Accurate

Next Generation Positioning On Board Unit

European Global Navigation Satellite Systems Agency (GSA)
Fundamental Elements

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D5.2 – Preliminary results on validation and verification

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CONTENTS

Executive Summary

The aim of ACCURATE is to develop a close-to-production high precision positioning on-board unit (OBU), which is based on tight heterogenous sensor fusion and can be integrated on automated driving platforms for any vehicle to reach SAE levels 4 and 5 of driving automation. The OBU will make use of the accuracy and integrity of the EGNSS components and services in a multifrequency approach, especially taking advantage of E5a and E5b. Additionally, a hybrid implementation of differential GNSS will be used as well as fusion with an IMU and perception sensors to enhance the capabilities of the positioning system in adverse conditions. In a safety-critical approach, certification in accordance with the automotive industry functional-safety standard ISO 26262 will be considered during the design phase.

1 Introduction

1.1 Purpose of Document

The WP5 aims to verify the OBU prototype complies with the functionalities and performances requirements defined during previous work packages. The T5.2 task focuses on the functional validation and this document reports the preliminary results obtained during this task.

1.2 Intended Audience

The dissemination level of D5.2 is confidential. Therefore, only the project partners and the GSA are the target audience for this deliverable

1.3 Approach

The content of this document is designed to address testing activities in the context of the ACCURATE project. This deliverable reports all test done in the testing and validation phase of the ACCURATE project

2 Terminology

Glossary of acronyms

Acronym	Definition
3GPP	3rd Generation Partnership Project
AD	Autonomous Driving
ADAS	Advanced Driver Assistance Systems
ADASIS	ADAS Interface Specifications
ALKS	Automated Lane Keeping Systems
API	Application Programming Interface
DDBB	Data Base
DGPS	Differential GPS
DOF	Degrees of Freedom
ECU	Electronic Component Unit
EGNOS	European Geostationary Navigation Overlay Service
EGNSS	European GNSS Agency/Service
FUT	Function-Under-Test
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HIL	Hardware-in-the-Loop
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
KPI	Key Performance Indicator
LIDAR	Light Detection and Ranging/Laser Imaging Detection and Ranging
LOC	Level of Confidence
ME	Measurement Engine
NTRIP	Networked Transport of RTCM via Internet Protocol
OBU	(Positioning) On-Board Unit
ODD	Operational Design Domain
PPP	Precise Point Positioning
RTCM	Radio Technical Commission for Maritime Services
RTMaps	Real-Time Multisensor Applications

SDK	Software Development Kit
SLAM	Simultaneous Localisation and Mapping
SUT	System Under Test
SWPE	(First level sensor fusion focusing on absolute positioning)
TCU	Telematics Control Unit
VUT	Vehicle Under Test
XiL	X-in-the-Loop (X stands for anything)

3 OBU Validation and Verification

This document covers the validation and verification tests performed during the task 5.2 of WP5. The D5.1 document provides the requirements that shall be addressed during this task 5.2.

As mentioned in D5.1 document, the first cycle testing focuses on the validation of the Telematic Control Unit and the Localization Unit, the two components of the ACCURATE OBU. However a section regarding the Daughter board is added to be consistent with the components provided by each partners.

In the following, for one or more requirements the verification and validation testing procedure is defined with these associated results.

3.1 Daughter board and Teseo V module

On this first version, it was agreed that the Teseo V module provides NMEA messages and not RTCM messages. These tests will therefore use NMEA messages.

Functionally, the daughter board can be seen as two components:

- The GNSS receiver (Teseo V module),
- The IMU.

The tests will focus on each of the 2 components.

3.1.1 REQ_FUNC_TCUIN_01 and REQ_FUNC_TCUIN_02

Number	Description:
CTP 00001	**Teseo V module: multi-frequency**
KPI	Not applicable
REQ_FUNC_TCUIN_01	The OBU shall be able to receive and process Galileo signals in at least two different frequency bands.
REQ_FUNC_TCUIN_02	The OBU shall be able to receive and process GPS signals in at least two different frequency bands.
Test Objective	This scenario allows to test if the Teseo V module supports multi-frequency processing on L1/E1+L5/E5a
Test Context	Laboratory test and open sky
Metrics	Not applicable
Reference(s)	Not applicable
Test description	
Testing Framework Mode	Not applicable
Toolchain	- A computer for data collection - Antenna and related cables for real signal test

Elements of the ODD	Not applicable
	Test Procedure
1	Connect the antenna input of the Teseo V module to an antenna in open sky condition.
2	The NMEA messages provided as output are collected
3	Inspect the log file to identify the satellites on L1/E1 and on L5/E5a used for compute the fix. Each satellite used has a PSTMTS proprietary message associated.
Required Inputs	Not applicable
Required Output	Not applicable
Test Analysis	Not applicable
	Pass Condition
Test criteria	In the log file, NMEA messages reporting • Fix status • Satellites (and constellations) used for Fix. This information shall match the ones from a reference receiver **PASS** / ~~**FAIL**~~
Evidences	$GNRMC,125627.000,A,4055.04821,N,01416.55384,E,0.0,0.0,160421,,,D,C*19 $GPAMC,125627.000,V,4055.04821,N,01416.55384,E,0.0,0.0,160421,,,N*66 $GNGGA,125627.000,4055.04821,N,01416.55384,E,2,20,0.6,083.41,M,42.9,M,,*77 $GNGNS,125627.000,4055.04821,N,01416.55384,E,DDANNN,20,0.6,083.41,42.9,, ,C*3E $GNVTG,0.0,T,,M,0.0,N,0.1,K,D*17 $GNGST,125627.000,1.5,3.8,3.6,-0.1,3.7,3.6,4.9*56 $GNGBS,125627.000,3.7,3.6,4.9,,,,,,*66 $GNGSA,A,3,25,05,31,26,18,29,12,20,,,,,1.0,0.6,0.8,1*39 $GNGSA,A,3,79,69,85,88,76,75,,,,,,,1.0,0.6,0.8,2*32 $GNGSA,A,3,,,,,,,,,,,,,1.0,0.6,0.8,5*3A $GNGSA,A,3,21,27,15,13,30,26,,,,,,,1.0,0.6,0.8,3*3B $GNGSA,A,3,,,,,,,,,,,,,1.0,0.6,0.8,1*3E $GNGSA,A,3,,,,,,,,,,,,,1.0,0.6,0.8,3*3C $GNASA,A,1,,,,,,,,,,,,,1.0,0.6,0.8*27 $GPGSV,3,1,11,29,69,020,48,31,52,271,48,25,52,109,47,18,46,186,47,1*6D $GPGSV,3,2,11,26,27,306,41,05,18,080,44,20,15,141,40,12,13,113,39,1*6E $GPGSV,3,3,11,49,41,194,46,33,33,221,26,36,39,154,46,,,,,1*5A $GLGSV,2,1,07,86,78,148,,76,64,018,49,69,56,239,48,85,40,325,42,1*74 $GLGSV,2,2,07,79,23,146,43,88,14,038,42,75,11,224,32,,,,,1*4B $GAGSV,2,1,06,27,75,118,47,15,63,057,47,13,57,202,48,21,48,313,47,7*7B $GAGSV,2,2,06,30,19,127,39,26,06,216,36,,,,,,,,,7*72 $GPGSV,1,1,03,25,,,48,26,,,46,18,,,49,,,,,7*68 $GAGSV,2,1,06,15,,,48,26,,,38,13,,,48,21,,,47,1*79 $GAGSV,2,2,06,27,,,49,30,,,41,,,,,,,,,1*7D $PSTMPRES,3.0,0.6,-4.1,-0.6,-1.5,-0.7,2.0,-1.3,-1.7,-4.2,1.8,0.7,-1.3,-6.0,-0.2,1.5,- 5.5,1.5,-0.1,-1.7,-7.2,,,,,,,,,,,,,,,,,,,,,,,,,*03 $PSTMVRES,0.0,0.0,0.0,0.0,0.0,-0.0,-0.0,0.0,0.0,-0.0,0.0,0.0,-0.0,0.0,0.0,0.0,-0.0,- 0.0,0.0,-0.0,0.0,,,,,,,,,,,,,,,,,,,,,,,,,*27 $PSTMSAT,25,1,16705612.62,16927019.19,11838462.50,427.85,1490.48,- 2648.41,35862.01,1.67,5.17,3.05,2,1.80,14,-1.99,0.00,0,0,0,0*51 $PSTMSAT,05,1,2310824.28,23518338.00,11789793.16,-916.67,- 1251.84,2661.09,-11760.62,-3.34,9.41,7.66,0,0.00,14,-4.16,0.00,0,0,0,0*48 $PSTMSAT,31,1,20242528.47,-8297364.91,15295856.97,1901.09,426.00,- 2226.91,-33553.51,-3.91,5.02,3.05,0,0.00,14,-1.88,0.00,0,0,0,0*4D

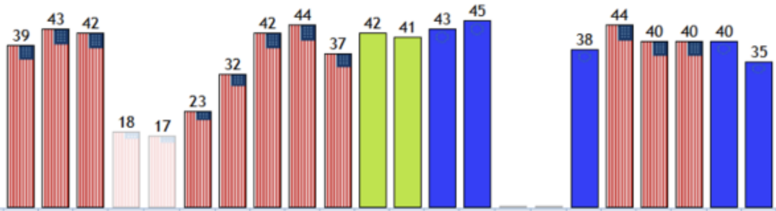
	$PSTMSAT,26,1,8789733.41,-14921313.16,20013406.41,1273.19,2233.69,1129.37,21856.76,2.09,7.27,5.33,1,0.44,14,-3.12,0.00,0,0,0,0*57 $PSTMSAT,18,1,25955519.88,5106423.81,2724614.12,-374.49,208.18,3162.28,105414.79,-2.51,5.75,3.39,0,-2.25,14,-2.59,0.00,0,0,0,0*57 $PSTMSAT,29,1,13848071.50,6034180.44,21803451.91,-1757.05,2144.88,517.06,-99227.12,-3.07,4.31,2.58,-2,0.00,14,-1.45,0.00,0,0,0,0*4D $PSTMSAT,321,1,13923612.78,-8947883.00,24534955.81,1434.70,2002.37,-83.63,-197757.68,0.70,5.20,3.25,0,1.25,2,-3.05,0.00,0,0,0,0*67 $PSTMSAT,12,1,9555677.59,24853644.34,636643.12,-176.39,182.85,-3193.10,-8561.33,-3.77,11.08,10.16,-1,0.00,14,-5.37,0.00,0,0,0,0*65 $PSTMSAT,20,1,17400707.84,19395096.31,-5817801.75,123.49,790.71,2988.90,156828.51,-2.51,10.95,9.30,0,0.00,14,-6.83,0.00,0,0,0,0*7E $PSTMSAT,79,1,19105597.72,16596257.97,-3134371.41,-255.40,-373.64,-3528.32,18945.07,0.00,8.86,6.14,0,0.00,2,-6.61,0.00,0,0,0,0*46 $PSTMSAT,69,1,22858675.53,-3939655.34,10556906.19,-1424.34,334.64,3218.10,21994.44,0.00,4.72,2.91,0,0.00,2,-3.02,0.00,0,0,0,0*7F $PSTMSAT,85,1,8745598.53,-7322989.44,22797564.47,2530.58,1835.58,-368.76,-4157.62,0.00,5.55,3.72,0,0.00,2,-3.16,0.00,0,0,0,0*5E $PSTMSAT,88,1,-6054212.06,12918297.78,21158901.66,-2677.30,1102.43,-1440.58,11713.23,0.00,9.17,10.22,0,0.00,2,-5.04,0.00,0,0,0,0*5F $PSTMSAT,76,1,11924142.97,5872385.25,21784640.50,-2798.74,1037.23,1249.90,124880.19,0.00,4.27,2.67,0,0.00,2,-2.53,0.00,0,0,0,0*59 $PSTMSAT,327,1,21764721.50,11032154.66,16761292.72,1042.63,1322.31,-2223.11,-3722.52,0.70,4.28,2.50,-2,1.19,2,-2.65,0.00,0,0,0,0*52 $PSTMSAT,75,1,22390793.41,-10862113.78,-5590739.47,634.13,-497.99,3508.15,-41973.69,0.00,11.27,12.58,0,0.00,2,-10.41,0.00,0,0,0,0*7D $PSTMSAT,315,1,14382647.41,13028840.16,22354137.59,-2239.03,174.87,1340.04,245578.45,2.09,4.52,2.70,0,3.63,2,-2.70,0.00,0,0,0,0*6E $PSTMSAT,313,1,28385660.72,2179464.59,8085269.12,-823.61,-61.71,2910.87,124444.62,0.20,4.89,2.88,0,0.43,2,-3.27,0.00,0,0,0,0*45 $PSTMSAT,330,1,16124393.06,24776116.03,-1692126.06,-13.33,-196.81,-3031.10,905507.48,0.55,9.75,7.16,-9,0.94,2,-6.87,0.00,0,0,0,0*59 $PSTMSAT,326,1,25233381.03,-10281145.28,-11554875.09,1142.07,-242.51,2709.08,575023.74,2.09,13.45,22.94,-13,3.52,0,0.00,0.00,0,0,0,0*50 $PSTMPPSDATA,1,1,1,0,1,0,0.500000,0,633,420,420,633,0,0,0,0,8,46,3,13,18,0,0,0,3.401e-09,65473977.43,26000007.58,4*1E $PSTMTRAIMSTATUS,1,0,15,2,13,1,46*67 $PSTMTRAIMUSED,1,13,25,5,31,26,18,29,321,12,20,327,315,313,330*46 $PSTMTRAIMRES,1,13,-4,4,0,0,0,-8,5,-5,8,-2,-2,2,4*19 $PSTMTRAIMREMOVED,1,1,326*00 $PSTMIFBRES,3,0*10 $PSTMIFBRES,4,0*17 $PSTMIFB,0,0,0,0,0,0,0,0,0*57 $PSTMIFBESTDATA,3,0,0,0,11,0,2,0,0,0,0,0,0,0.000,0.00000,0.00000,500.0,63.000,17.000*32 $PSTMIFBESTDATA,4,0,0,3,12,0,2,0,0,0,0,0,0,0.000,0.00000,0.00000,500.0,63.000,17.000*35 $PSTMPVRAW,125627.000,4055.04813,N,01416.55455,E,2,20,0.6,130.45,M,42.9,M,0.0,-0.0,0.0*4F $PSTMANTENNASTATUS,1,0,1,1*50 $PSTMNMASTATUS,1*51 $PSTMBIASDATA,-13.633,104.617,0.000,0.000,0.000,0.000*0F $PSTMGNSSINTEGRITY,0,0,0.0,0,0.0,0.0,0,0,0.0,0.0,0,0.0*48 $PSTMCPU,38.54,-1,261*7D $PSTMTG,2153,478606.00000001,0,500905003,9,-47581.9445,a000,6159,0,0,2153,478606.00000001,10,126,-1.534,18441,18,1950858863,489519,1662572785*51

	$PSTMTS,3,25,21209410.438,-49623.68,-111456201.539,21511,47,489070,452,483,0,0,52,0,0,0,850*16 $PSTMTS,2,525,21209572.812,-37056.65,-83230919.491,5155,49,482130,63,2095,0,0,-128,0,0,0,850*3A $PSTMTS,2,5,23727081.438,-46371.07,-124686645.407,21639,44,487622,433,551,0,0,18,0,0,0,850*25 $PSTMTS,2,31,21396793.625,-47764.35,-112440908.253,21635,48,488489,208,472,0,0,52,0,0,0,850*14 $PSTMTS,3,26,22955024.375,-44644.59,-120629477.630,21507,41,487804,-161,638,0,0,26,0,0,0,850*3F $PSTMTS,2,526,22955187.438,-33338.54,-90081084.572,5283,46,482924,20,1558,1,0,-128,0,0,0,850*3F $PSTMTS,3,18,21576591.625,-44751.82,-113385758.341,21635,47,487689,330,576,0,0,45,0,0,0,850*12 $PSTMTS,2,518,21576754.188,-33418.61,-84671829.056,5155,49,462289,44,1750,1,0,-128,0,0,0,850*34 $PSTMTS,2,29,20569076.500,-48455.38,-108091229.623,21635,48,487672,204,440,0,0,69,0,0,0,850*15 $PSTMTS,3,321,24765346.000,-45712.56,-130142771.173,21635,47,478361,18,853,0,0,47,1940887,2057898,0,920*1A $PSTMTS,2,621,24765610.938,-34136.03,-97185576.153,5283,46,475718,33,297,0,0,-128,0,0,0,850*0F $PSTMTS,2,12,24425048.062,-50746.53,-128354497.919,21507,39,487459,48,683,0,0,13,0,0,0,850*21 $PSTMTS,2,20,24189317.375,-44593.79,-127115718.147,21507,40,487460,192,663,0,0,14,0,0,0,850*1C $PSTMTS,2,79,22312388.188,-52152.13,-118937575.239,21643,43,486986,551,551,0,14,23,0,0,0,850*29 $PSTMTS,2,69,19923674.250,-46457.43,-106353934.914,21507,48,486714,-146,438,0,18,56,0,0,0,850*00 $PSTMTS,2,85,20897300.875,-45246.99,-111629621.179,21635,42,486591,175,517,0,16,40,0,0,0,850*26 $PSTMTS,2,88,23266357.438,-52362.34,-124415660.185,21639,42,486423,485,560,0,24,13,0,0,0,850*29 $PSTMTS,2,76,19502445.438,-50255.13,-104361512.543,21639,49,486296,190,481,0,17,64,0,0,0,850*20 $PSTMTS,3,327,23407491.625,-48211.95,-123007203.869,21507,47,476438,2,869,1,0,75,2274526,2360879,0,920*20 $PSTMTS,2,627,23407757.312,-36002.45,-91857066.617,5283,49,473923,53,373,0,0,-128,0,0,0,850*0E $PSTMTS,2,75,23578632.375,-44581.93,-126129797.581,21511,32,457702,78,2352,0,19,10,0,0,0,850*27 $PSTMTS,3,315,23535328.875,-48626.68,-123678994.224,21507,47,480281,14,808,1,0,63,2115588,2235876,0,920*11 $PSTMTS,2,615,23535595.250,-36312.12,-92358729.987,5283,48,477622,53,335,0,0,-128,0,0,0,850*00 $PSTMTS,3,313,23926966.938,-45801.70,-125737060.900,21507,47,480724,3,920,0,0,56,2591913,2672549,0,920*2D $PSTMTS,2,613,23927231.688,-34202.62,-93895599.832,5283,49,478121,47,416,0,0,-128,0,0,0,850*00 $PSTMTS,3,330,25955954.062,-50111.69,-136399458.039,21507,39,475481,-52,1589,0,0,19,313960,325000,0,860*02 $PSTMTS,2,630,25956222.875,-37421.00,-101857795.175,5283,41,472814,46,532,0,0,-128,0,0,0,850*34 $PSTMTS,3,326,27725404.438,-44554.53,-145697996.497,21635,36,68400,-15,3452,2,0,5,195420,196963,0,840*00 $PSTMTS,2,626,27725683.562,-33271.37,-108801540.859,5155,38,65808,3,586,0,0,-128,0,0,0,850*3C

$PSTMRFI,478606.00000001,f,0,0,0,,,,,,,,,f,1689,2405,3575,3769,11,0,25176,16640,7204,16640,15248,16640*50

Remark:
Note in $PSTMTS message
- Galileo sat id 03, Sat id 303 for Galileo E1, Sat id 603 for Galileo E5a
- GPS sat id 09, Sat id 09 for GPS L1, Sat id 509 for GPS L5.

View with another log file:



PRN	01	03	04	06	09	17	19	21	22	31	123	136	303	305	308	313	315	501	503	504	603	605
Band	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	E1	E1	E1	E1	E1	L5	L5	L5	E5a	E5a
Azimuth	118	043	172	302	199	263	299	125	069	066	139	171	170	060	208	308	294	-	-	-	-	-
Elevation	51	77	46	15	16	54	42	32	56	16	25	33	63	48	17	25	79	-	-	-	-	-
C/N0	39	43	42	18	17	23	32	42	44	37	42	41	43	45			38	44	40	40	40	35
Used	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y

3.1.2 REQ_FUNC_TCUIN_03

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00002	**Teseo V module : pseudo-range**
KPI	Not applicable
REQ_FUNC_TCUIN_03	The OBU shall be able to derive pseudo-range observables from the GNSS signals.
Test Objective	Verify that the GNSS pseudo-range observables are available on the output of the receiver
Test Context	Antenna in open sky condition
Metrics	Not applicable
Reference(s)	Not applicable
Test description	
Testing Framework Mode	Not applicable
Toolchain	- A computer for data collection - Antenna and related cables for real signal test
Elements of the ODD	Not applicable
Test Procedure	
1	Connect the antenna input of the Teseo V module to an antenna in open sky condition.
2	The NMEA messages provided as output are collected
3	Inspect the log file to identify the pseudo-range observable.
Required Inputs	Not applicable

Required Output	The pseudo-range observables values are available in a proprietary NMEA message called PSTMTS. In these messages, the second parameter is the satellite identifier and the third is the pseudo-range value in meter. In the evidences, a log of NMEA stream is provided and the satellite identifiers are highlighted in green and the pseudo-range observables in yellow.
Test Analysis	Not applicable
Pass Condition	
Test criteria	A log file is generated with NMEA stream. Check that the PSTMTS messages are present with their satellite identifier and pseudo-range observables value. **PASS** / ~~FAIL~~
Evidences	$GPRMC,144020.000,A,4850.90450,N,00133.95676,W,0.2,0.0,090921,,,D*70 $GPAMC,144020.000,V,4850.92103,N,00133.99567,W,0.1,0.0,090921,0.0,W*68 $GPGGA,144020.000,4850.90450,N,00133.95676,W,2,08,2.4,051.91,M,47.9,M,,*7D $GNGNS,144020.000,4850.90450,N,00133.95676,W,DNDNNN,08,2.4,051.91,47.9,,*4A $GPVTG,0.0,T,,M,0.2,N,0.4,K,D*0E $GPGST,144020.000,4.0,8.0,5.9,-0.5,7.6,6.4,12.6*7A $GPGBS,144020.000,7.6,6.4,12.6,,,,*44 $GNGSA,A,3,09,03,07,04,06,,,,,,,,3.8,2.4,2.9*25 $GNGSA,A,3,309,336,304,,,,,,,,,,3.8,2.4,2.9*11 $GNASA,A,2,,,,,,,,,,,,,99.0,99.0,99.0*1B $GPGSV,3,1,09,09,84,075,46,06,67,238,35,04,44,058,42,02,42,302,*75 $GPGSV,3,2,09,07,33,157,44,20,20,293,24,03,13,102,30,19,11,220,*72 $GPGSV,3,3,09,30,07,183,34,,,,,,,,,,,,*49 $PSTMPRES,1.8,-2.5,-0.2,-3.7,-1.7,-1.6,-0.4,0.3,1.2,1.1,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*2F $PSTMVRES,0.1,0.1,-0.0,0.0,0.1,-0.0,0.0,0.0,-0.1,-0.2,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*26 $PSTMSAT,09,1,17121880.38,1610645.59,20180378.94,-1540.79,2071.04,1135.78,-108122.55,0.41,3.94,2.45,0,0.18,14,-1.42,0.00,0,0,0,0*4F $PSTMSAT,03,1,12407784.12,22823519.91,5693803.47,27.48,769.98,-3079.91,-84979.81,0.55,10.44,10.27,-3,-0.15,14,-4.02,0.00,0,0,0,0*42 $PSTMSAT,07,1,25948597.38,6524986.44,2374096.50,-297.41,215.04,3103.86,72521.36,-3.34,7.09,4.47,2,0.00,14,-2.88,0.00,0,0,0,0*47 $PSTMSAT,04,1,8546261.56,12981260.06,21536178.69,-1863.80,2001.02,-473.01,-61246.81,-1.25,5.23,3.47,0,-2.08,14,-1.30,0.00,0,0,0,0*64 $PSTMSAT,309,1,15996416.88,6021705.50,24165663.00,-1222.95,2092.38,289.59,1660099.46,0.55,4.05,2.58,-3,1.00,2,-1.60,0.00,0,0,0,0*44 $PSTMSAT,06,1,19774561.75,-7374695.44,16216843.25,1984.81,494.74,-2197.71,21348.60,1.11,4.22,2.64,2,-0.90,14,-1.59,0.00,0,0,0,0*62 $PSTMSAT,336,1,28072803.09,-5158016.44,7833552.88,786.89,-157.01,-2922.95,-77961.32,1.95,5.38,3.30,-1,3.27,2,-2.19,0.00,0,0,0,0*69 $PSTMSAT,311,1,26705770.84,6988224.78,-10702192.81,-1073.37,-139.36,-2772.32,1634899.06,-4.32,14.12,20.55,-17,-7.48,2,-7.21,0.00,0,0,0,0*5F $PSTMSAT,30,1,24922406.44,-1924460.50,-9249576.16,1097.54,533.25,2801.05,-141242.39,1.11,13.64,18.16,-1,0.16,14,-6.94,0.00,0,0,0,0*4F $PSTMSAT,20,1,2542233.47,-20713082.09,16548590.53,1184.61,1750.13,1978.69,155666.26,-2.51,7.62,7.09,0,0.00,14,-3.39,0.00,0,0,0,0*46 $PSTMSAT,304,1,1455930.81,23155547.44,18386103.72,-910.32,1602.86,-1946.45,-255736.56,-0.98,8.59,8.19,-2,-1.63,2,-3.61,0.00,0,0,0,0*79 $PSTMSAT,331,1,11925340.09,26777144.47,4134632.97,-116.12,-409.00,2995.42,-145519.53,1.53,11.62,15.83,0,2.63,2,-5.00,0.00,0,0,0,0*6A $PSTMPPSDATA,1,1,1,0,1,0,0.500000,0,350,305,818,841,0,0,0,0,8,39,3,8,18,0,0,0,8.293e-09,65473874.65,25999966.77,4*29 $PSTMTRAIMSTATUS,1,0,15,0,8,0,39*56

