

GNSS-LESS AIRBORNE LASER SCANNING

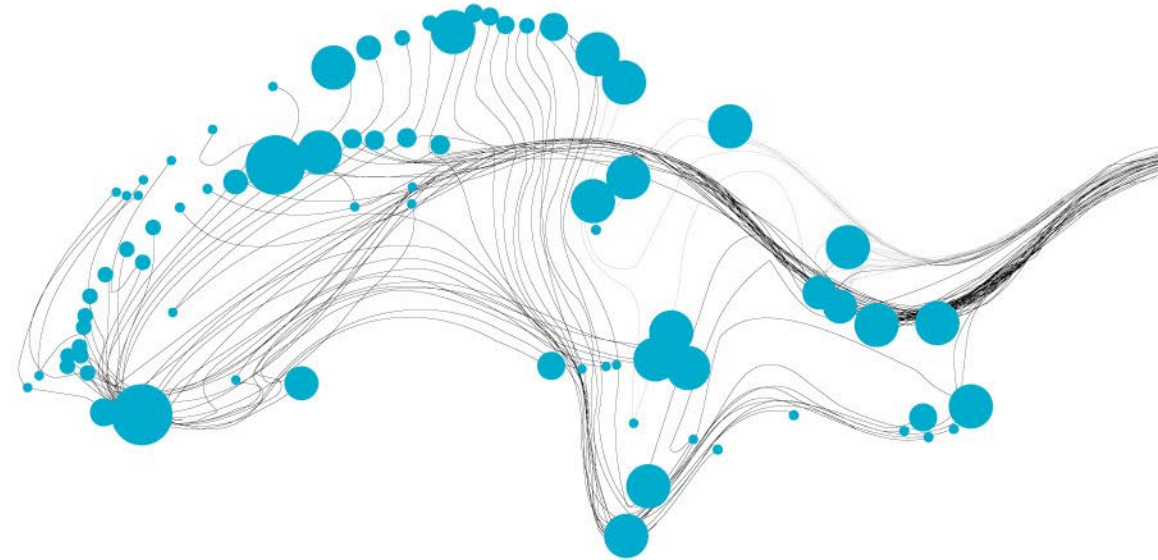
GEORGE VOSSELMAN (U TWENTE)

PETER RIEGER (RIEGL)

FLORIAN PÖPPL (RIEGL)

GOTTFRIED MANDLBURGER (TU VIENNA)

CAMILLO RESSL (TU VIENNA)

