone at **POS2**	
	4	verify	HMI stop displaying previous road signalling information	

5.6 UC6

5.6.1 Intersection Collision Risk Warning

5.6.1.1 Overview

- HV (host vehicle under test) will run ICRW.
- Target speed of RV can be 20/40 kmh (depends on real traffic situations)
- The distance (testing criteria) between cone RV-A and cone RV-D can be 50m/25m (can be changed according to a vendor's implementation) with respect to the target speed 20/40 kmh.

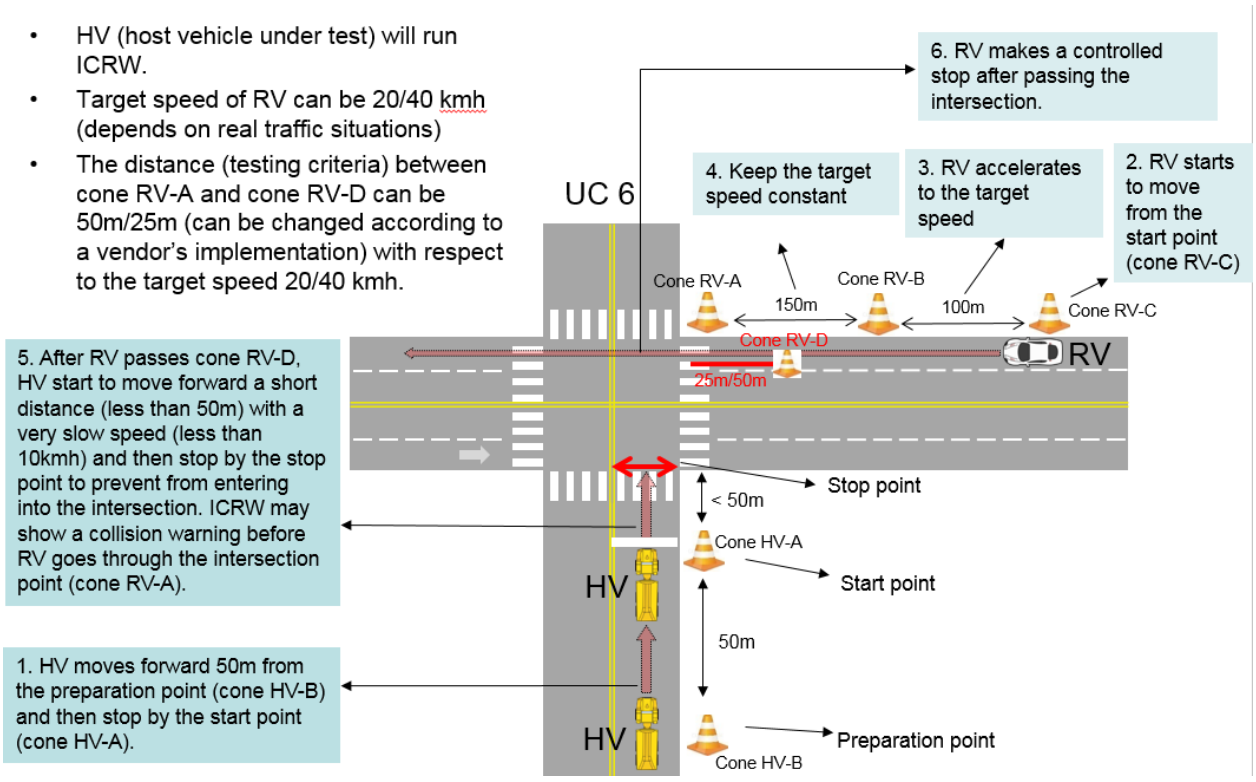


Figure 11: UC6 Test setup

The objective of this test is to verify the Intersection Collision Risk Warning (ICRW) scenario. In particular it is determined whether an OBU is able to process CAM messages from other vehicle to determine a potential collision risk.

