Cross-Border Testing: PCAP Exchange Specification

C-Roads Platform

Working Group 2 Technical Aspects

Task Force 5 Cross-Testing and Validation

Chairmanship:

- Chair: Marwane Ayaida, University of Reims, France
- Co-chair: Jan Schappacher, BASt, Germany

Publication History

Version	Date	Description, updates and changes	Status
0.1	10.04.2019	Marwane Ayaida: initiation of document for PCAP DENM	draft
0.2	25.04.2019	Marwane Ayaida: Comments of TF5 for V0.1	draft
0.3	26.04.2019	Marwane Ayaida: Comments from TF5 F2F Paris Meeting	draft
0.4	22.05.2019	Walter Zimmermann: Update for SPATEM and MAPEM Marwane Ayaida: Update for IVIM	draft
0.5	27.05.2019	Clean version	WG2
0.6	27.05.2019	Marwane Ayaida: Update based on the comments of WG2	SCOM

Table 1 Publication History

Index

Acronyms

Term	Meaning
C-ITS	Cooperative ITS
CAM	Cooperative Awareness Message
DENM	Decentralized Environmental Notification Message
ETSI	European Telecommunications Standards Institute
GLOSA	Green Light Optimal Speed Advisory
HLN	Hazardous Locations Notifications
IUT	Implementation Under Test
IVIM	In-Vehicle Information Message
IVS	In Vehicle Signage
ITS	Intelligent Transport Systems
ITS-S	ITS Station
MAPEM	MAP (topology) Extended Message
OBU	Onboard Unit
PCAP	Packet CAPture
MS	Member States
R-ITS-S	Roadside ITS Station (the so-called RSU)
RSU	Roadside Unit
RWW	Road Works Warning
SPATEM	Signal Phase And Timing Extended Message
SUT	System Under Test
TTCN-3	Testing and Test Control Notation
UT	Upper Tester
V-ITS-S	Vehicle ITS Station (the socalled OBU)

Table 2 Acronyms

Glossary

Term	Meaning	Source

Table 3 Glossary

References

Reference	Document
[ETSI Interoperability]	ETSI; IOT Best Practices; Interoperability Best practices; edition 2 (www.etsi.org, www.plugtests.org)
[EU Compliance Assessment]	C-ITS Platform Phase II; Working Group Compliance Assessment; Final Report; 12 July 2017.
[C-Roads Services]	C-Roads; Common C-ITS Service Definitions; Version 1.3; Release 1.3; 17/09/2018.
[C-Roads Functions&Specifications]	C-Roads; C-ITS Infrastructure Functions and Specifications; Version 8.0; release 1.3; 17/09/2018.
[C-Roads System Profile]	C-Roads; Roadside ITS G5 System Profile; Version 6.00.03; release 1.3; 17/09/2018.

Table 4 References

1. Laboratory Interoperability Test Method

1.1. Introduction

This document is a deliverable of Task Force 5 of Working Group 2 of the C-Roads Platform to present a way of interoperability testing that can be used to exchange data packets between C-Roads project partners by using various equipment before road test.

To ensure the interoperability between the Member States' (MS) equipments (OBU and RSU), we need to test first the communication between them. Since they are located in different places around Europe, we will start by testing the interoperability between them (using off-line principle). In this deliverable, we will describe, first, to C-Roads partners how to proceed to generate the log files to be exchanged. These log files save the messages sent by any ITS-station X. After sending the log files, they can be rebroadcasted in another site in order to test if the equipment Y could receive and interpret them properly.

This deliverable focuses only on exchanging PCAP files for packets without considering security. The security is excluded from these tests. Some other tests will target only this part. Therefore, when we speak about generating packets, readers must understand that packets do not include signature, security headers or certificates.

Such tests will allow us to ensure the same understanding of the ETSI standards and will facilitate the on-line tests since some bugs could be identified and corrected at this step.

