C-ITS French Cross-Border Testing Report: 2022

C-Roads Platform

Working Group 2 Technical Aspects

Taskforce 5 Cross-Testing and Validation

Publication History

Version	Date	Description, updates and changes	Status
0.1	03-01-2023	Template from TF5.	Draft
0.2	03-01-2023	First draft. - Younes BOUCHAALA, VIVERIS for MTECT.	Draft
0.3	03-01-2023	Review. - Emilie PETIT, MTECT.	Draft
0.4	04-01-2023	Taking into account the comments of version 0.3. - Younes BOUCHAALA, VIVERIS for MTECT.	Draft
0.5	20-01-2023	Adding partners contributions. - Younes BOUCHAALA, Viveris for MTECT.	Draft
0.6	24-01-2023	Editing sub-section 2.3.2. - Younes BOUCHAALA, Viveris for MTECT.	Draft
0.7	03-02-2023	Taking into account COCSIC Etudes' comments.	Submitted to the COPIL
0.8	06-03-2023	Editing table N3 and table N9.	Submitted to TF5

Table 1: Version History.

Acronyms

Term	Meaning
CAM	Cooperative Awareness Message.
DENM	Decentralized Environment Notification Message.
NFr-ITS-S	French National Node.
InDiD	"Infrastructure Digitale de Demain": a pilot project aiming to evaluate how connected infrastructures will bring enhanced perception to road users.
ITS-G5	European standard for vehicular communications based on the IEEE-1609.x and IEEE-802.11p standards.
SANEF	"Société des Autoroutes du Nord et de l'Est de la France" (Northern and Eastern French Highways Corporation) is a motorway operator company in France.
SPATEM	Signal, Phase and Timing Extended Message.
UBRs (RSU)	"Unité Bord de Route" = Road Side Unit.
APRR	"Autoroutes Paris-Rhin-Rhône" is one of the companies in charge of operating a French motorway network.
BxM	"Bordeaux Métropole".
DIRA	"Direction Interdépartementale des Routes Atlantique" (Interdepartmental Directorate of Atlantic Roads).
DIRE	"Direction Interdépartementale des Routes Est" (Interdepartmental Directorate of East Roads).
DIRIF	"La direction des routes d'Île-de-France" (The Ile-de-France roads department).
DIRMED	"Direction Interdépartementale des Routes de Méditerranée" (Interdepartmental Direction of Mediterranean Roads).
DIRO	"Direction interdépartementale des routes Ouest" (Interdepartmental Directorate of Western Roads.).
SNCF	"Société Nationale des Chemins de Fer Français" is the French public railway company.
Vro-ITS-S	Vehicular Road Operator equiped with an ITS-S (ITS Station).
VINCI_AUTOROUTES	Vinci Autoroutes is a division of the Vinci group specializing in the concession and operation of motorway infrastructure.
EurStras	Eurostar is an international high-speed rail service.

Table 2: Acronyms.

Index

List of figures

List of tables

1. Introduction

The objectives of the French cross-border tests (CBT) were to check the compliance of the messages to the French and European specifications as a part of the two projects *InDiD* and *C-ROADS platform*, in which France is involved.

The CBTs took place in two phases:

- A first phase (2021 - 2022) during which we tested IP-Based messages, via a direct connection to the French National Node (NFr-ITS-S).

- A second phase (summer 2022) during which we tested SPATEM, MAPEM, CAM, and DENM messages as follows:
    - SPATEM and MAPEM in ITS-G5 in Paris.
    - CAM and DENM in ITS G5 along the SANEF road networks.

We emphasize that in the spring of 2022, France attempted to organize physical tests (in person), but no other member state of the C-ROADS project or associated partner responded positively to the invitation. Consequently, in the summer of 2022, France decided to switch to virtual (remote) tests. PCAP captures were sent to all C-ROADS platform partners in September 2022, but only one country (Austria) responded to the invitation. A dedicated meeting was organized on November 7, 2022 with Austria to analyze the PCAP captures, then a second meeting on November 30, 2022 to do a more in-depth analysis of the obtained results.