	$PSTMTRAIMUSED,1,8,9,3,7,4,309,6,336,304*53 $PSTMTRAIMRES,1,8,8,-11,7,1,6,1,-2,-11*32 $PSTMTRAIMREMOVED,1,0*1A $PSTMIFBRES,5,0*16 $PSTMIFB,0,0,0,0,0,0,0,0*57 $PSTMIFBESTDATA,5,0,0,3,12,0,2,0,0,0,0,0,0.000,0.00000,0.00000,500.0,63.000,17.000*34 $PSTMPVRAW,144020.000,4850.92103,N,00133.99567,W,2,09,1.0,019.38,M,47.9,M,-0.0,-0.0,0.0*76 $PSTMNMASTATUS,1*51 $PSTMBIASDATA,0.000,107.547,0.000,0.000,0.000,0.000*13 $PSTMGNSSINTEGRITY,0,0,0.0,0.0,0.0,0,0.0,0.0,0.0*48 $PSTMCPU,25.94,0,261*51 $PSTMTG,2174,398439.00000006,0,2635476507,9,-45108.8659,a000,21001,0,0,2174,398439.00000006,9,126,14.034,22537,18,1257582819,2576093,471379751*79 $PSTMTS,2,9,20283498.375,-45412.79,-106590500.190,87171,46,2574573,109,1616,4,0,83,0,0,0,850*20 $PSTMTS,2,3,24464166.500,-48358.73,-128560064.731,21639,30,2574999,-80,2519,24,0,13,0,0,0,850*01 $PSTMTS,2,7,22789944.125,-42235.63,-119761969.235,87171,43,2574905,102,1458,5,0,32,0,0,0,850*2A $PSTMTS,2,4,21767745.500,-47575.87,-114390277.447,87171,42,2574668,228,1634,5,0,44,0,0,0,850*2D $PSTMTS,3,309,21846308.062,-46010.99,-114803126.795,87171,39,2569843,4,2054,0,0,71,208111,225354,0,860*24 $PSTMTS,2,659,21846574.125,-35255.40,-87967092.491,5347,39,2567228,95,1374,0,0,-128,0,0,0,850*09 $PSTMTS,2,6,20617784.125,-45664.81,-108347183.843,21639,35,924675,-170,1778,416,0,67,0,0,0,850*3B $PSTMTS,2,336,24664798.125,-47385.85,-129614381.548,21507,35,2505178,-16,3583,26,0,47,68889,63737,0,840*05 $PSTMTS,2,311,26587699.062,-48420.01,-139719267.426,21635,36,2285251,41,3581,127,0,6,111496,101791,0,840*22 $PSTMTS,2,305,24321081.875,-43521.12,-127808144.593,22819,25,120340,86,3256,23,0,-128,0,0,0,850*03 $PSTMTS,2,30,25227572.750,-41439.34,-132571772.445,21635,34,338520,223,2213,4,0,7,0,0,0,850*10 $PSTMTS,2,20,23625126.125,-41855.12,-124150898.265,21643,24,531725,28,7371,888,0,19,0,0,0,850*1F $PSTMTS,3,304,27352265.875,-47692.25,-143737128.711,21635,32,2493302,-22,8989,84,0,17,36970,41184,0,650*09 $PSTMTS,2,654,27352532.875,-36543.43,-110137318.407,5347,29,784910,85,2642,21,0,-128,0,0,0,850*33 $PSTMTS,3,331,28131030.438,-42513.66,-147829562.522,54659,30,708111,-35,11758,230,0,8,26582,20672,0,650*0B $PSTMTS,2,681,28131300.688,-32575.08,-113273092.500,5219,32,660607,82,1987,15,0,-128,0,0,0,850*36 $PSTMCHMON,0,9,-1660403560,-1660403560,39965,16856221,66711956,18358964,130857,4059361,39693712,39497975,4680353,60198,0.040054*6B $PSTMCHMON,0,9,-1660198495,-1660198495,98877,17302640,66740105,18110140,132020,4419203,39217614,39991802,4701313,123749,-0.030263*76 $PSTMCHMON,0,9,-1659994267,-1659994267,104562,17188358,68113010,18280943,111642,4372365,39707225,41121114,4271423,139042,-0.028423*4F

	$PSTMCHMON,0,9,-1659789202,-1659789202,158440,18419756,68901826,19609153,92587,4929013,40446563,42236799,5436524,43226,-0.035421*4A $PSTMCHMON,0,9,-1659584974,-1659584974,128485,18730496,67660700,18704454,146510,4858097,40580813,40805186,5205246,92316,-0.049655*7D $PSTMCHMON,1,7,-1660354177,-1660354177,199524,11898728,40115161,12023229,231290,3737382,24042876,24910859,3911381,98356,0.038060*5E $PSTMCHMON,1,7,-1660149112,-1660149112,234031,11892874,41369374,12824276,448924,3718543,25287071,25805279,4370765,244254,-0.029870*4F $PSTMCHMON,1,7,-1659944884,-1659944884,253987,12623857,43715361,12830331,290516,3946769,26729890,26988652,4016407,160213,-0.056001*48 $PSTMCHMON,1,7,-1659739819,-1659739819,372590,11924954,39776078,11163617,184931,4051220,24840754,24338116,3280389,113654,-0.013071*47 $PSTMCHMON,1,7,-1659535591,-1659535591,271032,11091190,38623175,11565601,332638,3429014,23716984,24003926,3705845,185788,0.055874*60 $PSTMCHMON,2,4,-1660499815,-1660499815,61431,6924155,27154515,6934519,76915,1608550,15408518,15967006,1634869,93968,-0.083268*7C $PSTMCHMON,2,4,-1660294750,-1660294750,69363,6663849,26981001,7316729,107759,1639679,15371577,16157992,1768753,133771,-0.022488*70 $PSTMCHMON,2,4,-1660090522,-1660090522,96591,7640665,27480024,7429846,134281,2071700,16321381,16736762,2188159,109814,-0.059552*7B $PSTMCHMON,2,4,-1659885457,-1659885457,54106,7095966,27953042,7964789,100563,1913907,16239807,17346498,2089623,77197,-0.013054*49 $PSTMCHMON,2,4,-1659681229,-1659681229,31767,6760934,25122762,6946840,90321,1633396,14904896,15362660,1784918,101963,-0.078621*4F $PSTMCHMON,3,309,-1660442062,-1660442062,88069,611634,2332141,653916,79163,264105,275254,275515,265236,89968,-0.011081*4C $PSTMCHMON,3,309,-1660236997,-1660236997,77986,510742,2026088,540330,76245,210630,221198,258194,210223,102728,-0.014908*72 $PSTMCHMON,3,309,-1660032769,-1660032769,82890,668029,2356558,554648,105730,246746,228499,310749,275094,86247,-0.031803*7D $PSTMCHMON,3,309,-1659827704,-1659827704,80054,552744,2223660,516181,90594,241568,198778,264243,236632,75675,-0.008511*47 $PSTMCHMON,3,309,-1659623476,-1659623476,97945,538991,1974213,581676,89126,187366,196964,220109,244916,83814,-0.015518*44 $PSTMVER,GNSSLIB_9.8.0.1_NMA_DFPVT_ARM*5B $GPRMC,144021.000,A,4850.90450,N,00133.95676,W,0.1,0.0,090921,,,D*72 $GPAMC,144021.000,V,4850.92112,N,00133.99581,W,0.1,0.0,090921,0.0,W*61 $GPGGA,144021.000,4850.90450,N,00133.95676,W,2,08,2.4,051.91,M,47.9,M,,*7C $GNGNS,144021.000,4850.90450,N,00133.95676,W,DNDNNN,08,2.4,051.91,47.9,,*4B

	$GPVTG,0.0,T,,M,0.1,N,0.2,K,D*0B $GPGST,144021.000,4.5,8.1,5.9,-0.5,7.6,6.4,12.6*7F $GPGBS,144021.000,7.6,6.4,12.6,,,,*45 $GNGSA,A,3,09,03,07,04,06,,,,,,,,3.8,2.4,2.9*25 $GNGSA,A,3,309,336,304,,,,,,,,,,3.8,2.4,2.9*11 $GNASA,A,2,,,,,,,,,,,,,99.0,99.0,99.0*1B $GPGSV,3,1,09,09,84,075,46,06,67,238,35,04,44,058,42,02,42,302,*75 $GPGSV,3,2,09,07,33,157,43,20,20,293,24,03,13,102,30,19,11,220,*75 $GPGSV,3,3,09,30,07,183,34,,,,,,,,,,,,*49 $PSTMPRES,1.9,-2.6,0.8,-3.9,-1.8,-1.9,-0.6,0.3,1.6,1.2,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*01 $PSTMVRES,0.1,-0.1,0.0,0.0,-0.0,0.0,-0.1,-0.0,-0.2,-0.1,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*26 $PSTMSAT,09,1,17120339.59,1612716.75,20181514.50,-1540.76,2071.24,1135.35,-108122.55,0.41,3.94,2.45,0,0.18,14,-1.42,0.00,0,0,0,0*4A $PSTMSAT,03,1,12407811.56,22824289.69,5690723.50,27.39,769.61,-3080.02,-84979.82,0.55,10.44,10.27,-3,-0.15,14,-4.02,0.00,0,0,0,0*48 $PSTMSAT,07,1,25948299.78,6525201.44,2377200.34,-297.78,214.98,3103.81,72521.36,-3.34,7.09,4.47,2,0.00,14,-2.88,0.00,0,0,0,0*4A $PSTMSAT,04,1,8544397.81,12983261.12,21535705.47,-1863.65,2001.08,-473.47,-61246.81,-1.25,5.23,3.47,0,-2.08,14,-1.30,0.00,0,0,0,0*62 $PSTMSAT,309,1,15995194.00,6023797.94,24165952.41,-1222.80,2092.50,289.22,1660099.45,0.55,4.05,2.58,-3,1.00,2,-1.60,0.00,0,0,0,0*44 $PSTMSAT,06,1,19776546.44,-7374200.78,16214645.38,1984.57,494.57,-2198.05,21348.61,1.11,4.22,2.64,2,-0.90,14,-1.59,0.00,0,0,0,0*61 $PSTMSAT,336,1,28073589.81,-5158173.47,7830629.88,786.59,-157.07,-2923.07,-77961.32,1.95,5.38,3.30,-1,3.27,2,-2.19,0.00,0,0,0,0*6B $PSTMSAT,311,1,26704697.34,6988085.47,-10704965.03,-1073.66,-139.28,-2772.16,1634899.04,-4.32,14.12,20.56,-17,-7.48,2,-7.21,0.00,0,0,0,0*58 $PSTMSAT,30,1,24923503.81,-1923927.31,-9246775.00,1097.22,533.12,2801.25,-141242.39,1.11,13.64,18.14,-1,0.16,14,-6.94,0.00,0,0,0,0*41 $PSTMSAT,20,1,2543418.19,-20711331.88,16550569.06,1184.83,1750.28,1978.34,155666.26,-2.51,7.62,7.09,0,0.00,14,-3.39,0.00,0,0,0,0*40 $PSTMSAT,304,1,1455020.59,23157150.25,18384157.12,-910.10,1602.76,-1946.73,-255736.56,-0.98,8.59,8.19,-2,-1.63,2,-3.61,0.00,0,0,0,0*7C $PSTMSAT,331,1,11925223.88,26776735.34,4137628.34,-116.30,-409.25,2995.36,-145519.53,1.53,11.62,15.83,0,2.63,2,-5.00,0.00,0,0,0,0*67 $PSTMPPSDATA,1,1,1,0,1,0,0.500000,0,350,305,818,841,0,0,0,0,8,40,3,8,18,0,0,0,3.759e-09,65473874.68,25999966.78,4*2D $PSTMTRAIMSTATUS,1,0,15,0,8,0,40*58 $PSTMTRAIMUSED,1,8,9,3,7,4,309,6,336,304*53 $PSTMTRAIMRES,1,8,9,-14,7,2,7,2,-2,-11*37 $PSTMTRAIMREMOVED,1,0*1A $PSTMIFBRES,5,0*16 $PSTMIFB,0,0,0,0,0,0,0,0*57 $PSTMIFBESTDATA,5,0,0,3,12,0,2,0,0,0,0,0,0.000,0.00000,0.00000,500.0,63.000,17.000*34 $PSTMPVRAW,144021.000,4850.92112,N,00133.99581,W,2,09,1.0,019.31,M,47.9,M,0.0,0.0,-0.0*5B $PSTMNMASTATUS,1*51 $PSTMBIASDATA,0.000,107.547,0.000,0.000,0.000,0.000*13 $PSTMGNSSINTEGRITY,0,0,0,0.0,0.0,0.0,0.0,0,0.0,0.0,0,0.0*48 $PSTMCPU,25.86,0,261*52 $PSTMTG,2174,398440.00000006,0,2636499536,9,-45109.5177,a000,21001,0,0,2174,398440.00000006,10,126,13.987,22537,18,1323120694,2577093,532868467*4F$PSTMTS,2,9,20283556.500,-45413.68,-106590804.244,87171,46,2575573,147,1913,4,0,83,0,0,0,850*24

	$PSTMTS,2,3,24464785.500,-48359.03,- 128563314.448,21639,30,2575999,58,3250,24,0,13,0,0,0,850*24 $PSTMTS,2,7,22789397.438,-42236.53,- 119759096.066,87171,43,2575905,77,1797,5,0,32,0,0,0,850*13 $PSTMTS,2,4,21768214.938,-47576.97,- 114392744.629,87171,42,2575668,203,1992,5,0,44,0,0,0,850*20 $PSTMTS,3,309,21846479.688,-46012.56,-114804029.385,87171,39,2570843,- 9,2504,0,0,71,204474,212820,0,860*04 $PSTMTS,2,659,21846745.750,-35256.25,-87967784.062,5347,39,2568228,93,1626,0,0,- 128,0,0,0,850*0E $PSTMTS,2,6,20617890.125,-45665.75,-108347739.981,21639,35,925675,- 29,2166,416,0,67,0,0,0,850*05 $PSTMTS,2,336,24665231.312,-47386.57,-129616658.498,21507,34,2506177,- 22,4015,26,0,47,66543,68228,0,650*0A $PSTMTS,2,311,26588329.125,-48421.04,- 139722578.617,21635,36,2286251,15,4149,127,0,6,108370,102145,0,840*2A $PSTMTS,2,305,24320780.625,-43521.43,-127806556.980,22819,25,121340,167,3439,23,0,- 128,0,0,0,850*3C $PSTMTS,2,30,25226874.188,-41440.32,- 132568102.792,21635,34,339520,232,2617,4,0,7,0,0,0,850*10 $PSTMTS,2,20,23624506.625,-41854.65,-124147644.117,21643,24,532725,- 9,7984,888,0,19,0,0,0,850*0C $PSTMTS,3,304,27352757.688,-47692.38,- 143739711.898,21635,32,2494301,7,9164,84,0,17,32063,34636,0,650*16 $PSTMTS,2,654,27353024.312,-36543.57,-110139297.812,5347,29,785909,73,2898,21,0,- 128,0,0,0,850*36 $PSTMTS,3,331,28130536.938,-42513.73,- 147826967.552,54659,30,709111,30,10590,231,0,8,23743,28061,0,650*28 $PSTMTS,2,681,28130806.812,-32575.83,-113271103.776,5219,32,661607,95,2163,15,0,- 128,0,0,0,850*3A $PSTMCHMON,0,9,-1659379909,- 1659379909,73471,17463288,69692182,18737433,129517,4102130,40803733,42546357,46 43110,63457,-0.008328*4C $PSTMCHMON,0,9,-1659175681,- 1659175681,119950,18760022,70823231,19345439,192736,4549351,41948914,43907765,5 308242,131375,-0.051854*4B $PSTMCHMON,0,9,-1658970616,- 1658970616,164567,18246364,70960482,19265508,131549,4046913,41543867,43798620,5 002210,93262,-0.047667*77 $PSTMCHMON,0,9,-1658766388,- 1658766388,180702,18183736,73264681,19723613,99141,4100529,42485841,44944654,50 17880,92207,-0.059134*43 $PSTMCHMON,0,9,-1658562160,- 1658562160,161274,18926587,70874463,18490368,126170,4747055,42436485,42597619,4 502689,108566,-0.065987*45 $PSTMCHMON,1,7,-1659330526,- 1659330526,266200,12560713,40629394,11198894,259948,3774585,25683793,24194150,3 202789,148183,-0.028475*40 $PSTMCHMON,1,7,-1659126298,- 1659126298,324969,12611649,41180725,12156257,365849,4058498,25509468,25652766,4 054123,211684,0.084410*64 $PSTMCHMON,1,7,-1658921233,- 1658921233,186548,12103752,42936099,12534713,332069,3737672,25892995,26179205,4 108842,186484,0.006692*6C

	$PSTMCHMON,1,7,-1658717005,-1658717005,250610,12189613,42031938,12752518,340873,3553181,25343638,26273547,4115199,195767,-0.028737*41 $PSTMCHMON,1,7,-1658511940,-1658511940,273224,11664625,40569294,12425102,318361,3762163,24528366,24713256,3980432,199760,-0.051035*46 $PSTMCHMON,2,4,-1659476164,-1659476164,150697,7134206,27115352,7102894,95765,1689272,15655968,16732955,1879127,82280,-0.033983*4D $PSTMCHMON,2,4,-1659271936,-1659271936,75872,5969177,24424226,6851508,148044,1498380,14335292,15120364,1781637,70301,-0.043540*4F $PSTMCHMON,2,4,-1659066871,-1659066871,91174,6137674,25013762,6741561,87470,1464952,14155911,15108307,1822625,95179,-0.082821*73 $PSTMCHMON,2,4,-1658862643,-1658862643,75196,7341711,28240145,7715919,55379,1750127,16611179,16802286,1969563,44884,-0.076368*7D $PSTMCHMON,2,4,-1658658415,-1658658415,81288,6491023,25994959,7420380,143484,1538627,14895027,15971313,2207266,71669,-0.027087*44 $PSTMCHMON,3,309,-1659419248,-1659419248,79073,579346,2268544,557758,91946,207161,247631,290751,315279,118904,-0.058029*78 $PSTMCHMON,3,309,-1659214183,-1659214183,92419,457009,1818490,489802,75610,199006,197702,238850,213325,78876,-0.062826*47 $PSTMCHMON,3,309,-1659009955,-1659009955,81836,519441,1822912,460757,88616,220034,186086,246096,247004,72821,-0.039291*44 $PSTMCHMON,3,309,-1658804890,-1658804890,87912,511295,2017028,480080,82347,250487,265729,282278,237457,95104,-0.019242*44 $PSTMCHMON,3,309,-1658600662,-1658600662,60778,595279,2027336,537767,90606,272186,230217,232291,220746,102263,0.016490*5D

3.1.3 REQ_FUNC_TCUIN_04

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00003	**Teseo V module : carrier phase**
KPI	Not applicable
REQ_FUNC_TCUIN_04	The OBU shall be able to derive carrier phase observables from the GNSS signals.
Test Objective	Verify that the GNSS carrier phase observables are available on the output of the receiver
Test Context	Antenna in open sky condition
Metrics	Not applicable
Reference(s)	Not applicable
Test description	

Testing Framework Mode	Not applicable
Toolchain	- A computer for data collection - Antenna and related cables for real signal test
Elements of the ODD	Not applicable
Test Procedure	
1	Connect the antenna input of the Teseo V module to an antenna in open sky condition.
2	The NMEA messages provided as output are collected
3	Inspect the log file to identify the carrier phase observable.
Required Inputs	Not applicable
Required Output	The carrier phase measurements are available in a proprietary NMEA message called PSTMTS. In these messages, the second parameter is the satellite identifier and the fifth is the carrier phase in cycle. In the evidences, a log of NMEA stream is provided and the satellite identifiers are highlighted in green and the carrier phase in yellow.
Test Analysis	
Pass Condition	
Test criteria	A log file is generated with NMEA stream. Check that the PSTMTS messages are present with their satellite identifier and carrier phase observables value. **PASS** / ~~FAIL~~
Evidences	$GPRMC,144020.000,A,4850.90450,N,00133.95676,W,0.2,0.0,090921,,,D*70 $GPAMC,144020.000,V,4850.92103,N,00133.99567,W,0.1,0.0,090921,0.0,W*68 $GPGGA,144020.000,4850.90450,N,00133.95676,W,2,08,2.4,051.91,M,47.9,M,,*7D $GNGNS,144020.000,4850.90450,N,00133.95676,W,DNDNNN,08,2.4,051.91,47.9,,*4A $GPVTG,0.0,T,,M,0.2,N,0.4,K,D*0E $GPGST,144020.000,4.0,8.0,5.9,-0.5,7.6,6.4,12.6*7A $GPGBS,144020.000,7.6,6.4,12.6,,,,*44 $GNGSA,A,3,09,03,07,04,06,,,,,,,,3.8,2.4,2.9*25 $GNGSA,A,3,309,336,304,,,,,,,,,,3.8,2.4,2.9*11 $GNASA,A,2,,,,,,,,,,,,,99.0,99.0,99.0*1B $GPGSV,3,1,09,09,84,075,46,06,67,238,35,04,44,058,42,02,42,302,*75 $GPGSV,3,2,09,07,33,157,44,20,20,293,24,03,13,102,30,19,11,220,*72 $GPGSV,3,3,09,30,07,183,34,,,,,,,,,,,,*49 $PSTMPRES,1.8,-2.5,-0.2,-3.7,-1.7,-1.6,-0.4,0.3,1.2,1.1,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*2F $PSTMVRES,0.1,0.1,-0.0,0.0,0.1,-0.0,0.0,0.0,-0.1,-0.2,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*26 $PSTMSAT,09,1,17121880.38,1610645.59,20180378.94,-1540.79,2071.04,1135.78,-108122.55,0.41,3.94,2.45,0,0.18,14,-1.42,0.00,0,0,0,0*4F $PSTMSAT,03,1,12407784.12,22823519.91,5693803.47,27.48,769.98,-3079.91,-84979.81,0.55,10.44,10.27,-3,-0.15,14,-4.02,0.00,0,0,0,0*42 $PSTMSAT,07,1,25948597.38,6524986.44,2374096.50,-297.41,215.04,3103.86,72521.36,-3.34,7.09,4.47,2,0.00,14,-2.88,0.00,0,0,0,0*47 $PSTMSAT,04,1,8546261.56,12981260.06,21536178.69,-1863.80,2001.02,-473.01,-61246.81,-1.25,5.23,3.47,0,-2.08,14,-1.30,0.00,0,0,0,0*64 $PSTMSAT,309,1,15996416.88,6021705.50,24165663.00,-1222.95,2092.38,289.59,1660099.46,0.55,4.05,2.58,-3,1.00,2,-1.60,0.00,0,0,0,0*44 $PSTMSAT,06,1,19774561.75,-7374695.44,16216843.25,1984.81,494.74,-2197.71,21348.60,1.11,4.22,2.64,2,-0.90,14,-1.59,0.00,0,0,0,0*62

	$PSTMSAT,336,1,28072803.09,-5158016.44,7833552.88,786.89,-157.01,-2922.95,-77961.32,1.95,5.38,3.30,-1,3.27,2,-2.19,0.00,0,0,0,0*69 $PSTMSAT,311,1,26705770.84,6988224.78,-10702192.81,-1073.37,-139.36,-2772.32,1634899.06,-4.32,14.12,20.55,-17,-7.48,2,-7.21,0.00,0,0,0,0*5F $PSTMSAT,30,1,24922406.44,-1924460.50,-9249576.16,1097.54,533.25,2801.05,-141242.39,1.11,13.64,18.16,-1,0.16,14,-6.94,0.00,0,0,0,0*4F $PSTMSAT,20,1,2542233.47,-20713082.09,16548590.53,1184.61,1750.13,1978.69,155666.26,-2.51,7.62,7.09,0,0.00,14,-3.39,0.00,0,0,0,0*46 $PSTMSAT,304,1,1455930.81,23155547.44,18386103.72,-910.32,1602.86,-1946.45,-255736.56,-0.98,8.59,8.19,-2,-1.63,2,-3.61,0.00,0,0,0,0*79 $PSTMSAT,331,1,11925340.09,26777144.47,4134632.97,-116.12,-409.00,2995.42,-145519.53,1.53,11.62,15.83,0,2.63,2,-5.00,0.00,0,0,0,0*6A $PSTMPPSDATA,1,1,1,0,1,0,0.500000,0,350,305,818,841,0,0,0,0,8,39,3,8,18,0,0,0,8.293e-09,65473874.65,25999966.77,4*29 $PSTMTRAIMSTATUS,1,0,15,0,8,0,39*56 $PSTMTRAIMUSED,1,8,9,3,7,4,309,6,336,304*53 $PSTMTRAIMRES,1,8,8,-11,7,1,6,1,-2,-11*32 $PSTMTRAIMREMOVED,1,0*1A $PSTMIFBRES,5,0*16 $PSTMIFB,0,0,0,0,0,0,0,0,0*57 $PSTMIFBESTDATA,5,0,0,3,12,0,2,0,0,0,0,0,0.000,0.00000,0.00000,500.0,63.000,17.000*34 $PSTMPVRAW,144020.000,4850.92103,N,00133.99567,W,2,09,1.0,019.38,M,47.9,M,-0.0,-0.0,0.0*76 $PSTMNMASTATUS,1*51 $PSTMBIASDATA,0.000,107.547,0.000,0.000,0.000,0.000*13 $PSTMGNSSINTEGRITY,0,0,0,0.0,0.0,0.0,0,0.0,0.0,0.0*48 $PSTMCPU,25.94,0,261*51 $PSTMTG,2174,398439.00000006,0,2635476507,9,-45108.8659,a000,21001,0,0,2174,398439.00000006,9,126,14.034,22537,18,1257582819,2576093,471379751*79 $PSTMTS,2,9,20283498.375,-45412.79,-106590500.190,87171,46,2574573,109,1616,4,0,83,0,0,0,850*20 $PSTMTS,2,3,24464166.500,-48358.73,-128560064.731,21639,30,2574999,-80,2519,24,0,13,0,0,0,850*01 $PSTMTS,2,7,22789944.125,-42235.63,-119761969.235,87171,43,2574905,102,1458,5,0,32,0,0,0,850*2A $PSTMTS,2,4,21767745.500,-47575.87,-114390277.447,87171,42,2574668,228,1634,5,0,44,0,0,0,850*2D $PSTMTS,3,309,21846308.062,-46010.99,-114803126.795,87171,39,2569843,4,2054,0,0,71,208111,225354,0,860*24 $PSTMTS,2,659,21846574.125,-35255.40,-87967092.491,5347,39,2567228,95,1374,0,0,-128,0,0,0,850*09 $PSTMTS,2,6,20617784.125,-45664.81,-108347183.843,21639,35,924675,-170,1778,416,0,67,0,0,0,850*3B $PSTMTS,2,336,24664798.125,-47385.85,-129614381.548,21507,35,2505178,-16,3583,26,0,47,68889,63737,0,840*05 $PSTMTS,2,311,26587699.062,-48420.01,-139719267.426,21635,36,2285251,41,3581,127,0,6,111496,101791,0,840*22 $PSTMTS,2,305,24321081.875,-43521.12,-127808144.593,22819,25,120340,86,3256,23,0,-128,0,0,0,850*03 $PSTMTS,2,30,25227572.750,-41439.34,-132571772.445,21635,34,338520,223,2213,4,0,7,0,0,0,850*10 $PSTMTS,2,20,23625126.125,-41855.12,-124150898.265,21643,24,531725,28,7371,888,0,19,0,0,0,850*1F

