SCOOP Crosstests evaluation – first series

Deliverable

Activity 4 : Cross Tests | Sub Activity 4.2

Version 1.0

Publication Date: 30/12/2019

Information on the document

Document: SCOOP Crosstests evaluation – first series

Date of publication: 30/12/2019

Responsible, Entity: José FERNANDEZ, CTAG

Status: Version 1.0

Publication History

Date	Version	Contributor(s)	Updates & changes	Diffusion
30/12/2019	1.0	X test working group	Initial version	Release 1

Reference to the version administration

Version number to be composed of 3 digits > vR.XY
- R corresponds to the release number: it is upgraded each time SC Studies validates the diffusion of a new release,
- X is the major version number: it is upgraded each time SC Studies validates the deliverable,
- Y is the minor version number: it is upgraded each time a contributor changes anything.

Once the deliverable is approved, its version number is upgraded from vR.XY to vR.(X+1)0
Once the deliverable is release, its version number is upgraded from vR.XY to v(R+1).00

As illustration:
0.03 > Work in progress version
0.10 > Del. Approved by SC Studies but not released
2.00 > Del. approved & released (in release 2)
2.05 > Del. Updated - in progress version

Contributors:

José Fernandez, CTAG

Lara Moura, Brisa

Hacene Fouchal, URCA

Marwane Ayda, TPT

Houda Labiod, TPT

Mounira Msahli, TPT

Stéphane Bourgeon, Viveris

Maxime Troccon, Viveris

Christine Tissot, Renault

Hasnaâ Aniss, IFSTTAR

Table of Contents

List of figures

List of tables

Acronym Table

CAM	Cooperative Aware Message
CAN	Controller Area Network
C-ITS	Cooperative ITS
CRL	Certificate Revocation List
EC	European Commission
DENM	Decentralized Environmental Notification Message
GPS	Global Positioning System
HMI	Human Machine Interface
I2V	Infrastructure to Vehicle (communication)
Vru-ITS-S	Vehicle road user ITS-S
Vro-ITS-S	Vehicle Road Operator ITS-S
OHLN	Other Hazardous Location Notification
PCA	Private Certificate Authority
PCAP	Packet CAPture
R-ITS-S	Road Side Unit
SUT	System under test
V2V	Vehicle to Vehicle (communication)

1 Introduction

As C-ITS can be defined as a process of communication and data sharing between components of transport systems - such as vehicles, infrastructure and pedestrians - that can be used to avoid collisions, reduce vehicle emissions and enable traffic to operate more efficiently, it must be assured that involved systems are able to provide data to and accept data from the others so the use of the exchanged data enables them to operate effectively together.

In other words, interoperability among different systems becomes key in order to take full advantage of the benefits that C-ITS based systems and applications can bring to the transport sector.

Being aware of this aspect, EC launched the EU standardization mandate M/453 inviting the European Standardization Organizations (ETSI, CEN, CENELEC) to prepare a coherent set of standards, specifications and guidelines to support the European Community in a wide implementation and deployment of C-ITS.

Under this perspective, once a solid standardization framework is available to be used as reference for C-ITS implementations, checking how interoperable is SCOOP@F system with other countries, existing C-ITS implementations becomes one of the major concerns of SCOOP@F.

For that, focusing on DAY 1 priority services and using ETSI ITS-G5 as communication technology without considering fully implemented security processes, a first series of Cross Tests sessions was organized to analyze interoperability with Austria, Portugal and Spain C-ITS implementations. Descriptions and results from these sessions are provided within the present document.

2 SCOOP@F Cross test workflow

In order to establish a solid framework for cross testing, the Cross-Test Activity was divided in two main work blocks: ‘Desk work’ and ‘Practical work’ (lab tests and on road tests).

2.1 “Desk work”

The objective of this part was to assure that no major constrains would be encountered during the ‘practical’ test phase in terms of standards used for implementations.

For that, within Subactivity 4.1, specifications used for implementations deployed in the different countries were exchanged in order to identify possible differences that may cause interoperability issues.

From this work, it was encountered that, taking as reference ETSI TR 101 607, standards followed for implementations were as listed in the next table, not being found evidences of potential issues for Xtest activities among the different participant countries.

N°	Standard	Title	France SCOOP@F	Austria Eco-AT	Spain SISCOGA	Portugal
ITS G5 Stack – Access Layer						
N° 1	EN 302 571	Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive	1.2.1 (2013-09)	Not mentioned	Idem SCOOP@F	Idem SCOOP@F
N° 2	EN 302 663	Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band	1.2.1 (2013-07)	V 1.2.0 (2012 11)	Idem SCOOP@F	Idem SCOOP@F
N° 3	TS 102 724	Intelligent Transport Systems (ITS); Harmonized Channel Specifications for Intelligent Transport Systems operating in the 5 GHz frequency band	1.1.1 (2012-10)	Not mentioned	Idem SCOOP@F	Idem SCOOP@F
N° 4	TS 102 792	Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range	1.1.1 (2012-10)	Not mentioned	Idem SCOOP@F	Idem SCOOP@F
ITS G5 Stack – Transport Layer						
N° 5	EN 302 636-4-1	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 4:	1.2.1 (2014-07)	1.2.1 (2014-07)	Idem SCOOP@F	Idem SCOOP@F

N°	Standard	Title	France SCOOP@F	Austria Eco-AT	Spain SISCOGA	Portugal
		Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality				
N° 6	EN 302 636-5-1	Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols; Sub-part 1: Basic Transport Protocol	1.2.1 (2014-08)	V 1.2.1 (2014-05)	Idem SCOOP @F	Idem SCOOP @F
ITS G5 Stack – Facilities Layer						
N° 7	EN 302 637-2	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service	1.3.2 (2014-11)	1.3.2 (2014-11)	Idem SCOOP @F	Idem SCOOP @F
N° 8	EN 302 637-3	Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service	1.2.2 (2014-11)	1.2.2. (2014-11)	Idem SCOOP @F	Idem SCOOP @F
N° 9	EN 302 931	Intelligent Transport Systems (ITS); Vehicular Communications; Geographical Area Definition	1.1.1 (2011-07)	Not mentioned	Idem SCOOP @F	Idem SCOOP @F
N° 10	TS 102 894-1	Intelligent Transport Systems (ITS); Users and applications requirements; Part 1: Facility layer structure, functional requirements	1.1.1 (2013-08)	Mentioned. No version nb.	Idem SCOOP @F	Idem SCOOP @F

N°	Standard	Title	France SCOOP@F	Austria Eco-AT	Spain SISCOGA	Portugal
		and specifications				
N° 11	TS 102 894-2	Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary	1.2.1 (2014-09)	1.2.1. (2014-09)	Idem SCOOP @F	Idem SCOOP @F
Security						
N° 15	TS 102 940	Intelligent Transport Systems (ITS); Security; ITS communications security architecture and security management	1.1.1 (2012-06)	Mentioned. No version nb.	To be used Idem SCOOP @F	To be used Idem SCOOP @F
N° 16	TS 102 941	Intelligent Transport Systems (ITS); Security; ITS; Trust and Privacy Management	1.1.1 (2012-06)	Mentioned. No version nb.	To be used Idem SCOOP @F	To be used Idem SCOOP @F
N° 17	TS 102 731	Intelligent Transport Systems (ITS); Security; ITS; Security services and architecture	1.1.1 (2010-09)	Mentioned. No version nb.	To be used Idem SCOOP @F	To be used Idem SCOOP @F
N° 18	TR 102 893	Intelligent Transport Systems (ITS); Security; Threat, Vulnerability and Risk Analysis (TVRA)	1.1.1 (2010-03)	1.1.1	To be used Idem SCOOP @F	To be used Idem SCOOP @F
N° 19	TR 103 097	Intelligent Transport Systems (ITS); Security; Security header and privacy management	1.2.1 (2015-06)	1.2.1 (2015-06)	To be used Idem SCOOP @F	To be used Idem SCOOP @F
N° 20	TS 102 965	Intelligent Transport Systems (ITS); Security, Application Object Identifier	1.2.1 (2015-06)		To be used Idem SCOOP @F	To be used Idem SCOOP @F

N°	Standard	Title	France SCOOP@F	Austria Eco-AT	Spain SISCOGA	Portugal
N° 21	ISO/TS17419	Intelligent Transport Systems (ITS); Security; ITS-AID Assigned Numbers"	1.1.1 (2010-03)		To be used Idem SCOOP @F	To be used Idem SCOOP @F
N° 22	TS 102 941	Intelligent Transport Systems (ITS); Security; Trust and Privacy management	1.1.1 (2010-03)	Mentioned. No version nb.	To be used Idem SCOOP @F	To be used Idem SCOOP @F

Figure 1: List of standards followed for implementations at SCOOP@F W1 Xtest activity

From this activity, also information on services deployed at the different countries was collected in order to select the convenient candidates to be cross tested taking into account a common availability for such purpose. The following tables summarizes this information:

Use-case (name in SCOOP@F)		DENM		France SCOOP@F			Austria Eco-AT			Spain SISCOGA			Portugal		
		Causecode	Sub-causecode	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center
A1	Traffic data collection (CAM aggregation)	-	-	X	X		X	X		X					
B1	Planned road works	3 : Roadworks	0 : unavailable		X	X		X	X			X		X	X
		3 : Roadworks	3 : Slow moving Road Maintenance		X	X		X	X					X	X
		3 : Roadworks	6 : winter Service			X						X			
B2	Road operator's intervention	15 : Rescue and recovery work in progress	0 : unavailable		X				X					X	X
		26 : Slow Vehicle	1 : maintenance Vehicle		X									X	
		95 : Emergency vehicle approaching	0 : unavailable		X									X	
B3		26 : slow vehicle	6 : snow plough		X									X	

Use-case (name in SCOOP@F)		DENM		France SCOOP@F			Austria Eco-AT			Spain SISCOGA			Portugal		
		Causecode	Sub-causecode	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center
	Winter maintenance	26 : slow vehicle	8 : salting vehicle		X									X	
		3 : Roadworks	6 : winter service		X										
D1	Temporary slippery road	6 : Adverse weather conditions – Adhesion	0 : Unavailable	X		X						X			X
		6 : Adverse weather condition - adhesion	1 : heavy frost on road			X									X
		6 : Adverse weather condition - adhesion	10 : roads Salted			X									
		6 : Adverse weather condition - adhesion	2 : fuel on road			X									X
		6 : Adverse weather	3 : mud on road			X									X