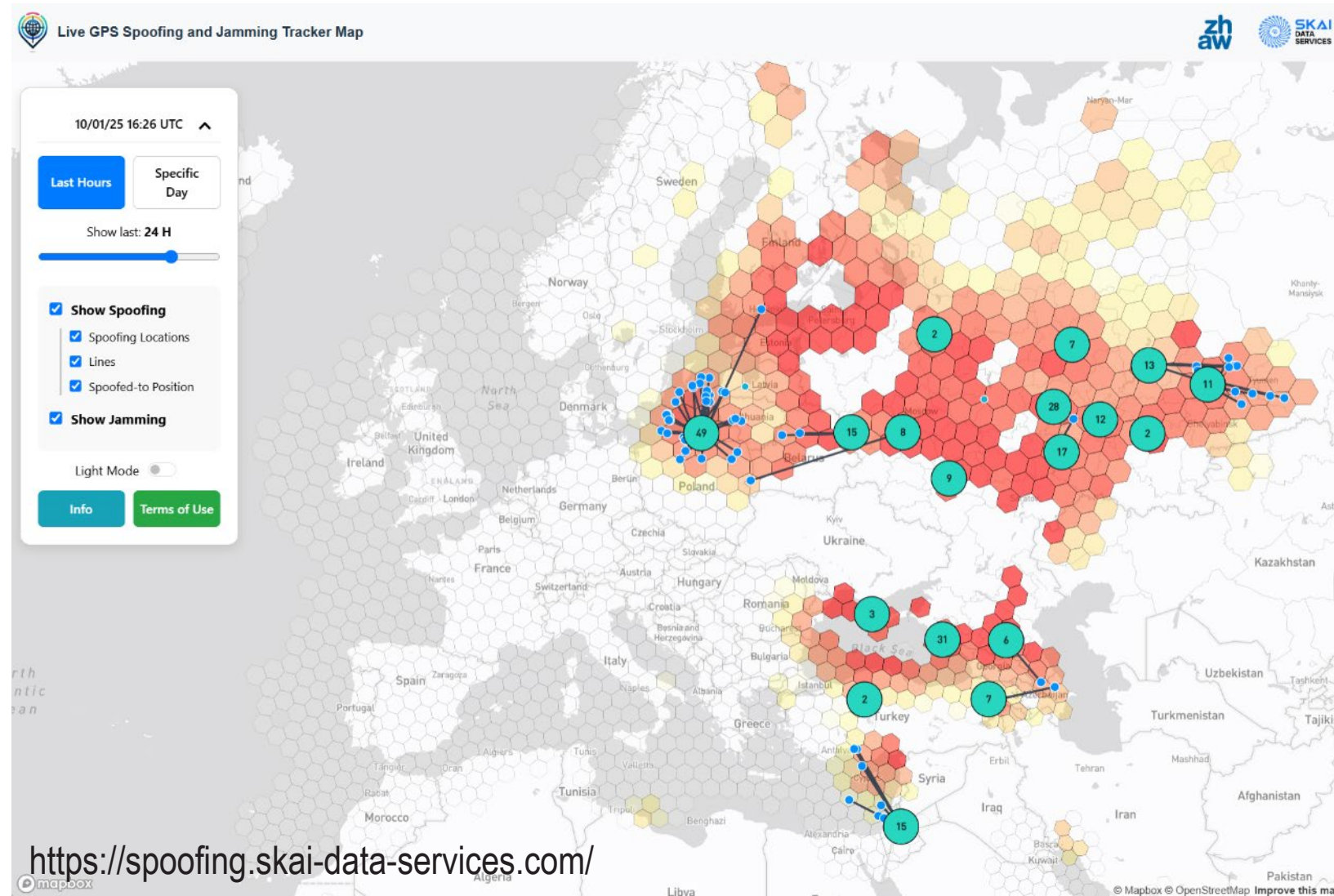


NO AIRBORNE LASER SCANNING NEAR CONFLICT ZONES

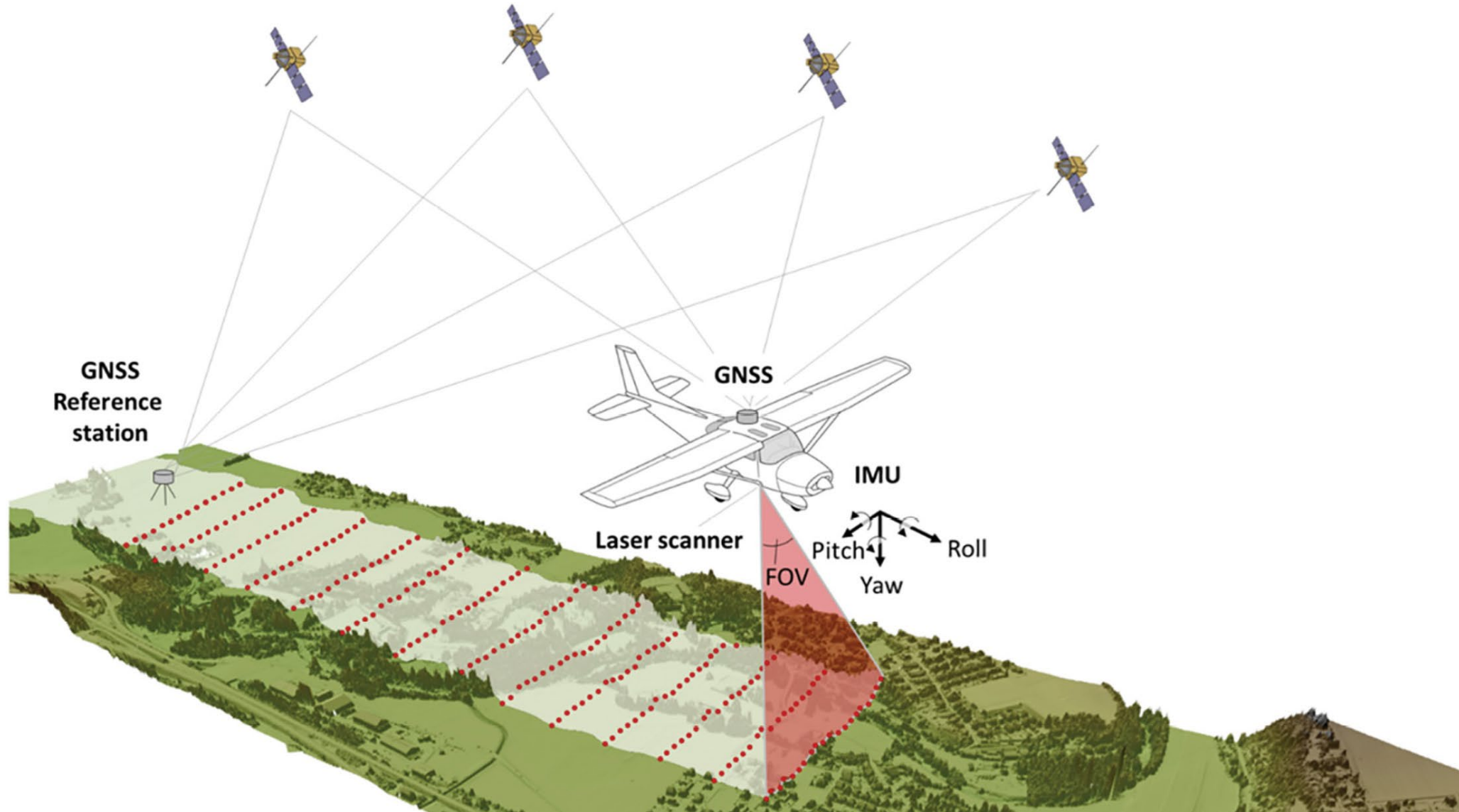
EuroSDR meeting autumn 2024:
Cyprus is unable to use airborne
laser scanning for 1.5 years

Reason:
GNSS jamming and spoofing

Affected: Cyprus, Norway, Finland,
Estonia, Latvia, Lithuania, Poland,
Moldova, Romania, Bulgaria