The equipment involved:

- RV: Mandatory
- HV: Mandatory
- HMI (HV): Mandatory

5.6.1.2 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC06_01			
Objective:	Process Signalling information and indicate Time To Green			
Configuration:	See Figure 11			
Pre-test conditions:	• HV is running ICRW • HV is positioned at point HV-B and sends CAMs • RV is positioned at point RV-C and sends CAMs • RV is accelerating to TARGET_SPEED between points RV-C and RV-B			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	RV passes point RV-D	
	2	stimulus	HV drives towards point HV-A and stops	
	3	verify	HMI indicates a forward collision risk before RV passes point RV-A	 intersection collision

5.7 UC7

5.7.1 Longitudinal Collision Risk Warning

5.7.1.1 Overview

- HV (vehicle under test) will run LCRW
- The distance (testing criteria) between the point A and the emulator is 20m (can be changed according to a vendor's implementation).

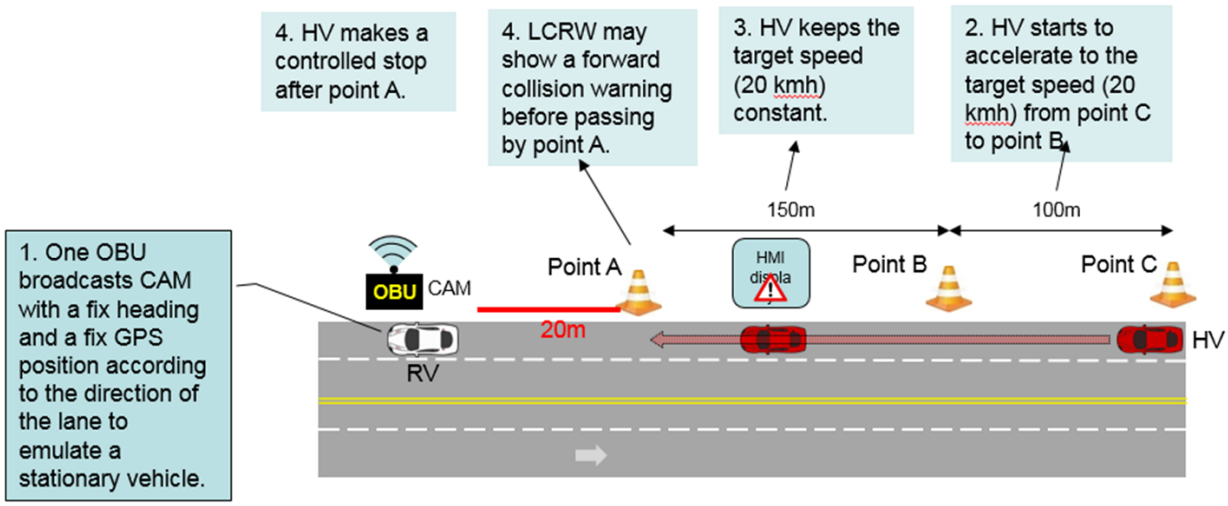


Figure 12: UC7 Test setup

The objective of this test is to verify the Longitudinal Collision Risk Warning (LCRW) scenario. In particular it is determined whether an OBU is able to process CAM messages from other vehicle to determine a potential collision risk.

The equipment involved:

- RV: Mandatory
- HV: Mandatory
- HMI (HV): Mandatory

5.7.1.2 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC07_01			
Objective:				
Configuration:	See Figure 12			
Pre-test conditions:	• HV is running LCRW • RV is stationary and sends CAMs • HV is accelerating to TARGET_SPEED between points C and B			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV passes point B	
	2	verify	HMI indicates a forward collision risk before point A	 Forward collision

5.8 UC8

This use case is described in clause 6.3 of the present document.

