

Outcomes from dual-frequency and Galileo alone smartphone test campaigns

4th Annual Raw Measurements Task Force Workshop

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27.05.2020

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DEFENCE AND SPACE

➤ **Dual-Frequency Mass Market Campaign**

- Test Plan
- Test Cases
- Test Setup
- Devices Under Test
- Location
- Results

➤ **Galileo Alone Mass Market Campaign**

- Test Plan
- Test Cases
- Test Setup
- Devices Under Test
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➤ **Conclusions**



➤ Objective

- Evaluate the accuracy improvement of dual-frequency smartphones compared to single-frequency ones
- Evaluate the Galileo usage -> Is there any improvement with respect to single-frequency smartphones?

➤ Testing Approach

- Live signals: Airbus carried out the live signal tests in real user conditions
- RFCS signals: Joint Research Centre (JRC) carried out the synthetic signal tests

➤ Receivers under test

- 3 dual-frequency
- 3 single-frequency



Dual Frequency Mass Market Test Plan
GSA-MKD-LBS-RPT-XXXXXX
Issue/Version: 01

Dual Frequency Mass Market
Test Plan


Reference:
GSA-MKD-LBS-RPT-XXXXXX
Issue/Version: 01
Date: 10.03.2019

prepared by/jrjgnd per M. Navarro-Gallardo

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Approved By:

Name	Role	Signature	Date

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Dual-Frequency Mass Market Campaign – Test Cases

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Test ID	Test case	Condition	Test configuration	Dynamic	Duration	Responsible
T-A-SIS-01	Open Sky	Assisted	Signal in Space	Static	4 h	Airbus
T-A-SIS-02	Open Sky	Assisted	Signal in Space	Static	24 h	Airbus
T-A-SIS-03	Open Sky	Unassisted	Signal in Space	Static	24 h	Airbus
T-A-SIS-04	Urban Static	Assisted	Signal in Space	Static	4 h	Airbus
T-A-SIS-05	Urban Pedestrian	Assisted	Signal in Space	Dynamic	4 h	Airbus
T-A-SIS-06	Suburban Pedestrian	Assisted	Signal in Space	Dynamic	4 h	Airbus
T-A-SIS-07	Highway	Assisted	Signal in Space	Dynamic	4 h	Airbus
T-U-LAB-08	Open Sky E1/E5	Unassisted	RFCS	Static	3 h	JRC
T-U-LAB-09	Open Sky E1	Unassisted	RFCS	Static	3 h	JRC
T-U-LAB-10	Open Sky E5	Unassisted	RFCS	Static	3 h	JRC
T-U-LAB-11	Open Sky Scintillation	Unassisted	RFCS	Static	3 h	JRC
T-U-LAB-12	Urban Pedestrian E1	Unassisted	RFCS	Dynamic	0.5 h	JRC
T-U-LAB-13	Urban Pedestrian E1/E5	Unassisted	RFCS	Dynamic	0.5 h	JRC

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Live test cases have been carried out by Airbus in the Munich area. Novatel system was used to compute the reference position.

