NavSpace 2019

The International Workshop on Navigation, Space and Security

Will GNSS deliver more than the „Zip-Code" in future Mass-Market Positioning?

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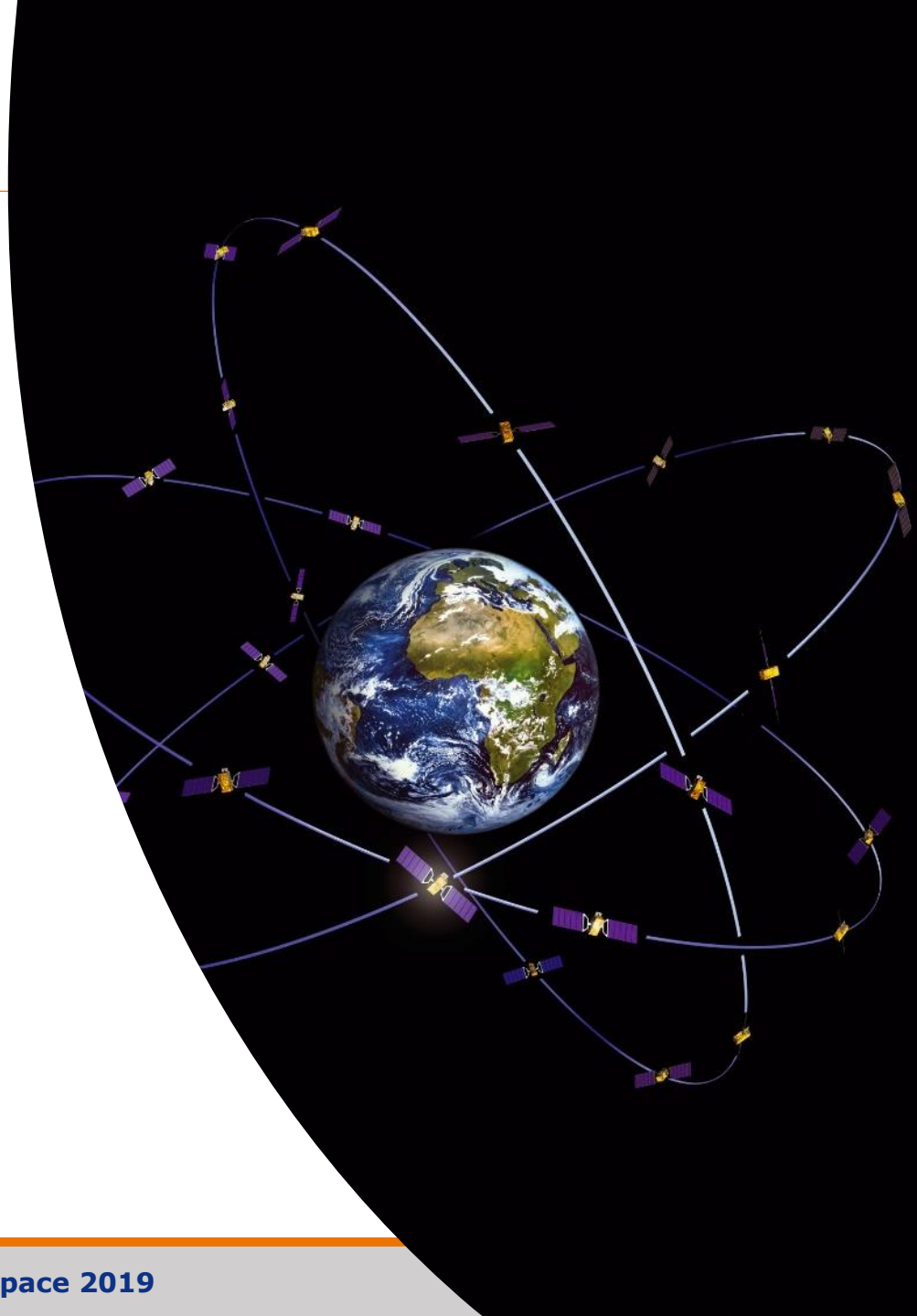
June 19th, 11:20

Overview

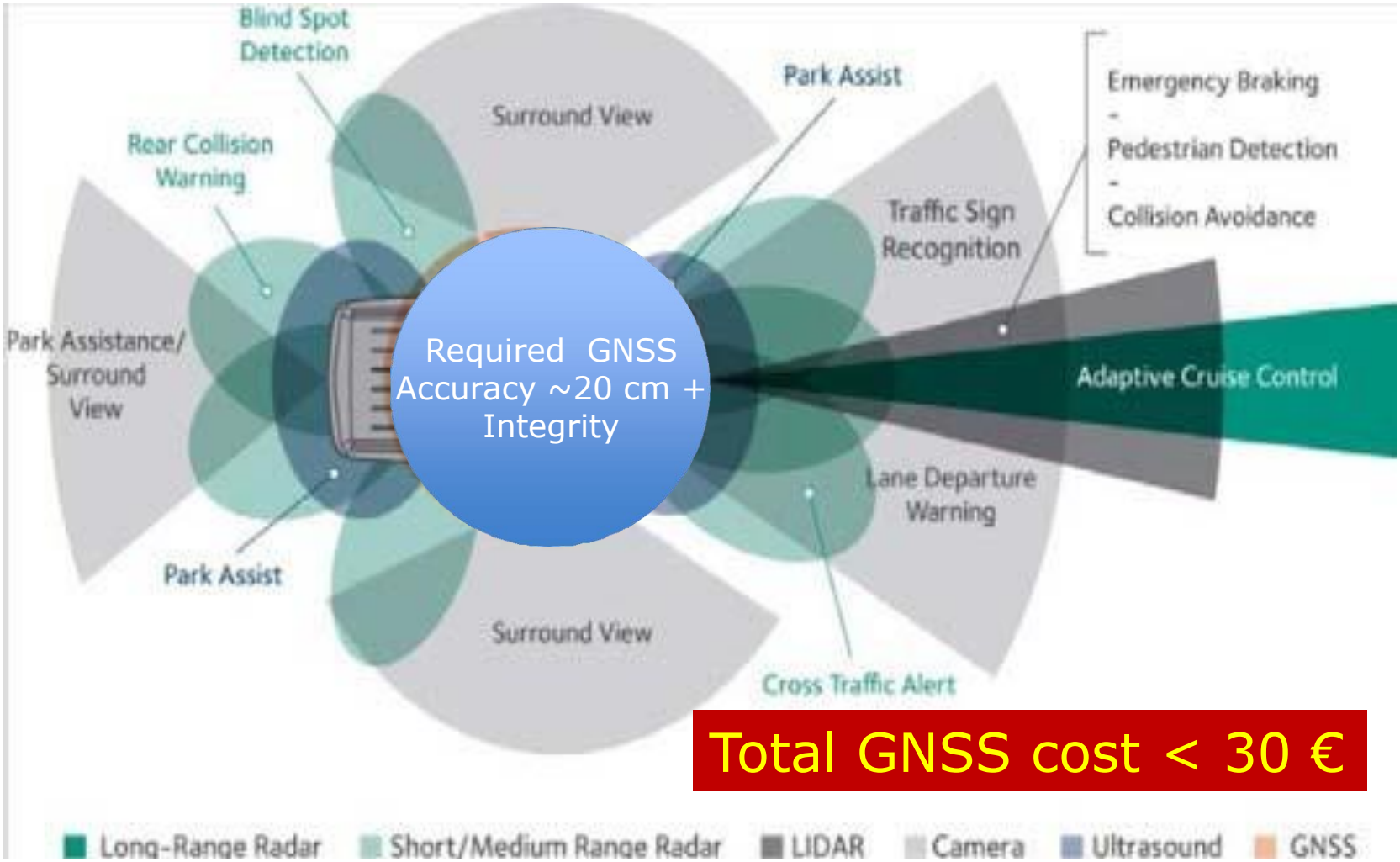
- Markets and responses
- Integrated RTK/GNSS on the mobile phone



(Real) Mass-Market-Positioning

Two Killer Applications and three Positioning Responses

Autonomous Cars

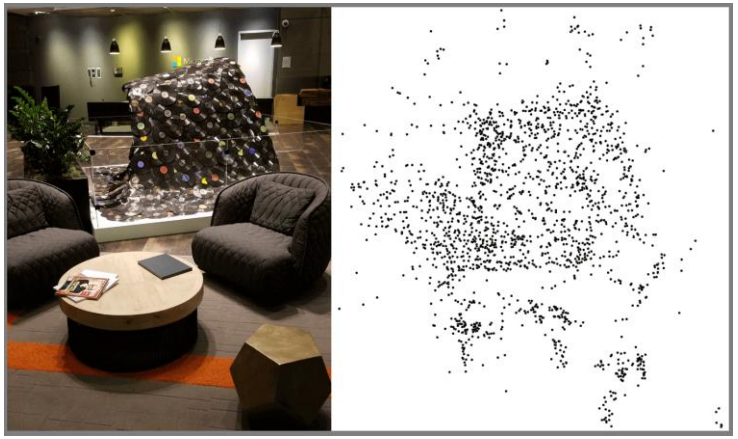


Augmented Reality

Augmented Reality

Upcoming Microsoft Solutions for Precise Positioning / **Camera**

- Azure Spatial Anchors
  - Cloud service for **global** 3D point clouds
  - Camera based
  - Ubiquitous cm-Positioning everywhere?

