

AIRBORNE MAGNETIC SURVEY

FOR

**THE NEWFOUNDLAND AND LABRADOR DEPARTMENT OF NATURAL RESOURCES
ENERGY BRANCH**

AND

NALCOR ENERGY

WEST COAST, NL 2008

**INDIAN HEAD AREA
DEER LAKE AREA
GROS MORNE & PORT-AU-CHOIX AREA**

PARTS OF NTS 12A, 12B, 12H and 12I



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1 INTRODUCTION

Starting in October 2008, Novatem Inc. flew a high resolution airborne magnetic survey for the Newfoundland and Labrador Department of Natural Resources – Energy Branch and Nalcor Energy. The survey was completed in May, 2009. The project was composed of 3 blocks: referred to as Deer Lake (DL) surrounding Deer Lake, Indian Head (IH) surrounding Stephenville and Gros Morne (GM) extending the West coast of the Newfoundland peninsula, which is a merge of the original Port-au-Choix and Gros Morne blocks. The initial coverage of the project was 37 713 km covering the 3 areas aforementioned. The total line kilometres actually flown is 37 713 km.

Each Geophysical system included two Geometrics Caesium magnetometers mounted in wing pods extension. Ancillary equipment included two APS flux-gates, a DGPS Novatel positioning system, an Optech laser altimeter and a GEM GSM19 magnetic and GPS base station.

This report describes the survey operations, equipments, quality control, the data acquisition and its processing.



Figure 1 : View of the survey area (west coast)

2 SURVEY AREA DETAILS

2.1 SURVEY LOCATION

The three blocks are located on the Western coast of Newfoundland, as shown on the following figure.

