Westfälische Wilhelms-Universität Münster

GEOPHYSIK WWU MÜNSTER

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M. Becken, J. Schmalzl, P. Kotowski, Y. Polkowski, V. Schmidt, S. Ueding

First experiences with the MagArrow total field magnetometer

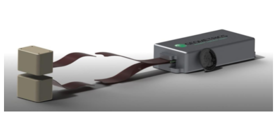
Summary

The MagArrow is a fast and light-weight Cs-vapour total field magnetometer that has been designed for drone applications. Here, we show first flight data acquired with the new system suspended below a DJI S1000+ octocopter. The data indicate a relative system noise level of <200 pT in stable flight operations.

We also tested the system in a semi-airborne EM configuration. Recordings show that motional noise is negligible and that EM responses can be extracted for frequencies below 400 Hz.

Specifications

- *Weight: 1 kg + Batt.*
- *Noise: 5 pT/√Hz*
- *Sample rate: 1000 Hz GPS Synchronized*
- *Bandwidth: 400 Hz*
- *Heading error: 5 nT*
- *IMU: Bosch BMI160 Accel/Gyro*
- *Compass*



Photos: The System includes 2 miniaturized OPM Sensors arranged in reversed orientation. Averaging of sensor data allows to reduce the heading error significantly. The DJI s1000+ achieves ~18 min flight endurance with the MagArrow bird suspended as payload.

UAS Airborne Magnetics

We performed test flights at high altitude (50-100 m) above a magnetically homogenous subsurface in Northern Germany to test the noise level and the heading error of the system.

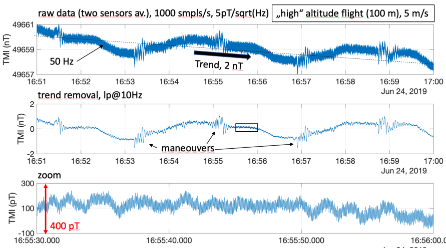
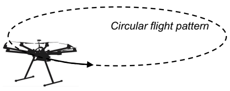


Figure 1: TMI time series from a flight at 100 m above ground. Shown is the average of the two sensors. Motional noise due to turning manoeuvres is not fully compensated for. Under steady flight conditions, the motional noise is probably below 100 pT.

Heading error:

The dependence of a scalar magnetometer reading on the relative orientation of the sensor axis and the main field.



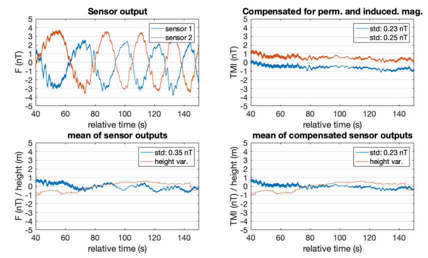


Figure 3: To test for heading errors, we performed circle flights at constant altitude. The total heading error is about 6 nT. Sensor averaging achieves similar compensation as a parametric model after Leliak (1969).

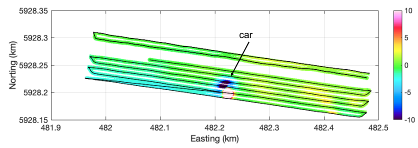


Figure 2: Flight over a metallic test object. Flight height was 5 m above ground, flight speed 5 m/s. Shown is the average of the two sensors.

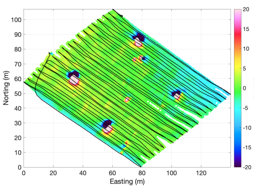


Figure 4: Example from the Zoowiese in Münster. Flight height was 1 m above ground. Four gullies arranged in a square cause anomalies of more than 1000 nT. Few more magnetic objects are detected. Note the consistent gradient across the surveyed field.

UAS semi-airborne EM

The idea of using a total field magnetometer for EM sounding has been introduced by Avdeev et al., (1997). A scalar magnetometer measures effectively the time-varying component of the EM field that points in the direction of the geomagnetic main field vector. Here, we aim at estimating transfer functions between the scalar field and the injection current. Scalar magnetometers may be superior to vector magnetometers for airborne measurements because of their low sensitivity to motion.

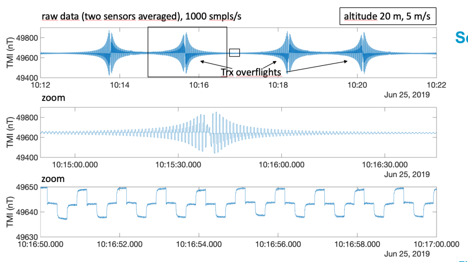


Figure 5: Multiple flights with a MagArrow total field magnetometer over a grounded electrical dipole source. The fundamental frequency of the source current is 1 Hz.

Semi-airborne EM with a scalar mag.:

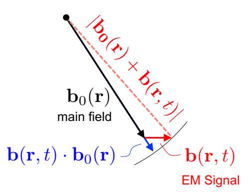
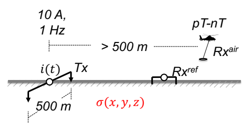


Figure 6: The projection of the EM signal onto the geomagnetic main field is a good approximation of the measured time variation of the total field.

Semi-airborne EM geometry:



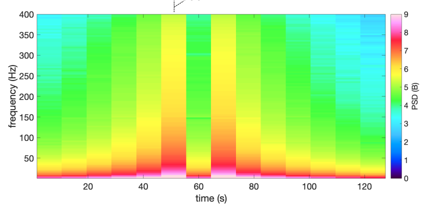


Figure 7: Power spectral density of the recorded EM Signal for the 1 Hz fundamental frequency and odd harmonics, shown for a single flight-line centred approximately at the transmitter. A window length of 12 s (60 m) and a Hanning taper window have been used for spectral estimation.

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