Flying Smartphones on UAVs to Avoid Multipath for Successful Carrier Phase Ambiguity Fixing

Mohamed Bochkati (M. Sc.)

Institute for Space Technology and Space Applications (ISTA)

Faculty of Aerospace Engineering (LRT)

Universität der Bundeswehr München

Agenda

- State of Research
- Experimental Setup
- Data Processing
- Results
- Conclusion

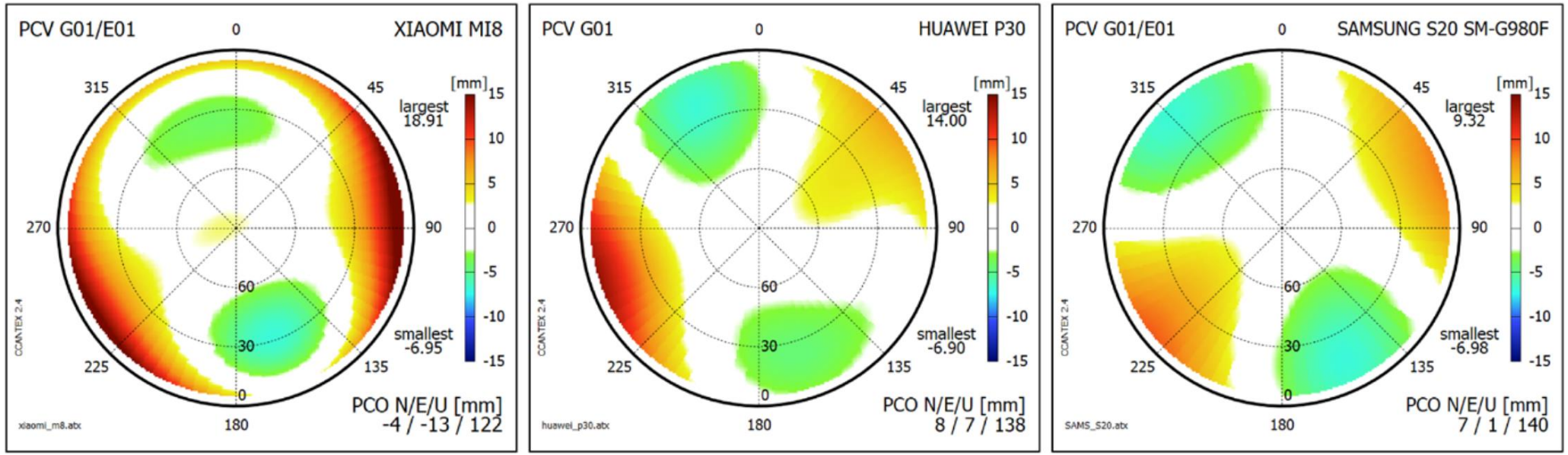
State of Research – cm-Level Positioning

- **What we want?**
  - reliable
  - cm-level positioning
  - with smartphones (low-cost GNSS receiver + low-cost antenna)

- **What we need?**
  - Carrier-phase positioning
  - with high ambiguity fixing rates
  - and calibrated PCO and PCV

State of Research – cm-Level Positioning

- PCO and PCV analysis
- Azimuth and elevation-dependent C/N0 analysis

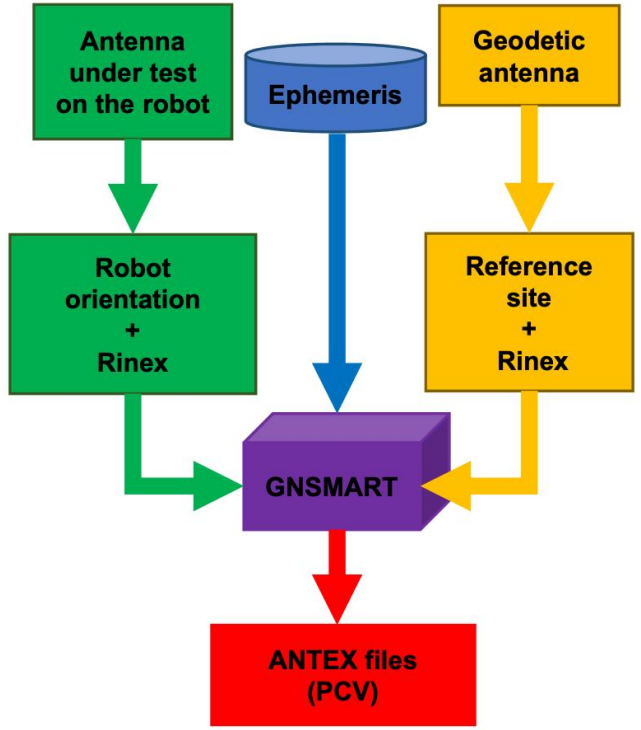


- Hesselbarth, Anja & Wanninger, Lambert. (2021). GNSS-Messungen mit Smartphones–Analyse der Beobachtungsdaten und cm-genaue Positionsbestimmung. ZFV - Zeitschrift fur Geodasie, Geoinformation und Landmanagement. 3/2021. 189-197.

State of Research – cm-Level Positioning

- Robot-based PCO and PCV calibration

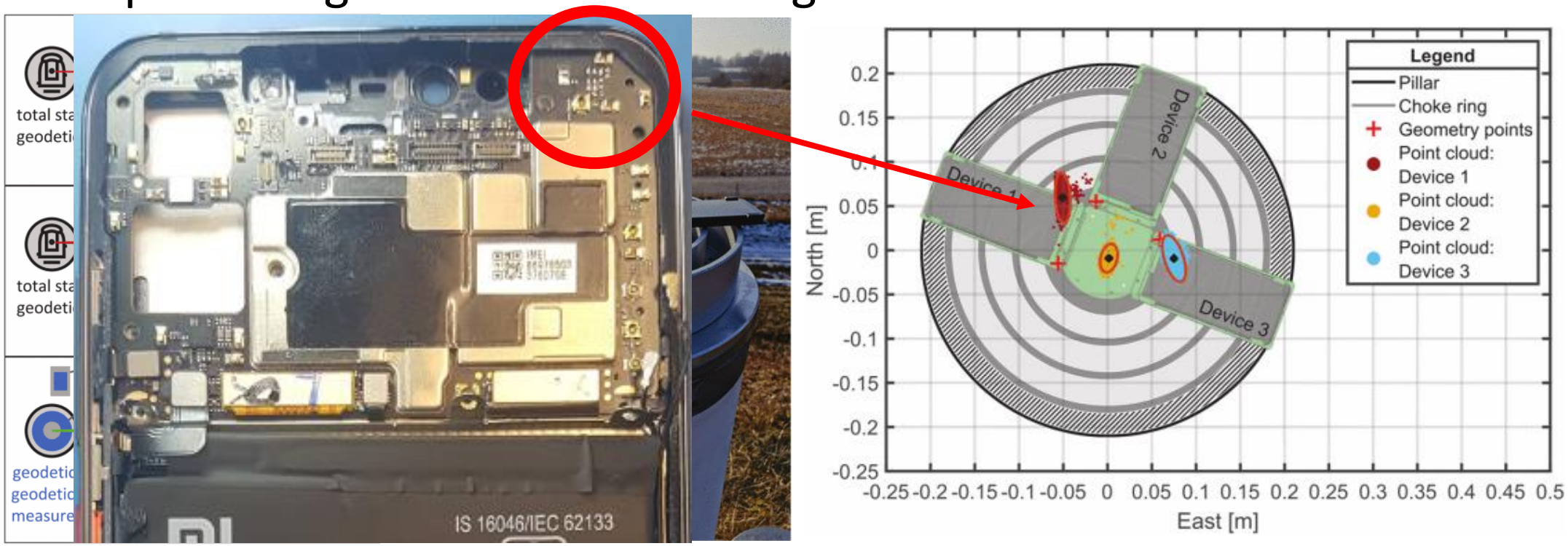
Fig. 1 From left to right: robot antenna calibration setup and simplified processing scheme of the calibration of the smartphone antenna. The Mate20X was carefully mounted, allowing the device to be continuously charged



- Darugna, Francesco & Wübbena, Jannes & Wübbena, Gerhard & Schmitz, Martin & Schön, Steffen & Warneke, André. (2021). Impact of robot antenna calibration on dual-frequency smartphone-based high-accuracy positioning: a case study using the Huawei Mate20X. GPS Solutions. 25.