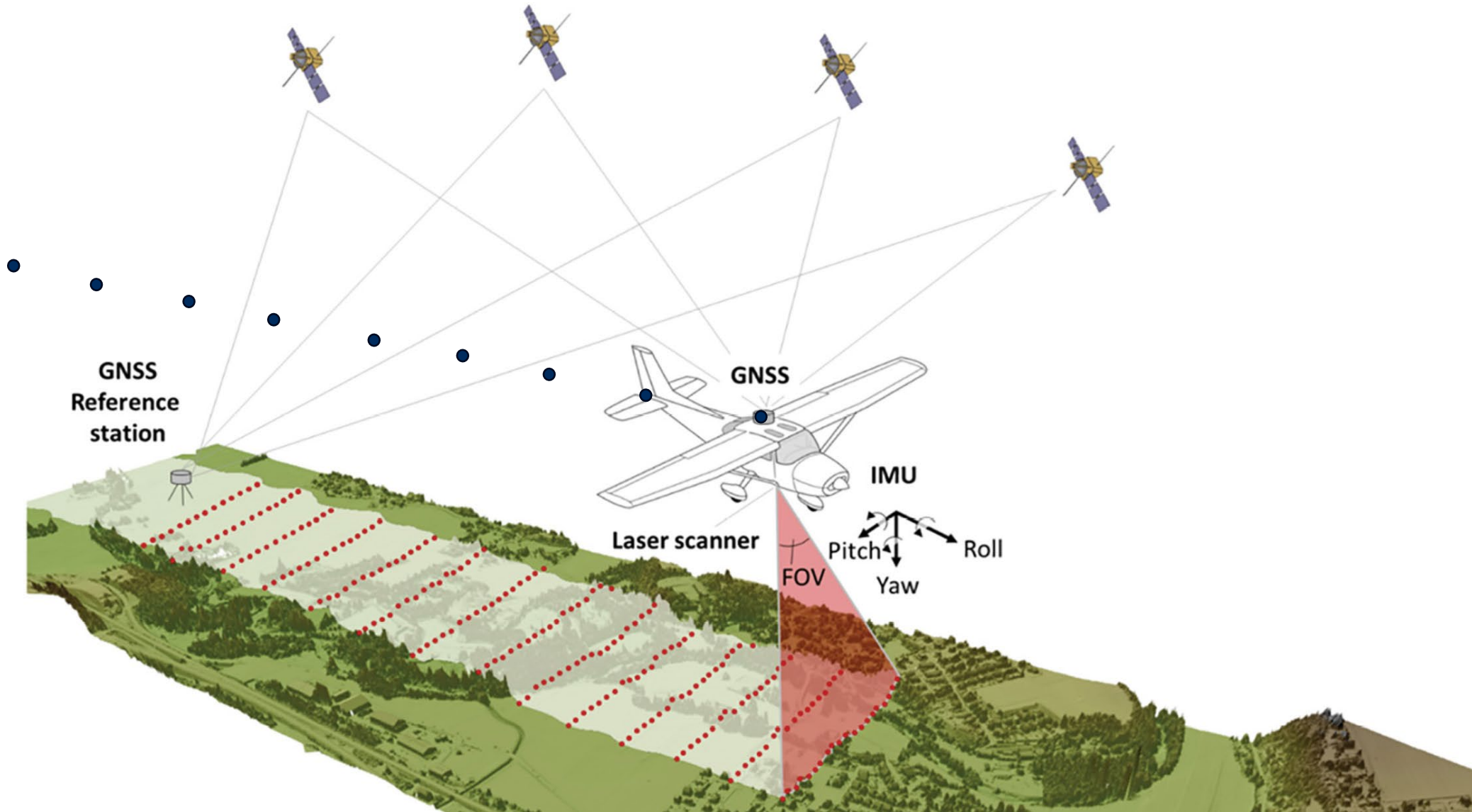
PRINCIPLE OF AIRBORNE LASER SCANNING



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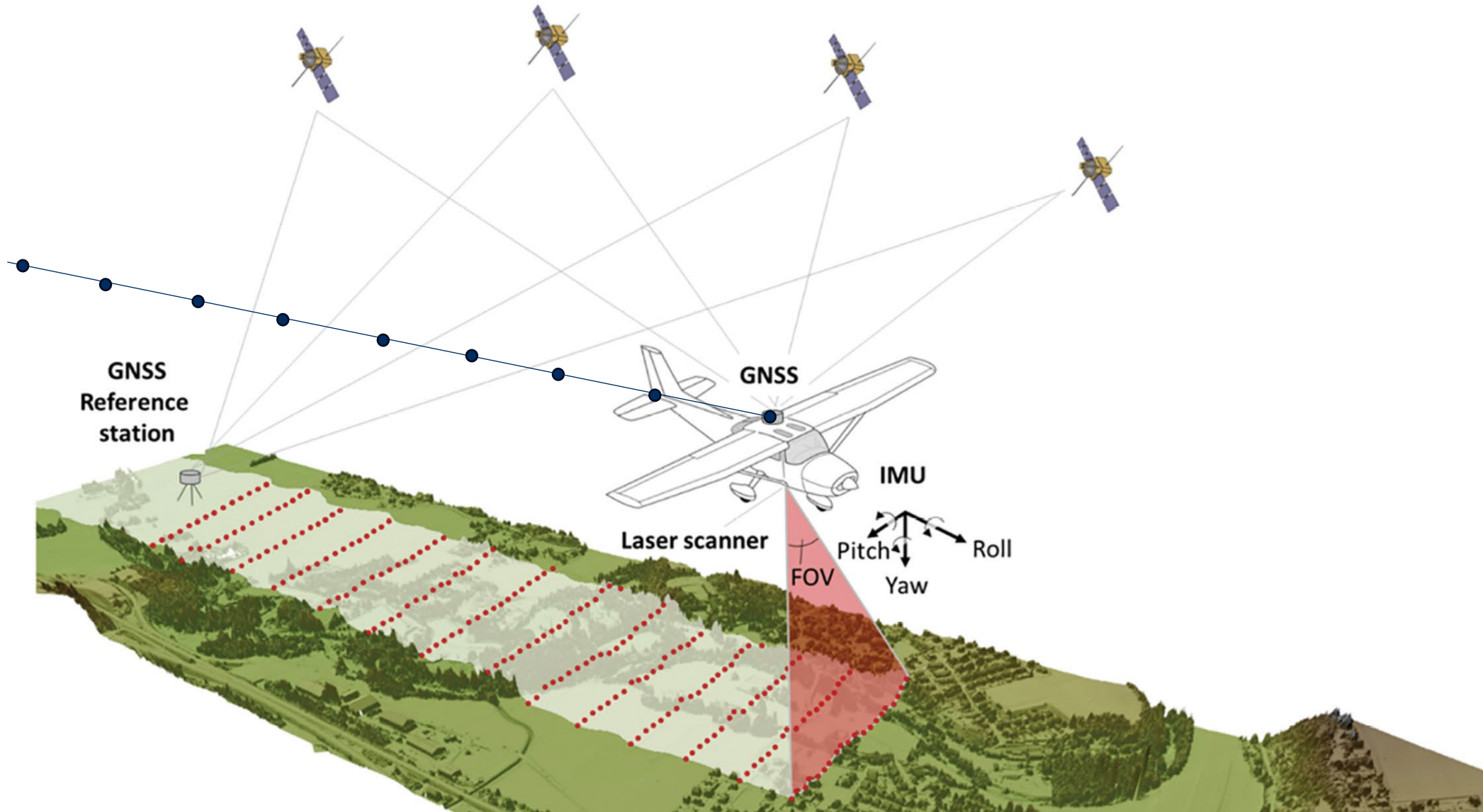
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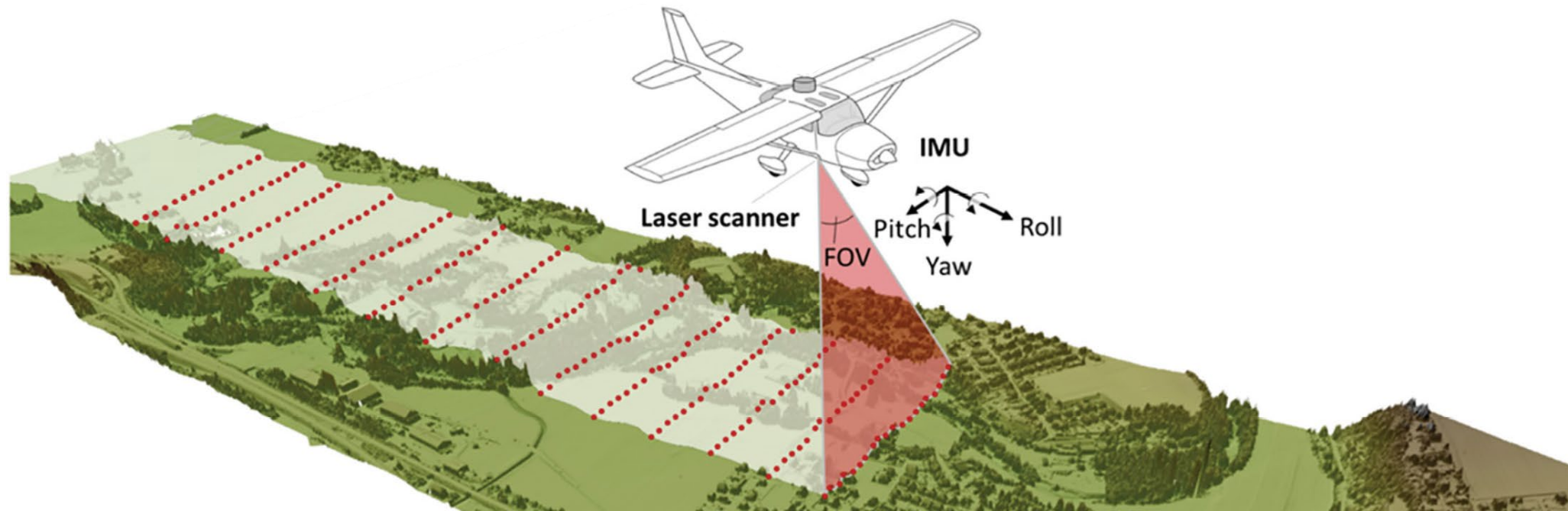
PRINCIPLE OF AIRBORNE LASER SCANNING