Use-case (name in SCOOP@F)		DENM		France SCOOP@F			Austria Eco-AT			Spain SISCOGA			Portugal		
		Causecode	Sub-causecode	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center
		condition - adhesion													
		6 : Adverse weather condition - adhesion	4 : snow on road			X									X
		6 : Adverse weather condition - adhesion	6 : black ice			X			X						
		6 : Adverse weather condition - adhesion	7 : oil on road			X									X
		6 : Adverse weather condition - adhesion	8 : loose Chippings			X									
		6 : Adverse weather condition - adhesion	9 : instant Black Ice			X									

Use-case (name in SCOOP@F)		DENM		France SCOOP@F			Austria Eco-AT			Spain SISCOGA			Portugal		
		Causecode	Sub-causecode	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center
D2a	Animal on the road	11 : Hazardous Location - Animal on the road	0 : Unavailable	X		X			X						X
		11 : hazardous location – animal on the road	1 : wild animal			X									X
		11 : hazardous location – animal on the road	2 : herd of animal			X									X
		11 : hazardous location – animal on the road	3 : small animal			X									X
		11 : hazardous location – animal on the road	4 : large animal			X									X
D2b	People on the road	12 : Human presence on the road	0 : Unavailable	X		X			X						X

Use-case (name in SCOOP@F)		DENM		France SCOOP@F			Austria Eco-AT			Spain SISCOGA			Portugal		
		Causecode	Sub-causecode	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center
D3	Obstacle on the road	10 : Hazardous Location - Obstacle on the road	0 : Unavailable	X		X						X			X
D4	Stationary vehicle, breakdown	94 : Stationary vehicle	0 : Unavailable	X		X				X		X			X
		94 : Stationary vehicle	2 : Vehicle breakdown	X		X									X
D5	Unprotected accident area	2 : Accident	0 : Unavailable	X		X			X	X		X			X
		2 : accident	1 : multi vehicle accident			X			X						X
		2 : accident	2 : heavy accident			X									X
		2 : accident	3 : accident involving lorry			X			X						X
		2 : accident	4 : accident involving bus			X			X						X

Use-case (name in SCOOP@F)		DENM		France SCOOP@F			Austria Eco-AT			Spain SISCOGA			Portugal		
		Causecode	Sub-causecode	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center
		2 : accident	5 : accident involving hazardous materials			X			X						X
		2 : accident	7 : unsecured Accident			X									X
		94 : Stationary vehicle	3 : Postcrash	X											X
D6	Reduced visibility	18 : Adverse weather conditions - Visibility	0 : Unavailable	X		X						X			X
		18 : adverse weather condition - visibility	1 : fog			X			X			X			X
		18 : adverse weather condition - visibility	2 : smoke			X									X
		18 : adverse weather	3 : heavy Snowfall			X									X

Use-case (name in SCOOP@F)		DENM		France SCOOP@F			Austria Eco-AT			Spain SISCOGA			Portugal		
		Causecode	Sub-causecode	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center
		condition - visibility													
		18 : adverse weather condition - visibility	4 : heavy Rain			X						X			X
		18 : adverse weather condition - visibility	5 : heavy Hail			X									X
D8	Unmanaged blockage of a road	9 : Hazardous location – Surface condition	0 : Unavailable	X					X						
		9 : Hazardous location – surface condition	1 : rock falls			X									X
		9 : Hazardous location – surface condition	4 : subsidence			X									X

Use-case (name in SCOOP@F)		DENM		France SCOOP@F			Austria Eco-AT			Spain SISCOGA			Portugal		
		Causecode	Sub-causecode	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center
		9 : Hazardous location – surface condition	5 : snow drifts			X									
		9 : Hazardous location – surface condition	7 : burst pipe			X									
D10	Emergency brake	99 : Dangerous situation	1 : Emergency electronic brake lights	X			X			X			X	X	
D11	End of queue	27 : Dangerous end of queue	0 : Unavailable	X	X	X						X		X	X
E6	Extreme weather conditions	17 : Adverse weather condition – extreme weather condition	1 : strong winds			X						X			X
		17 : Adverse weather condition – extreme weather condition	4 : thunderstorm			X									
		19 : Adverse weather	0 : Unavailable	X											X

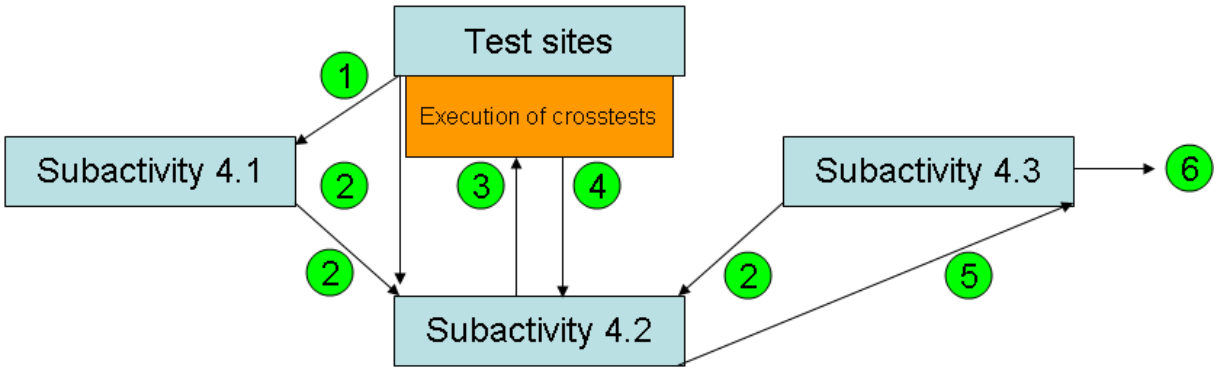
Use-case (name in SCOOP@F)		DENM		France SCOOP@F			Austria Eco-AT			Spain SISCOGA			Portugal		
		Causecode	Sub-causecode	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center	Emitted by vehicles	Emitted by road operator's vehicles	Emitted by traffic manag. center
		precipitation – Extreme weather condition													

Figure 2: List of available use cases for SCOOP@F W1 Xtest activity

Based on the information shown on the previous table, a primary list of common use cases with potential to be cross tested was elaborated:

- CAM aggregation (FR, AT, ES)
- Planned road works 3/0 and 3/3 (FR, AT, ES, PT)
- Animal on the road 11/0 (FR, AT, PT)
- People on the road 12/0 (FR, AT, PT)
- Obstacle on the road 10/0 (FR, ES, PT)
- Accident 2/0 (FR, AT, ES, PT) and 2/XX (FR, AT, PT) activities depicted within SCOOP project.

Descriptions of these three sessions are provided in coming sections.



1	Information on standards and use cases deployed at every test site
2	Conclusions from analysis on standards, uses cases and functional aspects to proceed with crosstesting (from S 4.1) Needs for crosstesting evalution purposes (from S 4.3) Feedback on needs and limitations (from Test Sites)
3	Guidelines for execution of crosstesting at different levels (lab-defined and carried out by URCA-,test track,open road)
4	Functional results from execution of crosstesting based on provided guidelines
5	Reports from analysis on functional results from execution of crosstesting
6	Evaluation of cross-test based on provided reports (synthesis, suggestions for standards and next steps,…)

Figure 3: Xtest activity workflow

3 Labtest

3.1 Scope

Main goal of this kind of tests is to ensure that basic data communication between road-side units and on-board equipment worked correctly.

~~Following a conformance test approach, by means of logs exchange (remote method) and participation at~~ ETSI Plugtests, it was checked that all participants shared a common understanding of the ETSI standards followed for implementations.

3.2 Location

University of Reims, France

3.3 Participants

France (Neavia, RSA, Yogoko, URCA), Portugal (A-to-Be, IP), Spain (CTAG) and Austria (AustriaTech).

3.4 Procedure

Before entering into the procedure, itself, an overview of the equipment suggested for obtaining log files is listed below:

- The equipment to be tested (SUT), only included in Lab Tests if already completely validated at the local tests of the origin country.
- A ETHERNET-G5 gateway
- A computer to save the log files
- A Wireshark tool

PCAP log files were generated by using architecture presented in figure 4.

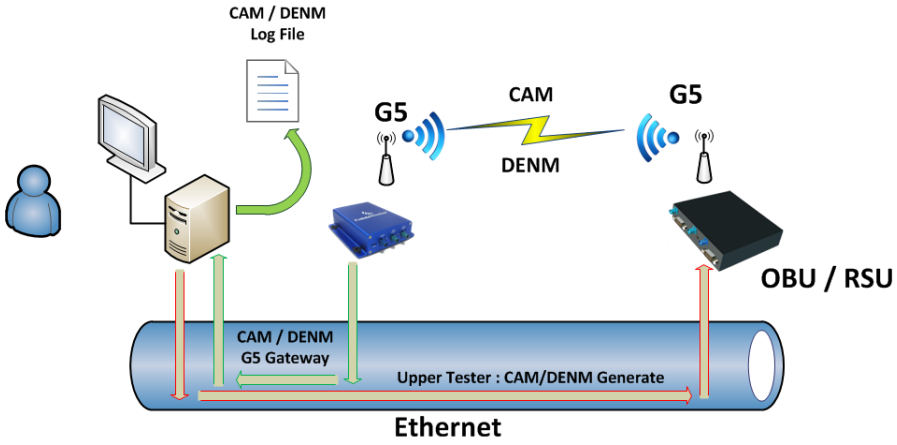


Figure 4: Architecture suggested for PCAP files generation

The SUT must be stimulated in order to start sending CAM and DENM messages. These messages, captured by the ETHERNET-G5 gateway, were transmitted to the PC via the ETHERNET link, where the Wireshark tool should be running to save each message in a PCAP format. In an alternative way, messages could be directly saved on the SUT using, for example, “tcpdump” command or similar.

For each equipment to be tested, next considerations were required for logs to be provided:

- CAM:
  - A log file contents a minimum of 10 CAM messages.
  - Log file is named as: “X-Tests_CAM_X_Date_Country.pcap”, where X represents the ID of the equipment tested.
- DENM:
  - A separate log file is created for each of the (12) use cases listed below including one sample of the corresponding DENM.

1. Planned road works 3/0
2. Planned road works 3/3
3. Animal on the road 11/0
4. People on the road 12/0
5. Obstacle on the road 10/0
6. Accident 2/0
7. Accident 2/XX
8. Fog 18/1
9. Emergency brake 99/1
10. Breakdown: AT 13/0 vs FR 94/0
11. Heavy rain: AT 19/1
12. Heavy snowfall: AT 19/2

- Log files is named as: "X-Tests_DENM_X_CauseCode_SubCauseCode_Date_Country.pcap", where X represents the ID of the equipment tested.

