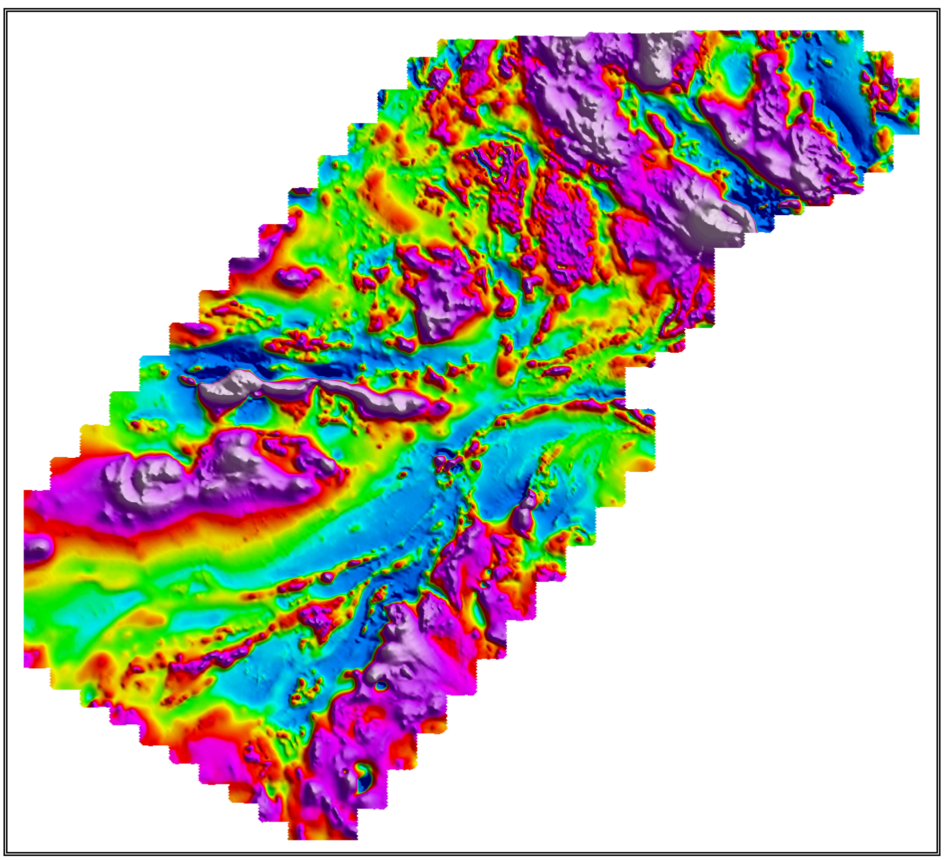
GEOSCIENCE BC

AEROMAGNETIC SURVEY
QUEST-NORTHWEST PROJECT
BLOCK 2

GEOSCIENCE BC REPORT 2012-3

Project # P11026

DECEMBER 2011



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By

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December 2011

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1.0 INTRODUCTION

On July 5th, 2011 **GEO SOLUTIONS DONNEES GDS / GEO DATA SOLUTIONS GDS INC.** was awarded contract Number P11026 by Geoscience BC. The contract required the acquisition and compilation of 11,345 line-km of digitally-recorded high sensitivity helicopter borne total magnetic field data in the Telegraph Creek area, BC (figure 1).

Data were recorded using split-beam cesium vapour magnetometers mounted in a stinger rigidly attached to the helicopter Astar 350 B2 (C-FNWE) which was leased from **Mustang Helicopters inc.** (C-FNWE). Nominal traverse and control line spacing were 250 m and 2 500 m respectively and the aircraft nominal terrain clearance was 80 m. The survey was flown on a pre-determined flight surface in order to minimize differences in magnetic values at the intersections of control and traverse lines. These differences were computer-analysed to obtain a mutually levelled set of flight-line magnetic data.

This report describes the survey procedures and data verification, which were carried out in the field, and data processing, which followed at the office.

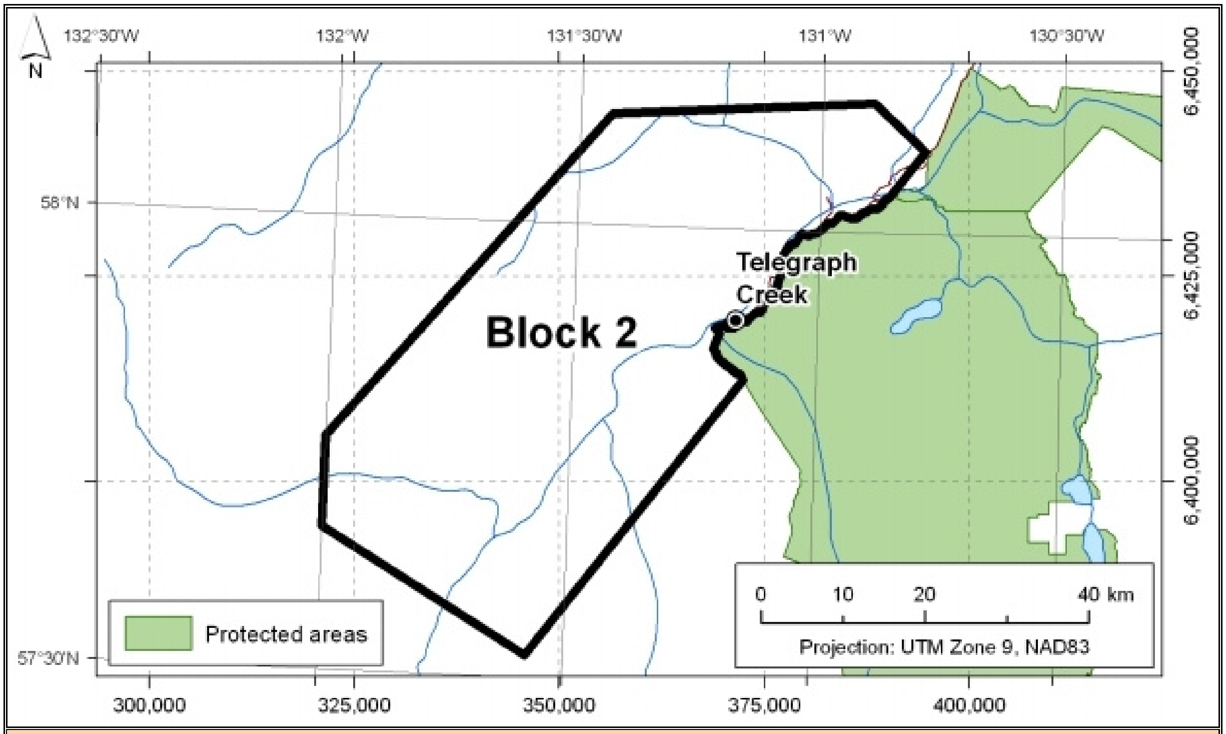


Figure 1: QUEST-Northwest Project, block 2 survey area location

2.0 RECONNAISSANCE OF PROJECT

Unstable weather conditions (rain and low clouds) were present during survey operation. Daylight periods were between 14 hours a day in August and up to 11 hours at the end of September.

