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Morewood Ontario Aeromagnetic Calibration Range

F. Kiss

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Corresponding digital profile data acquired for the Morewood calibration test flight are available from Natural Resources Canada's Geoscience Data Repository for Aeromagnetic data at http://gdr.agg.nrcan.gc.ca/gdrdap/dap/index-eng.php?db_project_no=418.

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Morewood, Ontario aeromagnetic calibration range

Abstract

An aeromagnetic calibration range has been established at Morewood, Ontario. The range is in close proximity to the Ottawa, Ontario geomagnetic observatory and in an area of low magnetic gradient. An airborne survey of the range was flown under contract to Natural Resources Canada by Geo Data Solutions Inc. of Montreal, Quebec. The survey consisted of traverses with a calibrated aircraft flown at a series of heights along the four cardinal directions. Magnetic data were acquired that profile the magnetic field above the traverse intersection point. From these airborne magnetic data and the magnetic diurnal variation data from the geomagnetic observatory, a magnetic offset constant between the Morewood site and the observatory was established at a height of 1500 ft. (457.2 m) above the site. Aeromagnetic survey aircraft acquire data over the range, remove the diurnal variation determined from geomagnetic observatory data, and apply the offset constant to calculate the aircraft's magnetic error.

Morewood Calibration Range

An aeromagnetic survey to establish a new calibration range for aeromagnetic survey aircraft was carried out by Geo Data Solutions Inc. on February 5, 2015. The range is located 35 kilometres southeast of the MacDonald-Cartier airport in Ottawa and 5 kilometres southeast of the town of Morewood, Ontario (Figure 1).

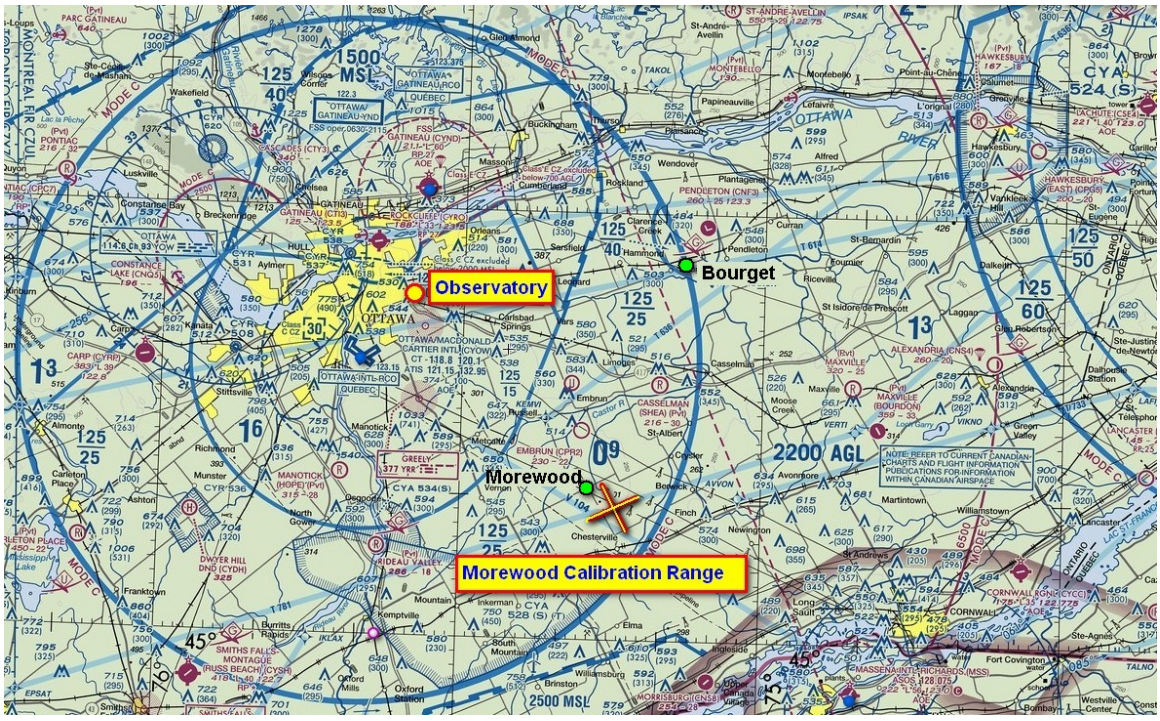

Figure 1: *CYOW VFR navigational chart, showing location of Morewood calibration range (cross) relative to the Ottawa geomagnetic observatory.*

The first aeromagnetic calibration range in Canada was established at a location near Bourget, Ontario east of Ottawa in the early 1980's and was described by Hood and Sawatzky (1983) as a means to test and ensure that aeromagnetic survey aircraft measure the total magnetic field with an absolute accuracy of better than 10 nT. However, the use of the Bourget range has become increasingly problematic due to light aircraft traffic and recent urban development in the area. An alternate site near Morewood, Ontario was chosen as it avoids these operational limitations while being within acceptable proximity to Natural Resources Canada's Ottawa geomagnetic observatory, which provides crucial diurnal magnetic field reference data for calibration flights. Using aeromagnetic survey data from Ontario's Ministry of Northern Development and Mines *Ontario Geological Survey (2014*) publication, the Morewood area was identified as having low magnetic gradient. The area was deemed suitable for use as an aeromagnetic calibration range.