2. Methodology of the experimentation

2.1. Logistics

As explained in the introduction of this document, only virtual testing took place during the relevant test campaign. The French Ministry of Transport took care of organizing the various required test sessions. Presentations of the different test sites and their characteristics were made to explain the context of these tests. The key elements of each site are detailed in subsection 2.1.2 of this document.

2.1.2 Test run description

a) Paris Site:

The Paris site is located in the city center of the capital. It extends over 3.5km, between three major train stations (Gare d'Austerlitz, Gare de Lyon, and Gare de Paris Bercy), and crosses 9 intersections connected with UBRs (RSU) and 9 smart Poles equipped with ITS equipment (cameras, lidars, etc).

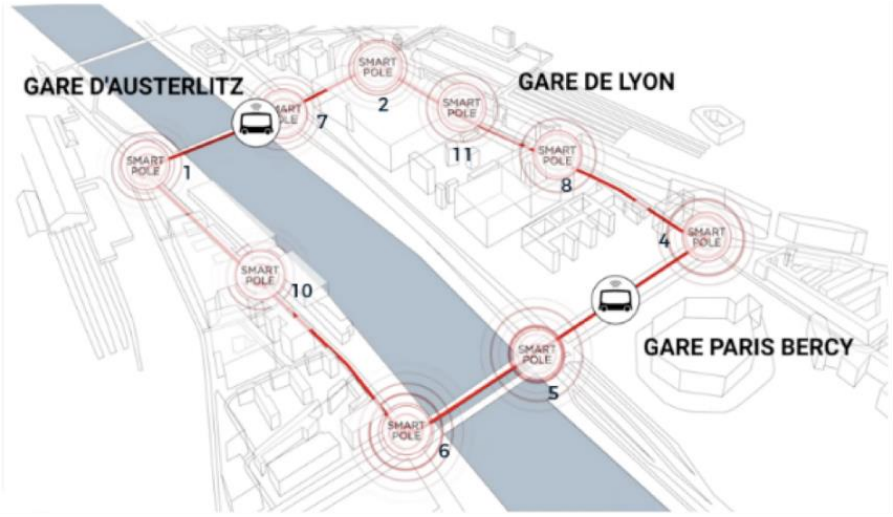

Figure 1: Paris stie.

Co-financed by the European Union
Connecting Europe Facility

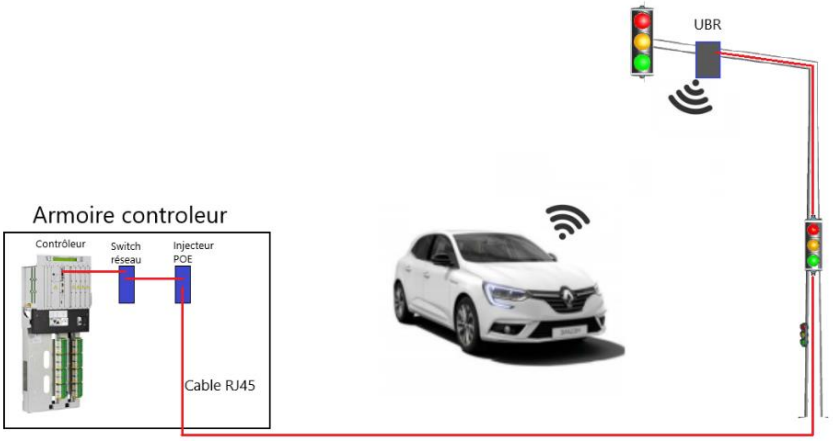

Figure 2: Illustration of the vehicle-to-UBR connection.

b) SANEF Site:

The SANEF site is located on the A14-A13 motorway. The R-ITS-S sending events are shown in the following map.