State of Research – cm-Level Positioning

- Multipath mitigation with choke-ring antenna



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- Sharma, H., Bochkati, M. and Pany, T. (2019). Influence of the Multipath Mitigation on Precise Positioning with Smartphone Raw GNSS Measurements. Proceedings of the ISGNSS 2019, Jeju, South Korea.

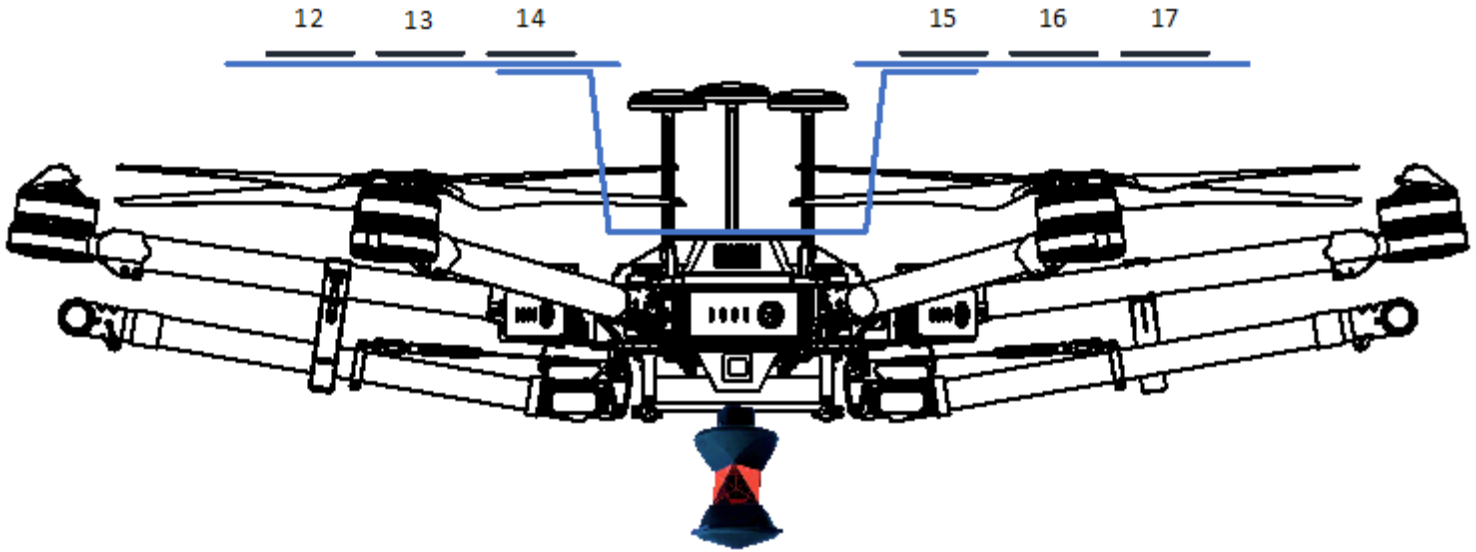
Idea and Hypothesis

- **Idea:** mitigate (ground-) multipath and enhance C/N0 without choke-ring antenna by „flying away“ from multipath

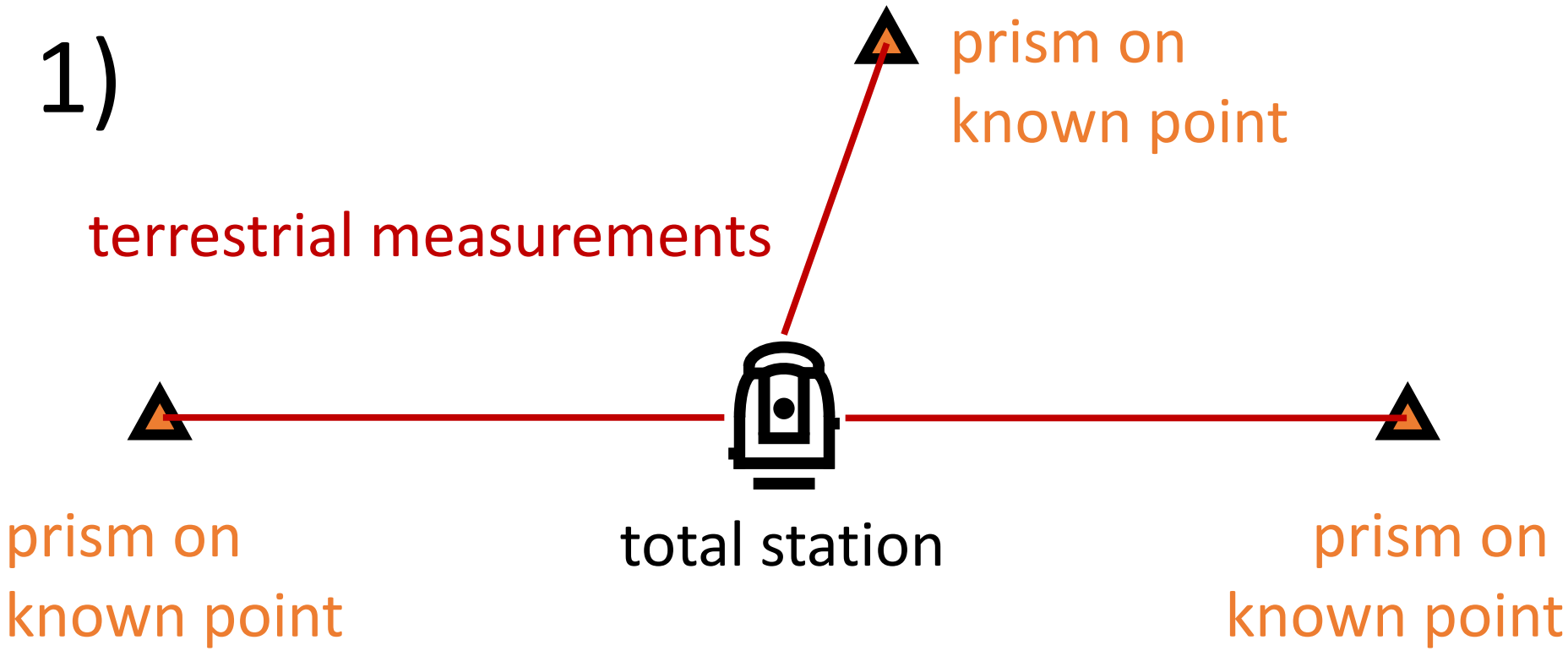
- **Hypothesis:**
  - Influence from multipath decreases with height over ground
  - Carrier-phase ambiguity fixing rates increases with height over ground

Experimental Setup

- Test Devices: **6 x Xiaomi Mi 8** with Broadcom BCM47755 GNSS chip
- Drone platform: DJI M600 Pro
- Terrestrial ground truth: Multistation Leica MS60

