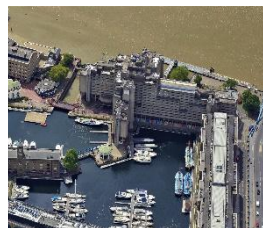


# **Robust Aerial Navigation and Georeferencing in GNSS-Challenged Environments**

***Kamil Wójcik / Jens Kremer***

***02.12.2025, EUROSDR WEBINAR***



- 47 Years in the Geospatial Market
- Mission Planning & Flight Guidance
- Sensor Management
- GNSS/IMU Navigation

- Airborne Sensor Systems
- Mobile Mapping Solutions
- Turn-key Solutions
- Defense Solutions

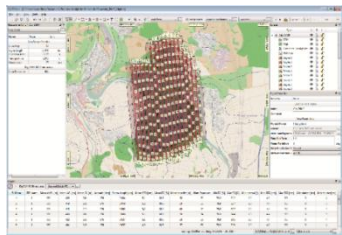


# Modular Sensor Systems



- Mission Planning
- Flight Guidance
- Sensor Management
- Georeferencing
- Quality Control in Real-Time
- Data Storage

# Modular Sensor Systems



**IGIplan**



**AEROoffice, IPS, 3rd party**



**CCNS-5**



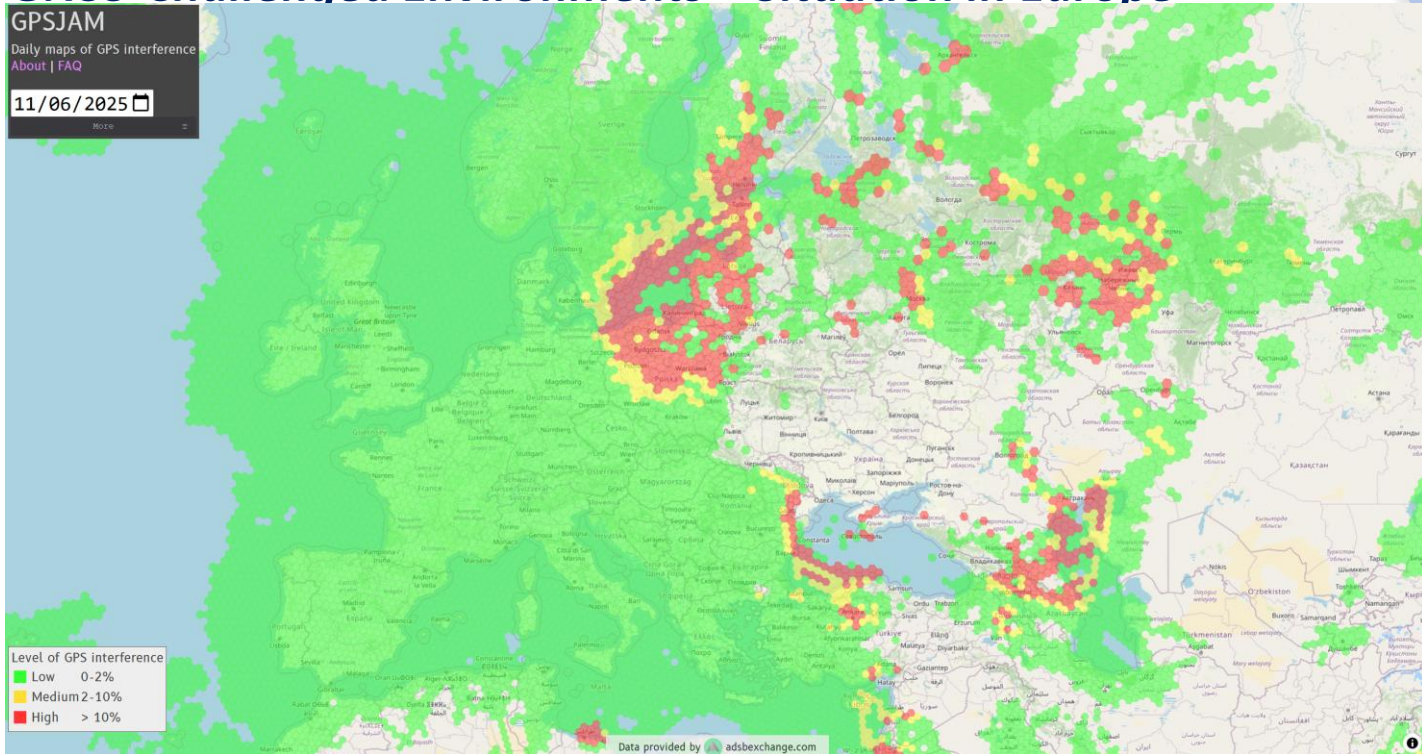
**AEROcontrol**



**SMU / IGIvisu**



# GNSS-Challenged Environments – Situation in Europe



Source: [jpsjam.org](#)