5.9 UC9

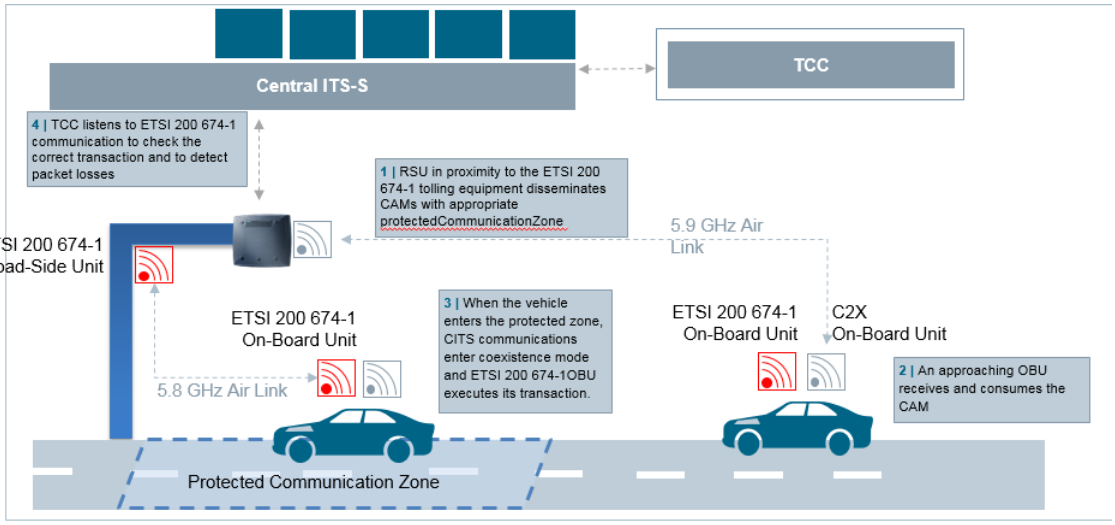


Figure 13: Mitigation

5.9.1 Overview

The objective of this test is to verify the correct coding of the ProtectedCommunicationZonesRSU message in a CAM, the correct decoding of the ProtectedCommunicationZonesRSU message from a CAM. Optionally, the TX power reduction mitigation method can be verified.

The equipment involved:

- ITS RSU
- ITS OBU

5.9.2 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC09_01			
Objective:	OBU with interference mitigation by TX power reduction			
Configuration:	See Figure 13: Mitigation			
Pre-test conditions:	• ITS RSU sends ProtectedCommunicationZonesRSU messages • ITS OBU has received ProtectedCommunicationZonesRSU messages • ITS OBU is outside the ProtectedCommunicationZone			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV moves into the protected Zone	
	2	verify	The TX power level of the ITS OBU inside the protected zone shall be less than or equal to 10 dBm	
	3	verify	HMI indicates the interference mitigation mode	Mitigation Mode
Note 1	An additional ITS receiver installed in the HV can monitor the TX power level of the ITS OBU. Alternatively, a peak envelope power meter can be used.			
Note 2	A measurement relative to the typical TX power level declared by the manufacturer is sufficiently accurate			

5.10 UC10

5.10.1 Authorization Tickets Reloading

5.10.1.1 Overview

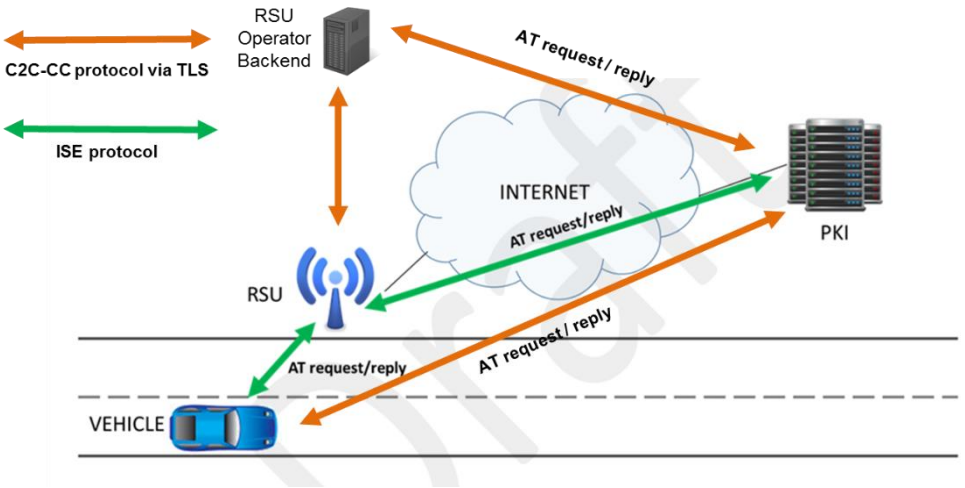


Figure 14: Authorization Tickets Reloading

The objective of this test is to verify the Authorization Tickets Reloading scenario. In particular it is determined whether an OBU or a RSU is able to request and receive an authorization ticket from a PKI.