In case there was more than one equipment, the table below must be filled and only the ID of the equipment had to be communicated:

Equipment ID	Manufacturer Name	Comments
1	Manufacturer 1	
2	Manufacturer 2	
..	..	
..	..	
N	Manufacturer N	

Also, a description of generation conditions for log files is provided together with the corresponding log files.

This description file is named in the same way than the PCAP file ("X-Tests_CAM_X_Date_Country.ods" or "X-Tests_DENM_X_CauseCode_SubCauseCode_Date_Country.ods") and contains a data table like the one described below

Software Elements	Version	Comments
ID of the equipment	5	ID in the list of Table 1
PC	HP…	PC used for log storing
Operating System	Windows/Linux	OS used for log storing
CAM or DENM Protocol	1.2.2	ETSI standard used
Wireshark	2.0.2	Version of tool used
Wireshark ETSI Plugins	wireshark-2.0.x/Linux/64bits	Version of plugins used
Cause Code if DENM	3	Cause Code in DENM stored
Sub-Cause Code if DENM	0	Sub-Cause Code in DENM stored

For the tests' execution, the architecture was almost the same than for the log file generation. However, the data flow became reversed. The Figure 5 describes this architecture.

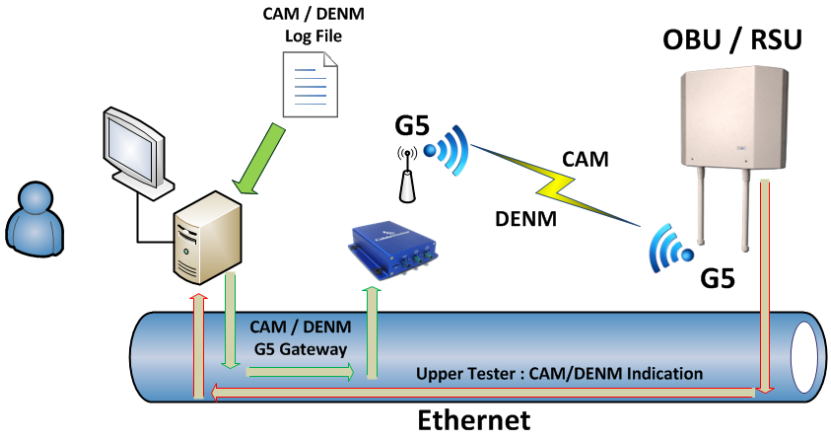


Figure 5: On-Lab X-Tests execution schema

A CAM or a DENM message was extracted from the PCAP log file, then broadcasted by the ETHERNET-G5 gateway. Message reception was verified by using the OBU/RSU HMI or Upper Tester indication.

It must be noted that original messages saved in the log files could not be used directly for analysis due to the content of data fields related to time and position, thus, they were changed manually before being analysed.

Here below the list of fields affected:

For CAM messages:

- CAM.cam.camParameters.basicContainer.referencePosition.latitude
- CAM.cam.camParameters.basicContainer.referencePosition.longitude

For DENM messages:

- DENM.denm.management.eventPosition.latitude
- DENM.denm.management.eventPosition.longitude
- DENM.denm.management.detecionTime
- DENM.denm.management.referenceTime

3.5 Main Results

Based on the results obtained and showed below, On-Lab tests demonstrated that there was no major issue for the interoperability between the different SCOOP@F partners.

Since AustriaTech was not able to run the On-Lab tests, a specific meeting was conducted in order to analyse by experts if there were issues about the interoperability, principally between France and Austria. After analysing different messages fields, experts agreed in the fact that the differences wouldn't constitute an obstacle to interoperability.

Origin Country	tested equipment	Files	Equipement used for test	Interoperability				Comment
				Success	Failed	Inconclusive	Not tested	
Spain	2 1	X-Tests_CAM_2_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_2_0_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_3_0_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_3_6_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_6_0_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_3_6_100416_Spain.pcap	1	X				
			5	X				
			7	X				
			1	X				

Origin Country	tested equipment	Files	Equipement used for test	Interoperability				Comment
				Success	Failed	Inconclusive	Not tested	
		X-Tests_DENM_2_6_0_100416_Spain.pcap	5	X				
			7	X				
		X-Tests_DENM_2_10_0_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_17_1_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_18_0_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_18_1_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_18_4_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_27_0_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_94_0_100416_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_CAM_1_100516_Spain.pcap	1	X				
			5	X				
			7	X				

Origin Country	tested equipment	Files	Equipement used for test	Interoperability				Comment
				Success	Failed	Inconclusive	Not tested	
		X-Tests_DENM_1_2_0_100516_Spain.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_1_94_0_100516_Spain.pcap	1	X				
			5	X				
			7	X				
Austria	1	Reference_Message_Coexistence_CAM_Protected_Zones_V03.60.pcapng	1	X				
			5	X				
			7	X				
		Reference_Message_OtherDENM_V03.60.pcapng	1				x	we can't execute tests with these headers
			5				X	
			7				X	
		Reference_Message_RWW_augmented_V03.60.pcapng	1				X	we can't execute tests with these headers
			5				X	
			7				X	
		Reference_Message_RWW_standalone_V03.60.pcapng	1				X	we can't execute tests with these headers
			5				X	
			7				X	
		Reference_Message_RWW_TCC_triggered_V03.60.pcapng	1				X	we can't execute tests with these headers
			5				X	
			7				X	
Portugal	2	X-Tests_DENM_2_2_0_110107_Portugal.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_	1	X				
			5	X				

Origin Country	tested equipment	Files	Equipement used for test	Interoperability				Comment
				Success	Failed	Inconclusive	Not tested	
		2_2_2_110107_Portugal.pcap	7	X				
		X-Tests_DENM_2_3_0_110107_Portugal.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_3_3_110107_Portugal.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_10_0_110107_Portugal.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_11_0_110107_Portugal.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_12_0_110107_Portugal.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_13_0_110107_Portugal.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_18_1_110107_Portugal.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_2_19_1_110107_Portugal.pcap	1	X				
			5	X				
			7	X				

Origin Country	tested equipment	Files	Equipement used for test	Interoperability				Comment
				Success	Failed	Inconclusive	Not tested	
		X-Tests_DENM_2_19_2_110107_Portugal.pcap	1	X				
			5	X				
			7	X				
	1	X-Tests_CAM_1_110117_Portugal.pcap	1	X				
			5	X				
			7	X				
		X-Tests_DENM_1_99_1_110107_Portugal.pcap	1	X				
			5	X				
			7	X				

Figure 6: Results of Lab Test execution

4 On road test: Fisrt Xtest session

4.1 Scope

As commented in previous sections, to validate end-to-end interoperability among participants in real environments, goal of this initial session was testing of just functional aspects of services, not involving security aspects;

4.2 Location

Vigo (Spain) and North Portugal

From the 18th to 20th of December 2017, the first On road Xtest session took place in 10 kilometers included in the permanent C-ITS corridor SISCOGA that lead from CTAG facilities (used as base camp for vehicle set up, brief and debrief sessions,…) to the Spain-Portugal border and the seamless 5 kilometers of Portuguese highway A3, creating a real cross-border scenario for this first SCOOP Xtest session on open road.

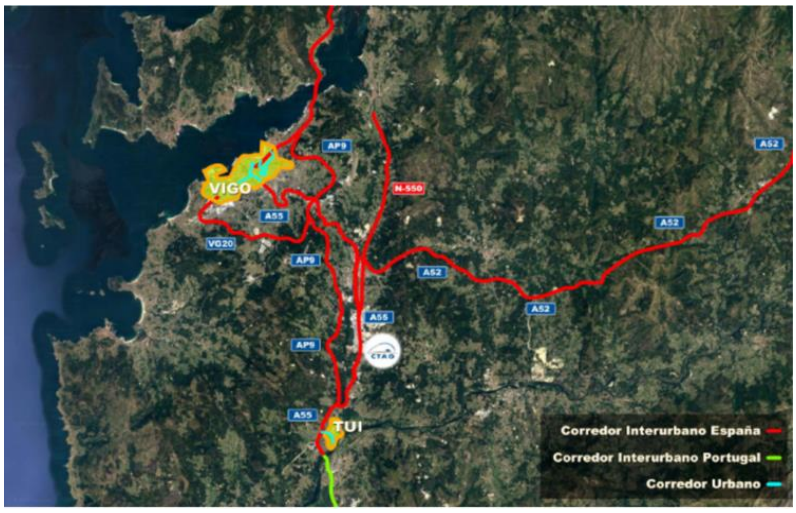


Figure 7 Vigo test session location map

It should be also noted that:

- C-ITS equipment deployed at SISCOGA corridor is analog to the one deployed at Spanish highway A6 (Madrid) and Portuguese motorways A27 and A28.
- C-ITS equipment deployed at the beginning of Portuguese motorway A3 is analog to the one deployed along the other Portuguese roads.

Above comments are indicated to highlight that results obtained from this test session are extensive to these locations.

4.3 Participant

France (PSA, URCA), Portugal (A-to-Be - Brisa, IP), Spain (CTAG).

4.4 Scenarios

Detailed information on this X-Tests itinerary and events could be found by following this link:

https://drive.google.com/open?id=1TojaIU9wWx_dniaMCpxTHNaY3LedJWCB&usp=sharing

Main aspects are provided below.

- Test track scenario

The aim of this scenario was, as a first step and before proceeding with open road field tests, to allow participants to perform some initial tests to validate their vehicle setups and configurations for executing the different test scenarios.

Figure 8 Test track at CTAG facilities

- I2V scenarios

The aim of this collection of scenarios was to perform I2V tests among the participant so different features of applications could be experimented by performing defined test events.

Events located at Spanish side are triggered by the 3 used Spanish RSUs, meanwhile events located at Portuguese side are triggered by the 2 used Portuguese RSUs.