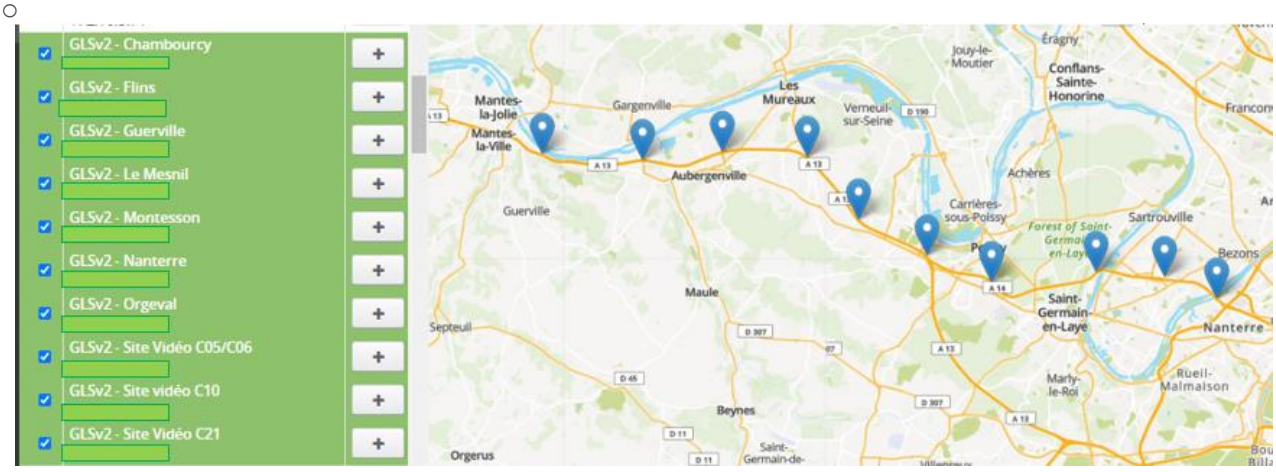

Figure 3: SANEF pilot site.

c) National Node (NFr-IST-S):

The NFr-ITS-S is a server connected to various sources of C-IST messages, such as: Road managers, equipped managers 'vehicles, cellular UBRs (RSUs), etc.

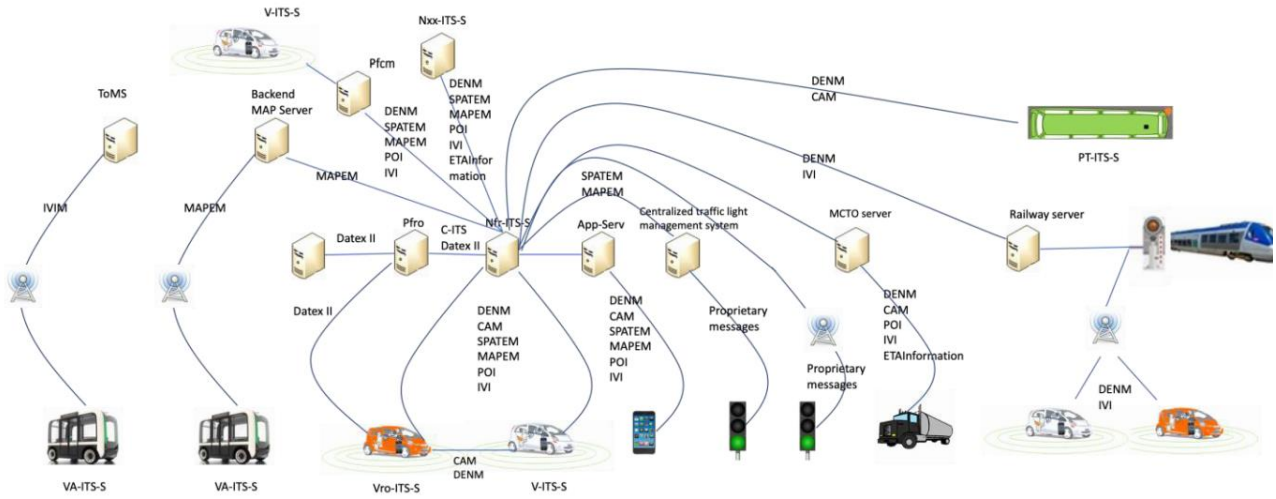

Figure 4: French functional architecture.

The NFr-ITS-S is permanently connected to its sources and continuously broadcasts the messages received from the mangers (for some, tests messages, for others, a copy of the real messages from the managers). The following figure shows an example of NFr-ITS-S messages distribution.

