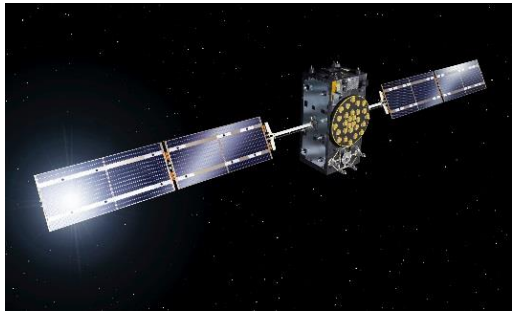
Testing of GNSS Dual-Frequency with Smartphones

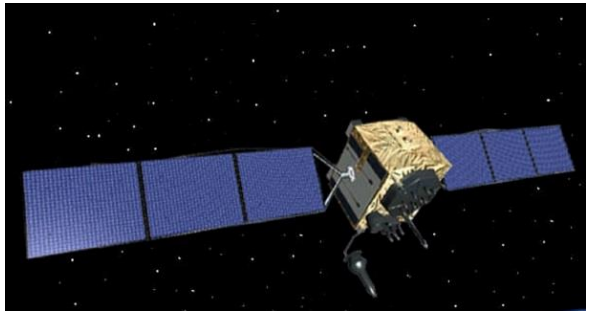
Towards better location performance in mass market applications

P. Crosta, G. Galluzzo, R. Orus, R. Lucas, *ESA*
J. Redelkiewicz, *GSA*

30 satellites with dual frequency

18 operational Galileo satellites (E1/E5) + **12 operational GPS Block IIF satellites (L1/L5)**



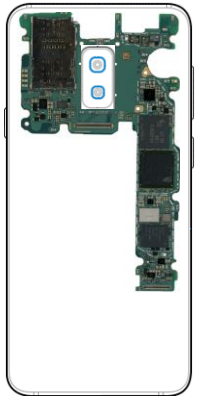


	L5 / L5OC/ E5a / B2a	L3OC/ E5b / B2b	L2 / L2C / L2OC	E6 / LEX	L1 / L1OC / E1 / B1
GPS	30		30		30
GLONASS	24	24	24		24
Galileo	30	30		30	30
BeiDou	35	35		35	35
QZSS	3		3	3	3
IRNSS	7				
	129				**122**

Future GNSS/RNSS common frequencies, showing the potential of E1/L1 and E5/L5 combination

Smartphone-based positioning

SATELLITE BASED SIGNALS



- GNSS chipset
- ACCELEROMETERS
- GYROSCOPES
- MAGNETOMETER
- BAROMETER

SENSORS/LOCATION HUB

FUSED LOCATION

- HIGH ACCURACY CORRECTIONS (IGS INTERNATIONAL GNSS SERVICE)
- A-GNSS DATA
- CELLULAR NETWORK/4G
- NFC
- WiFi
- BLUETOOTH

TERRESTRIAL RF

Last generation chips combine GNSS and sensors through tight integration in a single location hub, providing very smooth and accurate solutions

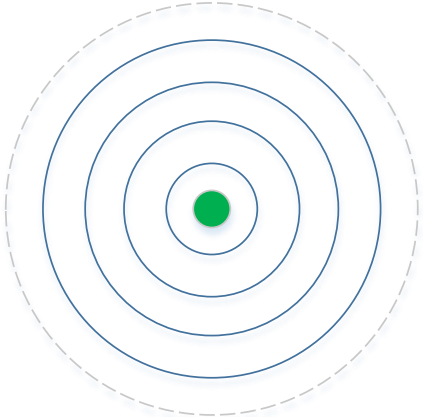
There are 3 families of smartphone based positioning:

1. **Satellite based signals (GNSS, SBAS)**
2. **Sensors**
3. **Terrestrial based RF signals**

Technology is evolving towards a indoor/outdoor seamless positioning solution on smartphones.