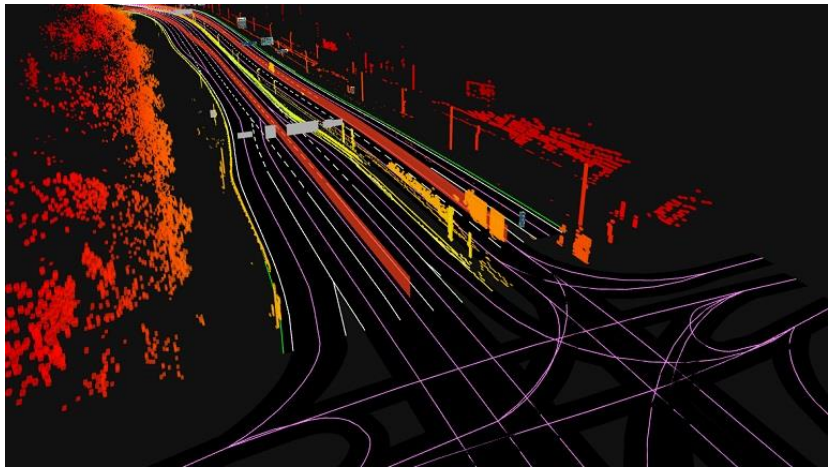


- Minecraft Earth
  - Millions of Users mapping the Earth

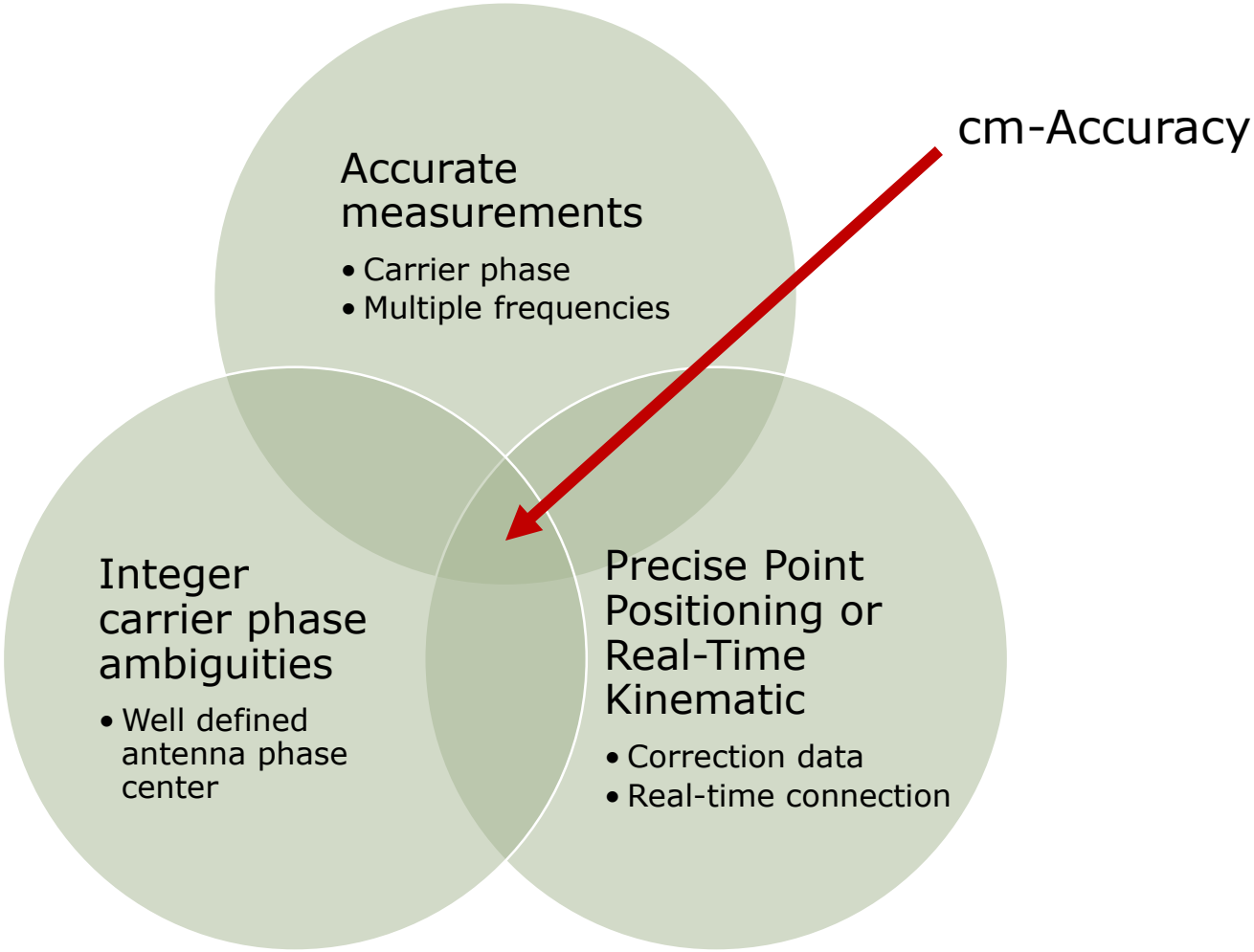
- Start of service/game in summer 2019

Bosch/TomTom **Radar** Signatures

- Radar signatures
  - at 77 GHz
  - 250 m range
  - Centimeter accuracy
  - Signatures in principle sensor dependent
- Captured by millions of cars
  - Cloud based solution for data management, transfer and map update
  - SLAM / fusion with other sensors
  - HD radar map
- Start of service in 2020



The **GNSS** Solution



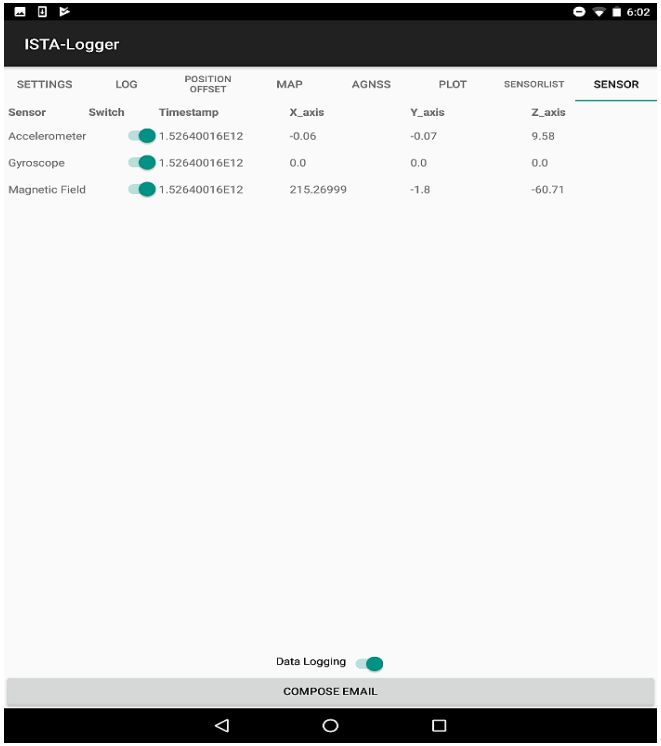
Robust/RTK on the Mobile Phone

Android-Raw Data, MuSNAT/RTKLIB Processing, Early Results

Android Application Development

- GNSS/INS data logger
  - Android based GNSS/INS data logger for Smartphones
  - GNSS raw data (based upon GNSSlogger from Google)
  - Embedded IMU (Acceelerometer, Gyroscope, Magnetometer) data logging
    - GNSS raw data to RINEX 3.03 Converter
    - IMU data compatable with Intertial Explorer
    - Seperate GNSS and IMU data
    - Synchronized GNSS/INS data