	$PSTMTS,3,304,27352265.875,-47692.25,-143737128.711,21635,32,2493302,-22,8989,84,0,17,36970,41184,0,650*09 $PSTMTS,2,654,27352532.875,-36543.43,-110137318.407,5347,29,784910,85,2642,21,0,-128,0,0,0,850*33 $PSTMTS,3,331,28131030.438,-42513.66,-147829562.522,54659,30,708111,-35,11758,230,0,8,26582,20672,0,650*0B $PSTMTS,2,681,28131300.688,-32575.08,-113273092.500,5219,32,660607,82,1987,15,0,-128,0,0,0,850*36 $PSTMCHMON,0,9,-1660403560,-1660403560,39965,16856221,66711956,18358964,130857,4059361,39693712,39497975,4680353,60198,0.040054*6B $PSTMCHMON,0,9,-1660198495,-1660198495,98877,17302640,66740105,18110140,132020,4419203,39217614,39991802,4701313,123749,-0.030263*76 $PSTMCHMON,0,9,-1659994267,-1659994267,104562,17188358,68113010,18280943,111642,4372365,39707225,41121114,4271423,139042,-0.028423*4F $PSTMCHMON,0,9,-1659789202,-1659789202,158440,18419756,68901826,19609153,92587,4929013,40446563,42236799,5436524,43226,-0.035421*4A $PSTMCHMON,0,9,-1659584974,-1659584974,128485,18730496,67660700,18704454,146510,4858097,40580813,40805186,5205246,92316,-0.049655*7D $PSTMCHMON,1,7,-1660354177,-1660354177,199524,11898728,40115161,12023229,231290,3737382,24042876,24910859,3911381,98356,0.038060*5E $PSTMCHMON,1,7,-1660149112,-1660149112,234031,11892874,41369374,12824276,448924,3718543,25287071,25805279,4370765,244254,-0.029870*4F $PSTMCHMON,1,7,-1659944884,-1659944884,253987,12623857,43715361,12830331,290516,3946769,26729890,26988652,4016407,160213,-0.056001*48 $PSTMCHMON,1,7,-1659739819,-1659739819,372590,11924954,39776078,11163617,184931,4051220,24840754,24338116,3280389,113654,-0.013071*47 $PSTMCHMON,1,7,-1659535591,-1659535591,271032,11091190,38623175,11565601,332638,3429014,23716984,24003926,3705845,185788,0.055874*60 $PSTMCHMON,2,4,-1660499815,-1660499815,61431,6924155,27154515,6934519,76915,1608550,15408518,15967006,1634869,93968,-0.083268*7C $PSTMCHMON,2,4,-1660294750,-1660294750,69363,6663849,26981001,7316729,107759,1639679,15371577,16157992,1768753,133771,-0.022488*70 $PSTMCHMON,2,4,-1660090522,-1660090522,96591,7640665,27480024,7429846,134281,2071700,16321381,16736762,2188159,109814,-0.059552*7B $PSTMCHMON,2,4,-1659885457,-1659885457,54106,7095966,27953042,7964789,100563,1913907,16239807,17346498,2089623,77197,-0.013054*49 $PSTMCHMON,2,4,-1659681229,-1659681229,31767,6760934,25122762,6946840,90321,1633396,14904896,15362660,1784918,101963,-0.078621*4F $PSTMCHMON,3,309,-1660442062,-1660442062,88069,611634,2332141,653916,79163,264105,275254,275515,265236,89968,-0.011081*4C

	$PSTMCHMON,3,309,-1660236997,-1660236997,77986,510742,2026088,540330,76245,210630,221198,258194,210223,102728,-0.014908*72 $PSTMCHMON,3,309,-1660032769,-1660032769,82890,668029,2356558,554648,105730,246746,228499,310749,275094,86247,-0.031803*7D $PSTMCHMON,3,309,-1659827704,-1659827704,80054,552744,2223660,516181,90594,241568,198778,264243,236632,75675,-0.008511*47 $PSTMCHMON,3,309,-1659623476,-1659623476,97945,538991,1974213,581676,89126,187366,196964,220109,244916,83814,-0.015518*44 $PSTMVER,GNSSLIB_9.8.0.1_NMA_DFPVT_ARM*5B $GPRMC,144021.000,A,4850.90450,N,00133.95676,W,0.1,0.0,090921,,,D*72 $GPAMC,144021.000,V,4850.92112,N,00133.99581,W,0.1,0.0,090921,0.0,W*61 $GPGGA,144021.000,4850.90450,N,00133.95676,W,2,08,2.4,051.91,M,47.9,M,,*7C $GNGNS,144021.000,4850.90450,N,00133.95676,W,DNDNNN,08,2.4,051.91,47.9,,*4B $GPVTG,0.0,T,,M,0.1,N,0.2,K,D*0B $GPGST,144021.000,4.5,8.1,5.9,-0.5,7.6,6.4,12.6*7F $GPGBS,144021.000,7.6,6.4,12.6,,,,*45 $GNGSA,A,3,09,03,07,04,06,,,,,,,,3.8,2.4,2.9*25 $GNGSA,A,3,309,336,304,,,,,,,,,,3.8,2.4,2.9*11 $GNASA,A,2,,,,,,,,,,,,,99.0,99.0,99.0*1B $GPGSV,3,1,09,09,84,075,46,06,67,238,35,04,44,058,42,02,42,302,*75 $GPGSV,3,2,09,07,33,157,43,20,20,293,24,03,13,102,30,19,11,220,*75 $GPGSV,3,3,09,30,07,183,34,,,,,,,,,,,,*49 $PSTMPRES,1.9,-2.6,0.8,-3.9,-1.8,-1.9,-0.6,0.3,1.6,1.2,,*01 $PSTMVRES,0.1,-0.1,0.0,0.0,-0.0,0.0,-0.1,-0.0,-0.2,-0.1,,*26 $PSTMSAT,09,1,17120339.59,1612716.75,20181514.50,-1540.76,2071.24,1135.35,-108122.55,0.41,3.94,2.45,0,0.18,14,-1.42,0.00,0,0,0,0*4A $PSTMSAT,03,1,12407811.56,22824289.69,5690723.50,27.39,769.61,-3080.02,-84979.82,0.55,10.44,10.27,-3,-0.15,14,-4.02,0.00,0,0,0,0*48 $PSTMSAT,07,1,25948299.78,6525201.44,2377200.34,-297.78,214.98,3103.81,72521.36,-3.34,7.09,4.47,2,0.00,14,-2.88,0.00,0,0,0,0*4A $PSTMSAT,04,1,8544397.81,12983261.12,21535705.47,-1863.65,2001.08,-473.47,-61246.81,-1.25,5.23,3.47,0,-2.08,14,-1.30,0.00,0,0,0,0*62 $PSTMSAT,309,1,15995194.00,6023797.94,24165952.41,-1222.80,2092.50,289.22,1660099.45,0.55,4.05,2.58,-3,1.00,2,-1.60,0.00,0,0,0,0*44 $PSTMSAT,06,1,19776546.44,-7374200.78,16214645.38,1984.57,494.57,-2198.05,21348.61,1.11,4.22,2.64,2,-0.90,14,-1.59,0.00,0,0,0,0*61 $PSTMSAT,336,1,28073589.81,-5158173.47,7830629.88,786.59,-157.07,-2923.07,-77961.32,1.95,5.38,3.30,-1,3.27,2,-2.19,0.00,0,0,0,0*6B $PSTMSAT,311,1,26704697.34,6988085.47,-10704965.03,-1073.66,-139.28,-2772.16,1634899.04,-4.32,14.12,20.56,-17,-7.48,2,-7.21,0.00,0,0,0,0*58 $PSTMSAT,30,1,24923503.81,-1923927.31,-9246775.00,1097.22,533.12,2801.25,-141242.39,1.11,13.64,18.14,-1,0.16,14,-6.94,0.00,0,0,0,0*41 $PSTMSAT,20,1,2543418.19,-20711331.88,16550569.06,1184.83,1750.28,1978.34,155666.26,-2.51,7.62,7.09,0,0.00,14,-3.39,0.00,0,0,0,0*40 $PSTMSAT,304,1,1455020.59,23157150.25,18384157.12,-910.10,1602.76,-1946.73,-255736.56,-0.98,8.59,8.19,-2,-1.63,2,-3.61,0.00,0,0,0,0*7C $PSTMSAT,331,1,11925223.88,26776735.34,4137628.34,-116.30,-409.25,2995.36,-145519.53,1.53,11.62,15.83,0,2.63,2,-5.00,0.00,0,0,0,0*67 $PSTMPPSDATA,1,1,1,0,1,0,0.500000,0,350,305,818,841,0,0,0,0,8,40,3,8,18,0,0,0,3.759e-09,65473874.68,25999966.78,4*2D $PSTMTRAIMSTATUS,1,0,15,0,8,0,40*58

	$PSTMTRAIMUSED,1,8,9,3,7,4,309,6,336,304*53 $PSTMTRAIMRES,1,8,9,-14,7,2,7,2,-2,-11*37 $PSTMTRAIMREMOVED,1,0*1A $PSTMIFBRES,5,0*16 $PSTMIFB,0,0,0,0,0,0,0,0*57 $PSTMIFBESTDATA,5,0,0,3,12,0,2,0,0,0,0,0,0.000,0.00000,0.00000,500.0,63.000,17.000*34 $PSTMPVRAW,144021.000,4850.92112,N,00133.99581,W,2,09,1.0,019.31,M,47.9,M,0.0,0.0,-0.0*5B $PSTMNMASTATUS,1*51 $PSTMBIASDATA,0.000,107.547,0.000,0.000,0.000,0.000*13 $PSTMGNSSINTEGRITY,0,0,0,0.0,0.0,0.0,0,0.0,0.0,0.0*48 $PSTMCPU,25.86,0,261*52 $PSTMTG,2174,398440.00000006,0,2636499536,9,-45109.5177,a000,21001,0,0,2174,398440.00000006,10,126,13.987,22537,18,1323120694,2577093,532868467*4F $PSTMTS,2,9,20283556.500,-45413.68,-106590804.244,87171,46,2575573,147,1913,4,0,83,0,0,0,850*24 $PSTMTS,2,3,24464785.500,-48359.03,-128563314.448,21639,30,2575999,58,3250,24,0,13,0,0,0,850*24 $PSTMTS,2,7,22789397.438,-42236.53,-119759096.066,87171,43,2575905,77,1797,5,0,32,0,0,0,850*13 $PSTMTS,2,4,21768214.938,-47576.97,-114392744.629,87171,42,2575668,203,1992,5,0,44,0,0,0,850*20 $PSTMTS,3,309,21846479.688,-46012.56,-114804029.385,87171,39,2570843,-9,2504,0,0,71,204474,212820,0,860*04 $PSTMTS,2,659,21846745.750,-35256.25,-87967784.062,5347,39,2568228,93,1626,0,0,-128,0,0,0,850*0E $PSTMTS,2,6,20617890.125,-45665.75,-108347739.981,21639,35,925675,-29,2166,416,0,67,0,0,0,850*05 $PSTMTS,2,336,24665231.312,-47386.57,-129616658.498,21507,34,2506177,-22,4015,26,0,47,66543,68228,0,650*0A $PSTMTS,2,311,26588329.125,-48421.04,-139722578.617,21635,36,2286251,15,4149,127,0,6,108370,102145,0,840*2A $PSTMTS,2,305,24320780.625,-43521.43,-127806556.980,22819,25,121340,167,3439,23,0,-128,0,0,0,850*3C $PSTMTS,2,30,25226874.188,-41440.32,-132568102.792,21635,34,339520,232,2617,4,0,7,0,0,0,850*10 $PSTMTS,2,20,23624506.625,-41854.65,-124147644.117,21643,24,532725,-9,7984,888,0,19,0,0,0,850*0C $PSTMTS,3,304,27352757.688,-47692.38,-143739711.898,21635,32,2494301,7,9164,84,0,17,32063,34636,0,650*16 $PSTMTS,2,654,27353024.312,-36543.57,-110139297.812,5347,29,785909,73,2898,21,0,-128,0,0,0,850*36 $PSTMTS,3,331,28130536.938,-42513.73,-147826967.552,54659,30,709111,30,10590,231,0,8,23743,28061,0,650*28 $PSTMTS,2,681,28130806.812,-32575.83,-113271103.776,5219,32,661607,95,2163,15,0,-128,0,0,0,850*3A $PSTMCHMON,0,9,-1659379909,-1659379909,73471,17463288,69692182,18737433,129517,4102130,40803733,42546357,4643110,63457,-0.008328*4C $PSTMCHMON,0,9,-1659175681,-1659175681,119950,18760022,70823231,19345439,192736,4549351,41948914,43907765,5308242,131375,-0.051854*4B

	$PSTMCHMON,0,9,-1658970616,-1658970616,164567,18246364,70960482,19265508,131549,4046913,41543867,43798620,5002210,93262,-0.047667*77 $PSTMCHMON,0,9,-1658766388,-1658766388,180702,18183736,73264681,19723613,99141,4100529,42485841,44944654,5017880,92207,-0.059134*43 $PSTMCHMON,0,9,-1658562160,-1658562160,161274,18926587,70874463,18490368,126170,4747055,42436485,42597619,4502689,108566,-0.065987*45 $PSTMCHMON,1,7,-1659330526,-1659330526,266200,12560713,40629394,11198894,259948,3774585,25683793,24194150,3202789,148183,-0.028475*40 $PSTMCHMON,1,7,-1659126298,-1659126298,324969,12611649,41180725,12156257,365849,4058498,25509468,25652766,4054123,211684,0.084410*64 $PSTMCHMON,1,7,-1658921233,-1658921233,186548,12103752,42936099,12534713,332069,3737672,25892995,26179205,4108842,186484,0.006692*6C $PSTMCHMON,1,7,-1658717005,-1658717005,250610,12189613,42031938,12752518,340873,3553181,25343638,26273547,4115199,195767,-0.028737*41 $PSTMCHMON,1,7,-1658511940,-1658511940,273224,11664625,40569294,12425102,318361,3762163,24528366,24713256,3980432,199760,-0.051035*46 $PSTMCHMON,2,4,-1659476164,-1659476164,150697,7134206,27115352,7102894,95765,1689272,15655968,16732955,1879127,82280,-0.033983*4D $PSTMCHMON,2,4,-1659271936,-1659271936,75872,5969177,24424226,6851508,148044,1498380,14335292,15120364,1781637,70301,-0.043540*4F $PSTMCHMON,2,4,-1659066871,-1659066871,91174,6137674,25013762,6741561,87470,1464952,14155911,15108307,1822625,95179,-0.082821*73 $PSTMCHMON,2,4,-1658862643,-1658862643,75196,7341711,28240145,7715919,55379,1750127,16611179,16802286,1969563,44884,-0.076368*7D $PSTMCHMON,2,4,-1658658415,-1658658415,81288,6491023,25994959,7420380,143484,1538627,14895027,15971313,2207266,71669,-0.027087*44 $PSTMCHMON,3,309,-1659419248,-1659419248,79073,579346,2268544,557758,91946,207161,247631,290751,315279,118904,-0.058029*78 $PSTMCHMON,3,309,-1659214183,-1659214183,92419,457009,1818490,489802,75610,199006,197702,238850,213325,78876,-0.062826*47 $PSTMCHMON,3,309,-1659009955,-1659009955,81836,519441,1822912,460757,88616,220034,186086,246096,247004,72821,-0.039291*44 $PSTMCHMON,3,309,-1658804890,-1658804890,87912,511295,2017028,480080,82347,250487,265729,282278,237457,95104,-0.019242*44 $PSTMCHMON,3,309,-1658600662,-1658600662,60778,595279,2027336,537767,90606,272186,230217,232291,220746,102263,0.016490*5D

3.1.4 REQ_FUNC_TCUIN_05

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00004	**Teseo V module: Doppler frequency**
KPI	Not applicable
REQ_FUNC_TCUIN_05	The OBU shall be able to derive Doppler frequency/range rate observables from the GNSS signals.
Test Objective	Verify that the GNSS Doppler frequency observables are available on the output of the receiver
Test Context	Antenna in open sky condition
Metrics	Not applicable
Reference(s)	Not applicable
Test description	
Testing Framework Mode	Not applicable
Toolchain	- A computer for data collection - Antenna and related cables for real signal test
Elements of the ODD	Not applicable
Test Procedure	
1	Connect the antenna input of the Teseo V module to an antenna in open sky condition.
2	The NMEA messages provided as output are collected
3	Inspect the log file to identify the carrier phase observable.
Required Inputs	Not applicable
Required Output	The Satellite Tracking Frequency Offset measurements are available in a proprietary NMEA message called PSTMTS. The Doppler value can be calculated in the following way: *Doppler = Satellite Tracking Frequency Offset + 47122.395833492279 Hz* In the PSTMTS messages, the second parameter is the satellite identifier and the fouth is the Satellite Tracking Frequency Offset in Hz. In the evidences, a log of NMEA stream is provided and the satellite identifiers are highlighted in green and the Satellite Tracking Frequency Offset in yellow.
Test Analysis	Not applicable
Pass Condition	
Test criteria	A log file is generated with NMEA stream. Check that the PSTMTS messages are present with their satellite identifier and the Satellite Tracking Frequency Offset measurement. **PASS** / ~~**FAIL**~~
Evidences	$GPRMC,144020.000,A,4850.90450,N,00133.95676,W,0.2,0.0,090921,,,D*70 $GPAMC,144020.000,V,4850.92103,N,00133.99567,W,0.1,0.0,090921,0.0,W*68 $GPGGA,144020.000,4850.90450,N,00133.95676,W,2,08,2.4,051.91,M,47.9,M,,*7D $GNGNS,144020.000,4850.90450,N,00133.95676,W,DNDNNN,08,2.4,051.91,47.9,,*4A $GPVTG,0.0,T,,M,0.2,N,0.4,K,D*0E $GPGST,144020.000,4.0,8.0,5.9,-0.5,7.6,6.4,12.6*7A $GPGBS,144020.000,7.6,6.4,12.6,,,,*44 $GNGSA,A,3,09,03,07,04,06,,,,,,,,3.8,2.4,2.9*25 $GNGSA,A,3,309,336,304,,,,,,,,,,3.8,2.4,2.9*11

	$GNASA,A,2,,,,,,,,,,,,,99.0,99.0,99.0*1B $GPGSV,3,1,09,09,84,075,46,06,67,238,35,04,44,058,42,02,42,302,*75 $GPGSV,3,2,09,07,33,157,44,20,20,293,24,03,13,102,30,19,11,220,*72 $GPGSV,3,3,09,30,07,183,34,,,,,,,,,,,,*49 $PSTMPRES,1.8,-2.5,-0.2,-3.7,-1.7,-1.6,-0.4,0.3,1.2,1.1,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*2F $PSTMVRES,0.1,0.1,-0.0,0.0,0.1,-0.0,0.0,0.0,-0.1,-0.2,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*26 $PSTMSAT,09,1,17121880.38,1610645.59,20180378.94,-1540.79,2071.04,1135.78,-108122.55,0.41,3.94,2.45,0,0.18,14,-1.42,0.00,0,0,0,0*4F $PSTMSAT,03,1,12407784.12,22823519.91,5693803.47,27.48,769.98,-3079.91,-84979.81,0.55,10.44,10.27,-3,-0.15,14,-4.02,0.00,0,0,0,0*42 $PSTMSAT,07,1,25948597.38,6524986.44,2374096.50,-297.41,215.04,3103.86,72521.36,-3.34,7.09,4.47,2,0.00,14,-2.88,0.00,0,0,0,0*47 $PSTMSAT,04,1,8546261.56,12981260.06,21536178.69,-1863.80,2001.02,-473.01,-61246.81,-1.25,5.23,3.47,0,-2.08,14,-1.30,0.00,0,0,0,0*64 $PSTMSAT,309,1,15996416.88,6021705.50,24165663.00,-1222.95,2092.38,289.59,1660099.46,0.55,4.05,2.58,-3,1.00,2,-1.60,0.00,0,0,0,0*44 $PSTMSAT,06,1,19774561.75,-7374695.44,16216843.25,1984.81,494.74,-2197.71,21348.60,1.11,4.22,2.64,2,-0.90,14,-1.59,0.00,0,0,0,0*62 $PSTMSAT,336,1,28072803.09,-5158016.44,7833552.88,786.89,-157.01,-2922.95,-77961.32,1.95,5.38,3.30,-1,3.27,2,-2.19,0.00,0,0,0,0*69 $PSTMSAT,311,1,26705770.84,6988224.78,-10702192.81,-1073.37,-139.36,-2772.32,1634899.06,-4.32,14.12,20.55,-17,-7.48,2,-7.21,0.00,0,0,0,0*5F $PSTMSAT,30,1,24922406.44,-1924460.50,-9249576.16,1097.54,533.25,2801.05,-141242.39,1.11,13.64,18.16,-1,0.16,14,-6.94,0.00,0,0,0,0*4F $PSTMSAT,20,1,2542233.47,-20713082.09,16548590.53,1184.61,1750.13,1978.69,155666.26,-2.51,7.62,7.09,0,0.00,14,-3.39,0.00,0,0,0,0*46 $PSTMSAT,304,1,1455930.81,23155547.44,18386103.72,-910.32,1602.86,-1946.45,-255736.56,-0.98,8.59,8.19,-2,-1.63,2,-3.61,0.00,0,0,0,0*79 $PSTMSAT,331,1,11925340.09,26777144.47,4134632.97,-116.12,-409.00,2995.42,-145519.53,1.53,11.62,15.83,0,2.63,2,-5.00,0.00,0,0,0,0*6A $PSTMPPSDATA,1,1,1,0,1,0,0.500000,0,350,305,818,841,0,0,0,0,8,39,3,8,18,0,0,0,8.293e-09,65473874.65,25999966.77,4*29 $PSTMTRAIMSTATUS,1,0,15,0,8,0,39*56 $PSTMTRAIMUSED,1,8,9,3,7,4,309,6,336,304*53 $PSTMTRAIMRES,1,8,8,-11,7,1,6,1,-2,-11*32 $PSTMTRAIMREMOVED,1,0*1A $PSTMIFBRES,5,0*16 $PSTMIFB,0,0,0,0,0,0,0,0,0*57 $PSTMIFBESTDATA,5,0,0,3,12,0,2,0,0,0,0,0,0,0.000,0.00000,0.00000,500.0,63.000,17.000*34 $PSTMPVRAW,144020.000,4850.92103,N,00133.99567,W,2,09,1.0,019.38,M,47.9,M,-0.0,-0.0,0.0*76 $PSTMNMASTATUS,1*51 $PSTMBIASDATA,0.000,107.547,0.000,0.000,0.000,0.000*13 $PSTMGNSSINTEGRITY,0,0,0.0,0.0,0.0,0,0.0,0.0,0.0*48 $PSTMCPU,25.94,0,261*51 $PSTMTG,2174,398439.00000006,0,2635476507,9,-45108.8659,a000,21001,0,0,2174,398439.00000006,9,126,14.034,22537,18,1257582819,2576093,471379751*79 $PSTMTS,2,9,20283498.375,-45412.79,-106590500.190,87171,46,2574573,109,1616,4,0,83,0,0,0,850*20 $PSTMTS,2,3,24464166.500,-48358.73,-128560064.731,21639,30,2574999,-80,2519,24,0,13,0,0,0,850*01 $PSTMTS,2,7,22789944.125,-42235.63,-119761969.235,87171,43,2574905,102,1458,5,0,32,0,0,0,850*2A

	$PSTMTS,2,4,21767745.500,-47575.87,- 114390277.447,87171,42,2574668,228,1634,5,0,44,0,0,0,850*2D $PSTMTS,3,309,21846308.062,-46010.99,- 114803126.795,87171,39,2569843,4,2054,0,0,71,208111,225354,0,860*24 $PSTMTS,2,659,21846574.125,-35255.40,-87967092.491,5347,39,2567228,95,1374,0,0,- 128,0,0,0,850*09 $PSTMTS,2,6,20617784.125,-45664.81,-108347183.843,21639,35,924675,- 170,1778,416,0,67,0,0,0,850*3B $PSTMTS,2,336,24664798.125,-47385.85,-129614381.548,21507,35,2505178,- 16,3583,26,0,47,68889,63737,0,840*05 $PSTMTS,2,311,26587699.062,-48420.01,- 139719267.426,21635,36,2285251,41,3581,127,0,6,111496,101791,0,840*22 $PSTMTS,2,305,24321081.875,-43521.12,-127808144.593,22819,25,120340,86,3256,23,0,- 128,0,0,0,850*03 $PSTMTS,2,30,25227572.750,-41439.34,- 132571772.445,21635,34,338520,223,2213,4,0,7,0,0,0,850*10 $PSTMTS,2,20,23625126.125,-41855.12,- 124150898.265,21643,24,531725,28,7371,888,0,19,0,0,0,850*1F $PSTMTS,3,304,27352265.875,-47692.25,-143737128.711,21635,32,2493302,- 22,8989,84,0,17,36970,41184,0,650*09 $PSTMTS,2,654,27352532.875,-36543.43,-110137318.407,5347,29,784910,85,2642,21,0,- 128,0,0,0,850*33 $PSTMTS,3,331,28131030.438,-42513.66,-147829562.522,54659,30,708111,- 35,11758,230,0,8,26582,20672,0,650*0B $PSTMTS,2,681,28131300.688,-32575.08,-113273092.500,5219,32,660607,82,1987,15,0,- 128,0,0,0,850*36 $PSTMCHMON,0,9,-1660403560,- 1660403560,39965,16856221,66711956,18358964,130857,4059361,39693712,39497975, 4680353,60198,0.040054*6B $PSTMCHMON,0,9,-1660198495,- 1660198495,98877,17302640,66740105,18110140,132020,4419203,39217614,39991802, 4701313,123749,-0.030263*76 $PSTMCHMON,0,9,-1659994267,- 1659994267,104562,17188358,68113010,18280943,111642,4372365,39707225,41121114 ,4271423,139042,-0.028423*4F $PSTMCHMON,0,9,-1659789202,- 1659789202,158440,18419756,68901826,19609153,92587,4929013,40446563,42236799, 5436524,43226,-0.035421*4A $PSTMCHMON,0,9,-1659584974,- 1659584974,128485,18730496,67660700,18704454,146510,4858097,40580813,40805186 ,5205246,92316,-0.049655*7D $PSTMCHMON,1,7,-1660354177,- 1660354177,199524,11898728,40115161,12023229,231290,3737382,24042876,24910859 ,3911381,98356,0.038060*5E $PSTMCHMON,1,7,-1660149112,- 1660149112,234031,11892874,41369374,12824276,448924,3718543,25287071,25805279 ,4370765,244254,-0.029870*4F $PSTMCHMON,1,7,-1659944884,- 1659944884,253987,12623857,43715361,12830331,290516,3946769,26729890,26988652 ,4016407,160213,-0.056001*48 $PSTMCHMON,1,7,-1659739819,- 1659739819,372590,11924954,39776078,11163617,184931,4051220,24840754,24338116 ,3280389,113654,-0.013071*47 $PSTMCHMON,1,7,-1659535591,- 1659535591,271032,11091190,38623175,11565601,332638,3429014,23716984,24003926 ,3705845,185788,0.055874*60