Car Setup

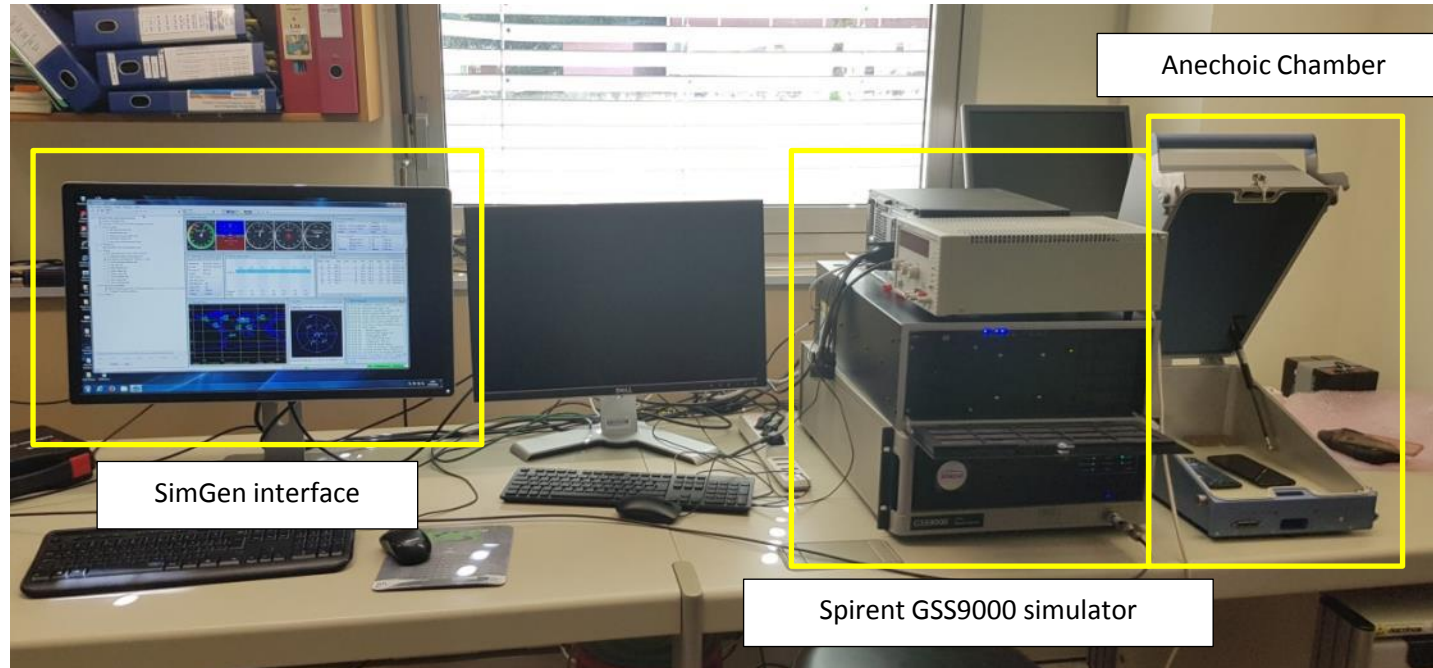
Pedestrian Setup

Open Sky Setup



Test cases with the RFCS have been carried out in the JRC facilities. Spirent GSS9000 simulator and Anechoic Chamber have been used.

JRC Test Setup





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Device	Single- /Dual- Frequency	Chipset	Release
Sony Xperia XZ Premium	SF	Qualcomm Snapdragon 835	June 2017
Samsung Galaxy S8	SF	Broadcom BCM4774	April 2017
Samsung Galaxy S10+	SF	Broadcom BCM47752	March 2019
Huawei Mate 20 Pro	DF	HiSilicon Kirin 980	October 2018
Xiaomi Mi 8	DF	Broadcom BCM47755	May 2018
Xiaomi Mi 9	DF	Qualcomm Snapdragon 855	March 2019



Positions and trajectories of the tests; from the top left to the bottom right: static positions, highway, suburban pedestrian, urban mobile simulation, urban pedestrian routes



Dual-Frequency Mass Market Campaign – Results

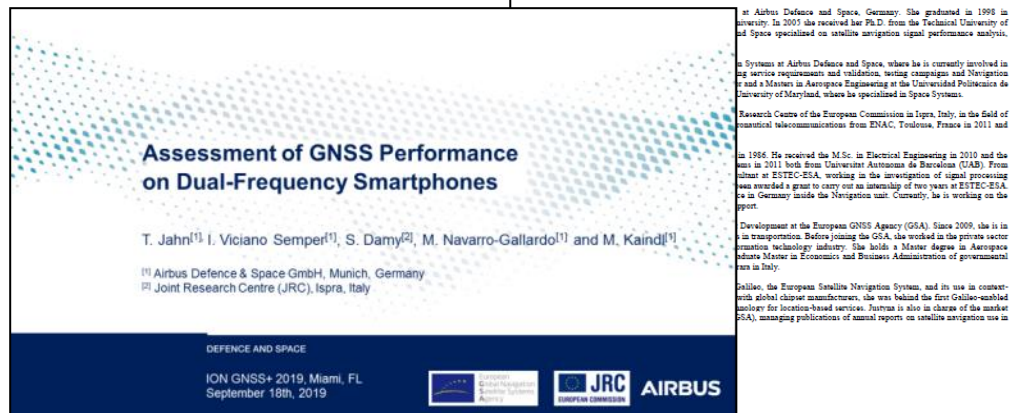
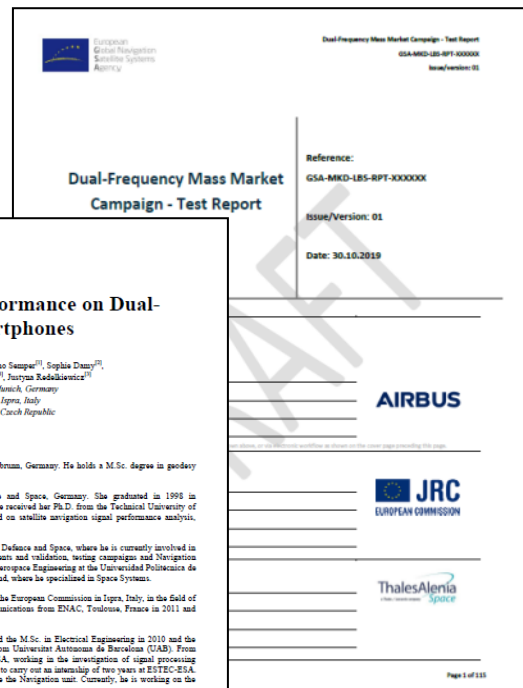


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Results from Dual-Frequency Mass Market Campaign:

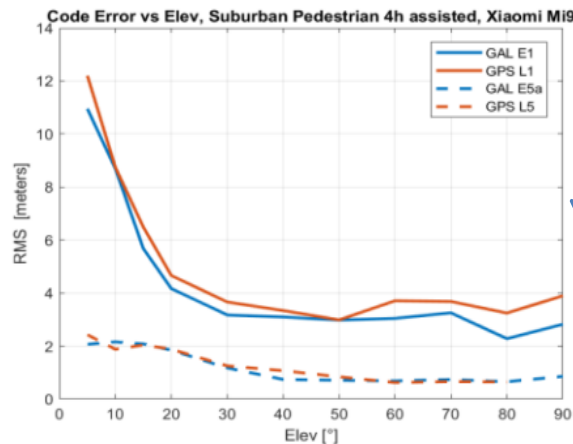
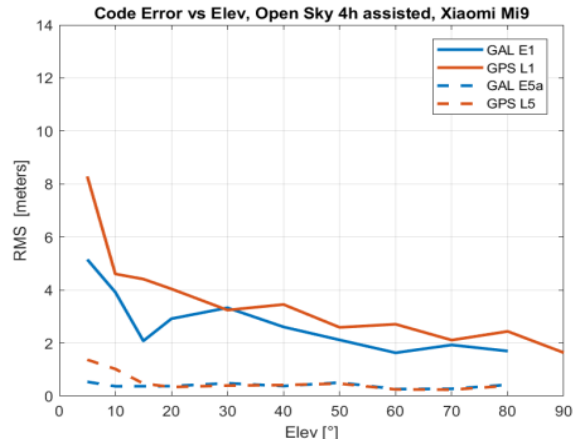
- Test Report
- ION GNSS+ 2019 Presentation
- ION GNSS+ 2019 Paper