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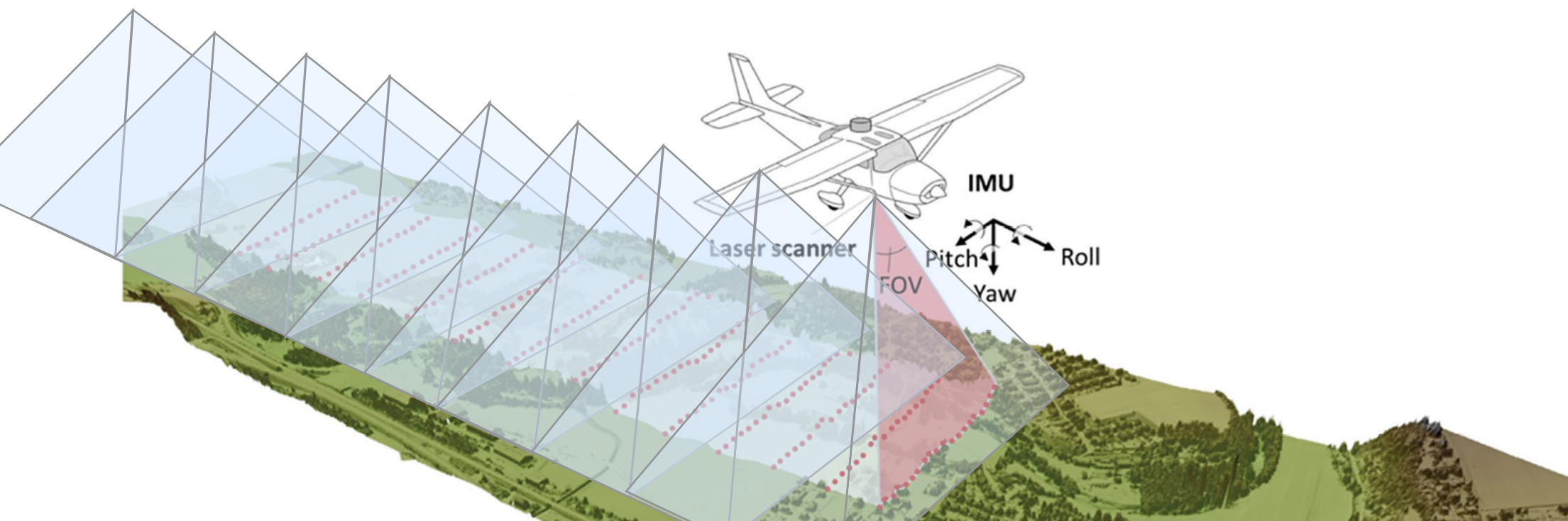
HOW TO POSITION THE AIRCRAFT WITHOUT GNSS?



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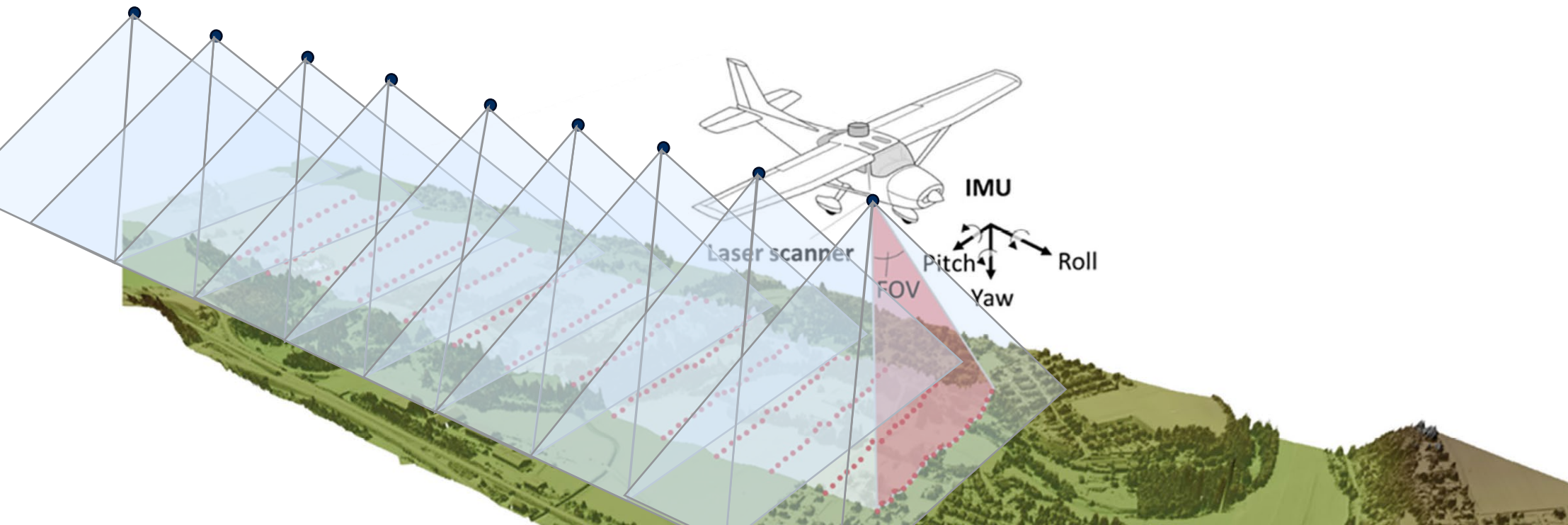
TAKE IMAGES



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USE AERIAL TRIANGULATION TO GET PROJECTION CENTRES



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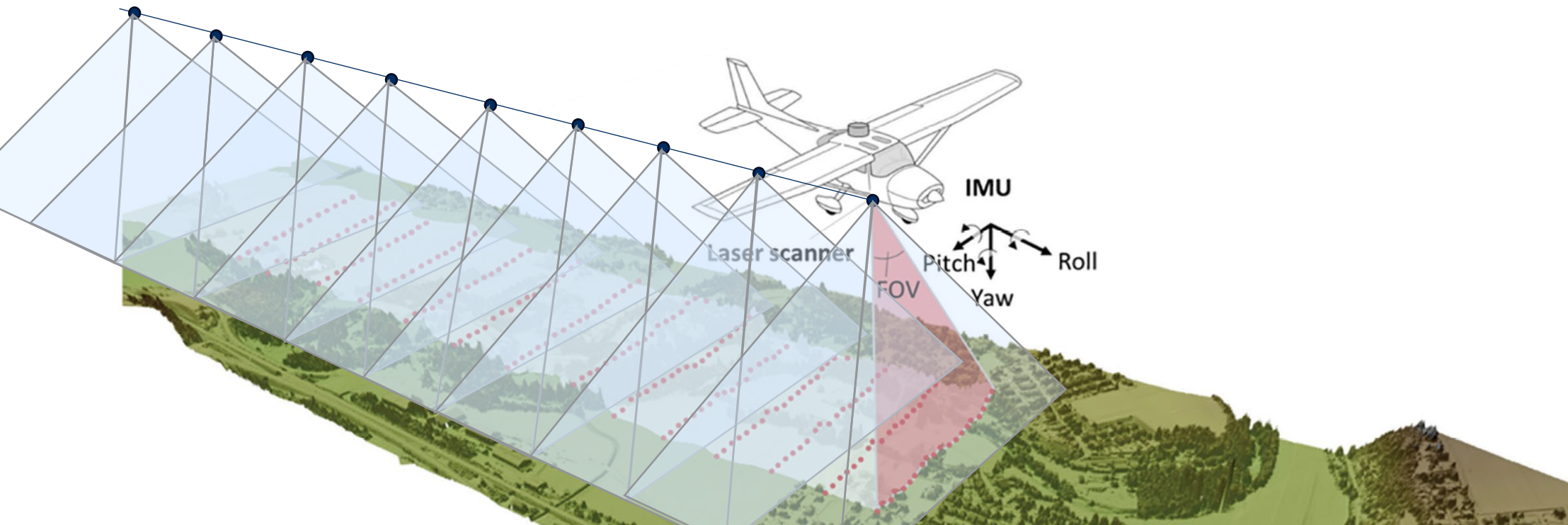