The aircraft contracted for the range survey, a Piper Navajo (registration C-FQQB), was equipped with a Geometrics split-beam G-822A cesium vapour magnetometer mounted in the tail boom of the aircraft. This aircraft was pre-calibrated at the Bourget calibration range prior to the Morewood survey.

In preparation for the Morewood survey, a GPS-time synchronized GEM System GSM-19 Overhauser ground magnetometer was also set up at the Morewood range to monitor and record the local diurnal magnetic field variations while the survey was in progress. One of the criteria for selecting a suitable location for the calibration range was close proximity to the geomagnetic observatory. Several studies (Lilley et al., 1999, Vallée et al., 2006) have documented that Earth's magnetic field can change signature over distances on the order of tens of kilometres and the coherence decreases with increasing distance between measurement stations. The ground magnetometer recording at Morewood and the observatory readings were compared (Figure 2) to demonstrate that the total magnetic field differences between the two locations separated by a distance of 37 kilometres were negligible. For the duration of the survey, the maximum difference in the total magnetic field between the observatory and the Morewood magnetic base station was 0.4 nT.

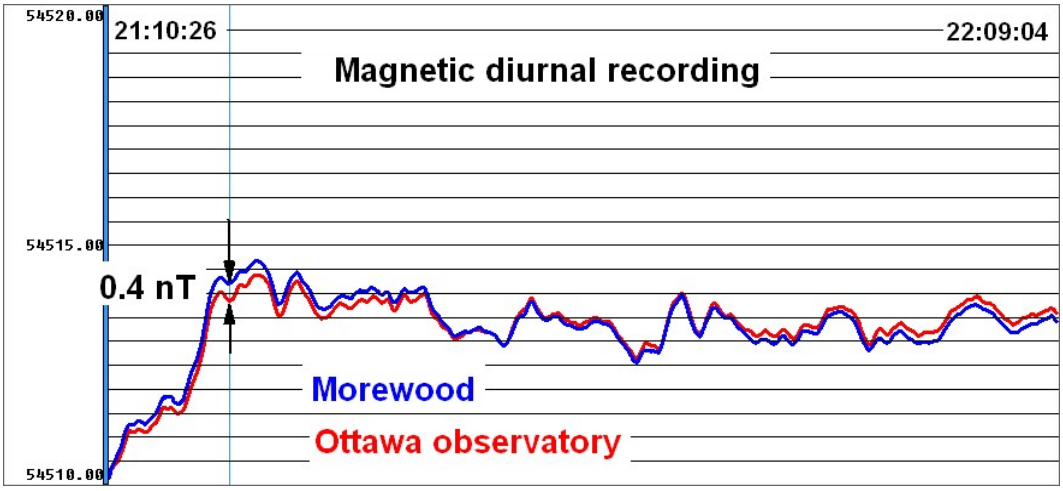

Figure 2: *Comparison of the magnetic diurnal variation between the Ottawa geomagnetic observatory and the Morewood magnetic base station. Maximum difference of the variation was 0.4 nT.*

The survey consisted of two intersecting orthogonal flight lines 5 kilometres in length intersecting at UTM zone 18N, NAD83 projection coordinates 481790E, 4999764N, and stacked above one another at five separate elevations, the mid elevation being close to but not exactly at the target elevation at 1500 feet (457.2 metres) above ground level (AGL) as shown in Figure 3.