Figure 5: Example of NFr-ITS-S messages distribution.

Co-financed by the European Union
Connecting Europe Facility

2.1.3 ITS-G5 Participants

Austria was the only country that responded to our invitation and took part in the tests. Two ITS-G5 virtual test sessions have been organized, on 07-11-2022, and 30-11-2022 respectively.
The list of participants is as follows:

Session of 07-11-2022:

- Anaïs Ducournau (France)
- Andreas Dis (Austria)
- Emilie Petit (France)
- Malalatiana Randriamasy (France)
- Marwane Ayaida (France)
- Walter Zimmermann (Austria)
- Younes Bouchaala (France)

Session of 30-11-2022:

- André Perpey (France)
- Clément Ruffin (France)
- Geoffrey Wilhelm (France)
- Jacek Dariusz Jaczynski (Austria)
- Malalatiana Randriamasy (France)
- Marie GUYONNAUD (France)
- Marwane Ayaida (France)
- Walter Zimmermann (Austria)
- Younes Bouchaala (France)

2.1.4 IP-based Participants

The tests took place between 2021 and 2022.
The following countries took part in the different test campaigns: Italy, Spain, Slovenia, and the Czech Republic.

2.2. Technical Configurations

2.2.1 Pre-conditions

All the messages, namely, DENM, CAM, SPATEM, and MAPEM, were signed, and supported the C-Roads Roadside System Profile / Mobile System Profile Release # 2.0 specifications, for both ITS-G5 and IP-based link. The receiver shall be able to handle those characteristics.

2.2.2 ITS-G5 configuration

No special ITS-G5 configuration was required.

2.2.3 IP-based configuration

IP-based configuration details were spread to the partners through the following BI registry:

Url.	IPSEC tunnel to have.
	Conections will be established in AMQP 1.0, under a IP Network address translation.
Responsible partner for BI	French Ministry of transport
Contact person name, contact person email	Emilie petit, emilie.petit@developpement-durable.gouv.fr
	Bruno Berenguer, bruno.berenguer@i-carre.net
Message types available	DENM, IVIM, SPATEM/MAPEM
Test period in CW	From 1 february 2021
Geographic indication for area served	especially France: 12022,031313,031331,031333,120202,120203
Remark1 (total number of available sets)	DENM: around 50 events a day
	IVIM : around 100 a day
	POI : around 100 a day
	SPAT/MAP: about 250 intersections
Remark 2 – connection security used (recommended TLS 1.3)	AMQPS over Ipsec with TLS 1.3

Table 3: IP-based configuration.

2.2.4 Security configuration

All messages were signed according to the following configuration:

- French PKI: https://dc-pilot-pp.france.c-its-pki.eu/, registered in the L0 ECTL
- Security Protocol Version ETSI TS 103 097: 1.4.1

2.2.5 Visiting MS configuration

For ITS-G5 PCAP, the software tools used by the participants was compliant with C-ITS messages according to C-Roads specifications Release # 2.0.

In order to be able to test the PCAP files, the following recommendations were respected:

- To be able to replay the PCAP messages.
- To be able to decode the messages and understand their content using reference standards.
- To be registered to the French PKI (or trust the French PKI) to validate the certificates, or be able to ignore the security of the messages while reading them.

For the IP based messages, a connection was made with the National Node. Participant software devices were compliant with C-ITS messages according to *C-Roads* specifications Release # 2.0.

In order to be able to test the PCAP files, the following recommendations were respected:

- To be able to decode the messages and understand their content using reference standards.

- To be registered to the French PKI (or trust the French PKI) to validate the certificates, or be able to ignore the security of the messages while reading them.

2.2.6 Used tools for validation

The tools used for validations are as follows:

a) Hosting MS tools:

For the storage of the different PCAP files that were used in CBT and as shown in the following figure, the equipment used is mainly composed of:

- An OBU MK5 from Cohda Wireless: it is used as a Bridge to collect the different messages sent by the RSUs (DENM, SPATEM and MAPEM). It allows also to generate CAMs to be also stored in the PCAP files.
- A recording PC: it is used to store the PCAP files using the tool Wireshark or the “tcpdump” command.