	$PSTMCHMON,2,4,-1660499815,-1660499815,61431,6924155,27154515,6934519,76915,1608550,15408518,15967006,1634869,93968,-0.083268*7C $PSTMCHMON,2,4,-1660294750,-1660294750,69363,6663849,26981001,7316729,107759,1639679,15371577,16157992,1768753,133771,-0.022488*70 $PSTMCHMON,2,4,-1660090522,-1660090522,96591,7640665,27480024,7429846,134281,2071700,16321381,16736762,2188159,109814,-0.059552*7B $PSTMCHMON,2,4,-1659885457,-1659885457,54106,7095966,27953042,7964789,100563,1913907,16239807,17346498,2089623,77197,-0.013054*49 $PSTMCHMON,2,4,-1659681229,-1659681229,31767,6760934,25122762,6946840,90321,1633396,14904896,15362660,1784918,101963,-0.078621*4F $PSTMCHMON,3,309,-1660442062,-1660442062,88069,611634,2332141,653916,79163,264105,275254,275515,265236,89968,-0.011081*4C $PSTMCHMON,3,309,-1660236997,-1660236997,77986,510742,2026088,540330,76245,210630,221198,258194,210223,102728,-0.014908*72 $PSTMCHMON,3,309,-1660032769,-1660032769,82890,668029,2356558,554648,105730,246746,228499,310749,275094,86247,-0.031803*7D $PSTMCHMON,3,309,-1659827704,-1659827704,80054,552744,2223660,516181,90594,241568,198778,264243,236632,75675,-0.008511*47 $PSTMCHMON,3,309,-1659623476,-1659623476,97945,538991,1974213,581676,89126,187366,196964,220109,244916,83814,-0.015518*44 $PSTMVER,GNSSLIB_9.8.0.1_NMA_DFPVT_ARM*5B $GPRMC,144021.000,A,4850.90450,N,00133.95676,W,0.1,0.0,090921,,,D*72 $GPAMC,144021.000,V,4850.92112,N,00133.99581,W,0.1,0.0,090921,0.0,W*61 $GPGGA,144021.000,4850.90450,N,00133.95676,W,2,08,2.4,051.91,M,47.9,M,,*7C $GNGNS,144021.000,4850.90450,N,00133.95676,W,DNDNNN,08,2.4,051.91,47.9,,*4B $GPVTG,0.0,T,,M,0.1,N,0.2,K,D*0B $GPGST,144021.000,4.5,8.1,5.9,-0.5,7.6,6.4,12.6*7F $GPGBS,144021.000,7.6,6.4,12.6,,,,*45 $GNGSA,A,3,09,03,07,04,06,,,,,,,,3.8,2.4,2.9*25 $GNGSA,A,3,309,336,304,,,,,,,,,,3.8,2.4,2.9*11 $GNASA,A,2,,,,,,,,,,,,,99.0,99.0,99.0*1B $GPGSV,3,1,09,09,84,075,46,06,67,238,35,04,44,058,42,02,42,302,*75 $GPGSV,3,2,09,07,33,157,43,20,20,293,24,03,13,102,30,19,11,220,*75 $GPGSV,3,3,09,30,07,183,34,,,,,,,,,,,,*49 $PSTMPRES,1.9,-2.6,0.8,-3.9,-1.8,-1.9,-0.6,0.3,1.6,1.2,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*01 $PSTMVRES,0.1,-0.1,0.0,0.0,-0.0,0.0,-0.1,-0.0,-0.2,-0.1,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*26 $PSTMSAT,09,1,17120339.59,1612716.75,20181514.50,-1540.76,2071.24,1135.35,-108122.55,0.41,3.94,2.45,0,0.18,14,-1.42,0.00,0,0,0,0*4A $PSTMSAT,03,1,12407811.56,22824289.69,5690723.50,27.39,769.61,-3080.02,-84979.82,0.55,10.44,10.27,-3,-0.15,14,-4.02,0.00,0,0,0,0*48 $PSTMSAT,07,1,25948299.78,6525201.44,2377200.34,-297.78,214.98,3103.81,72521.36,-3.34,7.09,4.47,2,0.00,14,-2.88,0.00,0,0,0,0*4A $PSTMSAT,04,1,8544397.81,12983261.12,21535705.47,-1863.65,2001.08,-473.47,-61246.81,-1.25,5.23,3.47,0,-2.08,14,-1.30,0.00,0,0,0,0*62 $PSTMSAT,309,1,15995194.00,6023797.94,24165952.41,-1222.80,2092.50,289.22,1660099.45,0.55,4.05,2.58,-3,1.00,2,-1.60,0.00,0,0,0,0*44

	$PSTMSAT,06,1,19776546.44,-7374200.78,16214645.38,1984.57,494.57,-2198.05,21348.61,1.11,4.22,2.64,2,-0.90,14,-1.59,0.00,0,0,0,0*61 $PSTMSAT,336,1,28073589.81,-5158173.47,7830629.88,786.59,-157.07,-2923.07,-77961.32,1.95,5.38,3.30,-1,3.27,2,-2.19,0.00,0,0,0,0*6B $PSTMSAT,311,1,26704697.34,6988085.47,-10704965.03,-1073.66,-139.28,-2772.16,1634899.04,-4.32,14.12,20.56,-17,-7.48,2,-7.21,0.00,0,0,0,0*58 $PSTMSAT,30,1,24923503.81,-1923927.31,-9246775.00,1097.22,533.12,2801.25,-141242.39,1.11,13.64,18.14,-1,0.16,14,-6.94,0.00,0,0,0,0*41 $PSTMSAT,20,1,2543418.19,-20711331.88,16550569.06,1184.83,1750.28,1978.34,155666.26,-2.51,7.62,7.09,0,0.00,14,-3.39,0.00,0,0,0,0*40 $PSTMSAT,304,1,1455020.59,23157150.25,18384157.12,-910.10,1602.76,-1946.73,-255736.56,-0.98,8.59,8.19,-2,-1.63,2,-3.61,0.00,0,0,0,0*7C $PSTMSAT,331,1,11925223.88,26776735.34,4137628.34,-116.30,-409.25,2995.36,-145519.53,1.53,11.62,15.83,0,2.63,2,-5.00,0.00,0,0,0,0*67 $PSTMPPSDATA,1,1,1,0,1,0,0.500000,0,350,305,818,841,0,0,0,0,8,40,3,8,18,0,0,0,3.759e-09,65473874.68,25999966.78,4*2D $PSTMTRAIMSTATUS,1,0,15,0,8,0,40*58 $PSTMTRAIMUSED,1,8,9,3,7,4,309,6,336,304*53 $PSTMTRAIMRES,1,8,9,-14,7,2,7,2,-2,-11*37 $PSTMTRAIMREMOVED,1,0*1A $PSTMIFBRES,5,0*16 $PSTMIFB,0,0,0,0,0,0,0,0*57 $PSTMIFBESTDATA,5,0,0,3,12,0,2,0,0,0,0,0,0.000,0.00000,0.00000,500.0,63.000,17.000*34 $PSTMPVRAW,144021.000,4850.92112,N,00133.99581,W,2,09,1.0,019.31,M,47.9,M,0.0,0.0,-0.0*5B $PSTMNMASTATUS,1*51 $PSTMBIASDATA,0.000,107.547,0.000,0.000,0.000,0.000*13 $PSTMGNSSINTEGRITY,0,0,0.0,0.0,0.0,0,0.0,0.0,0.0*48 $PSTMCPU,25.86,0,261*52 $PSTMTG,2174,398440.00000006,0,2636499536,9,-45109.5177,a000,21001,0,0,2174,398440.00000006,10,126,13.987,22537,18,1323120694,2577093,532868467*4F $PSTMTS,2,9,20283556.500,-45413.68,-106590804.244,87171,46,2575573,147,1913,4,0,83,0,0,0,850*24 $PSTMTS,2,3,24464785.500,-48359.03,-128563314.448,21639,30,2575999,58,3250,24,0,13,0,0,0,850*24 $PSTMTS,2,7,22789397.438,-42236.53,-119759096.066,87171,43,2575905,77,1797,5,0,32,0,0,0,850*13 $PSTMTS,2,4,21768214.938,-47576.97,-114392744.629,87171,42,2575668,203,1992,5,0,44,0,0,0,850*20 $PSTMTS,3,309,21846479.688,-46012.56,-114804029.385,87171,39,2570843,-9,2504,0,0,71,204474,212820,0,860*04 $PSTMTS,2,659,21846745.750,-35256.25,-87967784.062,5347,39,2568228,93,1626,0,0,-128,0,0,0,850*0E $PSTMTS,2,6,20617890.125,-45665.75,-108347739.981,21639,35,925675,-29,2166,416,0,67,0,0,0,850*05 $PSTMTS,2,336,24665231.312,-47386.57,-129616658.498,21507,34,2506177,-22,4015,26,0,47,66543,68228,0,650*0A $PSTMTS,2,311,26588329.125,-48421.04,-139722578.617,21635,36,2286251,15,4149,127,0,6,108370,102145,0,840*2A $PSTMTS,2,305,24320780.625,-43521.43,-127806556.980,22819,25,121340,167,3439,23,0,-128,0,0,0,850*3C $PSTMTS,2,30,25226874.188,-41440.32,-132568102.792,21635,34,339520,232,2617,4,0,7,0,0,0,850*10

	$PSTMTS,2,20,23624506.625,-41854.65,-124147644.117,21643,24,532725,- 9,7984,888,0,19,0,0,0,850*0C $PSTMTS,3,304,27352757.688,-47692.38,- 143739711.898,21635,32,2494301,7,9164,84,0,17,32063,34636,0,650*16 $PSTMTS,2,654,27353024.312,-36543.57,-110139297.812,5347,29,785909,73,2898,21,0,- 128,0,0,0,850*36 $PSTMTS,3,331,28130536.938,-42513.73,- 147826967.552,54659,30,709111,30,10590,231,0,8,23743,28061,0,650*28 $PSTMTS,2,681,28130806.812,-32575.83,-113271103.776,5219,32,661607,95,2163,15,0,- 128,0,0,0,850*3A $PSTMCHMON,0,9,-1659379909,- 1659379909,73471,17463288,69692182,18737433,129517,4102130,40803733,42546357, 4643110,63457,-0.008328*4C $PSTMCHMON,0,9,-1659175681,- 1659175681,119950,18760022,70823231,19345439,192736,4549351,41948914,43907765 ,5308242,131375,-0.051854*4B $PSTMCHMON,0,9,-1658970616,- 1658970616,164567,18246364,70960482,19265508,131549,4046913,41543867,43798620 ,5002210,93262,-0.047667*77 $PSTMCHMON,0,9,-1658766388,- 1658766388,180702,18183736,73264681,19723613,99141,4100529,42485841,44944654, 5017880,92207,-0.059134*43 $PSTMCHMON,0,9,-1658562160,- 1658562160,161274,18926587,70874463,18490368,126170,4747055,42436485,42597619 ,4502689,108566,-0.065987*45 $PSTMCHMON,1,7,-1659330526,- 1659330526,266200,12560713,40629394,11198894,259948,3774585,25683793,24194150 ,3202789,148183,-0.028475*40 $PSTMCHMON,1,7,-1659126298,- 1659126298,324969,12611649,41180725,12156257,365849,4058498,25509468,25652766 ,4054123,211684,0.084410*64 $PSTMCHMON,1,7,-1658921233,- 1658921233,186548,12103752,42936099,12534713,332069,3737672,25892995,26179205 ,4108842,186484,0.006692*6C $PSTMCHMON,1,7,-1658717005,- 1658717005,250610,12189613,42031938,12752518,340873,3553181,25343638,26273547 ,4115199,195767,-0.028737*41 $PSTMCHMON,1,7,-1658511940,- 1658511940,273224,11664625,40569294,12425102,318361,3762163,24528366,24713256 ,3980432,199760,-0.051035*46 $PSTMCHMON,2,4,-1659476164,- 1659476164,150697,7134206,27115352,7102894,95765,1689272,15655968,16732955,18 79127,82280,-0.033983*4D $PSTMCHMON,2,4,-1659271936,- 1659271936,75872,5969177,24424226,6851508,148044,1498380,14335292,15120364,17 81637,70301,-0.043540*4F $PSTMCHMON,2,4,-1659066871,- 1659066871,91174,6137674,25013762,6741561,87470,1464952,14155911,15108307,182 2625,95179,-0.082821*73 $PSTMCHMON,2,4,-1658862643,- 1658862643,75196,7341711,28240145,7715919,55379,1750127,16611179,16802286,196 9563,44884,-0.076368*7D $PSTMCHMON,2,4,-1658658415,- 1658658415,81288,6491023,25994959,7420380,143484,1538627,14895027,15971313,22 07266,71669,-0.027087*44

	$PSTMCHMON,3,309,-1659419248,-1659419248,79073,579346,2268544,557758,91946,207161,247631,290751,315279,118904,-0.058029*78 $PSTMCHMON,3,309,-1659214183,-1659214183,92419,457009,1818490,489802,75610,199006,197702,238850,213325,78876,-0.062826*47 $PSTMCHMON,3,309,-1659009955,-1659009955,81836,519441,1822912,460757,88616,220034,186086,246096,247004,72821,-0.039291*44 $PSTMCHMON,3,309,-1658804890,-1658804890,87912,511295,2017028,480080,82347,250487,265729,282278,237457,95104,-0.019242*44 $PSTMCHMON,3,309,-1658600662,-1658600662,60778,595279,2027336,537767,90606,272186,230217,232291,220746,102263,0.016490*5D

3.1.5 REQ_FUNC_INT_01

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00005	**Daughter board : IMU**
KPI	Not applicable
REQ_FUNC_INT_01	The OBU shall integrate a 6DOF inertial sensor.
Test Objective	Verify that the IMU mounted on the daughter board is able to communicate with an external processor
Test Context	Laboratory test
Metrics	Not applicable
Reference(s)	Not applicable
Test description	
Testing Framework Mode	Not applicable
Toolchain	- A Raspberry board with SPI bus activate - Oscilloscope
Elements of the ODD	Not applicable
Test Procedure	
1	Connect the IMU with the Raspberry board
2	Send the command Who Am I (0x8F 0x00)
3	The response waited is received
Required Inputs	Not applicable
Required Output	Not applicable
Test Analysis	Not applicable
Pass Condition	
Test criteria	The response received is 0x6B **PASS** / ~~FAIL~~
Evidences	The response was checked on the oscilloscope

3.1.6 REQ_FUNC_SEC_01

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00006	**Teseo V module : firmware integrity**
KPI	Not applicable
REQ_FUNC_SEC_01	The OBU shall implement security mechanisms to ensure data and firmware integrity.
Test Objective	This test concerns the firmware of the Teseo V module. It assesses the ST33 capability to prevent the Teseo V to start if its firmware is not the one expected by the ST33.
Test Context	Not applicable
Metrics	Not applicable
Reference(s)	Not applicable
Test description	
Testing Framework Mode	Not applicable
Toolchain	- A Raspberry Pi with FDC software tools - An ISO7816 reader - A cable USB/RS232
Elements of the ODD	Not applicable
Test Procedure	
1	The Teseo V is flashed with the firmware recognized by the ST33.
2	The Teseo V starts without issue.
3	The Teseo V is flashed with another firmware, not recognized by the ST33.
4	The Teseo V start-up stops with error message in the debug flow.
5	The ST33 detects firmware integrity test failed and advises the user through the ISO7816 link.
Required Inputs	Two Teseo V firmwares including few differences (version number for instance)
Required Output	Not applicable
Test Analysis	Not applicable
Pass Condition	
Test criteria	In case of bad Teseo V firmware: - The Teseo V sends an error message in the debug flow, - The user is advised by the ST33. On the ISO7816, it returns a 66 02 status words for any APDU command. **PASS** / ~~FAIL~~
Evidences	**Firmware recognized:** Debug Flow # 0 : [foster_spi_msp_init] [LV1] [ST33][MSP_ERROR] MSP init ok # 1 : [foster_spi_api_init] [LV3] [SPI_DEBUG] SPI is initialized # 2 : [foster_nvm_copy] [LV1] [ST33] st33NVM_copy called with id: 147. It return with code is: 11 . # 3 : [foster_orbital_load_gps_ref_ephemeris] [LV1] [orbital] Error at NVM read of foster_ephemeris_tmp_data # 4 : [foster_start_services_p] [LV1] [ST33] OSNMA UT start 1.

	Firmware not recognized: Debug Flow # 0 : [foster_spi_msp_init] [LV1] [ST33][MSP_ERROR] MSP init ok # 1 : [foster_spi_api_init] [LV3] [SPI_DEBUG] SPI is initialized # 2 : [foster_st33nvm_create] [LV3] [ST33] SPI command for CREATE failed # 3 : [foster_nvm_create] [LV1] [ST33] st33NVM_create called with id: 129. It return: 1 . # 4 : [foster_st33nvm_create] [LV3] [ST33] SPI command for CREATE failed # 5 : [foster_nvm_create] [LV1] [ST33] st33NVM_create called with id: 150. It return: 1 . # 6 : [foster_st33nvm_write] [LV3] [ST33][NVM_LIB] Can't write on a bad created item (bad size on item_id=0x96, converted_id=0x17). # 7 : [foster_nvm_write] [LV1] [ST33] st33NVM_write called with id: 150. It return: 9 . # 8 : [foster_init_reference_ephemeris] [LV1] [orbital] Reinit need_to_load flag failed # 9 : [foster_st33nvm_create] [LV3] [ST33] SPI command for CREATE failed # 10 : [foster_nvm_create] [LV1] [ST33] st33NVM_create called with id: 147. It return: 1 . # 11 : [foster_orbital_create_ephemeris_nvm_items] [LV1] [orbital] Error at NVM ephemeris buffer data item create. # 12 : [foster_nvm_copy] [LV1] [ST33] st33NVM_copy called with id: 147. It return with code is: 11 . # 13 : [foster_orbital_load_gps_ref_ephemeris] [LV1] [orbital] Error at NVM read of foster_ephemeris_tmp_data # 14 : [foster_start_services_p] [LV1] [ST33] OSNMA UT start 0. # 15 : [foster_start_services_p] [LV1] [ST33] Canceling OSNMA UT start. APDU on ISO7816 Sending: 00 A4 04 0C 06 FF 42 42 42 42 42 Received (SW1=0x66, SW2=0x02) APDU resp failed

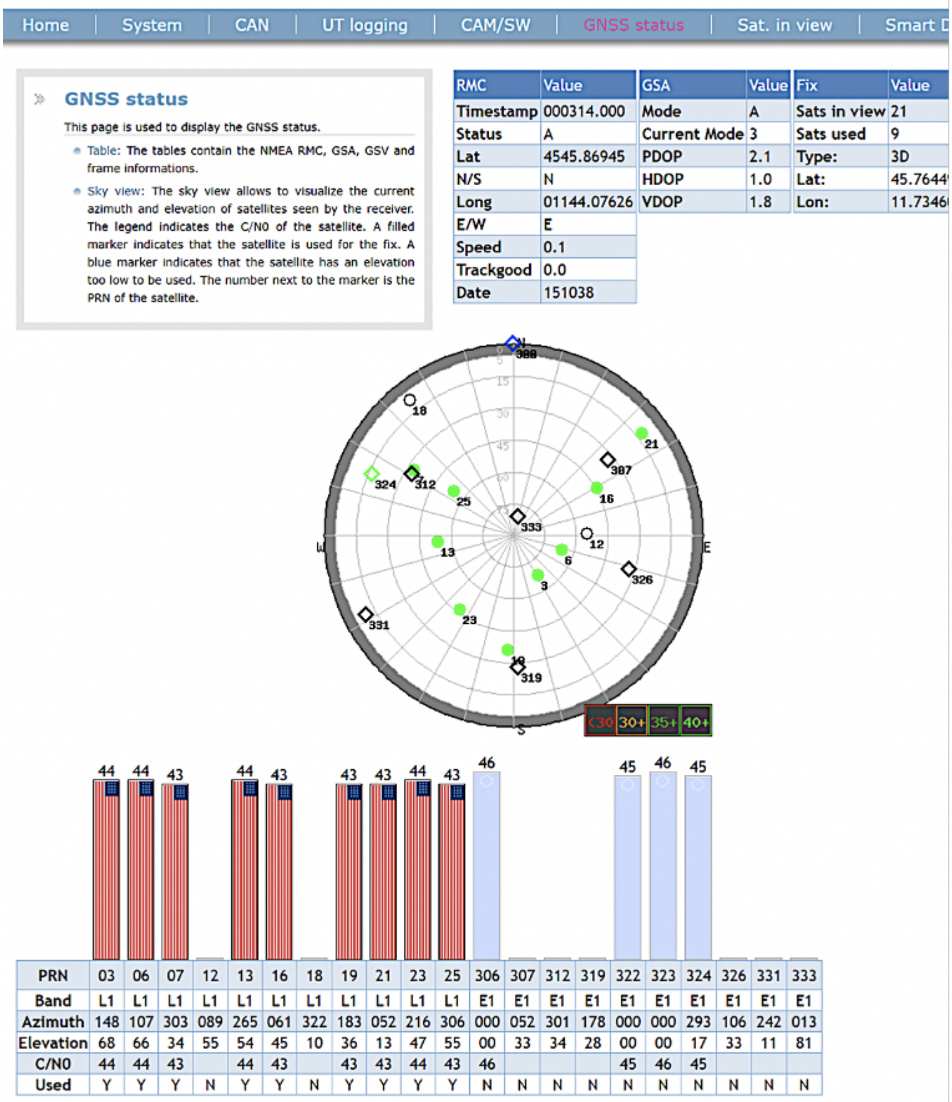
3.1.7 REQ_FUNC_SEC_03

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00008	**Teseo V module : PVT cross check (constellation agility)**
KPI	
REQ_FUNC_SEC_03	The OBU shall be able to detect attempts to compromise external systems used for positioning (e.g. GNSS)
Test Objective	Function not yet implemented
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	

Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00009	**Teseo V module : C/N0 monitoring**
KPI	Not applicable
REQ_FUNC_SEC_03	The OBU shall be able to detect attempts to compromise external systems used for positioning (e.g. GNSS)
Test Objective	This scenario allows to test if the Teseo V module implements algorithms based on monitoring the CN0 variance.
Test Context	Laboratory test, using live signals and GNSS signals from simulator.
Metrics	Not applicable
Reference(s)	Not applicable
Test description	
Testing Framework Mode	Not applicable
Toolchain	- Antenna and related cables for real signal test - GNSS simulator - A computer for data collection
Elements of the ODD	Not applicable
Test Procedure	
1	Switch the RF to a GNSS simulator.
2	Simulate a GNSS signal with at least one satellite with C/N0 that stays constant more than 120 seconds.
3	Simulate a GNSS signal with satellites that have same C/N0. The C/N0s are declared equal with an offset of ± 1 dB.
Required Inputs	TV220 scenario for GNSS simulator
Required Output	Not applicable

Test Analysis	Not applicable
	Pass Condition
Test criteria	The test is validated if the level of C/N0 monitoring sub-indicator decrease with spoofing. **PASS** / ~~FAIL~~
Evidences	



Home | System | CAN | UT logging | CAM/SW | GNSS status | Sat. in view | Smart D

GNSS status

This page is used to display the GNSS status.

- Table: The tables contain the NMEA RMC, GSA, GSV and frame informations.
- Sky view: The sky view allows to visualize the current azimuth and elevation of satellites seen by the receiver. The legend indicates the C/N0 of the satellite. A filled marker indicates that the satellite is used for the fix. A blue marker indicates that the satellite has an elevation too low to be used. The number next to the marker is the PRN of the satellite.