1.2. Environment Description

For these tests' purpose, we need these equipments:
- The equipment to be tested (SUT)
- Based on the option used:
  - An ETHERNET-G5 gateway, a computer to save the log files and a Wireshark tool
  - An ITS-G5 device (used for capturing)

1.3. Deliverable Organization

This deliverable is organized as follows: the first section describes how PCAP log files could be generated and exchanged, the way of tests' execution and it shows how the On-Lab Cross-Tests interoperability results should be presented.

2. Generation and Exchanging of PCAP Files

This section describes the way of generating and exchanging PCAP files for the tests. In general, Figure 1 represents the architecture of PCAP files' exchanging.

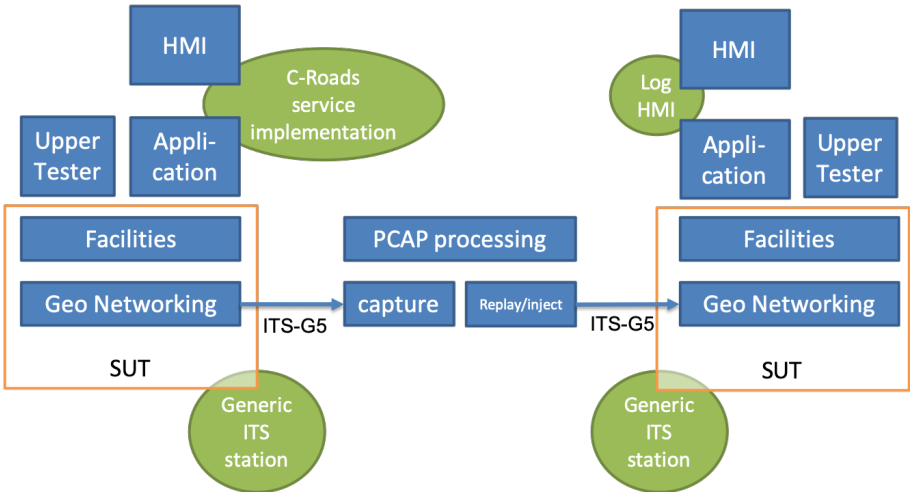

Figure 1 Architecture of the PCAP files generation

The PCAP file has to be captured, processed and then replayed in order to verify the interoperability and to avoid the major issues that could threaten the interoperability.

2.1. Generation of PCAP Files

2.1.1 Architecture

Two options are proposed to generate the PCAP files:

- Option 1:

To generate the PCAP log files, we use the architecture presented in the Figure 2.