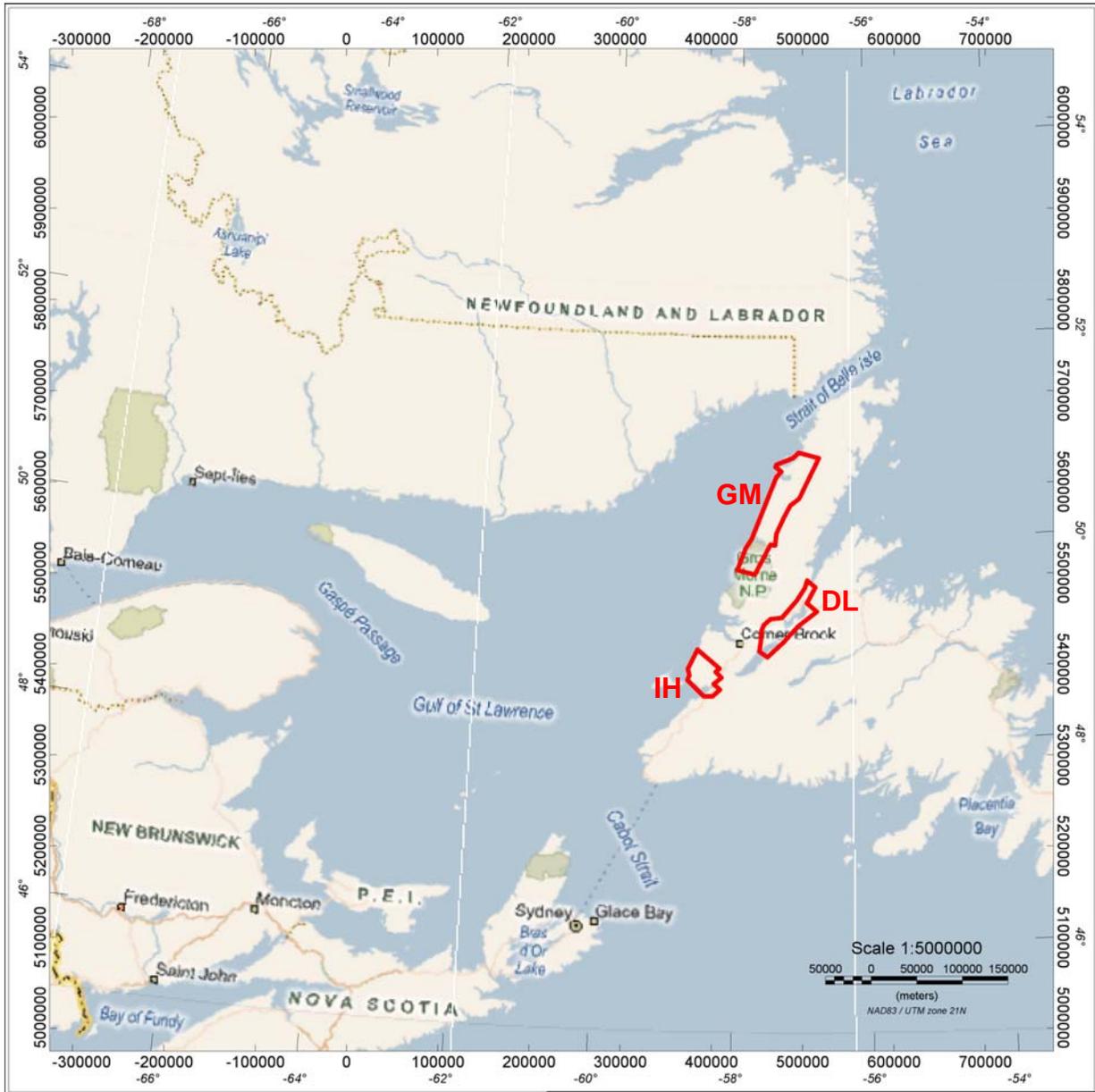


Figure 2 : Location of the claims to be flown

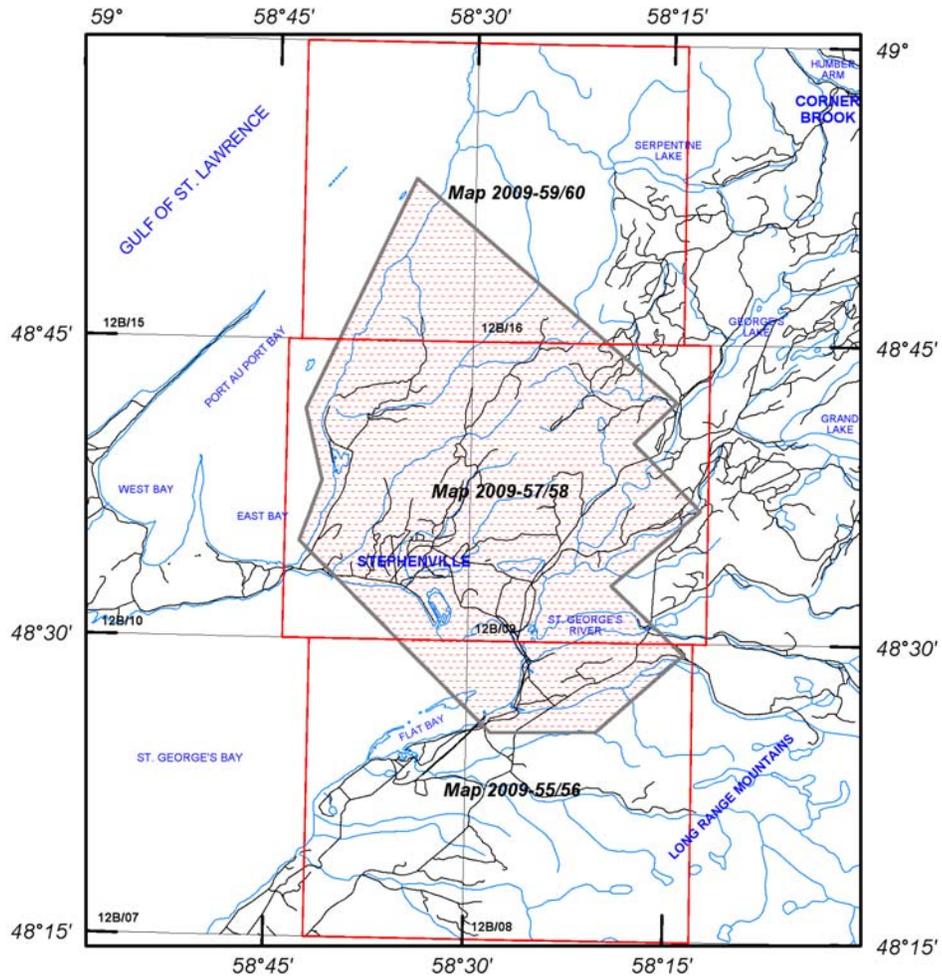


Figure 4 : Indian Head block outline over NTS Sheets

2.2 SURVEY BLOCKS PARAMETERS AND FLIGHT PATH

The survey covered portions of NTS sheets 12A, 12B, 12G, 12H and 12I. Tables giving the complete coordinates of the vertices of the blocks are shown in Appendix A. Geodetic parameters that were used for the plane positioning and all subsequent coordinate transformations are also presented in Appendix A.