# *IGI UrbanMapper-2P Demo in Estonia Sept. 4th-9th 2024*



**Test carried out with Estonian Land and Spatial Development Board (ELB), National Mapping Agency operating the latest generation of UrbanMapper-2 EVO equipped with IGI AEROcontrol**



REPUBLIC OF ESTONIA  
LAND AND SPATIAL  
DEVELOPMENT BOARD

## **Test objectives:**

- **Execute a survey in area affected and not affected by GNSS jamming**
- **Deploying two independent systems - with and without anti-jamming capabilities**
- **Attempt processing jammed trajectories**
- **Analyse usability of jammed trajectories for data processing**

# *IGI UrbanMapper-2P Demo in Estonia Sept. 4th-9th 2024*



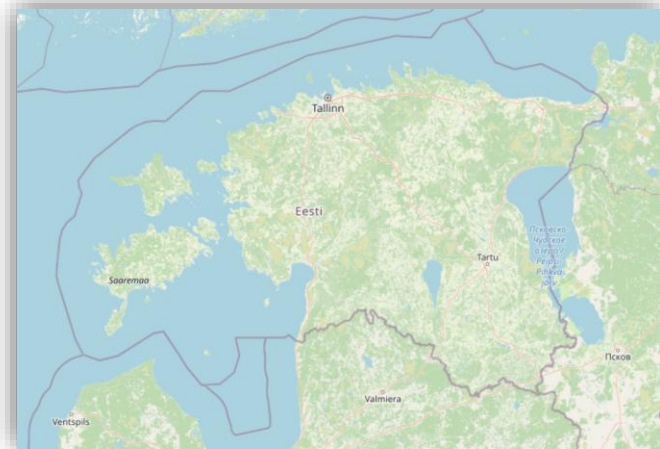
## **Test locations:**

- **Various areas across Estonian Territory, where jamming was very likely to be expected (central and eastern Estonia) and the opposite – mainly West of the country (situation Spet. 2024)**



REPUBLIC OF ESTONIA  
LAND AND SPATIAL  
DEVELOPMENT BOARD

**Testing areas designed at different altitudes from 500m AGL to 3 500m AGL**



# *IGI UrbanMapper-2P Demo in Estonia Sept. 4th-9th 2024*



REPUBLIC OF ESTONIA  
LAND AND SPATIAL  
DEVELOPMENT BOARD

## **Testing Setup:**

- **UrbanMapper-2 Performance + AEROcontrol CF-III with antijamming technology + CCNS-5**
- **ELB own LiDAR system with identified jamming vulnerability (deployment discontinued in 2024)**