RMC	Value
Timestamp	000314.000
Status	A
Lat	4545.86945
N/S	N
Long	01144.07626
E/W	E
Speed	0.1
Trackgood	0.0
Date	151038

GSA	Value
Mode	A
Current Mode	3
PDOP	2.1
HDOP	1.0
VDOP	1.8

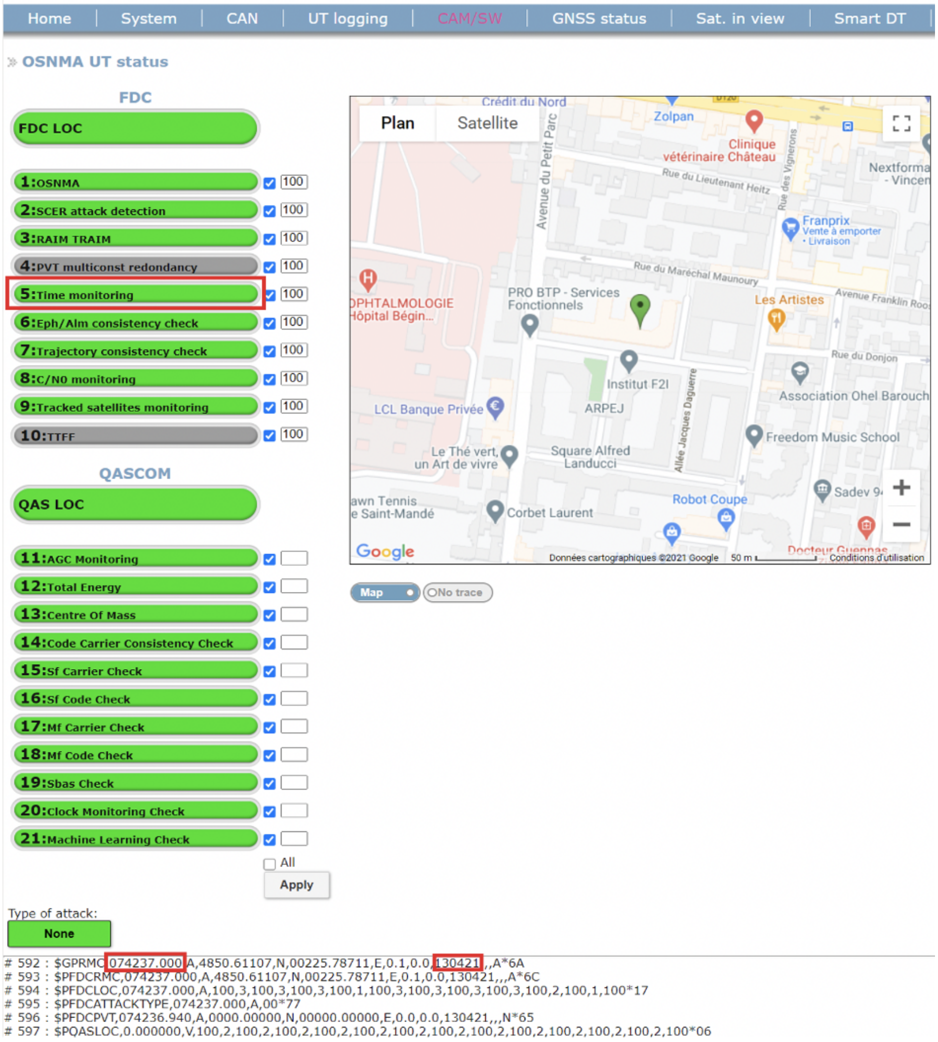
Fix	Value
Sats in view	21
Sats used	9
Type:	3D
Lat:	45.7644
Lon:	11.7346

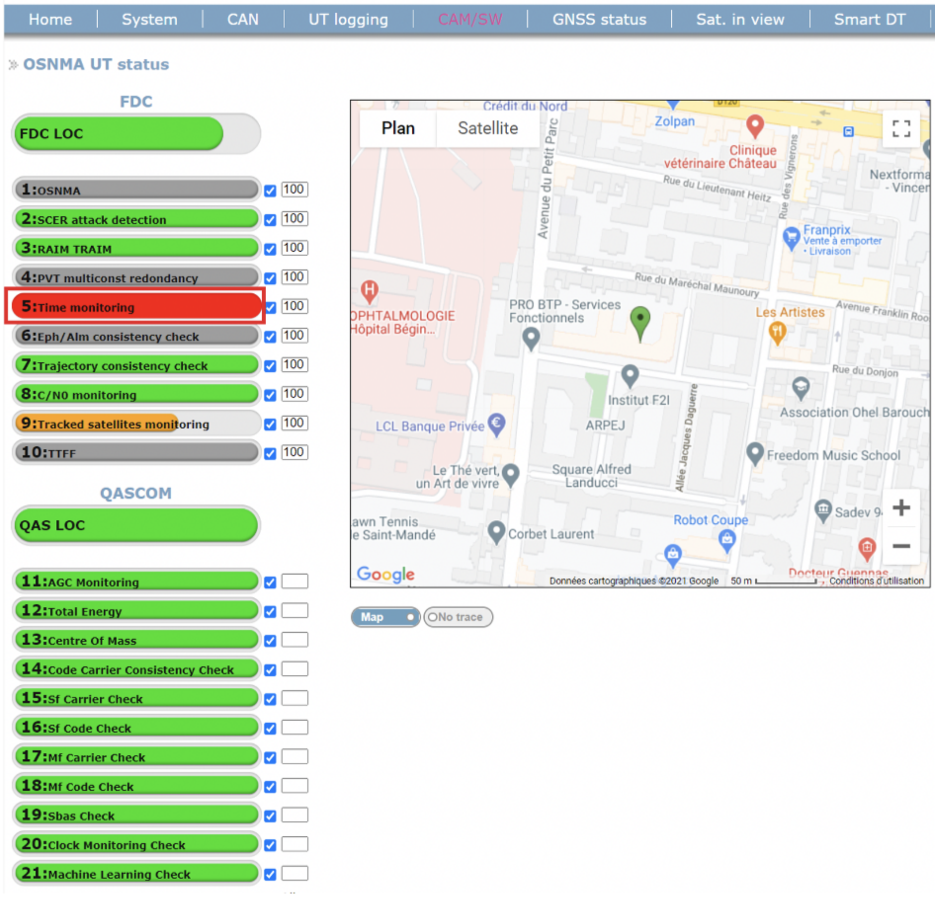
PRN	03	06	07	12	13	16	18	19	21	23	25	306	307	312	319	322	323	324	326	331	333
Band	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1
Azimuth	148	107	303	089	265	061	322	183	052	216	306	000	052	301	178	000	000	293	106	242	013
Elevation	68	66	34	55	54	45	10	36	13	47	55	00	33	34	28	00	00	17	33	11	81
C/N0	44	44	43		44	43		43	43	44	43	46				45	46	45			
Used	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N

	 On the first figure, the GPS satellites have C/N0 equal to ± 1 dB. This raises an alert on the C/N0 indicator. On the second figure shows that indicator 8, C/N0 monitoring, has decreased to 0.

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00010	**Teseo V module : Time monitoring**
KPI	Not applicable
REQ_FUNC_SEC_03	The OBU shall be able to detect attempts to compromise external systems used for positioning (e.g., GNSS).
Test Objective	This test allows to verify that the Teseo V module can detect a GNSS attack of type replay. It is shared in two parts: the first where the RTC drift is verified and the second part where a time inconsistency is detected (anti-raplay).
Test Context	Not applicable
Metrics	Not applicable
Reference(s)	Not applicable
Test description	

Testing Framework Mode	Not applicable
Toolchain	- Antenna and related cables for real signal test - GNSS simulator - A computer for data collection
Elements of the ODD	Not applicable
Test Procedure	
1	**RTC drift test:** • Start Teseo V module with genuine signal • Wait for a first fix • For RTC synchronisation using $PFDC RTCSYNC command • Check that the RTC is synchronize with UTC time • Switch off the Teseo V module during 7 days • Restart the receiver and check the RTC drift.
2	**Anti-Replay test:** • Ensure that the RTC has been initialised (see RTC drift test) • Start Teseo V module connected to a GNSS simulator playing a scenario with a time differing to the current UTC time of more than 1s • Check that the Teseo V module detects time inconsistency by checking the time_monitor indicator.
Required Inputs	Not applicable
Required Output	Not applicable
Test Analysis	Not applicable
Pass Condition	
Test criteria	For the RTC drift test, the delta between UTC time and RTC shall be below 5s. For the Anti-Replay test, the Teseo V module shall detect time inconsistency when starting on simulator generating fake signal with generating a time differing from 1s from the genuine time. **PASS** / ~~FAIL~~
Evidences	Synchronization of RTC on real signal

	 Replay signal (scenario GPS_001 07:20:00 13/04/2021):



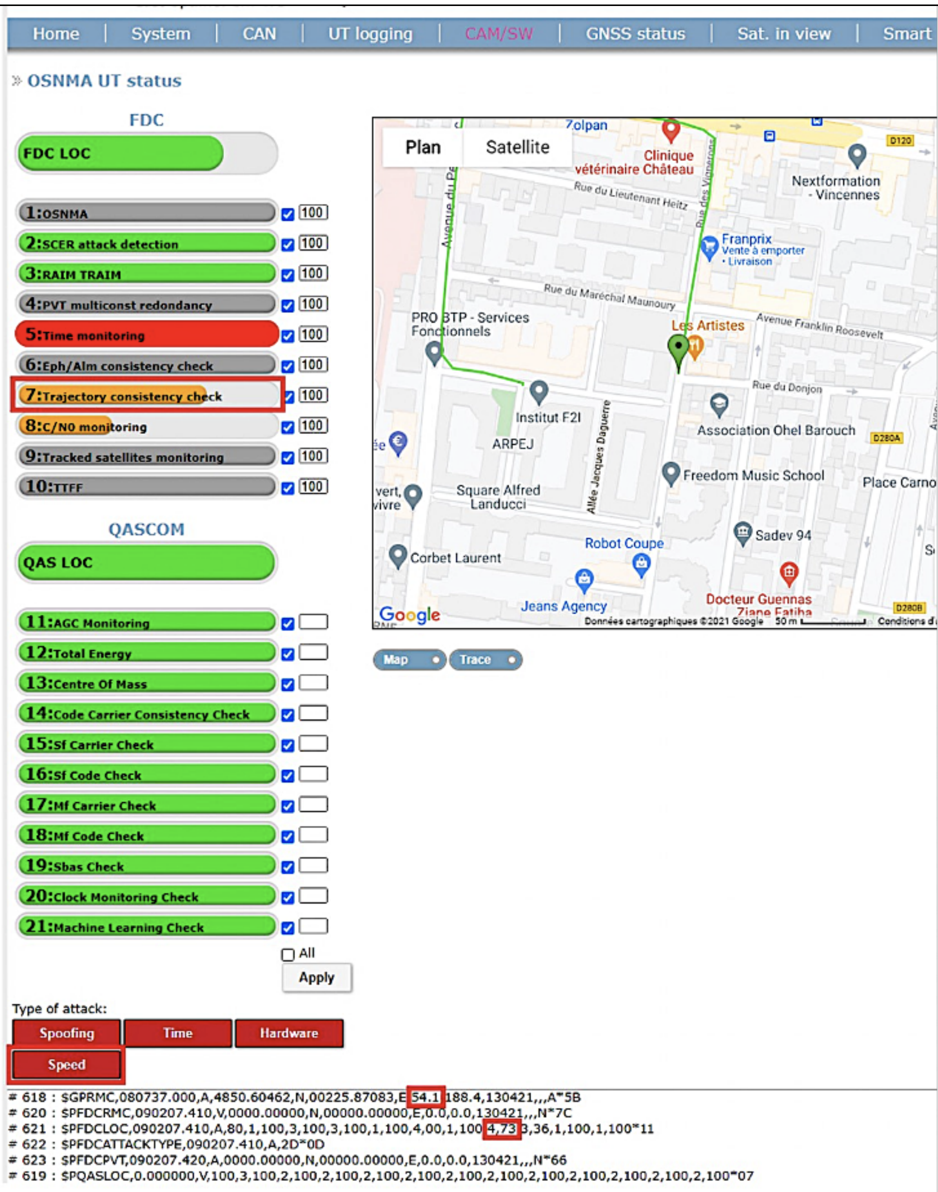
Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00011	**Teseo V module : TRAIM**
KPI	Not applicable
REQ_FUNC_SEC_03	The OBU shall be able to detect attempts to compromise external systems used for positioning (e.g., GNSS).
Test Objective	This test verifies the RAIM and TRAIM features
Test Context	Laboratory test using the GNSS signal simulator
Metrics	Not applicable
Reference(s)	Not applicable
Test description	
Testing Framework Mode	Not applicable
Toolchain	• GNSS signal simulator • A computer for data collection
Elements of the ODD	Not applicable
Test Procedure	

1	Connect the Platform to a GNSS signal simulator providing the needed scenario with at least one satellite or one constellation: • With modified pseudo-range • With modified timing
2	Connect the platform to a PC through communication channel.
3	Lauch data collection
Required Inputs	Not applicable
Required Output	Not applicable
Test Analysis	Not applicable
Pass Condition	
Test criteria	The NMEA message with signal Integrity/inconsistency warning message/flag will present the correct value indicating the corrupted signal integrity status **PASS** / ~~FAIL~~
Evidences	$GNRMC,002622.000,A,4548.89433,N,00836.77918,E,2.0,184.5,120919,,,A,C*16 $GPAMC,002622.000,V,4548.89433,N,00836.77918,E,2.0,184.5,120919,,,N*6C $GNGGA,002622.000,4548.89433,N,00836.77918,E,1,21,0.6,-213.94,M,48.0,M,,*5A $GNGNS,002622.000,4548.89433,N,00836.77918,E,AAANNN,21,0.6,-213.94,48.0,,,C*10 $GNVTG,184.5,T,,M,2.0,N,3.7,K,A*1D $GNGST,002622.000,41.0,6.2,3.8,-0.7,5.4,4.8,5.9*6C $GNGBS,002622.000,5.4,4.8,5.9,09,,-105.2,,1,1*66 $GNGSA,A,3,24,15,21,26,18,29,,,,,,,1.2,0.6,1.0,1*32 $GNGSA,A,3,84,78,79,77,83,89,,,,,,,1.2,0.6,1.0,2*31 $GNGSA,A,3,,,,,,,,,,,,,1.2,0.6,1.0,5*31 $GNGSA,A,3,06,10,04,05,11,17,18,26,27,,,,1.2,0.6,1.0,3*3F $GNGSA,A,3,,,,,,,,,,,,,1.2,0.6,1.0,1*35 $GNGSA,A,3,,,,,,,,,,,,,1.2,0.6,1.0,3*37 $GNASA,A,1,,,,,,,,,,,,,1.2,0.6,1.0*2C $GPGSV,3,1,12,15,74,099,45,24,67,135,45,21,65,302,44,26,57,065,44,1*66 $GPGSV,3,2,12,18,38,273,44,29,27,207,44,27,25,061,43,10,25,075,44,1*6F $GPGSV,3,3,12,06,13,323,43,09,10,155,43,08,10,035,43,22,06,266,43,1*63 $GLGSV,2,1,07,84,60,033,45,79,45,299,45,78,42,270,45,89,37,110,45,1*72 $GLGSV,2,2,07,83,29,043,44,77,28,222,44,88,07,158,44,,,,,1*4B $GAGSV,3,1,10,11,76,337,46,27,64,060,47,12,39,077,46,05,35,243,46,7*79 $GAGSV,3,2,10,18,31,066,46,17,31,128,46,10,29,279,46,04,27,304,46,7*77 $GAGSV,3,3,10,26,25,216,46,06,10,195,45,,,,,,,,,7*7D $GPGSV,3,1,11,27,,,46,06,,,46,24,,,47,15,,,47,7*61 $GPGSV,3,2,11,08,,,45,21,,,47,10,,,46,26,,,47,7*6E $GPGSV,3,3,11,29,,,46,09,,,46,22,,,46,,,,,7*62 $GAGSV,3,1,10,11,,,46,10,,,45,04,,,46,06,,,45,1*75 $GAGSV,3,2,10,18,,,45,05,,,45,17,,,45,26,,,45,1*7B $GAGSV,3,3,10,27,,,46,12,,,45,,,,,,,,,1*71 $PSTMPRES,56.1,-80.3,-123.3,-111.5,11.9,16.7,5.5,-78.6,-7.2,-39.4,-55.2,25.3,-47.1,-6.1,6.1,-14.6,13.4,70.0,0.4,0.4,-8.0,-8.4,-120.2,56.7,-23.3,-44.5,-11.3,-105.2,,,,,,,,,,,,,,,,,,,,*0F $PSTMVRES,1.2,-1.5,-2.2,-1.6,0.5,0.5,0.3,-1.1,-0.1,-0.1,0.6,-0.4,-1.3,-1.8,0.0,-2.2,-1.0,-1.2,-0.2,-1.4,-2.5,-0.9,-0.7,-1.4,0.5,-1.4,-0.2,-0.1,,,,,,,,,,,,,,,,,,,*09 $PSTMSAT,27,1,1317050.28,18946592.66,18567691.91,-1830.49,-1493.79,1654.11,0.00,0.00,2.92,5.98,0,0.00,0,0.00,0.00,0,0,0,0*6B $PSTMSAT,08,1,-8597906.72,13074843.03,21461399.19,-1804.78,-2042.81,521.49,0.00,0.00,4.03,13.83,0,0.00,0,0.00,0.00,0,0,0,0*4F $PSTMSAT,06,1,-2983531.84,-14980916.00,21728733.69,2651.73,-763.46,-162.27,0.00,0.00,3.77,10.98,0,0.00,0,0.00,0.00,0,0,0,0*59

	$PSTMSAT,24,1,20717229.38,8917576.47,14026418.16,1001.45,1489.13,-2425.88,0.00,0.00,1.58,2.75,0,0.00,0,0.00,0.00,0,0,0,0*44 $PSTMSAT,15,1,17834745.09,8277477.59,17856998.91,-2153.54,728.95,1812.94,0.00,0.00,1.52,2.64,0,0.00,0,0.00,0.00,0,0,0,0*7B $PSTMSAT,21,1,15144543.78,-5404325.38,21140085.91,1768.66,2020.83,-750.43,0.00,0.00,1.61,2.81,0,0.00,0,0.00,0.00,0,0,0,0*56 $PSTMSAT,10,1,4361108.25,21362053.25,15169396.31,-777.84,1774.21,-2274.86,0.00,0.00,2.95,6.03,0,0.00,0,0.00,0.00,0,0,0,0*5A $PSTMSAT,26,1,11748499.44,12296974.97,20401577.00,-2526.11,584.09,1102.62,0.00,0.00,1.72,3.02,0,0.00,0,0.00,0.00,0,0,0,0*41 $PSTMSAT,18,1,15857628.84,-15392300.78,14733630.31,-379.45,1844.16,2334.99,0.00,0.00,2.27,4.16,0,-1.91,0,0.00,0.00,0,0,0,0*49 $PSTMSAT,29,1,26013219.62,-5334512.53,-567939.81,-8.99,293.88,-3172.27,0.00,0.00,2.78,5.45,0,0.00,0,0.00,0.00,0,0,0,0*68 $PSTMSAT,84,1,9522559.78,7120417.06,22567360.84,-502.96,3049.78,-749.91,149896.25,0.00,1.62,2.94,0,0.00,0,0.00,0.00,0,0,0,0*69 $PSTMSAT,306,1,27537612.31,-2998958.69,-10432936.25,-1012.32,284.06,-2753.65,0.00,0.00,4.05,13.97,0,0.00,0,0.00,0.00,0,0,0,0*51 $PSTMSAT,310,1,14106727.00,-20656544.88,15826162.25,-330.65,1555.56,2325.06,0.00,0.00,2.69,5.25,0,0.00,0,0.00,0.00,0,0,0,0*5E $PSTMSAT,78,1,16338310.28,-13182913.69,14489025.22,1818.32,-806.60,-2784.27,149896.25,0.00,2.05,3.78,0,0.00,0,0.00,0.00,0,0,0,0*72 $PSTMSAT,304,1,6401493.91,-18488907.44,22211284.78,2065.74,-838.62,-1293.43,0.00,0.00,2.78,5.50,0,0.00,0,0.00,0.00,0,0,0,0*46 $PSTMSAT,305,1,23998569.66,-15194215.53,8328533.12,744.88,-392.13,-2861.71,0.00,0.00,2.41,4.42,0,0.00,0,0.00,0.00,0,0,0,0*7B $PSTMSAT,311,1,16680563.91,133201.66,24452015.16,-395.61,2421.80,256.68,0.00,0.00,1.52,2.61,0,0.00,0,0.00,0.00,0,0,0,0*4D $PSTMSAT,79,1,11460509.56,-11309772.34,19783991.91,-562.96,2651.92,1842.10,149896.25,0.00,1.97,3.59,0,0.00,0,0.00,0.00,0,0,0,0*59 $PSTMSAT,317,1,20780908.41,20629486.34,4328757.31,-271.24,-355.14,2994.58,0.00,0.00,2.58,4.92,0,0.00,0,0.00,0.00,0,0,0,0*54 $PSTMSAT,318,1,4567044.25,21204915.59,20140845.72,-1530.96,-1321.08,1738.01,0.00,0.00,2.58,4.86,0,0.00,0,0.00,0.00,0,0,0,0*55 $PSTMSAT,326,1,27891176.88,-9846073.59,-1138897.50,-144.74,-58.49,-3039.01,0.00,0.00,2.94,6.02,0,0.00,0,0.00,0.00,0,0,0,0*72 $PSTMSAT,22,1,11493088.50,-23407651.28,5045587.53,61.36,695.51,3086.84,0.00,0.00,4.38,21.58,0,0.00,0,0.00,0.00,0,0,0,0*47 $PSTMSAT,327,1,14159703.38,11353267.72,23383030.34,-337.94,2322.37,-922.94,0.00,0.00,1.61,2.83,0,0.00,0,0.00,0.00,0,0,0,0*64 $PSTMSAT,77,1,23649053.12,-9414186.03,1658796.25,153.17,-243.53,-3567.62,149896.25,0.00,2.67,5.44,0,0.00,0,0.00,0.00,0,0,0,0*47 $PSTMSAT,83,1,-233960.62,13215557.22,21816434.69,-2249.73,-1967.00,1167.45,149896.25,0.00,2.62,5.28,0,0.00,0,0.00,0.00,0,0,0,0*46 $PSTMSAT,89,1,14883914.75,18380276.25,9554597.31,-898.12,-965.39,3255.87,149896.25,0.00,2.25,4.23,0,0.00,0,0.00,0.00,0,0,0,0*5C $PSTMSAT,09,1,21587368.78,13349389.72,-7826012.62,527.02,883.61,2960.95,0.00,0.00,4.02,13.94,0,0.00,0,0.00,0.00,0,0,0,0*79 $PSTMPPSDATA,1,0,1,0,1,0,0.500000,0,633,420,420,633,0,0,0,0,8,41,3,14,18,0,0,0,1.521e-08,65473975.41,26000006.78,4*1C $PSTMTRAIMSTATUS,1,1,15,732,14,4,41*67 $PSTMTRAIMUSED,1,14,27,10,18,29,306,310,304,305,311,317,318,326,327,9*6E $PSTMTRAIMRES,1,14,-1197,-1203,-1333,-1281,1019,882,910,817,628,860,888,890,673,-1114*03 $PSTMTRAIMREMOVED,1,4,24,15,21,26*1B

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00012	**Teseo V module : trajectory consistent check**
KPI	Not applicable
REQ_FUNC_SEC_03	The OBU shall be able to detect attempts to compromise external systems used for positioning (e.g., GNSS).
Test Objective	This scenario tests that the Teseo V module is able to detect inconsistency between information given by the motion sensors and information given by GNSS.
Test Context	Laboratory test, using GNSS signals from simulator.
Metrics	Not applicable
Reference(s)	Not applicable
Test description	
Testing Framework Mode	Not applicable
Toolchain	- GNSS simulator - Management board generating false odometer information. - A computer for data collection
Elements of the ODD	Not applicable
Test Procedure	
1	Connect the Teseo V module to the GNSS simulator.
2	The Teseo V module is standstill and feed with odometer data indicating a null speed.
3	Start the GNSS simulator simulating a dynamic trajectory with a non null speed.
Required Inputs	Scenario with a non-null speed for GNSS simulator
Required Output	Not applicable
Test Analysis	Not applicable
Pass Condition	
Test criteria	The Teseo V module shall detect trajectory inconsistency. The inconsistence shall be mentioned in the debug stream and the sub-indicator shall decrease with spoofing. **PASS** / ~~FAIL~~

Evidences



Debug stream:

[foster_distance_traveled] [LV1] Odo Distance traveled calculated with success: (0.000000) with odo scale = 0.100000 and reverse 0
[foster_speed_analyzer] [LV1] Delta speed (46.408141) odo(0.000000) gnss(46.408141)

Remark:
The scenario lasts 2 min, the sub-indicator does not have time to decrease to 0.

3.1.8 REQ_FUNC_SEC_04

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00013	**Teseo V module : OSNMA**
KPI	Not applicable

REQ_FUNC_SEC_04	The OBU shall implement available GNSS security mechanisms (e.g., Galileo OS-NMA).
Test Objective	This test verifies if the Teseo V module can provide an authenticated PVT
Test Context	Test using GNSS live signal
Metrics	Not applicable
Reference(s)	Not applicable
Test description	
Testing Framework Mode	Not applicable
Toolchain	• Antenna • A computer for data collection
Elements of the ODD	Not applicable
Test Procedure	
1	Connect the Teseo V module to a GNSS simulator providing recorded GNSS signals (with Galileo signal and OSNMA data)
2	Check the fix status
3	Check the satellites used for fix and the flag in NMEA message reporting the use of Trusted signals
Required Inputs	Not applicable
Required Output	Not applicable
Test Analysis	Not applicable
Pass Condition	
Test criteria	PVT reported in NMEA messages is authenticated by Galileo satellites with OSNMA **PASS** / ~~FAIL~~
Evidences	$GPRMC,111714.000,A,4714.63540,N,00130.77924,W,0.0,0.0,130921,,,D*7D $GPAMC,111714.000,A,4714.63535,N,00130.78085,W,0.1,0.0,130921,0.0,W*71 $GPGGA,111714.000,4714.63540,N,00130.77924,W,2,12,0.9,030.10,M,48.5,M,,*70 $GNGNS,111714.000,4714.63540,N,00130.77924,W,DNDNNN,12,0.9,030.10,48.5,,*47 $GPVTG,0.0,T,,M,0.0,N,0.1,K,D*09 $GPGST,111714.000,1.0,3.6,1.8,90.5,2.3,3.2,2.6*51 $GPGBS,111714.000,2.3,3.2,2.6,,,,*76 $GNGSA,A,3,22,03,17,04,21,01,31,19,,,,,1.5,0.9,1.1*28 $GNGSA,A,3,,,,,,,,,,,,,1.5,0.9,1.1*21 $GNGSA,A,3,333,312,319,304,,,,,,,,,1.5,0.9,1.1*2E $GNASA,A,2,333,312,319,304,,,,,,,,,5.6,3.5,4.4*21 $GNGSV,9,1,19,03,84,337,44,,,,,,,,,,,,*5F $GNGSV,9,2,19,312,69,309,37,,,,,,,,,,,,*65 $GNGSV,9,3,19,22,66,059,45,01,63,103,39,,,,,,,,*64 $GNGSV,9,4,19,319,59,165,37,333,54,121,42,,,,,,,,*65 $GNGSV,9,5,19,17,53,285,41,21,43,116,41,04,36,175,43,19,33,310,30*62 $GNGSV,9,6,19,311,15,305,24,,,,,,,,,,,,*67 $GNGSV,9,7,19,31,12,076,28,,,,,,,,,,,,*5B $GNGSV,9,8,19,304,10,205,39,307,09,039,25,326,07,123,24,325,07,310,30*61