The Indian Head and Deer Lake blocks were flown with the same traverse and control line spacing and direction; while the Gros Morne block was flown in a different direction. These parameters are summarized in tables 1 and 2 with all the related flight specifications. Figure 6 through 8 show flight paths superimposed to SRTM. All maps are presented in UTM Zone 21N coordinates, NAD83.

Draping surfaces were calculated with the CGC software prior to the survey. Because of rough topography and for safety reasons, a nominal terrain clearance of 90 m was used, which correspond to the lowest theoretical elevation above the ground. Mean provisional terrain clearance was 200 m at 150 km/h.

Parameters	Specifications
Traverse line spacing	200 m
Control line spacing	2 000 m
Traverse line direction	N 75 W
Control line direction	N 15 E
Sample rate	10Hz, 5m at 180 km/h
Nominal height of the draping surface	90 m MTC
Mean sensors terrain clearance	200 m MTC

Table 1 : Flight specifications for Gros Morne block

Parameters	Specifications
Traverse line spacing	200 m
Control line spacing	2 000 m
Traverse line direction	N 50 W
Control line direction	N 40 E
Sample rate	10Hz, 5m at 180 km/h
Nominal height of the draping surface	90 m MTC
Mean sensors terrain clearance	200 m MTC

Table 2 : Flight specifications for Indian Head & Deer lake blocks

Block	Km flown
Deer Lake	10 349 km
Indian Head	6 544 km
Port au Choix & Gros Morne	20 820 km
TOTAL	37 713 km