The equipment involved:

- PKI: Mandatory
- OBU/RSU: Mandatory
- IP Gateway (RSU): Optional

5.10.1.2 Test Procedure

Interoperability Test Description			
Identifier:	TD_ITS_UC10_01		
Objective:	Authorization Tickets Reloading		
Configuration:	See Figure 14		
Pre-test conditions:	• OBU/RSU registered with PKI • OBU/RSU obtained enrolment certificate • IP Connectivity established between OBU/RSU and PKI (IPv6 prefix delegation configured on IPv6 backbone for RSU) • RSUs broadcasts Router Advertisement		
Test Sequence:	**Step**	**Type**	**Description**
	1	stimulus	Trigger Authorization Tickets Reloading
	2	verify	OBU/RSU sends an AuthorizationRequest
	3	verify	OBU/RSU receives the AuthorizationResponse
	4	verify	OBU/RSU sends secured DENMs signed using the obtained AT certificate
Note1: The test sequence is valid for an OBU as well as for a RSU. Note2: RSUs providing a GN6 connection can be used as IP gateways by the OBUs. Otherwise OBUs can connect to a PKI using other means of IP connections.			

6 IoT Test Scenarios

6.1 UC1

6.1.1 Hazard on the Road

6.1.1.1 Overview

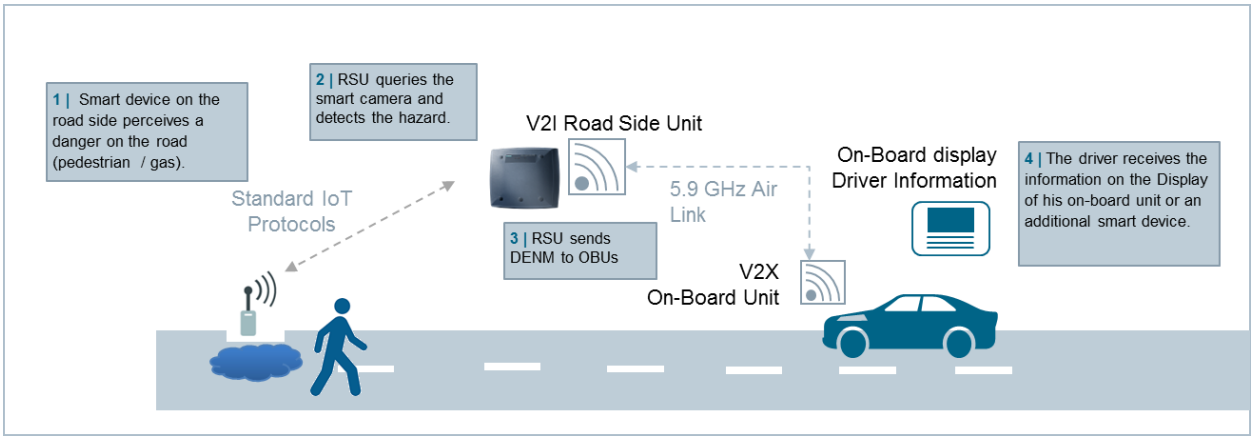


Figure 15: Hazard on the road

The objective of this test is to verify the interoperability of ITS OBUs and RSUs in the context of a Hazard on the Road Warning (HRW) detected by an IoT-enabled Smart device. Hazard on the road can be of any nature, such as pedestrian or fuel.

Can be mapped to ETSI BSA TR 102 638:

- Active road safety; Driving assistance; Road hazard signalling (RHS)

- Smart mobility; Urban mobility; Vulnerable road user Warning (Also part of TR 103 300, Release 2)

The equipment involved:

- RSU: Mandatory
- HV: Mandatory
- HMI: Mandatory
- Smart Device (IoT-enabled): Mandatory

Pre-conditions:

- HV is outside the relevance area
- Smart device detects the hazard and is ready to send the CoAP message

Test Sequence:

- HV enters the use case zone on the test track
- RSU queries the Smart device and detects hazard condition
- RSU broadcasts HRW DENMs (pre-configured)
- HV receives and processes the DENM
- HV enters the relevance area. It determines that the received DENM is relevant
- HMI notifies the driver