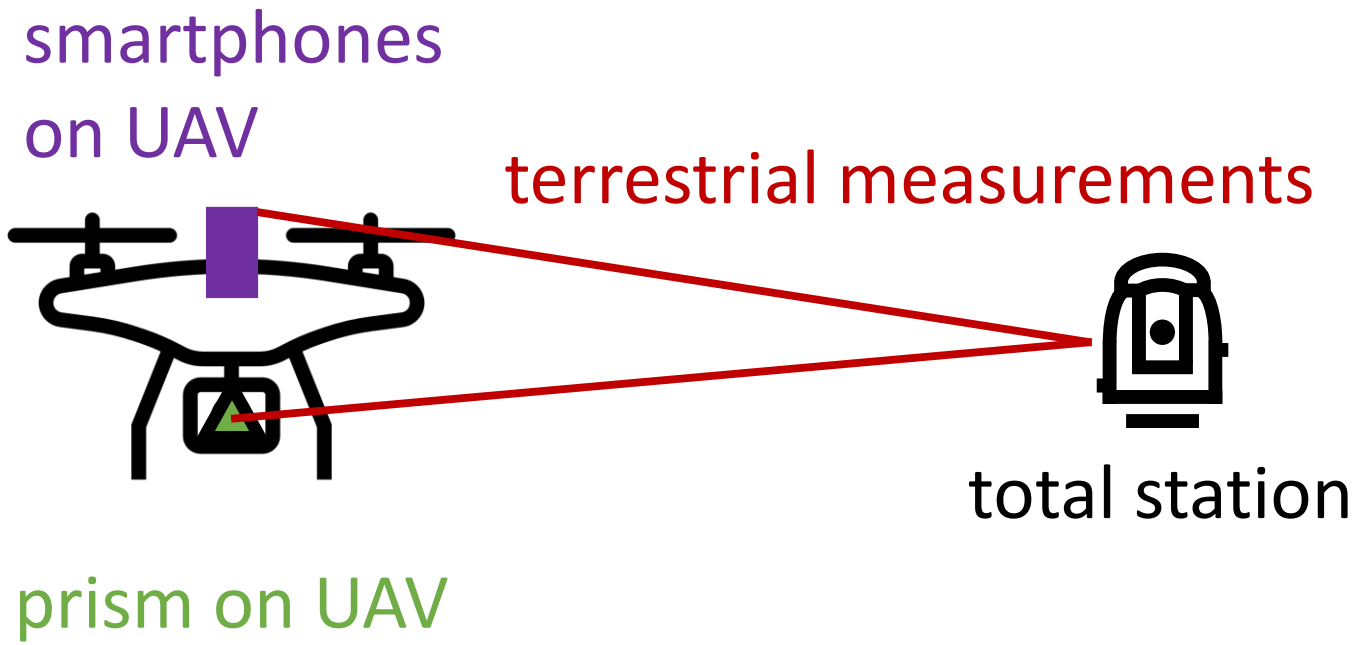


Experimental Setup



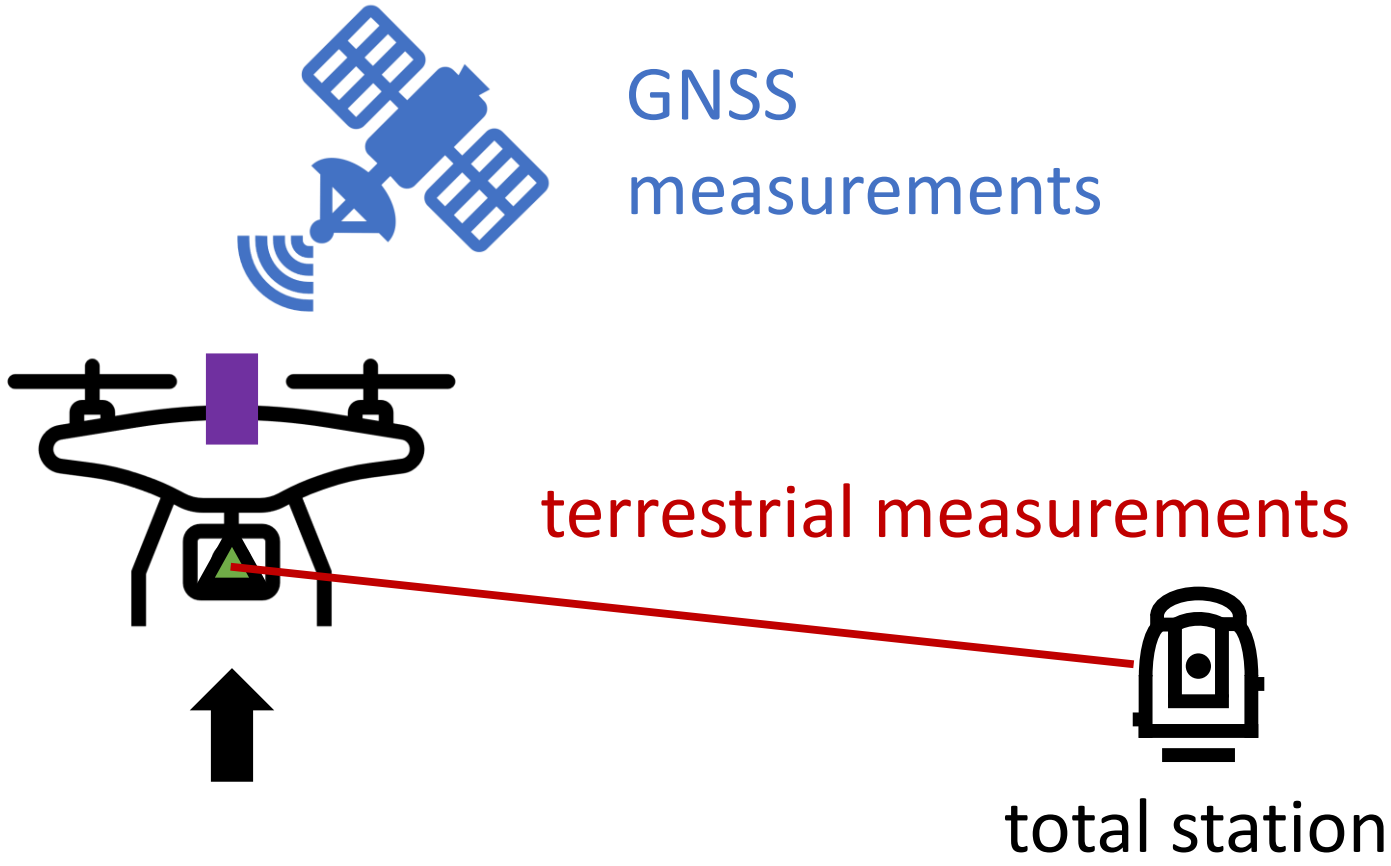
Experimental Setup

2)



Experimental Setup

3)

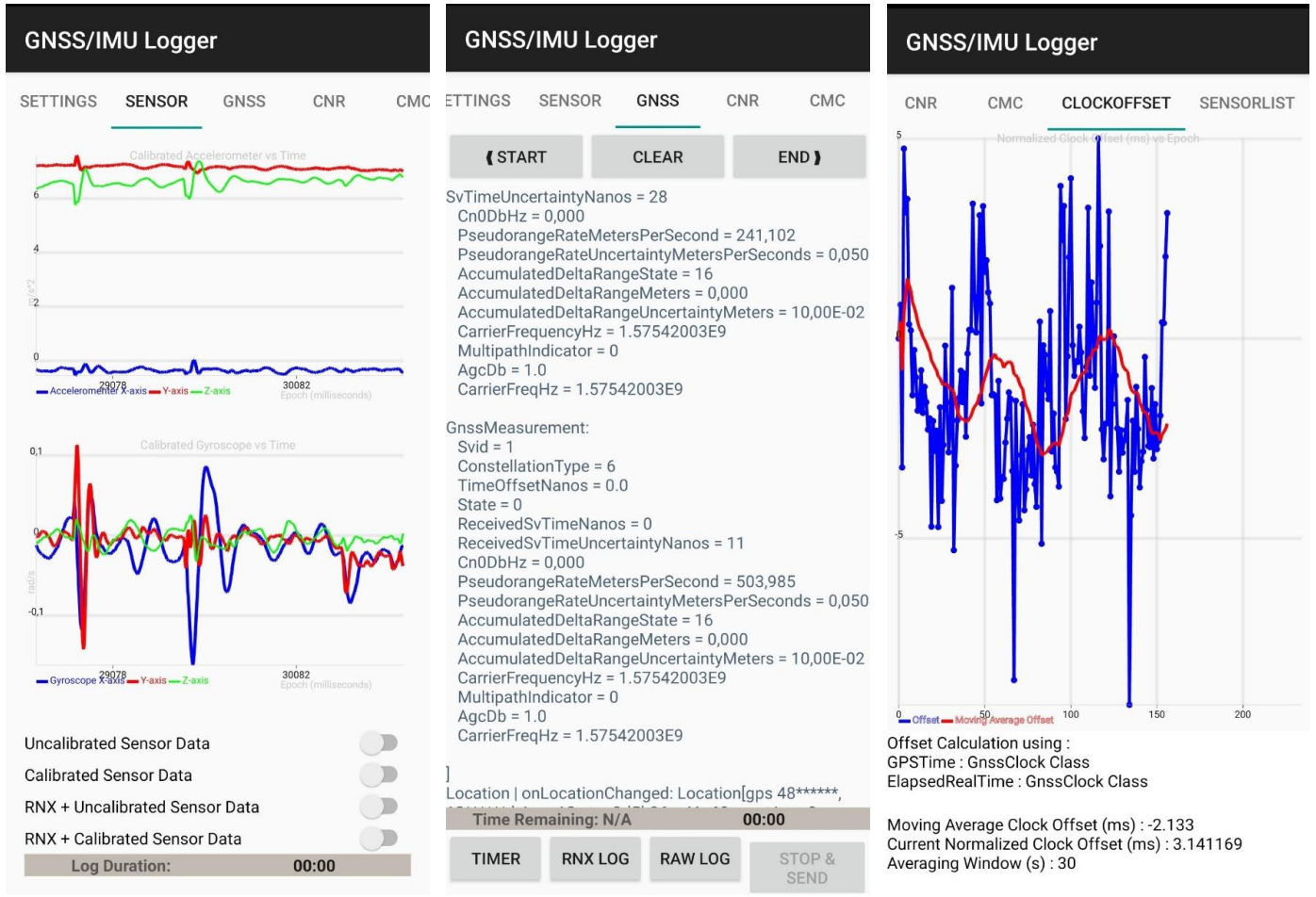


Experimental Setup

- Real impressions from the experiment

GNSS/IMU Logger

- Logger for time-synchronous RINEX and IMU data
- Available in Google Play Store