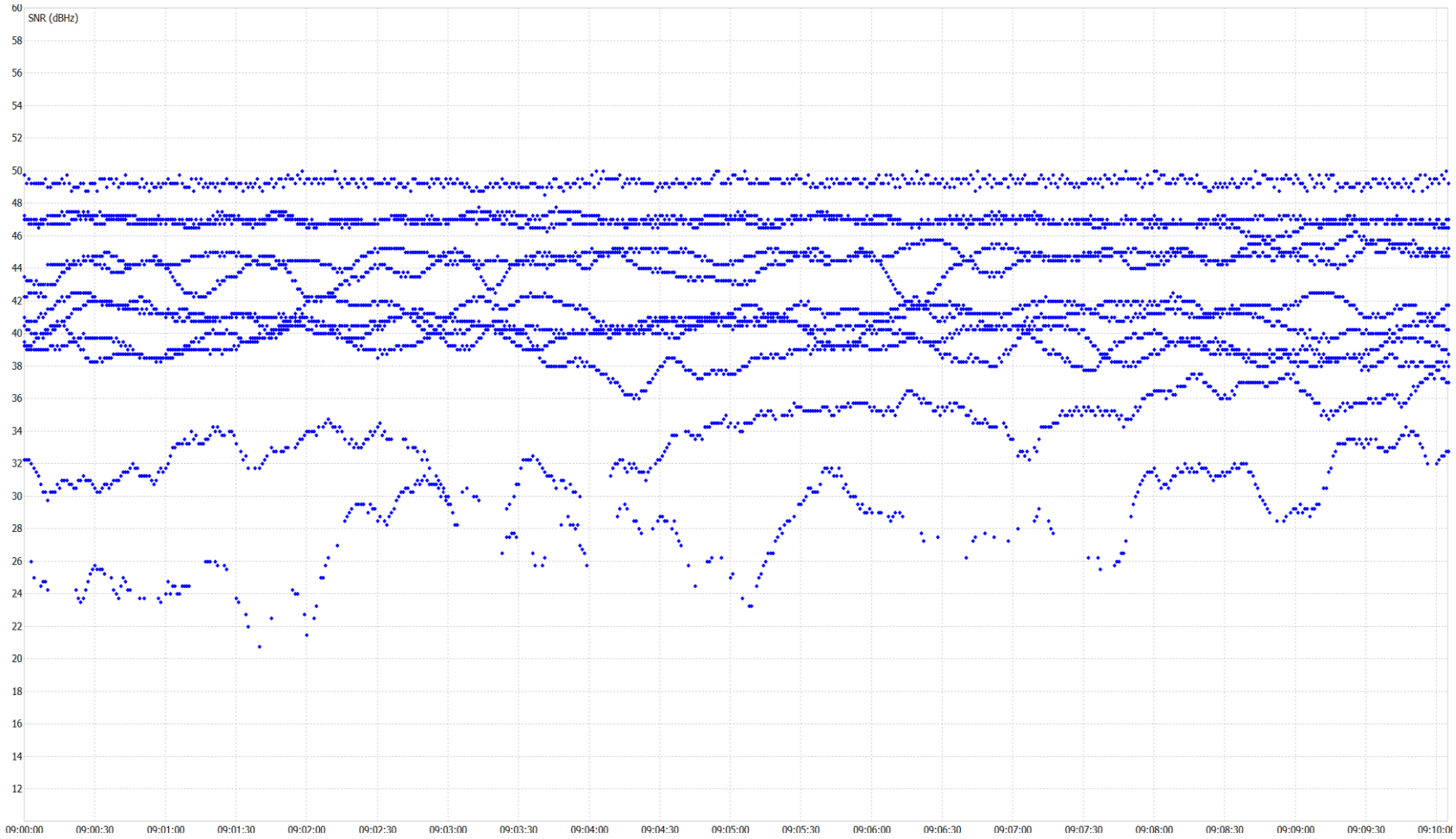
Xiaomi MI 8
dual frequency L1/L5
GPS/Galileo chip
with carrier phase



Retransmission Setup

- Both L1 and L5 signals were amplified
- Transmit antenna was kept near to smartphone so as to minimize the reception of signal directly from satellite.

C/N_0 for MI8 with Retransmission



10 min.

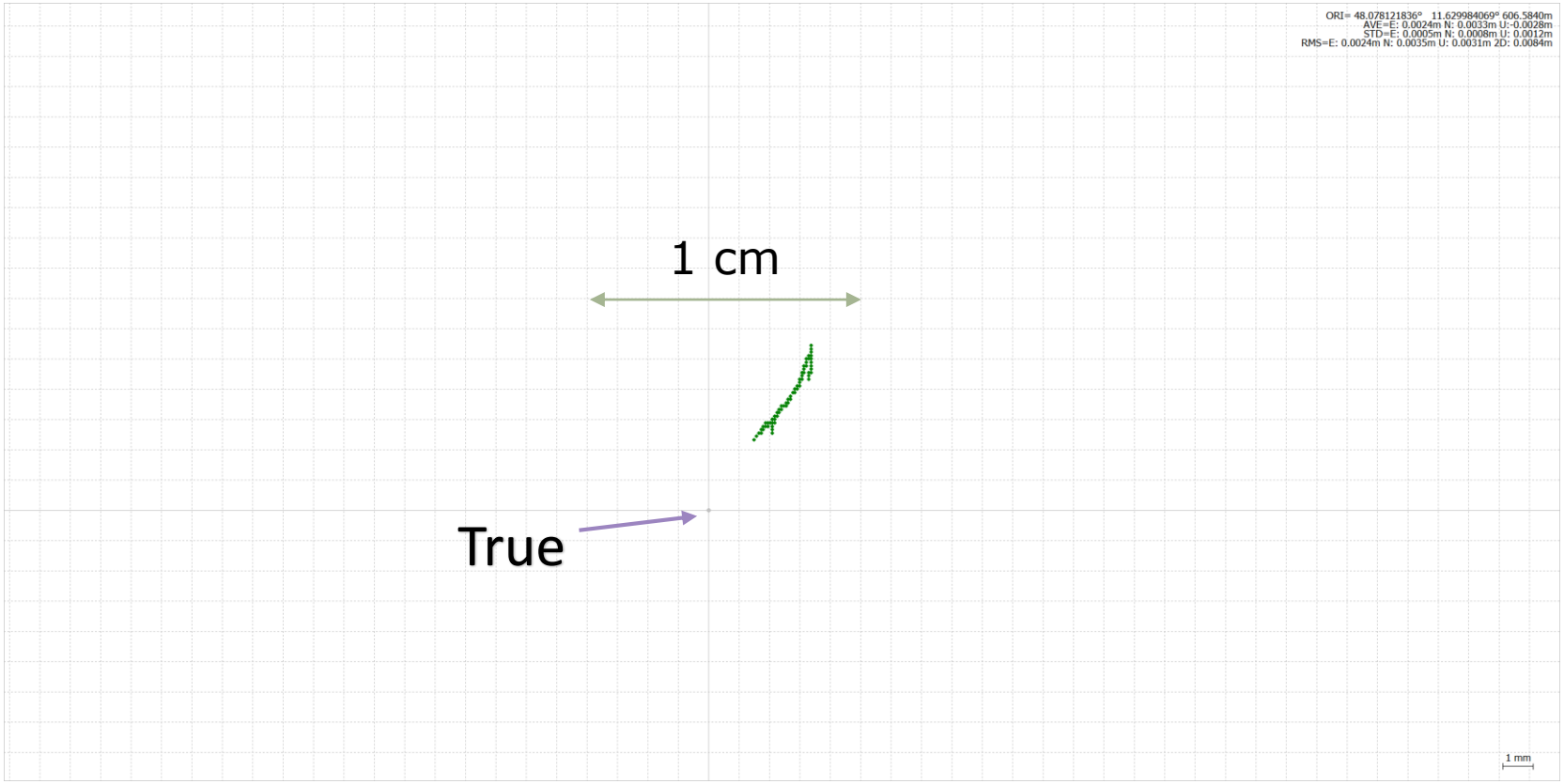
RTK with Retransmission

- Configuration Parameters

Parameter	Value
Positioning Mode	Static
Frequency and Constellation	L1+L5 and GPS only
Integer Ambiguity Res.	Cont.
Base Station coordinates (roof top antenna :61)	48 04 41.238610, 11 37 47.942650, 606.5840
Ionosphere Correction	OFF
Troposphere Correction	OFF
Satellite Ephemeris	Broadcast
Filter Type	Combined