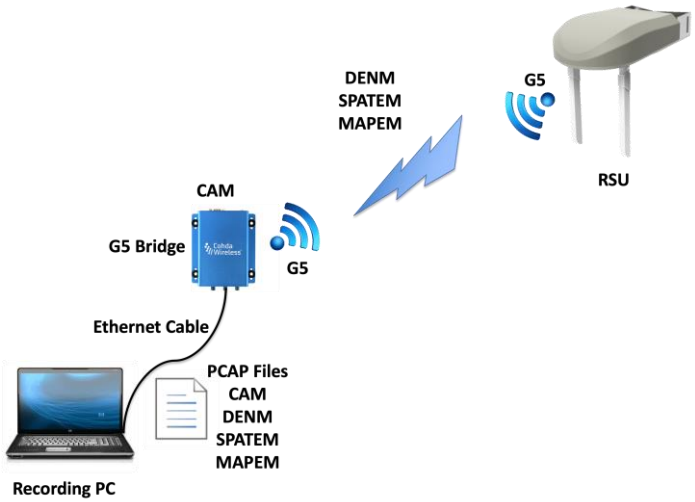

Figure 6: Storing PCAP architecture.

b) Visiting MS tools:

Austria used *CANoe*, which is a development and testing software, mainly used by automotive manufactures and electronic control unit suppliers for testing, simulation, and diagnostics.

2.3. Testing Program

2.3.1 Tested services and use-cases

The list of service and use-cases tested by the Paris site is as follows:

a) Paris Site:

Service	Use-cases
Signalized Intersections (SI)	Green Light Optimal Speed Advisory (SI-GLOSA).

Table 4: Paris stie tested service, and use-cases.

b) SANEF Site:

The list of service and use-cases tested by the SANEF site is as follows:

Service	Use-cases
Hazardous Locations Notification (HLN)	Accident Zone (HLN-AZ) : accident.
	Traffic Jam Ahead (HLN-TJA): stationary Traffic.
	Stationary vehicle (HLN - SV): brokenDownVehicle.
	Weather Condition Warning (HLN-WCW): seriousFire.
	Temporarily slippery road (HLN-TSR): slipperyRoad.
	Animal or person on the road (HLN-APR): peopleOnRoadway.
	Animal or person on the road (HLN-APR): animalsOnRoadway.
	Obstacle on the road (HLN-OR): objectOnTheRoad.

Table 5: SANEF tested service, and use-cases.

c) National Node (NFr-ITS-S):

The list of services and use-cases tested by the National Node in cellular is as follows:

Services	Use-cases
In-Vehicle Signage (IVS)	Traffic Signs (IVS-TS)
	Free Text (IVS-FT)
Hazardous Locations Notification (HLN)	Accident Zone (HLN-AZ)
	Traffic Jam Ahead (HLN-TJA)
	Stationary vehicle (HLN - SV)
	Weather Condition Warning (HLN-WCW)
	Temporarily slippery road (HLN-TSR)
	Animal or person on the road (HLN-APR)
	Obstacle on the road (HLN-OR)
	Railway Level Crossing (HLN-RLX)
	Unsecured Blockage of a Road (HLN-UBR)
	Alert Wrong Way Driving (HLN-AWWD)
Road Works Warning (RWW)	Lane closure (and other restrictions) (RWW-LC)
	Road Closure (RWW – RC)
	Road Works Mobile (RWW-RM)
	Winter Maintenance (RWW-WM)
Signalized Intersections (SI)	Green Light Optimal Speed Advisory (SI-GLOSA)

Table 6: NFr-ITS-S tested services and use-cases.