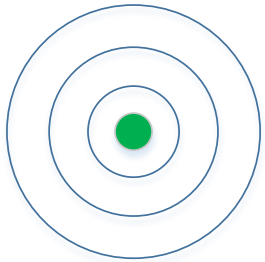
Images/Icons credit https://icons8.com/icon/2305/nfc-tag | TechInsights

Typical Outdoor Open Sky Positioning Accuracy



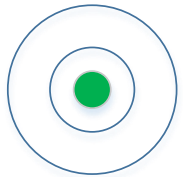
METER-LEVEL

SINGLE FREQUENCY multi-GNSS



METER/SUB-METER

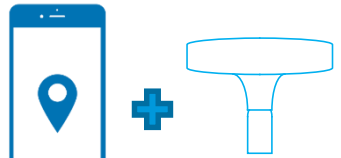
DUAL FREQUENCY multi-GNSS



DECIMETER

PPP/RTK

CENTIMETER

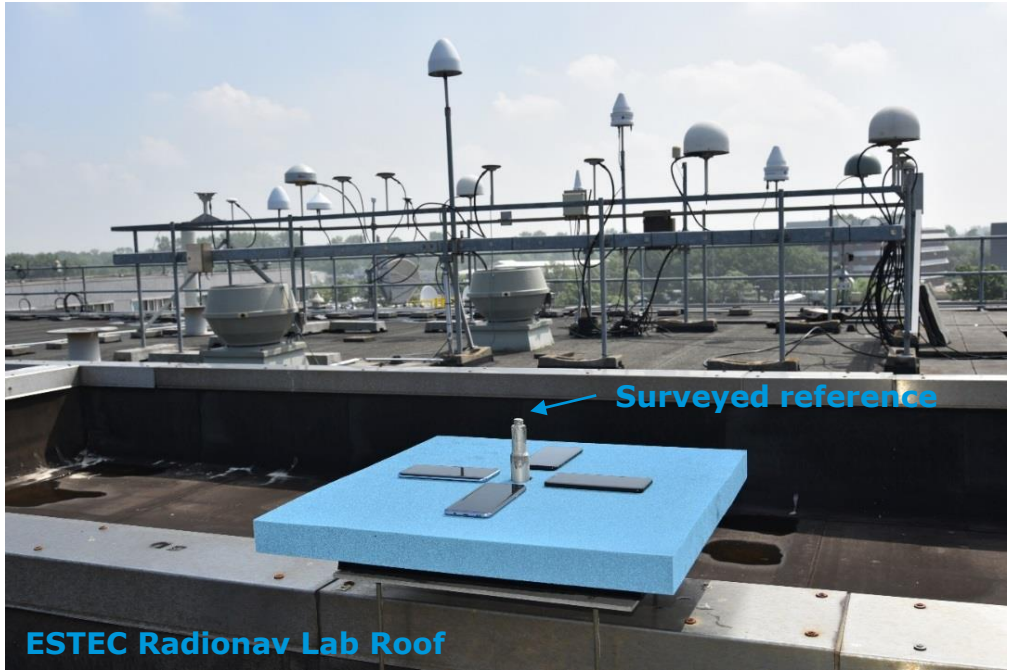


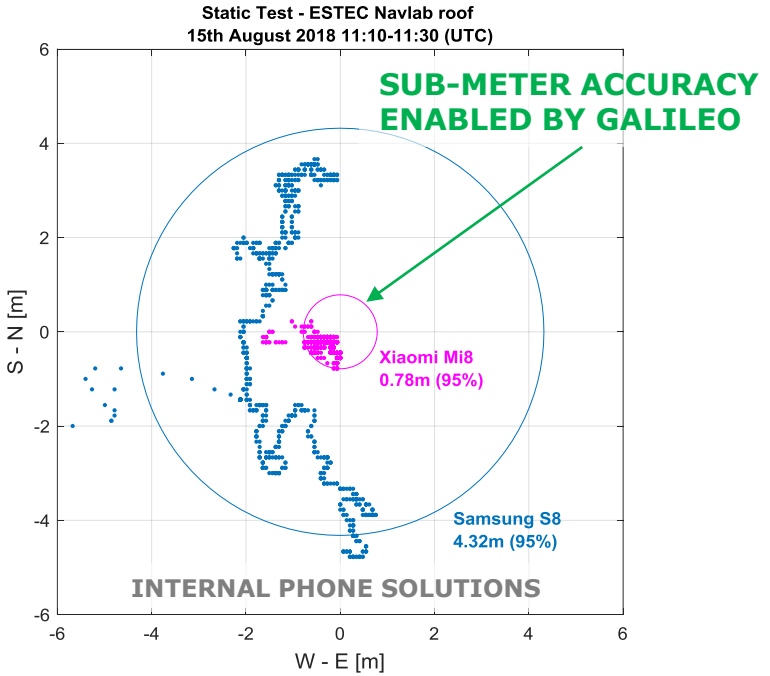