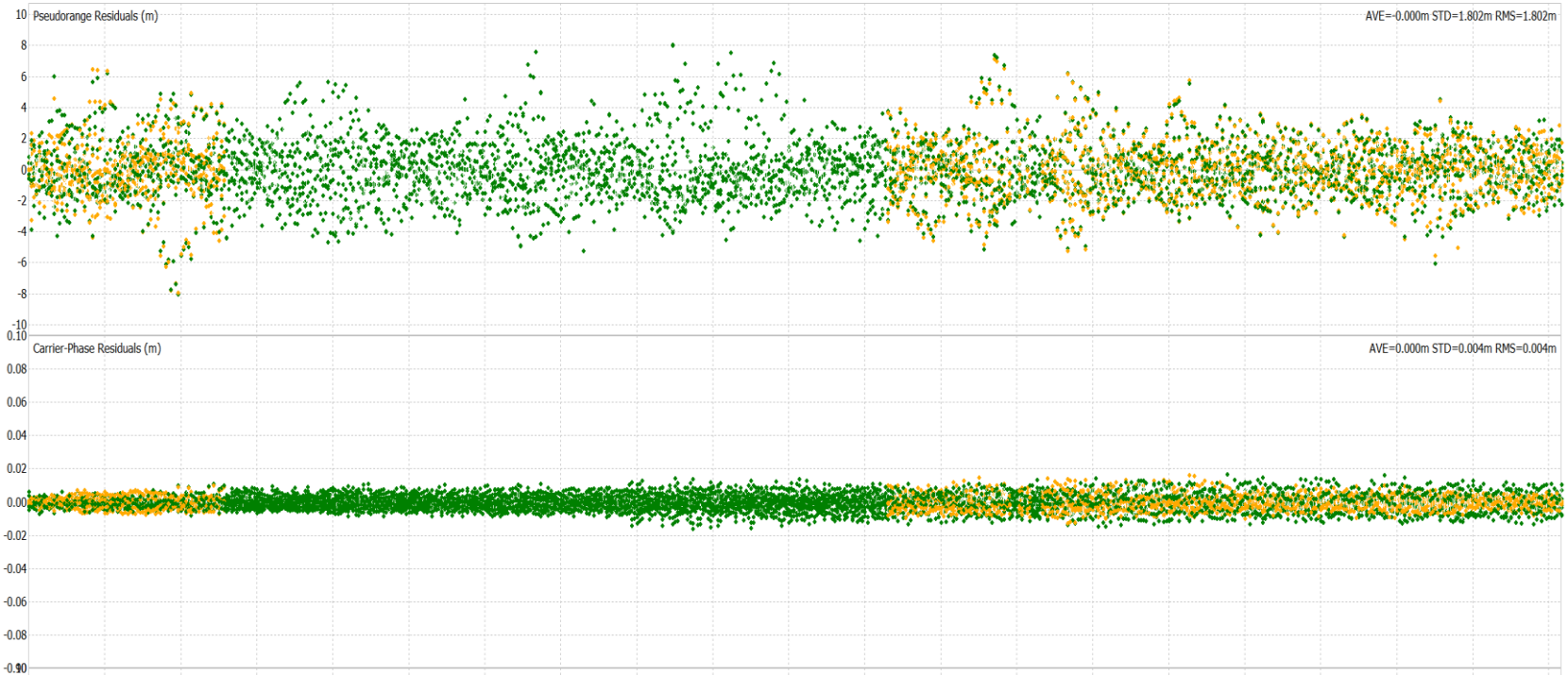
RTK with Retransmission-Ground Track

- RMS value E/N/U = 0.0024/0.0035/0.0031 meters
- Standard deviation = 0.0005/0.0008/0.00012 meters

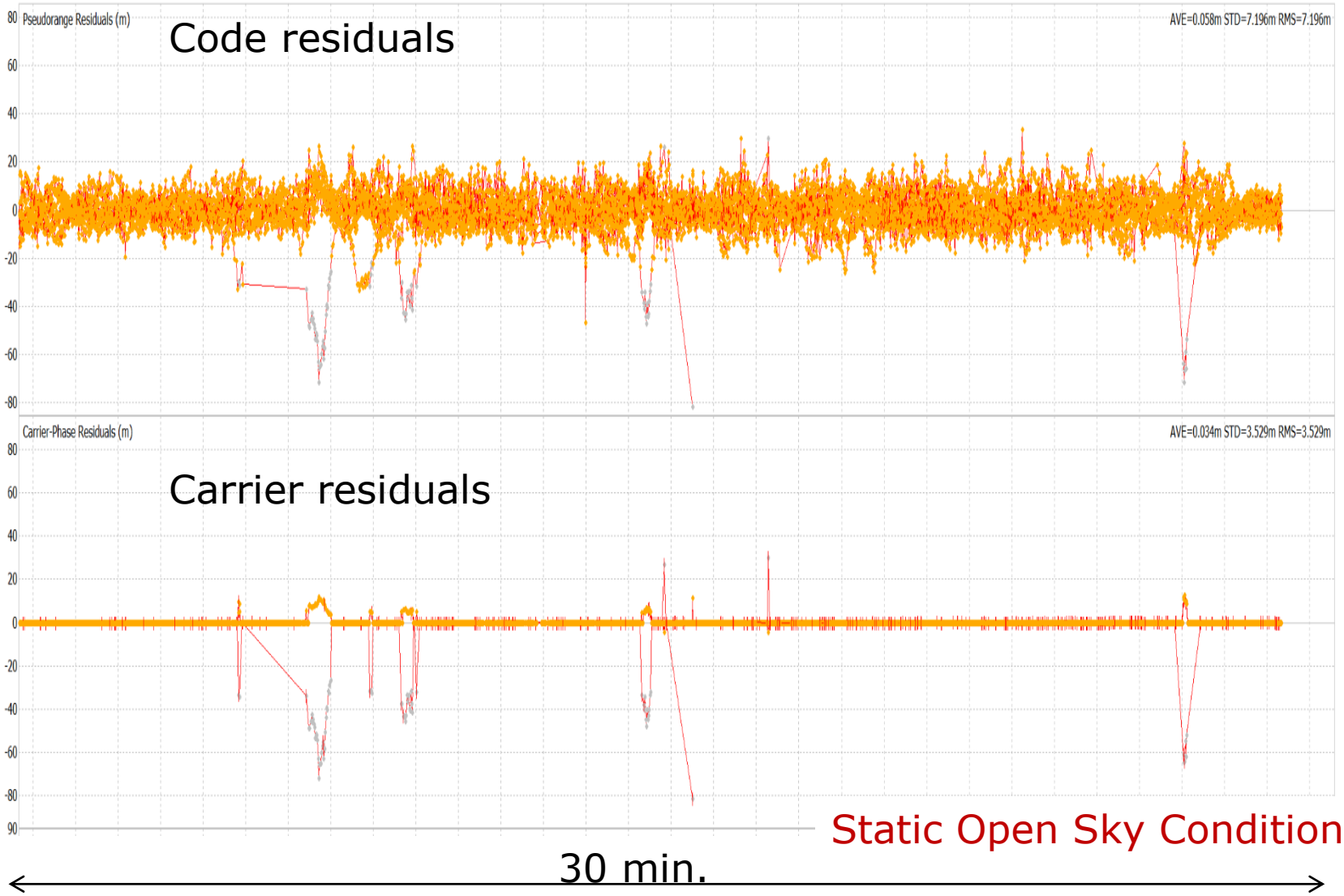


RTK with Retransmission-Residuals

- Code and Carrier Residuals (after outlier removal)
  - Code (L1+L5) Residual RMS = 1.802m
  - Carrier Residual RMS = 0.004m

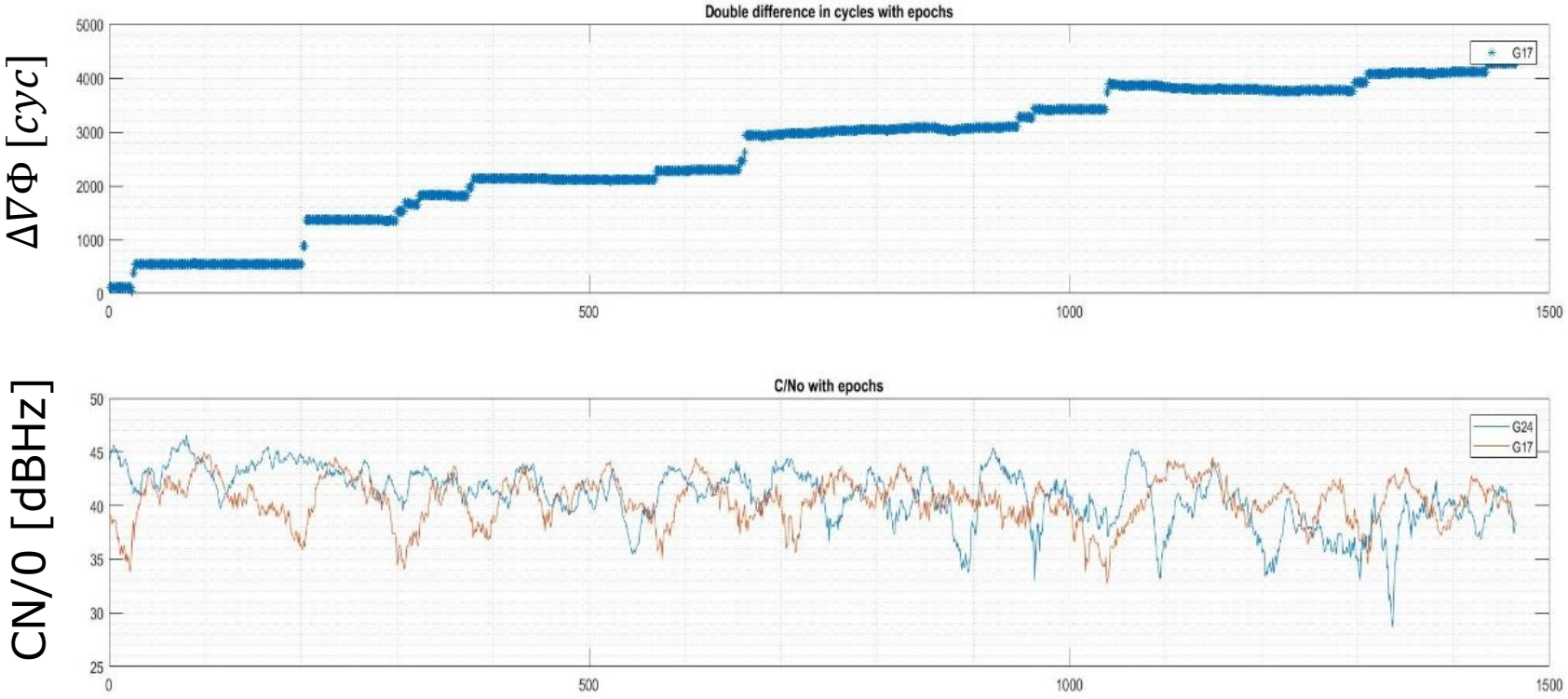


RTK with ≈15 cm baseline
Use of Smartphone Antenna



RTK with ≈15 cm baseline
Use of Smartphone Antenna

Double-Difference Analysis

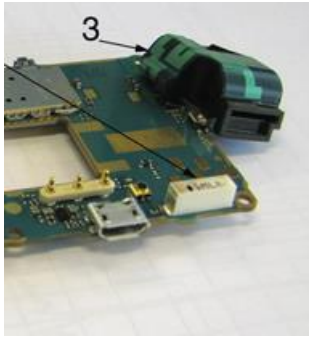


Static Open Sky Conditions!!!