2.3.2 Events description

a) Paris Site:

The Paris site is made up of nine intersections with traffic lights, each of which sends SPATEMs and MAPEMs. Given the amount of information exchanged in these messages, they will not be presented in this document.

b) SANEF Site:

The list of events triggered on the SANEF site is listed in the following table:

N°	ID event in the PFro	Type of the DENM	Location of the events	
E1	SANEF_221004_1006018_1	HLN-OR: objectOnTheRoad	A0014 - 78PR7DC	48.9050022 – 2.1959048
E2	SANEF_221004_1006019_1	HLN-APR: peopleOnRoadway	A0014 - 78PR11DC	48.9170189 – 2.1160920
E3	SANEF_221004_1006020_1	HLN-APR: animalsOnTheRoad	A0014 - 78PR17DC	48.9127693 – 2.0448720
E4	SANEF_221004_1006022_1	HLN-AZ: accident	A0014 - 78PR20DC	48.9206886 – 2.0062499
E5	SANEF_221004_1006023_1	HLN-TSR: slipperyRoad	A0013 - 78PR29DC	48.9391708 – 1.9558860
E6	SANEF_221004_1006024_1	HLN-TJA: stationaryTraffic	A0013 - 78PR31DC-> 78PR32DC	48.9539642 – 1.9394830 48.961006 - 1.930333
E7	SANEF_221004_1006025_1	HLN-WCW: seriousFire	A0013 - 78PR33DC-> 78PR34GC	48.9673004 - 1.9209880 48.970373 - 1.908029
E8	SANEF_221004_1006026_1	HLN - SV:brokenDownVehicle	A0014 - 78PR36DC	48.9704819 – 1.8740240

Table 7: SANEF site, use-case ID, PFro event ID, and DENM type.

The following figure shows the distribution of the event history on a map for SANEF site. The points of traces are in pink color.

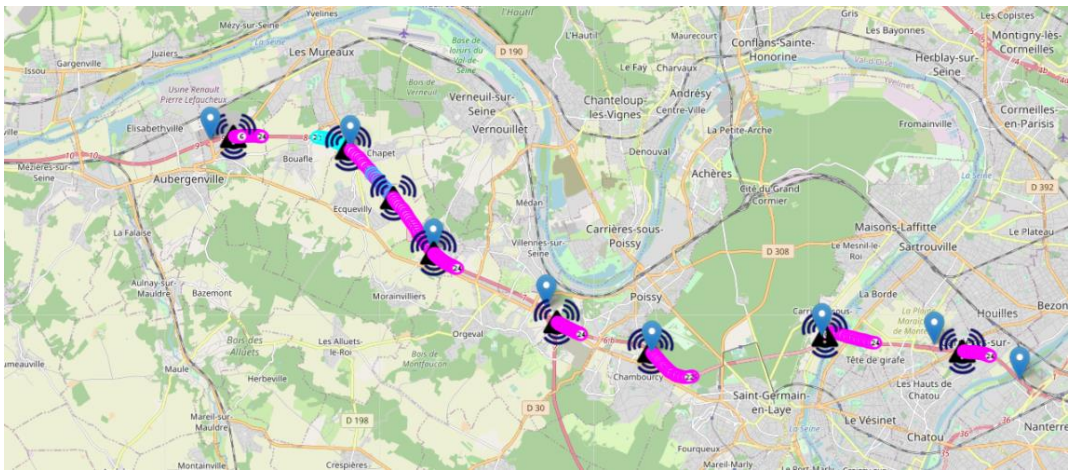

Figure 7: SANFE site, PCAP recording positions.

c) National Node (NFr-IST-S):

The NFr-ITS-S received a lot of messages during the test period: about 7 billion messages. It is not relevant to list them here. For information, here are the types of messages broadcasted by the NFR-ITS-S according to its sources:

Source	DENM	IVIM	MAPEM	POI	SPATEM
APRR	X	X			
BxM	X	X	X	X	X
DIRA	X	X			
DIRE	X	X			
DIRIF	X	X			
DIRMED	X				
DIRO	X	X			
EurStras	X	X		X	
NAPSER	X				
SANEF	X	X		X	
SNCF	X	X			
Vro-ITS-S	X	X		X	
VINCI_AUTOROUTES	X	X			

Table 8: types of messages broadcasted by the NFR-ITS-S.

2.3.3 Testing scenarios

ITS G5: the scenario had to consist of circulating in accordance with the CAM present in the PCAP captures (in accordance with the TF5 procedure).
NFr-ITS-S: There was no predefined test scenario.