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Dual-Frequency Mass Market Campaign – Results

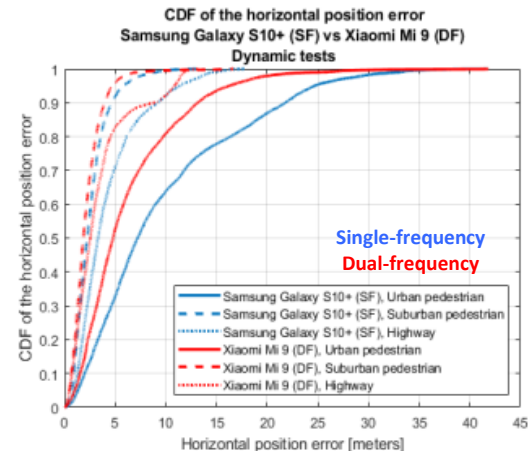
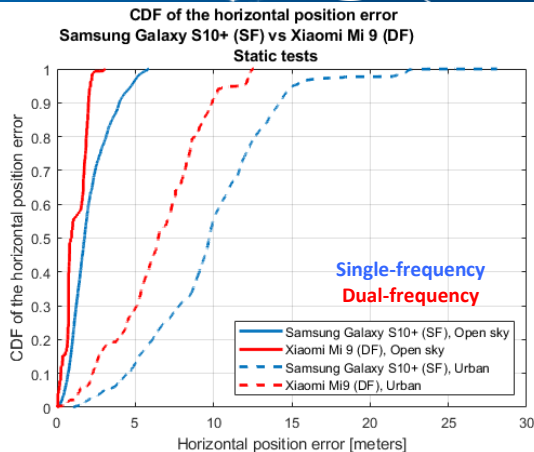
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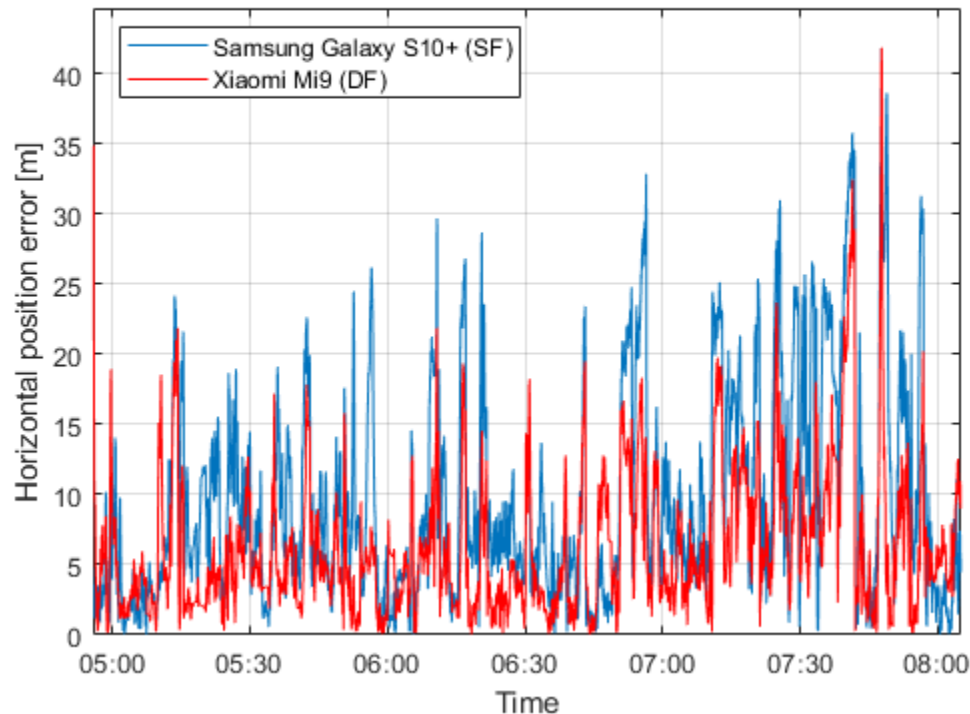
Better multipath and noise rejection with L5/E5a signals (higher bandwidth, narrower correlation)