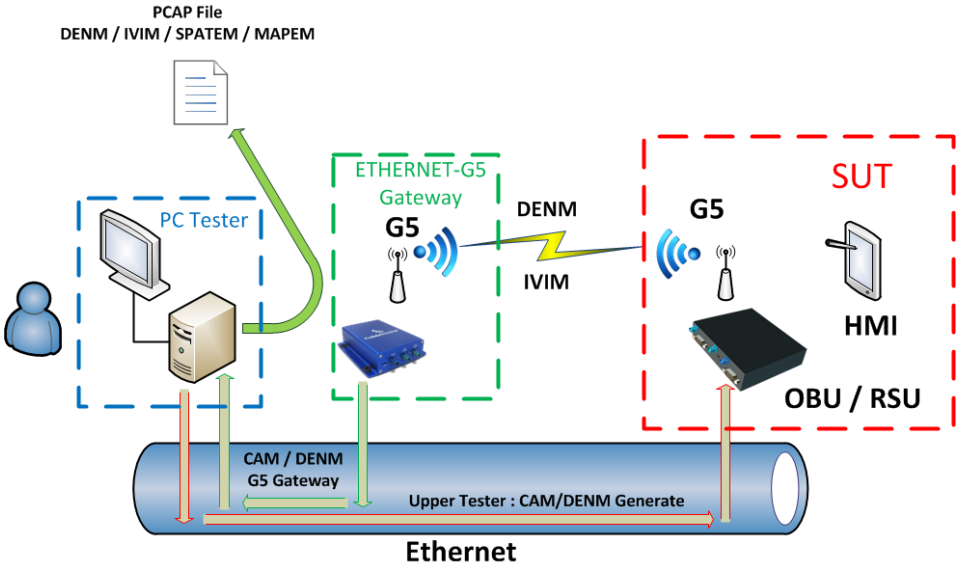

Figure 2 Architecture of the PCAP files generation with Option 1

The SUT must be stimulated (using the ETSI Upper Tester or the HMI) in order to start sending packets. The messages sent will be captured by the ETHERNET-G5 gateway.
These messages are transmitted to the PC using the ETHERNET link to the PC, where the Wireshark tool should be running. This tool is used then to save each message in a PCAP format. The files could be also generated directly on the SUT using for example the “tcpdump” command.

The PCAP file must have the format presented by the Figure 3.

Figure 3 Architecture of the PCAP files generation with Option 1

- Option 2:

To generate the PCAP log files, we use the architecture presented in the Figure 4.

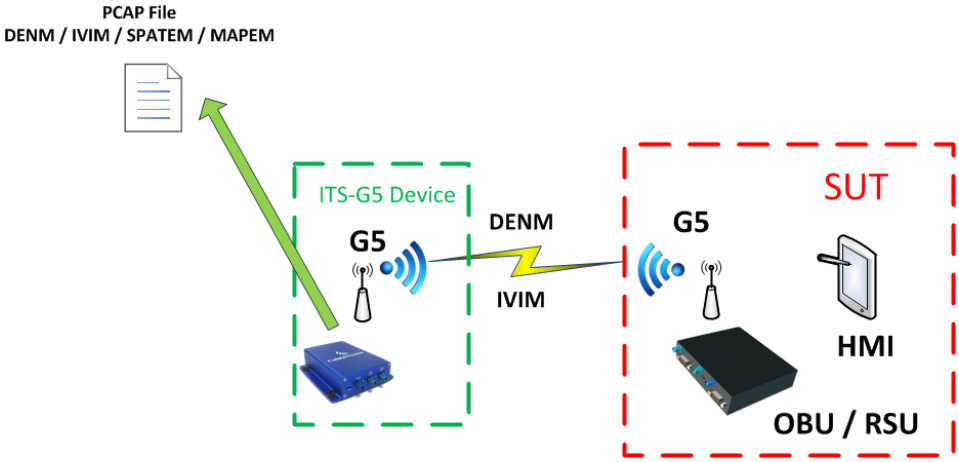

Figure 4 Architecture of the PCAP files generation with Option 2

These messages are directly saved at the RSU / R-ITS-S or by an additional ITS-G5 device capturing the messages on the air. Therefore, the files should have the format presented by the Figure 5.

Figure 5 Architecture of the PCAP files generation with Option 2

Note that, for the moment, the scope of the present release is also limited to ITS-G5 communication, i.e. Security and Hybrid communication are not yet included but will be in upcoming releases.

2.1.2 Generated messages

Each MS has to select for each type of message a representative Pilot Site if there are few. The messages generated have to come from only one equipment from one Pilot Site.

2.1.2.1 DENM

For DENM messages, **63** messages (as listed below) must be saved when using automated testing. If testing is not automated, the test set can be limited to **19** messages by providing only one sub-cause code for each cause code, each in a separate file. Each message/file presents

one use-case for the Cross-Tests targeted in C-Roads. The cause codes and sub-cause codes used should be based on the C-Roads deliverable [C-Roads Functions&Specifications]:

1. Road Works Warning - Unknown: 3/0
2. Road Works Warning - Closure of part of a lane, whole lane or several lanes / Alert planned closure of road or a carriageway: 3/1
3. Road Works Warning - Closure of part of a lane, whole lane or several lanes: 3/2
4. Road Works Warning - Alert planned road works mobile: 3/3
5. Road Works Warning - Closure of part of a lane, whole lane or several lanes / Alert planned closure of road or a carriageway: 3/4
6. Road Works Warning - Closure of part of a lane, whole lane or several lanes: 3/5
7. Hazardous Location Notifications - Traffic condition: 1/0
8. Hazardous Location Notifications – Accident: 2/0
9. Hazardous Location Notifications – Accident: 2/1
10. Hazardous Location Notifications – Accident: 2/2
11. Hazardous Location Notifications – Accident: 2/3
12. Hazardous Location Notifications – Accident: 2/4
13. Hazardous Location Notifications – Accident: 2/5
14. Hazardous Location Notifications – Accident: 2/7
15. Hazardous Location Notifications - Adhesion: 6/0
16. Hazardous Location Notifications - Adhesion: 6/1
17. Hazardous Location Notifications - Adhesion: 6/2
18. Hazardous Location Notifications - Adhesion: 6/3
19. Hazardous Location Notifications - Adhesion: 6/4
20. Hazardous Location Notifications - Adhesion: 6/5
21. Hazardous Location Notifications - Adhesion: 6/6
22. Hazardous Location Notifications - Adhesion: 6/7
23. Hazardous Location Notifications - Adhesion: 6/8
24. Hazardous Location Notifications - Adhesion: 6/9
25. Hazardous Location Notifications - Surface condition: 9/0
26. Hazardous Location Notifications - Surface condition: 9/1
27. Hazardous Location Notifications - Surface condition: 9/4
28. Hazardous Location Notifications - Surface condition: 9/5
29. Hazardous Location Notifications - Surface condition: 9/7
30. Hazardous Location Notifications - Obstacle on the road: 10/0
31. Hazardous Location Notifications - Obstacle on the road: 10/1
32. Hazardous Location Notifications - Obstacle on the road: 10/2
33. Hazardous Location Notifications - Obstacle on the road: 10/3
34. Hazardous Location Notifications - Obstacle on the road: 10/4
35. Hazardous Location Notifications - Obstacle on the road: 10/5
36. Hazardous Location Notifications - Animal on the road: 11/0
37. Hazardous Location Notifications - Animal on the road: 11/2
38. Hazardous Location Notifications - Animal on the road: 11/4
39. Hazardous Location Notifications - Human presence on the road: 12/0
40. Hazardous Location Notifications - Human presence on the road: 12/1
41. Hazardous Location Notifications - Human presence on the road: 12/2
42. Hazardous Location Notifications - Wrong way driving: 14/2
43. Hazardous Location Notifications - Rescue and recovery work in progress: 15/0
44. Hazardous Location Notifications - Extreme weather condition: 17/1
45. Hazardous Location Notifications - Extreme weather condition: 17/2
46. Hazardous Location Notifications - Extreme weather condition: 17/4
47. Hazardous Location Notifications - Visibility: 18/0
48. Hazardous Location Notifications - Visibility: 18/1
49. Hazardous Location Notifications - Visibility: 18/2

50. Hazardous Location Notifications - Visibility: 18/3
51. Hazardous Location Notifications - Visibility: 18/4
52. Hazardous Location Notifications - Visibility: 18/5
53. Hazardous Location Notifications - Visibility: 18/6
54. Hazardous Location Notifications - Precipitation: 19/0
55. Hazardous Location Notifications - Precipitation: 19/1
56. Hazardous Location Notifications - Slow vehicle: 26/3
57. Hazardous Location Notifications - Dangerous end of queue: 27/0
58. Hazardous Location Notifications - Stationary vehicle: 94/0
59. Hazardous Location Notifications - Stationary vehicle: 94/2
60. Hazardous Location Notifications - Emergency vehicle approach: /
61. Hazardous Location Notifications - Collision risk: 97/1
62. Hazardous Location Notifications - : Dangerous situation: 99/0
63. Hazardous Location Notifications - : Dangerous situation: 99/1

A MS has to generate only the events that are managed by its pilot sites. Each file has to contain a unique packet and has to be named:
“C-Roads_DENM_CauseCode_SubCauseCode_Date_Country.pcap”.