Table 3 : Total line kilometres flown

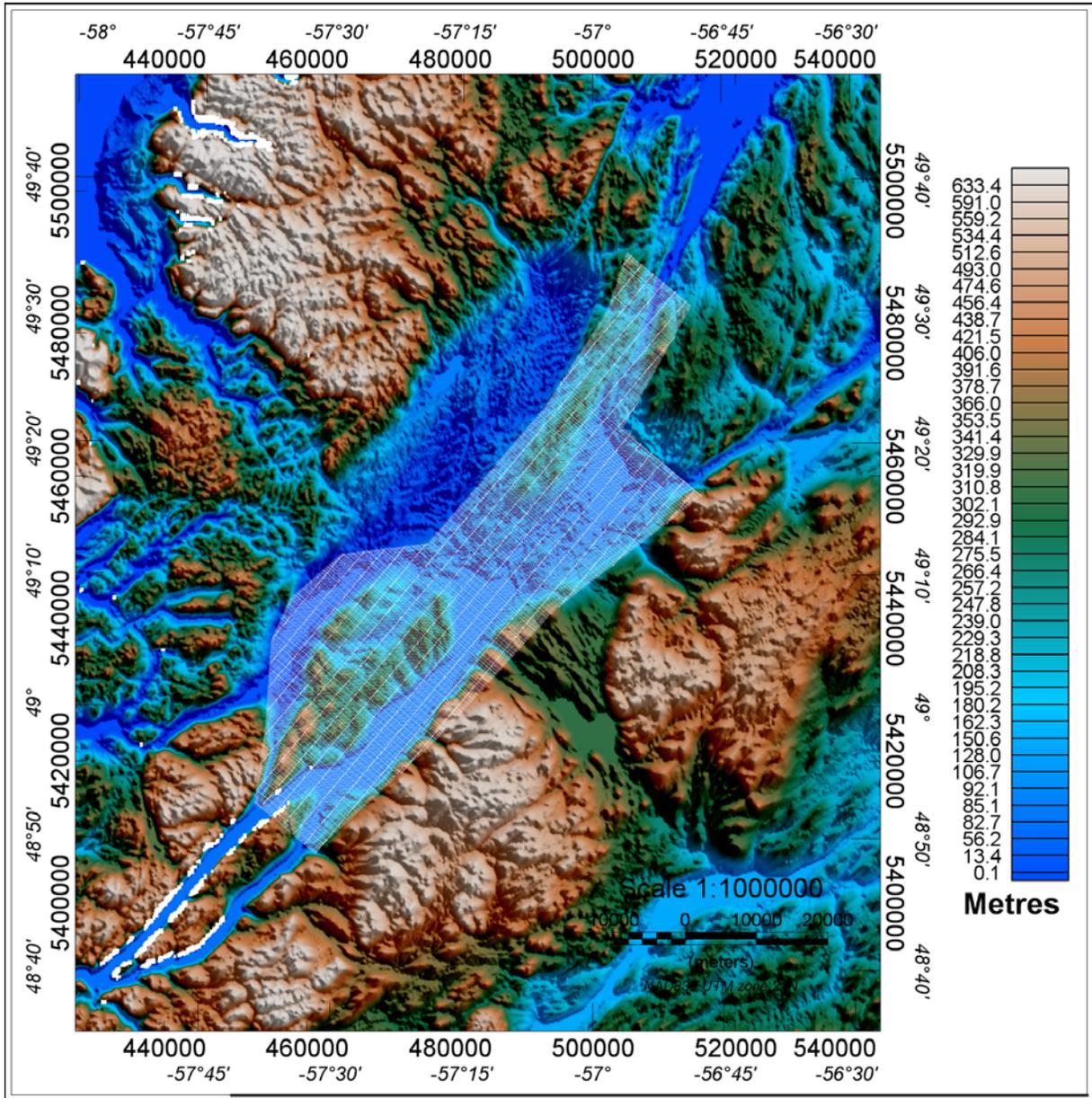


Figure 6 : Deer Lake flight path over 90m SRTM

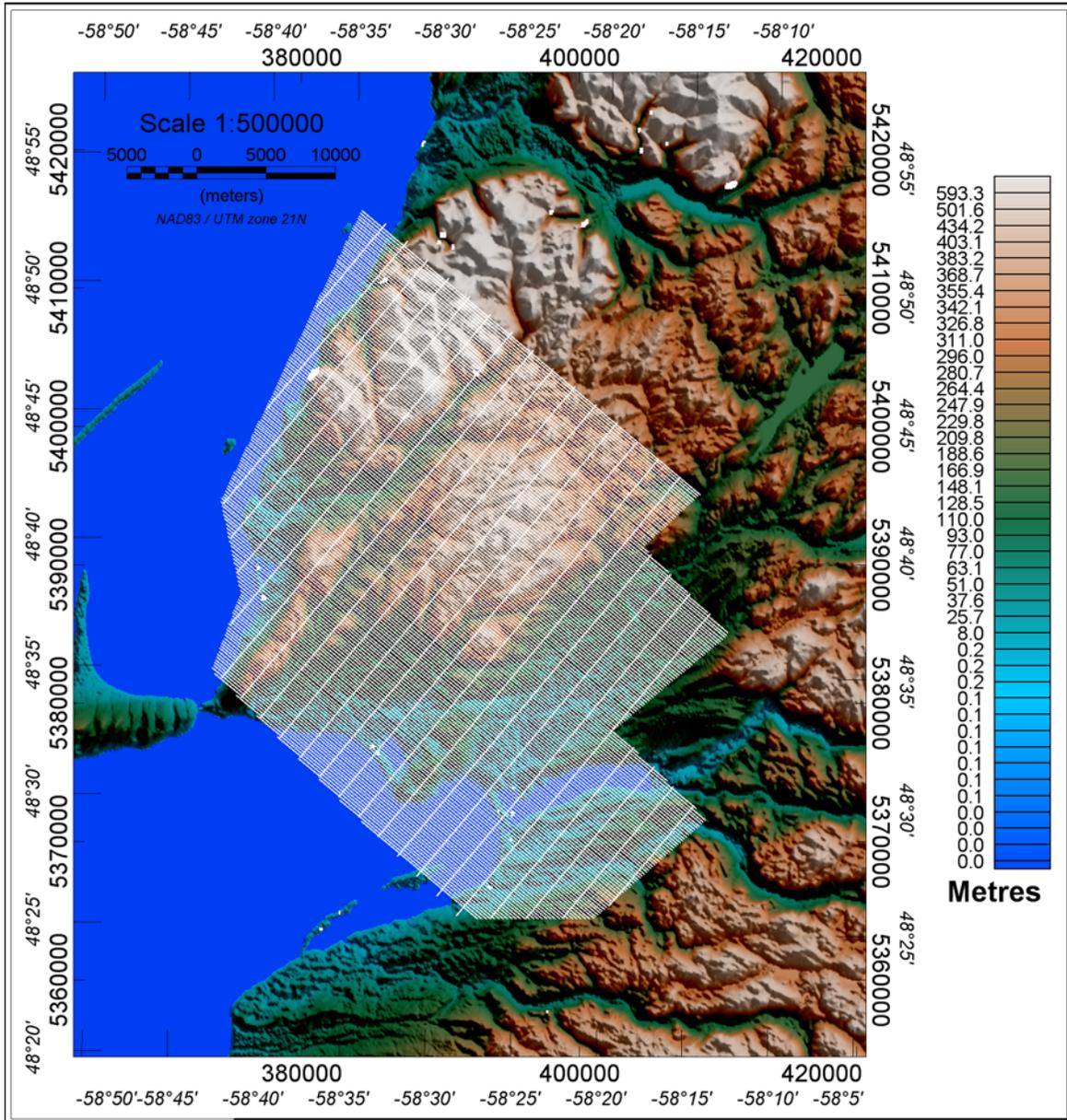


Figure 7 : Indian Head flight path over 90m SRTM

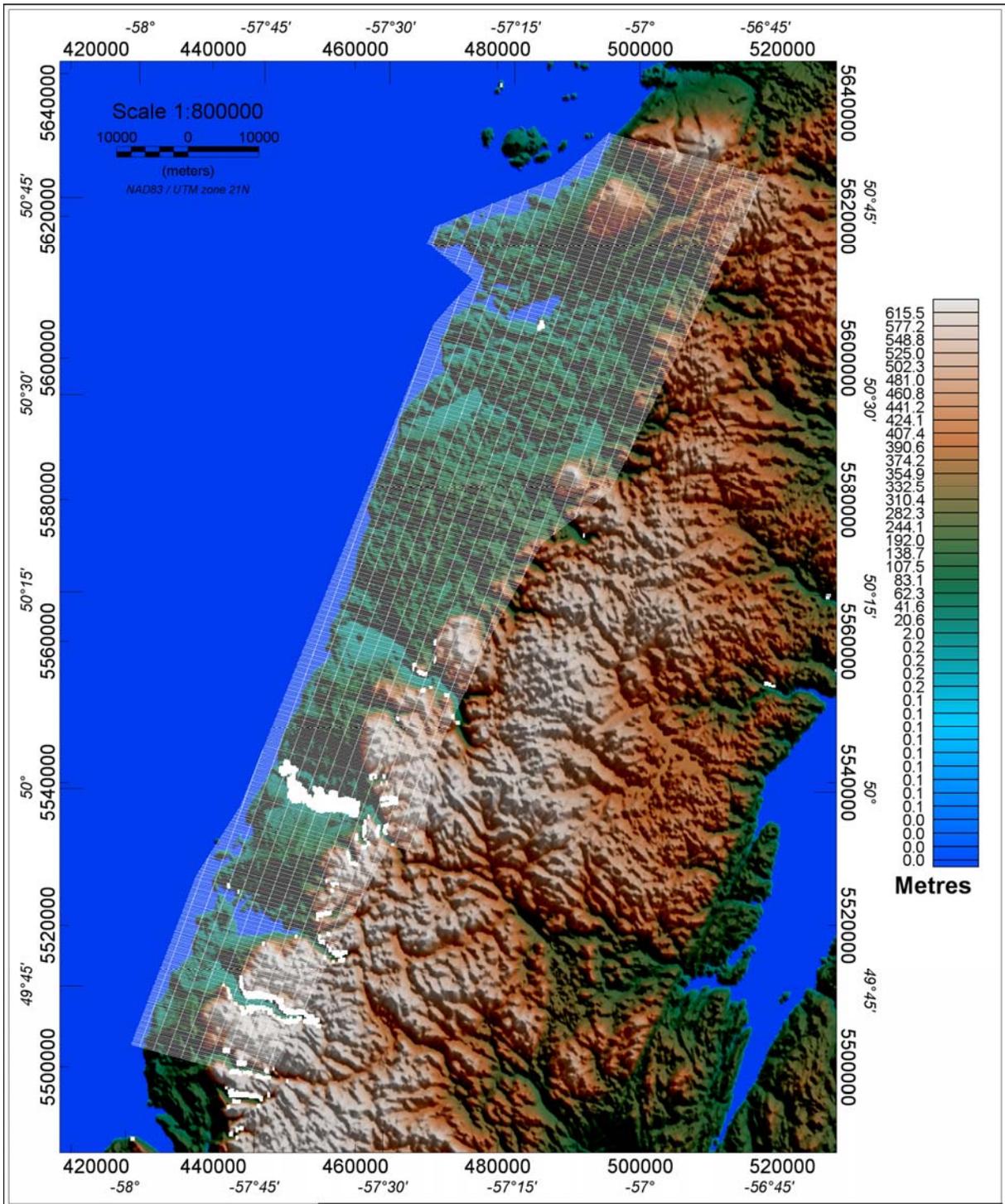


Figure 8 : Gros Morne flight path over 90m SRTM

3 SURVEY OPERATION

3.1 PERSONNEL

The airborne geophysical survey C08072 was carried out by the personnel listed below. Acquisition, processing and presentation of data were done exclusively by employees of **Novatem Inc.**

Pascal Mouge	Geophysicist/Supervisor
Maxime Boudreault	Geophysicist/Supervisor
Olivier Savignet	Geophysicist/Project manager, Data processor
Jérémie Largeaud	Geophysicist/Quality control
Sébastien Jubelin	Geophysical Operator
Fabrice Pont	Geophysical Operator
Éric Pelletier	Pilot (Novatem Inc)
Guy Handfield	Pilot (Novatem Inc)
4 AME	At St-Mathias, QC and Deer Lake, NL

3.2 AIRCRAFT

The aircraft used for the survey is a Cessna 185 (C-FARU), specially adapted for very high resolution magnetic mapping. The aircraft underwent a « magnetic clean-up » meant to remove the parts with a permanent magnetization, or those which could acquire magnetization over time. Magnetometers are installed at the extremity