6.1.1.2 Test Setup

The figure below shows the test setup.

```
CoAP-GET {
 GET coap://<addr>:5683/rhs
}
```

```
CoAP-ACK {
 2.05 Content
 Content-Format: application/json
 "CauseCode" : CAUSE_CODE, "SubCauseCode": SUB_CAUSE_CODE
}
```

```
D1 {
 management {
  eventPosition POS,
  relevanceDistance lessThan100m(1)
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode CAUSE_CODE,
   subCauseCode SUB_CAUSE_CODE
  },
 }
}
```

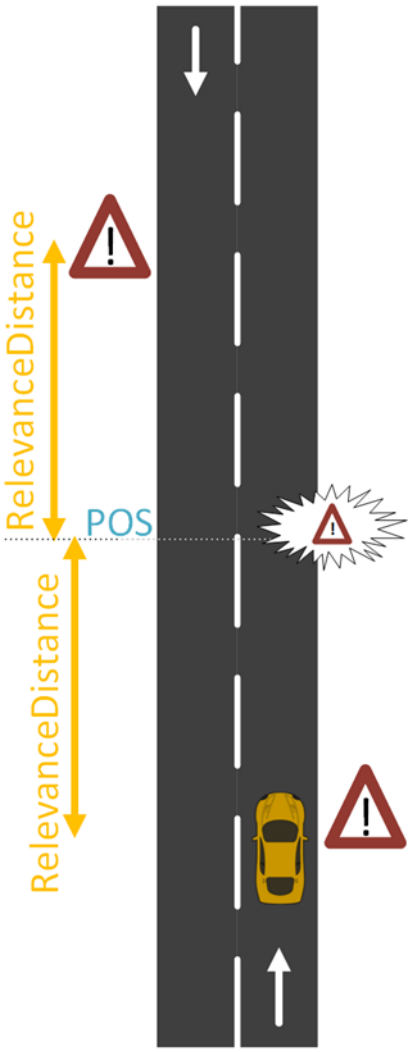


Figure 16: Test Setup

6.1.1.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_IOT_UC01_01			
Objective:	Process Hazard on the Road Warning (HRW) Information			
Configuration:	See Figure 16			
Pre-test conditions:	• HV is outside the relevance area • Smart device detects the hazard and is ready to send the CoAP message			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters the use case zone on the test track	
	2	verify	RSU queries the Smart device and detects hazard condition	
	3	verify	RSU broadcasts D1	
	4	stimulus	HV enters the Relevance Area	
	5	verify	HMI displays the Hazard on the Road Warning	