Mass Market GNSS Antennas

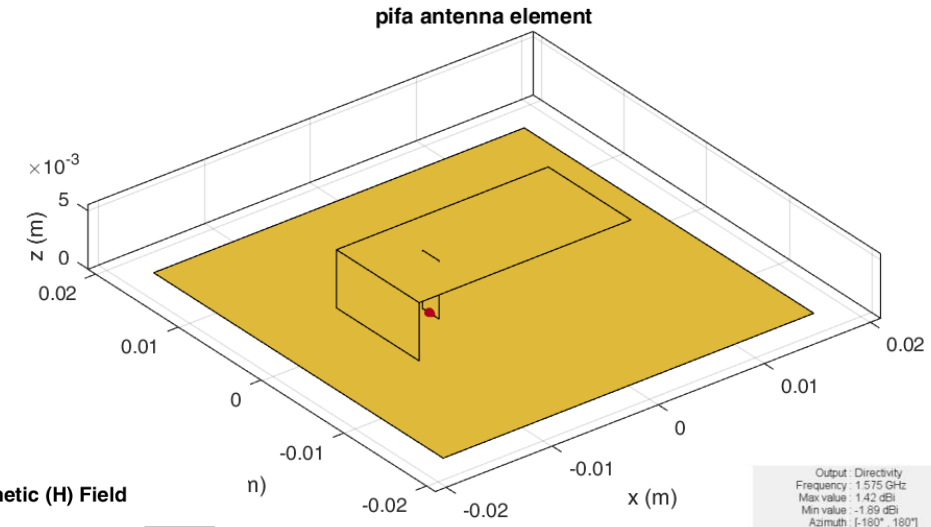
Wearable, flexible antenna

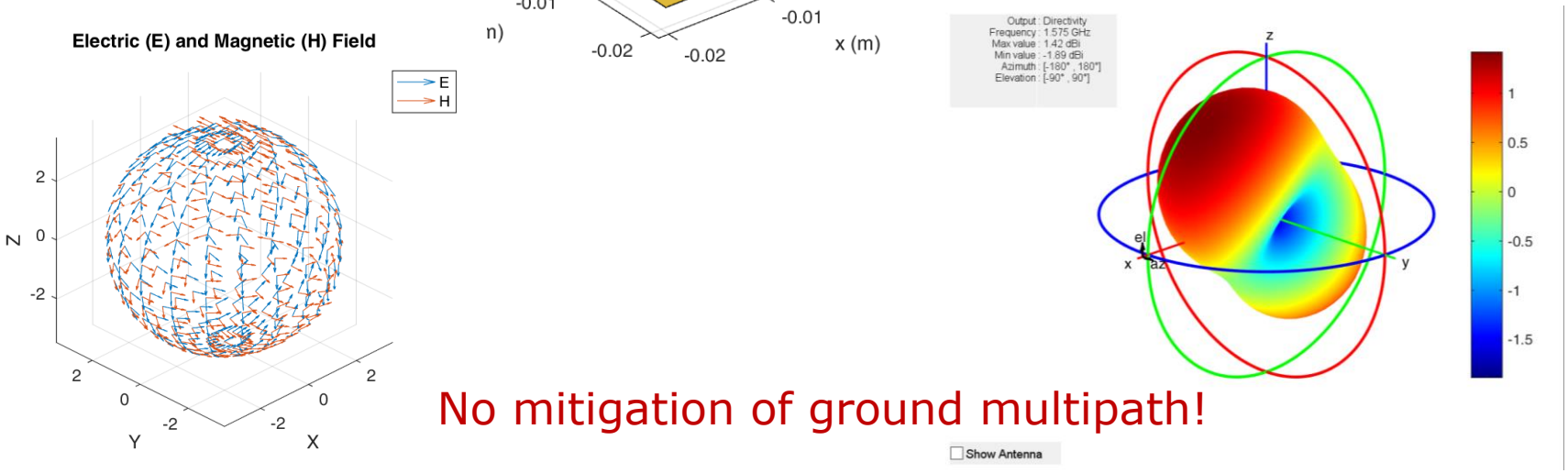
Smartphone antennas



Automotive antenna

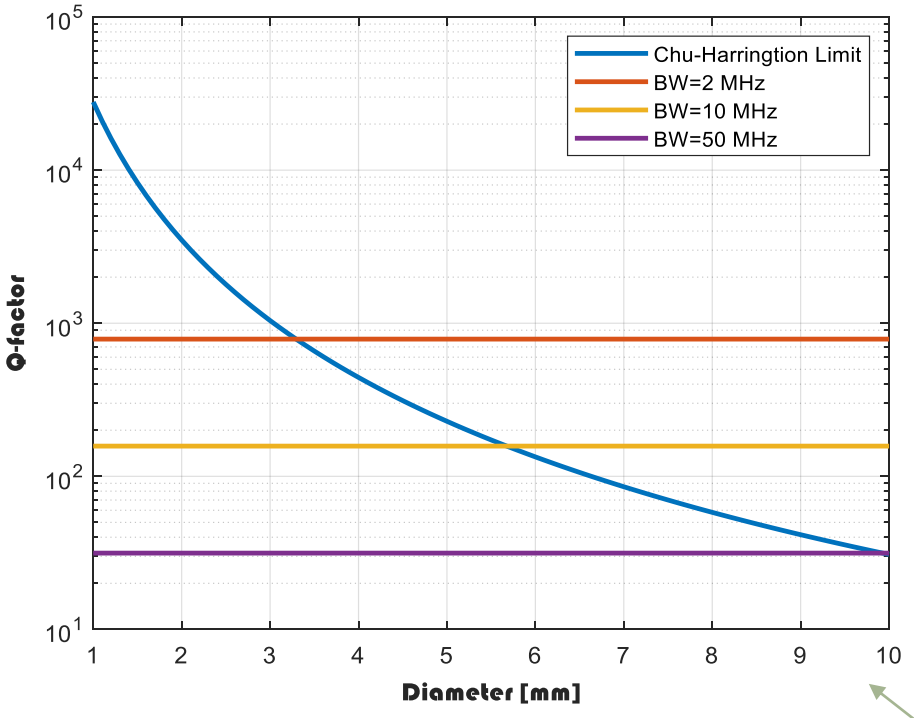
Antenna Analysis (Outline)





No mitigation of ground multipath!