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$GNGSV,9,9,19,14,07,250,40,09,07,198,36,32,05,035,30,,,,*54
$GPGLL,4714.63540,N,00130.77924,W,111714.000,A,D*42
$PSTMPRES,1.5,-0.6,0.1,1.1,-0.6,0.1,-1.7,-3.1,0.4,2.4,-0.4,1.5,-1.9,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*06
$PSTMVRES,0.0,0.0,-0.0,-0.0,-0.0,-0.0,0.0,-0.0,0.0,0.0,0.1,0.0,0.0,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*26
$PSTMSAT,22,1,14298456.44,6884690.44,21479343.09,-972.81,2513.84,-139.14,-154186.40,-5.30,3.78,2.67,2,0.00,14,-2.38,0.00,0,0,0,0*44
$PSTMSAT,03,1,16520866.78,-1339383.12,20627877.97,-1116.41,2396.49,1054.61,-86299.67,0.55,3.50,2.45,-3,-0.15,14,-0.70,0.00,0,0,0,0*54
$PSTMSAT,17,1,13197474.03,-12947189.53,19505542.97,2378.38,110.52,-1570.10,151111.06,-3.34,4.08,3.06,1,0.00,14,-1.56,0.00,0,0,0,0*63
$PSTMSAT,04,1,26518475.84,789493.72,1890905.75,-233.67,279.35,3159.73,-61248.02,-1.25,6.00,4.17,0,-2.08,14,-2.52,0.00,0,0,0,0*77
$PSTMSAT,14,1,12366871.66,-23451184.25,1017580.75,328.07,35.79,-3163.45,707.48,-2.37,9.05,17.92,-2,0.00,14,-3.52,0.00,0,0,0,0*72
$PSTMSAT,21,1,20420900.28,14112153.53,10855129.66,610.76,1118.05,-2728.71,42727.95,-3.07,5.27,3.58,0,0.00,14,-3.90,0.00,0,0,0,0*7D
$PSTMSAT,01,1,18649910.88,8627128.78,16741386.28,1058.52,1886.61,-2084.47,170558.68,1.53,3.95,2.73,-3,0.51,14,-1.40,0.00,0,0,0,0*4B
$PSTMSAT,31,1,4160843.03,22989178.16,12082000.69,-1065.66,-1184.77,2647.00,-41827.46,-3.91,10.16,11.86,0,0.00,14,-4.11,0.00,0,0,0,0*79
$PSTMSAT,333,3,23356591.00,11428759.25,14139539.41,1072.07,942.07,-2532.49,-139408.28,-1.11,4.39,3.00,0,-1.88,2,-2.22,0.00,0,0,0,0*49
$PSTMSAT,312,3,15207296.75,-7040923.97,24394800.47,1695.59,1770.66,-545.27,1502544.51,-3.07,3.59,2.62,-5,-5.61,2,-1.80,0.00,0,0,0,0*64
$PSTMSAT,19,1,3496649.31,-14418445.81,21746542.31,2817.26,178.62,-345.72,15706.62,-4.60,5.14,4.47,1,0.00,14,-3.40,0.00,0,0,0,0*57
$PSTMSAT,319,3,27128580.66,2231127.94,11631787.19,-1149.30,205.54,2641.10,112872.47,-0.91,4.12,2.84,2,-1.56,2,-2.07,0.00,0,0,0,0*58
$PSTMSAT,32,1,-8938417.53,14800196.03,20228784.84,-2551.32,41.78,-1181.83,-31.99,0.13,9.39,25.02,-1,1.34,14,-3.80,0.00,0,0,0,0*58
$PSTMSAT,304,3,25571465.09,-12083440.25,-8728545.75,845.69,-229.72,2795.16,-256547.78,-0.98,10.47,13.53,-2,-1.63,2,-5.20,0.00,0,0,0,0*64
$PSTMSAT,09,1,23611712.69,-8174904.28,-9112235.19,1164.42,189.29,2866.30,-108187.11,0.41,11.52,18.12,0,0.18,14,-5.42,0.00,0,0,0,0*66
$PSTMSAT,326,1,18418975.78,22922670.06,-3323980.59,-125.33,-339.74,-3039.36,404410.94,2.02,12.98,19.38,-13,3.45,2,-6.51,0.00,0,0,0,0*53
$PSTMIFB,0,0,0,0,0,0,0,0,0*57
$PSTMANTENNASTATUS,1,0,1,1*50
$PSTMSBAS,1,2,123,26,138,40*10
$PSTMSBAS,1,2,136,35,171,43*18
$PSTMNAVM,15,312,5555950055555555555555555046FFC51C04F2E9AAAAA0A004FB6BC99403FD9D2*6D
$PSTMNAVM,15,319,5555950055555555555555555046FFC51C04F3E94AAAA0A002F9F3A9F40BF7CDA*18
$PSTMNAVM,15,333,5555950055555555555555555046FFC51C04F7E90AAAA0A00BF13449140FF4ED0*68
$PSTMNAVM,15,304,5555950055555555555555555046FFC51C04F2E9AAAAA0A004FB6BC99403FD9D2*6A
$PSTMNMASTATUS,1*51
$PSTMNMAMACV,0,80,127051.406,2175,2924051018,2893319066,2920001892,19,19,2948,2,0,1,155966000361,1,1,1,126990,1151*40
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```

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	$PFDCLOC,111714.000,A,90,3,100,3,100,1,100,1,100,4,00,1,100,1,100,3,100,1,100,1,100,1,100*1E $PFDCATTACKTYPE,111714.000,A,05*74 $PFDCPVT,034454.550,A,0000.00000,N,00000.00000,E,0.0,0.0,010100,,,N*6B $PSTMGNSSINTEGRITY,0,0,0.0,0.0,0.0,0,0.0,0.0,0.0*48 $PSTMCPU,50.86,0,261*50 $PSTMTG,2175,127052.99999999,0,2925682135,9,-44880.9182,a000,22541,0,0,2175,127052.99999999,9,126,-5.575,18441,18,910311593,1063466,603385137*51 $PSTMTS,2,22,20917734.500,-46289.26,-109923428.899,87171,45,1062791,246,1845,0,0,66,0,0,0,850*10 $PSTMTS,2,3,20209119.875,-44959.92,-106199641.339,21507,44,1062233,253,1855,0,0,83,0,0,0,850*2B $PSTMTS,2,17,21379612.812,-43990.09,-112350624.831,21635,41,1062209,88,1879,0,0,52,0,0,0,850*2E $PSTMTS,2,4,22433244.312,-41667.63,-117887502.547,21507,43,1062106,327,1871,0,0,35,0,0,0,850*2F $PSTMTS,2,14,24946973.062,-47687.54,-131097226.151,21635,40,1062097,223,1906,0,0,7,0,0,0,850*22 $PSTMTS,2,21,22306879.875,-46956.36,-117223441.554,21507,41,1061986,28,1931,0,0,42,0,0,0,850*25 $PSTMTS,2,1,20499728.500,-46523.75,-107726790.435,21635,39,1061752,345,1862,0,0,63,0,0,0,850*27 $PSTMTS,2,31,24308662.375,-43248.61,-127742833.888,21507,28,1031723,67,4264,1691,0,11,0,0,0,850*13 $PSTMTS,2,311,25675519.000,-42191.44,-134925763.113,55603,24,1026715,86,4159,16,0,-128,0,0,0,850*38 $PSTMTS,2,333,24323757.250,-46458.67,-127822198.286,87171,42,1030047,4,2488,0,0,54,513486,512484,0,900*24 $PSTMTS,2,312,22068417.375,-43856.88,-115970314.276,87171,37,1029355,-27,3562,0,0,68,159014,157362,0,840*33 $PSTMTS,2,19,22282885.375,-42329.55,-117097296.265,21511,30,1028340,126,3769,3,0,33,0,0,0,850*1B $PSTMTS,2,319,23836453.812,-43279.46,-125261411.099,21507,37,1053708,-27,3292,0,0,59,145606,148026,0,840*3B $PSTMTS,2,325,28330156.688,-46049.58,-148875960.657,22819,31,873446,3,3435,1,0,-128,0,0,0,850*09 $PSTMTS,2,32,25319597.562,-48220.72,-133055371.884,21511,30,6459,229,5789,0,0,4,0,0,0,850*1B $PSTMTS,2,304,28066758.938,-41722.21,-147491810.591,87171,39,919319,1,2759,0,0,10,292175,287487,0,860*10 $PSTMTS,2,9,25131291.000,-40983.77,-132065834.495,21635,36,309993,154,2154,0,0,7,0,0,0,850*2F $PSTMTS,2,307,28156563.938,-47697.15,-147963741.178,22819,25,72987,6,3950,5,0,-128,0,0,0,850*3D $PSTMTS,2,326,27752380.188,-47620.21,-145839747.596,22819,24,116408,-121,4545,19,0,-128,0,0,0,850*1D $PSTMCHMON,0,333,-1370105305,-1370105305,86518,1216764,4903061,1397025,101160,511387,475562,461530,469201,106504,0.018309*6C $PSTMCHMON,0,333,-1369900240,-1369900240,101365,1084188,4413455,1135880,65259,481634,504872,468942,489290,96573,-0.028285*70 $PSTMCHMON,0,333,-1369696012,-1369696012,109585,1197827,4406061,1139992,119175,422173,397917,423748,405307,103434,0.002875*5D $PSTMCHMON,0,333,-1369490947,-1369490947,116008,1091712,4394856,1118297,107331,403541,433264,467067,477898,95092,0.008915*64

	$PSTMCHMON,0,333,-1369286719,- 1369286719,107704,1197334,5034965,1309660,89198,528649,510677,439623,49733 5,109997,-0.028685*42 $PSTMCHMON,1,312,-1370256802,- 1370256802,86635,642045,2338010,628411,104264,249831,278010,301157,302770,9 8027,-0.035568*7A $PSTMCHMON,1,312,-1370052574,- 1370052574,122629,621147,2344251,617568,101040,318873,348383,258511,262981, 106428,-0.034252*76 $PSTMCHMON,1,312,-1369847509,- 1369847509,150297,615970,2267570,652064,95731,278589,278038,280085,309026,9 9172,0.072915*59 $PSTMCHMON,1,312,-1369643281,- 1369643281,101715,568565,2256813,618140,77571,263616,267584,242160,256979,1 12740,-0.006179*4C $PSTMCHMON,1,312,-1369438216,- 1369438216,100865,567396,1920372,580789,113664,292023,229718,241852,225634, 108050,0.002938*53 $PSTMCHMON,2,304,-1370209093,- 1370209093,85549,683731,2404441,602744,124053,272603,228572,334449,368562,9 8369,-0.026367*7B $PSTMCHMON,2,304,-1370004028,- 1370004028,113748,709122,2681928,644388,122247,352102,348053,288774,292331, 97039,-0.066274*4E $PSTMCHMON,2,304,-1369799800,- 1369799800,97410,551254,2414389,605872,113999,317496,333262,305956,299892,8 4247,0.065358*50 $PSTMCHMON,2,304,-1369594735,- 1369594735,108082,675871,2634782,681607,123799,312709,320348,331882,324271, 93658,-0.010892*48 $PSTMCHMON,2,304,-1369390507,- 1369390507,83381,671906,2601103,704033,78706,332955,332689,288315,331817,92 933,-0.016908*43 $PSTMCHMON,3,22,-1369765483,- 1369765483,178903,15732869,65396131,15596569,197762,3025354,37743363,38456 792,3152180,220524,-0.162288*78 $PSTMCHMON,3,22,-1369561255,- 1369561255,367892,15543067,72366052,17512957,216460,2786132,40199251,42242 361,3515443,156383,-0.011053*79 $PSTMCHMON,3,22,-1369356190,- 1369356190,287962,16255437,70902390,16696077,231065,2846510,40343620,41457 753,3201613,271571,-0.063440*73 $PSTMRFI,127052.99999999,f,0,0,0,,,,,,,,,f,4095,4095,63,63,1,0,17518,16640,16640,1 6640,16640,16640*54 $PSTMVER,GNSSLIB_9.8.0.1_NMA_DFPVT_ARM*5B $GPRMC,111715.000,A,4714.63541,N,00130.77925,W,0.1,0.0,130921,,,D*7D $GPAMC,111715.000,A,4714.63542,N,00130.78110,W,0.2,325.9,130921,0.0,W*73 $GPGGA,111715.000,4714.63541,N,00130.77925,W,2,12,0.9,030.13,M,48.5,M,,*72 $GNGNS,111715.000,4714.63541,N,00130.77925,W,DNDNNN,12,0.9,030.13,48.5,,*45 $GPVTG,0.0,T,,M,0.1,N,0.2,K,D*0B $GPGST,111715.000,1.0,3.6,1.8,90.5,2.3,3.2,2.6*50 $GPGBS,111715.000,2.3,3.2,2.6,,,,*77 $GNGSA,A,3,22,03,17,04,21,01,31,19,,,,,1.5,0.9,1.1*28 $GNGSA,A,3,,,,,,,,,,,,,1.5,0.9,1.1*21 $GNGSA,A,3,333,312,319,304,,,,,,,,,1.5,0.9,1.1*2E $GNASA,A,2,333,312,319,304,,,,,,,,,5.6,3.5,4.4*21 $GNGSV,10,1,20,03,84,337,44,,,,,,,,,,,,*6D $GNGSV,10,2,20,312,69,309,37,,,,,,,,,,,,*57 $GNGSV,10,3,20,22,66,059,45,01,63,103,39,,,,,,,,*56

$GNGSV,10,4,20,319,59,165,37,333,54,121,42,,,,,,,*57
$GNGSV,10,5,20,17,53,285,41,21,43,116,41,04,36,175,43,19,33,310,30*50
$GNGSV,10,6,20,311,15,305,24,,,,,,,,,,,*55
$GNGSV,10,7,20,31,12,076,28,,,,,,,,,,,*69
$GNGSV,10,8,20,304,10,205,39,307,09,039,25,326,07,123,24,325,07,310,31*52
$GNGSV,10,9,20,14,07,250,40,09,07,198,36,32,05,035,30,,,,*66
$GNGSV,10,10,20,504,00,000,16,,,,,,,,,,,*63
$GPGLL,4714.63541,N,00130.77925,W,111715.000,A,D*43
$PSTMPRES,1.4,-0.5,-0.1,1.2,-0.5,0.3,-1.6,-2.1,0.2,2.4,-1.5,1.4,-1.8,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*2D
$PSTMVRES,0.0,-0.0,0.0,-0.0,0.0,0.0,0.0,-0.1,-0.0,0.1,-0.0,0.0,0.0,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,*27
$PSTMSAT,22,1,14297483.69,6887204.31,21479203.75,-972.67,2513.88,-139.59,-154186.40,-5.30,3.78,2.67,2,0.00,14,-2.38,0.00,0,0,0,0*47
$PSTMSAT,03,1,16519750.44,-1336986.53,20628932.34,-1116.33,2396.67,1054.17,-86299.67,0.55,3.50,2.45,-3,-0.15,14,-0.70,0.00,0,0,0,0*50
$PSTMSAT,17,1,13199852.31,-12947079.06,19503972.69,2378.20,110.37,-1570.50,151111.06,-3.34,4.08,3.06,1,0.00,14,-1.56,0.00,0,0,0,0*6C
$PSTMSAT,04,1,26518241.97,789773.06,1894065.44,-234.05,279.38,3159.68,-61248.02,-1.25,6.00,4.17,0,-2.08,14,-2.52,0.00,0,0,0,0*77
$PSTMSAT,14,1,12367199.62,-23451148.28,1014417.31,327.87,36.12,-3163.47,707.47,-2.37,9.05,17.94,-2,0.00,14,-3.52,0.00,0,0,0,0*7B
$PSTMSAT,21,1,20421510.97,14113271.44,10852400.81,610.62,1117.75,-2728.93,42727.95,-3.07,5.27,3.58,0,0.00,14,-3.90,0.00,0,0,0,0*70
$PSTMSAT,01,1,18650969.38,8629015.25,16739301.62,1058.49,1886.32,-2084.83,170558.68,1.53,3.95,2.73,-3,0.51,14,-1.40,0.00,0,0,0,0*45
$PSTMSAT,31,1,4159777.25,22987993.28,12084647.56,-1065.90,-1184.99,2646.74,-41827.46,-3.91,10.16,11.84,0,0.00,14,-4.11,0.00,0,0,0,0*77
$PSTMSAT,333,3,23357663.03,11429701.19,14137006.81,1071.97,941.80,-2532.71,-139408.28,-1.11,4.39,3.00,0,-1.88,2,-2.22,0.00,0,0,0,0*40
$PSTMSAT,312,3,15208992.38,-7039153.41,24394255.03,1695.69,1770.48,-545.65,1502544.50,-3.07,3.59,2.62,-5,-5.61,2,-1.80,0.00,0,0,0,0*65
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$PSTMSAT,32,1,-8940968.78,14800237.88,20227602.78,-2551.17,41.91,-1182.26,-31.99,0.13,9.39,25.02,-1,1.34,14,-3.80,0.00,0,0,0,0*5F
$PSTMSAT,304,3,25572310.66,-12083669.97,-8725750.50,845.40,-229.72,2795.29,-256547.78,-0.98,10.47,13.53,-2,-1.63,2,-5.20,0.00,0,0,0,0*60
$PSTMSAT,09,1,23612876.94,-8174715.00,-9109368.78,1164.07,189.25,2866.49,-108187.11,0.41,11.52,18.11,0,0.18,14,-5.42,0.00,0,0,0,0*6A
$PSTMSAT,326,1,18418850.31,22922330.22,-3327019.94,-125.56,-339.95,-3039.30,404410.93,2.02,12.98,19.38,-13,3.45,2,-6.51,0.00,0,0,0,0*5E
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$PSTMGNSSINTEGRITY,0,0,0.0,0.0,0.0,0,0.0,0.0,0.0*48
$PSTMCPU,46.20,0,261*5B

	$PSTMTG,2175,127054.00000000,0,2926705164,9,-44880.9079,a000,22541,0,0,2175,127054.00000000,10,126,-5.560,18441,18,975849459,1064466,664563133*6F $PSTMTS,2,22,20918002.562,-46289.21,-109924837.149,87171,45,1063791,203,1662,0,0,66,0,0,0,850*14 $PSTMTS,2,3,20209134.562,-44960.13,-106199720.446,21507,44,1063233,229,1672,0,0,83,0,0,0,850*22 $PSTMTS,2,17,21379443.188,-43990.40,-112349734.148,21635,41,1063209,127,1719,0,0,52,0,0,0,850*1C $PSTMTS,2,4,22432632.812,-41667.61,-117884289.239,21507,43,1063106,373,1722,0,0,35,0,0,0,850*22 $PSTMTS,2,14,24947507.375,-47687.31,-131100032.524,21635,40,1063097,254,1732,0,0,7,0,0,0,850*2C $PSTMTS,2,21,22307274.625,-46956.33,-117225516.847,21507,41,1062986,-53,1716,0,0,42,0,0,0,850*0E $PSTMTS,2,1,20500041.062,-46523.79,-107728433.215,21635,39,1062752,337,1708,0,0,63,0,0,0,850*26 $PSTMTS,2,31,24308351.812,-43248.63,-127741201.568,21507,28,1032722,70,3898,1691,0,11,0,0,0,850*1F $PSTMTS,2,311,25675006.562,-42191.28,-134923073.352,22819,24,1027715,-13,3756,16,0,-128,0,0,0,850*14 $PSTMTS,2,333,24324057.375,-46458.53,-127823775.752,21635,42,1031047,-6,2377,0,0,54,502598,542623,0,900*0B $PSTMTS,2,312,22068222.250,-43856.85,-115969290.549,87171,37,1030355,-51,3146,0,0,68,148458,163609,0,840*3E $PSTMTS,2,19,22282398.688,-42329.87,-117094744.987,21515,30,1029340,-48,3356,3,0,33,0,0,0,850*03 $PSTMTS,2,319,23836149.000,-43279.57,-125259809.552,21507,37,1054708,-15,3149,0,0,59,140267,135748,0,840*32 $PSTMTS,2,325,28330379.188,-46049.27,-148877129.224,22819,30,874446,31,3410,1,0,-128,0,0,0,850*3E $PSTMTS,2,32,25320233.438,-48220.63,-133058711.892,21511,30,7459,153,5277,0,0,4,0,0,0,850*15 $PSTMTS,2,304,28066157.750,-41721.99,-147488651.705,87171,40,920319,-12,2401,0,0,10,274103,276896,0,860*0B $PSTMTS,2,9,25130549.688,-40983.44,-132061937.000,21635,36,310993,160,1904,0,0,7,0,0,0,850*25 $PSTMTS,2,307,28157099.500,-47696.99,-147966556.911,22819,25,73986,-56,3801,5,0,-128,0,0,0,850*25 $PSTMTS,2,326,27752901.812,-47619.92,-145842486.412,22819,24,117408,-26,4295,19,0,-128,0,0,0,850*24 $PSTMCHMON,1,312,-1369233988,-1369233988,105355,596225,2024959,625864,131699,256383,228191,327741,290704,131516,0.014613*5D $PSTMCHMON,1,312,-1369029760,-1369029760,92050,530541,2200549,648337,87993,321118,361893,215138,312722,104622,-0.093757*7B $PSTMCHMON,1,312,-1368824695,-1368824695,82733,598010,2256022,641882,102643,270059,308055,242886,255441,104457,0.018819*6F $PSTMCHMON,1,312,-1368620467,-1368620467,98000,586379,2129229,645410,109745,246554,287838,210585,249916,97522,0.007094*55 $PSTMCHMON,1,312,-1368415402,-1368415402,92078,720148,2213237,602694,98626,276469,254915,305740,315972,104839,0.001463*55 $PSTMCHMON,2,304,-1369186279,-1369186279,112353,667699,2606996,638253,82313,338777,334158,324020,328725,98539,0.006943*55

	$PSTMCHMON,2,304,-1368981214,-1368981214,106242,677929,2395018,525052,104787,279705,269111,393749,354582,89284,0.030562*60 $PSTMCHMON,2,304,-1368776986,-1368776986,117789,733614,2272368,592715,86794,280373,259265,319577,271799,97773,-0.018865*73 $PSTMCHMON,2,304,-1368571921,-1368571921,105646,592494,2138968,592438,90484,231684,268655,289848,337021,113530,0.052877*6B $PSTMCHMON,2,304,-1368367693,-1368367693,85775,640650,2311174,479786,75260,296961,231575,393861,330140,128610,-0.052040*70 $PSTMCHMON,3,22,-1369151962,-1369151962,205794,16843042,70107820,16641942,142440,3200739,40110157,40931017,3698596,137236,-0.026134*79 $PSTMCHMON,3,22,-1368947734,-1368947734,348850,16824762,71799782,15846384,324490,2852832,40854755,41435206,2797861,315585,-0.015038*75 $PSTMCHMON,3,22,-1368742669,-1368742669,406197,15475867,71716830,16812008,293227,2506550,39247879,42637735,3321146,370443,0.006647*51 $PSTMCHMON,3,22,-1368538441,-1368538441,336639,15959716,70520326,16823793,113956,2664971,40470216,40983086,3559727,189579,-0.075681*7A $PSTMCHMON,3,22,-1368333376,-1368333376,315303,16537169,71405723,15795658,350134,2867847,40373384,40371963,2853043,283033,-0.029056*70 $PSTMRFI,127054.00000000,f,0,0,0,,,,,,,,,f,4095,4095,63,63,1,0,17447,16640,16640,16640,16640,16640*59 $PSTMVER,GNSSLIB_9.8.0.1_NMA_DFPVT_ARM*5B **Remark :** A PSTMNMAMACV message with the first parameter at 0 indicates that the satellite is authenticate.

3.1.9 Results analysis

For this first step, functional tests show that the Teseo V module and the IMU comply with the requirements defined during WP2 and provide the expected data.

WP5.3 will focus on system performance.

3.2 Telematics Control Unit

3.2.1 REQ_FUNC_TCUIN_06

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00014	
KPI	

REQ_FUNC_TCUIN_06	The OBU shall be able to receive and process GNSS PPP correction data for the supported satellite constellations.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.2 REQ_FUNC_TCUIN_07

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00015	
KPI	
REQ_FUNC_TCUIN_07	The OBU may be able to receive and process odometry measurements from a wheel tick sensor. (Note: Single wheel or multiple wheel ticks may be supported.)
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	

Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.3 REQ_FUNC_TCUIN_08

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00016	
KPI	
REQ_FUNC_TCUIN_08	The OBU may be able to receive and process angular measurements from a steering angle sensor.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	

Pass Condition	
Test criteria	

3.2.4 REQ_FUNC_TCUIN_09

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00017	
KPI	
REQ_FUNC_TCUIN_09	The OBU shall be able to receive and process information to update the HD map dynamically.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.5 REQ_FUNC_PERCIN_01

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00018	
KPI	

REQ_FUNC_PERCIN_01	The OBU shall be able to receive, and process point cloud data from at least one laser scanner.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.6 REQ_FUNC_PERCIN_02

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00019	
KPI	
REQ_FUNC_PERCIN_02	The OBU shall be able to receive and process images from at least one camera.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	

1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.7 REQ_FUNC_PERCIN_03

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00020	
KPI	
REQ_FUNC_PERCIN_03	The OBU may be able to receive and process radar data.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	

Test criteria	

3.2.8 REQ_FUNC_INT_02

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00021	
KPI	
REQ_FUNC_INT_02	The OBU shall be able to process linear acceleration and angular rate measurements from the 6DOF inertial sensor.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.9 REQ_FUNC_INT_03

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00022	
KPI	

REQ_FUNC_INT_03	The OBU shall use an HD map to improve localization.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.10 REQ_FUNC_OUT_01

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00023	
KPI	
REQ_FUNC_OUT_01	The OBU shall provide the vehicle position.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	

Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.11 REQ_FUNC_OUT_02

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00024	
KPI	
REQ_FUNC_OUT_02	The OBU shall provide the vehicle velocity.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	

Pass Condition	
Test criteria	

3.2.12 REQ_FUNC_OUT_03

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00025	
KPI	
REQ_FUNC_OUT_03	The OBU may provide the linear acceleration of the vehicle.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.13 REQ_FUNC_OUT_04

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00026	

KPI	
REQ_FUNC_OUT_04	The OBU shall provide the vehicle heading.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.14 REQ_FUNC_OUT_05

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00027	
KPI	
REQ_FUNC_OUT_05	The OBU shall provide the angular speed of the vehicle.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	

Elements of the ODD	
Test Procedure	
1	
2	
3	
4	
5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.15 REQ_FUNC_OUT_06

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00028	
KPI	
REQ_FUNC_OUT_06	The OBU may provide the angular acceleration of the vehicle.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
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4	
5	
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7	
8	

Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.16 REQ_FUNC_OUT_07

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00029	
KPI	
REQ_FUNC_OUT_07	The OBU may provide the UTC time.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
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8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.17 REQ_FUNC_OUT_08

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00030	
KPI	
REQ_FUNC_OUT_08	The OBU shall provide the position integrity including horizontal and vertical protection levels.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
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8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.18 REQ_FUNC_OUT_09

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00031	
KPI	
REQ_FUNC_OUT_09	The OBU shall provide the estimated position error.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	

Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
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5	
6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.19 REQ_FUNC_OUT_10

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00032	
KPI	
REQ_FUNC_OUT_10	The OBU shall support the ADS in monitoring its ODD by providing necessary information.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
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8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.20 REQ_FUNC_OUT_11

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00033	
KPI	
REQ_FUNC_OUT_11	The OBU shall provide its outputs at an output rate of at least 33.3 Hz. (Note: The ideal output rate is 100 Hz.)
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
2	
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6	
7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.2.21 REQ_FUNC_SEC_02

Table to be adapted according to the test, an example is given in the D5.1 document

Conformity Test Procedures (CTP)	
Number	**Description:**
CTP 00034	
KPI	
REQ_FUNC_SEC_02	The OBU shall implement authentication mechanisms to prevent unauthorized firmware update and OBU configuration.
Test Objective	
Test Context	
Metrics	
Reference(s)	
Test description	
Testing Framework Mode	
Toolchain	
Elements of the ODD	
Test Procedure	
1	
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7	
8	
Required Inputs	
Required Output	
Test Analysis	
Pass Condition	
Test criteria	

3.3 Localization Unit

3.3.1 Introduction

This chapter presents validation tests and functional validation results of the different components of the Localization Unit.

