1st Cellular V2X Plugtests Event;
ETSI Field Based Interoperability Test Plan;

PLUGTESTS™
INTEROP EVENTS

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Foreword

This Plugtests guide has been produced by ETSI Center of Testing and Interoperability (CTI).

1 Scope

This document forms the guidelines to lead the technical organization of the 1st CV2X 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.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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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 (V1.4.0): "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 (V1.4.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[6] ETSI EN 302 637-3 (V1.3.1): "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 (V1.3.1): " Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary"

[10] ETSI EN 303 613 (V 1.1.1): “Intelligent Transport Systems (ITS); LTE-V2X Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band

[11] ETSI TS 136 331 (V14.6.2): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (3GPP TS 36.331 version 14.6.2 Release 14)".

[12] ETSI TS 136 321 (V14.7.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification (3GPP TS 36.321 version 14.7.0 Release 14)".

[13] ETSI TS 136 322 (V14.1.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification (3GPP TS 36.322 version 14.1.0 Release 14)".

[14] ETSI TS 136 323 (V14.5.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) specification (3GPP TS 36.323 version 14.5.0 Release 14)".

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

CPS Central Position Server

DENM Decentralized Environmental Notification Message

EUT Equipment Under Test

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

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

LTE Long Term Evolution

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

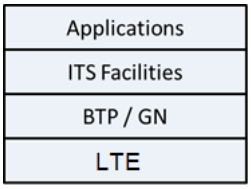
RSU	Road Side Unit
RWW	Road Works Warning
TVL	Topological Virtual Link
VIS	ITS Vehicle Station
V2V	Vehicle to Vehicle
V2X	Vehicle to Anything

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



4.2 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)`

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

4.6 Common rules for Access

More information about the access layer configuration was provided during the Plugtests event.