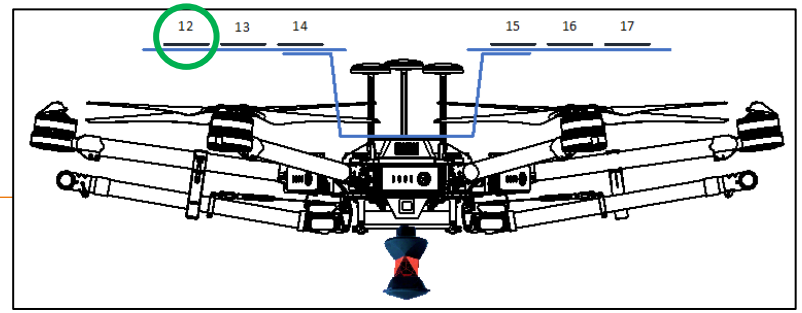


- ISTA-UniBw M (2021). GNSS/IMU Logger (Version v2.1.0.0) [Mobile app]. Retrieved from https://play.google.com/store/apps/details?id=com.ista.android.apps.location.gps.gnsslogger&hl=de&gl=US

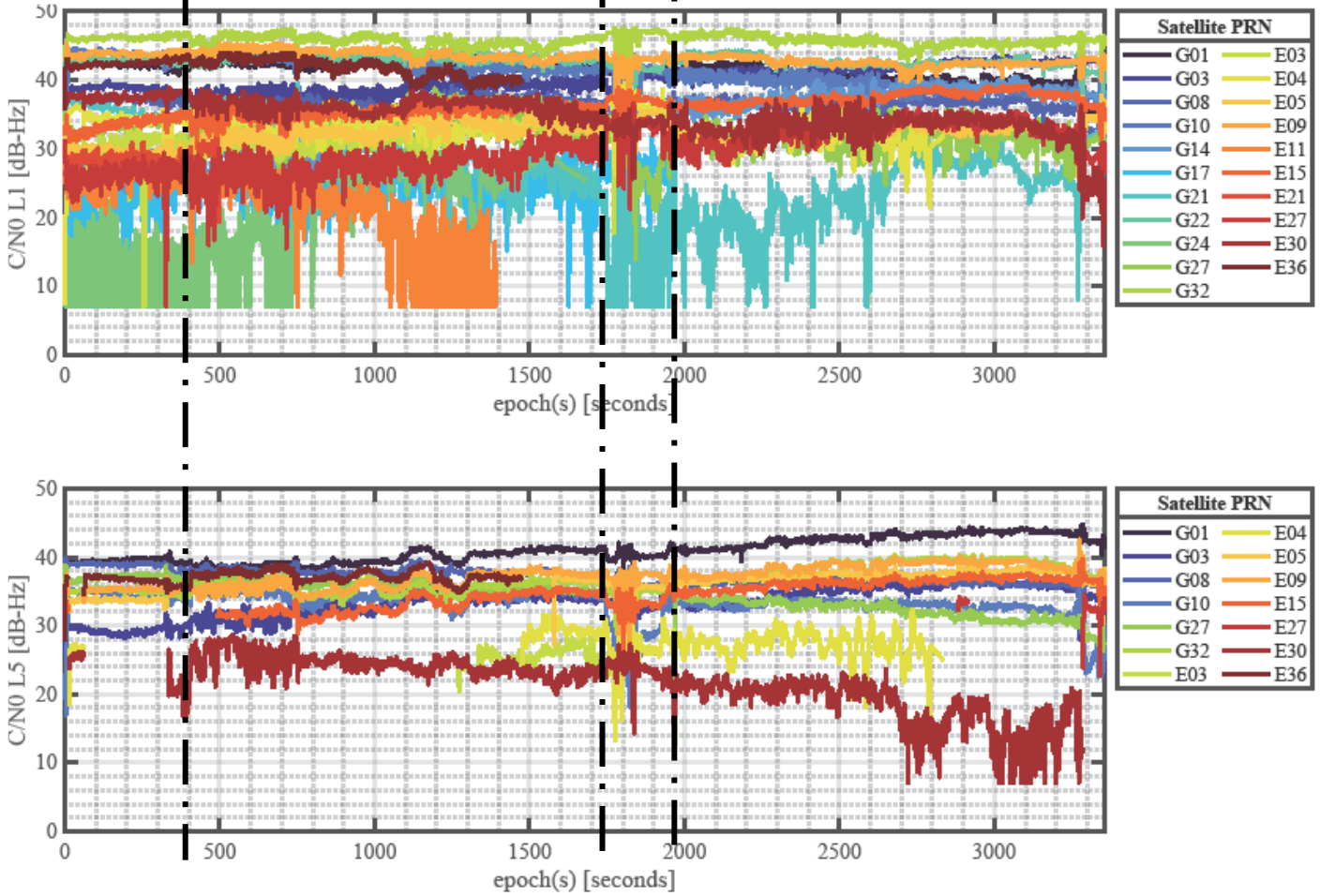
Data Processing

- Geodetic reference station (baseline < 1 km) on campus site
- Time synchronisation between terrestrial and GNSS measurements
- Code-minus-carrier (CMC) method for multipath calculation
- NovAtel Inc. Inertial Explorer (version 8.70.4301) for RTK processing

Results (Device 12, best)



- Carrier-to-noise ratio



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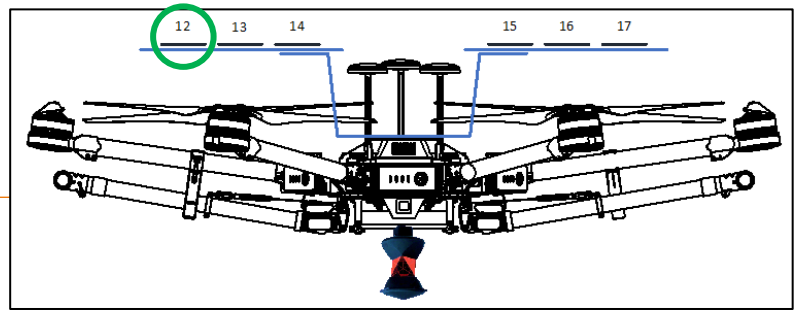
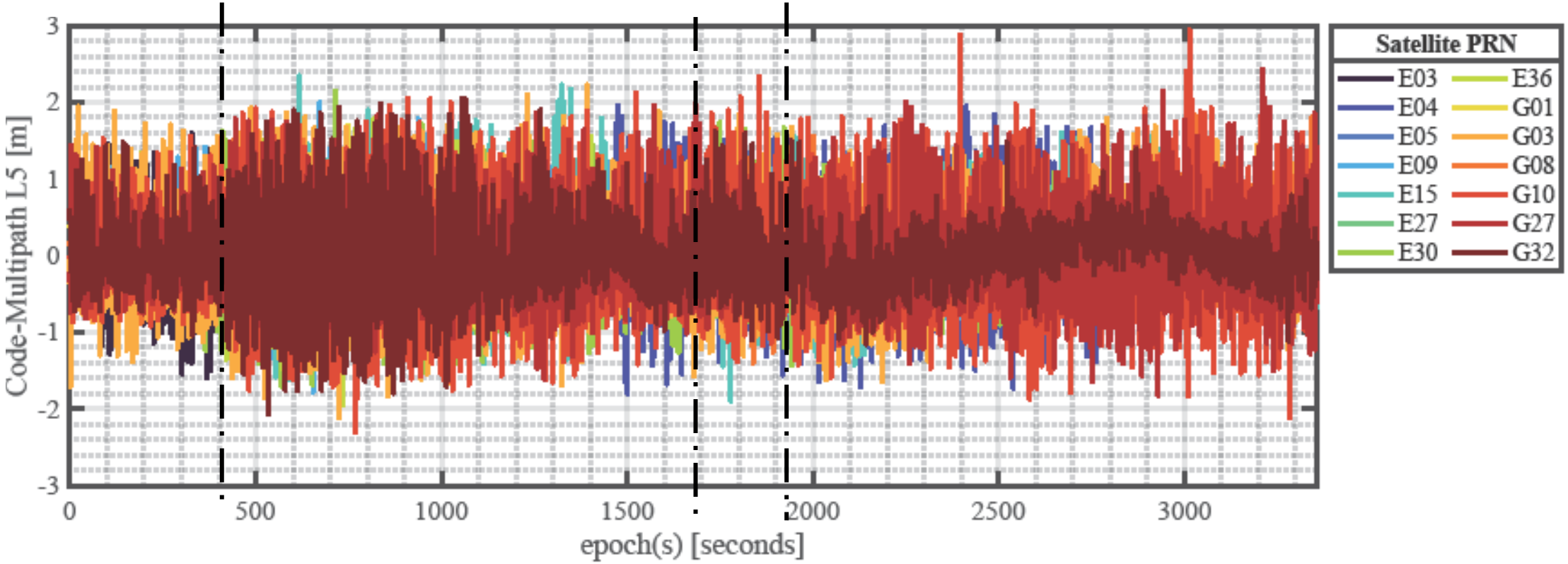