For most of the survey area, the topographic relief can be described as moderate to rugged (figure 3 and 4). **GDS** used a 3D-Drape navigation software to fly a smooth drape surface with a rate of climb of 30%. The use of this technique minimizes Tie/Traverse intersection differences at the risk of not achieving optimal ground clearance in some areas of steep topography. The surface was created using SRTM elevation data along with software provided by the Geological Survey of Canada (Drape_dtm). There were no restricted or danger zones and no special operating licence was required.

GDS set up its base of operations in Telegraph Creek, BC, which is located at the Northeast border of the survey block. As such, the range capability of the Astar 350 B2 aircraft to fly the survey was suitable to collect large volumes of data on each flight.

A primary magnetic base station (Mag Base A) was set up near the airport at a magnetic noise-free location, away from magnetic objects, vehicles and DC electrical power lines. A second magnetic base station (Mag Base B) was established midway between Telegraph Creek and the airport (figure 2 and 7).

The nominal traverse and control line spacing were 250 m and 2 500 m respectively. Traverse lines were oriented N90°E with orthogonal control lines. The survey was flown with a nominal terrain clearance of 80 metres.

The survey block location is shown on figure 3 while table 1 defines its co-ordinates in NAD83 longitude/latitude and UTM zone 9N.

Table 1: QUEST-Northwest Project, block 2 co-ordinates

Longitude	Latitude	X	Y
131.08.55°W	57.50.03°N	372432	6412286
131.34.36°W	57.31.30°N	345701	6378742
132.00.00°W	57.39.26°N	321016	6394513
132.00.00°W	57.45.27°N	321510	6405653
131.26.05°W	58.07.21°N	356589	6444933
130.53.39°W	58.08.33°N	388490	6446140
130.47.13°W	58.05.26°N	394651	6440191
130.51.43°W	58.02.16°N	390064	6434432
and many points along the North-West limits of Mt Edziza provincial park (see figure 1)			

Figure 2: Magnetic base station locations

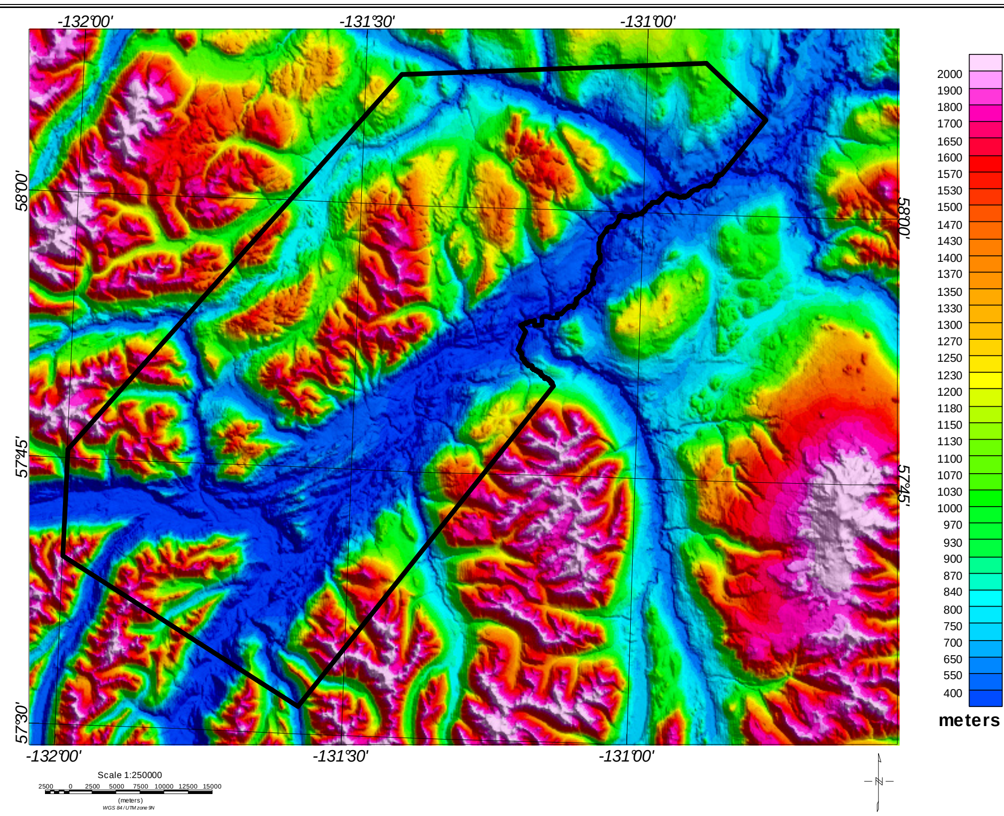


Figure 3: QUEST-Northwest Project, block 2 survey area topographic relief

Figure 4: QUEST-Northwest survey area pictures

3.0 TEST AND CALIBRATION

The following is a summary of all tests and calibration performed before survey production. Results are presented in appendix A.

Aircraft	Radar	Lag	FOM
C-FNWE	2011-08-11	2011-08-11	2011-08-12

3.1 Magnetometer Tests

Effects of aircraft manoeuvres (roll, pitch and yaw) were determined and results of this test submitted to the Technical Inspector. This test was performed over a magnetically quiet zone in Fort St-James, at a high altitude. It consisted of flying ±10^o rolls, ±5^o pitches and ±5^o yaws along North, South, East and West headings over periods of 4-5 seconds. A compensation Figure of Merit (FOM) for the aircraft was calculated by summing up the peak-to-peak amplitudes of the 12 magnetic signatures. The FOM value obtained was 2.07 nT. Appendix A presents detailed results of the FOM test.

3.2 Altimeter Calibration

The altimeter calibration was performed by flying a range of altitudes representative of the survey area conditions, above and below the designated nominal ground clearance. These altitudes covered the minimum and maximum range at 9 different altitudes. These levels were determined by the real time GPS-Z above the elevation of the Fort St-James airstrip. Appendix A presents detailed results of the altimeter calibration.

3.3 Lag Tests

Prior to the initial commencement of survey production and after any major survey equipment alteration or replacement on the aircraft, GDS's personnel performed a lag test to ascertain the time difference between magnetometer readings and positioning devices. The test was carried out at Fort St-James by flying in opposite directions at the normal survey ground clearance over a distinct magnetic anomaly with known co-ordinates. Test results were submitted to the Technical Inspector. Lags value of 0.12 and 0.16 sec were obtained. Appendix A presents detailed results of the lag test.

4.0 TIMING

The total number of line-km needed to cover the requested Block 2 area was 11,345. One helicopter (C-FNWE) and a field crew mobilized progressively to Fort St-James, BC, starting on August 1st, 2011. Survey equipments were then installed on the aircraft, followed by calibrations and tests. Then, on August 18th, 2011, helicopter and field crew mobilized to Telegraph Creek. The first production flight began on August 20th, 2011 and the last flight ended on October 3rd, 2011. Three days later, aircraft and field crew had already demobilized from the survey area. Preliminary results were sent to the Technical Inspector progressively during the acquisition phase while final maps and data were sent early in December 2011.

Excluding calibration and test flights, a total of 47 flights were needed to cover the survey area. Table 2 illustrates the production period, while table 3 shows the production statistics.