# *IGI UrbanMapper-2P Demo in Estonia Sept. 4th-9th 2024*

**Cessna 208B Grand Caravan of ELB**



REPUBLIC OF ESTONIA  
LAND AND SPATIAL  
DEVELOPMENT BOARD



# *IGI UrbanMapper-2P Demo in Estonia Sept. 4th-9th 2024*



## **UrbanMapper-2 Performance with AEROcontrol CF-III**



# *IGI UrbanMapper-2P Demo in Estonia Sept. 4th-9th 2024*

CCNS-5 in C208





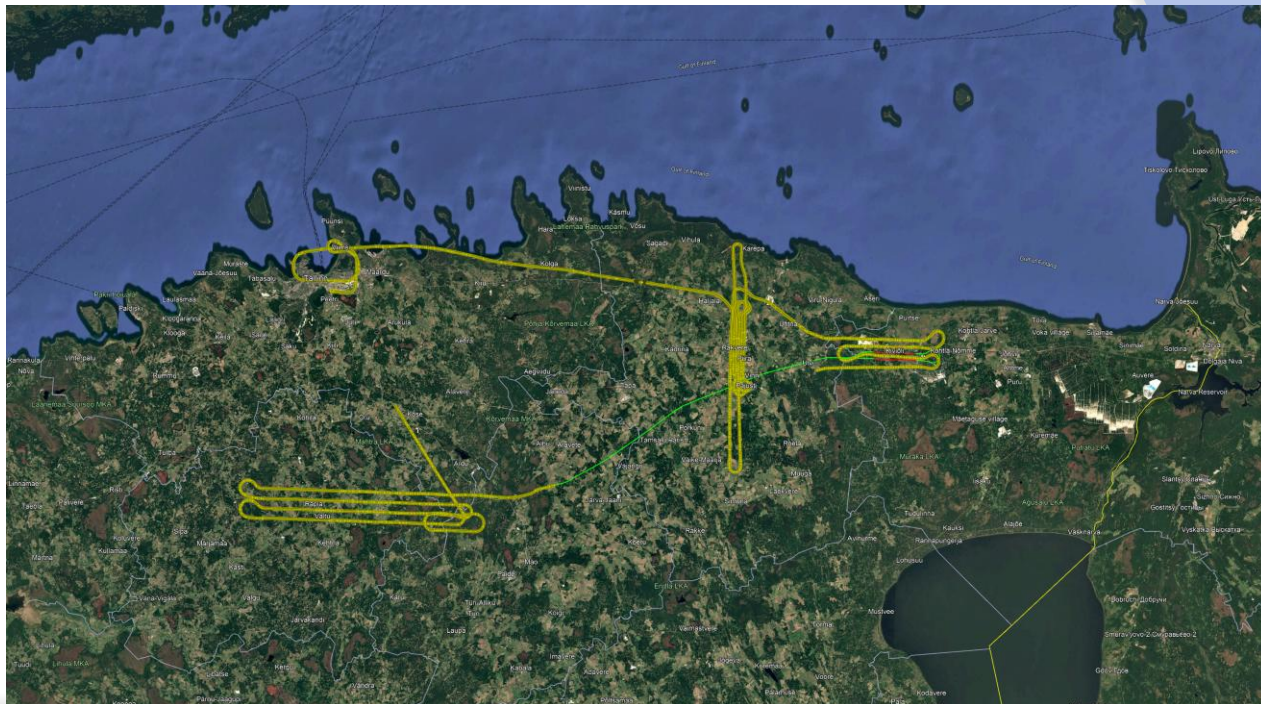
**IGI**



# IGI UrbanMapper-2P Demo in Estonia Sept. 4th-9th 2024



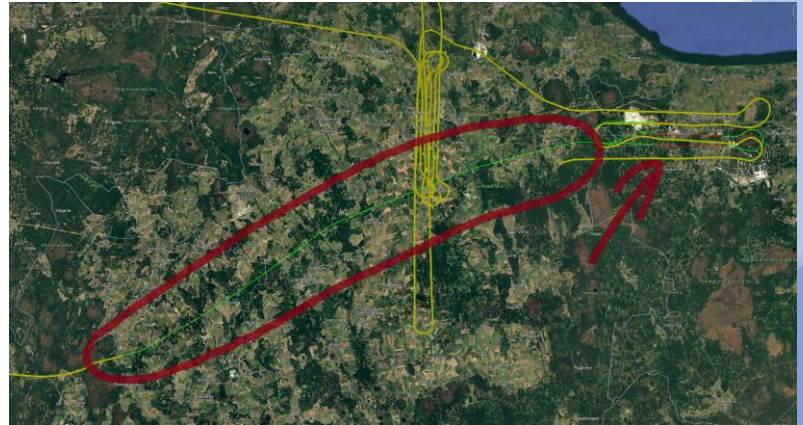
Example of a flight during GNSS jamming event:



## ***IGI UrbanMapper-2P Demo in Estonia Sept. 4th-9th 2024***

**Example of a flight during GNSS jamming event – observations:**

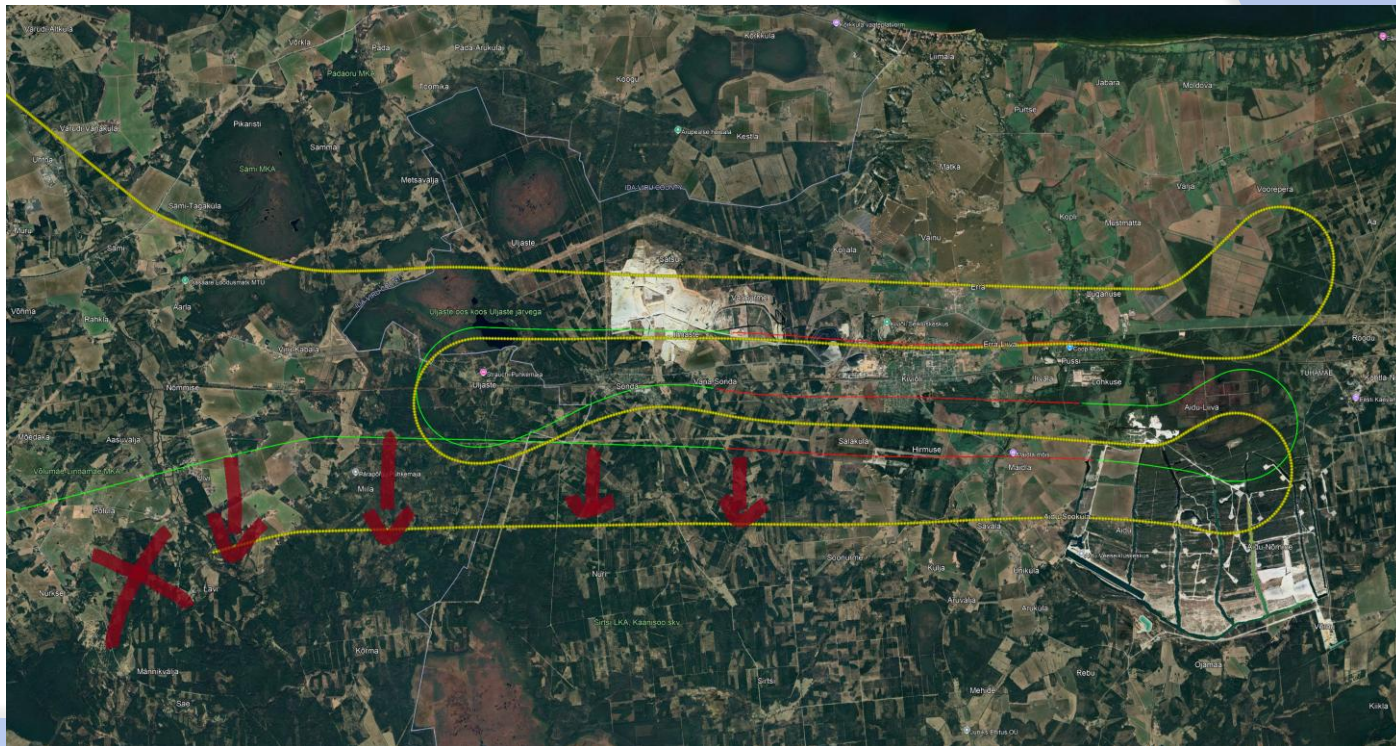
- **ELB System Realtime Solution started to deteriorate and finally no position was available in a certain part of the flight until getting out of the area with GPS jamming**
- **IGI system maintained Realtime Solution which allowed the survey and sensor operation**



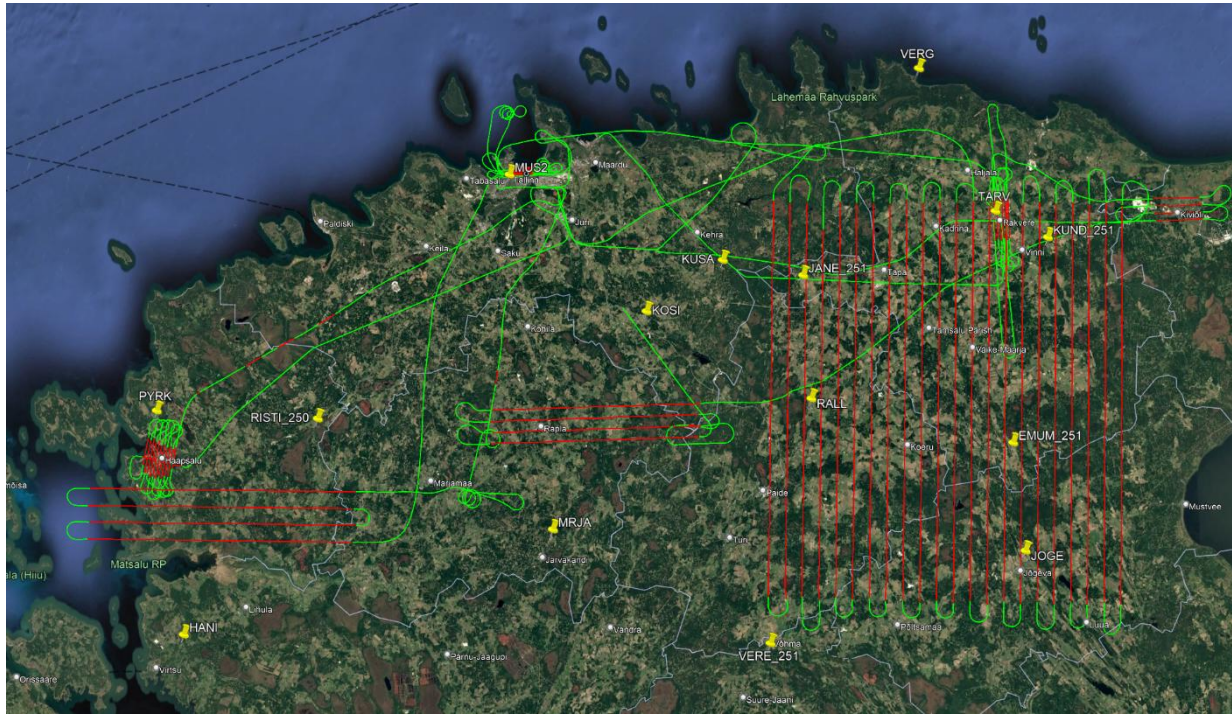
# IGI UrbanMapper-2P Demo in Estonia Sept. 4th-9th 2024