2.1.2.2 IVIM

For IVIM messages, **14** messages must be saved each in a separate file. Each message/file presents one use-case for the Cross-Tests targeted in C-Roads. The details of the generated messages are defined in these different cases:

1. Case 1: The reference IVIM message:
    a. serviceCategoryCode: trafficSignPictogram/dangerWarning (11)
    b. PictogramCode (as defined in ISO/TS 14823): 11 / 999 
    c. Sign attributes: without
    d. relevanceZone: 1
    e. detectionZone: 1
    f. IviStatus: 1 (Update)
    g. extraText: without
    h. applicableLanes: without
2. Case 2: change serviceCategoryCode sub-case 1:
    a. serviceCategoryCode: trafficSignPictogram/regulatory (12)
    b. PictogramCode (as defined in ISO/TS 14823): 12 / 542 
    c. Sign attributes: without
    d. relevanceZone: 1
    e. detectionZone: 1
    f. IviStatus: 1 (Update)
    g. extraText: without
    h. applicableLanes: without
3. Case 3: change serviceCategoryCode sub-case 2:
    a. serviceCategoryCode: trafficSignPictogram/informative (13)
    b. PictogramCode (as defined in ISO/TS 14823): 13 / 660 
    c. Sign attributes: without
    d. relevanceZone: 1
    e. detectionZone: 1
    f. IviStatus: 1 (Update)

   g. extraText: without
   h. applicableLanes: without
4. Case 4: change serviceCategoryCode sub-case 3:
   a. serviceCategoryCode: publicFacilitiesPictogram/publicFacilities (21)
   b. PictogramCode (as defined in ISO/TS 14823): 21 / 115 
   c. Sign attributes: without
   d. relevanceZone: 1
   e. detectionZone: 1
   f. IviStatus: 1 (Update)
   g. extraText: without
   h. applicableLanes: without
5. Case 5: change serviceCategoryCode sub-case 5:
   a. serviceCategoryCode: ambientOrRoadConditionPictogram/ambientCondition (31)
   b. PictogramCode (as defined in ISO/TS 14823): 31 / 112 
   c. Sign attributes: without
   d. relevanceZone: 1
   e. detectionZone: 1
   f. IviStatus: 1 (Update)
   g. extraText: without
   h. applicableLanes: without
6. Case 6: change serviceCategoryCode sub-case 6:
   a. serviceCategoryCode: ambientOrRoadConditionPictogram/roadCondition (32)
   b. PictogramCode (as defined in ISO/TS 14823): 32 / 111 
   c. Sign attributes: without
   d. relevanceZone: 1
   e. detectionZone: 1
   f. IviStatus: 1 (Update)
   g. extraText: without
   h. applicableLanes: without
7. Case 7: include sign attributes:
   a. serviceCategoryCode: trafficSignPictogram/dangerWarning (11)
   b. PictogramCode (as defined in ISO/TS 14823): 11 / XXX (let as the tester's choice)
   c. Sign attributes: yes (let as the tester's choice)
   d. relevanceZone: 1
   e. detectionZone: 1
   f. IviStatus: 1 (Update)
   g. extraText: without
   h. applicableLanes: without
8. Case 8: change relevanceZone:
   a. serviceCategoryCode: trafficSignPictogram/dangerWarning (11)
   b. PictogramCode (as defined in ISO/TS 14823): 11 / 999 
   c. Sign attributes: without
   d. relevanceZone: 2
   e. detectionZone: 1
   f. IviStatus: 1 (Update)
   g. extraText: without
   h. applicableLanes: without
9. Case 9: change detectionZone:

a. serviceCategoryCode: trafficSignPictogram/dangerWarning (11)
b. PictogramCode (as defined in ISO/TS 14823): 11 / 999 
c. Sign attributes: without
d. relevanceZone: 1
e. detectionZone: 2
f. IviStatus: 1 (Update)
g. extraText: without
h. applicableLanes: without

