SENSYS®
Magnetometers & Survey Solutions

UAV / drone magnetometer survey kit

MAGDRONE R4 3.0

Applications

- Survey & Surveillance
- Mine exploration / tracking / monitoring at flexible heights
- UXO detection on unreachable, flooded or mined areas

Features

- Dismountable system with 5 Fluxgate sensors
- Attachable to any UAV with 1.5+ kg payload
- **Made for DJI M300**
- 8 GB internal memory
- 200 Hz recording rate
- Data loss prevention
- WLAN interface
- Data processing tool

The MagDrone R4 is an ultra light weight magnetometer survey kit with 5 triaxial Fluxgates to be attached to any UAV with **a 1,500 g payload**. Its dismountable sensor tube allows for sensor spacing of either 25cm or 50cm providing a 2.5m swath width.

With 200Hz sampling rate the R4 can easily filter out noise from infrastructure, net frequencies or UAV motors. Hence, it can be directly installed on UAV's landing gear for a very compact setup.

The MagDrone R4 can be used for i.e. magnetic cartographies, mine exploration, area scanning for bombs and ammunition (UXO), preventive check and surveillance of areas and camps against intrusion.

Videos on youtube

R4: ALL UNIQUE SELLING POINTS AT HAND

Your benefits with our solution

- ✓ **Universal usage**
  - UXO Search
  - Exploration
  - Surveillance
- ✓ **Ideal for DJI M300**
  With 1,500g, the R4 gets on board any professional UAV easily, but especially the DJI M300!
- ✓ **Straight interface**
  Access the R4 via WLAN for configuration or start/stop triggers.
- ✓ **Most simple installation**
  Take 4 cable ties and strap it on your UAV landing gear.
- ✓ **1-button operation**
  You can't go wrong – the R4 has only one button to make operation as simple as possible!
- ✓ **Noise cancellation**
  Due to a high sampling rate, UAV motor noise is accepted, detected and can be filtered out during raw data export.
- ✓ **Powerful DataTool**
  The free MagDrone DataTool lets you delete tracks, compensate, filter, … and allows various exports!

Most frequent questions

- ➢ **What can it detect?**
  The magnetometers detect everything ferrous (iron) – but i.e. not Aluminum or Gold as they are conductive only.
- ➢ **How deep can it sense?**
  It depends. The R4 sees a harvester machine from 40m distance; but a hand grenade from only a few centimeters.
- ➢ **Ideal flight height?**
  For compact objects: as close as possible – 50cm above ground. Can be dozen of meters for soil structures.
- ➢ **Does it work over water?**
  Yes. Water doesn't affect sensor operation or damping the magnetic field strength (to be detected).
- ➢ **Sensitivity of the sensors**
  The sensitivity of the installed FGM3D/75 is 0.13V/µT, the resolution is better than 150pT.
- ➢ **Interference from UAV**
  Constant noise (motors) is ok and is filtered out, but don't use a camera gimbal with the R4.

R4: TECHNICAL

General Technical Data

Power Supply	12-32 V
Operating Temperature	-20°C to +50°C
Weight	1,500 g
Overall power consumption	10 W
Sensor tube dimensions (L x D)	2,074 x 29 mm

FGM3D/75 Fluxgate

Number and orientation of sensors	5 sensors, laid horizontal, parallel
Specified measurement range	±75,000 nT (other ranges on request)
Number of sensor axis	3
Distance between sensors	500 mm
Noise level @1Hz [pT/ (Hz)]	10 pT < all sensors M1-M5 < 20 pT

Datalogger

Power	50 mA
Sensor input	Hard wired, 75cm sensor cable
User Interface	Start/Stop button; Webserver
Survey mode	Continuous recording while airborne
Sampling rate	200 Hz (higher rates available on request)
Internal memory	8 GB (approx. 120h recording)
Datalogger dimensions (W x D x H)	264,5 x 104,5 x 80 mm