PPP/RTK

Only commercial/professional apps for real time solution

Icon credit: TMD Nuon Project

Testing internal phone solutions - static

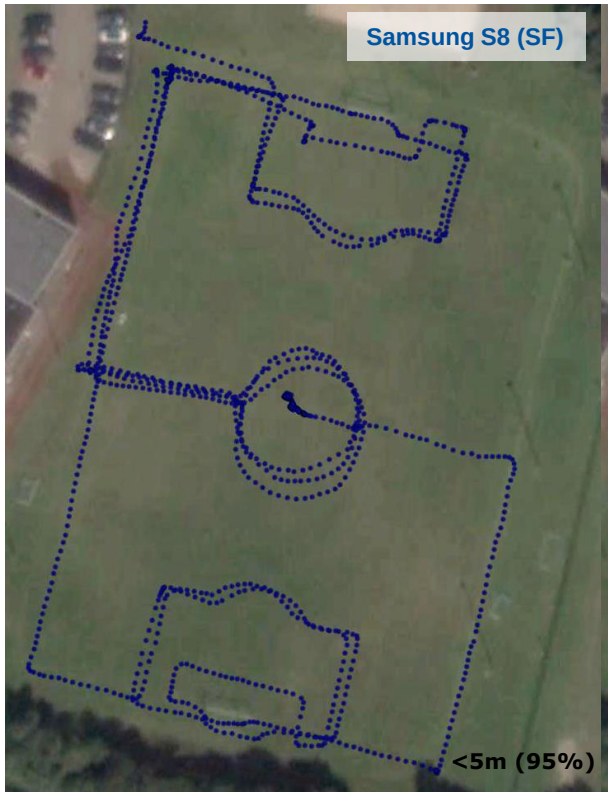




Multi-GNSS solution

5 GPS DF + 8 Galileo DF in view during this test

Opens Sky Pedestrian test SF vs DF GNSS chipsets



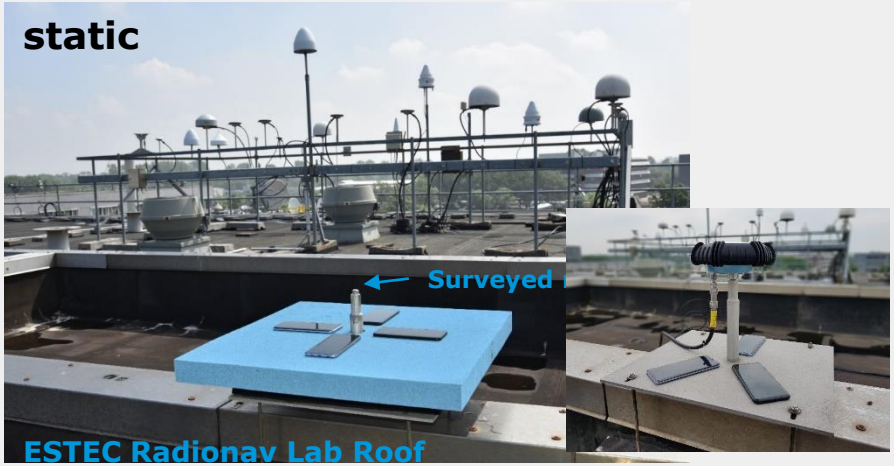
TEST #1 15-08-2018
6-8 Galileo satellites in view during the test