10. Case 10: change relevanceZone and detectionZone:
    a. serviceCategoryCode: trafficSignPictogram/dangerWarning (11)
    b. PictogramCode (as defined in ISO/TS 14823): 11 / 999 
    c. Sign attributes: without
    d. relevanceZone: 2
    e. detectionZone: 2
    f. IviStatus: 1 (Update)
    g. extraText: without
    h. applicableLanes: without
11. Case 11: change IviStatus sub-case 1:
    a. serviceCategoryCode: trafficSignPictogram/dangerWarning (11)
    b. PictogramCode (as defined in ISO/TS 14823): 11 / 999 
    c. Sign attributes: without
    d. relevanceZone: 1
    e. detectionZone: 1
    f. IviStatus: 0 (New)
    g. extraText: without
    h. applicableLanes: without
12. Case 12: change IviStatus sub-case 2:
    a. serviceCategoryCode: trafficSignPictogram/dangerWarning (11)
    b. PictogramCode (as defined in ISO/TS 14823): 11 / 999 
    c. Sign attributes: without
    d. relevanceZone: 1
    e. detectionZone: 1
    f. IviStatus: 2 (Cancellation)
    g. extraText: without
    h. applicableLanes: without
13. Case 13: including extraText:
    a. serviceCategoryCode: trafficSignPictogram/dangerWarning (11)
    b. PictogramCode (as defined in ISO/TS 14823): 11 / 999 
    c. Sign attributes: without
    d. relevanceZone: 1
    e. detectionZone: 1
    f. IviStatus: 1 (Update)
    g. extraText: with extraText
    h. applicableLanes: without
14. Case 14: including applicableLanes:
    a. serviceCategoryCode: trafficSignPictogram/dangerWarning (11)

Co-financed by the European Union
Connecting Europe Facility

b. PictogramCode (as defined in ISO/TS 14823): 11 / 999 
c. Sign attributes: without
d. relevanceZone: 1
e. detectionZone: 1
f. IviStatus: 1 (Update)
g. extraText: without
h. applicableLanes: with applicableLanes

A MS has to generate only the events that are managed by its pilot sites. Each file has to contain a unique packet and has to be named:
“C-Roads_IVIM_CaseX_Date_Country.pcap”, where CaseX is the number of the cases described previously.

2.1.2.3 SPATEM

For SPATEM messages, all messages must be saved each in a separate file.
Each message/file presents one use-case for the Cross-Tests targeted in C-Roads.
Each file has to contain a unique packet and has to be named:
“C-Roads_SPATEM_IntersectionX_Y_Date_Country.pcap”, where IntersectionX represents the number of the Intersection where the message was generated, and Y represents the number of the SPATEM message stored within this Intersection.

Each MS has to generate at least 9 SPATEM (min 3 SPATEM for 3 different Intersections)

2.1.2.4 MAPEM

For MAPEM messages, all messages must be saved each in a separate file.
Each message/file presents one use-case for the Cross-Tests targeted in C-Roads.
Each file has to contain a unique packet and has to be named:
“C-Roads_MAPEM_IntersectionX_Y_Date_Country.pcap”, where IntersectionX represents the number of the Intersection where the message was generated, and Y represents the number of the SPATEM message stored within this Intersection.

Each MS has to generate at least 9 MAPEM (min 3 MAPEM for 3 different Intersections).

It would be better if the generated MAPEM and SPATEM messages will be stored at the same time and for the same Intersections. This will make testing easier.