5 ITS Test Scenarios

5.1 UC1

5.1.1 Road Works Warning

5.1.1.1 Overview

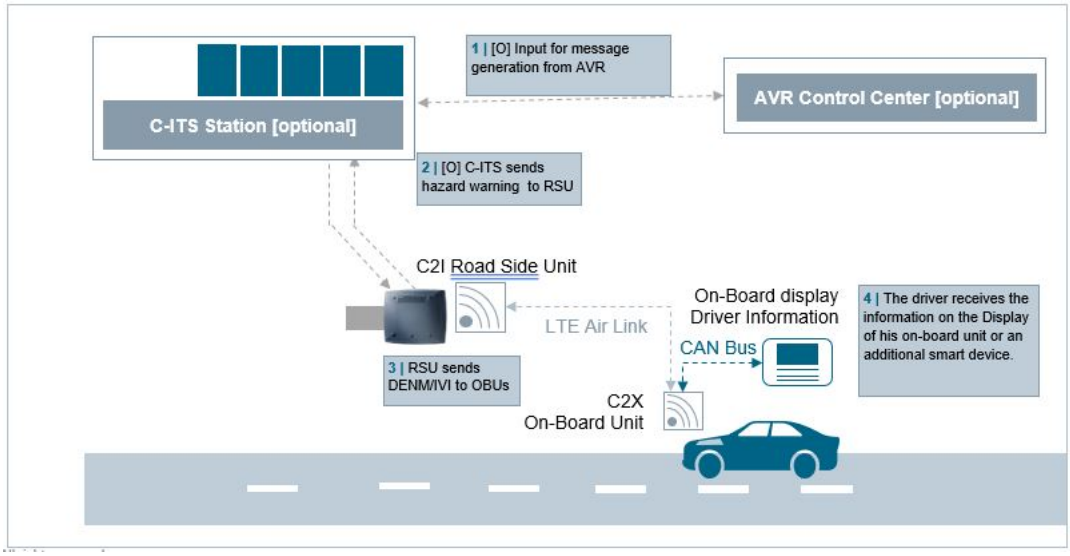


Figure 1: Road Works Warning

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 {
    outerhardShoulderStatus closed(1),
    drivingLaneStatus '10'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 {
    outerhardShoulderStatus availableForDriving(2),
    drivingLaneStatus '01'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 {
    outerhardShoulderStatus availableForDriving(2),
    drivingLaneStatus '00'B
   },
   speedLimit 30,
   startingPointSpeedLimit POS0,
   trafficFlowRule passToRight(2),
   referenceDenms { D2, D3 }
  }
 }
}
```

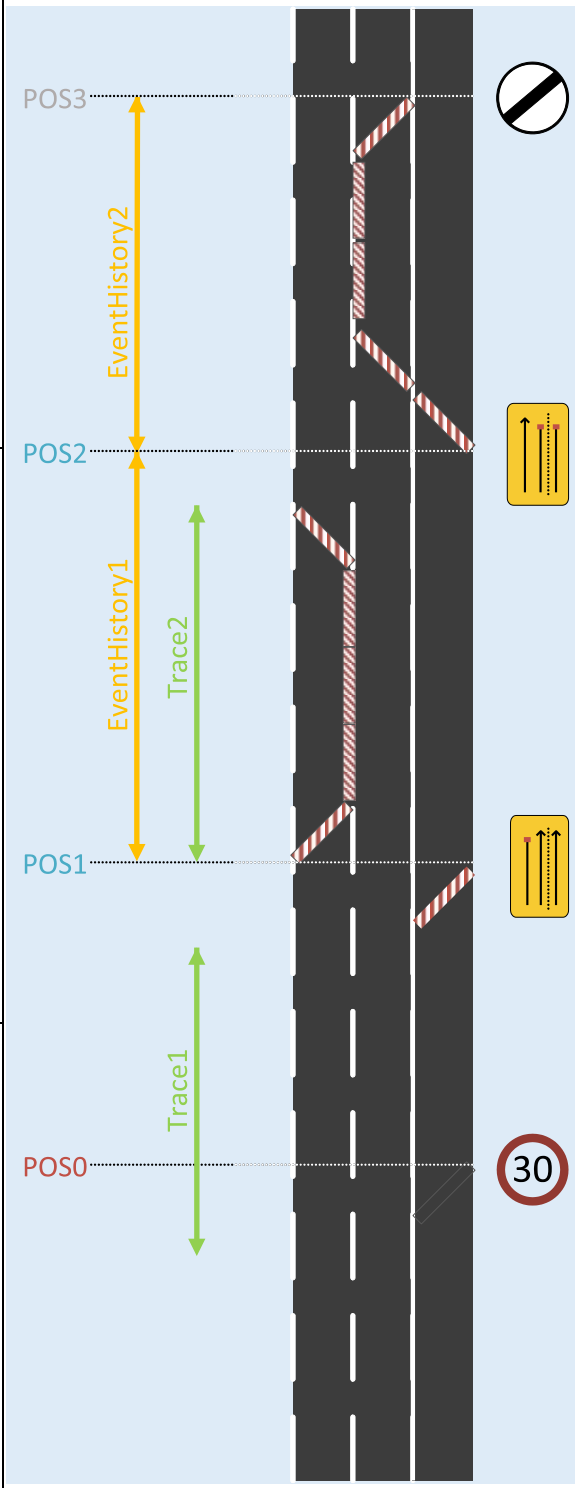
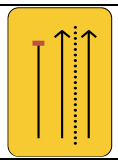
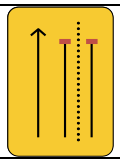
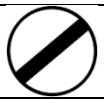


Figure 2: UC1 Test Setup

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	verify	HMI shows no more closed lane information and end of speed limitation	

5.2 UC2

5.2.1 Hazard on the Road: Accident

5.2.1.1 Overview

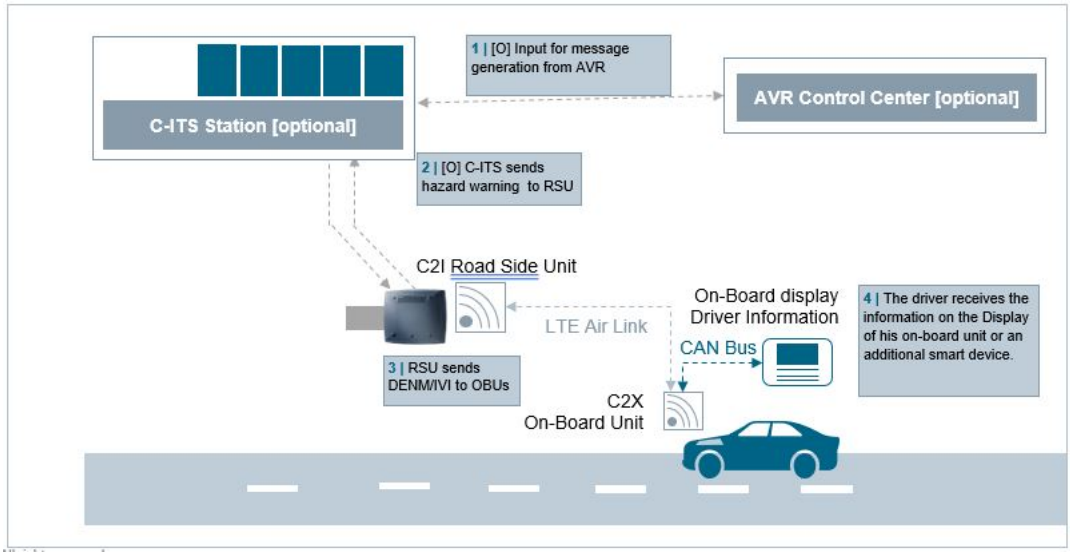


Figure 3: Hazard on the road

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

The equipment involved:

- 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 DENM
- HV enters the relevance area. It 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 POS,
  relevanceDistance lessThan100m(1)
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode accident(2),
   subCauseCode 0
  },
 }
}
```

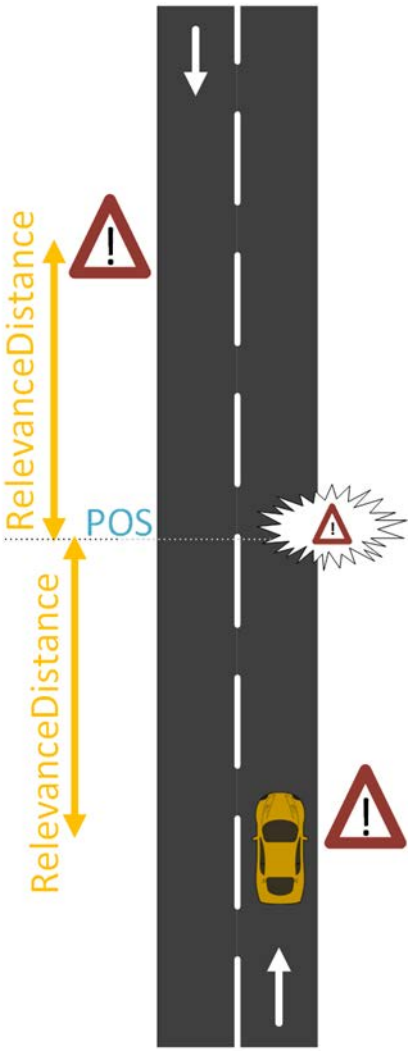


Figure 4: Test Setup

5.2.1.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC02_01			
Objective:	Process Hazard on the Road Warning (HRW) Information (Accident)			
Configuration:	See Figure 4			
Pre-test conditions:	• HV is outside the relevance area			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters the use case zone on the test track	
	3	verify	RSU broadcasts D1	
	4	stimulus	HV enters the Relevance Area	
	5	verify	HMI displays the Hazard on the Road Warning	