Slightly accuracy improvement with dual-frequency

All benefit of the code error is not reflected in the PVT solution



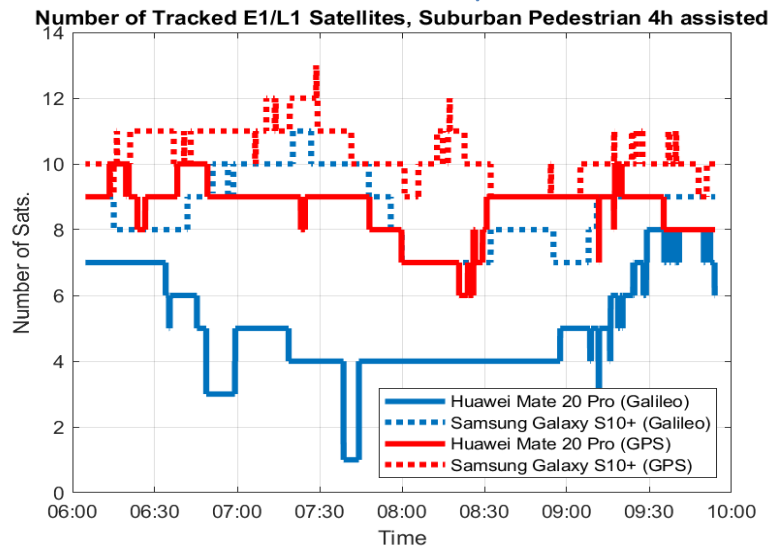
Horizontal position error vs time
Samsung Galaxy S10+ (SF) vs Xiaomi Mi 9 (DF)
Urban Pedestrian



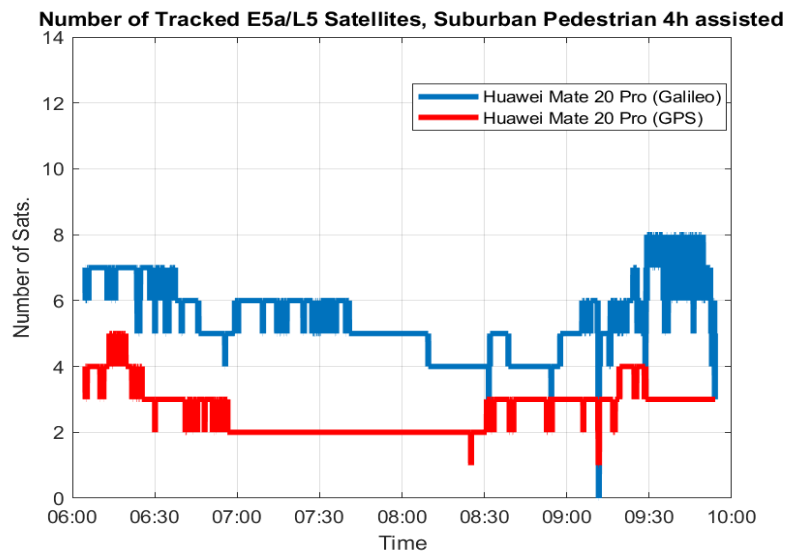
	Horizontal position error [m] Urban Pedestrian	
	Samsung Galaxy S10+ (SF)	Xiaomi Mi 9 (DF)
63.2 th percentile	9.0	5.8
95.0 th percentile	24.4	16.2

Number of Galileo and GPS tracked satellites by Huawei Mate 20 Pro and Samsung Galaxy S10+.

Samsung Galaxy S10+ is tracking almost the same number of Galileo and GPS satellites on E1/L1



More Galileo satellites is tracked on E5a than GPS on L5





➤ Objective

- Assess the possibility to use and performance when using Galileo alone with mass market receivers under usual operational conditions (experienced by user most of the time)

➤ Testing Approach

- All the defined test cases are based on the RFCS and have been executed in the JRC premises
- RFCS signals have been used in order to limit the used constellations, satellites and signals

➤ Receivers under test

- 3 dual-frequency
- 2 single-frequency




Galileo Alone Mass Market Test Plan
GSA-MKD-LES-RPT-000000
Issue/Version: 01

Galileo Alone Mass Market
Test Plan

Reference:
GSA-MKD-LES-RPT-000000
Issue/Version: 01
Date: 25.10.2019

prepared by/prepared for: T. Lovandevski

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Configuration: F. Bell-Angela
Program Manager: A. Schmitt-Pfeiffer



Technical Manager: M. Marinelli
Product assurance: F. Maraschi
Configuration: D. Tallanda
Program Manager: J. Sauerbrenn



Approved By:

Name	Role	Signature	Date

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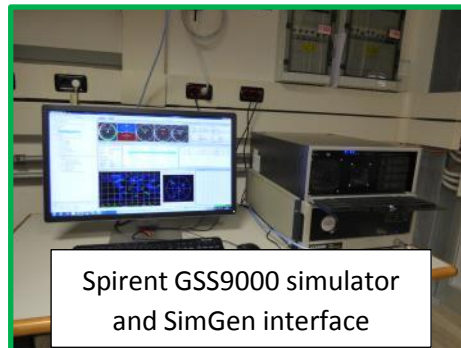
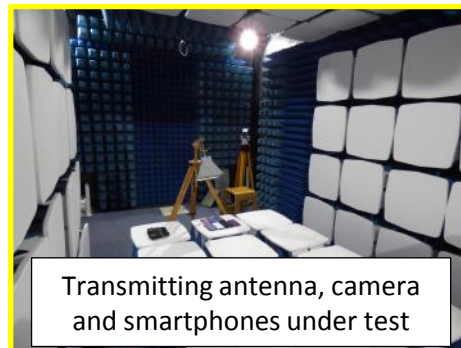
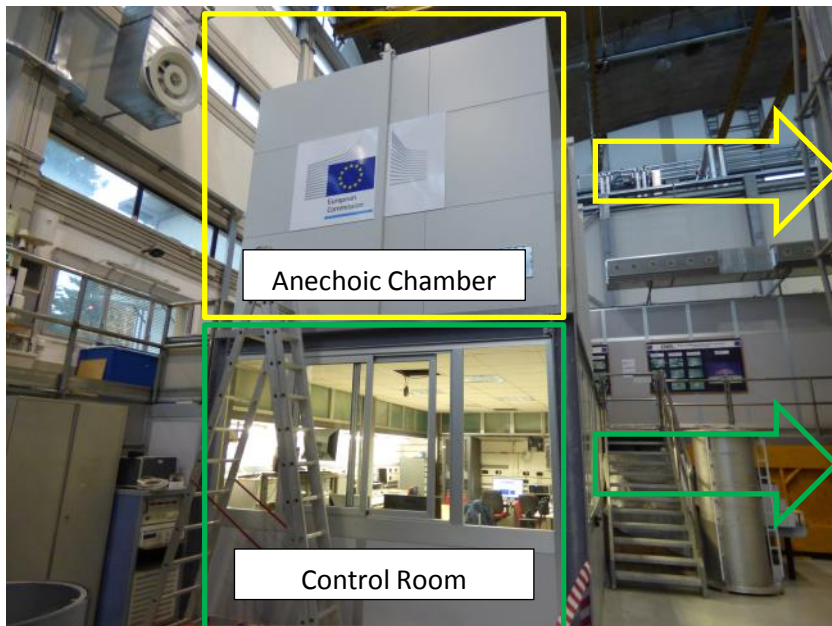
Galileo Alone Mass Market Campaign – Test Cases



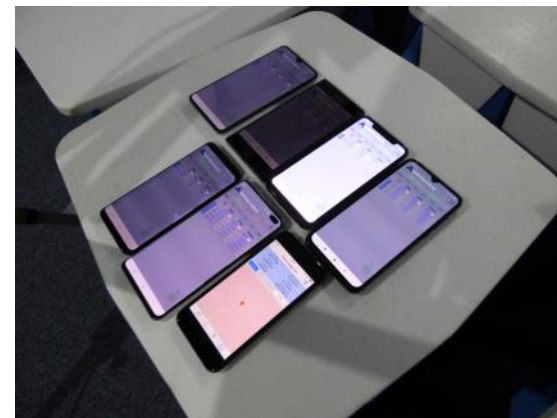
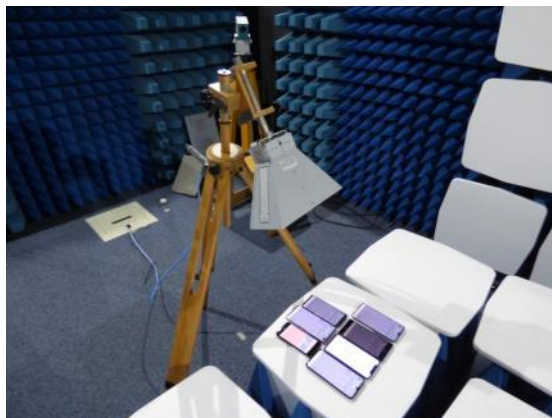
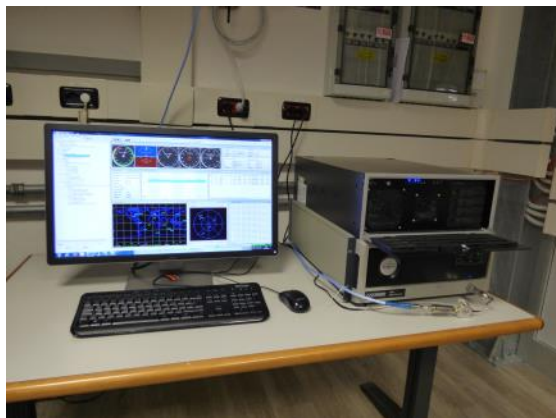
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Test ID	Constellations and signals	Test case	Condition	Test configuration	Dynamic	Duration	Comment
T-A-LAB-01	Galileo (E1 and E5) and GPS (L1 and L5)	Open Sky	Assisted Data (real time simulation)	RFCS	Static	2 h or 3 h	GPS constellation shall be switched off after 1 hour of simulation
T-A-LAB-02	Galileo (E1 and E5) and 1 GPS satellite (L1 and L5)	Open Sky	Assisted Data (real time simulation)	RFCS	Static	2 h or 3 h	GPS constellation shall be switched off after 1 hour of simulation
T-A-LAB-03	Galileo (E1 and E5)	Open Sky	Assisted Data (real time simulation)	RFCS	Static	2 h or 3 h	-
T-A-LAB-04	Galileo E1	Open Sky	Assisted Data (real time simulation)	RFCS	Static	2 h or 3 h	-
T-A-LAB-05	Galileo E5	Open Sky	Assisted Data (real time simulation)	RFCS	Static	2 h or 3 h	-
T-A-LAB-06	Galileo (E1 and E5) and GPS (L1 and L5)	Urban Pedestrian	Assisted Data (real time simulation)	RFCS	15 min Static + 33 min Dynamic	48 min	GPS constellation shall be switched off after 25 min of simulation
T-A-LAB-07	Galileo (E1 and E5) and 1 GPS satellite (L1 and L5)	Urban Pedestrian	Assisted Data (real time simulation)	RFCS	15 min Static + 33 min Dynamic	48 min	GPS constellation shall be switched off after 25 min of simulation
T-A-LAB-08	Galileo (E1 and E5)	Urban Pedestrian	Assisted Data (real time simulation)	RFCS	15 min Static + 33 min Dynamic	48 min	-
T-A-LAB-09	Galileo E1	Urban Pedestrian	Assisted Data (real time simulation)	RFCS	15 min Static + 33 min Dynamic	48 min	-
T-A-LAB-10	Galileo E5	Urban Pedestrian	Assisted Data (real time simulation)	RFCS	15 min Static + 33 min Dynamic	48 min	-