- Multipath L1



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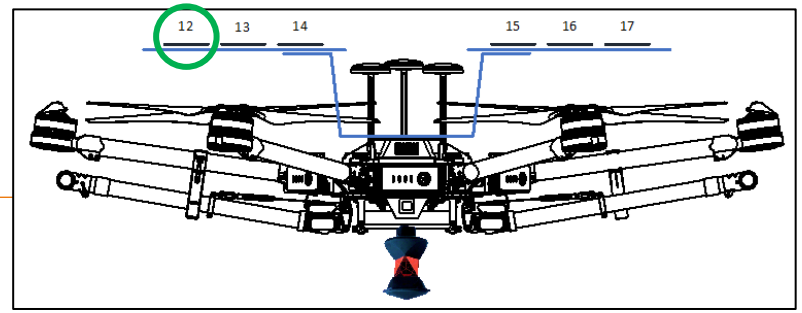
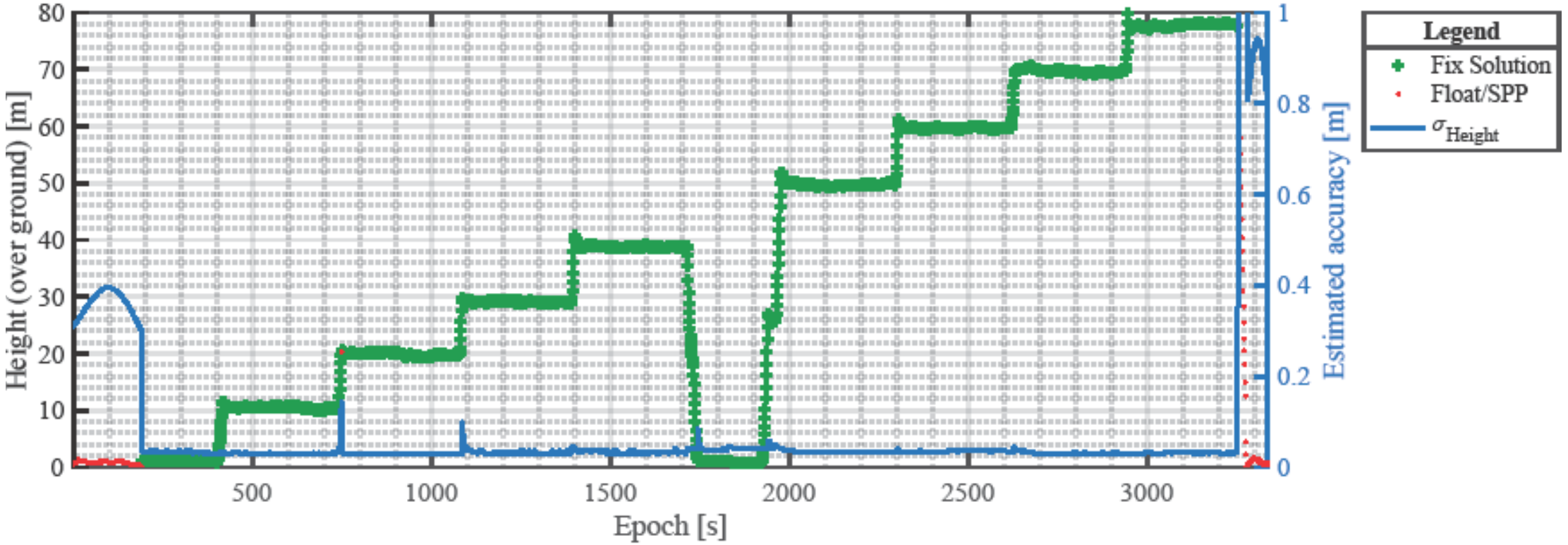


- Ambiguity fixing



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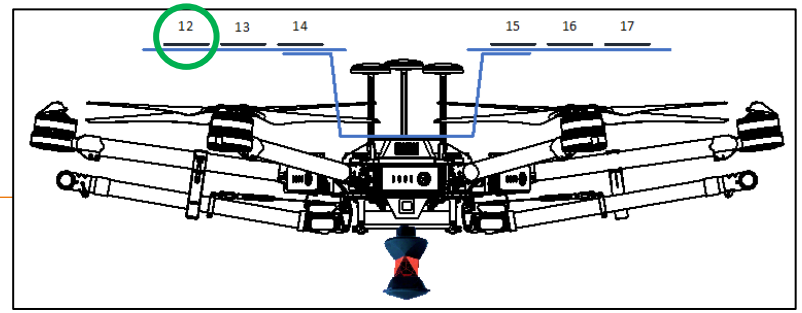
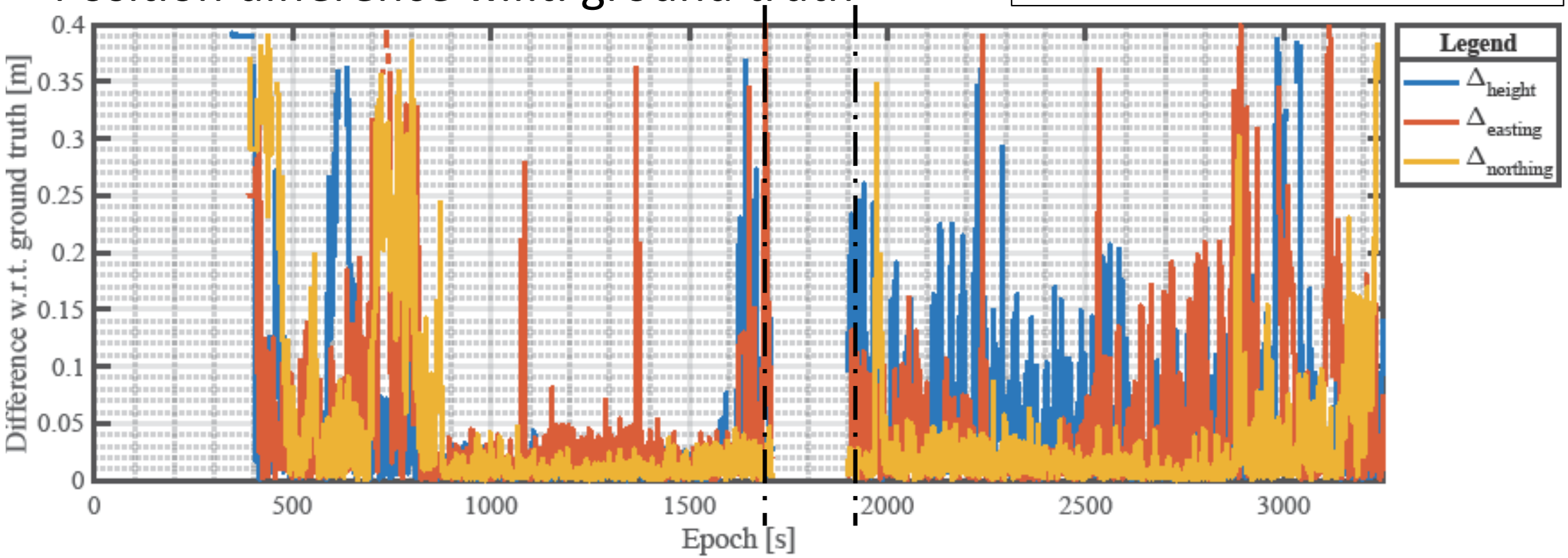
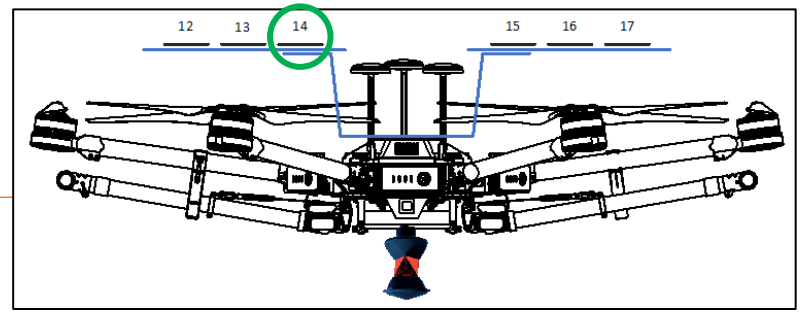