5.2.2 Hazard on the Road: Adverse weather condition - extreme weather condition

5.2.2.1 Overview

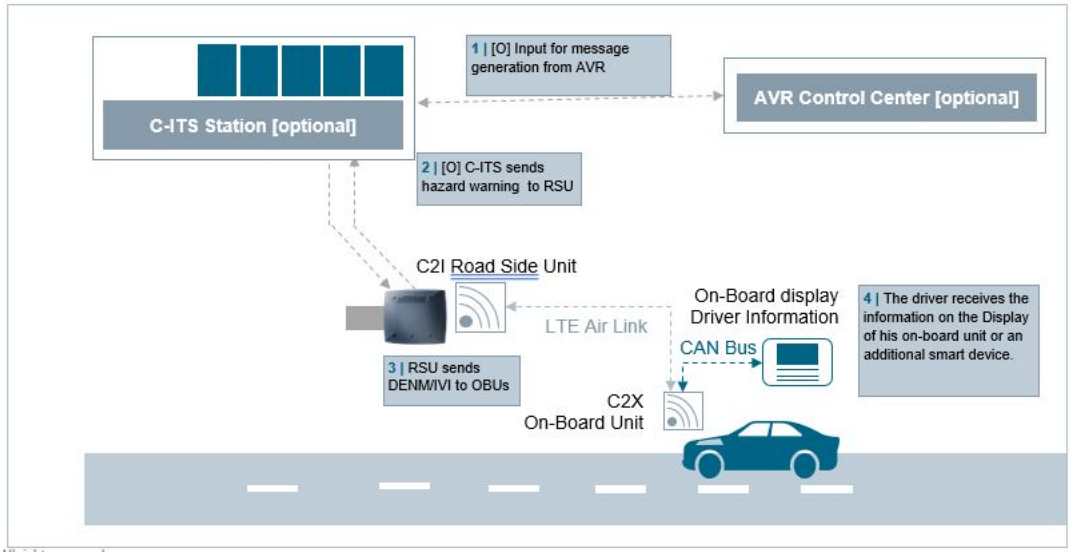


Figure 5: Hazard on the road

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

The equipment involved:

- 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 DENM
- HV enters the relevance area. It determines that the received DENM is relevant
- HMI notifies the driver

5.2.2.2 Test Setup

The figure below shows the test setup.

```
D1 {
 management {
  eventPosition POS,
  relevanceDistance lessThan100m(1)
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode adverse_weather_condition(17),
   subCauseCode 0
  },
 }
}
```

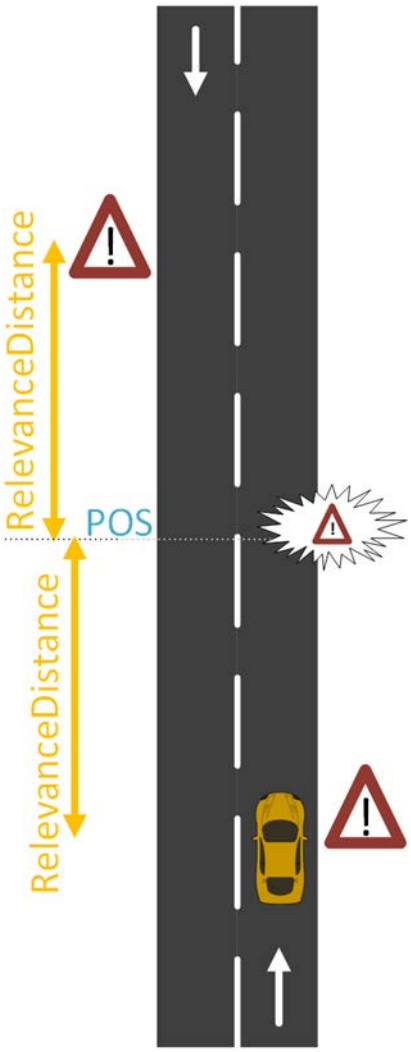


Figure 6: Test Setup

5.2.2.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC02_02			
Objective:	Process Hazard on the Road Warning (HRW) Information (Adverse weather condition - extreme weather condition)			
Configuration:	See Figure 4			
Pre-test conditions:	• HV is outside the relevance area			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters the use case zone on the test track	
	3	verify	RSU broadcasts D1	
	4	stimulus	HV enters the Relevance Area	
	5	verify	HMI displays the Hazard on the Road Warning	