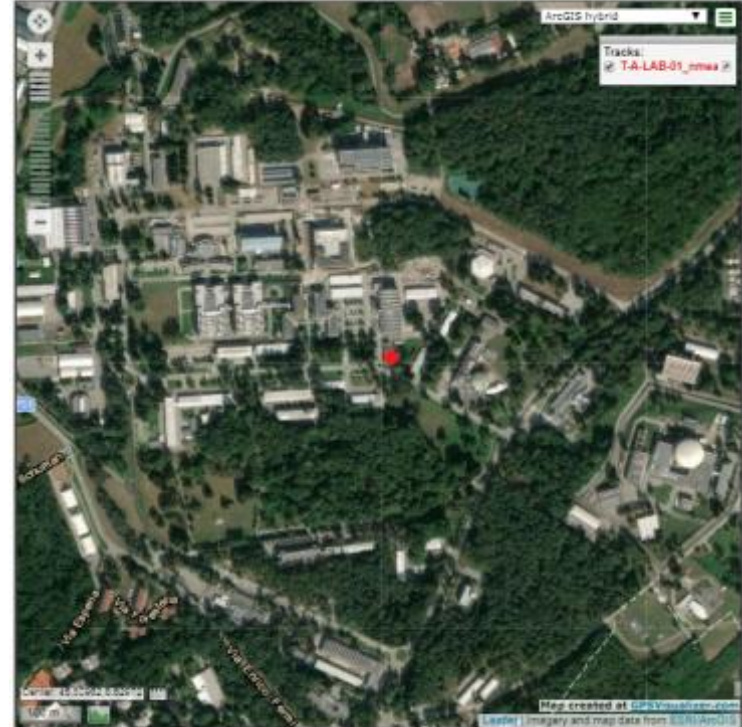
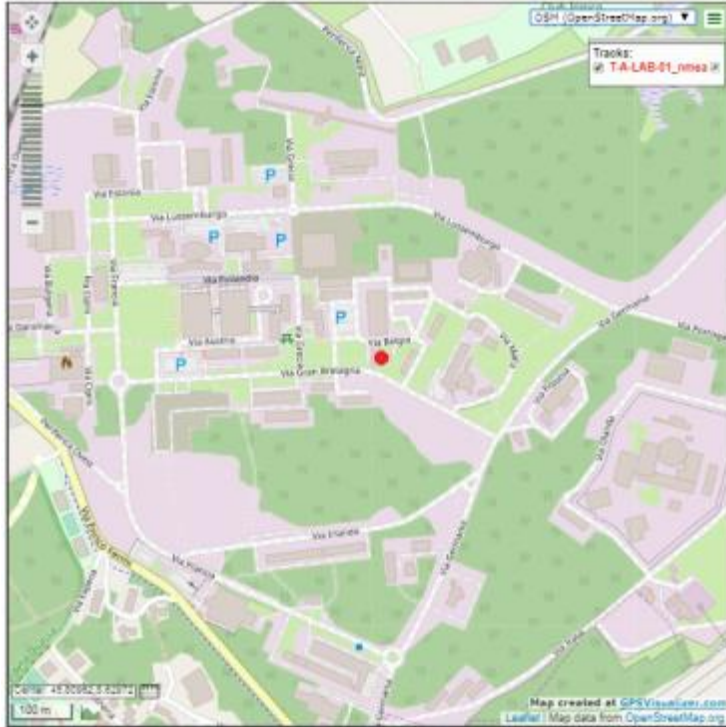
Test cases have been carried out in the JRC facilities. Spirent GSS9000 simulator and Anechoic Chamber have been used.



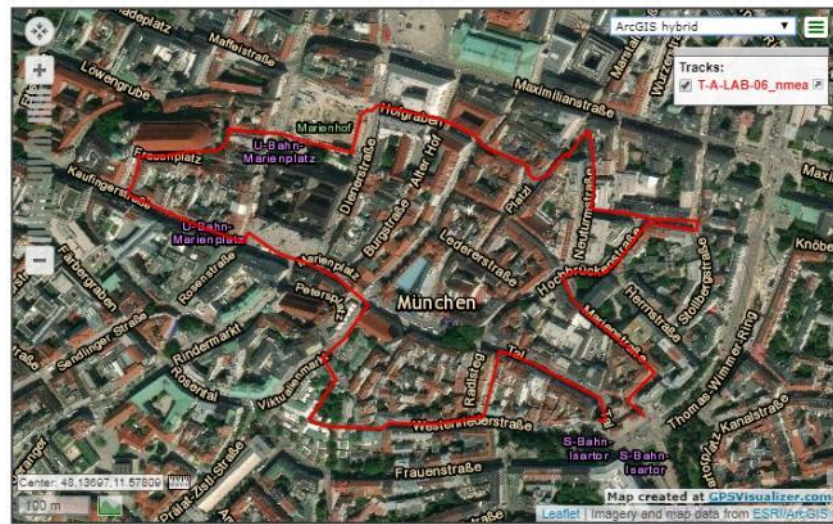
Device	Single-/Dual-Frequency	Chipset	Release
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Samsung Galaxy S10+	SF	Broadcom BCM47752	March 2019
Huawei Mate 20 Pro	DF	HiSilicon Kirin 980	October 2018
Xiaomi Mi 8	DF	Broadcom BCM47755	May 2018
Xiaomi Mi 9	DF	Qualcomm Snapdragon 855	March 2019