- Scenario **1**

Figure 9 I2V Scenario 1

Accident on the road	• 2/0 • Upstream -> Relevance Traffic Direction
Adhesion	• 6/6 • Upstream • With trace and EventHistory
Animal on the road:	• 11/0 • AllTrafficDirection
Adverse Weather:	• 18/1 • AllTrafficDirections • With EventHistory
Obstacle on the road	• 10/0 • Upstream • Two traces
RoadWorks	• 3/0 • Upstream • With trace and EventHistory
Accident on the road	• 2/0 • Upstream • With trace

Fog	• 18/1 • Upstream • With trace and EventHistory

- Scenario **2**

Figure 10 I2V Scenario 2

Adhesion	• 6/0 • With Trace • Upstream
Wind	• 17/1 • AllTrafficDirections • Without trace and EventHistory
Vehicle BreakDown	• 94/2 • Upstream • With trace
Adhesion	• 6/6 • Upstream • With Trace and EventHistory
Fog	• 18/1 • AllTrafficDirection • Without Trace and EventHistory
Accident on the road	• 2/0 • Upstream • With Trace
Obstacle on the road	• 10/0 • UpStream • With trace
RoadWorks	• 3/0 • UpStream • With trace and EventHistory

- V2V scenario

The aim of these scenario was to perform V2V tests among the participant partners. Tests were carried out both in the V2I scenarios and also close to CTAG premises where both static and dynamic V2V tests with vehicles can be performed in a real environment but under controlled conditions avoiding traffic perturbations.

Figure 11 V2V Scenario location

Human presence on the road (12/0, Upstream, With Trace) was the event selected to test this conditioning and participants successfully acted as emitters, forwarders and final receivers at different test executions (all executions triggered manually).

As specific values and conditioning for DENM were shown in the previous section, here below is depicted those DENM fields that remained fixed.

Name	Value
Header	
protocolVersion	1
messageID	1
stationID	ID of the RSU
Management Container	
actionId	ID of the event (server)
detectionTime	Time when event starts (server)
referenceTime	Time when events arrive to facilities
termination	Not used
eventPosition	Position of the event
relevanceDistance	Not used
relevanceTrafficDirection	upstreamTraffic(1), alltrafficDirections(0)
validityDuration	3600
TransmissionInterval	1000
stationType	RoadsideUnit(15)
Situation Container	
informationQuality	7
eventType	CauseCode and SubCauseCode of event
linkedCause	Not used
eventHistory	Path (duration) of the event
Location Container	
eventSpeed	Not used
eventPositionHeading	Not used
traces	Aproximation path of the event
roadType	Not used
Alacarte Container	Not used

Figure 12 DENM fields at RSU side

NOTES:

- ActionID uses the originatingstationID of the C-ITSS used at every country.
- StationID = stationID of each RSU

Name	Value
Header	
protocolVersion	1
messageID	1
stationID	ID of the Vehicle
Management Container	
actionId	ID of the event
detectionTime	Time when event starts
referenceTime	Time when events arrive to facilities
termination	Not used
eventPosition	Position of the vehicle
relevanceDistance	LessThan100m(1)
relevanceTrafficDirection	upstreamTraffic(1), alltrafficDirections(0)
validityDuration	1200
TransmissionInterval	1000
stationType	PassengerCar(5)
Situation Container	
informationQuality	7
eventType	CauseCode and SubCauseCode of event
linkedCause	Not used
eventHistory	Not used
Location Container	
eventSpeed	Not used
eventPositionHeading	Not used
traces	Path route of the vehicle
roadType	Not used
Alacarte Container	Not used

Figure 13 DENM fields at vehicle side

4.5 Main results

The main conclusion arisen from this session is that end-to-end interoperability among Spanish and French participants (both V2I and V2V) was validated as HMI results obtained during test executions matched with what expected according to the predefined event conditioning in the different scenarios.
Besides this, it was also possible to:

detect a communication issue - at access layer level - in some of the Portuguese equipment; discuss on different message parameters configuration (e.g. event distance radius) that could cause functional issues even systems are interoperable; confirm that provision of traces and event history values is key to release reliable information to the driver.

Figure 14: Different HMIs (serial-PSA- and nomadic-CTAG-) displaying same warning during a test trip

The Portuguese partner (A-to-Be) found some interoperability problems since that the captures (pcaps) provided by SCOOP@F to prepare the tests were captured at Facilities layers, lacking the 802.11 MAC and LLC headers. In the Portuguese implementation messages are directly received and transmitted from/to Lower MAC, and the messages received from other partners had extra fields (from MAC and LLC layers) that were not expected. After implementing a full 802.11 MAC and LLC layer, the tests were performed again and all the scenarios were correctly validated, with both Portuguese and Spanish Vru-ITS-S being able to receive, decode and validate I2V and V2V DENM messages. This second Xtest session was identical to the first one, with the exception that URCA vehicle was not able to join. The satisfactory results were checked so communication with Portuguese vehicles was possible and HMI results obtained during test executions matched with what expected according to the predefined event conditioning in the different scenarios.

5 On road test: Second Xtest session

5.1 Scope

As commented in previous sections, to validate end-to-end interoperability among participants in real environments, goal of this second session was to test security aspects according to the guidelines and scenarios established for the task force created to deal with this specific topic.

5.2 Location

The X-Tests were held in the city of Reims, using University of Reims facilities as base camp for vehicle set up, brief and debrief sessions, and driving along A4 highway operated by SANEF, to perform the different scenarios.

As commented, this session took place jointly the Intercor PKI Security TESTFEST on April 23 – April 26, 2019.

The objective was to check if the use of different Public Key Infrastructures (PKIs) and the authentication of messages sent from different ITS stations was aligned with the scope of the X-tests activities within SCOOP project.

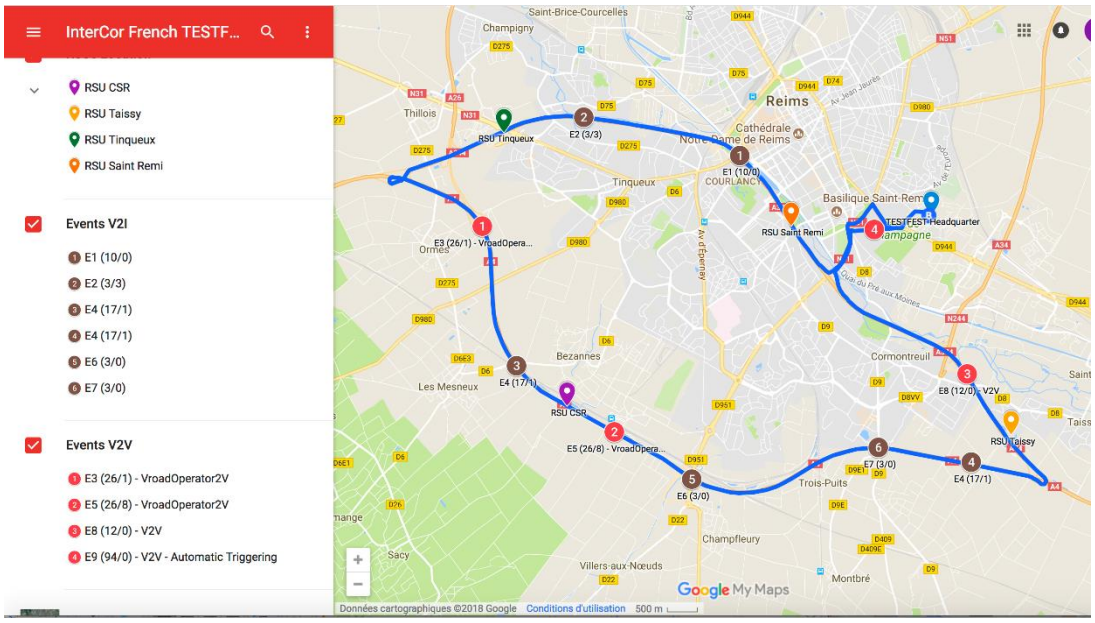


Figure 15: Reims test session location map

5.3 Participants

Number of vehicles/ Vru-ITS-S	Number of R-ITSS-S	Compagnies	PKI
1	1	Austriatech	AU
1		CTAG	ES
1		DIRIF	FR
1	1	Neavia	FR
1	1	NEOGLS	FR
1		PSA	FR
1		Renault	FR
1	4	SANEF	FR
	1	Siemens	AU
1		URCA	FR
	1	Yogoko	FR
1		A-to-Be	PT
10	9	Total	

5.4 Scenarios (functional aspects)

Detailed information on this X-Tests itinerary and events could be found by following this link:

https://drive.google.com/open?id=1eA1NgDNuT9a1w2xHhfbo5x7F4YHsQEhr&usp=sharing

Main aspects are provided below.

- Events:

Obstacle on the road	I2V RSU Saint Remi sends a DENM with “Obstacle on the road - 10-0” Event for one-point location
Road Works	I2V RSU Tinqueux sends DENM with “planned road works slow moving road maintenance 3/3” Message valid for a linear event
Road operator intervention	V_ro2X OBU_ro sends a DENM with “Road operator intervention 26/1”
Extreme weather conditions	I2V RSU CSR sends a DENM with “OHLN: extreme weather conditions: 17-1” Message relevant on a large part the of A4 highway.
Extreme weather condition	I2V RSU Taissy sends a DENM with extreme weather conditions: 17-1” Message relevant on a large part the of A4 highway.
Winter maintenance	V_ro2X OBU_ro sends a DENM with “Winter maintenance – Salting in progress: 26 – 8”
Neutralization part of a lane	I2V RSU CSR sends a DENM with “Alert neutralization of part of a lane: 3-0” Message valid for a linear event
Neutralization part of a lane	I2V RSU CSR sends a DENM with “Alert neutralization of part of a lane: 3-0” Message valid for a linear event Opposite way to Event 7
Human presence on the road	V2V

	A vehicle sends a DENM with "**Human presence on the road: 12-0"** (triggered manually)
Stationary vehicle	V2V A vehicle sends a DENM with "Stationary vehicle: 94-0" (triggered automatically)

Note for I2V events:

- ActionID uses the originatingstationID of Sanef C-ITSS.
- StationID = stationID of each RSU

5.5 Scenarios (security aspects)

As commented in previous sections, the main goal of this session was to tackle the test of security aspects. In this section, we list all the approved X-Tests scenarios. These tests concern the interactions in different trust domains. They detail the secure exchange between ITSSs retrieving their pcs from different PKIs.

The main objective of the tests is to verify messages authentication and validate the trust chain as illustrated in Figure 16.