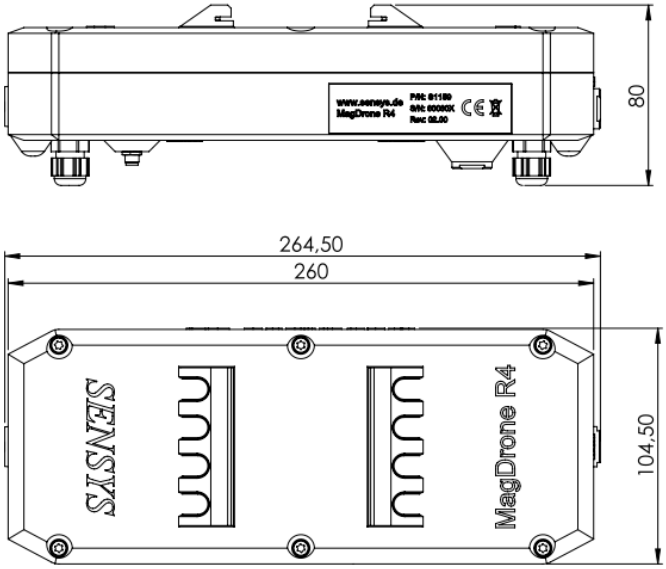
Data Processing

MagDrone DataTool (included)	Raw data filtering, track & flight direction detection, noise compensation, MagBase or GPS referencing, export, preview
MAGNETO® Software	Data interpretation, visualization, object calculation, etc.
Live output	Via Webserver

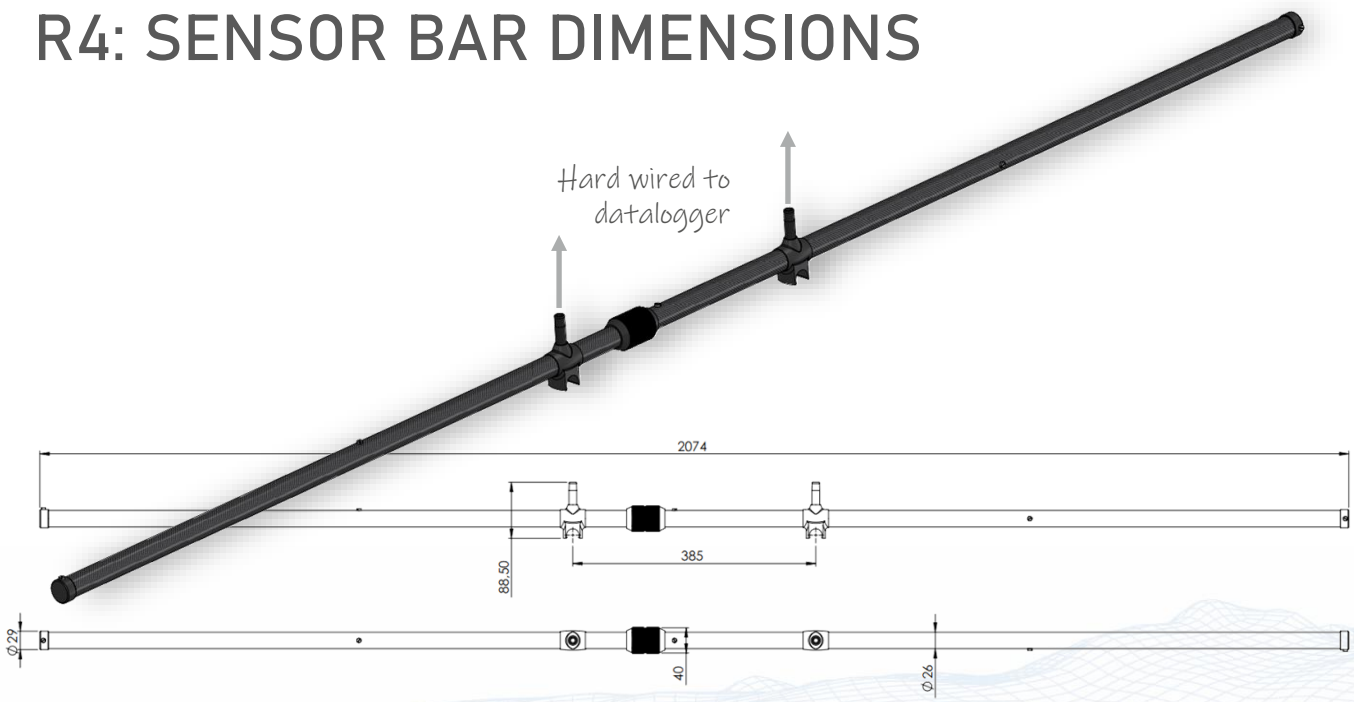
GPS Add-on

EMLID M2 / RS2	Interface for EMLID M2 multiband RTK GPS with optional EMLID RS2 base station