2.2. Exchanging the PCAP Files

When exchanging PCAP log files, each test campaign must have its own file that describes the generation conditions. The description file has to be named in the same way as the PCAP file (“C-Roads_Date_Country.ods” or “C-Roads_Date_Country.xls”). The file must contain such a table with at least the following data (example):

Software Elements	Version	Comments
Capture Option	Option 1	Using Ethernet Gateway
DENM Protocol	1.3.2	DENM ETSI used standard
IVIM Protocol	1.2.2	IVIM ETSI used standard
SPATEM Protocol	1.3.2	SPATEM ETSI used standard
MAPEM Protocol	1.3.2	MAPEM ETSI used standard
Wireshark	1.12.8	Version of tool used
Wireshark ETSI Plugins	Wireshark-1.12.x/Windows/64bits	Version of plugins used

Table 5 Generation conditions of the PCAP file

The equipment could be included in the On-lab Cross-border tests only if it was already completely validated the local tests of the origin country.

2.3. Execution of the On-Lab Cross-Border Tests

2.3.1 Architecture

The architecture is almost the same than for the log file generation. However, the data flow will be reversed. Therefore, two options are proposed to execute tests with the generated files:

- Option 1:

The Figure 6 describes the architecture when using Option 1.
A packet must be extracted from the PCAP log file. Then, it has to be broadcasted directly by the ETHERNET-G5 gateway. The message reception is verified using the OBU/RSU HMI or using the Upper Tester indication.

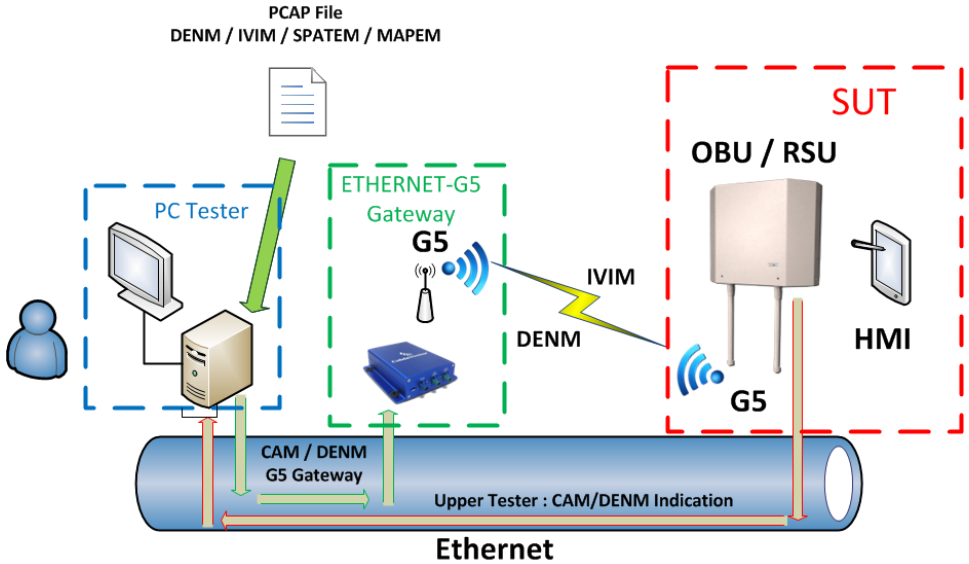

Figure 6 Architecture of the PCAP test execution with option 1

- Option 2:

The Figure 7 describes the architecture when using Option 2.