6.2 UC2

6.2.1 Detection of dangerous goods information and local dissemination

6.2.1.1 Overview

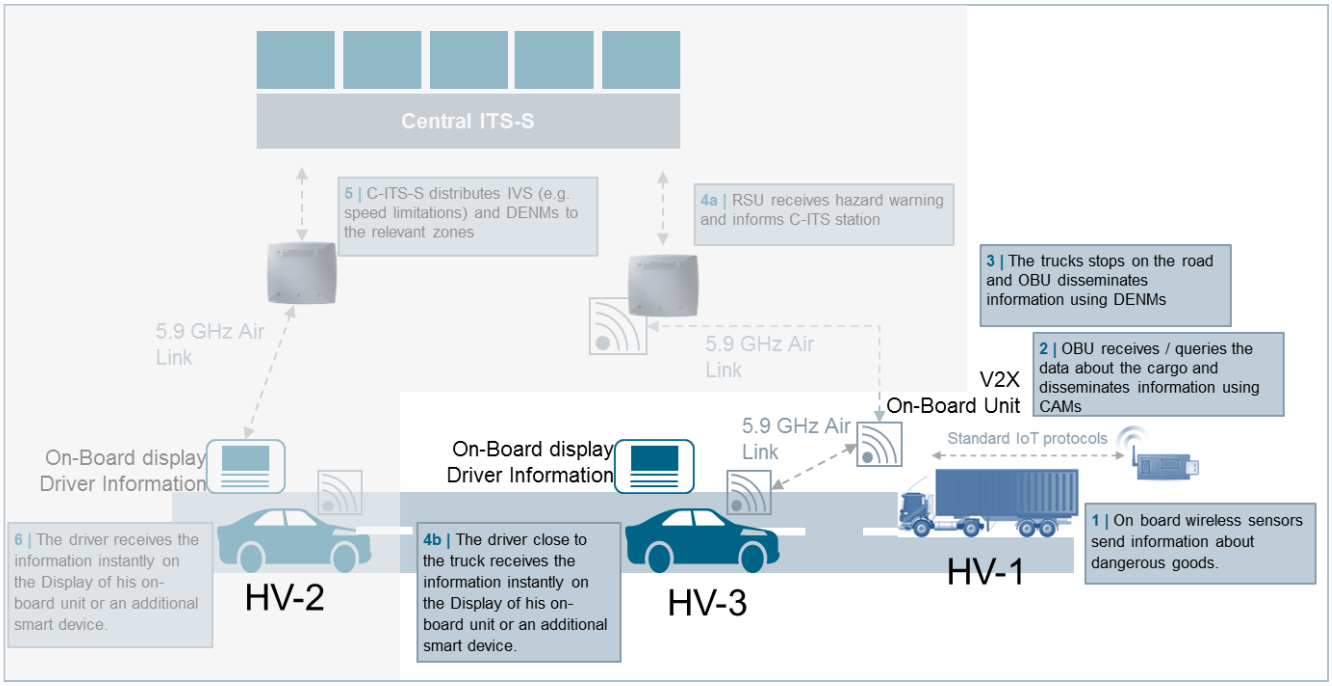


Figure 17: Detection of dangerous goods information and local dissemination

The objective of this test is to verify the interoperability of ITS OBUs in the context of the distribution of dangerous goods information using CAMs and SVW (Stationary Vehicle Warning) DENMs.

<u>Can be mapped to ETSI BSA TR 102 638:</u>

- Active Road safety; Cooperative awareness.

- Active Road safety; Driving assistance – Road hazard Signalling (RHS); Stationary vehicle.

The equipment involved:

- HV (x2): Mandatory
- HMI (x2): Mandatory
- Smart Device: on-board wireless sensors (IoT-enabled): Mandatory

Pre-conditions:

- HV-1 driving on the road with cargo of dangerous goods
- HV-3 is outside the relevance area
- HV-1 queries the Smart Device and broadcasts pre-configured CAMs

Test Sequence:

- HV-3 enters the relevance area and parks on the side of the road

- HV-3 receives and processes the CAM with dangerous goods information
- HV-3 OBU Application notifies the driver via HMI if required
- HV-1 stops on the road. OBU disseminates information using SVW DENMs (pre-configured)
- HV-3 receives and processes the DENM
- HV-3 determines that the received DENMs are relevant
- HMI notifies the driver

6.2.1.2 Test Setup

The figure below shows the test setup.

```
CoAP-REQ {
 GET coap://<addr>:5683/dangerous-goods
}
```

```
CoAP-ACK {
 2.05 Content
 Content-Format: application/json
 "CauseCode" : CAUSE_CODE, "SubCauseCode": SUB_CAUSE_CODE
}
```

```
C1 {
 lowFrequencyContainer {
  basicVehicleContainerLowFrequency {
   vehicleRole dangerousGoods(3)  },
 },
 specialVehicleContainer {
  dangerousGoodsContainer {
   dangerousGoodsBasic DangerousGoodsType,
  }
 }
}
```

```
D1 {
 management {
  eventPosition POS,
  relevanceDistance lessThan100m(1),
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode CAUSE_CODE,
   subCauseCode SUB_CAUSE_CODE
  }
 alacarte {
  stationaryVehicle {
   carryingDangerousGoods {
    DangerousGoodsBasic DangerousGoodsType,
    unNumber            Number,
    elevatedTemperature FALSE,
    tunnelsRestricted   FALSE,
    limitedQuantity     TRUE,
   },
  }
 }
}
```