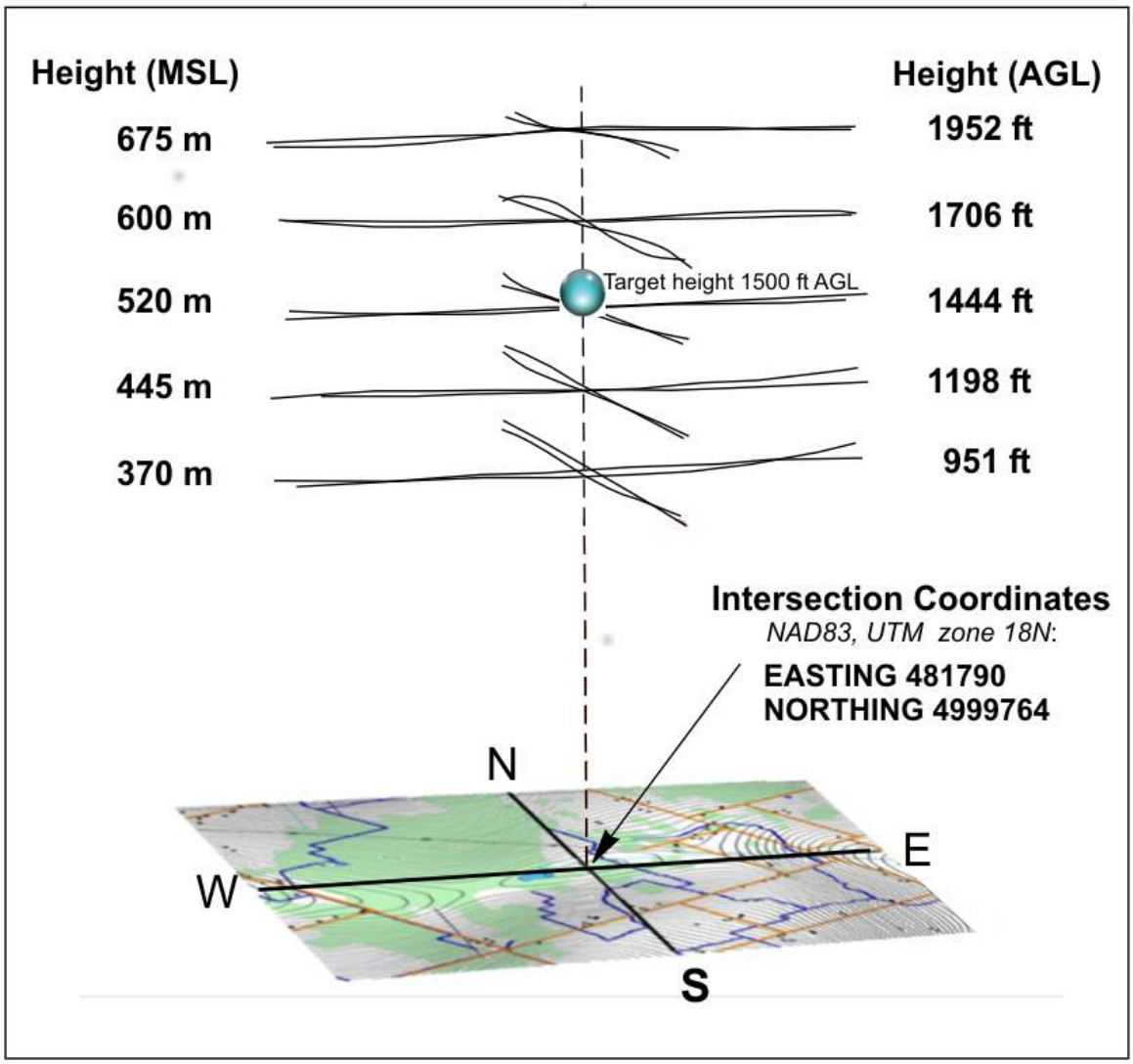

Figure 3: *Aeromagnetic survey layout at Morewood above the designated range intersection. The flight lines (in black) were flown along the four cardinal directions. The sphere marks the target height at 1500 feet above ground level.*

The total field magnetic values at the intersection point for each flight elevation were measured by the magnetometer in the aircraft and recorded with GPS time, as were the observatory's magnetic diurnal readings. Since the Morewood magnetic diurnal variation followed the observatory's variation very closely (Figure 2), the diurnal varying component of the magnetic field measured by the aircraft at each intersection at each elevation level could be calculated by subtracting the time-synchronized observatory

value from the aircraft recorded magnetic value. This resulted in a constant difference between the observatory and the calibration range at each height of the survey in each of the four cardinal directions. The average magnetic total field values over the intersection site at each height are subtracted from the corresponding averaged observatory values to determine the magnetic offsets. The relationship between height and magnetic offset at Morewood (Figure 4) is described by the polynomial equation:

$$y = - 1.375*10^{-5} x^2 - 0.0354 x + 661.715$$

where x is the height in metres in reference to the mean sea level (MSL) datum and y is the offset in nT.