USE PROJECTION CENTRES INSTEAD OF GNSS LOCATIONS

Simultaneously acquire data with a laser scanner and a camera

Estimate projection centres with aerial triangulation

Replace GNSS with the camera's projection centre in the lever arm



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HYBRID SENSORS ARE ON THE MARKET



Vexcel UltraCam Dragon
0.7 seconds/image



Leica CityMapper-2
0.9 seconds/image



RIEGL VQ-1560-II-S
0.7 seconds/image

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DEPENDENCY OF AERIAL TRIANGULATION ON GNSS

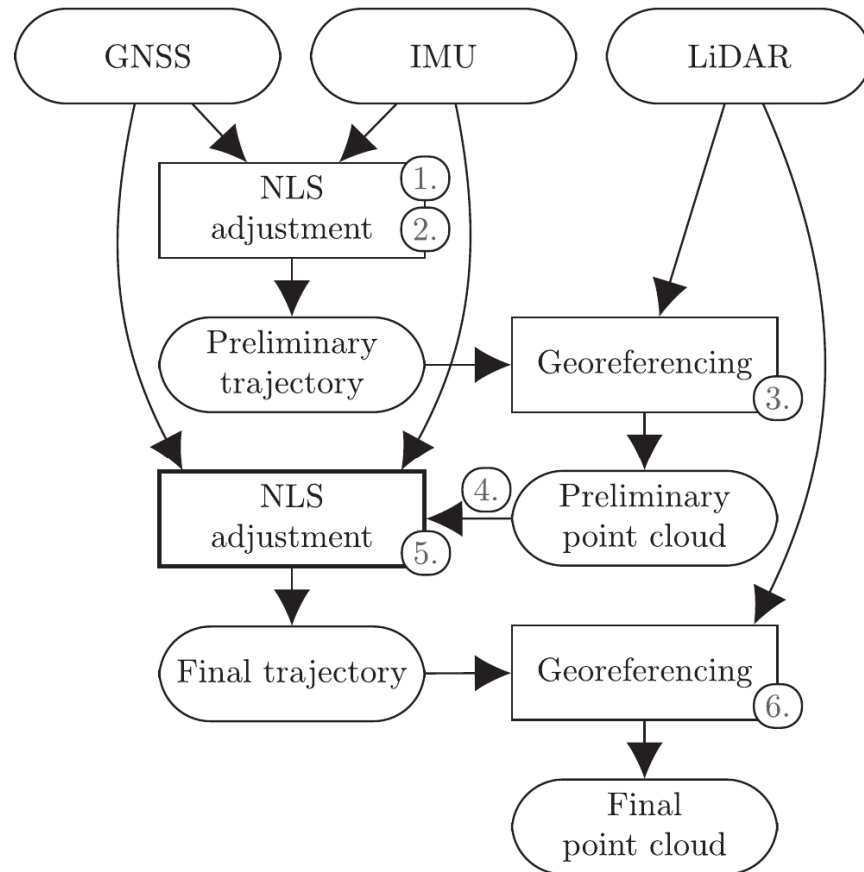
GNSS is used for

- Flight management
- Sensor synchronisation
- Aircraft position estimation to reduce the need for ground control points
- Ground control point measurements

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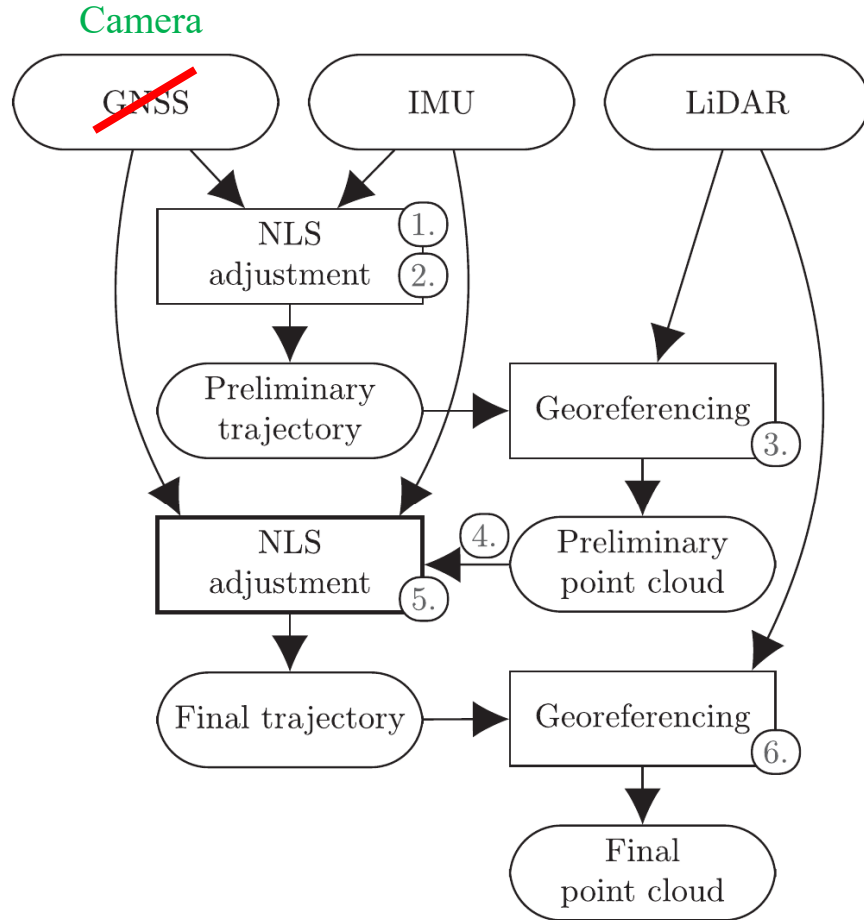