2.3.4 Testing planning

NFr-ITS-S: partners were able to test during the entire CBT period, and the NFr-ITS-S was always available.

3. Cross Border Testing Results

3.1 ITS-G5 results

The following table lists the use-cases tested in ITS-G5 by Austria:

Services	Use-cases	Tested?	Austria
In-Vehicle Signage (IVS)	Traffic Signs (IVS-TS)	No	--
	Free Text (IVS-FT)	No	--
Hazardous Locations Notification (HLN)	Accident Zone (HLN-AZ)	Yes	OK
	Traffic Jam Ahead (HLN-TJA)	Yes	OK
	Stationary vehicle (HLN - SV)	Yes	OK
	Weather Condition Warning (HLN-WCW)	Yes	OK
	Temporarily slippery road (HLN-TSR)	Yes	OK
	Animal or person on the road (HLN-APR)	Yes	OK
	Obstacle on the road (HLN-OR)	Yes	OK
	Emergency or Rescue/Recovery Vehicle in Intervention (HLN-ERVI)	No	--
	Emergency or Prioritized Vehicle Approaching (HLN-EPVA)	No	--
	Railway Level Crossing (HLN-RLX)	No	--
	Unsecured Blockage of a Road (HLN-UBR)	No	--
	Alert Wrong Way Driving (HLN-AWWD)	No	--
	Public Transport Vehicle Crossing (HLN-PTVC)	No	--
	Public Transport Vehicle at a Stop (HLN-PTVS)	No	--
Road Works Warning (RWW)	Lane closure (and other restrictions) (RWW-LC)	No	--
	Road Closure (RWW – RC)	No	--
	Road Works Mobile (RWW-RM)	No	--
	Winter Maintenance (RWW-WM)	No	--
Signalized Intersections (SI)	Signal Phase and Timing Information (SI-SPTI)	No	--
	Green Light Optimal Speed Advisory (SI-GLOSA)	Yes	OK
	Imminent Signal Violation Warning (SI-ISVW)	No	--
	Traffic Light Prioritisation (SI-TLP)	No	--
	Emergency Vehicle Priority (SI-EVP)	No	--
Automated Vehicle Guidance (AVG)	SAE Level Guidance (AVG-SAELG)	No	--
	Platoon Support Information (AVG-PSI)	No	--
Probe Vehicle Data (PVD)	Vehicle Data Collection (PVD-VDC)	No	--
	Event Data Collection (PVD-EDC)	No	--

Table 9: On-road ITS-G5 summary results.

Comments on the results:

We would like to thank the Mobile lab *Austriatech* (Austria) for the analysis of the French PCAPs. No major issues were highlighted. Our partners were able to correctly display the expected messages on their test tool. However, some malformed packets were observed in the initial PCAPs. After investigation, we have concluded that the source of the problem was due the threshold of the received signal strength on the V-ITS-S used to capture the PCAPs. For instance, in case of a low RSSI from other ITS stations, the packet may be incomplete or malformed. Necessary steps have been taken from our side to fix this problem, and the new PCAPs (without the malformed packets) have been shared with the partners through the C-ROADS cloud.

3.2 IP-based results

The four countries (Italy, Spain, Slovenia, and the Czech Republic) were able to establish a connection with the NFR-ITS-S and receive the broadcasted messages.

For Spain, Slovenia and the Czech Republic, the messages received were in line with expectations. They were made available to their partners. However, we did not receive a detailed analysis of the results.

For Italy, we received a detailed analysis of more than 26000 SPATEM/MAPEM, which were synthesized as follows:

Results were totally ok.