Table 2: Production period				
Aircraft	**July**	**August**	**September**	**October**
C-FNWE				

Table 3: Aircraft statistics	
	C-FNWE
Flight number range	003-050
Number of production flights	47
Production days	24
Standby days	39
Calibration, test, maintenance days	2
Mobilization date	2011-08-01
First production flight date	2011-08-20
Last production flight date	2011-10-03
Demobilization date	2011-10-06
Production hours (hh:mm)	99:17
Ferry hours	18:53
Total hours	118:12
Traverses flown (km)	10,258
Tie lines flown	1,087
Total line-km flown	**11,345**

5.0 QUALITY CONTROL - FIELD

All work was performed to the satisfaction and subject to the acceptance of the Technical Inspector. A copy of the Technical Specifications was available to **GDS**'s personnel responsible in the execution of the contract.

The field processing system consisted of a computer equipped with commercial and custom software, profile and flight path plots (Geosoft Montaj), and all processing software necessary to calculate intersections, and to carry out preliminary levelling and gridding.

Digital data were verified daily with the in-field processing system to ensure the recorded parameters meet contract specifications. Checks were performed to verify the accuracy of the differentially corrected flight path positions independent of base maps.

5.1 GPS Data

Navigation and positioning were achieved through real time differential GPS. C-FNWE was equipped with a Novatel DL-V3 GPS receiver. After each flight, data including GPS positions, were transferred to the field computer systems and merged into the database. Base station data were also amalgamated periodically. GPS data were differentially processed, using the Canadian Spatial Reference System "Precise Point Positioning" programs. Navigational data were also plotted in XY plan format. Errors were noted and re-flights called where necessary.

Verification on the positioning included a calculation of a digital elevation model (DEM), using the differentially corrected GPS altitude and Radar data. The DEM was gridded and plotted.

A plot of the flight path was made from the digital electronic flight path data with appropriate latitude and longitude labelled registration markers allowing verification relative to NTS map co-ordinates. GPS receivers generated latitudes and longitudes, and UTM Conformal Northing and Easting, according to the NAD 83 datum.

5.2 Grid Specifications

The survey height was controlled according to a pre-defined smooth drape surface. The nominal terrain clearance was 80 metres except in areas where Transport Canada regulations prevent flying at this height. In areas where obstacles or topography conflicted with the drape surface, the pilot's judgement prevailed within reason. Traverse lines and control lines were flown at the same altitude at points of intersection. The altitude tolerance was limited to no more than 30 metres difference between traverse lines and control lines.

GDS verified that lines flown outside the following positioning tolerances were re-flown at its own cost:

	Traverse line	Control lines
Bearing	N90°E	N00°E
Spacing	250 m	2 500 m
Allowed min. separation	200 m over 1500 m	
Allowed max. separation	300 m over 1500 m	

Part of traverse lines re-flown to complete a traverse line crossed control lines at either end and joined the original traverse line at a low angle at a point where the data conformed to the technical specifications. All segments of a traverse line began and ended by crossing control lines. Conversely, segments of a control line started and ended by crossing a common traverse line. All traverse lines intersected a minimum of two control lines. Outside survey boundaries, all traverse lines started or ended by intersecting a control line.

For each survey flight, adjacent lines were flown consecutively and in opposite directions. Racetrack flying pattern was not permitted.

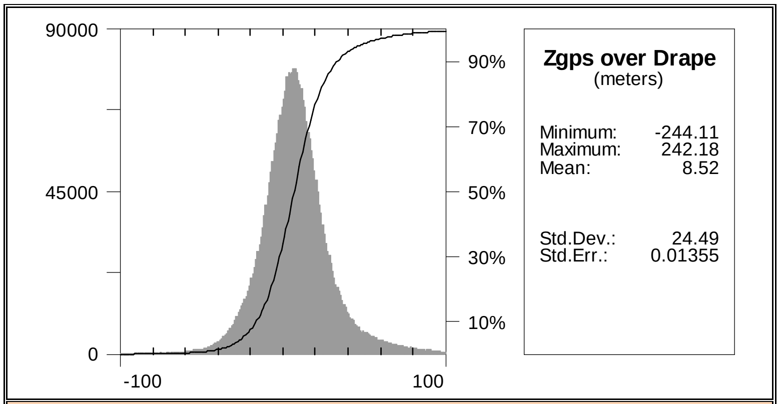


Figure 5: Deviation from the flight surface (Z - Drape)

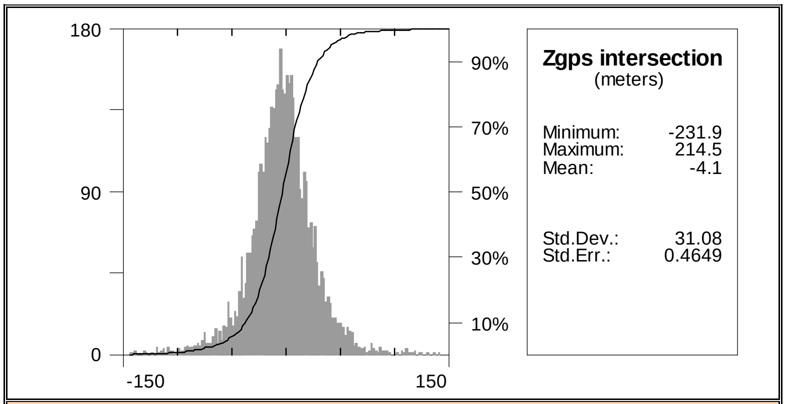


Figure 6: Traverse/Tie Altitude difference

Magnetic base station A

Magnetic base station B

Figure 7: Magnetic base station installations

5.3 Diurnal Specifications

Diurnal magnetic variations were monitored and recorded using two base stations. Base station time and aircraft acquisition time were synchronized via GPS time.

For each base station, a maximum tolerance of 10.0 nT (peak to peak) deviation from a long chord equivalent to a period of 5 minutes was requested. Base station magnetometers were located at the following coordinates (WGS84):

	Latitude	Longitude
Magnetic base station A	57°54'38.31" N	131°07'50.22" W
Magnetic base station B	57°54'14.65" N	131°08'39.71" W

5.4 Maintenance of speed and sampling

Pilots maintained a slower, economic cruising speed for the aircraft, which reduced fuel consumption and time required for repositioning between survey lines, while increasing the sampling density. Pilots were instructed to fly this survey so as to achieve a ground speed at an average of 35 m/sec (figure 8).

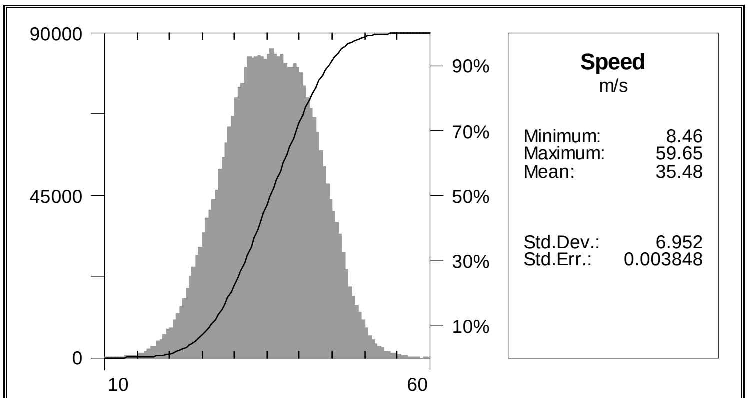


Figure 8: Aircraft speed statistics

5.5 Magnetic data

All magnetic data recorded in flight were checked for noise by an inspection of the fourth difference trace. When enough and adequate data were accumulated, magnetic values for traverse/tie line intersections were calculated and preliminary magnetic levelling carried out. Finally, grids and preliminary magnetic contours were produced, to ensure completeness and veracity of data.