The Localization Unit architecture includes several components. Where each component is designed to fill one main function required to satisfy the functional specifications of the Localization Unit.

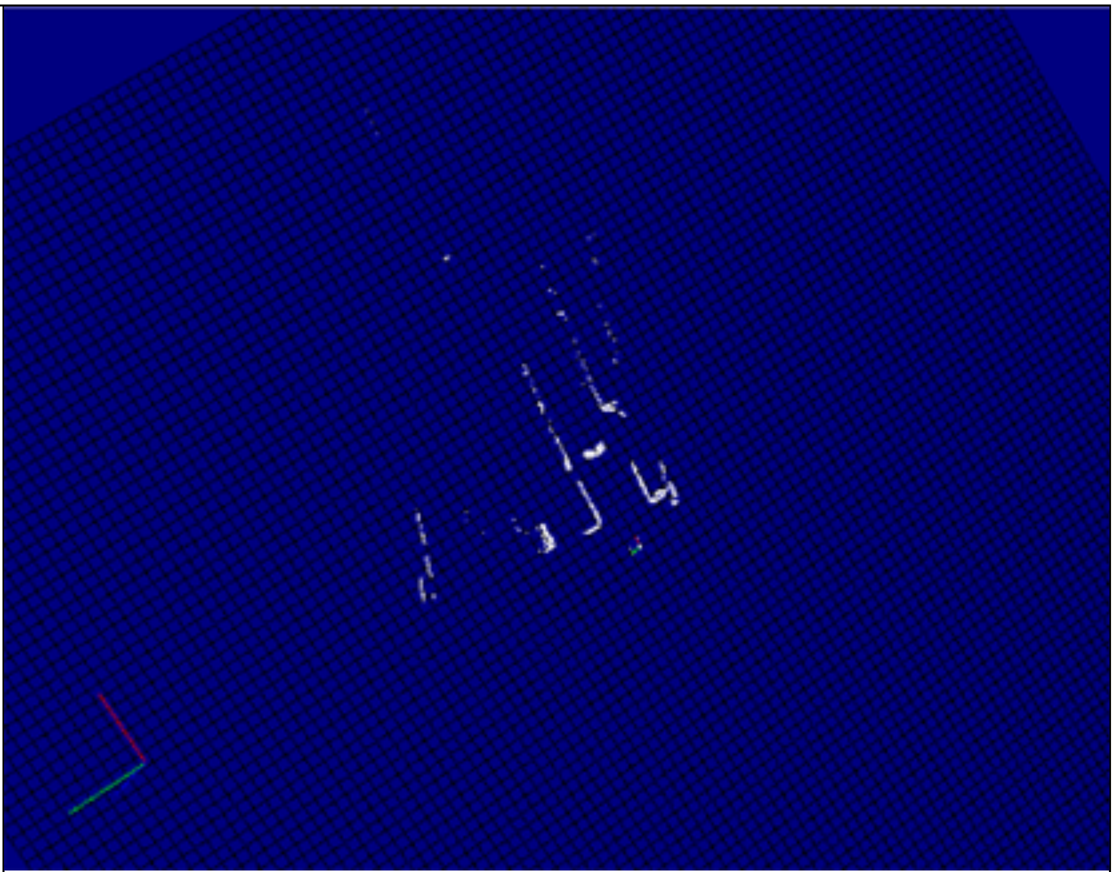
During the first project iteration, three components of the Localization Unit were developed and integrated. Namely these components are:

1. rtmaps_point_motion_classification
2. rtmaps_map_matching_pf
3. rtmaps_pose_estimation

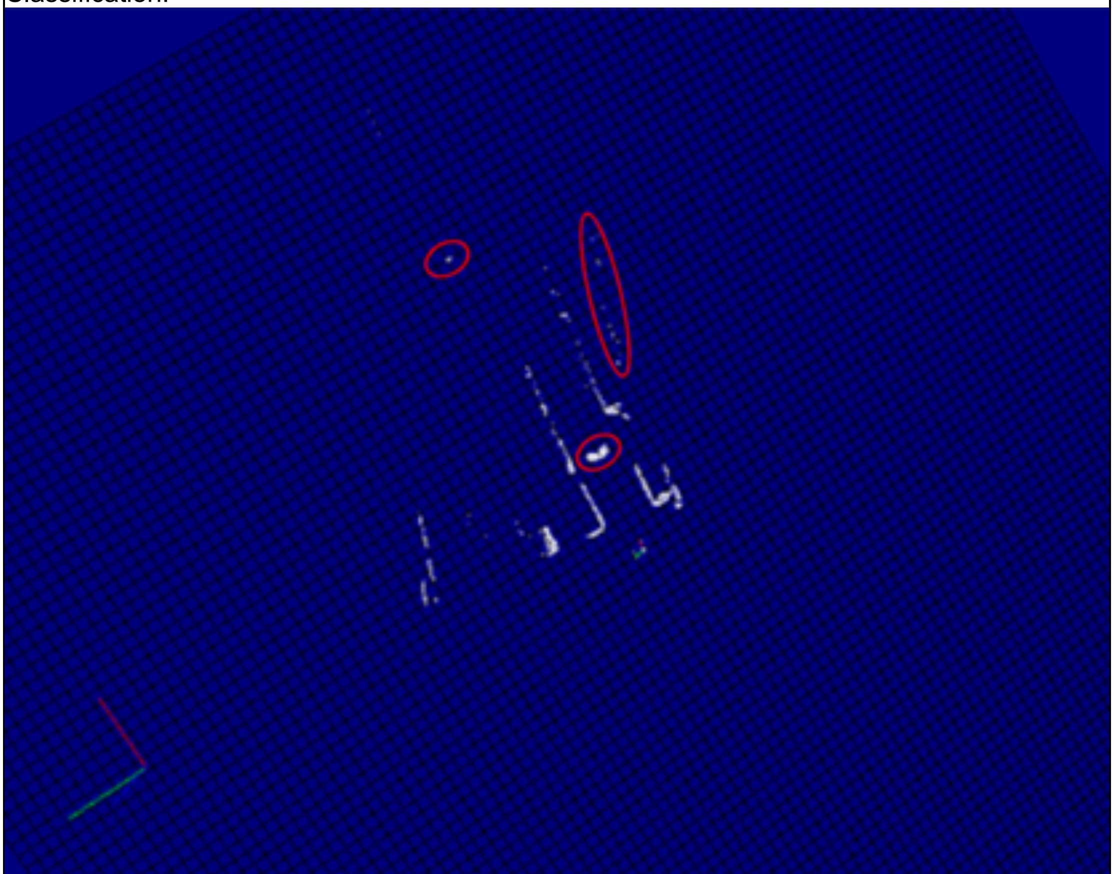
3.3.2 Tests and results

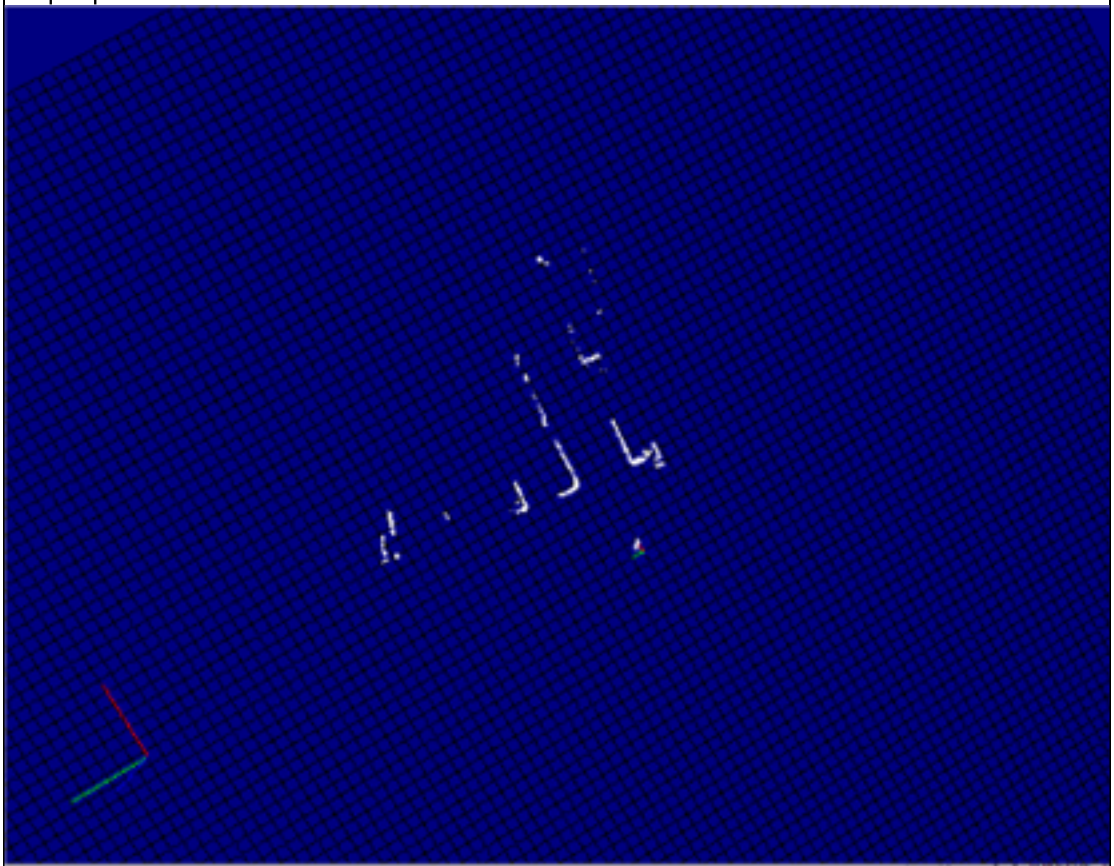
Hereafter we describe the functional test for each component and the obtained results.

Test name	**Functional validation of rtmaps_point_motion_classification**
Test id	REQ_FUNC_PERCIN_01
Test goal	Verify if the component is able to filter out the points that hit on moving objects from the laser point-cloud.
Test description	We test that the algorithm is capable of removing the points from the point-cloud that belongs to moving objects or to ground. Moving objects can be cars, cyclists etc. Input of the algorithm are “point-cloud” and “motion”. Output is the filtered “point-cloud”.
Prerequisites	RTMaps studio installed Valid rtmaps license Valid Valeo SW License
Means of verification	Comparing the input and the outputted point-clouds.
Expected result	Points that belongs to moving objects such as cars or points that hit the ground to be filtered out from the point-cloud at the output of the component
Obtained result (Pass/Fail)	The output point-cloud is filtered from points that belong to the moving cars and from points that hit the ground. Pass
Evidences	Input point cloud:

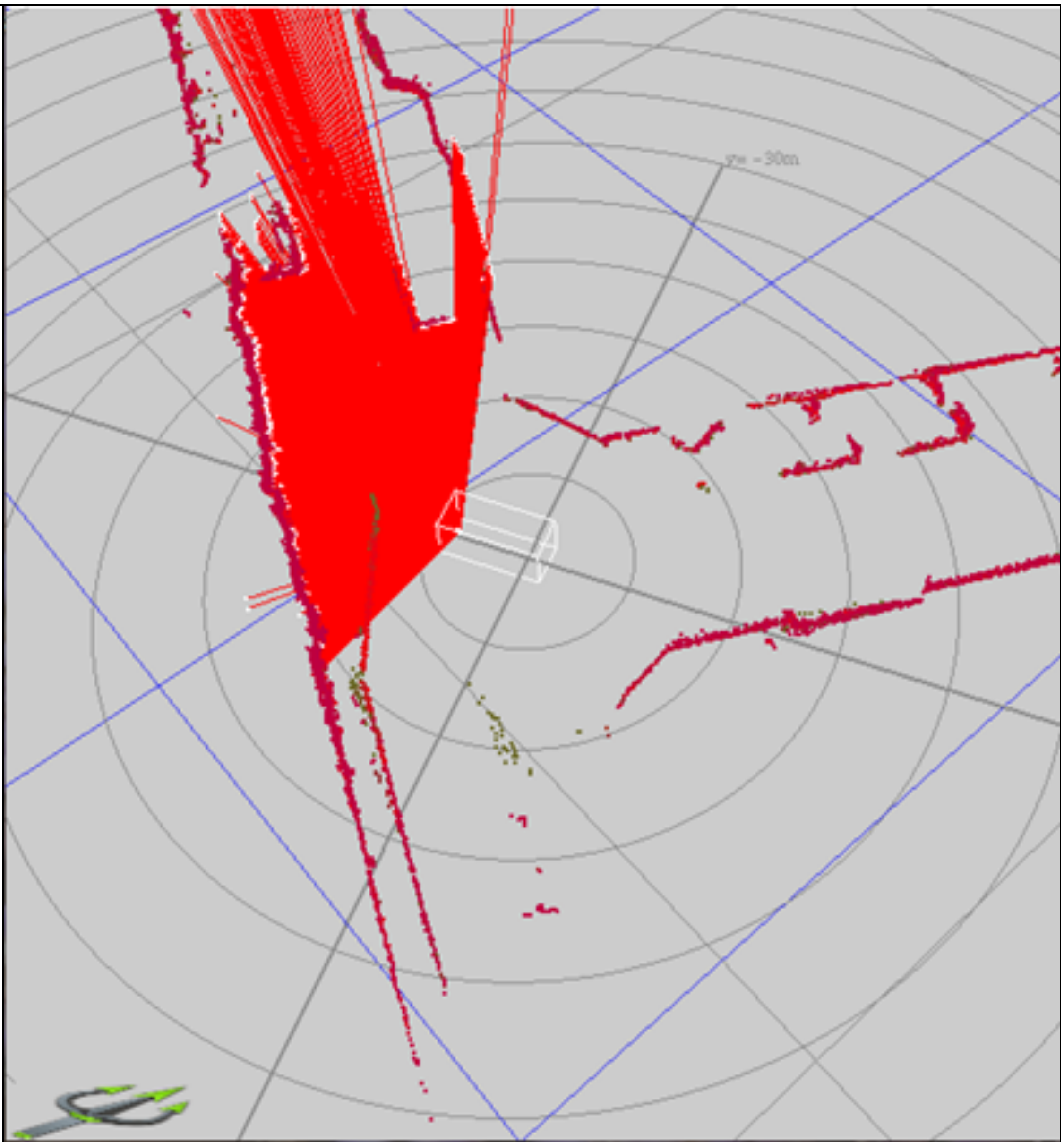


Classification:

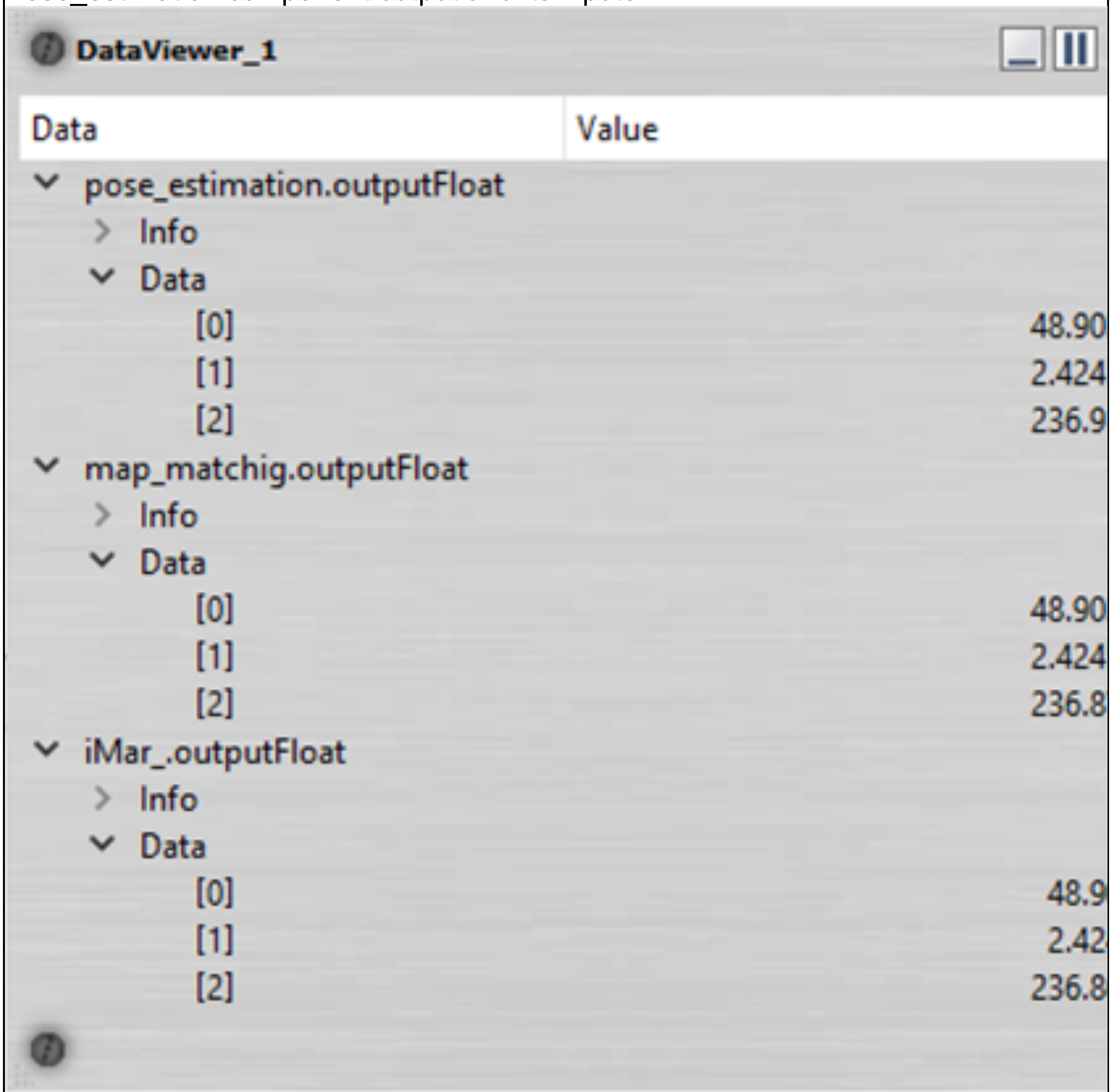


	Output point cloud: 

Test name	**Functional validation of rtmaps_map_matching_pf**
Test id	REQ_FUNC_PERCIN_01
Test goal	Verify if the component is able to: • Perform matching correctly of the laser point-cloud to the environment map. • Provide an estimated LLA position and orientation at the output.
Test description	This functional test aims to verify the proper operation of the matching algorithm. The matching algorithm requires three inputs: 1. Gnss reading 2. Motion reading and 3. Laser point-cloud reading.[Saut de retour à la ligne]Additionally the environment map must be provided together with configuration parameters of the component.
Prerequisites	RTMaps studio installed Valid rtmaps license Valid Valeo SW License
Means of verification	Verifying visually that the laser observation is properly matched to the point-cloud map.
Expected result	The laser point cloud to be properly matched to the point-cloud map and the vehicle position is projed on the visualization.
Obtained result (Pass/Fail)	Matching operates properly. Pass

Evidences	

Test name	Functional validation of rtmaps_pose_estimation
Test id	REQ_FUNC_OUT_01 REQ_FUNC_OUT_04 REQ_FUNC_OUT_09 REQ_FUNC_OUT_11
Test goal	Verify that the fusion component takes into account the different inputs to provide an estimation of the vehicle position and orientation. The pose_estimation provides the vehicle position, orientation and estimation errors at an update rate of 100 sample/sec.
Test description	The fusion algorithm takes as input Gnss readings from multiple sources to provide a unique Gnss estimation at the output. In this test we use Gnss readings from two sources: 1. iMariTrace and 2. Map_matching_pf. The output should be Gnss estimation that takes into account readings from both sources.
Prerequisites	RTMaps studio installed Valid rtmaps license Valid Valeo SW License

Means of verification	Compare the fusion output to the Gnss readings from inputs.
Expected result	We expect to have an estimate that is very close but different from inputs readings.
Obtained result (Pass/Fail)	Pose_estimation estimate is very close to inputs but yet slightly different… Pass
Evidences	Pose_estimation component output and its inputs:  rtmaps_pose_estimation outputs:


DataViewer_3
Data
Value
InterfacesParser_1.o_status
Info
Data
[0]
1
InterfacesParser_1.o_timestamp
Info
Data
[0]
72754
InterfacesParser_1.o_latitude
Info
Data
[0]
48.9017
InterfacesParser_1.o_longitude
Info
Data
[0]
2.42254
InterfacesParser_1.o_altitude
Info
Data
[0]
0
InterfacesParser_1.o_heading
Info
Data
[0]
63.3678
InterfacesParser_1.o_latitude_sigma
Info
Data
[0]
1.33448
InterfacesParser_1.o_longitude_sigma
Info
Data
[0]
1.82764
InterfacesParser_1.o_altitude_sigma
Info
Data
[0]
0
InterfacesParser_1.o_heading_sigma
Info
Data
[0]
0.648845
InterfacesParser_1.o_a_sigma
Info
Data
[0]
0
InterfacesParser_1.o_b_sigma
Info
Data
[0]
0
InterfacesParser_1.o_quality
Info
Data
[0]
9
InterfacesParser_1.o_number_of_satellites
Info
Data
[0]
10

	The output update rate
	`Info: component map_matching: 100 samples/sec. Bandwidth: 10200 bytes`
	`Info: component iMar: 100 samples/sec. Bandwidth: 2400 bytes/sec.`
	`Info: component pose_estimaiton: 101 samples/sec. Bandwidth: 10302 by`

3.3.3 Conclusion

According to the functional tests conducted and the results obtained we were able to verify the good operation of the different components of the Localization Unit Release 1.1.

This release integrates three main components. Namely:
1. rtmaps_point_motion_classification 2. rtmaps_map_matching_pf 3. rtmaps_pose_estimation.
These components run inside the rtmaps studio environment and they were tested using real data acquired on test vehicles.
Functional validation tests show that each of these components fulfill its functional requirements. Each component reads correctly its inputs and provides expected outputs in real time. The accuracy and precision of the outputs is subject of performance validation (WP5.3) during the second year of the project.

3.4 Compliance matrix

Req ID	Tests ID	Compliant (Yes/No/Partially)
	TCU INPUT	
REQ_FUNC_TCUIN_01	**CTP 00001**	**Yes** (Teseo V module level)
REQ_FUNC_TCUIN_02	**CTP 00001**	**Yes** (Teseo V module level)
REQ_FUNC_TCUIN_03	**CTP 00002**	**Yes** (Teseo V module level)
REQ_FUNC_TCUIN_04	**CTP 00003**	**Yes** (Teseo V module level)
REQ_FUNC_TCUIN_05	**CTP 00004**	**Yes** (Teseo V module level)
REQ_FUNC_TCUIN_06		
REQ_FUNC_TCUIN_07		
REQ_FUNC_TCUIN_08		
REQ_FUNC_TCUIN_09		
	Perception inputs	

REQ_FUNC_PERCIN_01	**CTP 000XX, CTP 000XX**	
REQ_FUNC_PERCIN_02		
REQ_FUNC_PERCIN_03		
Internal requirements of the ACCURATE OBU		
REQ_FUNC_INT_01	**CTP 00005**	**Partially (1)**
REQ_FUNC_INT_02		
REQ_FUNC_INT_03		
REQ_FUNC_OUT_01	**CTP 000XX**	
REQ_FUNC_OUT_02		
REQ_FUNC_OUT_03		
REQ_FUNC_OUT_04	**CTP 000XX**	
REQ_FUNC_OUT_05		
REQ_FUNC_OUT_06		
REQ_FUNC_OUT_07		
REQ_FUNC_OUT_08		
REQ_FUNC_OUT_09	**CTP 000XX**	
REQ_FUNC_OUT_10		
REQ_FUNC_OUT_11	**CTP 000XX**	
Security requirements of the ACCURATE OBU		
REQ_FUNC_SEC_01	**CTP 00006**	**Yes** (Teseo V module level)
REQ_FUNC_SEC_02		
REQ_FUNC_SEC_03	**CTP 00008, CTP 00009, CTP 00010, CTP 00011, CTP 00012**	**Partially (2)**
REQ_FUNC_SEC_04	**CTP 00013**	**Yes** (Teseo V module level)

1- The IMU is not yet tested in the final context (integrated with the Vulcano board)

2- The PVT Cross Check countermeasure is not yet implemented

4 Testing and Validation of ACCURATE as part of Perception and Decision System for AD Functions

4.1 Introduction

This section describes the tests prepared to validate functional and performance features of the developed Local Dynamic Map (LDM) component as the main consumer of the ACCURATE OBU output.

The tests related to interfaces and performance will be reported in the second cycle of development once the complete solution is integrated. As in the D2.1 the requirements and specification are only devoted to describe the ACCURATE OBU and not the components that will consume its output, the tests and the results of the LDM are not going to be compared against any requirements

The LDM component is a complex entity with three main sub-components:

- LDM Python API: library to manage access to the database
- LDM Neo4j database: storage of static and dynamic information
- LDM RTMaps Python script: example application in RTMaps that uses the LDM Python API to access the Neo4j database

The functional tests focus on the following features:

- Test LDM to receive correctly positioning information
- Test LDM to correctly load OSM (Open Street Maps) map
- Test LDM to correctly load VCD (Video Content Description) content
- Test LDM to correctly load KITTI sequence
- Test LDM to correctly load SUMO simulated data
- Test LDM to correctly return information about surrounding dynamic objects

Performance-related tests focus on the following aspects:

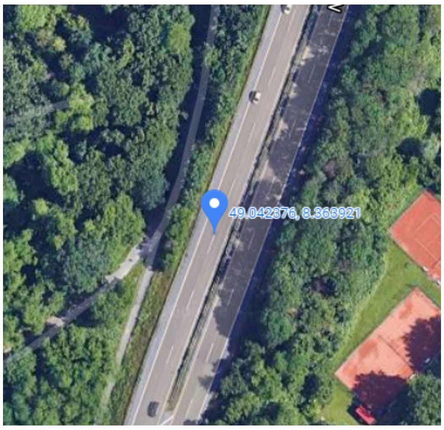
- Test loading time of OSM map (time and map size)
- Test conversion time RTMaps Real Object into VCD format
- Test loading time of dynamic objects (time and number of objects)
- Test retrieve time from database (e.g. query objects closer than 50 meters, time and number of objects)

Next sections describe the tests and the achieved results.