Number of hexstrings with wrong headers (message type is unreadable): 0
Number of invalid SPATEM hexstrings: 0
Number of invalid MAPEM hexstrings: 0
Number of hexstrings with correct headers: 26673
of which SPATEMs: 26613
of which MAPEMs: 60
Number of valid messages: 26673
Number of valid messages with mismatched signalGroups: 0
Number of failure messages: 0

SPATEMs:
Success: 26613
Warnings: 0
Failures: 0

MAPEMs:
Success: 60
Failures: 0

Services	Use-cases	Tested?	SP	IT	SI	CZ
In-Vehicle Signage (IVS)	Traffic Signs (IVS-TS)	Yes	OK	OK	OK	OK
	Free Text (IVS-FT)	Yes	OK	OK	OK	OK
Hazardous Locations Notification (HLN)	Accident Zone (HLN-AZ)	Yes	OK	OK	OK	OK
	Traffic Jam Ahead (HLN-TJA)	Yes	OK	OK	OK	OK
	Stationary vehicle (HLN - SV)	Yes	OK	OK	OK	OK
	Weather Condition Warning (HLN-WCW)	Yes	OK	OK	OK	OK
	Temporarily slippery road (HLN-TSR)	Yes	OK	OK	OK	OK
	Animal or person on the road (HLN-APR)	Yes	OK	OK	OK	OK
	Obstacle on the road (HLN-OR)	Yes	OK	OK	OK	OK
	Emergency or Rescue/Recovery Vehicle in Intervention (HLN-ERVI)	No	--	--	--	--
	Emergency or Prioritized Vehicle Approaching (HLN-EPVA)	No	--	--	--	--
	Railway Level Crossing (HLN-RLX)	Yes	OK	OK	OK	OK
	Unsecured Blockage of a Road (HLN-UBR)	Yes	OK	OK	OK	OK
	Alert Wrong Way Driving (HLN-AWWD)	Yes	OK	OK	OK	OK
	Public Transport Vehicle Crossing (HLN-PTVC)	No	--	--	--	--
	Public Transport Vehicle at a Stop (HLN-PTVS)	No	--	--	--	--
Road Works Warning	Lane closure (and other restrictions) (RWW-LC)	Yes	OK	OK	OK	OK

Co-financed by the European Union
Connecting Europe Facility

(RWW)	Road Closure (RWW – RC)	Yes	OK	OK	OK	OK
	Road Works Mobile (RWW-RM)	Yes	OK	OK	OK	OK
	Winter Maintenance (RWW-WM)	Yes	OK	OK	OK	OK
Signalized Intersections (SI)	Signal Phase and Timing Information (SI-SPTI)	No	--	--	--	--
	Green Light Optimal Speed Advisory (SI-GLOSA)	Yes	OK	OK	OK	OK
	Imminent Signal Violation Warning (SI-ISVW)	No	--	--	--	--
	Traffic Light Prioritisation (SI-TLP)	No	--	--	--	--
	Emergency Vehicle Priority (SI-EVP)	No	--	--	--	--
Automated Vehicle Guidance (AVG)	SAE Level Guidance (AVG-SAELG)	No	--	--	--	--
	Platoon Support Information (AVG-PSI)	No	--	--	--	--
Probe Vehicle Data (PVD)	Vehicle Data Collection (PVD-VDC)	No	--	--	--	--
	Event Data Collection (PVD-EDC)	No	--	--	--	--

Table 10: On-road IP-based summary results.

Comments on the results:

No member state reported any anomaly on the messages made available by the NFr-ITS-S. However, It should be noted that the connection took longer time to be established than initially estimated because it can only be done through an IPSEC tunnel.

4. Conclusion

4.1. General conclusion about the test

France was ready for the real physical tests, but the invitations did not follow up with positive responses from the guests. France has therefore opted for the choice of remote virtual tests. Only one country responded to the invitation: Austria. France therefore organized two virtual test sessions during which the participants tested the PCAP files of Paris, SANEF, and NN sites.

For the IP-based tests, no member state reported any anomaly on the messages made available by the NFr-ITS-S.

4.2. Learned lessons for cross border interoperability

- Take into consideration the fact that connection to the Nfr-ITS-S take longer to be established than usual when it is done through an IPSEC tunnel.
- Coordinate on the method of analysis and its scope before the CBT between all stakeholders.
- Have a preparatory meeting with the partners involved.
- Make sure participants have all the necessary procedures.

4.3. Harmonization points to be raised to the WG2

We have had little formalized feedbacks from European partners. The WG2 could impose a template adapted to cellular tests.