6.0 Data Processing - Office

Essentially the office processing system has all of the capabilities of the field system, plus additional presentation and colour plotting facilities. Since data had been edited and processed in the field, it was not expected that additional serious problems will be encountered in the office. Nevertheless, with increased capacity, personnel and time available, editing and compilation procedures were carried out to detect and correct any remaining isolated errors, to refine the positioning, carry out levelling and gridding through to final contours (figure 9 and 10). Processing was monitored closely by the Project Leader. All requirements of the Solicitation were met. Preliminary data and final products were submitted to the Technical Inspector for checking according to the contract specifications.

6.1 Positioning Data (GPS and altimeters)

The raw GPS data from the aircraft was recovered. The Canadian Spatial Reference System "Precise Point Positioning" programs were used for post-processing the raw GPS data. The latitudes and longitudes were converted from the WGS84 spheroid to the local map projection and datum (NAD83) in UTM coordinates. A point to point speed calculation was then done from the final X, Y, Z coordinates and reviewed as part of the quality control. The flight data was then cut back to the proper survey line limits and a preliminary plot of the actual flight path was done and compared to the theoretical flight path to verify the navigation. No gaps were detected in real time GPS.

The positional data, which includes the radar altimeter and the post-processed corrected GPS elevation values were checked and corrected for spikes using a fourth difference editing routine. No period of poor satellite visibility were detected. The raw radar altimeter data was adjusted using the calibrations determined from the altimeter flight test. A small noise filter, such as a non-linear filter (0.3sec) + low-pass (0.5sec), was then applied to the data. The filtered radar altimeter data were also lagged to account for system parallax.

A digital elevation model (DEM) was then computed by subtracting the radar altimeter values from the differentially corrected GPS elevation values. Following a QC inspection, the DEM channel was tie-line levelled and adjusted using the SRTM1 Digital Elevation Data.

6.2 Magnetic base station data

The recorded magnetic diurnal base station data are loaded into the flight database based on common GPS time stamps. After initial verification of its integrity, the data was checked and corrected for spikes then slightly smoothed using a non-linear noise filter of 2 seconds width and a low-pass filter of 0.5sec.

The airborne magnetic data were corrected for diurnal drift. The mean value of the ground mag used in the drift calculation is 56157.711 nT.

6.3 Airborne Magnetic Data

The RMS DAARC500 binary raw data (mag, analog and serial inputs) was reformatted and loaded into the Montaj database. After initial verification of the data by statistical analysis, the values were adjusted for system lag.

A preliminary grid of the values was then created and verified for obvious problems, such as errors in positioning, jumps in the magnetic data or bad diurnal. Appropriate corrections were then applied to the data, as required.

The airborne magnetic data were corrected for diurnal drift. Magnetic data was then corrected for altitude using the drape surface and Zgps values. The correction was calculated using the grid of the First Vertical Derivative of the pre-levelled magnetic data, then sampled into the database and multiplied by the differences between Zgps and drape surface.

The final levelling process was applied to data. This consists of calculating positions of the control points (intersections of traverses and tie lines), calculating magnetic differences at the control points and producing a pattern of smooth adjustments in order to level the data and reduce the misclosures to zero. In areas of steep magnetic gradient and/or of rugged topographic relief, intersection adjustments could be deleted or an appropriate adjustment assigned to the traverse line.

A new grid of values was then created and checked for residual errors. Any gross errors detected were corrected in the profile database and levelling process repeated. Levelling was done using the following procedures:

Table 4: Tie line levelling parameters

Pass	Filter	Tie	Traverse
1	6^{th} order LP Butterworth(5000)	x	
2	8^{th} order LP Butterworth(1000)		x
3	6^{th} order LP Butterworth(500)	x	

6.4 Micro-levelling

Complex airborne datasets acquired on parallel lines often exhibit subtle artefacts in the line direction. Micro-levelling is used to filter the primary gridded data in order to reduce or remove long-wavelength noise along survey lines, caused by non-geological effects. For this survey, GDS used a standard micro-levelling technique. A decorrugation grid is calculated from the magnetic values using Butterworth and directional cosine filters then sampled back into the main database to a noise channel. Those values are clipped out, smoothed with a Butterworth filter and saved to a micro-levelling correction channel that will be subtracted from the previously levelled magnetic data.

Once the micro-levelling process is applied, colour-shaded images are studied to verify that the residual line noise has been minimized, and that new line noise has not been introduced. The micro-level correction grid is reviewed to confirm that no significant geological signal had been lost. The final stage is to sample the correction grid and apply these corrections to the geophysical data profile.

6.5 IGRF Subtraction

The International Geomagnetic Reference Field (IGRF) was then calculated from the 2010 model year. A constant date (September 10, 2011) and constant elevation (1126m MSL) were used in the calculation and results were removed from levelled values to obtain the Residual Total Magnetic Field.

6.6 Gridding of the Residual Magnetic Field and First Vertical Derivative

The grid of the Residual Magnetic Total Field and its First Vertical Derivative were finally calculated by a minimum curvature algorithm using only traverse lines. A tolerance of 0.0001, a Pass Tolerance of 99.99999% and maximum iterations of at least 1000 were used as gridding parameters. Minimum curvature gridding provides the smoothest possible grid surface that also honours profile line data. However, sometimes this can cause narrow linear anomalies cutting across flight lines to appear as a series of isolated spots.

The First Vertical Derivative of the magnetic field is the rate of change of the magnetic field in the vertical direction. Computation of the first vertical derivative removes long-wavelength features of the magnetic field and significantly improves the resolution of closely spaced and superposed anomalies. The grid of the First Vertical Derivative was computed from the gridded Residual Magnetic Total Field data using a fast Fourier transform, sampled back into the main database and then gridded with the same enhanced parameters. This technique improves the look of the grid between lines.