Array Antenna Element Size



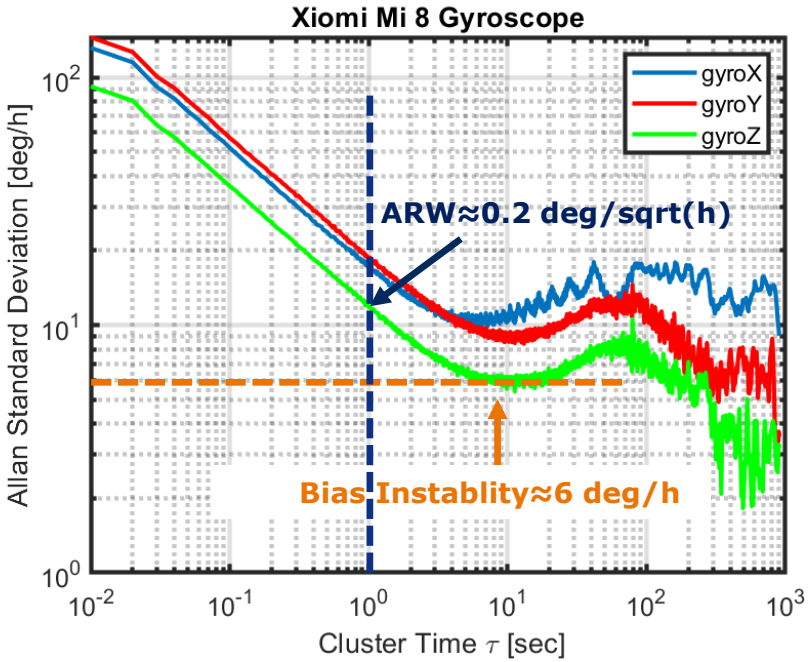
Chu-Harrington Limit

$f_0 = 1.575{,}42\ MHz$
$Q = f_0/BW$

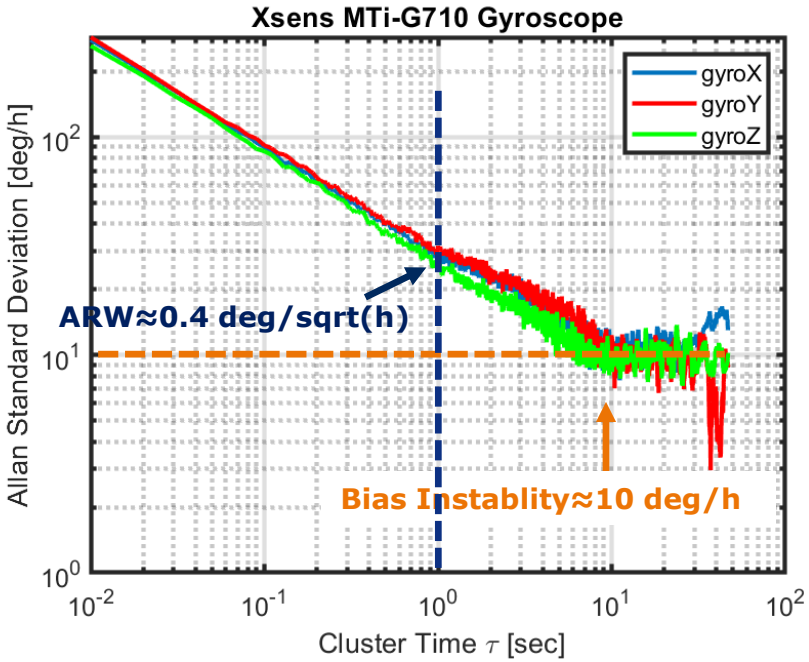
Minimum required diameter of an the antenna enclosing sphere, to achieve a certain Q-factor (=bandwidth)