Realtime solution comparison of both systems:

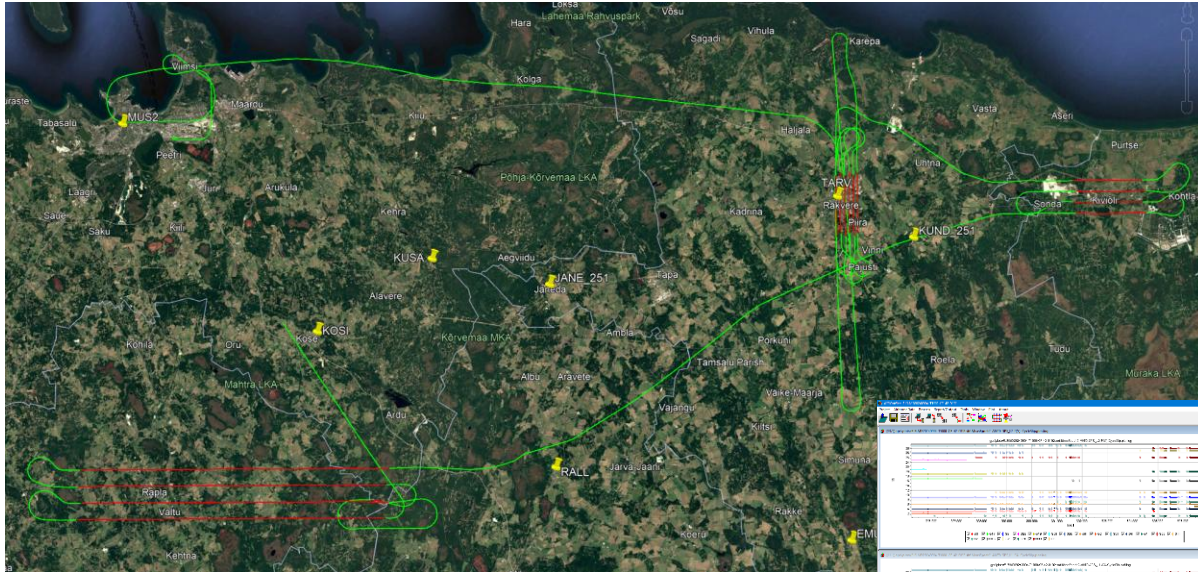


# IGI UrbanMapper-2P Demo in Estonia Sept. 4<sup>th</sup> to 9<sup>th</sup> 2024



For some areas and flying days, strong jamming was present, especially in the eastern parts of the mission area