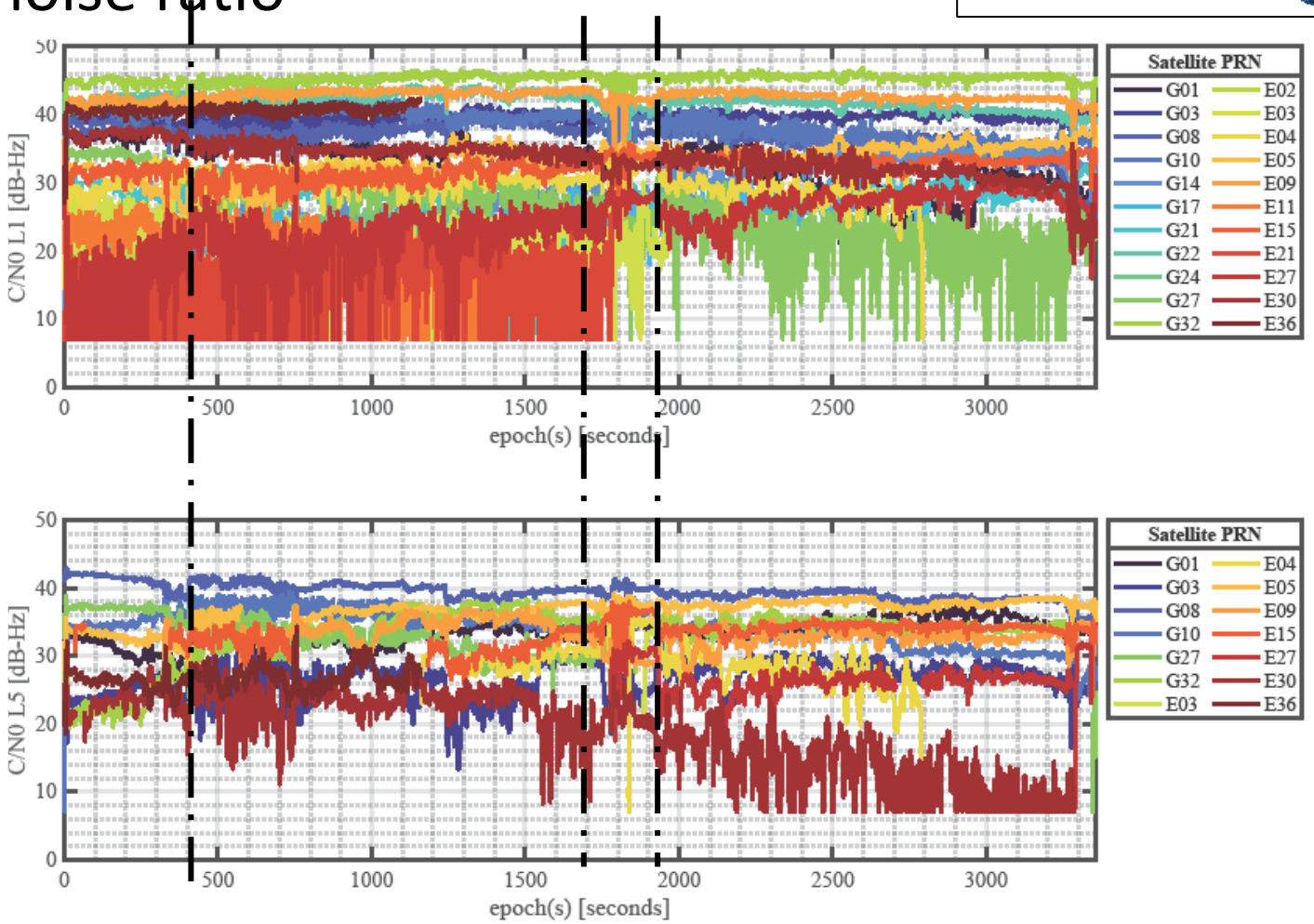
- Position difference w.r.t. ground truth



Results (Device 14, worst)



- Carrier-to-noise ratio



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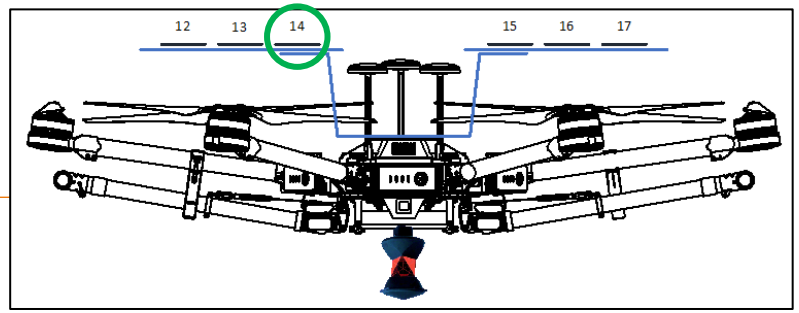

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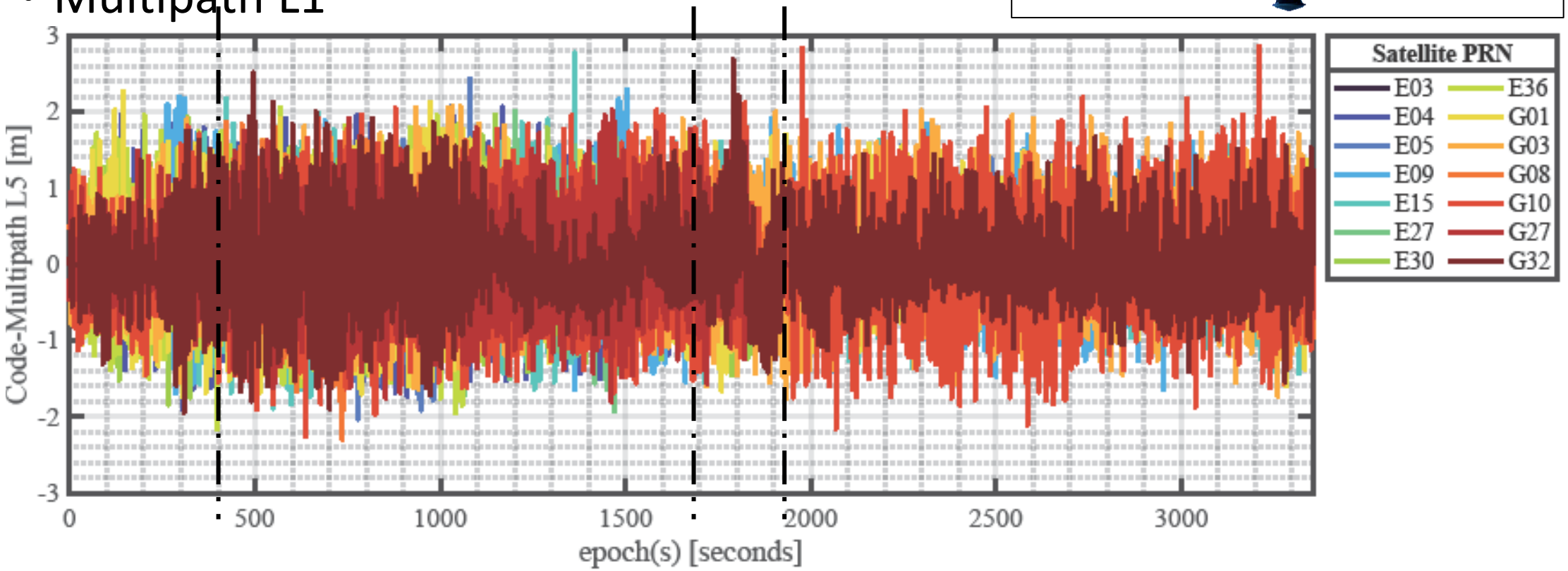