Xiaomi MI8 Inertial Navigation

- Gyro Allan Deviation



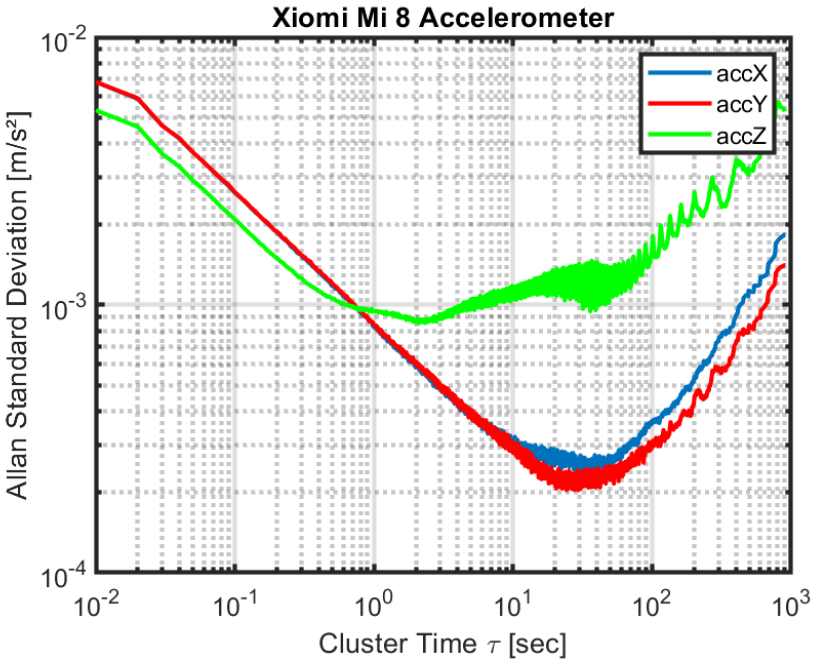
1€ Smartphone IMU



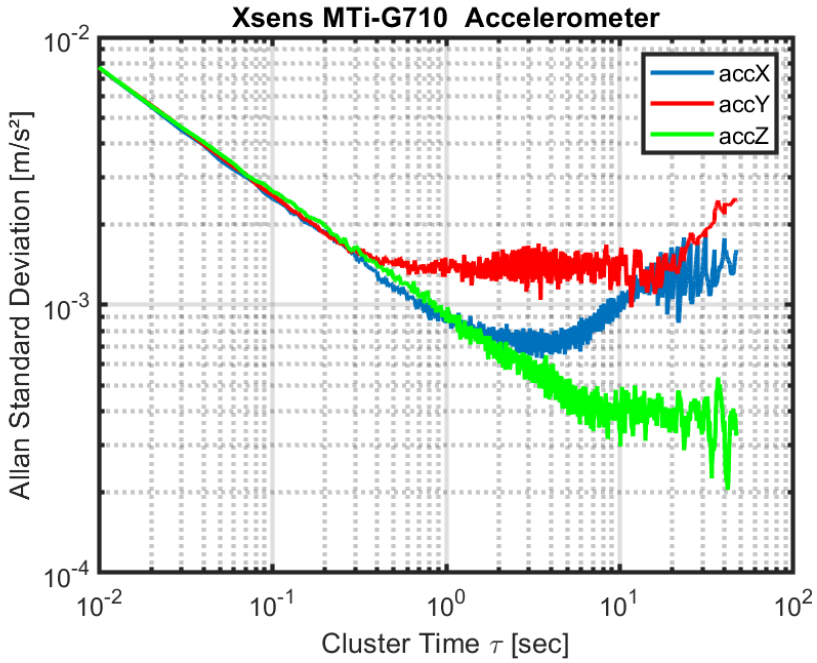
Commercial 2000 € MEMS IMU

Xiaomi MI8 Inertial Navigation

- Accelerometer Allan Deviation

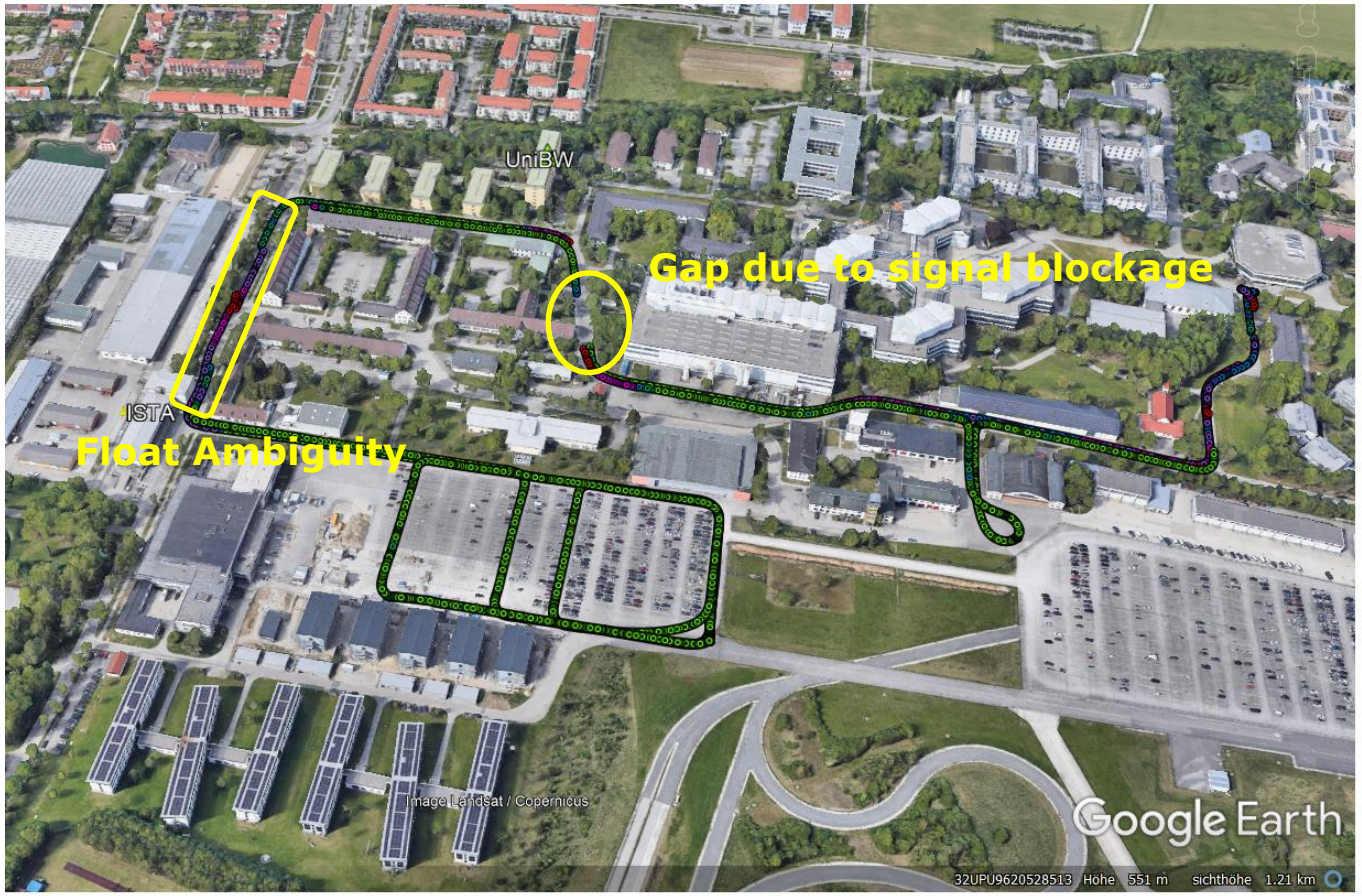


1€ Smartphone IMU



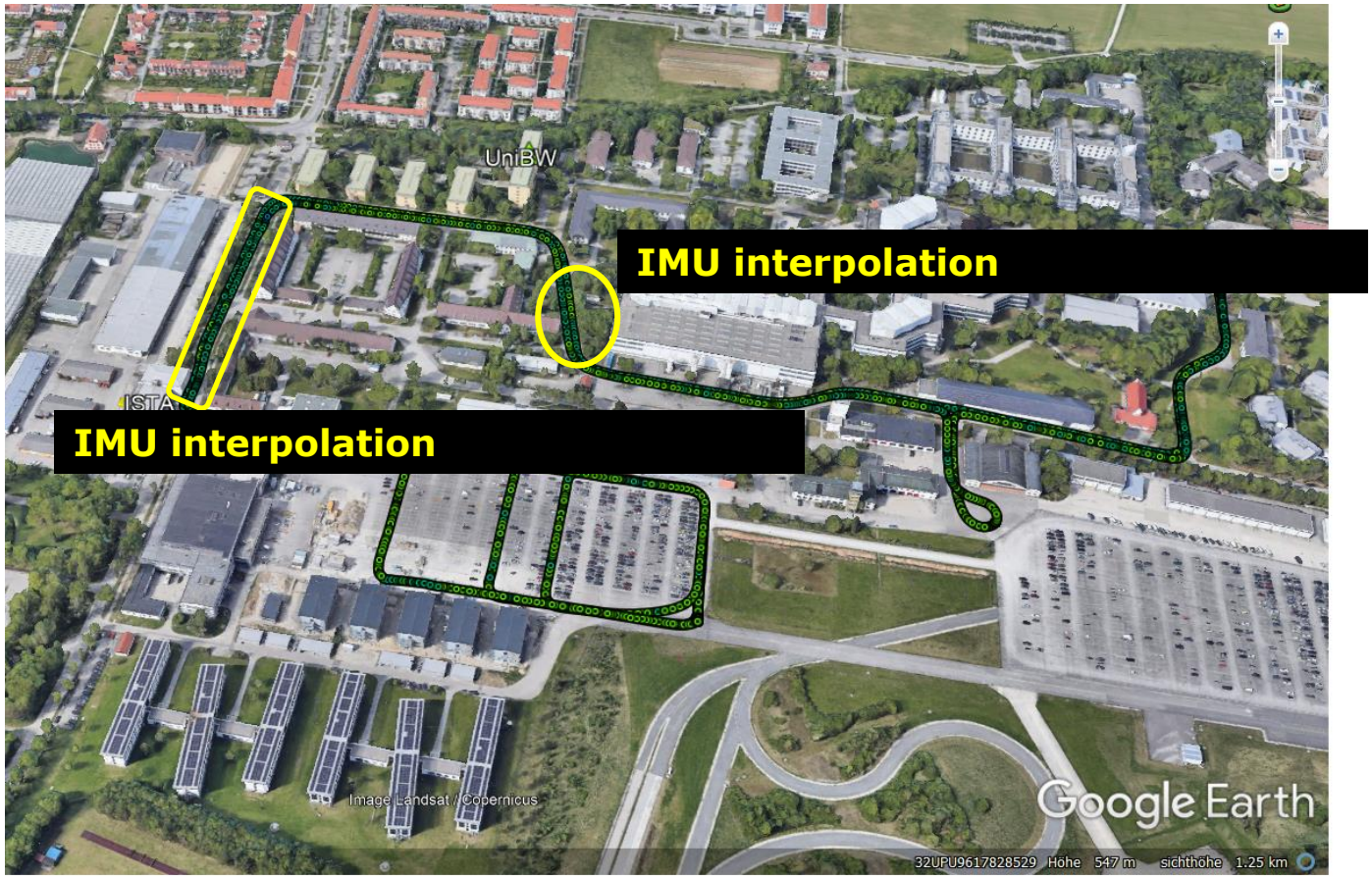
Commercial 2000 € MEMS IMU

Fusion: Trimble RTK + MI8 IMU



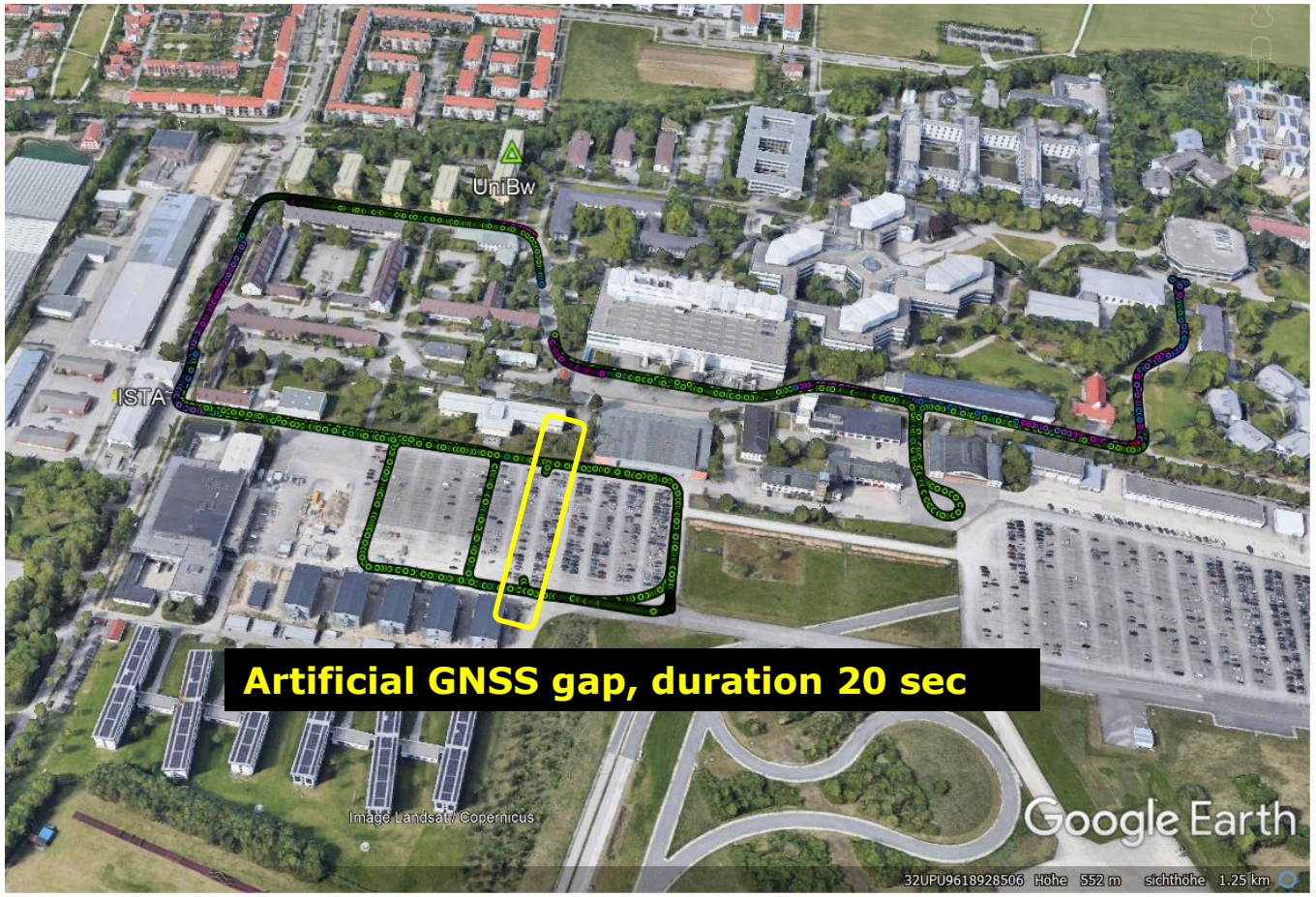
GNSS-only (Trimble Net R9)