STANDARD SENSOR INTEGRATION APPROACH



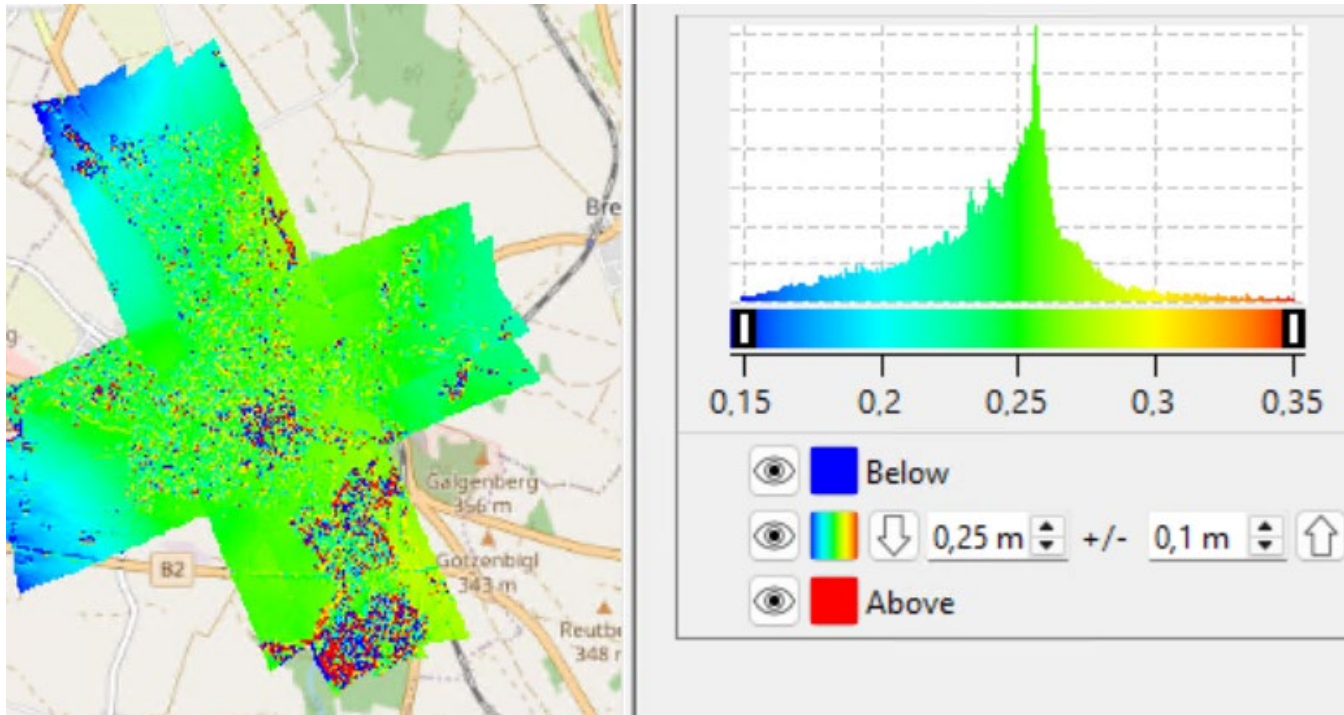
- Initial trajectory: Kalman filter or sliding-window adjustment of GNSS and IMU data
- Non-linear least-squares adjustment with
 - Positions from GNSS
 - Inertial measurements from the IMU
 - Plane-based observations derived from the LiDAR point cloud

ADAPTED SENSOR INTEGRATION APPROACH



- Initial trajectory: **poor GNSS solution, single point positioning**
- Non-linear least-squares adjustment with
 - Positions from **aerial triangulation**
 - Inertial measurements from the IMU
 - Plane-based observations derived from LiDAR pointcloud

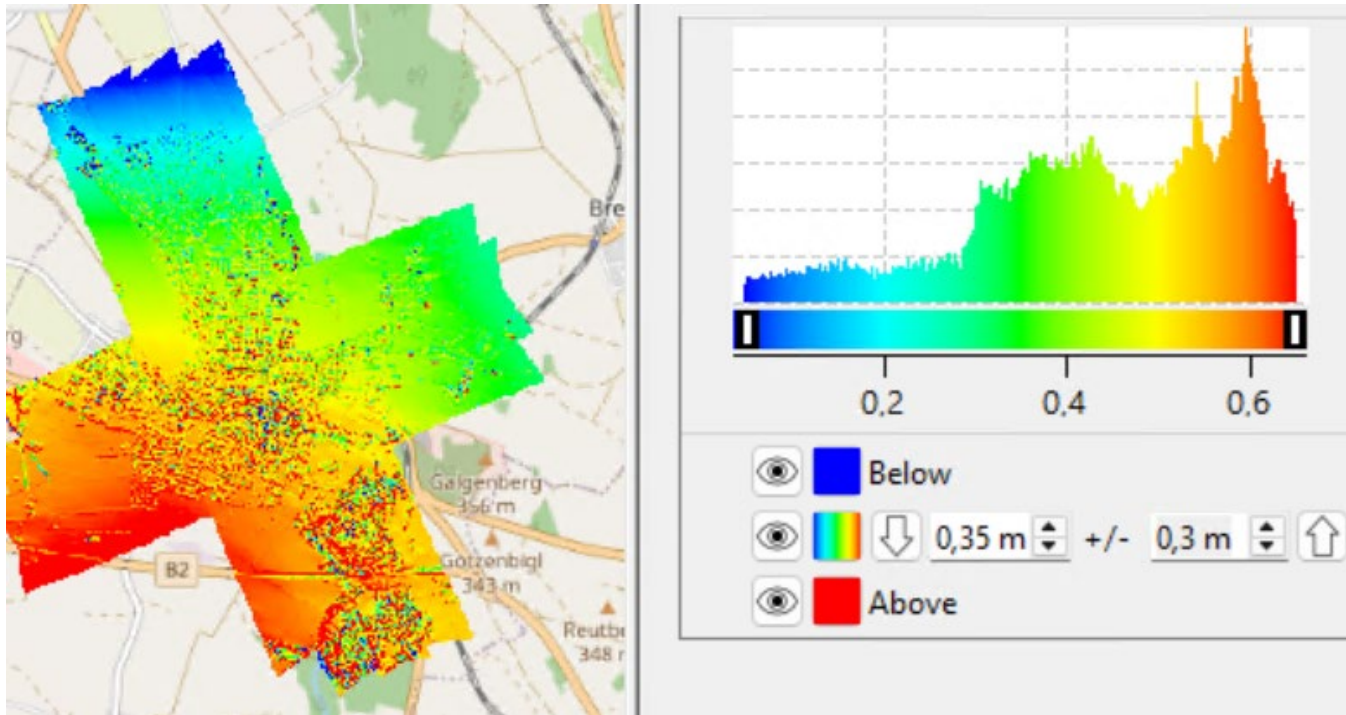
RESULTS – TEST BLOCK HORN WITH 39 GROUND CONTROL POINTS



- Vertical offset of some 25 cm
- Possibly due to datum shift or inaccurate camera constant