(a)

MSL Height (m)	AGL Height (ft)	Avg. observatory TF (nT)	Avg. int TF (nT)	Offset (nT)
82	4.6	54435.4	53776.7	658.7
370	951.5	54512.2	53865.4	646.8
445	1197.6	54513.2	53869.9	643.3
520	1443.6	54513.7	53874.3	639.4
537	1500.0			638.7
600	1706.1	54513.7	53878.2	635.5
675	1952.2	54513.3	53881.7	631.6

(b)

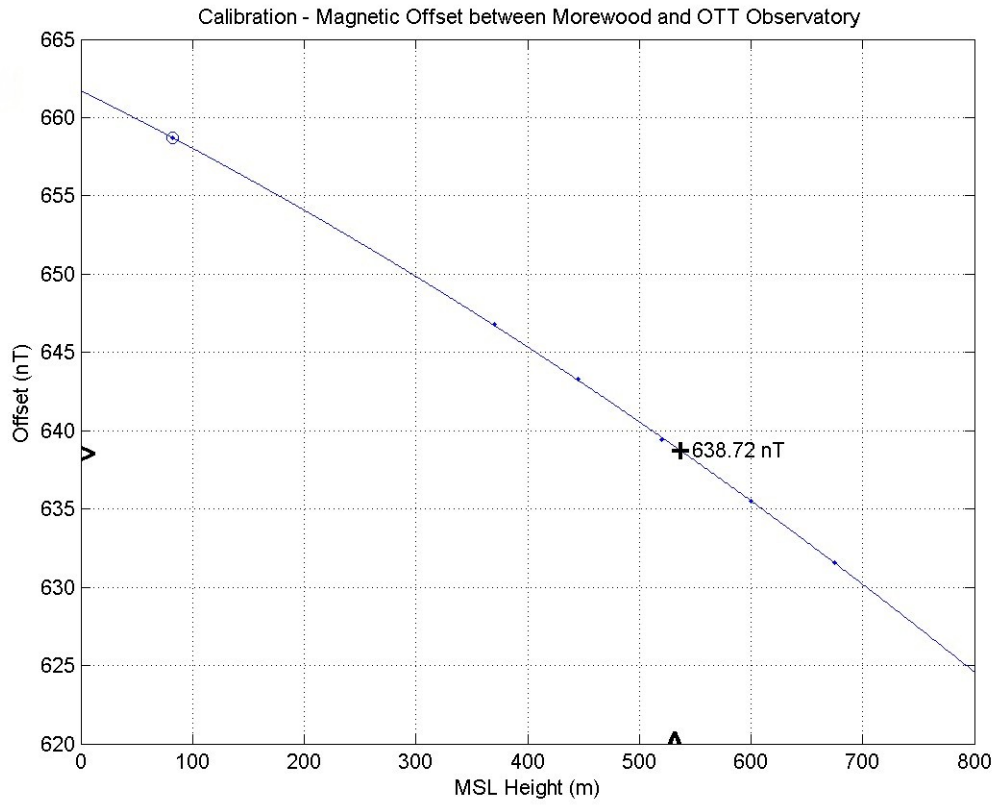

Figure 4: *(a) Tabulation of simultaneous observatory and aircraft magnetic total field measurements and calculated offset values; (b) Graph of calculated offset values vs MSL heights (points); Interpolated offset value of 638.72 nT (cross) is at target flying height of 1500 feet AGL or 537 m ASL. The circled point at 82 metres MSL corresponds to ground surface measurement.*

At the calibration flight height of 1500 feet (AGL) over the intersection point at Morewood, the offset value is 638.72 nT. For any given time, the total magnetic field value at this point can be calculated by subtracting the offset value from the observatory magnetic value at that time. The difference between the calculated total magnetic field value and the aircraft's magnetic value is the aircraft's error. Any observed difference between the calculated magnetic field value and the observed magnetic value of lines flown in opposing directions at the same elevation also provides the heading error of that aircraft. Natural Resources Canada specifications require aircraft to have a total calibration error of <10 nT and a heading error of <5 nT.

A final adjustment to the orientation of the original N-S and E-W flight line axes was implemented based on suggestions from the flight crew to avoid flying directly in the direction of Chesterville, Ontario. The final flight path axes are now oriented N28W and N62E. However, this does not preclude calibrating aircraft along any orthogonal axes of orientation provided that the axes cross at the established intersection point and that the Figure of Merit (FOM) compensation test (Coyle et al., 2014) is also flown along the chosen flight line axes.

This publication is available for free download through GEOSCAN (http://geoscan.nrcan.gc.ca/) as OF7969. Corresponding digital profile data acquired for the Morewood calibration test flight are available from Natural Resources Canada's Geoscience Data Repository for Aeromagnetic data at http://gdr.agg.nrcan.gc.ca/gdrdap/dap/index-eng.php?db_project_no=418. The internal survey report that is associated with the survey data by D'Amours (2015) is included in the data repository. The same products are also available, for a fee, from the Geophysical Data Centre, Geological Survey of Canada, 615 Booth Street, Ottawa, Ontario K1A 0E9. Telephone: (613) 995-5326, email: infogdc@agg.nrcan.gc.ca.

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