R4: DATALOGGER INSTALLATION



R4: SENSOR BAR DIMENSIONS



R4: STANDARD PACKAGE AND OPTIONS

Standard package

MagDrone R4 Survey kit with 5 triaxial Fluxgates — **Ask for price!**

- 5x FGM3D/75 at 50cm distance
- Carbone sensor tube
- Data logger with internal storage
- Mounting plate and screws for DJI M300
- USB memory clip with MagDrone DataTool
- Manual / Certificate
- Transport hard case

Options

FGM3D Option: Non-Dual Use Version — **Ask for price!**

- This noise modification of the sensor is necessary for all single sensors or sensors within a system that are intended for export into countries with export restrictions.)

MAGNETO® Software — **Ask for price!**

- For data interpretation, visualization, object calculation, etc.

EMLID M2 + RS2 RTK DGPS Rover and base package — **Ask for price!**

or

SPH SkyHub Controller for DJI M300 — **Ask for price!**

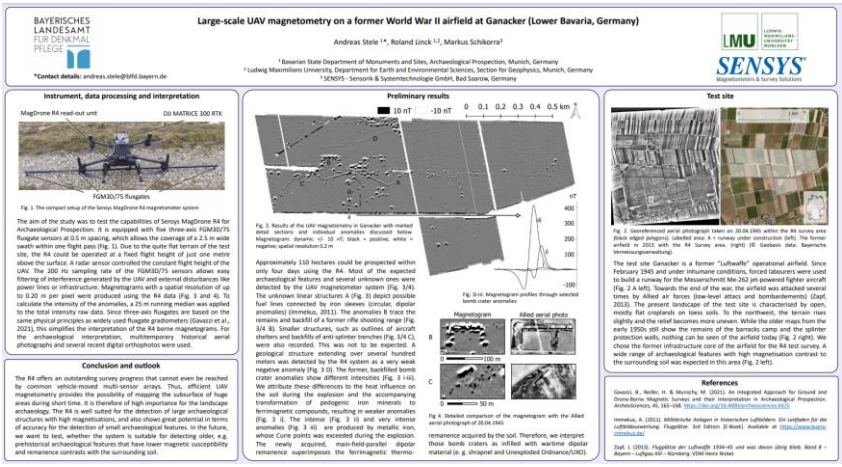
- To overrule DJI controls for low altitude flights and terrain following mode, output GPS stream

R4: IN OPERATION WITH OUR CLIENTS

MagDrone R4 in Bavaria - 120 ha in 4 days

The **Bavarian State Department of Monuments and Sites, Archaeological Prospection**, Munich, Germany undertook a Large-scale UAV magnetometry on a former World War II airfield at Ganacker (Lower Bavaria, Germany), published at DGG's 2022 conference in Munich.

"The aim of the study was to test the capabilities of SENSYS MagDrone R4 for Archaeological Prospection. [...] Due to the quite flat terrain of the test site, the R4 could be operated at a fixed flight height of just one metre above the surface. A radar sensor controlled the constant flight height of the UAV. The 200 Hz sampling rate of the FGM3D/75 sensors allows easy filtering of interference generated by the UAV and external disturbances like power lines or infrastructure. Magnetograms with a spatial resolution of up to 0.20 m per pixel were produced using the R4 data. To calculate the intensity of the anomalies, a 25 m running median was applied to the total intensity raw data. Since three-axis fluxgates are based on the same physical principles as widely used fluxgate gradiometers (Gavazzi et al., 2021), this simplifies the interpretation of the R4 borne magnetograms. For the archaeological interpretation, multi-temporary historical aerial photographs and several recent digital orthophotos were used."