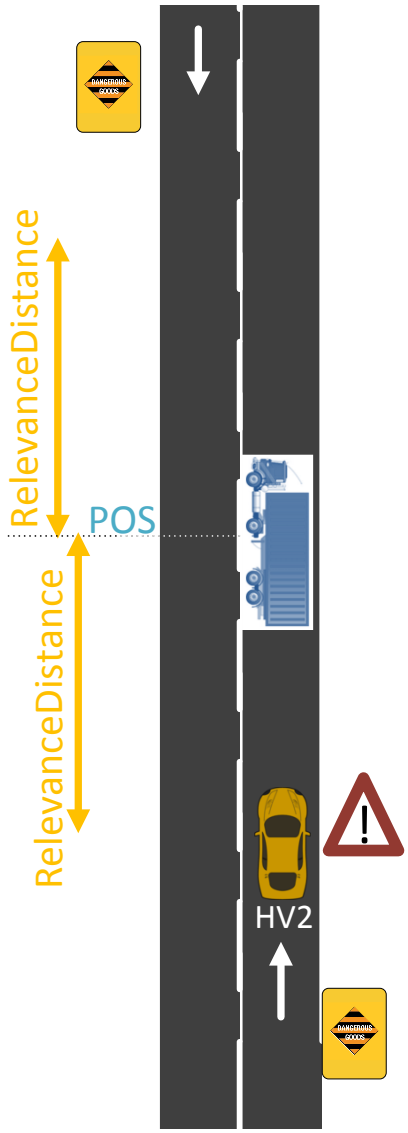


Figure 18: Test Setup

6.2.1.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_IOT_UC02_01			
Objective:	Process dangerous goods information using CAMs and SVW (Stationary Vehicle Warning) DENMs			
Configuration:	See Figure 4			
Pre-test conditions:	• HV-1 driving on the road with cargo of dangerous goods. • HV-3 is outside the relevance area • HV-1 queries the Smart Device and broadcasts C1			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV-3 enters the Relevance Area	
	2	verify	HMI (HV-3) optionally displays presence of dangerous goods	
	3	stimulus	HV-1 stops on the road.	
	4	verify	HV-1 broadcasts D1	
	5	verify	HMI (HV-3) displays the Stationary Vehicle Warning and Presence of Dangerous Goods	 
Note 1: This test can be executed in conjunction with TD_ITS_UC02_01				

6.3 UC8

6.3.1 Loading zone management

6.3.1.1 Overview

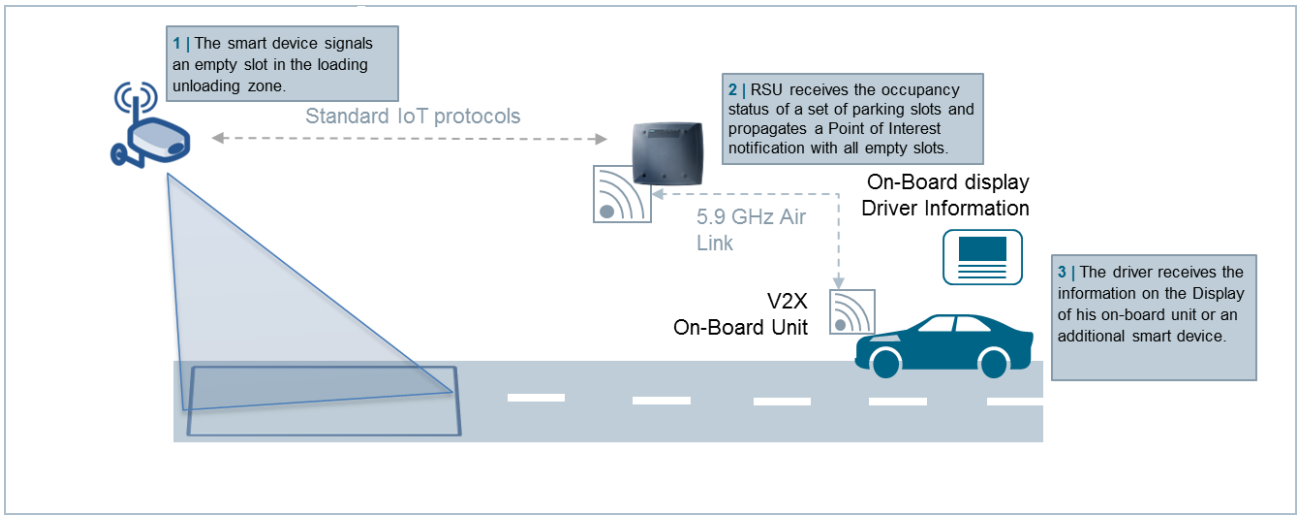


Figure 19: Loading zone management

The objective of this test is to verify the interoperability of ITS OBUs and RSUs in the context of the distribution of a loading zone availability notification (PoI Notification) detected by an IoT-enabled Smart device.