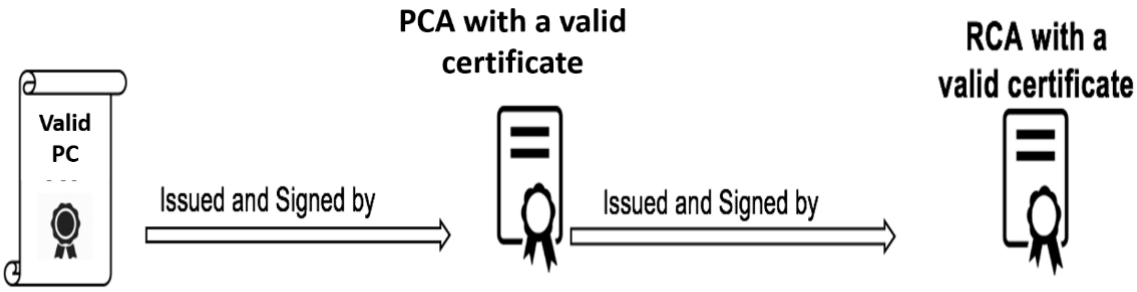


Figure 16: Trust chain validation

Test ID	Description
Security X-TESTS_1	Verification of message signature received from a foreign ITSS and signed with a valid AT.
Security X-TESTS_2	Verification of message signature received from a foreign ITSS and signed with an AT issued by a revoked foreign AA.
Security X-TESTS_3	Verification of message signature received from a foreign ITSS and signed with a valid AT but the foreign Common Scoop_CRL has expired.

Security X-TESTS_4	Verification of message signature received from a foreign ITSS and signed with an AT issued by a non-trusted foreign RCA.
Security X-TESTS_5	Verification of message signature received from a foreign ITSS and signed with a valid AT with a new updated Scoop_CRL

5.6 Tests Scenarios details

In the scenarios description, we consider Portugal "PT" as the home trust domain and France "FR" as the foreign trust domain (see figure 17).

- Security X-Test_1
  - Objective:

This test aims to verify the authenticity of a message received from an ITSS belonging to a foreign trust domain and signed with a valid PC (see figure 17).

- Pre-Conditions:

The RCA_FR is trusted in the TSL_PT.

- Steps:

1. ITSS_PT receives a signed message from ITSS_FR
2. ITSS_PT verifies the message is signed by a valid PC.
3. ITSS_PT verifies the PC is issued and signed by PCA_FR.
4. ITSS_PT verifies the PCA_FR's certificate is issued and signed by the RCA_FR.
5. ITSS-PT verifies the presence of RCA_FR's certificate in its TSL_PT.
6. ITSS_PT verifies the PCA_FR's certificate is not revoked in CRL_FR.

- Expected Test Result:

The trust chain is verified and the message is accepted.

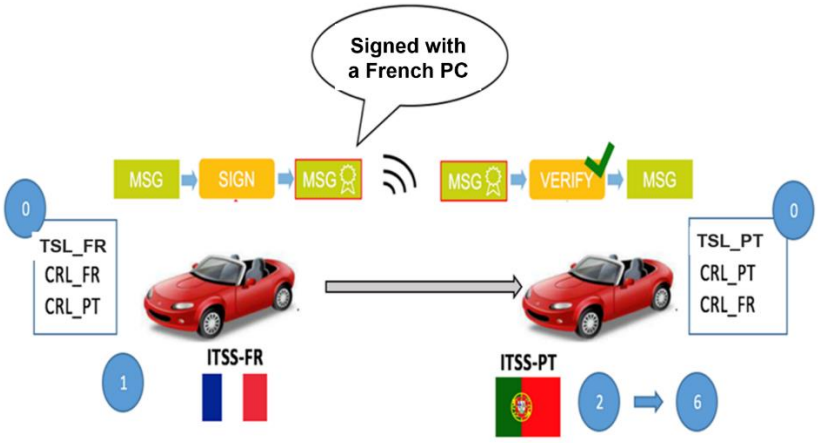


Figure 17: Test_F1 Scenario.

- Security X-Test_2
  - Objective:

This test aims to verify the authenticity of a message received from an ITSS

belonging to a foreign trust domain and signed with an PC issued by a revoked foreign PCA (see figure 18).

- Pre-Conditions:

The RCA_FR is trusted in the TSL_PT.

- Steps:

1. ITSS_PT receives a signed message from ITSS_FR
2. ITSS_PT verifies the message is signed by a valid PC.
3. ITSS_PT verifies the PC issued and signed by PCA_FR.
4. ITSS_PT verifies the PCA_FR's certificate is issued and signed by the RCA_FR.
5. ITSS-PT verifies the presence of RCA_FR's certificate in its TSL_PT.
6. ITSS_PT verifies the PCA_FR's certificate and finds out that it is **revoked** in CRL_FR.

- Expected Test Result:

The trust chain is not valid and the message is rejected.

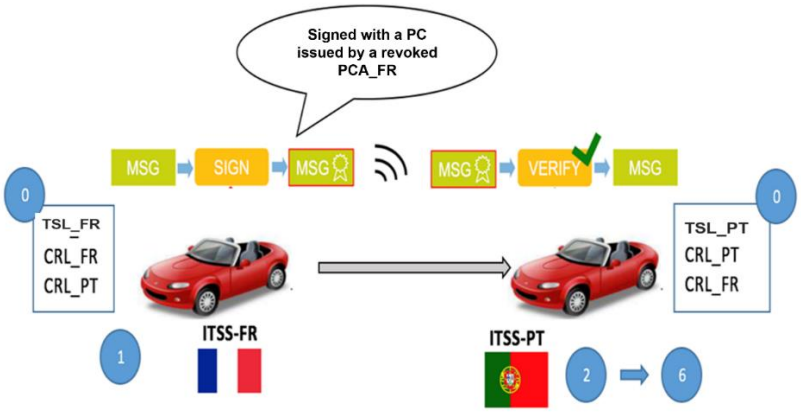


Figure 18: Test_F2 Scenario.

- Security X-Test_3

- Objective:

This test aims to verify the authenticity of a message received from an ITSS belonging to a foreign trust domain and signed with an PC issued by a foreign PCA (see figure 19).

- Pre-Conditions:

The RCA_FR is trusted in the TSL_PT and CRL_FR is expired.

- Steps:

1. ITSS_PT receives a signed message from ITSS_FR
2. ITSS_PT verifies the message is signed by a valid PC.
3. ITSS_PT verifies that the PC issued and signed by PCA_FR.
4. ITSS_PT verifies that the PCA_FR's certificate is issued and signed by the RCA_FR.
5. ITSS_PT verifies the presence of RCA_FR's certificate in its TSL_PT.
6. ITSS_PT verifies the revocation status of PCA_FR's certificate and finds out that the CRL_FR is expired.

- Expected Test Results:

The trust chain is not verified and the message is rejected.

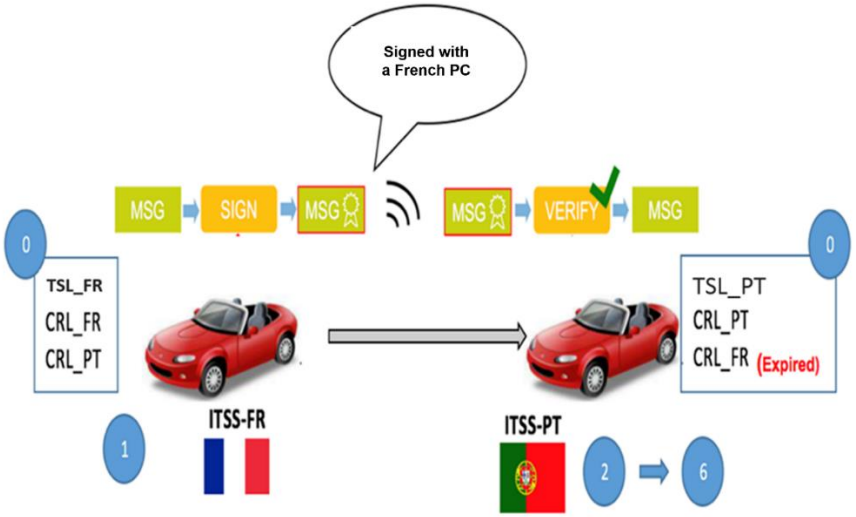


Figure 19: Test_F3 Scenario

- Security X-Test_4
  - Objective:

This test aims to verify the authenticity of a message received from an ITSS belonging to a foreign trust domain and signed with an PC issued by a foreign PCA (see figure 20).

  - Pre-Conditions:

The RCA_FR is NOT trusted in the TSL_PT.

  - Steps:

1. ITSS_PT receives a signed message from ITSS_FR
2. ITSS_PT verifies that the message is signed by a valid PC.
3. ITSS_PT verifies that the PC issued and signed by PCA_FR.
4. ITSS_PT verifies the PCA_FR's certificate is issued and signed by the RCA_FR.
5. ITSS-PT verifies the presence of RCA_FR's certificate in its TSL_PT

➔ RCA_FR's certificate is not present in TSL_PT.

  - Expected Test Results:

The trust chain is not verified and the message is rejected.

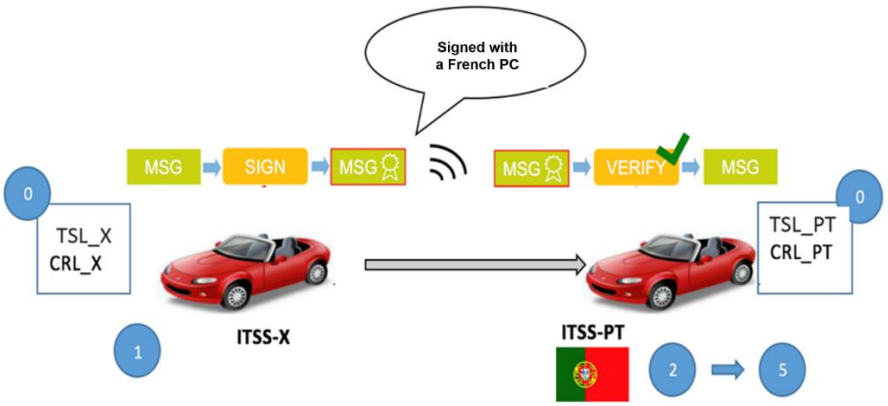


Figure 20:Test_F4 Scenario

- Security X-Test_5

  - Objective:

This test aims to verify the authenticity of a message received from a foreign ITSS and signed with a valid PC with a new updated of a CRL (see figure 21).

  - Pre-Conditions:

The RCA_FR is trusted in the TSL_PT.

  - Steps:

1. ITSS_PT receives a signed message from ITSS_FR
2. ITSS-PT updates its CRL
3. ITSS_PT verifies the message is signed with a valid PC.
4. ITSS_PT verifies the PC is issued and signed by PCA_FR.
5. ITSS_PT verifies the PCA_FR's certificate is issued and signed by the RCA_FR.
6. ITSS-PT verifies the presence of RCA_FR's certificate in its TSL_PT.
7. ITSS_PT verifies the PCA_FR's certificate is not revoked in CRL_FR.

  - Expected Test Result:

The trust chain is verified and the message is accepted.