Height differences between GNSS-based point cloud and AT-based point cloud

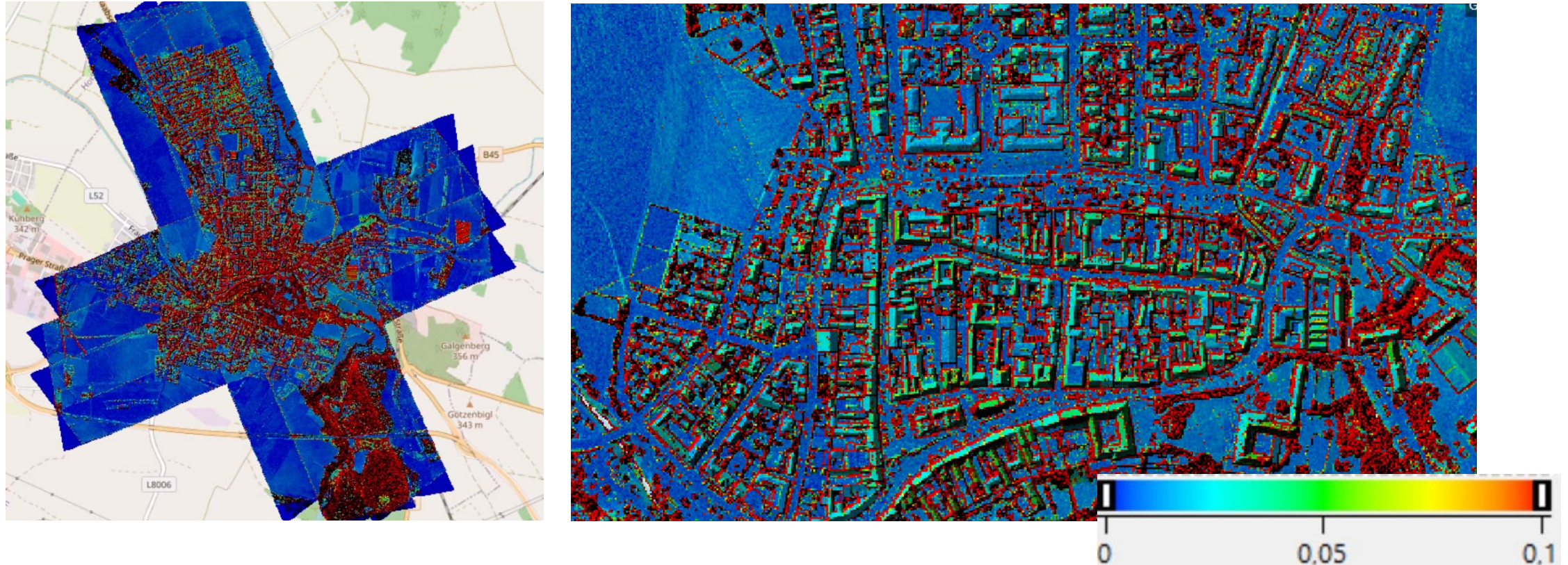
RESULTS – TEST BLOCK HORN WITH 4 GROUND CONTROL POINTS



- Strong block tilt

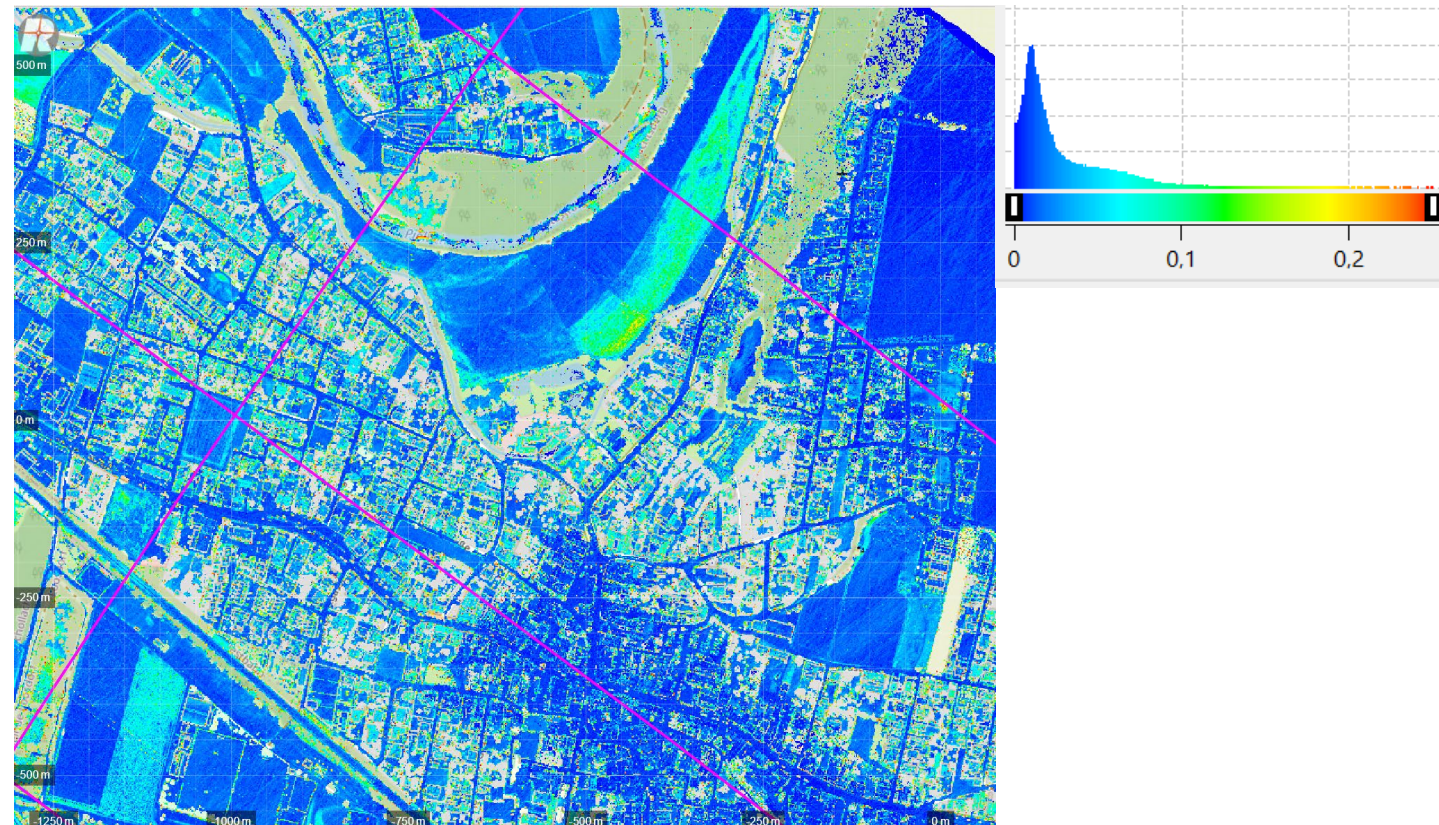
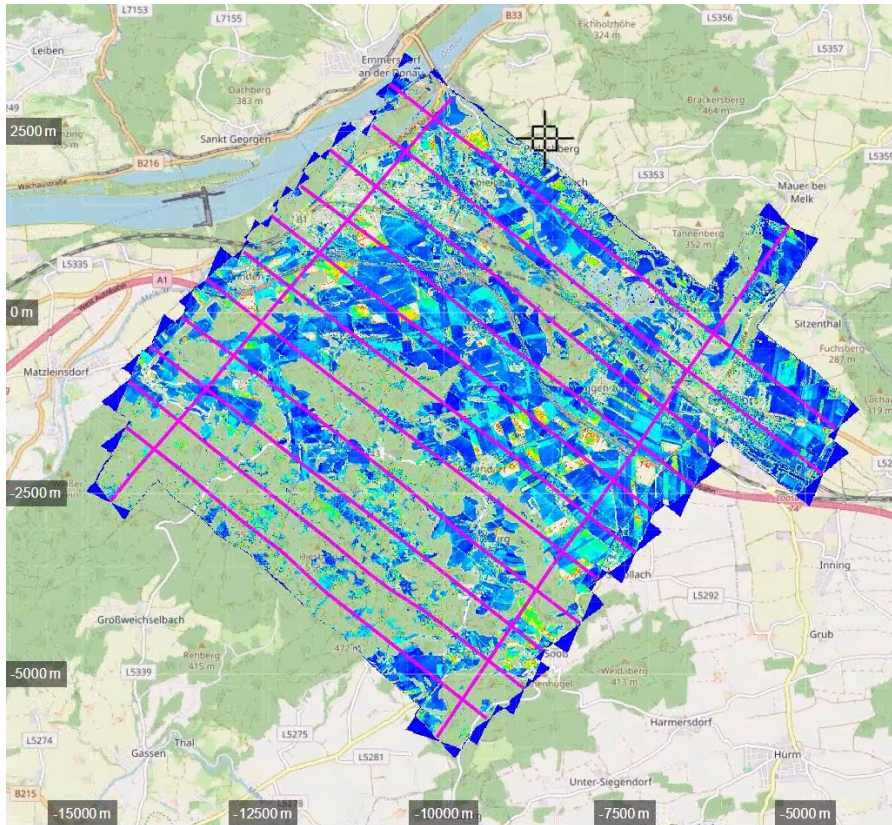
Height differences between GNSS-based point cloud and AT-based point cloud