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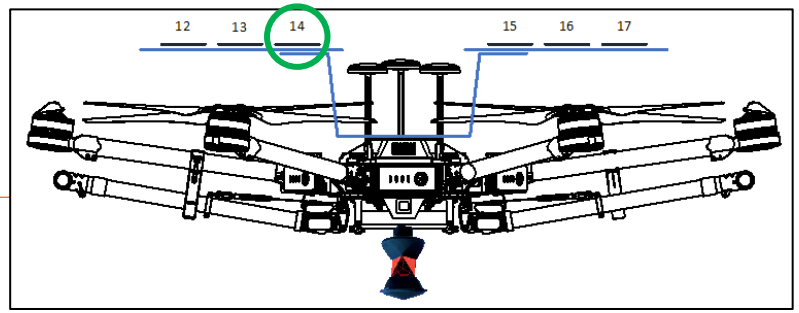
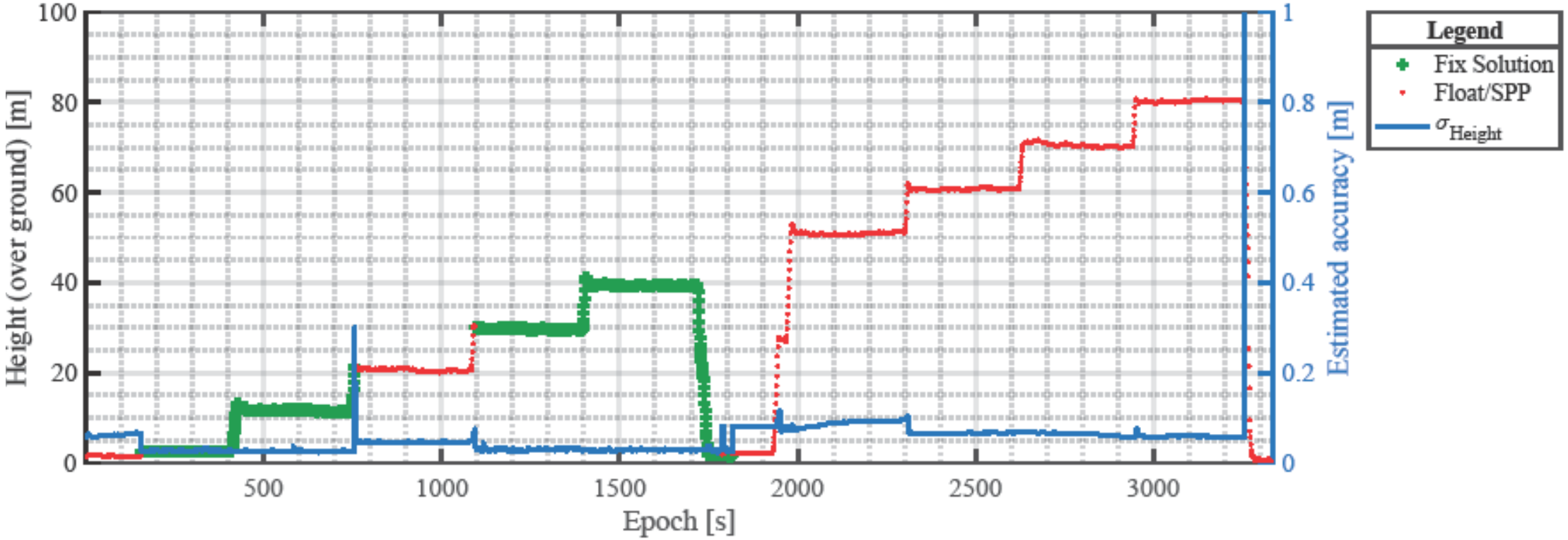


- Ambiguity fixing



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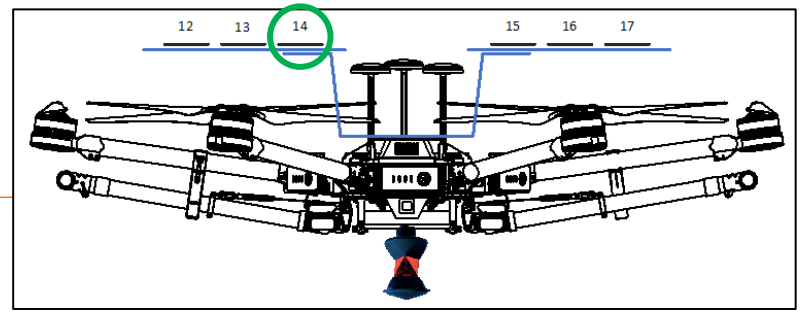

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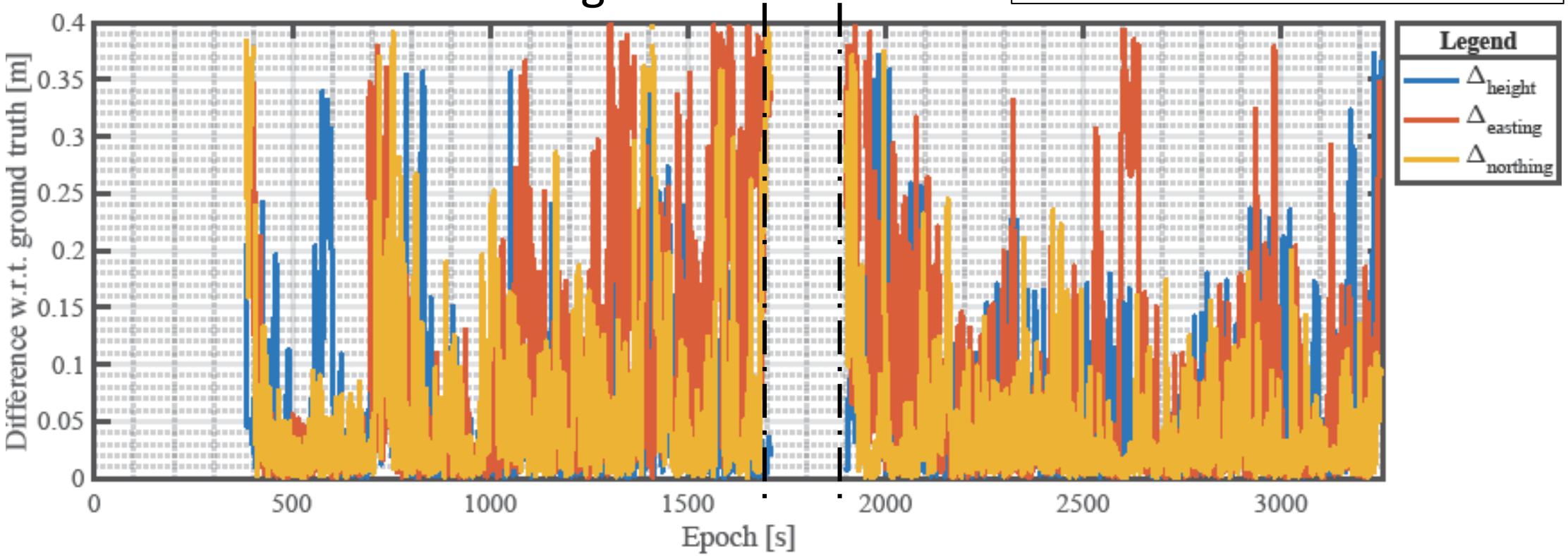
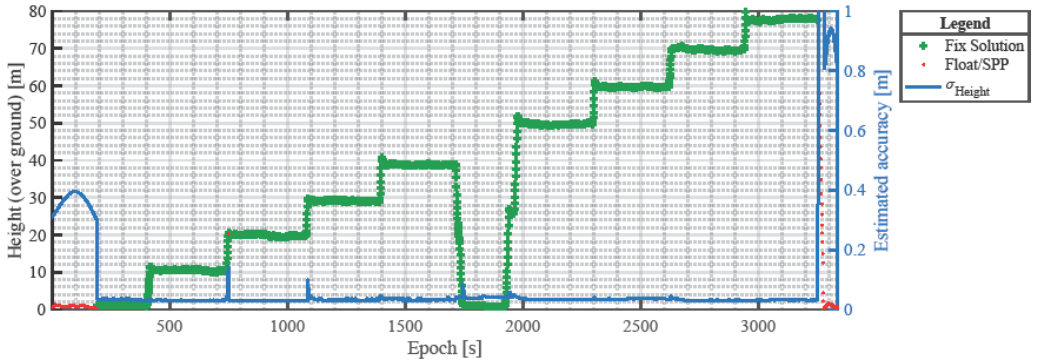