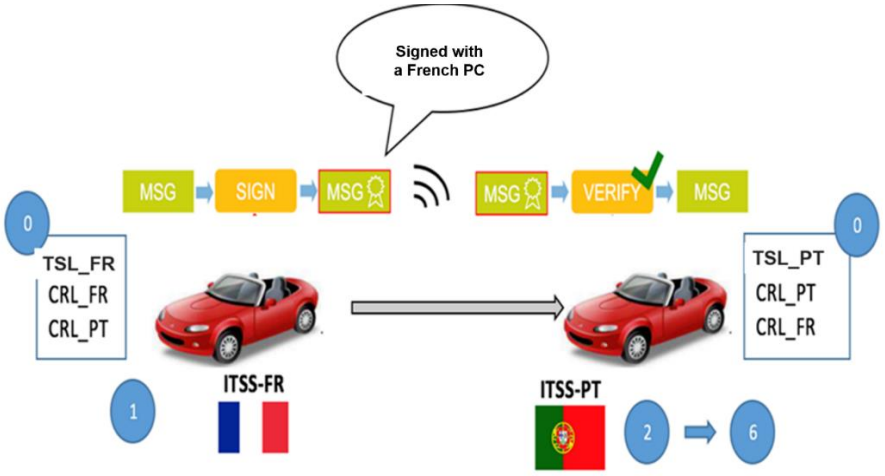


Figure 21: Test_F5 Scenario

5.7 Main results

5.7.1HMI results

For evaluation of this X-Test session, qualitative results could be extracted from analyzing logs obtained from participants.
To obtain these logs, each participant was given an electronic tablet in order to get their individual results for every scenario execution.

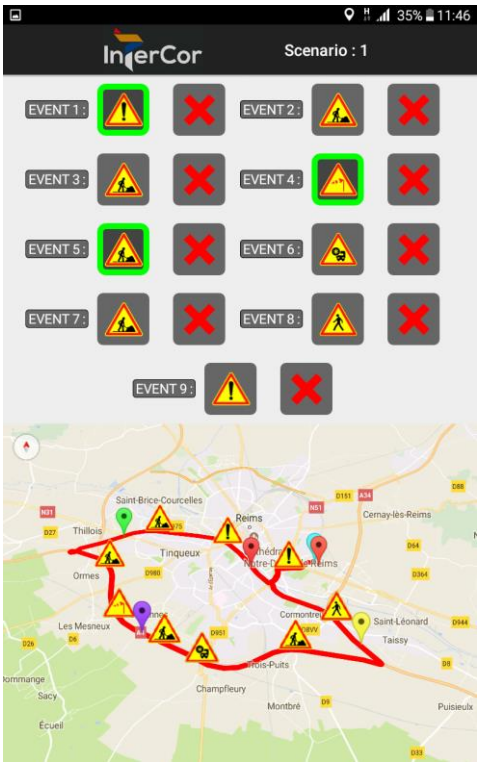


Figure 22 Screenshot of the Tablet Application

For every participant in every scenario, the number of successes displaying or not the different events were logged (input provided taking into account what was expected according to the predefined event conditioning in the different scenarios).

The results have been recorded for each participant for each scenario. All collected results will not be included on this report, but we will present some significant results for each scenario, we show the results of the first tour and the last tour. The aim is to check if improvements have done between the first tour and the last one. Indeed, most of the participants have enhanced their performances due to the debugging process successfully performed by on test site.

5.7.1.1 Scenario 1

For scenario 1, 17 participants have run 44 tours. The verdicts observed on scenario 1 are shown on Table 1. Success means the event has to be displayed on the HMI, fail means that the event has not displayed and inconclusive means that the observer has no idea about what is displayed.

	success	*fail*	*inconclusive*
Event 1	*31*	*11*	*2*
Event 2	*30*	*6*	*8*
Event 3	*22*	*16*	*6*
Event 4	*28*	*8*	*8*
Event 5	*18*	*17*	*9*
Event 6	*18*	*16*	*10*
Event 7	*17*	*22*	*5*
Event 8	*10*	*19*	*15*
Event 9	*13*	*19*	*12*

Table 1: verdicts of scenario 1

In each figure, we represent two diagrams, the one in the left concerns the results of the first tour on the trajectory and the second one represents the results the last one. The figures below depict for each scenario the results for all participants. We can see that the results progress in general and we have more successful tests. For every scenario, we have helped the participants to enhance their OBU or RSU implementation by on-line debugging after several trials after debriefing meetings held many times per day.

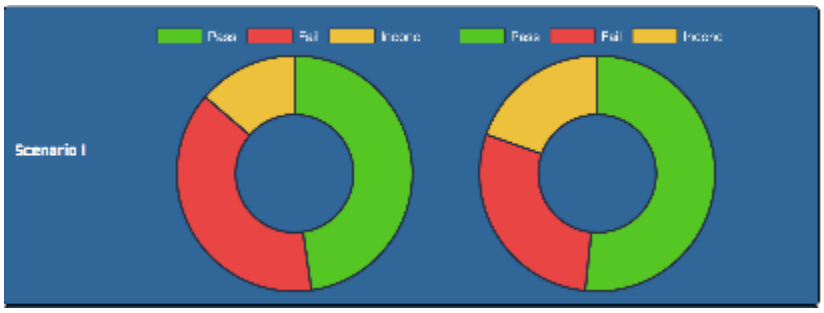


Figure 23: Scenario 1 results for all participants

The improvements from the first tour and the last tour are minor. Most of the false and the inconclusive verdicts are mainly caused by some DENM parameters which are not understood by some participants (Cause code values, lack of synchronization for instance) or about wrong signature.

5.7.1.2 Scenario 2

Success means the event has not displayed on the HMI, fail means that the event has been displayed and inconclusive means that the observer has no idea about what is displayed.

	success	*fail*	*inconclusive*
Event 1	*10*	*5*	*0*
Event 2	*10*	*5*	*8*
Event 3	*10*	*4*	*1*
Event 4	*10*	*5*	*0*
Event 5	*11*	*3*	*1*
Event 6	*9*	*3*	*3*
Event 7	*10*	*2*	*3*
Event 8	*9*	*3*	*3*
Event 9	*11*	*1*	*3*

Table 2: verdicts of scenario 2

Erreur ! Source du renvoi introuvable. shows the results of scenario 2. As we see some events have been displayed properly either on the first tour or the second tour. The improvement between the first tour and the last tour is interesting. **The reason is that some partners have not considered the revocation principle then events which should not be displayed have been displayed.**

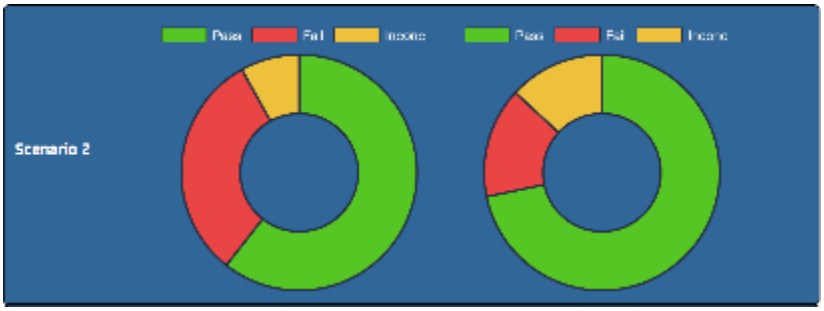


Figure 24: Scenario 2 results for all participants

5.7.1.3 Scenario 3

For scenario 3, 8 participants have run 13 tours. The verdicts observed on scenario 3 are shown on **Erreur ! Source du renvoi introuvable.**. Success means the event is not displayed on the HMI, Fail means that the event has been displayed and inconclusive means that the observer has no idea about what is displayed

	success	*fail*	*inconclusive*
Event 1	*6*	*6*	*1*
Event 2	*3*	*7*	*3*
Event 3	*5*	*6*	*2*
Event 4	*5*	*5*	*3*
Event 5	*5*	*5*	*3*
Event 6	*5*	*5*	*3*
Event 7	*4*	*6*	*3*
Event 8	*10*	*0*	*3*
Event 9	*8*	*2*	*3*

Table 3: verdicts of scenario 3

Erreur ! Source du renvoi introuvable. shows the results of scenario 3. As we see, some events have been displayed properly either on the first tour or the last tour. There is no improvement between the first tour and the last tour. **The reason is that some partners have displayed events coming from RSUs which are supposed to be revoked (the CRL is expired)**. The understanding of expired CRL is not the same from one country to another. Indeed, in France expired CRL means that no one could be trusted and the content will not handle, then all received messages will not be considered but for others, if the CRL is expired, they will check the CRL content. If it is empty, they will consider the received events signed with external PCAs.

Figure 25: Scenario 3 results for all participants

5.7.1.4 Scenario 4

For scenario 4, 7 participants have run 8 tours. The verdicts observed on scenario 4 are shown on Table 9. Success means the event is not displayed on the HMI, Fail means that the event has been displayed and inconclusive means that the observer has no idea about what is displayed.

	success	***fail***	***inconclusive***
Event 1	*7*	*1*	*0*
Event 2	*7*	*1*	*0*
Event 3	*7*	*1*	*0*
Event 4	*7*	*1*	*0*
Event 5	*7*	*1*	*0*
Event 6	*7*	*1*	*0*
Event 7	*7*	*1*	*0*
Event 8	*7*	*1*	*0*
Event 9	*6*	*1*	*1*

Table 4: verdicts of scenario 4

Figure 26 shows the results of scenario 4. As we see some events have been displayed properly either on the first tour or the second tour. There is no improvement between the first tour and the last tour. The debugging is not so easy in this situation. Some participants have not been able to change their CRL files on-line.