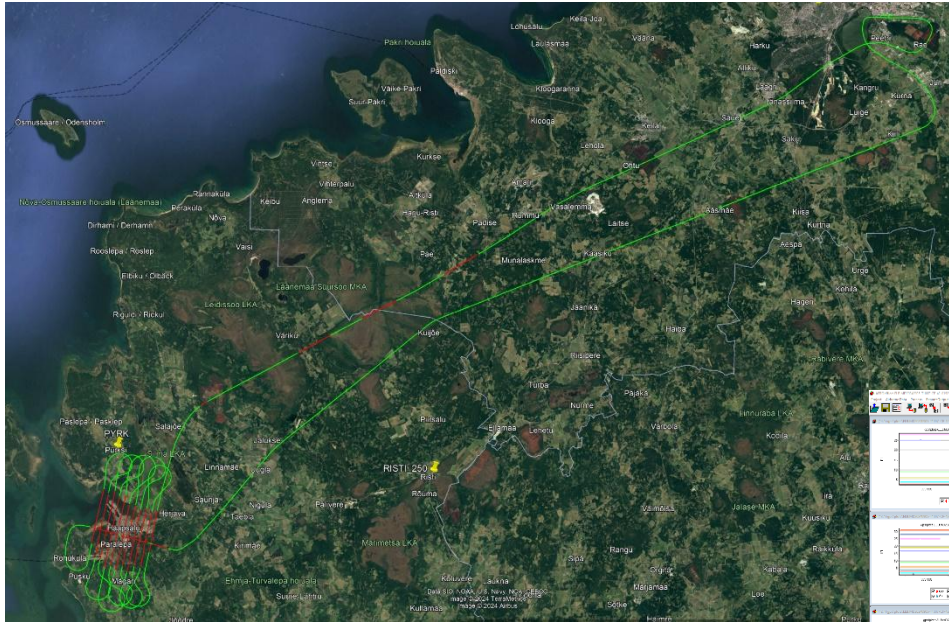
# Flight 1: 4.9.2024



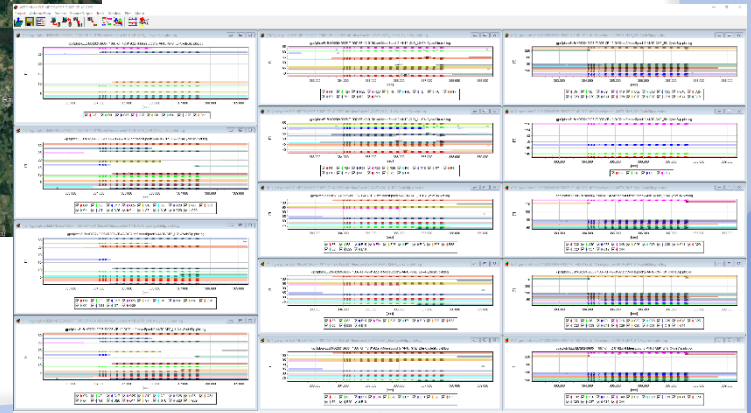
**Strong jamming,  
especially in the eastern parts of the flight mission**



# Flight 2: 5.9.2024



No jamming visible



# Flight 1: 4.9.2024

No GNSS post-processing was possible with GrafNav.  
PPSDK with standard setting did not produce a useful post-processed solution.

The jammed signals were identified and excluded in PPSDK.  
The GNSS solution was introduced into AEROoffice.

An important quality indicator is the difference between the GNSS measurements and the predicted positions from the INS.

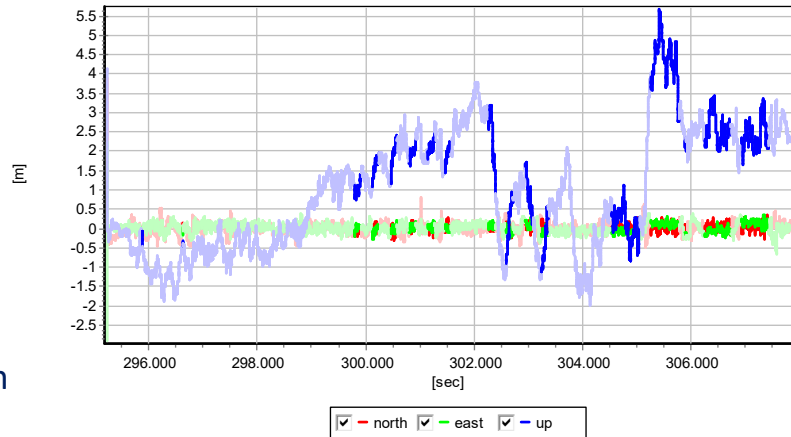
These values show larger values compared to an unjammed flight:

RMS north: 14cm

RMS east: 12cm

RMS up: 183cm

The estimated position accuracy is about 0.5m



## ***Flight 2: 5.9.2024***

No jamming was observed.

GNSS post-processing was possible with GrafNav and PPSDK.

This allows to simulate effect of the jamming and compare the results with and without these effects.

For this comparison, two INS solutions were produced:

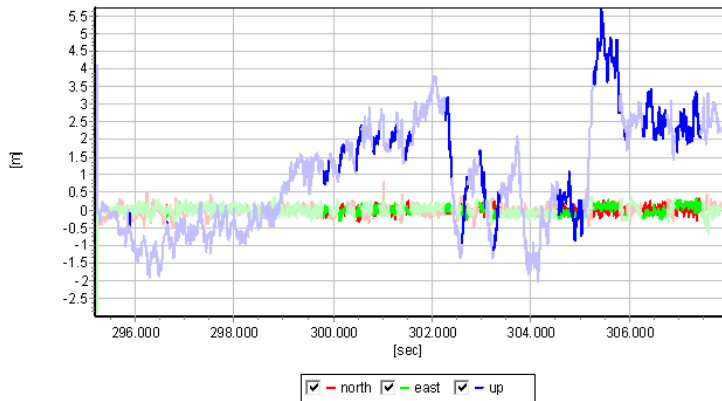
1. A reference solution using the standard workflow with GrafNav and AEROoffice.
2. A PPSDK solution choosing the constellation that was usable on the 4.9.2024 (jamming) integrated into AEROoffice.



# Flight 1 & 2

Comparison of the quality indicator “GNSS/INS position difference” between the jammed flight on the 4.9.2024 and the solution for the 5.9.2024 with simulated jamming effects.