Fusion: Trimble RTK + MI8 IMU



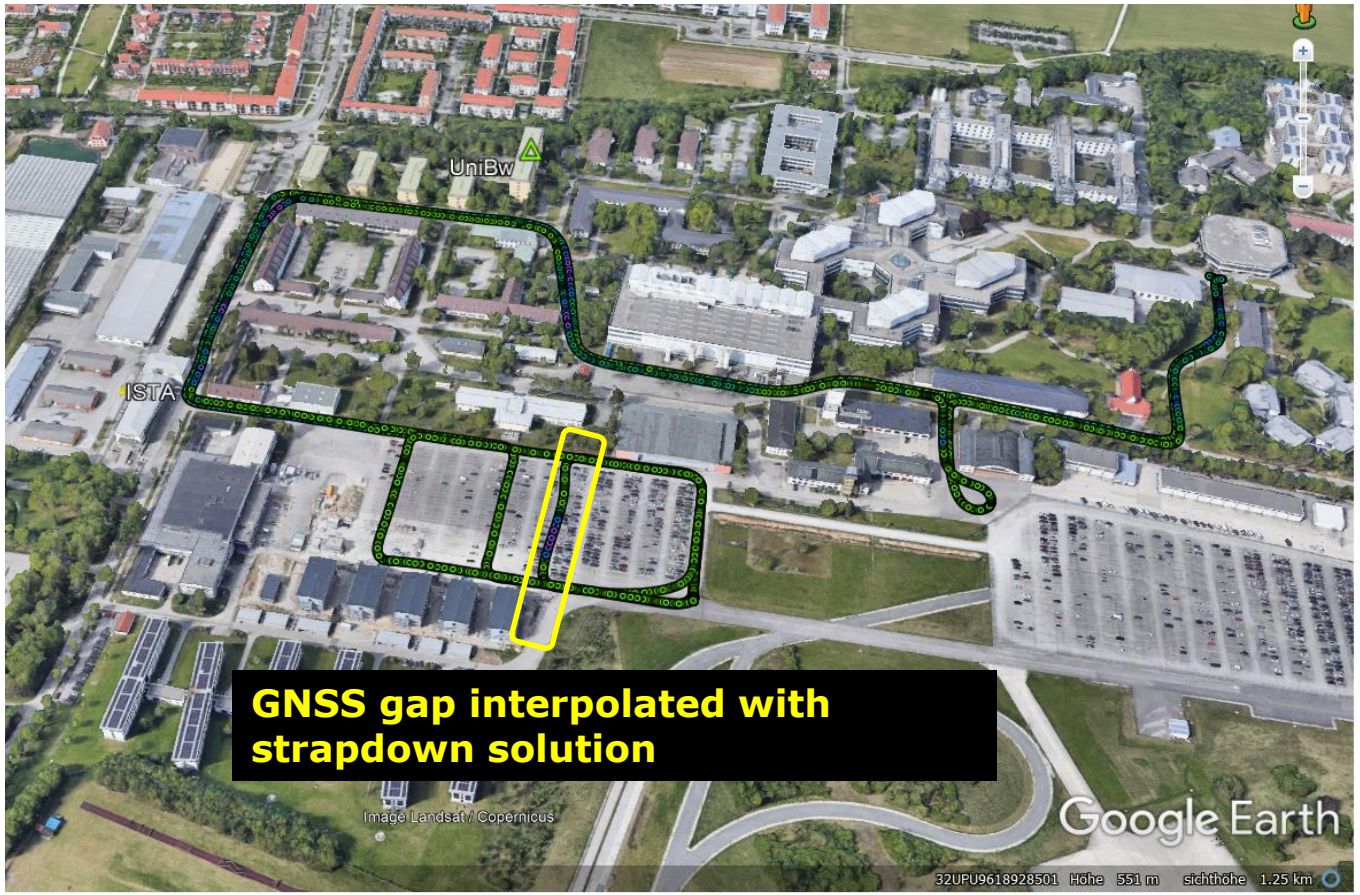
Loose coupling-INS/GNSS (Trimble Net R9 + Xiaomi Mi8 built-in IMU)

Fusion: Trimble RTK + MI8 IMU



GNSS-only (Trimble Net R9) – One artificial gap was introduced

Fusion: Trimble RTK + MI8 IMU



Loose-coupling-INS/GNSS (Timble Net R9 + Xiomi Mi8 Built-In IMU)
– One artificial gap was introduced

3-30 € GNSS-PPP Receiver – Research

...

to survive the attack of the cloud

Signal Processing – Acquisition/ Tracking

Text book style solved!!!

Deep GNSS/IMU
Super correlation
Synthetic aperture
Array processing

Antenna

Research on **small / uncalibrated antennas**

Correction Data

Precise correction data (PPP incl. phase biases)

Reliable, outage-tolerant data link / data format

New GNSS signals

Research on **support to ambiguity fixing**

Higher frequency to support smaller (and more) antennas

Thank You !

RAMBO wird durch das Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages gefördert (FKZ: 50NA1720) und vom Projektträger des Deutschen Zentrums für Luft- und Raumfahrt (DLR) in Bonn verwaltet.

ISTA
INSTITUTE OF
SPACE TECHNOLOGY & SPACE APPLICATIONS

DLR Deutsches Zentrum für Luft- und Raumfahrt

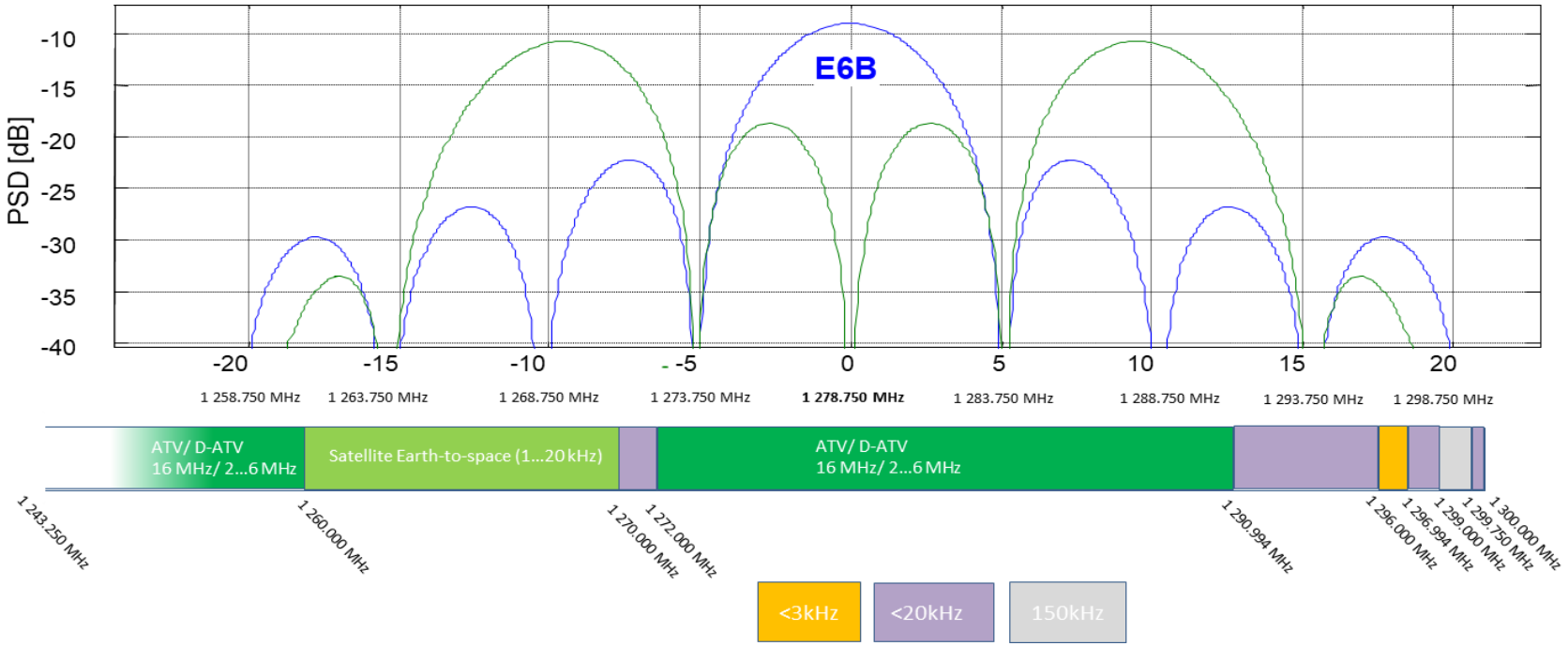
Backup

Amateur Radio Interference on E6

Problem, Test-measurements at UniBw M,

Results with and w/o interference mitigation

Frequency plan according to IARU (Region 1)



Galileo E6 Spectrum in comparison with the band plan (incl. bandwidth) of Amateur Radio Applications (IARU Region 1)

Coexistence between Galileo E6 and Amateur Radio

- ISTA supports the „Bundesnetzagentur“ (BNetzA) to investigate the influence of Amateur Radio signals to the Galileo E6 services
  - BNetzA supervised tests
    (includes the writing of a test plan with the partners)
  - ISTA provided the GNSS and test equipment
  - RTA organized the amateur radio transmitters
- **Objectives:**
  - Creation of the situational awareness
  - *Definition of criteria for coexistence*
  - No pre-judgment within the test results
- **Situation:**
  - Even that the signal allocation of Galileo E6 came later as of amateur radio, they are declared as primary users. Amateur radio is using the band as secondary user.

European Conference of Postal and Telecommunications Administrations
– 48 European countries cooperating to regulate posts, radio spectrum and communications networks
CEPT ECC Electronic Communications Committee

Bundesnetzagentur

Universität der Bundeswehr München

Runder Tisch Amateurfunk e.V. (RTA)

First preliminary results (Group 3: FM Voice)