5.2.3 Hazard on the Road: Human presence on the road

5.2.3.1 Overview

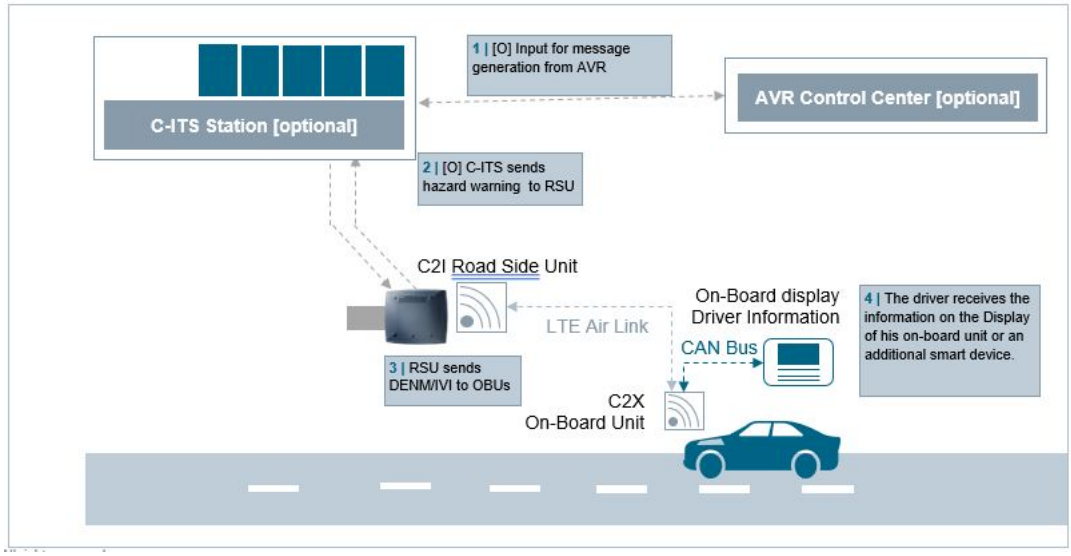


Figure 7: Hazard on the road

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

The equipment involved:

- 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 DENM
- HV enters the relevance area. It determines that the received DENM is relevant
- HMI notifies the driver

5.2.3.2 Test Setup

The figure below shows the test setup.

```
D1 {
 management {
  eventPosition POS,
  relevanceDistance lessThan100m(1)
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode human_presence_on_the_road(12),
   subCauseCode 0
  },
 }
}
```

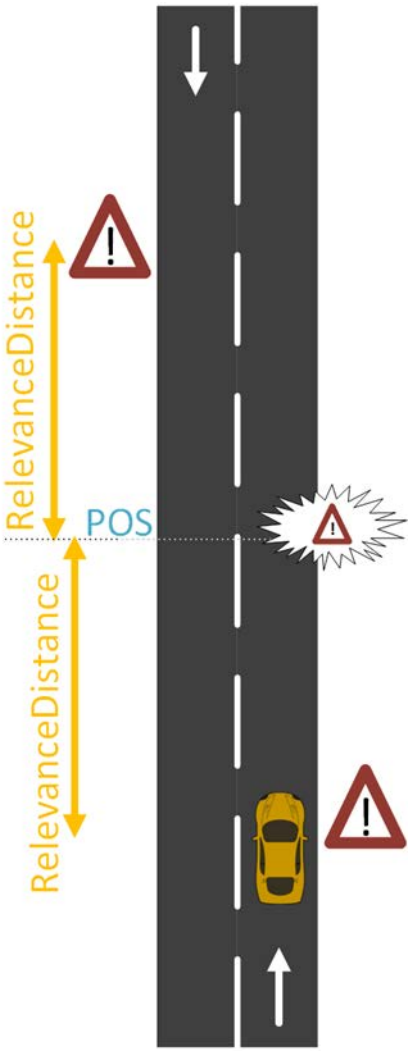


Figure 8: Test Setup

5.2.3.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC02_03			
Objective:	Process Hazard on the Road Warning (HRW) Information (Human presence on the road)			
Configuration:	See Figure 4			
Pre-test conditions:	• HV is outside the relevance area			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters the use case zone on the test track	
	3	verify	RSU broadcasts D1	
	4	stimulus	HV enters the Relevance Area	
	5	verify	HMI displays the Hazard on the Road Warning	

5.2.4 Hazard on the Road: Stationary vehicle

5.2.4.1 Overview

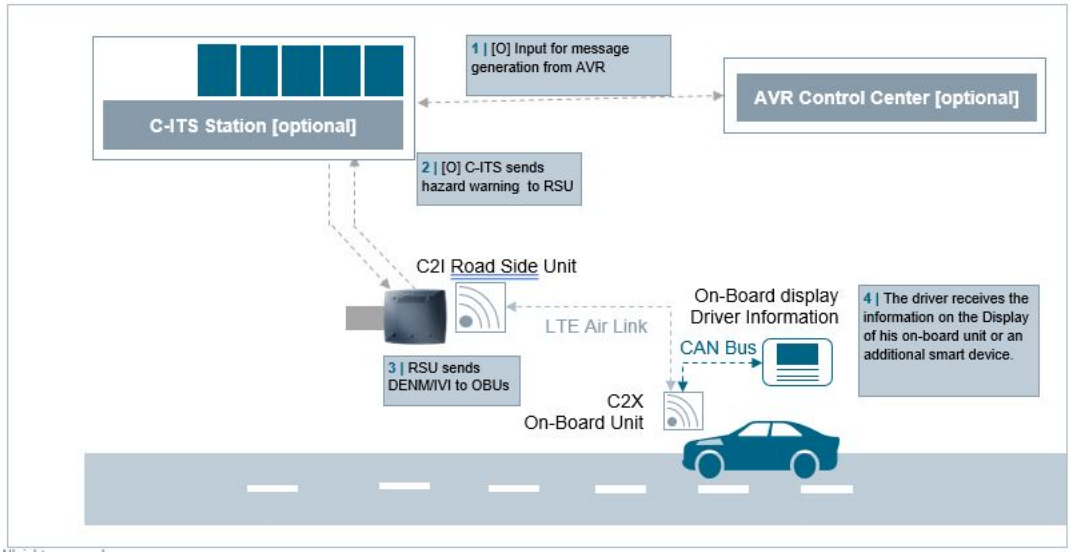


Figure 9: Hazard on the road

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

The equipment involved:

- 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 DENM
- HV enters the relevance area. It determines that the received DENM is relevant
- HMI notifies the driver

5.2.4.2 Test Setup

The figure below shows the test setup.

```
D1 {
 management {
  eventPosition POS,
  relevanceDistance lessThan100m(1)
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode stationary_vehicle(94),
   subCauseCode post_crash(3)
  },
 }
}
```

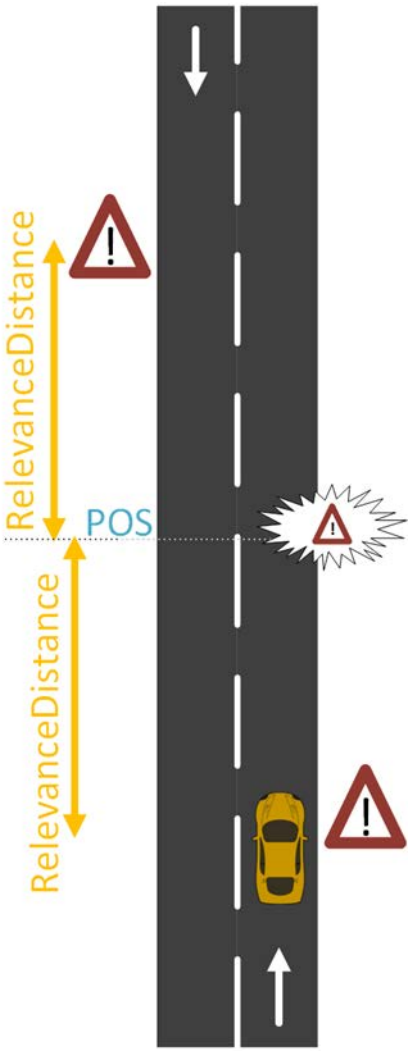


Figure 10: Test Setup

5.2.4.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC02_04			
Objective:	Process Hazard on the Road Warning (HRW) Information (Stationary vehicle)			
Configuration:	See Figure 4			
Pre-test conditions:	• HV is outside the relevance area			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters the use case zone on the test track	
	3	verify	RSU broadcasts D1	
	4	stimulus	HV enters the Relevance Area	
	5	verify	HMI displays the Hazard on the Road Warning	

5.2.5 Hazard on the Road: Emergency vehicle approaching

5.2.5.1 Overview

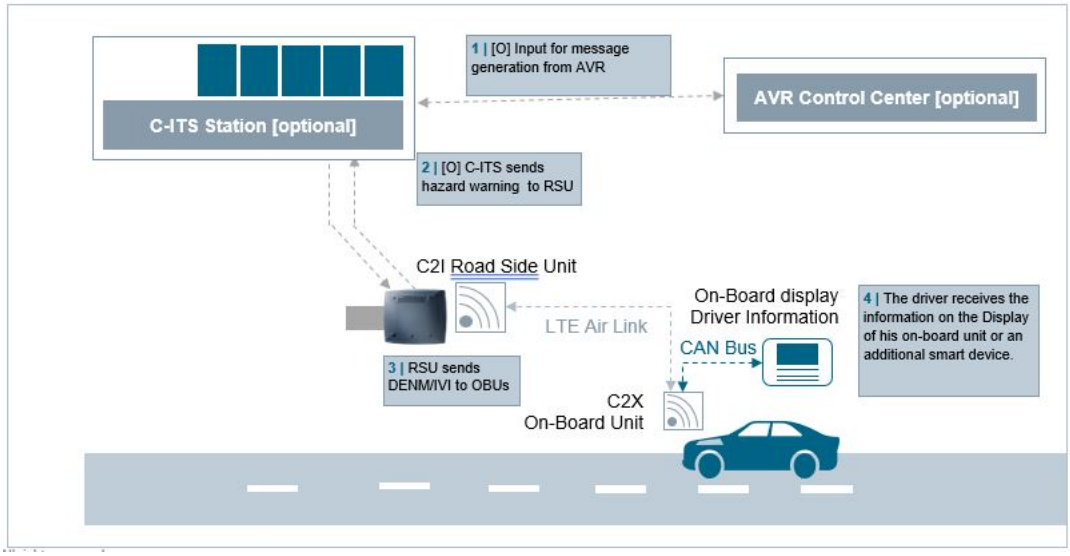


Figure 11: Hazard on the road

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

The equipment involved:

- 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 DENM
- HV enters the relevance area. It determines that the received DENM is relevant
- HMI notifies the driver

5.2.5.2 Test Setup

The figure below shows the test setup.

```
D1 {
 management {
  eventPosition POS,
  relevanceDistance lessThan100m(1)
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode Emergency_vehicle_approaching(95),
   subCauseCode 0
  },
 }
}
```