Location for T-A-LAB-01 - T-A-LAB-05 was set on the roof of 72C building, JRC, Ispra, Italy



Trajectory for T-A-LAB-06 - T-A-LAB-10 was set in Munich, Germany





Galileo Alone Mass Market Campaign Tests Results

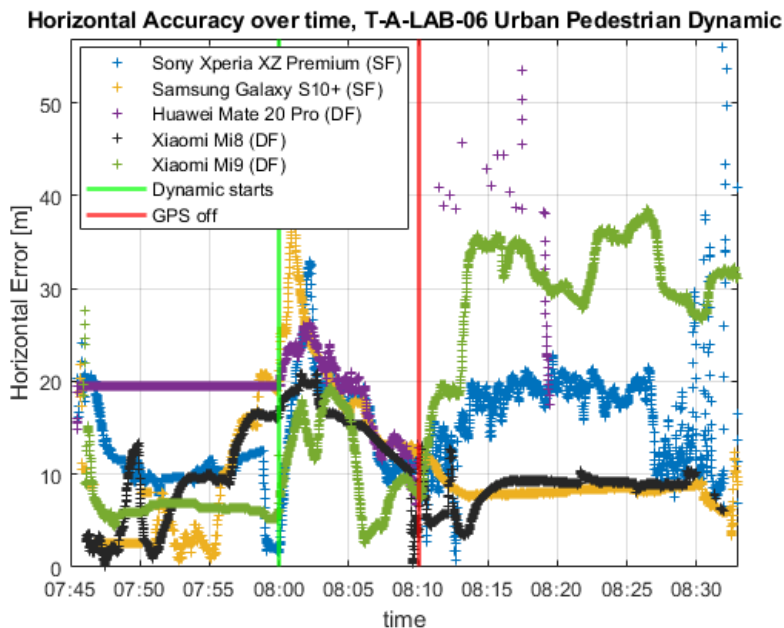
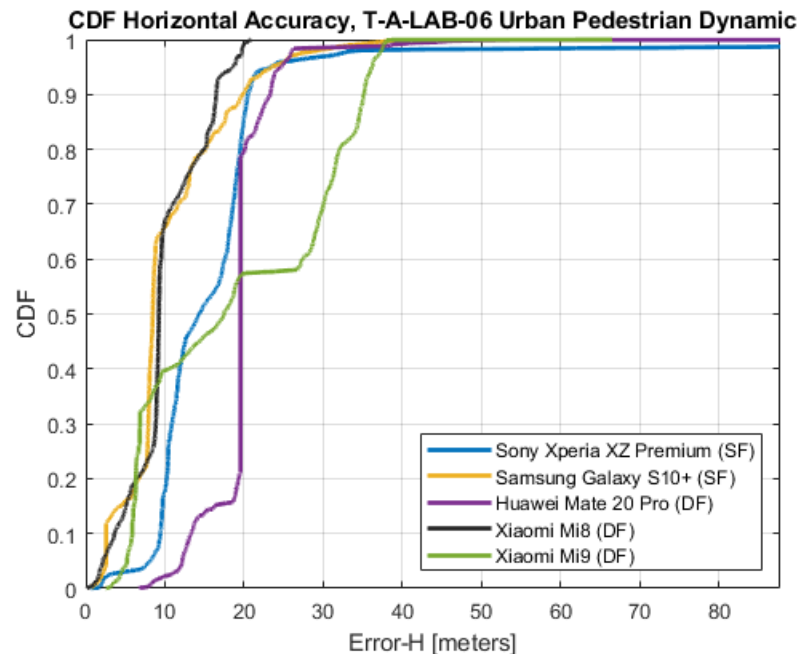
GAL-PS-ADSO-SYST-X-1000688509_01, Issue 01