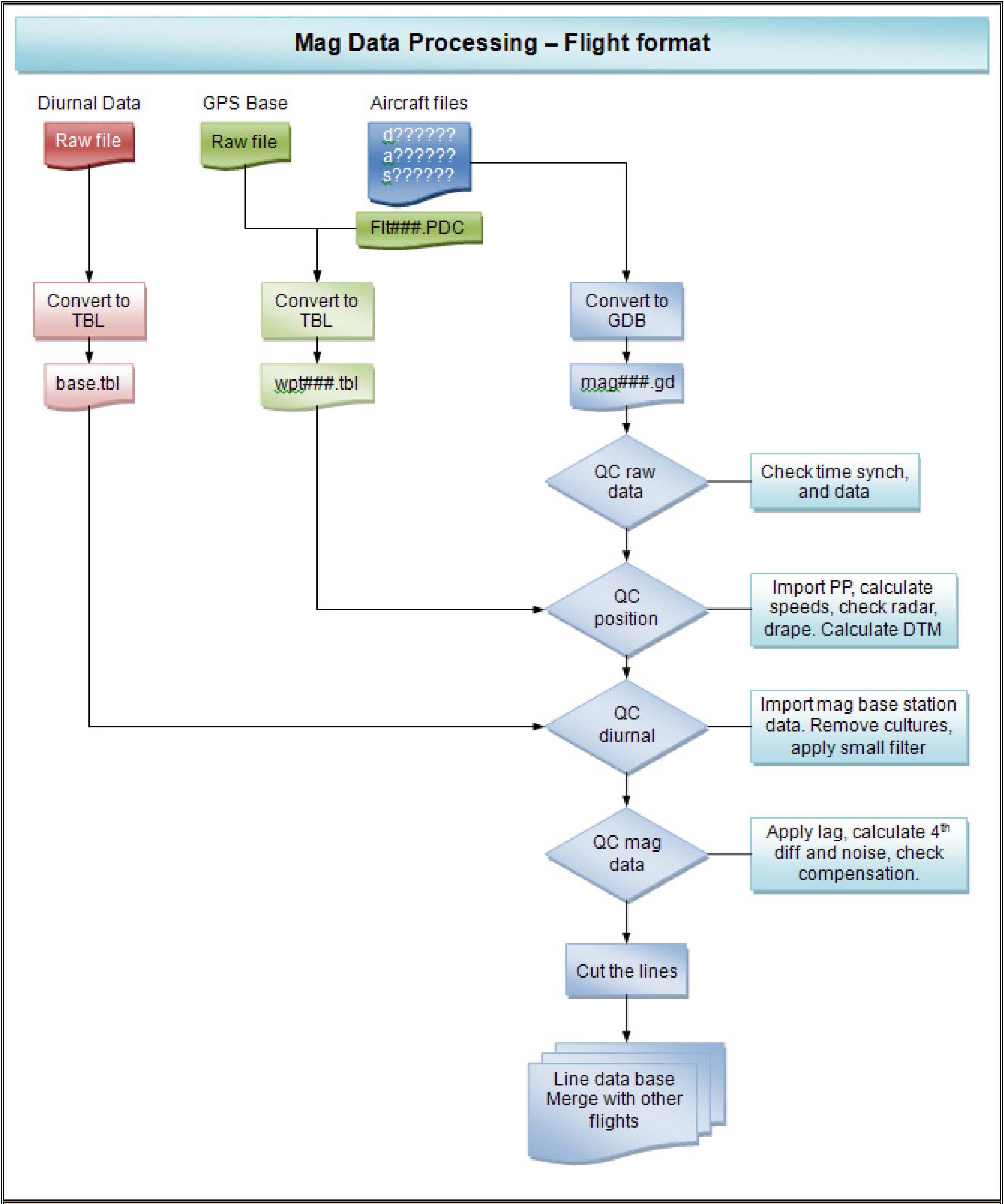


Figure 9: Standard magnetic data processing flowchart in flight format

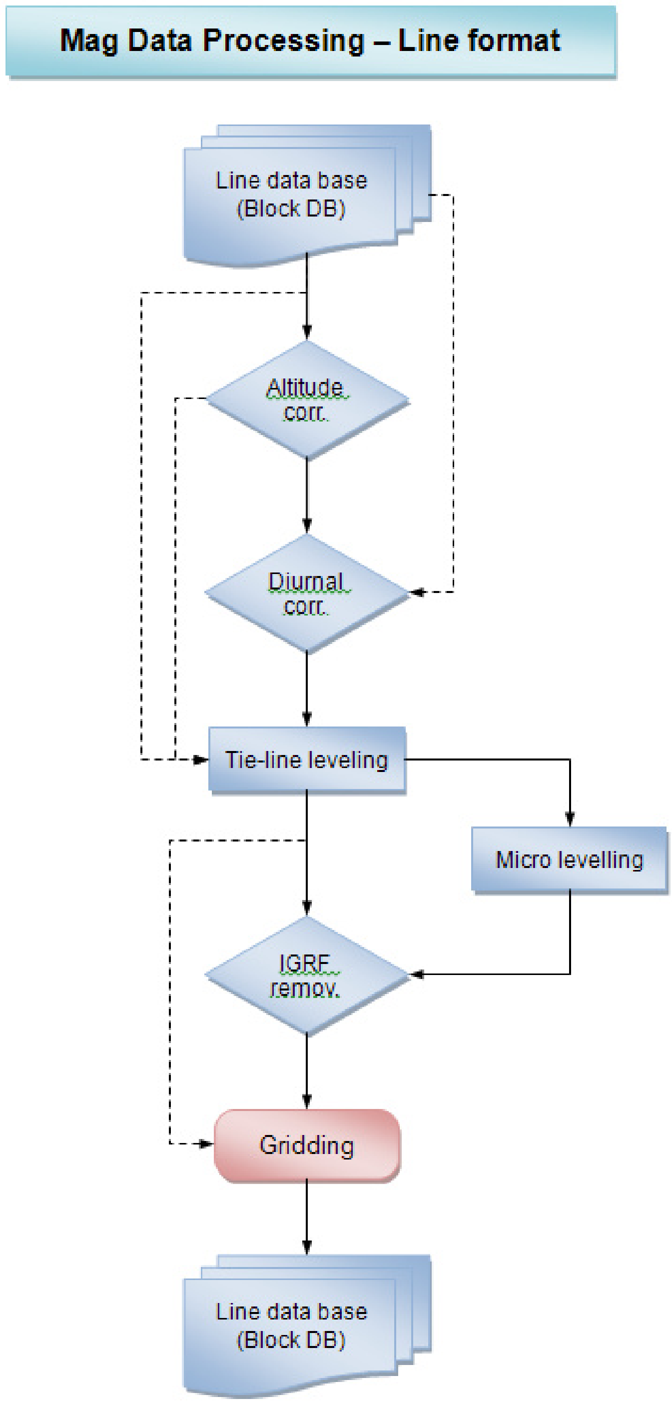


Figure 10: Standard magnetic data processing flowchart in line format

7.0 FIELD AND OFFICE CREW

General management of the project was monitored offsite by Mr. Mouhamed Moussaoui. Mr. Saleh ElMoussaoui and Mrs. My Phuong Thi Vo were responsible for the field data processing. The Technical Inspector for Geoscience BC, Peter Kowalczyk, was responsible to ensure that the work was carried out according to contractual specifications. Final data evaluation and processing was carried out at the GDS office by My Phuong Thi Vo. Field and office personnel are listed in table 5.

Table 5: Field and Office Crew

Position	Name
Project Manager	Mr. Mouhamed Moussaoui, Eng.
Data Quality Control	Mr. Saleh Elmoussaoui Mrs. My Phuong Thi Vo
Field Manager	Mr. Saleh ElMoussaoui
Field Instrument Operators	Mr. Pierre Gagnon Mr. Pierre Filion
Professional Pilots	Ms. Allison Smith Mr. Ralph Greenaway
Final Processing	Mrs. My Phuong Thi Vo
CAD Specialist (Drawing Products)	Mr. Albert Sayegh
Survey Report	Mr. Camille St-Hilaire

8.0 AIRCRAFT AND EQUIPMENT

8.1 Aircraft

In order to minimize ground clearance, **GDS** flew the survey with an Astar 350 B2 helicopter. **GDS** is Transport Canada approved to carry out this particular type of survey. Figure 11 presents main aircraft characteristics of the aircraft.