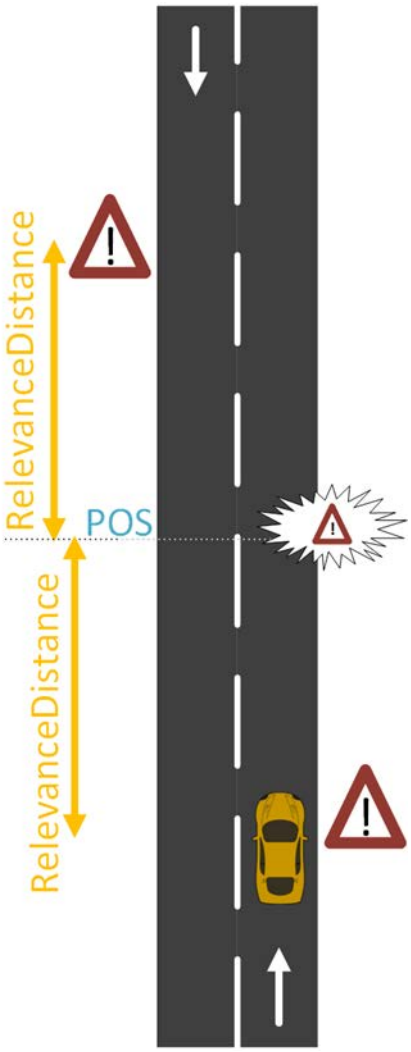


Figure 12: Test Setup

5.2.5.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC02_05			
Objective:	Process Hazard on the Road Warning (HRW) Information (Emergency vehicle approaching)			
Configuration:	See Figure 4			
Pre-test conditions:	• HV is outside the relevance area			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters the use case zone on the test track	
	3	verify	RSU broadcasts D1	
	4	stimulus	HV enters the Relevance Area	
	5	verify	HMI displays the Hazard on the Road Warning	

5.2.6 Hazard on the Road: Hazardous location

5.2.6.1 Overview

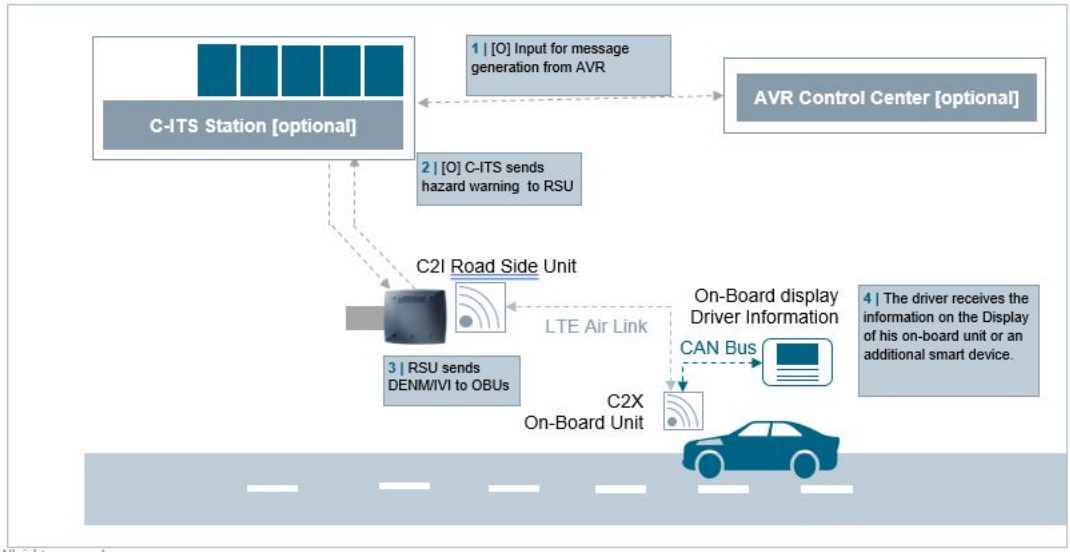


Figure 13: Hazard on the road

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

The equipment involved:

- 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 DENM
- HV enters the relevance area. It determines that the received DENM is relevant
- HMI notifies the driver

5.2.6.2 Test Setup

The figure below shows the test setup.

```
D1 {
 management {
  eventPosition POS,
  relevanceDistance lessThan100m(1)
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode Obstacle_on_the_road(10),
   subCauseCode 0
  },
 }
}
```

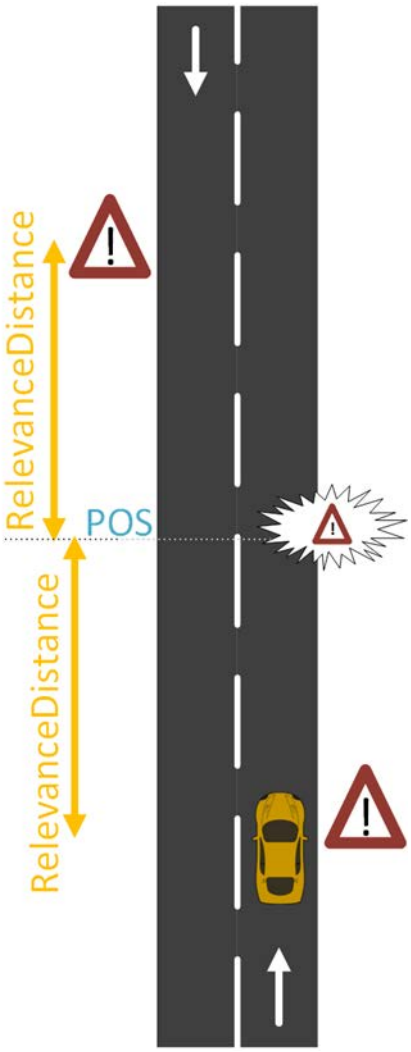


Figure 14: Test Setup

5.2.6.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC02_06			
Objective:	Process Hazard on the Road Warning (HRW) Information (Hazardous location - Obstacle on the road)			
Configuration:	See Figure 4			
Pre-test conditions:	• HV is outside the relevance area			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters the use case zone on the test track	
	3	verify	RSU broadcasts D1	
	4	stimulus	HV enters the Relevance Area	
	5	verify	HMI displays the Hazard on the Road Warning	