Can be mapped to ETSI BSA TR 102 638:

- Smart Mobility; Location based services; Point of Interest Notification

- Smart Mobility; Communities services; Loading zone management

The equipment involved:

- RSU: Mandatory
- HV: Mandatory
- HMI: Mandatory
- Smart Device (IoT-enabled): Mandatory

Pre-conditions:

- HV is outside the relevance area
- Smart Device monitors the loading zone.

Test Sequence:

- RSU queries the Smart Device and detects empty slot condition
- RSU broadcasts PoI notification (pre-configured)
- HV enters the use case zone on the test track
- HV receives and processes the Point Of Interest message
- HV OBU Application notifies the driver via HMI if required

6.3.1.2 Test Setup

The figure below shows the test setup.

```
CoAP-REQ {
 GET coap://<addr>:5683/parking
}
```

```
CoAP-ACK {
 2.05 Content
 Content-Format: application/json
 "parking_slots":"CSID":TRUE
}
```

```
E1 {
 evcsnData {
  totalNumberOfStations 1,
  chargingStationsData {
   chargingStationID CSID,
   chargingStationLocation POS
   accessibility "open",
   openingDaysHours "open",
   pricing "open",
   chargingSpotsAvailable {
    type other(15),
    typeOfReceptacle "loading zone",
    parkingPlacesData {
     maxWaitingTimeMinutes 0,
     blocking FALSE,
    },
   },
  },
 },
}
```

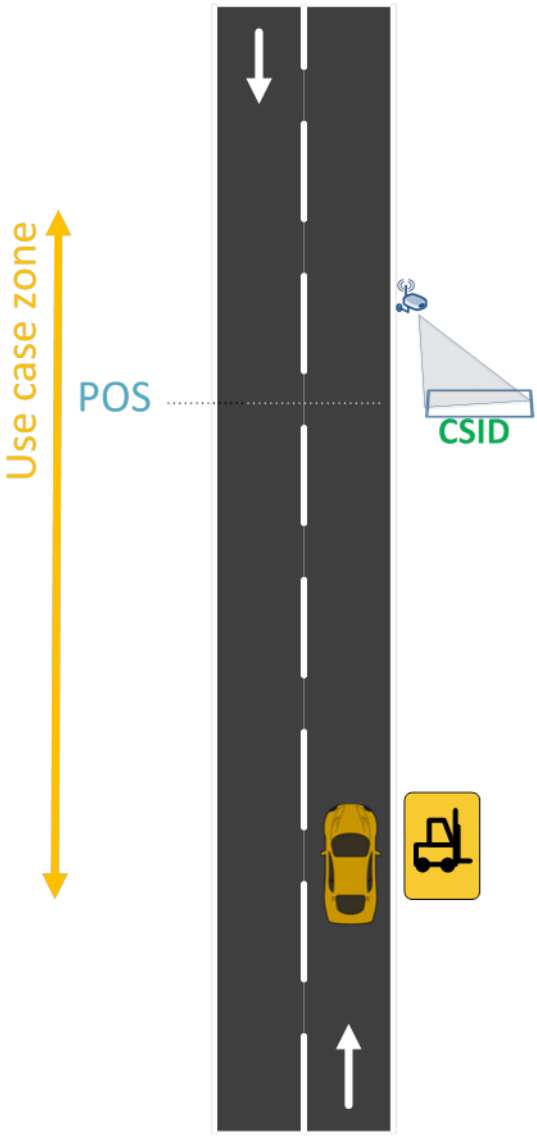


Figure 20: Test Setup

6.3.1.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_IOT_UC08_01			
Objective:	Process PoI Notification			
Configuration:	See Figure 20: Test Setup			
Pre-test conditions:	• HV is outside the relevance area • Smart Device monitors the loading zone.			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	RSU queries the Smart Device and detects empty slot condition	
	2	verify	RSU broadcasts E1	
	3	stimulus	HV enters the use case zone on the test track	
	4	verify	HMI displays the notification