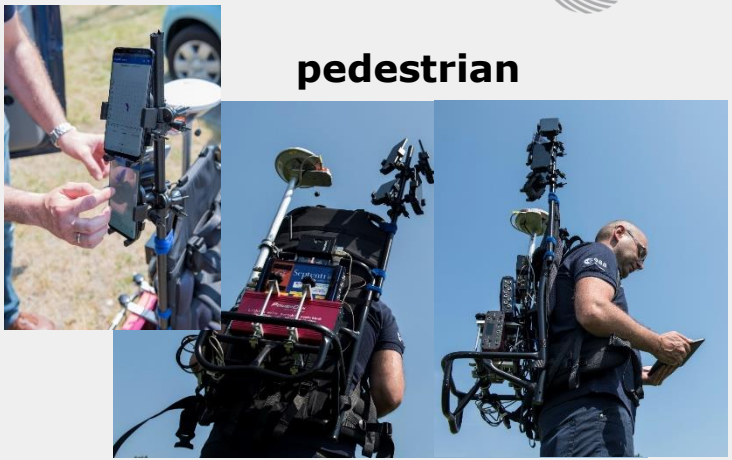
TEST #2 14-09-2018

→ Dual Frequency (DF) measurements along with GNSS chipset algorithmic enhancements enable a significant reduction of positioning error

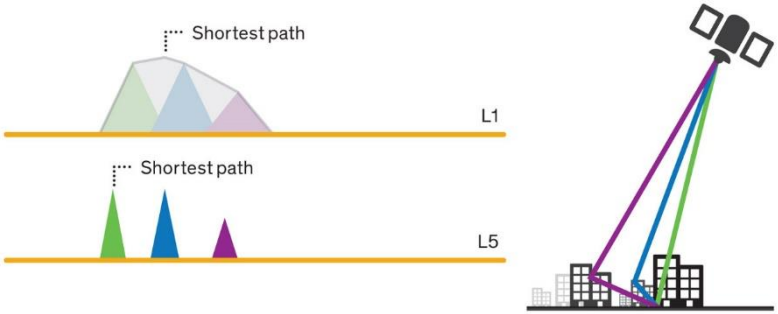
INTERNAL PHONE SOLUTIONS

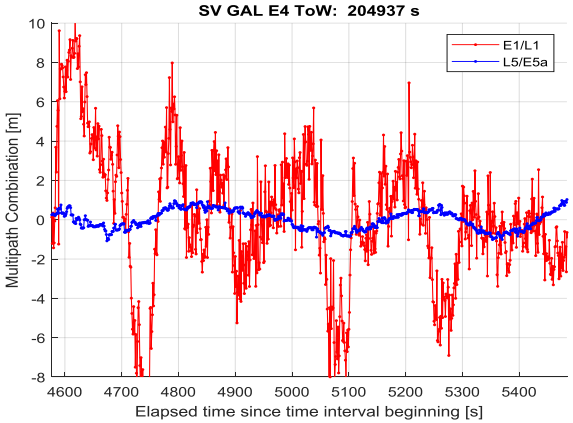
ESA R&D: Assessing quality of Raw Measurements