Type	Astar 350 B2
Powerplant	Turbomeca Arriel 1B turbine
Power	732 shp
Number of main rotor blades	3
Average cruising speed	226 km/hr
Average survey speed	125 km/hr
Maximum gross weight	Internal: 4960 lbs
	External: 5512 lbs
Aircraft empty weight	2690 lbs
Maximum range	410 miles
Fuel consumption	170 l/hr
External sling load	1650 lbs

Figure 11: Characteristics of the Astar 350 B2 helicopter

8.2 Magnetometer and digital acquisition systems

8.2.1 Airborne magnetometer

The following table describes the airborne magnetometer. The sensor is mounted in a stinger rigidly attached to the helicopter.

Airborne Magnetometer	
Manufacturer	Geometrics
Type and Model	Cesium G-822A
Serial Number	75427 / C1853
Ambient Range	20 000 - 100 000 nT
Sensitivity	± 0.005 nT
Absolute Accuracy	< 3 nT
Noise Envelope	0.10 nT
Sampling Rate	10 Hz
Sampling Interval	3.5 m at typical survey speed
Heading effect	<2.0 nT

The cesium G822 sensor is a versatile and highly sensitive means of accurately measuring the Earth's total magnetic field intensity. Based upon the principle of optical pumping and monitoring, the cesium sensor is capable of resolving millisecond variations as small as 0.005 nT (gamma) or 1 part of 10,000,000 of the Earth's magnetic field. This unique process involves the interaction of the magnetic moment and angular momentum of the valence electron of cesium with the ambient magnetic field to produce an oscillation whose frequency is dependent on the magnetic field intensity. The sensor, operating on an atomic process, contains no moving parts and is inherently simple, rugged, and accurate.

8.2.2 Magnetic Compensator and Data Acquisition system

The magnetic field generated by the aircrafts was compensated using a DAARC500, an Automatic Aeromagnetic Digital Compensator system manufactured by RMS Instruments (figure 12). The DAARC500 incorporates a sophisticated and flexible data acquisition system.

Acquisition system and Mag compensator	
Manufacturer	RMS Instruments
Model	DAARC500
Serial number	0606966
GPS synchronization	PPS signal
Magnetic compensator	integrated

The DAARC500 is an instrument used to compensate or correct in real time magnetic interference caused by the aircraft itself and aircraft maneuvering in the Earth's magnetic field, when using inboard-mounted high sensitivity magnetometers. The compensation accounts for effects of permanent magnetism, induced magnetism, Eddy currents and also removes heading errors caused by sensors themselves. It provides a frequency bandwidth of DC to 0.9 Hz, which are frequencies of most interest for geophysicists. Other bandwidths are optionally available. Signal(s) from the magnetometer(s) are digitized faithfully without aliasing or phase distortion.

Figure 12: The RMS DAARC500 unit and its Graphical User Interface

The DAARC500 is based on many years of research and development on automatic aeromagnetic compensation by the National Aeronautical Establishment (NAE), a division of the National Research Council of Canada. Following the transfer of technology, RMS Instruments continued with the development resulting in an instrument which is extremely reliable, capable of accepting the Larmor frequencies of up to four high sensitivity magnetometers, and is based on a sophisticated compensation algorithm which is extremely robust.

Geophysical instruments and sensors may be directly connected to the DAARC500, via 8 Outputs and Inputs high speed RS232 digital ports and 16 analogic Inputs ports as well as an Ethernet port. Incoming data are real time processed via serial ports. All acquired data are synchronized through a GPS receiver pulse-per-second (PPS).

Table 6: Airborne Recording Specifications

RECORDING PARAMETER	ACCURACY	RECORDING INTERVAL
Magnetic total field	0.01 nT	0.1 sec
Radar Altimeter	5%	0.2 sec
Time	0.01 sec	0.1 sec
GPS	3 m	0.2 sec

8.3 Ground base station magnetometer

Two GEM System inc. Overhauser type ground magnetometers with combined GPS system operated continuously throughout the survey production (figure 13). They provided synchronized GPS time and recorded the total intensity of the earth's magnetic field with a resolution of 0.01 nT.

The following table describes the base station magnetometers:

Magnetic base station	Magnetic Base A	Magnetic Base B
Manufacturer	GEM System inc	GEM System inc
Type	Overhauser	Overhauser
Model	GSM-19 with GPS	GSM-19 with GPS
Serial Number	7104522	7052348
Dynamic Range	20 000 - 120 000 nT	20 000 - 120 000 nT
Sensitivity	± 0.01 nT	± 0.01 nT
Sampling Rate	1 Hz	1 Hz
Noise Level	0.10 nT	0.10 nT

The primary magnetic base station was set up at a magnetic noise-free location, away from magnetic objects, vehicles and DC electrical power lines close to the airport. A second magnetic base station was established between the airport and Telegraph Creek (figures 2 and 7). Both magnetometers sampled at a rate of one per second. Records, including GPS time, were dumped digitally on a computer, merged with airborne data and plotted daily.

Figure 13: The base station magnetometer and console

8.4 Positioning and navigation systems

8.4.1 Video system

The following table describes the video system installed in the aircraft:

Video camera	
Camera Manufacturer	Samsung
Model	SDC-415
Mounting	Vertical
Video digital recorder	Archos 5
Format	NTSC Color
Iris Exposure	Automatic

The vertically-mounted, continuous-recording video camera, with a wide angle lens to maximize ground coverage at survey altitude, operated at all times while aircraft was surveying. Data, which were displayed alphanumerically in the top portion of each frame, included time in tenths of seconds after midnight, and GPS generated lat/lon co-ordinates. The video system also displayed an image-centre crosshair. Data and video were available for review immediately after each flight with no further processing.

Figure 14: Samsung video camera and Archos 5 digital video recorder

8.4.2 Differential GPS and Navigation System

A dual frequency GPS antenna was mounted on the aircraft. The following table describes the airborne GPS system, which obtained a complete coverage and provided both real-time navigation and flight-path recovery:

GPS and Navigation System	
GPS Manufacturer	Novatel
Model	DL-V3 dual-freq L1/L2
Serial Number	NBV07240010
Number of Channels	12
Sampling Interval	5 Hz
Differential System	OmniStar Real Time
Navigation System	AGNAV (LiNAV)
Navigation system s/n	15160705

Figure 15: Novatel GPS receiver (left) and AGNAV navigation system (right)

8.4.3 Radar altimeter

Frequency-modulated radio altimeter was used for measuring accurately the distance between aircraft and ground. Whole survey data were covered using this kind of radar. The following table presents its technical characteristics:

Radar altimeter	
Manufacturer	Free Flight
Model	TRA 3000
Serial number	7053006
Minimum Range	0 to 800 meter
Accuracy	5%
Sampling rate	5 Hz