5.2.7 Hazard on the Road: Signal violation

5.2.7.1 Overview

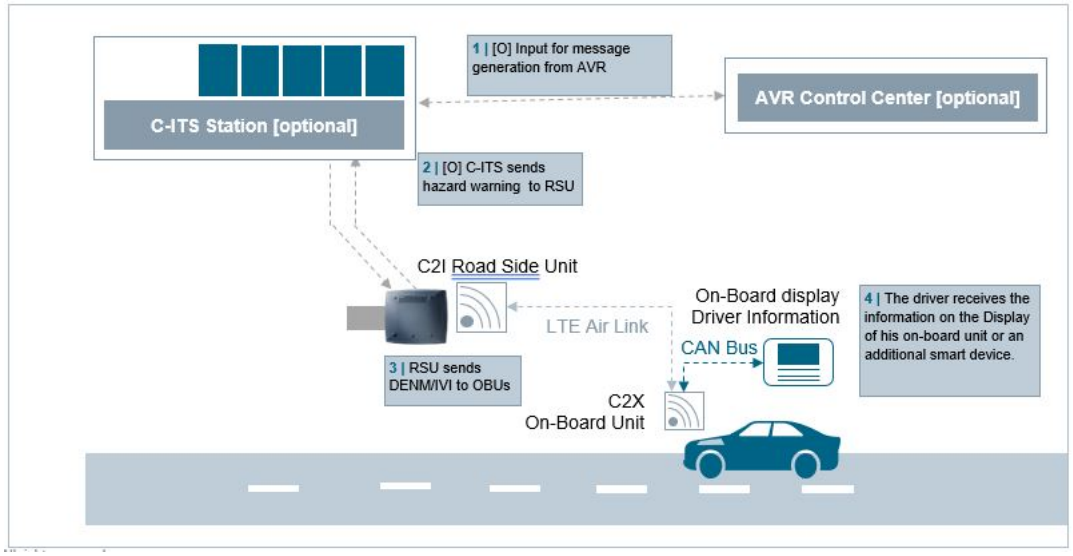


Figure 15: Hazard on the road

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

The equipment involved:

- 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 DENM
- HV enters the relevance area. It determines that the received DENM is relevant
- HMI notifies the driver

5.2.7.2 Test Setup

The figure below shows the test setup.

```
D1 {
 management {
  eventPosition POS,
  relevanceDistance lessThan100m(1)
  relevanceTrafficDirection allTrafficDirections(0)
 },
 situation {
  eventType {
   causeCode Signal_violation(98),
   subCauseCode Traffic_light_violation(2)
  },
 }
}
```

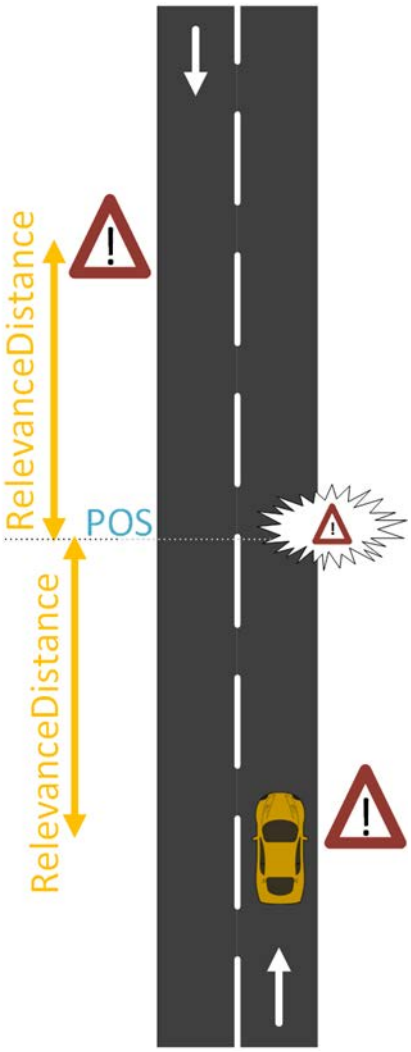


Figure 16: Test Setup

5.2.7.3 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC02_07			
Objective:	Process Hazard on the Road Warning (HRW) Information (Signal violation)			
Configuration:	See Figure 4			
Pre-test conditions:	• HV is outside the relevance area			
Test Sequence:	**Step**	**Type**	**Description**	**HMI**
	1	stimulus	HV enters the use case zone on the test track	
	3	verify	RSU broadcasts D1	
	4	stimulus	HV enters the Relevance Area	
	5	verify	HMI displays the Hazard on the Road Warning	

5.3 UC3

5.3.1 Longitudinal Collision Risk Warning

5.3.1.1 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).