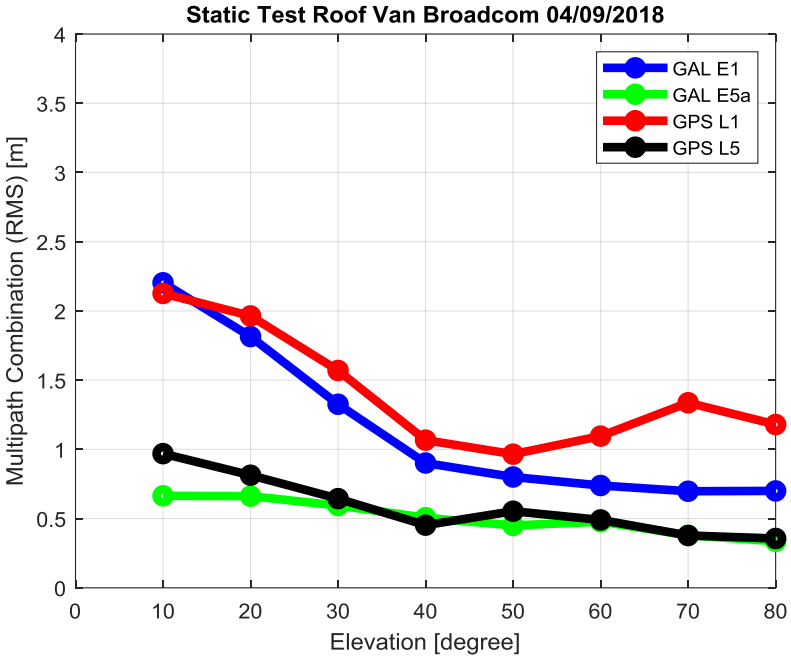




ESA R&D: Assessing quality of Raw Measurements

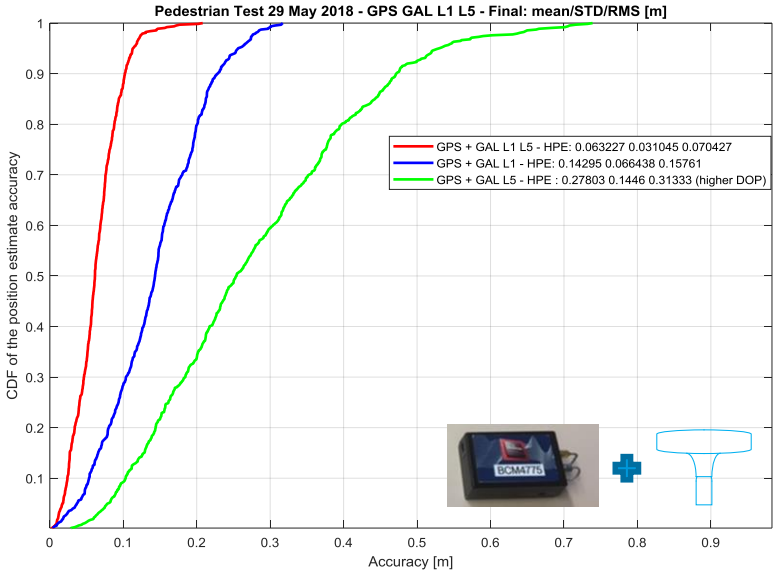




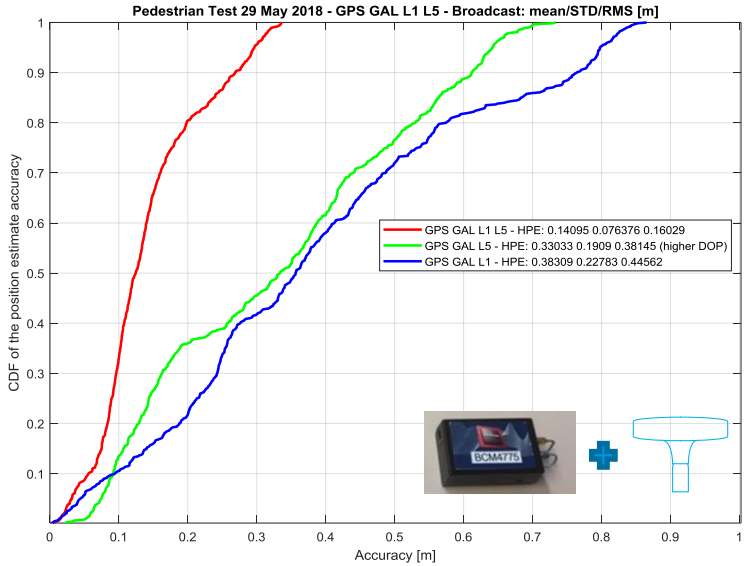


Horizontal Position Accuracy - Pedestrian

PPP (Final orbits)