RESULTS – TEST BLOCK HORN WITH 4 GROUND CONTROL POINTS



Height differences in AT-based point cloud within 1 m raster cells
Good inter-strip consistency, even with only 4 GCPs

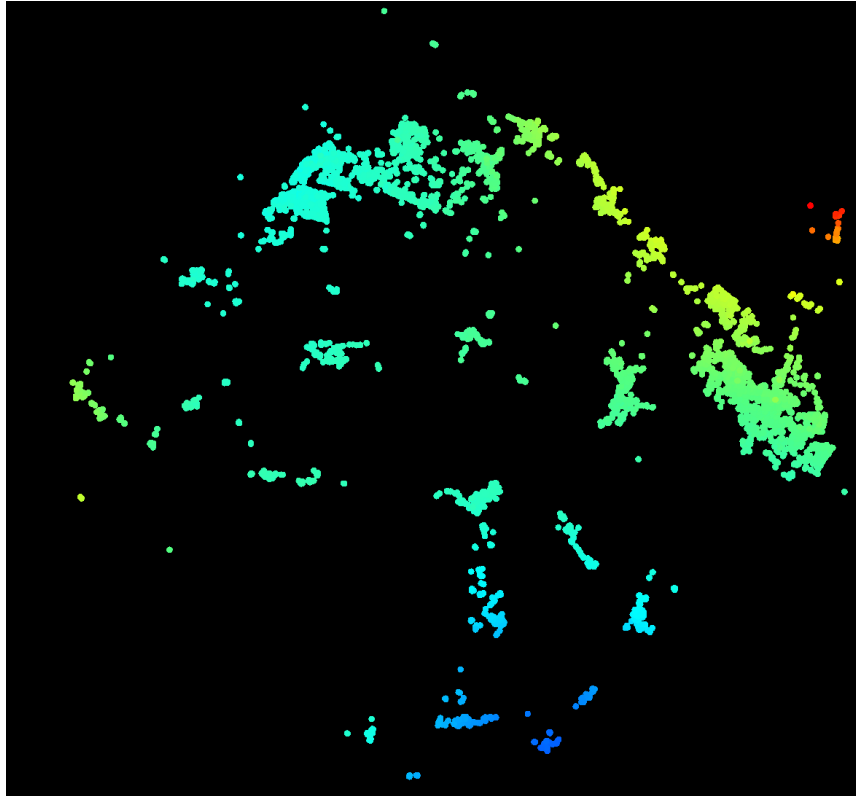
RESULTS – TEST BLOCK LOOSDORF WITH 6 GROUND CONTROL POINTS



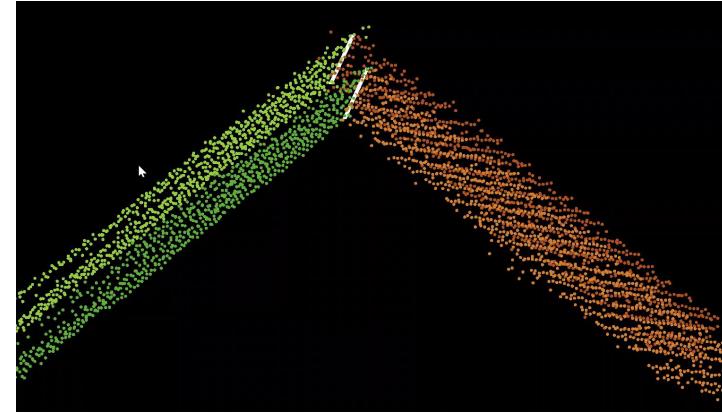
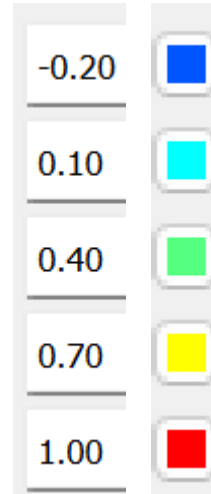
Height differences in AT-based point cloud within 1 m raster cells, masked above 0.25 m height differences

Good inter-strip consistency

RESULTS – TEST BLOCK LOOSDORF WITH 6 GROUND CONTROL POINTS



Height differences between roof ridgelines in the GNSS-based and AT-based point clouds



- Comparison at 4500 roof ridgelines
- Height deformation of the AT-based point cloud
- Offset of 38 and 31 cm in X- and Y-direction due to a datum issue (ETRS89 vs. ITRF)
- 6 cm standard deviation in planimetric ridgeline residuals

RESULTS AND LIMITATIONS

Results:

- Georeferencing using image projection centres instead of GNSS measurements is feasible
- Height accuracy depends on number of control points
- Planimetric accuracy and inter-strip consistency is good

Limitations:

- GNSS was still used to obtain an approximate initial trajectory
- A navigation solution remains necessary

OUTLOOK

Many opportunities for improvement:

- Higher imaging rate
- Use of estimated camera rotations in the trajectory estimation
- Better stochastic model for projection centre coordinates
- Integration of bundle block with IMU/LiDAR adjustment
- Including oblique imagery

Real world test data from Romania

- 8 flight lines at ~2300m AGL
- 291 images, 15 seconds in between images
- System: RIEGL VQ-1460 with a PhaseOne iXU-RS1000 (100MP), flown by MGGP Aero



(Google Maps)