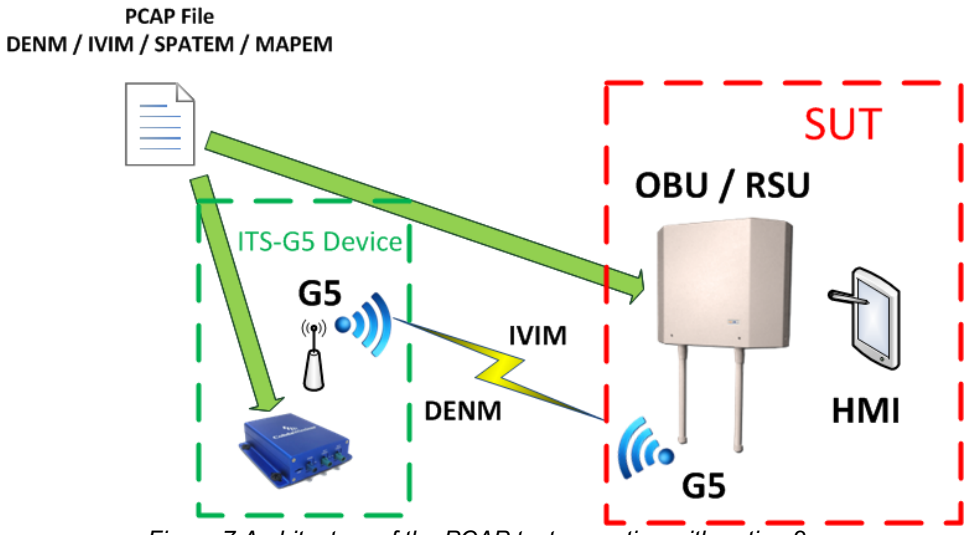

Figure 7 Architecture of the PCAP test execution with option 2

With Option 2, the capture may be either sent via ITS-G5 or fed directly into the SUT / RSU / OBU.

2.3.2 Messages Updates

The messages saved in the log files could not be sent as they are. In fact, several fields will not be valid. More specifically, those relating to the time and the position. Thus, these data, usually stored in the message-header, must be modified before being sent back. This will be the case whenever using the Capture Option 1 or 2. To automate the execution of the tests, an application to be installed on the PC Tester will be provided. This application will manage only the Capture Option 1 and will not work for the Option 2. A tutorial of the usage of this application will follow and will be added as Annex to this deliverable. Some of these fields are cited below:

- For DENM messages:
  - DENM.denm.management.eventPosition.latitude
  - DENM.denm.management.eventPosition.longitude
  - DENM.denm.management.detectionTime
  - DENM.denm.management.referenceTime
- For IVIM messages:
  - IVIM.ivi.ManagementContainer.timestamp
  - IVIM.ivi.ManagementContainer.validFrom (if present, since optional)
  - IVIM.ivi.ManagementContainer.validTo
  - IVIM.ivi.GeographicLocationContainer.referencePosition
- For SPATEM messages:
  - Modifying the position of the vehicle to be close to the intersection
  - SPATEM.IntersectionStateList.IntersectionState.timeStamp
- For MAPEM messages:
  - Modifying the position of the vehicle to be close to the intersection
- For GEONET messages:
  - GeoAreaPos.LatitudeLongitude
  - GeoAreaPos.Longitude
  - Geobroadcast.latitude
  - Geobroadcast.longitude
  - Geobroadcast.source position vector.timestamp.

2.4. Results‘ Presentation of the Exchanged PCAP Files

The results of the Cross-Border PCAP exchange must be communicated in tabular form as follows:

PCAP File	Origin Country	Testing Country	Interoperability results				Comments
			Success	Fail	Inconclusive	Not Tested	
C-Roads_DENM_3_0_01012020_France.pcap	France	Slovenia	X				
C-Roads_DENM_2_2_01012020_France.pcap				X			Fail because…
C-Roads_DENM_10_4_01012020_France.pcap						X	Not possible to test because…
C-Roads_DENM_94_2_01012020_France.pcap			X				
C-Roads_DENM_3_0_01012020_Germany.pcap	Germany	Slovenia			X		Inconclusive because…
C-Roads_DENM_2_2_01012020_Germany.pcap				X			Fail because…
C-Roads_DENM_10_4_01012020_Germany.pcap			X				
C-Roads_DENM_94_2_01012020_Germany.pcap				X			Fail because…

Table 6 Example of some results of the Cross-Border PCAP exchange