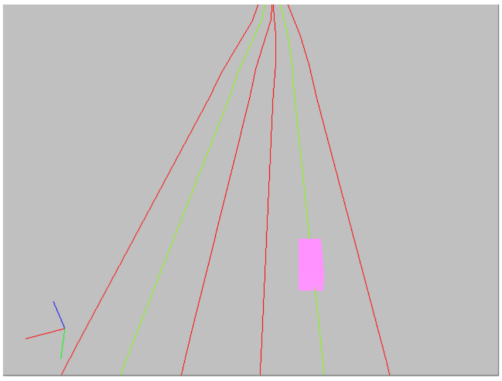
4.2 Test description and results

4.2.1 Functional tests

Test name	**Reception of positioning information**

Test id	LDM-FUNC-001
Test goal	Verify the LDM database can receive the geo-location of the ego-vehicle
Test description	A feed of geo-location information is produced (format undefined) and the LDM Python API is used to add the ego geo-location information into the database The LDM Neo4j database is visualized after adding the geo-location information to verify the content exists
Pre-requisites	Neo4j installation is ready (see [https://neo4j.com/)](https://neo4j.com/) Feed of geo-location information Neo4j browser
Means of verification	Use the Neo4j browser to visualize the ego-vehicle nodes and properties
Expected result	The LDM Neo4j can receive, via the LDM Python API geo-location information of the ego-vehicle
Obtained result (Pass/Fail)	The LDM Neo4j can receive, via the LDM Python API geo-location information of the ego-vehicle **Passed**
Evidences	Sample trace of GPS entries  Loaded nodes in Neo4j

Visualization in RTMaps



Test name	Load OSM (Open Street Map) information
Test id	LDM-FUNC-002
Test goal	Verify the LDM database can be populated with L1 information from a standard-definition digital map
Test description	A Python script loads the OSM map into the Neo4j database The LDM Neo4j database is visualized after adding the map to verify the content exists
Pre-requisites	Neo4j installation is ready OSM file is ready Loading script (see https://github.com/neo4j-contrib/osm) Neo4j browser

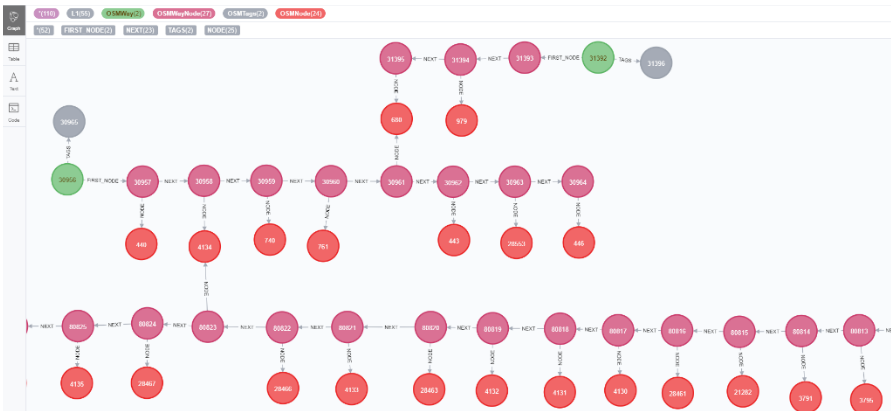
<table>
<tr><td>Means of verification</td><td>Use the Neo4j browser to visualize the OSM nodes exist in the database</td></tr>
<tr><td>Expected result</td><td>All OSM nodes exist in the LDM Neo4j database with L1 label on them</td></tr>
<tr><td>Obtained result (Pass/Fail)</td><td>All OSM nodes exist in the LDM Neo4j database with L1 label on them

Passed</td></tr>
<tr><td>Evidences</td><td>Sample OSM node loaded in Neo4j

<pre>
$ MATCH (n:OSM) RETURN n as osm_metadata LIMIT 25

Graph | Table | Text

"osm_metadata"
{"attribution":"http://www.openstreetmap.org/copyright","name":"C:\Users\iurbieta\osm-master\samples\map.osm","license":"http://opendatacommons.org/licenses/odbl/1-0/","generator":"CGImap 0.8.5 (1734536 spike-06.openstreetmap.org)","copyright":"OpenStreetMap and contributors","version":"0.6"}
</pre>
Visualization of node grid in Neo4j browser

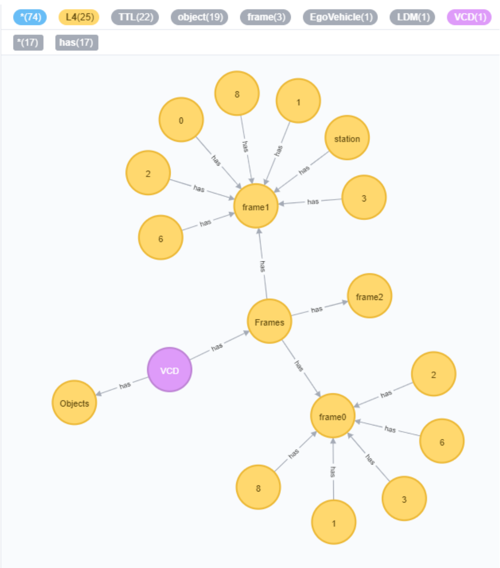


<pre>
$ MATCH (n) RETURN count(n) as osm_nodes_count
</pre>
<table><tr><th>osm_nodes_count</th></tr><tr><td>81255</td></tr></table>
<pre>
$ MATCH (m:L1) RETURN count(m) as osm_nodes_labelled_count
</pre>
<table><tr><th>osm_nodes_labelled_count</th></tr><tr><td>81255</td></tr></table>
</td></tr>
</table>

Test name	**Load VCD content with dynamic (L4) object information**
Test id	LDM-FUNC-003
Test goal	Verify the LDM Python API can read JSON payloads following VCD (Video Content Description) format with dynamic (L4) object information
Test description	A VCD JSON file or payload containing dynamic object information is loaded in a Python script which then calls the LDM Python API to load the content into the LDM Neo4j database The LDM Neo4j database is visualized after adding the objects to verify the content exists
Pre-requisites	Neo4j installation is ready VCD file is ready (see https://pypi.org/project/vcd/) Loading script Neo4j browser
Means of verification	Use the Neo4j browser to visualize the dynamic objects exist in the database
Expected result	All dynamic objects exist in the LDM Neo4j database with L4 label on them
Obtained result (Pass/Fail)	All dynamic objects exist in the LDM Neo4j database with L4 label on them **Passed**
Evidences	Sample VCD JSON payload

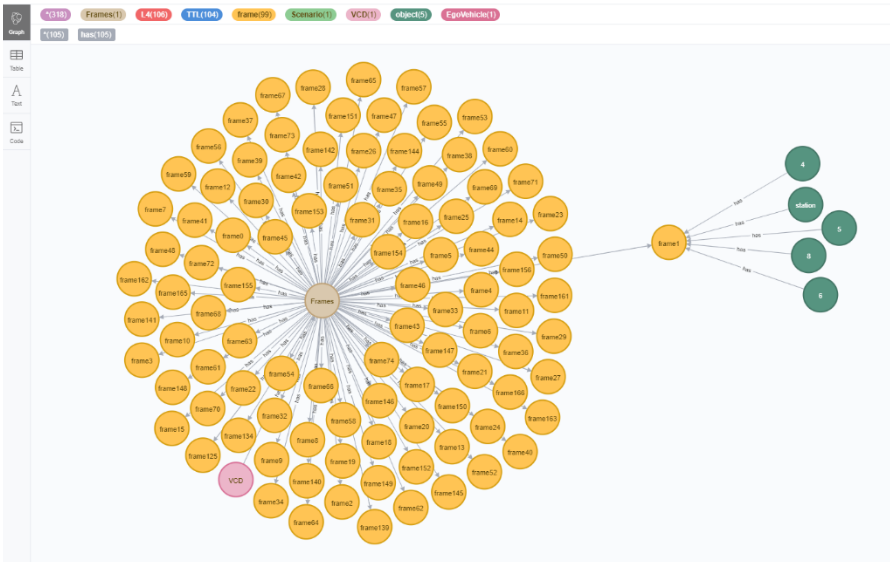
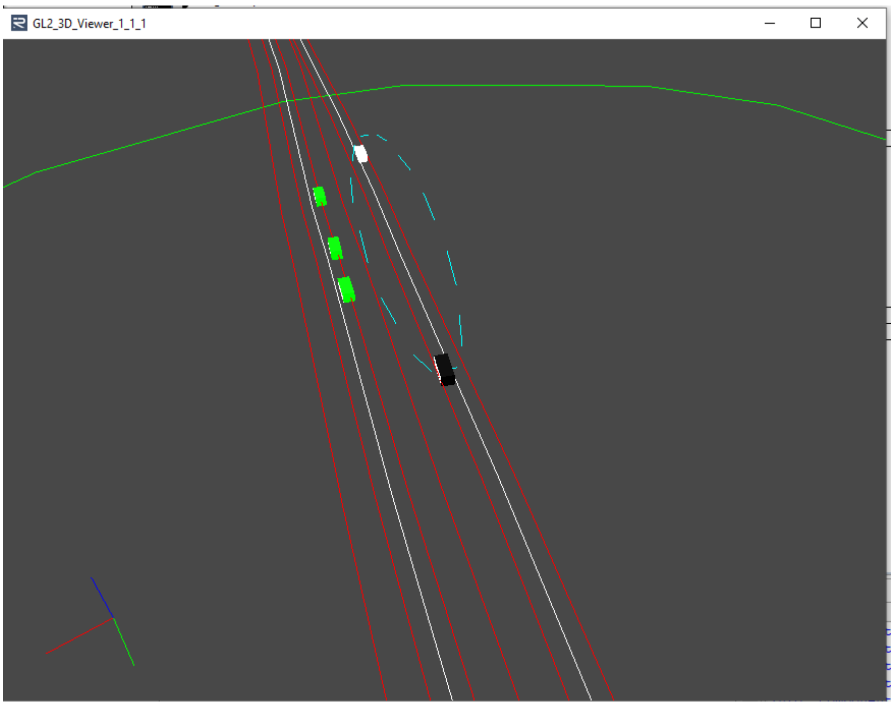
```json
{
    "vcd": {
        "metadata": {
            "schema_version": "4.3.0",
            "type": "CPM message",
            "protocolVersion": 1,
            "messageID": 14,
            "stationID": 0
        },
        "frames": {
            "0": {
                "frame_properties": {
                    "timestamp": "1000"
                }
            }
        },
        "coordinate_systems": {
            "geo_wgs84": {
                "type": "geo_wgs84",
                "parent": "",
                "pose_wrt_parent": [],
                "children": []
            }
        },
        "objects": {
            "999": {
                "name": "station",
                "type": "passengerCar",
                "object_data": {
                    "num": [
                        {
                            "name": "latitude",
                            "val": 43.314805
                        },
                        {
                            "name": "longitude",
                            "val": -2.005766
                        },
                        {
                            "name": "altitude",
                            "val": 10
                        },
                        {
                            "name": "heading",
                            "val": 900
                        },
                        {
                            "name": "speedValue",
                            "val": 10
                        },
                        {
                            "name": "speedConfidence",
                            "val": 1
                        },
```


Visualization in Neo4j browser

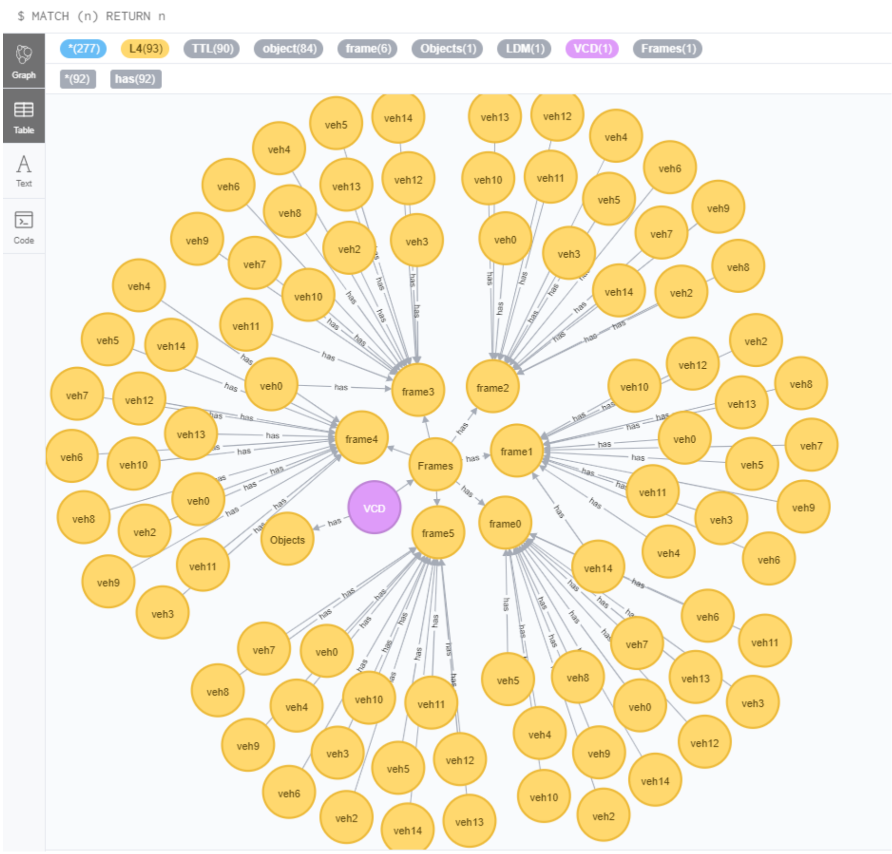


	{ "altitude": "28", "yawAngle": "1809", "latitude": "49.04220790680143", "type": "Perceived object", "ttl": 1630312178.0964482, "classificationSubType_0": "7", "verticalObjectDimension": "16", "uid": "1", "classificationType_0": "vehicle", "timeOfMeasurement": "100", "name": "1", "planarObjectDimension1": "18", "planarObjectDimension2": "40", "longitude": "8.363960931877813", "frame": 0, "timestamp": 1630312158.0964482 }

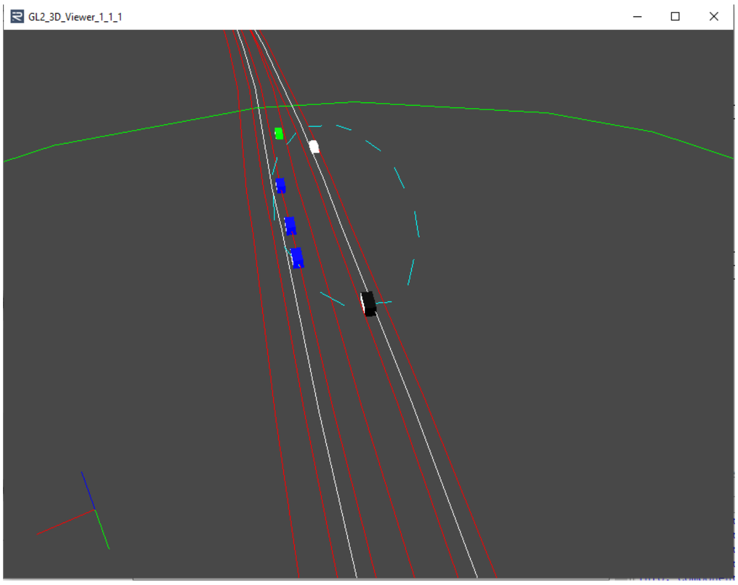
Test name	**Load KITTI dataset content**
Test id	LDM-FUNC-004
Test goal	Verify the LDM database can read rich information from a recorded dataset including geo-location of the ego-vehicle and dynamic objects of a real scene
Test description	A KITTI scene is loaded (e.g. with RTMaps reader) and GPS and dynamic objects are read and fed into the LDM The LDM Neo4j database is visualized after adding the objects to verify the content exists
Pre-requisites	Neo4j installation is ready KITTI sequence file is ready LDM Python API Loading script (e.g. using RTMaps and Python) Neo4j browser
Means of verification	Use the Neo4j browser to visualize the dynamic objects exist in the database

	Additionally, an OSM map of the corresponding area can be loaded as well to validate the L1 elements are loaded correctly
Expected result	All dynamic objects exist in the LDM Neo4j database with L4 label on them
Obtained result (Pass/Fail)	All dynamic objects exist in the LDM Neo4j database with L4 label on them **Passed**
Evidences	Visualization of KITTI scene in Neo4j browser  Visualization of scene in RTMaps 

Test name	**Load SUMO dataset content**
Test id	LDM-FUNC-005
Test goal	Verify the LDM database can read large volumes of information from a simulated domain (SUMO)
Test description	A SUMO simulated data payload is produced and loaded into the LDM database The LDM Neo4j database is visualized after adding the objects to verify the content exists
Pre-requisites	Neo4j installation is ready SUMO payload is available as file or produced online LDM Python API is ready Loading script (e.g. using RTMaps and Python) Neo4j browser
Means of verification	Use the Neo4j browser to visualize the dynamic objects exist in the database Additionally, an OSM map of the simulated area can be loaded as well to validate the L1 elements are loaded correctly
Expected result	All dynamic objects exist in the LDM Neo4j database with L4 label on them
Obtained result (Pass/Fail)	All dynamic objects exist in the LDM Neo4j database with L4 label on them **Passed**
Evidences	Visualization of scene in Neo4j browser

Test name	Return information about surrounding dynamic objects
Test id	LDM-FUNC-006
Test goal	Verify the LDM component can be used to retrieve live information about dynamic objects, such as in a Vehicle Discovery Service (VDS) which asks the LDM about moving objects within a certain distance threshold
Test description	A living LDM database is created and populated with dynamic information (e.g. using SUMO or KITTI loaders previously tested). Then, the LDM Python API is used to create queries that retrieve information about vehicles around the ego-vehicle, sequentially through time.
Pre-requisites	Neo4j installation is ready LDM Python API is ready A scene with dynamic objects is ready and loaded into the LDM database

	A script that creates queries and uses the LDM Python API Neo4j browser
Means of verification	Use the Neo4j browser to visualize the dynamic objects exist in the database Additionally, the script can be wrapped in RTMaps to create an online VDS application
Expected result	The LDM returns timely information about surrounding vehicles
Obtained result (Pass/Fail)	The LDM returns timely information about surrounding vehicles, the parameters of the VDS can be updated real-time and the response time in the 3D Viewer is instantaneous. **Passed**
Evidences	Visualization of returned results in RTMaps 

4.2.2 Performance tests

The following tests have been carried out using regular computers at the laboratory. Their specifications are the following:

- CPU1: Intel i5-9400F @ 2.90 GHz, 8 GB RAM
- CPU2: Intel i5-7400 @ 3.00 GHz, 8 GB RAM

Test name	**Loading time of OSM map**
Test id	LDM-PERF-001
Test goal	Study the necessary time needed to load an OSM file into the LDM map
Test description	An OSM file is available either offline or downloaded through an internet service. Then, the OSM file is processed and loaded into the LDM database. The time needed is measured to understand how much loading time is needed when entering into a new city or area of interest previously not available in the database.
Pre-requisites	Neo4j installation is ready OSM file ready Neo4j browser
Means of verification	Use the windows command line and Neo4j browser to measure the loading time
Expected result	The loading time depends on the size of the OSM file Road-only nodes of a city with 10000 nodes shall be loaded in less than 10 seconds
Obtained result	81.255 nodes loaded in 56.945 s NOTE: we have observed the total time needed to load the map does not decrease if the map is filtered and has less nodes. Further testing improvements will investigate the relation of loading time with map volume

Evidences	Using CPU2.
	`command took 0:0:55.59 (55.59s total)`
	`$ MATCH (n) SET n:L1`
	Table Added 81255 labels, completed after 1355 ms.

Test name	**Conversion time of RTMaps RealObjects into VCD format**
Test id	LDM-PERF-002

Test goal	Study the overhead to convert from RTMaps RealObject format (potentially the format of the perceived objects of an ADAS/AD function) into the VCD format (input format used by the LDM system).
Test description	An RTMaps diagram is prepared where perceived objects are loaded or computed (e.g. real time from a perception component or via playback recording) and injected into an RTMaps Python script which reads the data and uses the VCD Python API to convert into VCD format previously to calling the LDM Python API to add the data into the database
Pre-requisites	Neo4j installation is ready RTMaps is available RTMaps RealObjects are produced (e.g. from RTMaps KITTI player) RTMaps Python script to convert into VCD
Means of verification	Use the Python script to measure the latency of the converter
Expected result	The conversion time depends on the amount of dynamic objects in the scene Expected value is less than 1 ms for scenes with up to 10 objects
Obtained result	**Not passed** `Average time for 10 RealObjects is 9.963017399028196 ms`

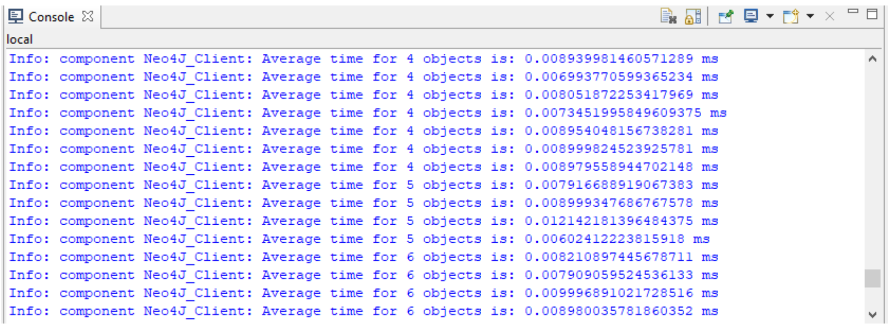
Evidences	Using CPU1.
	
	`KITTI2VCD: Time for 6 RealObjects is 3.998994827270508 ms`
	`KITTI2VCD: Time for 6 RealObjects is 5.991697311401367 ms`
	`KITTI2VCD: Time for 7 RealObjects is 3.998994827270508 ms`
	`KITTI2VCD: Time for 7 RealObjects is 4.999876022338867 ms`
	`KITTI2VCD: Time for 7 RealObjects is 5.00178337097168 ms`
	`KITTI2VCD: Time for 7 RealObjects is 9.008169174194336 ms`
	`KITTI2VCD: Time for 7 RealObjects is 6.999492645263672 ms`
	`KITTI2VCD: Time for 6 RealObjects is 3.9985179901123047 ms`
	`KITTI2VCD: Time for 6 RealObjects is 4.997730255126953 ms`
	`KITTI2VCD: Time for 6 RealObjects is 3.9980411529541016 ms`
	`KITTI2VCD: Time for 6 RealObjects is 4.998445510864258 ms`
	`KITTI2VCD: Time for 6 RealObjects is 4.001617431640625 ms`
	`KITTI2VCD: Time for 5 RealObjects is 3.0012130737304688 ms`

Test name	**Loading time of dynamic objects**
Test id	LDM-PERF-003

Test goal	Study the overhead to inject dynamic objects in VCD format into the LDM database
Test description	Following test LDM-PERF-002, dynamic data is prepared and converted into VCD. Then, it is added to the LDM database via the LDM Python API. The latency of the addition callback is measured.
Pre-requisites	Neo4j installation is ready A VCD object is ready at the Python script LDM Python API is ready
Means of verification	Use the Python script to measure the latency of the callback
Expected result	The conversion time depends on the amount of dynamic objects in the scene Expected value is less than 10 ms for scenes with up to 10 objects
Obtained result	**Not passed** `Average time for uploading a scene is 809.5396206929133 ms`

Evidences	Using CPU1.
	`Time for uploading a scene is 715.6856060028076 ms`
	`Time for uploading a scene is 715.9719467163086 ms`
	`Time for uploading a scene is 895.9214687347412 ms`
	`Time for uploading a scene is 701.0016441345215 ms`
	`Time for uploading a scene is 892.0009136199951 ms`
	`Time for uploading a scene is 877.9795169830322 ms`
	`Time for uploading a scene is 814.9404525756836 ms`
	`Time for uploading a scene is 777.3046493530273 ms`

Test name	**Response time from database**
Test id	LDM-PERF-004
Test goal	Study the response time for querying about nearby objects
Test description	Measure the latency of the database responding via the LDM Python API to queries asking for retrieving information about objects closer than a certain distance threshold to the ego-vehicle (e.g. 50 meters)
Pre-requisites	Neo4j installation is ready

	An LDM database is ready and populated LDM Python API is ready Script to prepare query and measure time
Means of verification	Use the Python script to measure the latency of the callback
Expected result	The conversion time depends on the amount of dynamic objects in the scene Expected value is less than 10 ms for scenes with up to 10 objects
Obtained result	**Passed**
Evidences	Using CPU1. 

4.3 Discussion and conclusion

The tests on the implementation of the LDM have revealed that this version is functional in the sense it does provide the expected functionality in terms of input and output interfaces.

The tests have focused on the LDM Python API and the LDM database, and thus the RTMaps-related interfacing and integration with the ACCURATE OBU is still pending and subject to further analysis.

Some of the presented tests have shown that the LDM in its current form can be used in RTMaps, using the RTMaps Python bridge. As a consequence, it is expected that the interoperability requirements with the ACCURATE OBU can be met without major problems.

In terms of performance, this version of the LDM is yet not ready for real-time operation in a vehicle. This implementation has used Python as main driver for rapid prototyping and development, reaching functional compliance validating that the proposed architecture and principles meet the expected behaviour of the component. However, further effort will be needed to optimize the implementation and reduce the latencies of the different involved steps. Possible actions include improving the interaction with the database (via more efficient Cypher querying approaches), reshaping some of the database models, and also migrating the API functions to C++ or selecting other database engines instead of Neo4j.

The utilisation of real (KITTI) and simulated (SUMO) data recordings during the presented tests also helps understanding that the LDM implementation can be used in a variety of applications thanks to the harmonised interfaces using the VCD data format.

From the results obtained, the following list of actions can be drawn:

- Optimize the LDM API to reduce latency
- Implement an example RTMaps Python component which reads from the ACCURATE OBU positioning signals
- Test real-time operation in the demonstrator vehicle

5 Conclusions

This document presents the first set of tests to validate the first ACCURATE prototype against the requirements defined in WP2. The document also includes the testing of the LDM function which is the main consumer od the ACCURATE output for enabling highly automated driving functions.

The document includes the results of the tests of the three main modules of the ACCURATE project

6 References

[1] D2.1 – OBU Requirements.

[2] D3.1 – Preliminary OBU architecture

[3] D5.1 – OBU functional verification and performance validation plan