9.0 FINAL PRODUCTS

9.1 Compilation Specifics

Map Scale and projection: 1:50 000 NAD83 UTM Zone 9
Grid cell size: 62.5 meters

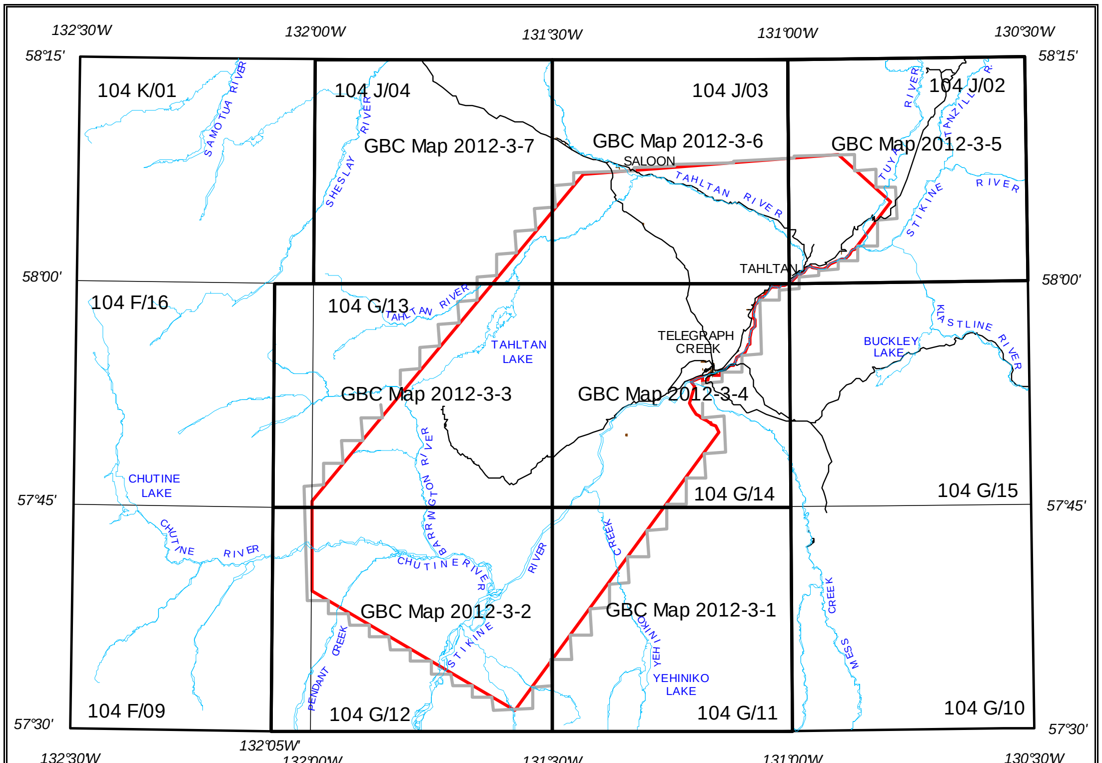


Figure 16: Final map index

9.2 Final Products

Processed parameters

The following parameters were processed:

- Total Field Magnetic data
- Residual Total Magnetic Field data
- First Vertical Derivative of the Magnetic Field data
- Second Vertical Derivative of the Magnetic Field data

Maps

Five (5) final paper copies of the following maps have been delivered. All final map products were also delivered in both Geosoft MAP and Adobe PDF formats at resolution suitable to accurately reproduce the plotted products.

- Residual Total Magnetic Field (colour and contour interval)
- First Vertical derivative of the Magnetic Field (colour interval)

Archives

GDS prepared archives of data (3 copies) using formats, parameters and media specified in the solicitation. Digital data were provided in the standard Geosoft GDB archive format, with positional data expressed in geographic and UTM coordinates.

- Archive media: DVD
- One Geosoft format digital archive of the final line data.
- One Geosoft format grid file for each of the processed parameters for the entire survey in NAD83, UTM Zone 9 projection.

Digital video files of the flight path were also provided on DVD.

Final Report

- Final technical report (3 paper copies) accompanied by one digital file in PDF format.

9.3 Profile Data

Magnetic line archive profiles are provided in Geosoft Montaj binary database (GDB) sampled at 10Hz. The database content is summarized in table 7.

Table 7: Magnetic Line archive channel description				
Channel	**Description**	**Sampling**	**Unit**	**Format**
date	Flight date	10Hz	yyyy/mm/dd	d11.0
flt	Flight number	10Hz		s5.0
line	Line number	10Hz		i6.0
UTC	UTC Time in second after midnight	10Hz	second	d8.1
xrt	Raw Real time easting UTM, NAD83,Zone 9N	10Hz	meters	d9.2
yrt	Raw Real time northing UTM, NAD83,Zone 9N	10Hz	meters	d10.2
zrt	Raw Real time GPS elevation (MSL)	10Hz	meters	d7.2
lon	Post-processed longitude, NAD83	10Hz	dd.mm.ss.s	d14.2
lat	Post-processed latitude, NAD83	10Hz	dd.mm.ss.s	d13.2
x	Post-processed easting UTM, NAD83, Zone 9N	10Hz	meters	d9.2
y	Post-processed northing UTM, NAD83, Zone 9N	10Hz	meters	d10.2
z	Post-processed GPS elevation – orthometric MSL	10Hz	meters	d7.2
raltlc	Corrected Radar altimeter	10Hz	meters	d8.2
drape	Drape surface used for height navigation	10Hz	meters	d7.2
DTMC	Digital Terrain Model (levelled)	10Hz	meters	d7.2
baseao	Base A diurnal data original (main base mag)	10Hz	nanoteslas	d10.3
basea	Filtered main base mag	10Hz	nanoteslas	d10.3
basebo	Base B diurnal data original (backup base mag)	10Hz	nanoteslas	d10.3
baseb	Filtered backup base mag	10Hz	nanoteslas	d10.3
mfluxX	Fluxgate X component	10Hz	nanoteslas	d10.3
mfluxY	Fluxgate Y component	10Hz	nanoteslas	d10.3
mfluxZ	Fluxgate Z component	10Hz	nanoteslas	d10.3
MBu	Raw uncompensated mag	10Hz	nanoteslas	d10.3
MBul	Lagged uncompensated mag	10Hz	nanoteslas	d10.3
Mbc	Raw compensated mag	10Hz	nanoteslas	d10.3
Mbclc	Compensated mag (edited, lagged and de-spiked)	10Hz	nanoteslas	d10.3
drift_LF	Low-frequency diurnal correction	10Hz	nanoteslas	d10.3
magbc	Magnetic field, diurnally corrected (TMI)	10Hz	nanoteslas	d10.3
coralt	Altitude correction	10Hz	nanoteslas	d10.3
magalt	Magnetic field, corrected by altitude	10Hz	nanoteslas	d10.3
corlvl	Cumulative tie line mag levelling adjustment	10Hz	nanoteslas	d10.3
maglvl	Levelled mag	10Hz	nanoteslas	d10.3
cormicro	Microleveling correction	10Hz	nanoteslas	d10.3
magmicro	Microleveled mag	10Hz	nanoteslas	d10.3
igrf	International geo-referenced field (model 2010; 2011-09-10)	10Hz	nanoteslas	d10.3
magres	Mag IGRF removed (residual)	10Hz	nanoteslas	d10.3

10.0 CONCLUSION

Flown from August 20th to October 3rd, 2011, the aeromagnetic survey was completed inside the time frame allowed by the contract.