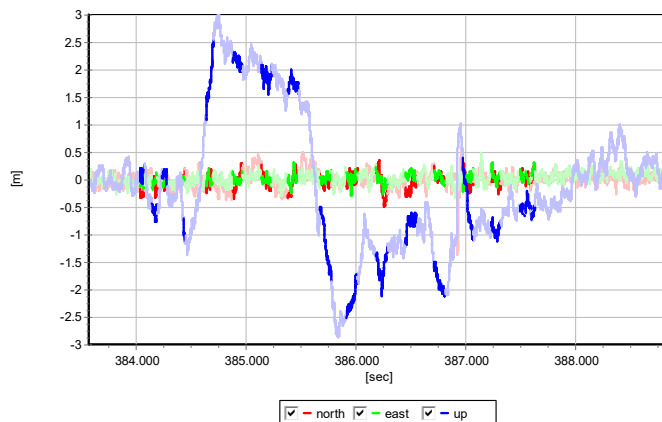
## Jammed flight 4.9.:



**RMS north: 14 cm**  
**RMS east: 12 cm**  
**RMS up: 183 cm**

**comparable!**

## Simulated jamming solution for 5.9.:

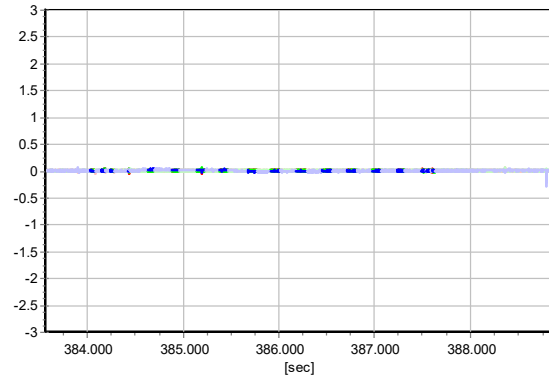


**RMS north: 15 cm**  
**RMS east: 10 cm**  
**RMS up: 121 cm**

# Flight 2: 5.9.2024

Quality indicator: difference between the GNSS measurements and the predicted positions from the INS.

## Reference solution:



✓ - north ✓ - east ✓ - up

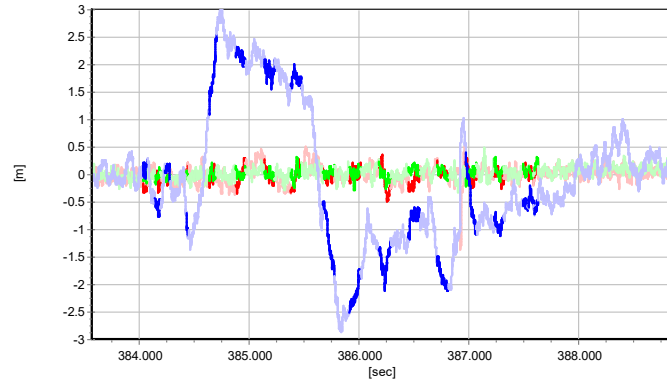
**RMS north: 0.46 cm**

**RMS east: 0.35 cm**

**RMS up: 1.13 cm**

**~ factor 30**

## Simulated jamming solution:



✓ - north ✓ - east ✓ - up

**RMS north: 15.5 cm**

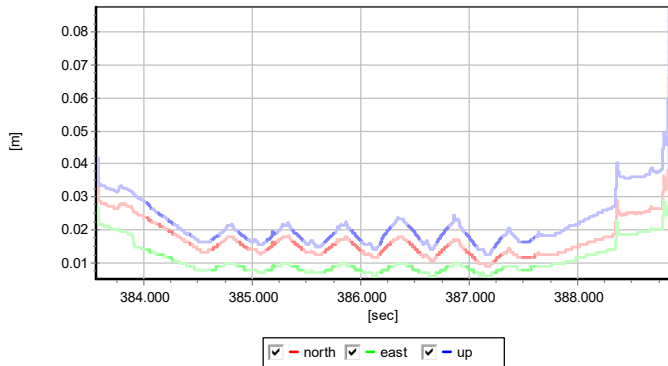
**RMS east: 10.2 cm**

**RMS up: 121 cm**

# Flight 2: 5.9.2024

Quality indicator: estimated position accuracy (estimation of the Kalman Filter).