Large-scale UAV magnetometry on a former World War II airfield at Ganacker (Lower Bavaria, Germany)

Andreas Stele [1*], Roland Linck [1,2], Markus Schikorra [3]

[1] Bavarian State Department of Monuments and Sites, Archaeological Prospection, Munich, Germany
[2] Ludwig Maximilians University, Department for Earth and Environmental Sciences, Section for Geophysics, Munich, Germany
[3] SENSYS - Sensorik & Systemtechnologie GmbH, Bad Saarow, Germany

*Contact details: andreas.stele@blfd.bayern.de

BAYERISCHES LANDESAMT FÜR DENKMALPFLEGE

SENSYS Magnetometers & Survey Solutions

Instrument, data processing and interpretation

MagDrone R4 read-out unit

DJI MATRICE 300 RTK

FGM3D/75 fluxgates

Fig. 1: The compact setup of the Sensys MagDrone R4 magnetometer system

The aim of the study was to test the capabilities of Sensys MagDrone R4 for Archaeological Prospection. It is equipped with five three-axis FGM3D/75 fluxgate sensors at 0.5 m spacing, which allows the coverage of a 2.5 m wide swath within one flight pass (Fig. 1). Due to the quite flat terrain of the test site, the R4 could be operated at a fixed flight height of just one metre above the surface. A radar sensor controlled the constant flight height of the UAV. The 200 Hz sampling rate of the FGM3D/75 sensors allows easy filtering of interference generated by the UAV and external disturbances like power lines or infrastructure. Magnetograms with a spatial resolution of up to 0.20 m per pixel were produced using the R4 data (Fig. 3 and 4). To calculate the intensity of the anomalies, a 25 m running median was applied to the total intensity raw data. Since three-axis fluxgates are based on the same physical principles as widely used fluxgate gradiometers (Gavazzi et al., 2021), this simplifies the interpretation of the R4 borne magnetograms. For the archaeological interpretation, multitemporary historical aerial photographs and several recent digital orthophotos were used.

Conclusion and outlook

The R4 offers an outstanding survey progress that cannot even be reached by common vehicle-moved multi-sensor arrays. Thus, efficient UAV magnetometry provides the possibility of mapping the subsurface of huge areas during short time. It is therefore of high importance for the landscape archaeology. The R4 is well suited for the detection of large archaeological structures with high magnetisations, and also shows great potential in terms of accuracy for the detection of small archaeological features. In the future, we want to test, whether the system is suitable for detecting older, e.g. prehistorical archaeological features that have lower magnetic susceptibility and remanence contrasts with the surrounding soil.

Preliminary results

10 nT -10 nT 0 0.1 0.2 0.3 0.4 0.5 km

Fig. 3: Results of the UAV magnetometry in Ganacker with marked detail sections and individual anomalies discussed below. Magnetogram: dynamic +/- 10 nT, black = positive, white = negative; spatial resolution 0.2 m

Approximately 110 hectares could be prospected within only four days using the R4. Most of the expected archaeological features and several unknown ones were detected by the UAV magnetometer system (Fig. 3/A). The unknown linear structures A (Fig. 3) depict possible fuel lines connected by iron sleeves (circular, dipolar anomalies) (Immekus, 2011). The anomalies B trace the remains and backfill of a former rifle shooting range (Fig. 3/4 B). Smaller structures, such as outlines of aircraft shelters and backfills of anti-splinter trenches (Fig. 3/4 C), were also recorded. This was not to be expected. A geological structure extending over several hundred meters was detected by the R4 system as a very weak negative anomaly (Fig. 3 D). The former, backfilled bomb crater anomalies show different intensities (Fig. 3 I-III). We attribute these differences to the heat influence on the soil during the explosion and the accompanying transformation of pedogenic iron minerals to ferrimagnetic compounds, resulting in weaker anomalies (Fig. 3 I). The intense (Fig. 3 II) and very intense anomalies (Fig. 3 III) are produced by metallic iron, whose Curie points was exceeded during the explosion. The newly acquired, main-field-parallel dipolar remanence superimposes the ferrimagnetic thermo-remanence acquired by the soil. Therefore, we interpret those bomb craters as infilled with wartime dipolar material (e. g. shrapnel and Unexploded Ordnance/UXO).