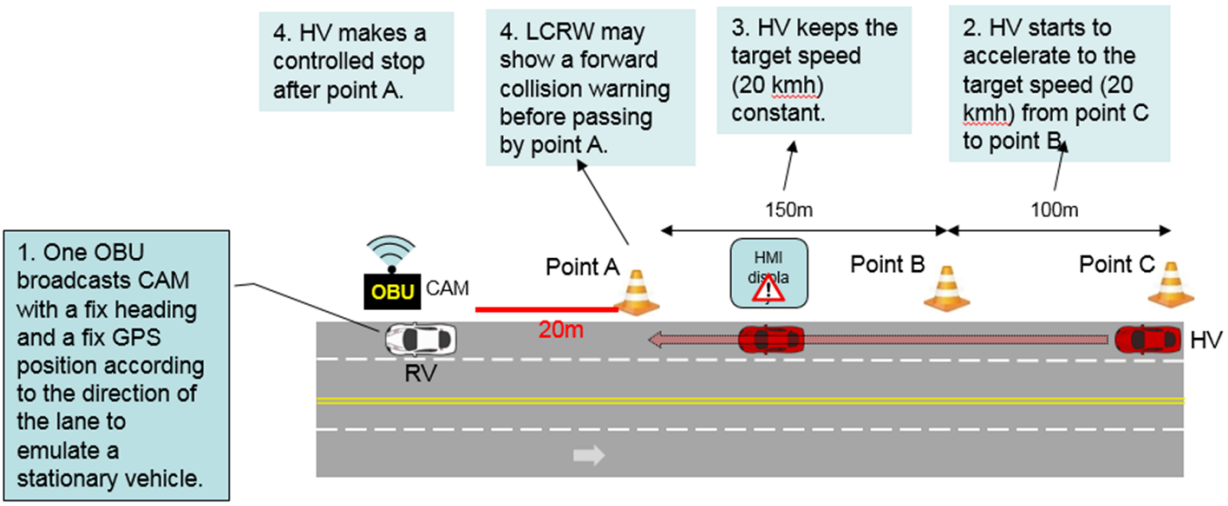


Figure 17: UC3 Test setup

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

5.3.1.2 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC03_01			
Objective:	Verify longitudinal collision risk warning use case			
Configuration:	See Figure 17			
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

5.4 UC4

5.4.1 Intersection Collision Risk Warning

5.4.1.1 Overview

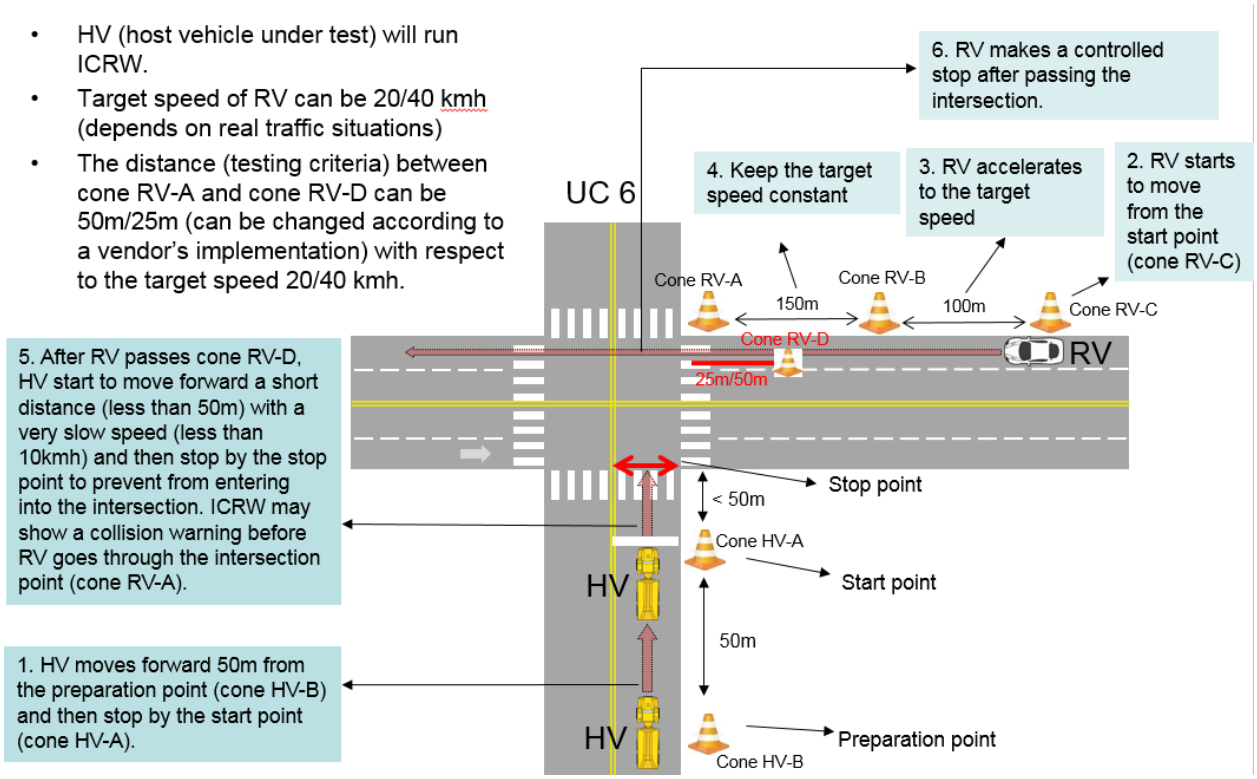


Figure 18: UC4 Test setup

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

5.4.1.2 Test Procedure

Interoperability Test Description				
Identifier:	TD_ITS_UC04_01			
Objective:	Verify Intersection Collision Risk Warning use case			
Configuration:	See Figure 18			
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