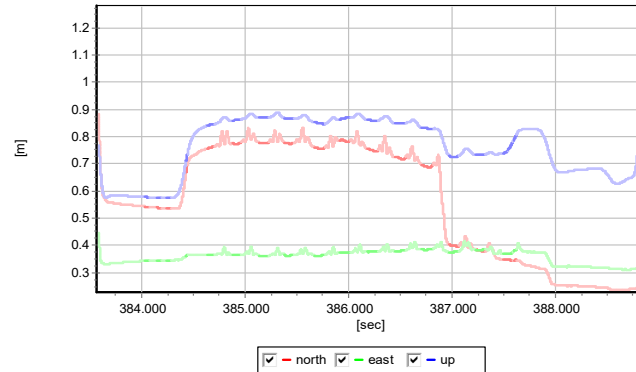
## Reference solution:



~ 2cm

~ factor 40

## Simulated jamming solution:



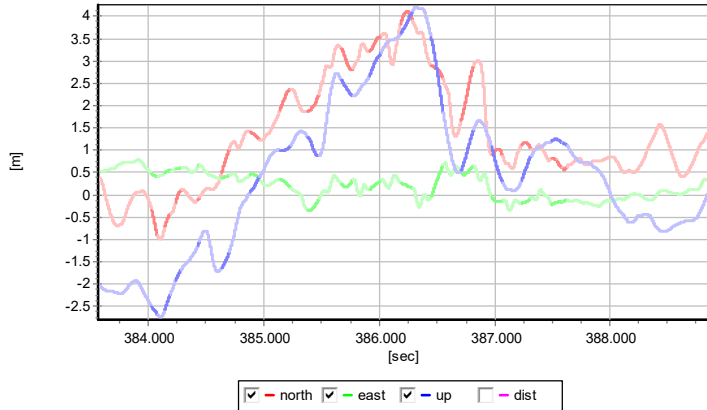
~ 80cm

# Flight 2: 5.9.2024

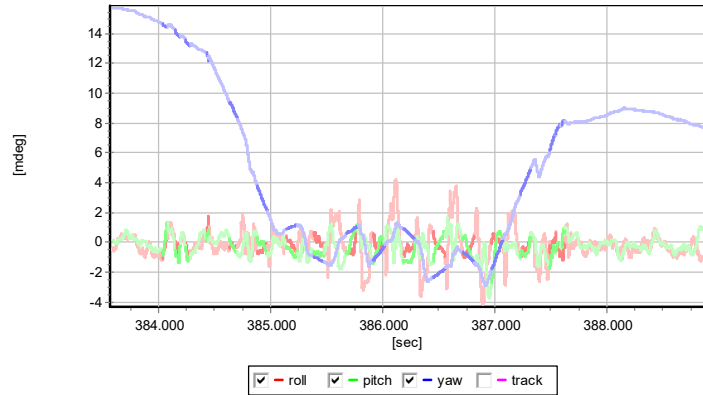


Comparison of the final position and attitude (real comparison).

Position difference:



Attitude difference:



## ***Flight 1 & 2***



If the GNSS reception is affected by jamming as seen on the 4.9.2024, the standard processing chain incl. GrafNav can't produce a usable trajectory.

A modified processing chain using PPSDK allows for the creation of a usable trajectory solution. The comparison above shows a reduction in the estimated position accuracy from the range of below one dm to values in the one-meter range.

In this simulation for the flight from the 5.9.2024, the maximum position difference between the reference trajectory and the trajectory with simulated jamming went up to 4m in the middle of the flight. The roll and pitch angle were affected very little and showed differences of 1/1000deg. The heading angle showed differences in the range of 1/100deg.



## ***Flight 1 & 2: Conclusion***

The use of the latest GNSS-receiver technology together with a modified workflow employing PPSDK allowed for the creation of a usable trajectory for complete flight.

The comparison between simulated jamming and real jamming, as well as the comparison of standard-processing with simulated-jammed processing gives indications for the reachable accuracies.

The usability for “direct georeferencing” under these conditions is limited to projects with low accuracy requirements.

**-> Direct Georeferencing is not suitable under Jamming Conditions**

We found, that the trajectory quality under jamming-conditions is good enough for a combined INS/AT georeferencing workflow. The reduced trajectory accuracy should be considered by reducing the related accuracy estimations in the used AT software.

**-> Combined INS/AT imagery processing delivers good results under Jamming Conditions**

**-> For LiDAR georeferencing, adjustment techniques need to be used**





Save the date – 4<sup>th</sup> of December, 3:00 PM - 4:30 PM CET



Webinar

## Achieve reliable 1 cm corridor data with the CM-1 from IGI & Phase One

Practical insights from Kavel 10 and Esri



**Robert Bosch**  
Product Manager



**Arkadiusz Szadkowski**  
Global Sales Manager

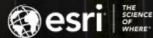


**Philipp Grimm**  
CEO



**Sam van Kerkhof**  
Project Manager

PHASEONE



Kavel 10



Thank you!