Fig. 3/III: Magnetogram profiles through selected bomb crater anomalies

Magnetogram

Allied aerial photo

B

C

0 100 m

0 50 m

Fig. 4: Detailed comparison of the magnetogram with the Allied aerial photograph of 20.04.1945

Test site

Fig. 2: Georeferenced aerial photograph taken on 20.04.1945 within the R4 survey area (black edged polygon). Labelled area: A = runway under construction (left). The former airfield in 2013 with the R4 Survey area, (right) (© Geobasis data: Bayerische Vermessungsverwaltung).

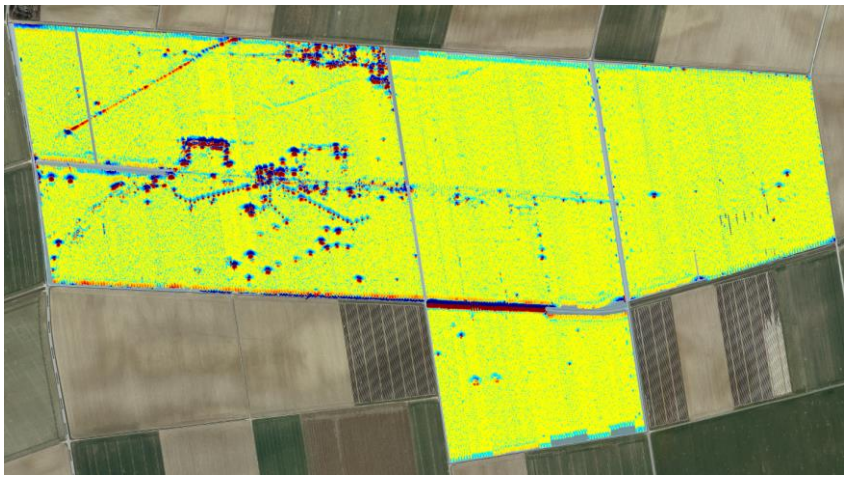
The test site Ganacker is a former "Luftwaffe" operational airfield. Since February 1945 and under inhumane conditions, forced labourers were used to build a runway for the Messerschmitt Me-262 jet-powered fighter aircraft (Fig. 2 A left). Towards the end of the war, the airfield was attacked several times by Allied air forces (low-level attacs and bombardements) (Zapf, 2013). The present landscape of the test site is characterised by open, mostly flat croplands on loess soils. To the northwest, the terrain rises slightly and the relief becomes more uneven. While the older maps from the early 1950s still show the remains of the barracks camp and the splinter protection walls, nothing can be seen of the airfield today (Fig. 2 right). We chose the former infrastructure core of the airfield for the R4 test survey. A wide range of archaeological features with high magnetisation contrast to the surrounding soil was expected in this area (Fig. 2 left).

References

Gavazzi, B., Reiller, H. & Munschy, M. (2021): An Integrated Approach for Ground and Drone-Borne Magnetic Surveys and their Interpretation in Archaeological Prospection. Archéosciences, 45, 145–168. https://doi.org/10.4000/archeosciences.8325

Immekus, A. (2011). Militärische Anlagen in historischen Luftbildern. Ein Leitfaden für die Luftbildauswertung. Flugplätze. 3rd Edition [E-Book]. Available at https://www.buero-immekus.de/

Zapf, I. (2013). Flugplätze der Luftwaffe 1934-45 und was davon übrig blieb. Band II – Bayern – Luftgau XII – Nürnberg. VDM Heinz Nickel.



Conclusion:
"The R4 offers an outstanding survey progress that cannot even be reached by common vehicle-moved multi-sensor arrays. Thus, efficient UAV magnetometry provides the possibility of mapping the subsurface of huge areas during short time."

By: Andreas Stele, Roland Linck, Markus Schikorra