All airborne and ground-based records were of excellent quality. Noise levels for the measured Total Magnetic Field were well within accepted limits, determined from the fourth difference of the lagged, edited airborne magnetic data.

GPS results proved to be of high quality. The flight path was surveyed accurately according to the digital elevation model available. The speed checks showed no abnormal jumps in the data.

It is hoped that information presented in this report, and on the accompanying products, will be useful both in planning subsequent exploration efforts and in the interpretation of related exploration data.

Respectfully Submitted,

Camille St-Hilaire, P.Geo.

APPENDIX A

CALIBRATION AND TESTS

Geo Data Solutions GDS Inc.

FOM Test

Location: Fort St-James
Pilot: Allison Smith
Operator: Pierre Filion
Compiled by: My Phuong Vo

Date: Aug. 12, 2011
Aircraft: C-FNWE
Configuration: Heli-mag
Altitude: 10000 feet

Sensor3 - Tail Stinger

North (360º)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	64468.0 - 64484.0	4.017	0.285	14.095
ROLL	64488.0 - 64502.4	16.259	0.163	99.748
YAW	64505.0 - 64522.0	2.445	0.207	11.812
	TOTAL	**22.721**	**0.655**	**34.689**

East (90º)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	64572.4 - 64583.9	3.947	0.096	41.115
ROLL	64586.4 - 64598.0	20.230	0.083	243.735
YAW	64602.5 - 64615.1	6.436	0.143	45.007
	TOTAL	**30.613**	**0.322**	**95.071**

South (180º)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	64655.2 - 64668.2	9.463	0.153	61.850
ROLL	64673.3 - 64685.5	19.776	0.149	132.725
YAW	64693.6 - 64705.4	9.782	0.237	41.274
	TOTAL	**39.021**	**0.539**	**72.395**

West (270º)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	64743.2 - 64754.7	6.820	0.152	44.868
ROLL	64757.0 - 64769.5	16.716	0.160	104.475
YAW	64774.1 - 64786.0	5.238	0.243	21.556
	TOTAL	**28.774**	**0.555**	**51.845**

Uncomp. mag (nT)	Comp. Mag (nT)	Improv. Ratio
121.129	**2.071**	**58.488**

Geo Data Solutions GDS Inc.

ALTIMETER CALIBRATION

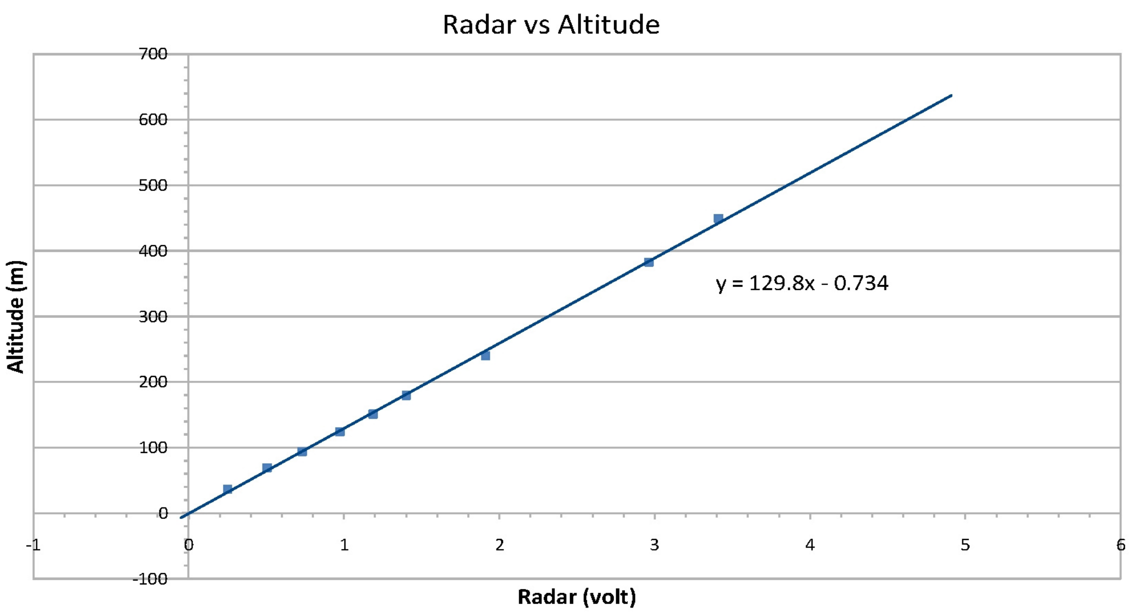
Location: Fort St-James
Pilot: Allison Smith
Operator: Pierre Filion

Date: 11-Aug-11
Aircraft: C-FNWE (Helicopter)
Compiled by: My Phuong Vo

Antenna Height (m): 2.0

Terrain clearance (ft)	Radar raw (volt)	Zgps (m)	Topo (m)	Altitude (m)
100	0.25	756.17	717.87	36.30
200	0.50	788.72	717.75	68.97
300	0.73	814.01	718.15	93.86
400	0.97	844.07	718.05	124.02
500	1.19	870.98	718.11	150.87
600	1.40	897.91	716.46	179.45
800	1.91	960.20	718.77	239.43
1200	2.96	1102.21	717.70	382.51
1500	3.41	1171.89	720.64	449.25

radar(m)= **129.84** x (volt) **- 0.73**

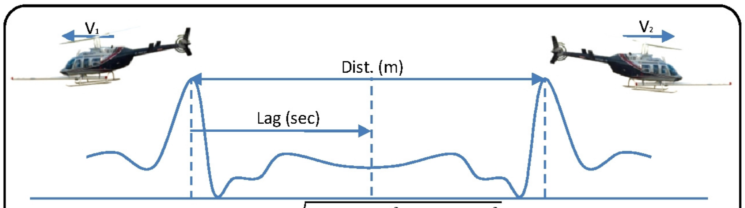


Geo Data Solutions GDS Inc.

LAG Test

Location: Fort St.-James
Date: Aug. 11, 2011
Compiled by: My Phuong Vo

Aircraft: C-FNWE (helicopter)
Configuration: Heli-Mag
Apply Tail Lag: +0.1



$$Lag = \frac{\sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2}}{V_1 + V_2}$$

	Line Dir	Fiducial (sec)	X (m)	Y (m)	Z (m)	Mag Field (nT)	Vx (m/s)	Vy (m/s)	Speed (m/s)
A)	South	84008.00	418072.72	6028112.85	785.98	56754.268	13.60	21.78	25.68
B)	North	84045.00	418077.67	6028109.98	771.89	56789.292	-13.44	-19.70	23.85

Ave Speed = **24.76 m/s**
Distance = **5.72 m**
Tail Lag = **+0.12 sec**

	Line Dir	Fiducial (sec)	X (m)	Y (m)	Z (m)	Mag Field (nT)	Vx (m/s)	Vy (m/s)	Speed (m/s)
A)	South	84116.00	418075.10	6028115.04	785.13	56781.227	10.56	17.27	20.24
B)	North	84171.10	418075.57	6028108.85	779.03	56762.036	-10.15	-15.57	18.59

Ave Speed = **19.41 m/s**
Distance = **6.21 m**
Tail Lag = **+0.16 sec**