Results (Overview)

12



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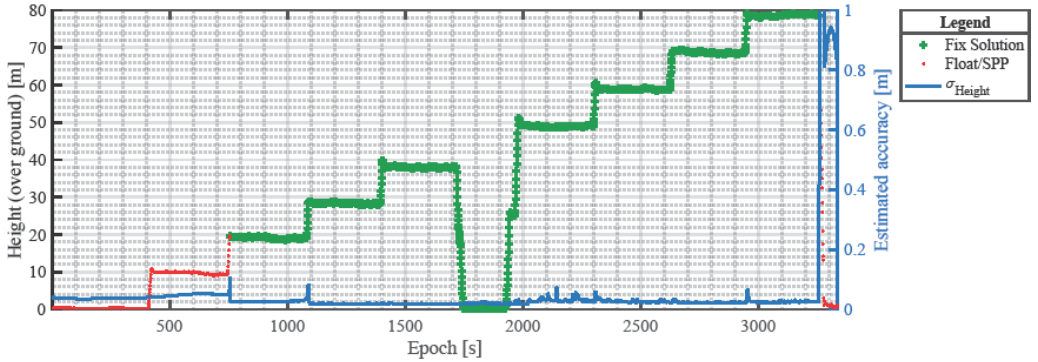

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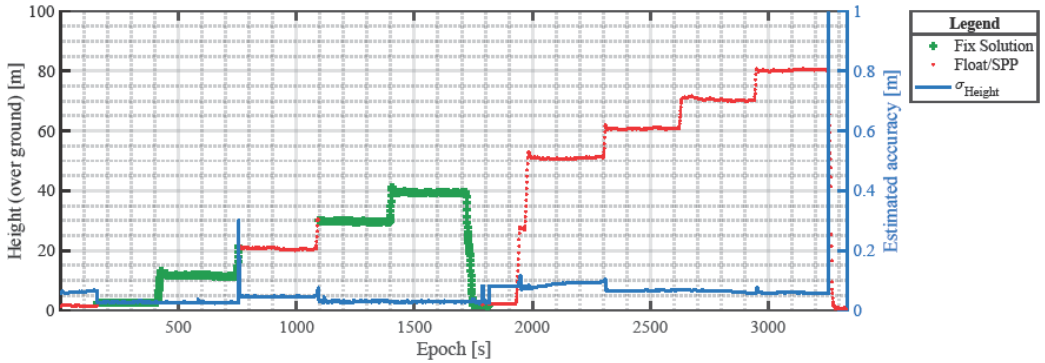

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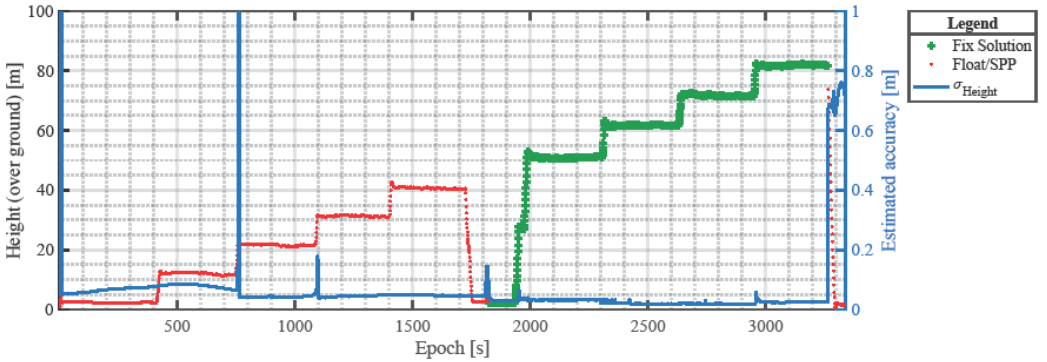

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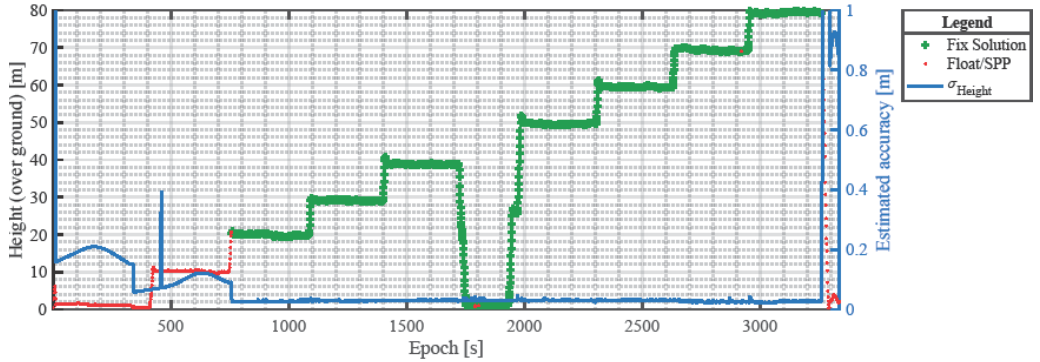

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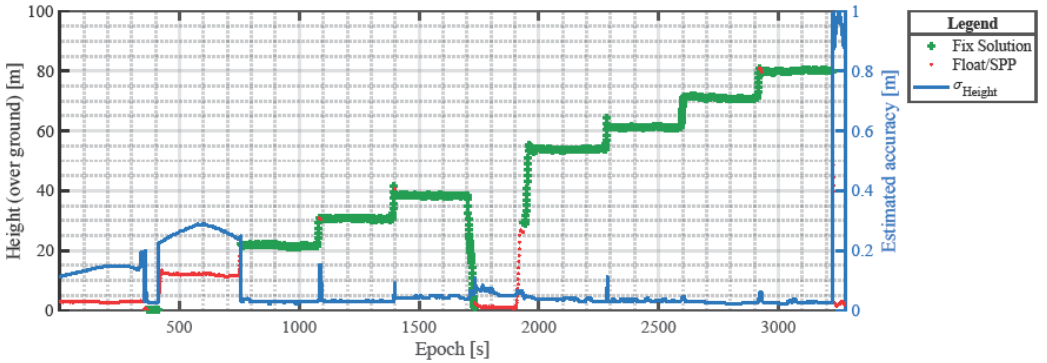

Results

Smartphone device		12 (best)	14 (worst)
fixing rate [%]	forward filtering	66	40
	backward filtering	26	0
	combined filtering	92	40

coordinate component	best (device 12)		worst (device 14)	
	mean	RMS	mean	RMS
Easting [m]	0.060	0.152	0.070	0.162
Northing [m]	0.065	0.134	0.072	0.140
Height [m]	0.080	0.180	0.119	0.215

Conclusion

- Multipath effect on smartphone GNSS receivers can be reduced, while the altitude increases
- No time-consuming calibration needed for adequate ambiguity fixing rates
- cm- or dm-level accuracy achieved without any hardware support (e.g. special antennas or retransmitting of signals)

Future Work

- Replace drone platform with (helium-) balloon to avoid self-jamming from drone onboard electronics

- Potential application: low-cost drones with low-cost GNSS-receivers/antennas
  - e.g. SmartMap concept: smartphone for drone control and 3D-mapping

Thank you for your attention!

Gefördert durch:

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des Deutschen Bundestages

Project initiative based on the space management department of the DLR

DLR Deutsches Zentrum für Luft- und Raumfahrt