SAGA-AEM 2013 EXTENDED ABSTRACT

EXTENDED ABSTRACT FOR: SAGA

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MAGNETIC TENSOR MEASUREMENTS VALIDATED BY MEANS OF A SIMULATED MAGNETIC SOURCE

An experimental facility was established in which a helicopter borne magnetic gradient sensor was flown over a known magnetic source. A comparison of the measured gradients and the calculated gradients served as a validation of the proper functioning of the complete system.

A magnetic gradiometer was developed based on superconducting quantum interference technology. The system is located on a helicopter borne platform and is capable of measuring the full magnetic gradient tensor.

The purpose of this work was to establish an experiment in which the system is flown over a known magnetic source of which the gradients can be calculated and then compared to the measured magnetic gradients.

In designing the experiment, the object was to establish a magnetic gradient which would measure in the order of 1 nanotesla/metre while the observation point is 20 metre directly above the magnetic source.
The experiment was conducted by arranging two turns of copper cable in a square shape with side length 40 metre. A 12V battery was connected across the cable endpoints which gave a direct current of about 10 ampere. The system was flown over the cable loop at a nominal altitude of 20 metre.

For the purposes of calculating the magnetic gradients, use was made of the following expression of the magnetic field due to a current carrying conductor of arbitrary shape (Reitz et al., 1979):

$$\mathbf{B}(\boldsymbol{r}_2) = \frac{\mu I}{4\pi} \oint_C \frac{d\mathbf{l} \times (\boldsymbol{r}_2 - \boldsymbol{r}_1)}{|\boldsymbol{r}_2 - \boldsymbol{r}_1|^3}$$

(1)

where

B: magnetic flux density vector

$\boldsymbol{r}_1$: position of line element (integration variable)

$\boldsymbol{r}_2$: position of observation point

*d***l:** line element vector of contour C

μ: free space magnetic permeability

I: current

The physical quantities of importance are the gradients of the magnetic field in expression 1, which forms the tensor

$$G = \begin{bmatrix} \frac{dB_x}{dx} & \frac{dB_y}{dx} & \frac{dB_z}{dx} \\ \frac{dB_x}{dy} & \frac{dB_y}{dy} & \frac{dB_z}{dy} \\ \frac{dB_x}{dz} & \frac{dB_y}{dz} & \frac{dB_z}{dz} \end{bmatrix}$$

(2)

A numerical model was developed to calculate the magnetic gradient tensor in expression 2.

The following two processes caused the proposed method to be a validation of the proper functioning and calibration, not only of the gradiometers, but also of the other important instruments of the system: Firstly the GPS position and altitude of the platform were input to the numerical model. Secondly, in the processing of the gradiometer data, use was made of the recorded data from the GPS receiver, magnetometers, accelerometers and gyroscopes. Consequently the method also formed a verification of the accuracy of the data processing.

Reference

Reitz, J.R., Milford, F.J. and Christy, R.W., 1979, Foundations of electromagnetic theory, third edition: Addison-Wesley Publishing Company.