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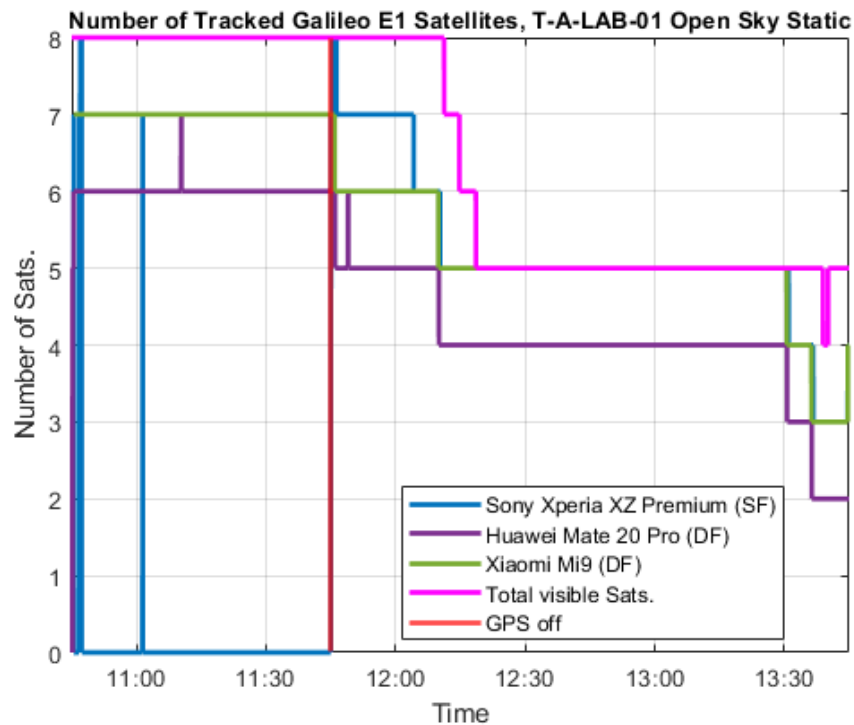
Thorsten Jahn, Melanie Kaindl , Tomasz Lewandowski
07.02.2020

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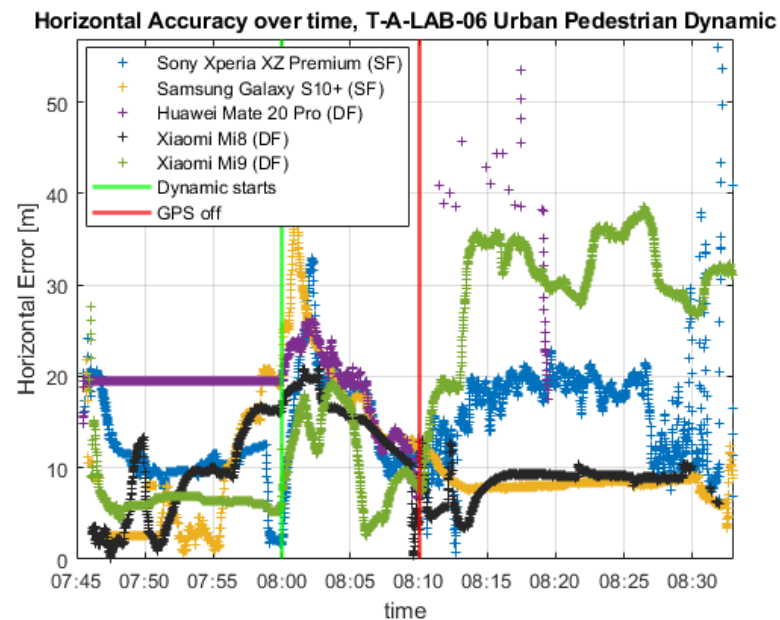
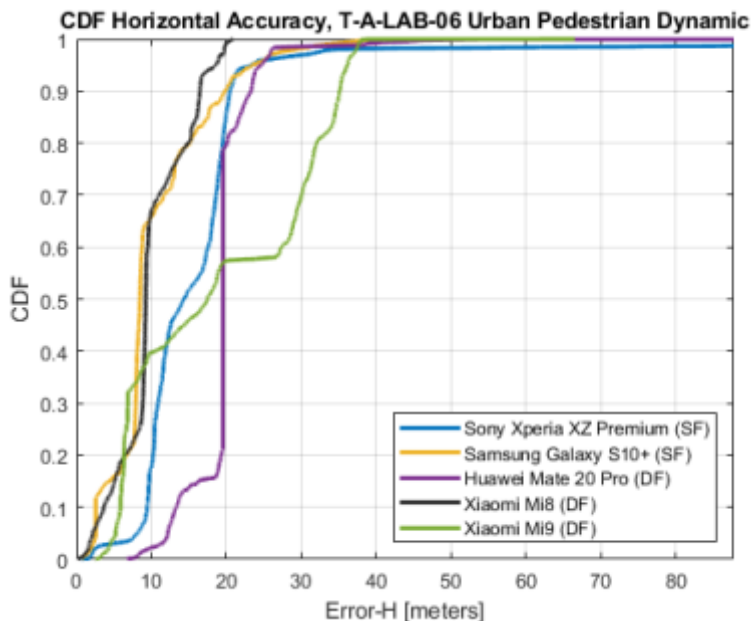
All the tested phones were able to provide a PVT with Galileo signals only.



Sony Xperia XZ Premium tracks Galileo continuously only after GPS is turned off.



There are few values for Huawei Mate 20 Pro (low position update rate) when the user is static, when dynamic starts position gets updated.





➤ Dual-Frequency Mass Market Campaign

- Dual-frequency smartphones take advantage of the L5/E5a signals to get better positioning solution.
- Galileo has currently greater contribution to dual-frequency than GPS (more Galileo satellites broadcast on E5a than GPS on L5).

➤ Galileo Alone Mass Market Campaign

- Mass market receivers are able to provide a PVT with Galileo signals only.
- Receiver manufacturers consider Galileo in a better and better way in their implementations.

Thank you!

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Thank you for your attention!

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