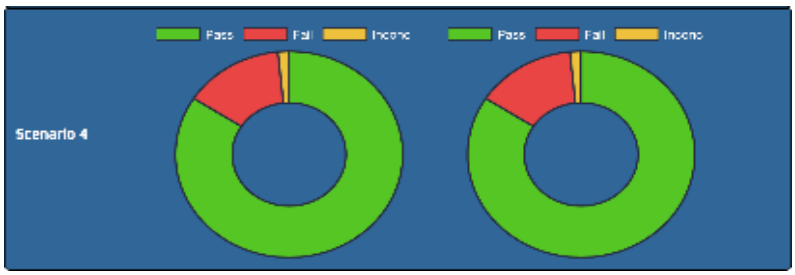


Figure 26: Scenario 4 results for all participants

5.7.1.5 Scenario 5

For scenario 5, the aims is to verify the authenticity of a message received from a foreign ITSS and signed with a valid AT with a new updated Common InterCor_CRL. The verdicts observed on scenario 5 are shown on **Erreur ! Source du renvoi introuvable.**. Success means the event is displayed on the HMI, Fail means that the event has not been displayed and inconclusive means that the observer has no idea about what is displayed.

	success	*fail*	*inconclusive*
Event 1	*7*	*2*	*1*
Event 2	*7*	*2*	*1*
Event 3	*6*	*3*	*1*
Event 4	*6*	*3*	*1*
Event 5	*6*	*3*	*1*
Event 6	*7*	*2*	*1*
Event 7	*2*	*7*	*1*
Event 8	*2*	*4*	*4*
Event 9	*1*	*3*	*6*

Table 5: verdicts of scenario 5

Figure 27 shows the results of scenario 5. As we see some events have not been considered properly either on the first tour or the second tour. There are some improvements between the first tour and the last tour. The reason is that some participants have not configured their stations correctly in the first tour. This scenario is similar to scenario1. In fact, the aim was to update the CRL to be valid.

Figure 27: Scenario 5 results for all participants

5.7.1.6 Conclusion

As usually happens in sessions when some feature is newly tested, comparison of results from first to last day of testing brings a clear enhancement for performance obtained, bringing interoperability closer than it was before the sessions as the higher number of successful interoperability tests is, the better interoperability could be guaranteed

In this sense, some interesting discussions concerning differences in interpretation of CRL exceptions in cases like “regular” revocation of a PCA or an expired CRL or management of multiple CRLs in reception side came up, showing this way a high level of implementation maturity of security by the different participants.

In general lines, this session allowed to meet an important milestone as for first time all involved partners in Xtest activity were able to test not only functional aspects (including forwarding algorithms using the platoon of 19 vehicles of the first day), but also security, paving the road for coming Xtest sessions where all these aspects may be tested more in depth.

5.7.2 Results Analysis of the ECO-AT and RSA OBU communication

It is clear that the problems of V2X communications messages are not only due to the PKI interoperability, that why some of participants tried to study the communications problems from different approaches here is Results analysis done by the French partner RSA (Renault) which has looked more on other themes, and has decided to highlight some tests that they did with Siemens during the XTest, **Note: these tests were not part of the scenario of the TestFest**.

This chapter is related to the “Rapport du TestFest de Reim 23/04/18-26/04/19 Version: A00”, the document is the property of Renault and was written in French. You find in the chapter some extract translate in English.

5.7.2.1 Test results

The diagram below describes the context in which the tests took place, the test was performed on at laboratory level.

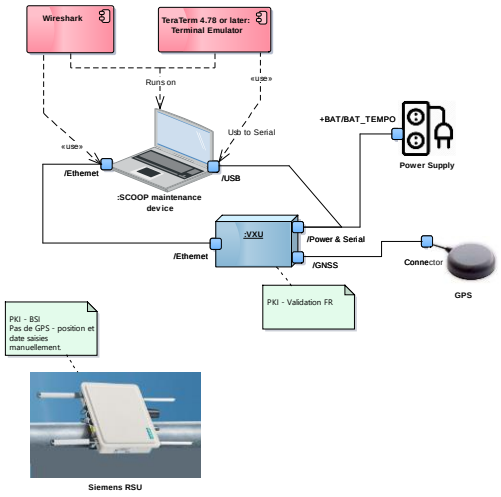


Figure 28: Test ECO-AT RSU

Siemens RSU was registered on the ECO-AT BSI-PKI PKI

- As a first step, Siemens' RSU does not transmit CAM messages but only a signed DENM cc/sc: 2/5 (Accident involving hazardous materials).

By activating the traces on the DENM module of the VXU box, no message is displayed. The DENM is therefore not received at the application level, the chain of confidence cannot be verified since the VXU cannot recover the PCA via the exchange mechanism of the CAM => **nominal behavior**.

- Siemens then activates the CAMs on its OBU, the chain of trust is checked but **the messages are filtered temporally by the security layer** (see console trace below).

```
ate> ulog SignMsgVerif D+
ate>
<7>1351:  ARM:  Apr  24  2018  13:29:50.049877:  D  016b3b  Ev=0013  Unit:SignMsgVerif  HashID8  of  signer  :
15daed9fa1ebf9a6
<7>1352:  ARM:  Apr  24  2018  13:29:50.557373:  D  016b6d  Ev=0013  Unit:SignMsgVerif  HashID8  of  signer  :
15daed9fa1ebf9a6
<7>1353:  ARM:  Apr  24  2018  13:29:51.066520:  D  016ba0  Ev=0013  Unit:SignMsgVerif  HashID8  of  signer  :
15daed9fa1ebf9a6
<7>1354:  ARM:  Apr  24  2018  13:29:51.367479:  D  016bbe  Ev=0013  Unit:SignMsgVerif  HashID8  of  signer  :
04bbdc7888b9ca68
<7>1355:  ARM:  Apr  24  2018  13:29:51.568218:  D  016bd2  Ev=0013  Unit:SignMsgVerif  HashID8  of  signer  :
15daed9fa1ebf9a6
<7>1356:  ARM:  Apr  24  2018  13:29:52.073193:  D  016c03  Ev=0013  Unit:SignMsgVerif  HashID8  of  signer  :
15daed9fa1ebf9a6
```

```
<7>1357: ARM: Apr 24 2018 13:29:52.369334: D 016c21 Ev=0013 Unit:SignMsgVerif HashID8 of signer :
04bbdc7888b9ca68
<7>1358: ARM: Apr 24 2018 13:29:52.576929: D 016c36 Ev=0013 Unit:SignMsgVerif HashID8 of signer :
15daed9fa1ebf9a6
<7>1359: ARM: Apr 24 2018 13:29:52.879370: D 016c54 Ev=0013 Unit:SignMsgVerif HashID8 of signer :
e8e97bd4d006fa2a
<6>1360: ARM: Apr 24 2018 13:29:52.879678: I 016c54 Ev=0011 Unit:SignMsgVerif ValidityRestriction:region check
passed
<7>1361: ARM: Apr 24 2018 13:29:52.880959: D 016c54 Ev=0004 Unit:SignMsgVerif verify with 040cfa0a65da98b6 -
fae563d86b29adf8 - 630a438a0d1dae42 - 873372d7a5c012f0 - a311b4360665ce1a - 09a6c81e7a59cceb -
65cee929197d9090 - 8
<6>1362: ARM: Apr 24 2018 13:29:52.882963: I 016c54 Ev=000a Unit:SignMsgVerif replay filter elimates on time
consideration, delta of 2106782102 of 451659290930898 to 451661397713000
```

As a reminder, the time filter on the SCOOP@F project is fixed at 3 second for CAM and 10 minutes for DENMs.

- The filter is disabled on the VXU via the configuration file and the VXU restarts. By activating the traces on the CAM module then DENM module, the messages are well decoded and processed by the application layer (see console trace below).

```
ate> ulog CAM D+
ate> <7>4500: ARM: Apr 24 2018 13:46:48.812375: D 014230 Ev=0017 Unit:CAM Time to send a CAM (AppInterval=1000,
AppPriority=2)
<6>4501: ARM: Apr 24 2018 13:46:48.812556: I 014230 Ev=000e Unit:CAM Time to send a CAM (tGenCam_=998)
<7>4502: ARM: Apr 24 2018 13:46:48.814849: D 014230 Ev=0007 Unit:CAM UPER encoding success
<CAM><header><protocolVersion>1</protocolVersion><messageID>2</messageID><stationID>1454212176</stationID><
/header><cam><generationDe
<7>4503: ARM: Apr 24 2018 13:46:48.815390: D 014230 Ev=001b Unit:CAM CAM generation DT:27544, current DT:27563,
complement of current DT:451662381056, computed CAM generation time:451662408600
<7>4504: ARM: Apr 24 2018 13:46:48.822643: D 014231 Ev=0004 Unit:CAM UPER decoding success
<CAM><header><protocolVersion>1</protocolVersion><messageID>2</messageID><stationID>1048980</stationID></he
ader><cam><generationDelta
<7>4505: ARM: Apr 24 2018 13:46:48.823026: D 014231 Ev=001b Unit:CAM CAM generation DT:0, current DT:27571,
complement of current DT:451662381056, computed CAM generation time:451662381056
...
ate> ulog DENM D+
ate> <7>4855: ARM: Apr 24 2018 13:47:53.159313: D 015b3d Ev=0000 Unit:DENM UPER decoding success
<DENM><header><protocolVersion>1</protocolVersion><messageID>1</messageID><stationID>1048980</stationID></h
eader><denm><management><
<5>4856: ARM: Apr 24 2018 13:47:53.159530: N 015b3d Ev=0022 Unit:DENM DENM dropped for causeCode 2 due to
SSP = 0x01 0x00 0x00 0x00
<7>4857: ARM: Apr 24 2018 13:47:53.159727: D 015b3d Ev=0021 Unit:DENM Problem Report 3
<7>4858: ARM: Apr 24 2018 13:47:58.163651: D 015d30 Ev=0000 Unit:DENM UPER decoding success
<DENM><header><protocolVersion>1</protocolVersion><messageID>1</messageID><stationID>1048980</stationID></h
eader><denm><management><
<5>4859: ARM: Apr 24 2018 13:47:58.163914: N 015d30 Ev=0022 Unit:DENM DENM dropped for causeCode 2 due to
SSP = 0x01 0x00 0x00 0x00
<7>4860: ARM: Apr 24 2018 13:47:58.164135: D 015d30 Ev=0021 Unit:DENM Problem Report 3
```

The Eco-AT RSU CAM (stationID = 1048980) is well present in the TLOG-UEVu-CAM-I at 13:33:48 (TimeStampITs = 451661628659) but no DENM in the TLOG-UEVu-DENMReceived since the latter is not accepted. In the TLOG-FaultyMessage, we find the ault code 2/2 [DENM - SSP not valid (Security Info)].

5.7.2.2 Summary

The messages transmitted by the Eco-AT RSU are well interpreted by the RSA OBU as soon as the CAMs are well exchanged. The DENM is well treated but not allowed because the certificate used by the Eco-AT RSU does not allow the sending of DENM. It was not possible for Siemens to retrieve a certificate authorizing the broadcast during this test day.

5.7.2.3 Conclusion done by RSA during this test fest

This chapter is related to the “Rapport du TestFest de Reim 23/04/18-26/04/19 Version: A00”, the document is the property of Renault and was written in French. You find in the chapter some extract translate in English.