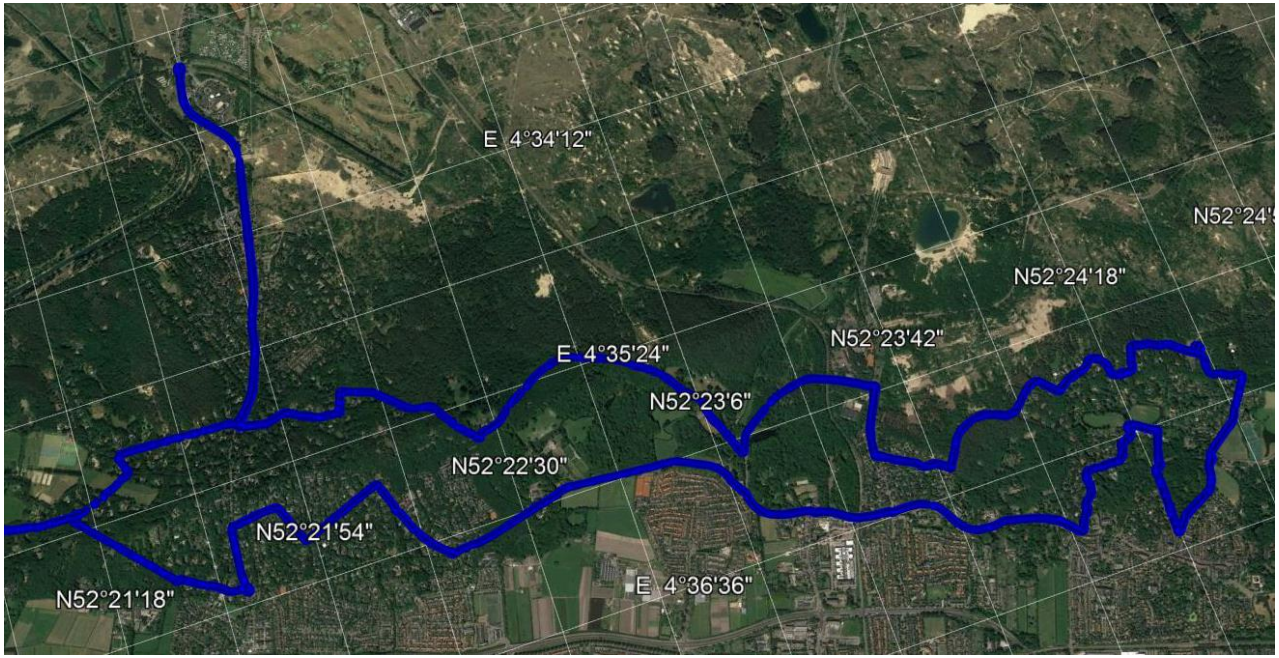


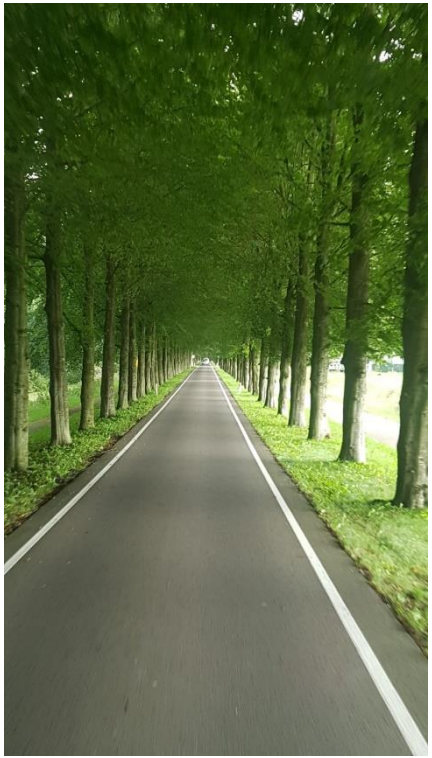
Broadcast orbits



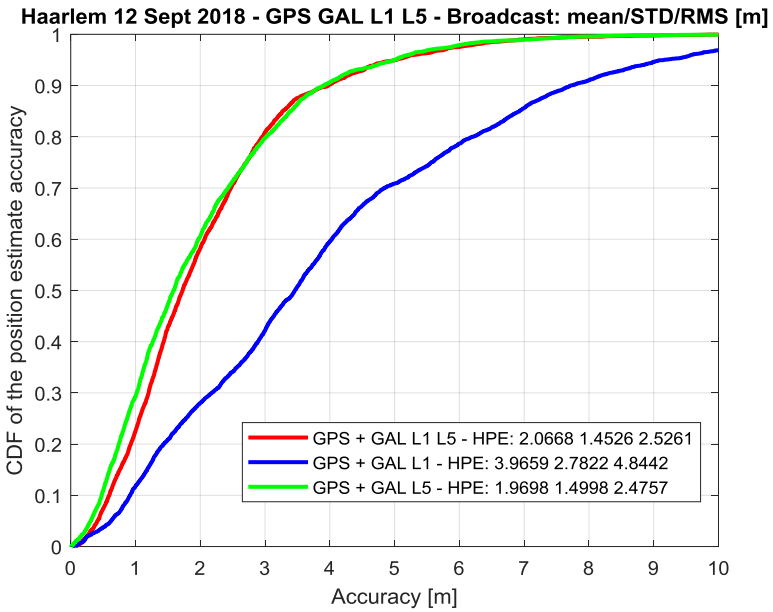
→ Environment with good quality of raw measurements allows PPP solution

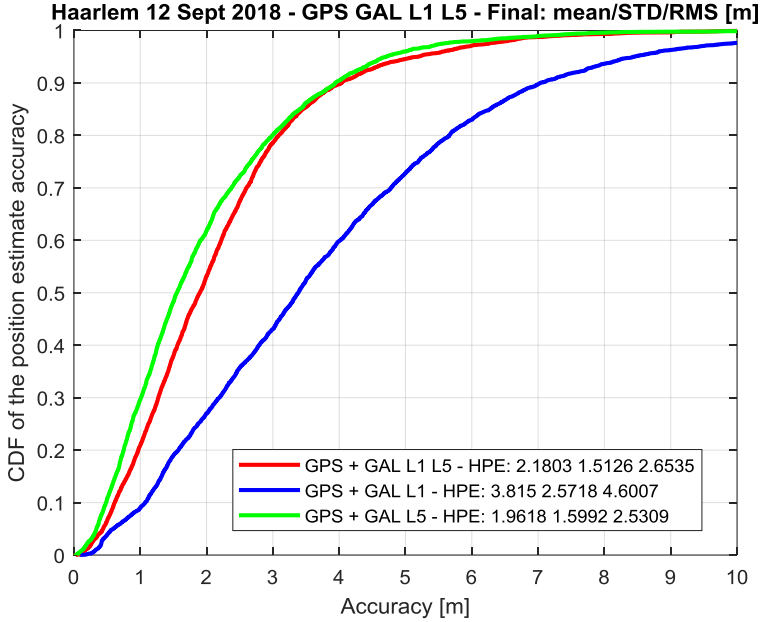
Horizontal Position Accuracy - Vehicular





Horizontal Position Accuracy - Vehicular





→ Environment with bad quality of raw measurements limits PPP solution
→ Lower noise in E5a – L5 only outperforms L1-E1 only, even with less satellites in view.

Conclusions

- 30 satellites already available with dual frequency
- Dual frequency outperforms single frequency in smartphones
- ESA assessed the quality of the raw measurements to understand the feasibility of high accuracy solutions on smartphones
- Wide-band signals beneficial for multipath rejection
- The code noise (multipath) is often the main source of error: hiding the benefits of more accurate clocks and orbital data
- E5a – L5 only even with fewer SVs can outperform L1-E1 only.
- Results show potential for high accurate positioning with ultra low cost GNSS chipsets, but quality of raw measurements to be improved for non open sky environments.

GSA GNSS Raw Measurements Task Force

- Discussion forum for industry, academia and research institutes
- 80 members including ESA
- Sharing of tests results, raw data, technology trends
- Direct access to publications on GNSS raw data use
- Annual meeting to facilitate sharing of best practises
- More information and information on how to join the group here: https://www.gsa.europa.eu/gnss-raw-measurements-task-force

GALILEO