

# Application Note: Airborne & Aerospace Surveys



Photo: Courtesy of New Resolution Geophysics, South Africa.

## OVERVIEW

Fluxgate magnetometers have long been used for airborne applications. Here we provide an overview of some of the most common applications and include recommendations as to the most suitable sensors. We also include details of sensors suitable for mounting on unmanned vehicles.

## Magnetic Anomaly Detection

This is one of the most common airborne application of fluxgate magnetometers. The idea is that an aircraft is used to locate submerged submarines through the magnetic disturbance created by the presence of a ferromagnetic mass in the Earth's magnetic field.

The typical setup includes a scalar magnetometer that precisely measures the amplitude of the Earth's field, and a 3-axis fluxgate magnetometer which is used to quantify the disturbances from the aircraft as it changes orientation. The fluxgate's output is used to correct the data from the scalar magnetometer.

Typically, for military applications, the Mag669 or Mag629 will be the preferred solution as these sensors have been subjected to a series of testing to Mil-std. The Mag669 also has the added benefit of offering extremely low noise helping improve overall platform noise. Its unpackaged nature makes it more compact for use on smaller platform, with the potential of use as part of a MAD system for unmanned vehicles.

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## Equipment

- Three-axis Fluxgate Magnetometer



## Applications

- Measure magnetic field variations from an airborne platform
- Determine the magnetic signature from an airborne platform and use the input to compensate its interference on a total field magnetometer

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## Airborne Magnetic Surveys

A similar setup to MAD is also used commercially for the purpose of mapping magnetic anomalies for mineral exploration purposes. The same principle of a two-magnetometer setup with a scalar and 3-axis fluxgate sensor applies, though here as testing requirement may not be as stringent, sensors such as the Mag-13MSL (or its predecessor the Mag-03) have been widely used.

<https://www.nrgex.co.za/our-services/xtract-fixed-wing-gravity-and-magnetics/>

## UAV-based Mapping

The advent of unmanned technology has permitted more flexible and more cost-effective surveys. Geophysics among other markets have make use of UAV to replace manned platforms. For use on smaller platform, users have developed correction algorithms that enable correction of 3-axis sensors data to provide accurate scalar data. The benefit here is that fluxgate sensors are both smaller, lighter and less power hungry than their scalar counterparts.

In addition to mapping for mineral application, fluxgate sensors can be used for airborne UXO mapping or archaeology.

Here Mag-03 or Mag-13 standard noise sensor would be ideal. Due to the noise present on the corrections, low noise versions of the sensors do not bring much improvement. The analogue outputs of the sensor are fed into an onboard digitisation system.

*Le Maire, P., Bertrand, L., Munsch, M., Diraison, M. and Géraud, Y. Aerial magnetic mapping with a UAV and a fluxgate magnetometer: a new method for rapid mapping and upscaling from the field to regional scale. Geophysical Prospecting, Wiley, 2020, ff10.1111/1365-2478.12991*

*Gavazzi, B., Le Maire, P., Munsch, M., and Dechamp, A. Fluxgate vector magnetometers: A multisensor device for ground, UAV, and airborne magnetic surveys. Leading Edge, Society of Exploration Geophysicists, 2016, 35 (9), pp.795-797*

## Compassing

Fluxgate sensors can be used to determine the heading (with reference to the Earth's magnetic field) of an airborne vehicle. The use of 3-axis component provides accurate heading output. Typically, the fluxgate output will also be combined with other sensor's information.

However magnetic measurements are not subject to the same bias instability as gyros and are often used as a back-up heading sensor.

A number of sensors will here be suitable and may be dependent on the platform on which the sensor will be mounted, power requirement, space available etc...

## Attitude/Heading sensor

An extension of the compassing application is the use of fluxgate magnetometers as heading sensors for sounding rockets / high altitude balloons or spacecraft. Here, the 3-axis sensor is used to measure the Earth's field and determine the rocket/spacecraft/payload's orientation in relation to the Earth's field.

For the use on sounding rockets standard sensors such as the Mag-03, Mag-13 or some of the low power sensors (Mag648/Mag649) will be suitable for the application.

For spacecraft application, sensors which have been tested in flight include the Mag566 and Spacemag-Lite.

The sensor's output is then used to determine the position of the spacecraft, and if required, the attitude control system will adjust the orientation of the spacecraft.

<https://sites.wff.nasa.gov/code810/files/SRHB.pdf>

## High Altitude and Space-borne Magnetic Field Measurement

In addition to attitude control, magnetometers mounted on spacecraft or high-altitude balloons can be used to measure the magnetic field surrounding the platform. Application include measurement for the purpose of space weather, recording upper atmosphere field variations and find potential link to earthquake precursors.

The Spacemag-lite is suitable for this application as the sensor head can be easily remotely located away from the electronics in order to avoid disturbances associated with the spacecraft.

*Millan, R.M., McCarthy, M.P., Sample, J.G. et al. The Balloon Array for RBSP Relativistic Electron Losses (BARREL). Space Sci Rev* **179**, 503–530 (2013).

<https://doi.org/10.1007/s11214-013-9971-z>