In general, the tests worked very well: all the events were received (except RSU bug or bad events sent by the managers) and were displayed as needed on the HMI. The rounds of 23/04/18 afternoon raise the problem of the non-harmonization of itsGnMaxGeoAreaSize field between ITS-S preventing ITS-S from making hops. The table below gives the ranges for the different tours:

		Tour			itsGnMaxGeoAreaSize	
Event (cc/sc)	RSU	23/04 A-M Round 1	23/04 A-M Round 2	24 morning	24/03 A-M Round 1	24/03 A-M Round 2
10/0	Saint-Rémi	0,187096977	0,522037507	0,5524378	0,72572243	0,6032976
3/3	Saint-Rémi	0,912719573	0,791269387	0,5524378	0,72572243	0,6032976
17/1	Tinqueux	0,99999221	0,77110194	1,14802077	0,69322774	0,6556783
3/0 (1)	CSR	1,054121391	0,870839781	(non reçu)	1,08845166	0,77291157
3/0 (2)	CSR	1,054121391	0,901655099	(non reçu)	1,05598449	0,77291157

A difference in range area between the various events sent by Saint-Rémi RSU is notable for the two rounds different of 23/04 (in light blue).

The following diagrams illustrate the exchanges between vehicles for these tours:

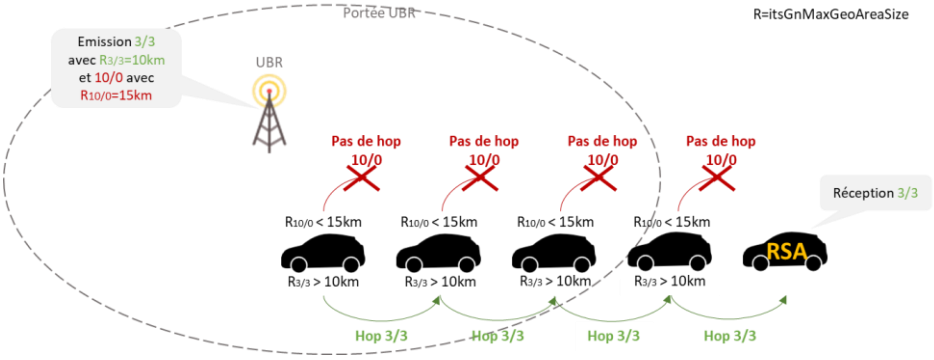


Figure 29: Hops round 1 23/04/18

• 23/04/18 turn 1: Unlike DENM 3/3, the vehicles around the RSA vehicle cannot perform 10/0 event hops because their itsGnMaxGeoAreaSize is lower than that of the transmitting RSU. Thus, we can receive the DENM 10/0 only by the RSU, when we are within reach, while the mobile yard is received from other vehicles 700m earlier than the obstacle.

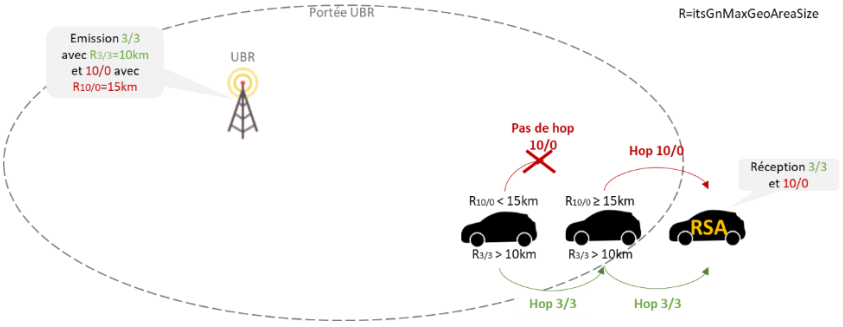


Figure 30: Hops round 2 23/04/18

• 23/04/18 lap 2: In the second lap, a vehicle around RSA vehicle had the opportunity to hop the 10/0 event while two vehicles could do it for the DENM 3/3. Therefore, we always receive the mobile yard ahead of the obstacle, but with a smaller range gap than the previous round.

• Since this hop problem was fixed on 24/04/18, the 3/3 and 10/0 events were then received at the same time for further tests.
The relatively large number of cars (19) in the procession was not an obstacle to the good reception of the messages. This procession included vehicles not recognized by the VXU (continuous message exchange type Request unrecognized certificate) as well as some French vehicles.

The only cross-test that could be done on the table with the Siemens UBR is also conclusive. It is just unfortunate to have been unable to display the DENM in the vehicle due to an SSP problem in the Siemens certificate.

6 On road test: Third Xtest session

6.1 Scope

As done in Vienna, the goal of this third session was to keep on testing end-to-end interoperability among Xtest participants in real environment involving security aspects for G5 based communication.

6.2 Location

Location for this Xtest session was the Living Lab existing in Vienna, supported by AutsriaTech and operated by ASFINAG together with industry partners Kapsch TrafficCom, Siemens and Swarco (10-11/07/2018).

6.3 Participants

- Siemens (Austria): 4 RSUs
- Swarco (Austria): 1 RSU
- AustriaTech (Austria): 1 OBU
- RSA (France): 1 OBU
- A-to-Be (Portugal): 1 OBU (without security)
- Magna: 1 OBU (without security)

Figure 31: Xtest scenario in Viena for DENM messages

6.4 Scenarios

Scenario deployed for this session was based on the configuration existing for the last test cycle experienced in the Vienna Living Lab (4 test rounds).

The following DENM based use cases were tested (I2V mode):

- Roadworks Warning (RWW) (3/0)
- Road Hazard Signalling (RHS)
  - Accident (2/0)
  - Snow (6/4)
  - Fog (18/1)
  - Animal on the road (11/0)
  - Ice (6/5)
  - Rescue & Recovery (15/0)
  - Human presence on the rodad (12/0)

Between brackets, corresponding cause codes and subcause codes. All messages were configurated as upstream for the relevanceTrafficDirection parameter.

RHS also tested in V2V mode.

Also mitigation on Protected Communication Zones was tested by means of including this info into CAM messages and checking if Vru-ITS-S reduced their power when entering into these zones.

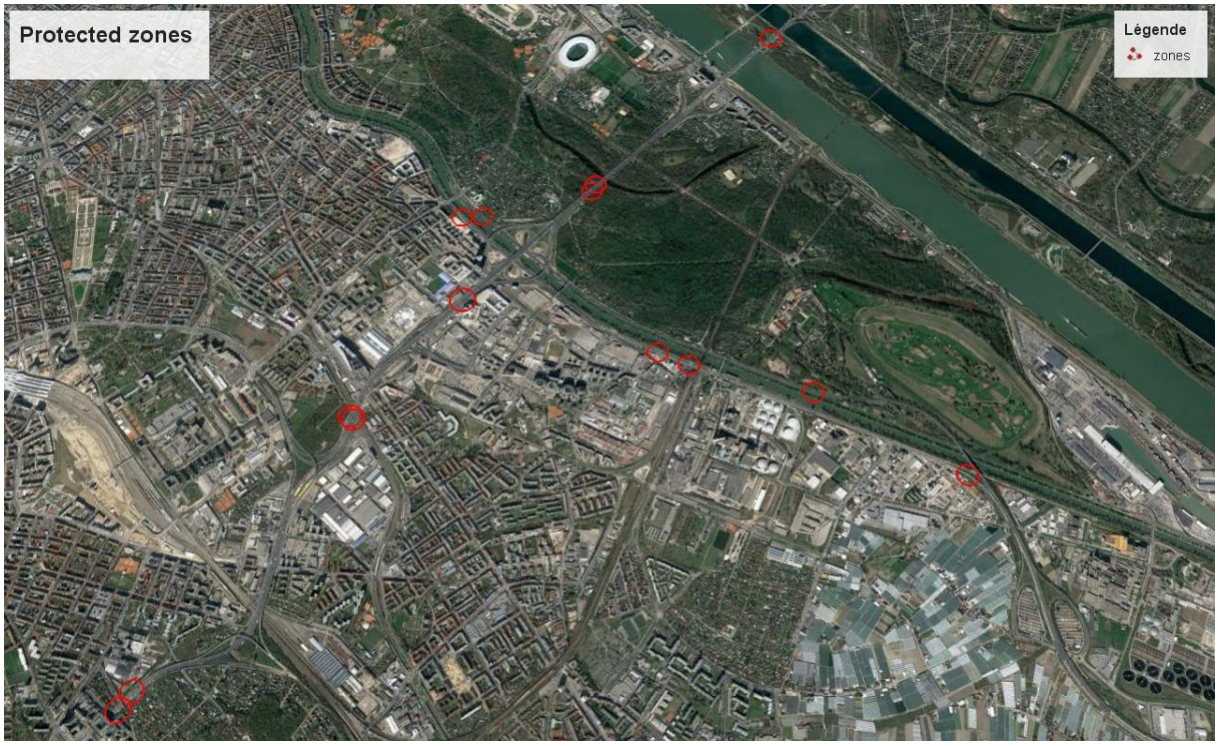


Figure 32: Xtest scenario in Vienna for Protected communication zones

Concerning security aspects, a similar approach to what was tested in Reims for scenario 1 was followed. As tested there, every participant was enrolled on his own PKI and RCA of participants was known by the rest of participants (over TSL or other means).

6.5 Main Results

Concerning DENM based use cases testing, as HMI results obtained during test executions matched with what expected according to the predefined event conditioning and no issues were detected dealing with security configuration when messages were in vehicle received, end-to-end interoperability was validated between participant partners.

In terms of DENM usage, it was detected that RSA used cause code 9 for road closure; Austrian partners for surface condition.

Concerning protected zones (CAM based use case), messages were well interpreted as emission power was decreased in all the protected zones in round 1, round 2 and round 3 (no change in round 4 as message was rejected).

7 Lessons learned for next steps

Apart of specific conclusions described in previous sections, some considerations obtained may be useful to apply for coming Xtest activities:

- Xtest work framework established for W1 activity resulted reliable enough to both allow early detection of a wide range of potential interoperability issues since the initial step (e.g. potential discrepancies with application of standards, issues at communication layer...) and establish discussions to improve functional aspects (e.g. communication parameters…).
- Concerning security, further than keep on going with discussions on interpretation of CRL exceptions or management of multiple CRLs in reception, it became clear than the trust relationship between security X-Tests partners PKIs established at RCAs' level in order to create a (project specific) global trust domain should step forward to an European global trust domain.
- Activities like Xtests in SCOOP or whole projects like Intercor, C-ROADS… should be continued as dealing with interoperability issues at international level is key to leverage a successful and optimal C-ITS deployment.