of the wings (wing-tips), which have been extended in order to increase even more the distance to the engine. Floats are exclusively made of aluminum and non magnetic stainless. When the water started freezing, floats were replaced at St-Mathias seaplane base by a titanium landing gear.

Novatem Inc. owns the aircraft and has all the necessary STC required for safely operating its instruments.

Novatem Inc. owns the aircraft, and therefore the equipment is permanently installed on board of the aircraft, allowing more expedient mobilisations. The installations consisted of mounting the wing pods, magnetometers, altimeters, GPS antennas and running cables for power to the acquisition system, mounting the bright bar and display units on the dashboard. The aircraft operated from a seaplane base at Pasadena in 2008 and from Deer Lake airport in 2009. The equipment underwent ground and airborne testing prior to beginning data collection.

The installation of geophysical equipment was performed by qualified technicians. **Colibri** system belonging to **Novatem Inc.** is covered by a STC issued by Transport Canada. The STC registration number is: *SA06-47 Issue 5*.

3.3 LOGISTICS

Novatem Inc. provided the following items:

- Qualified crew necessary for an efficient completion of the survey
- Supply technical equipments and spare parts necessary for a timely completion of the survey
- Supervision of the aircraft and its crew
- Fuel supply for the survey, and food and housing for the crew

- Preliminary processing and on the field quality control of geophysical data
- Preparation and delivery to the client of all the final products specified in paragraph 5

3.4 TIME SCHEDULE

The first tests and various equipment checks were carried out at the week of October 22nd 2008. Production flights started on October 3rd 2008 and finished on May 14th 2009. Preliminary products were prepared on the field following the work progress, and were delivered early June.

4 SURVEY EQUIPMENTS

The geophysical means per system deployed, included mainly:

- Two optical pumping magnetometers with caesium vapour, used to measure in-flight the total magnetic field
- An in-flight dual frequency DGPS positioning system including an inertial measurement unit
- A laser altimeter measuring the aircraft clearance over the ground
- Two digital fluxgate magnetometers with a high sampling rate used for compensation
- Three magnetic base stations, equipped with a high resolution sensor for the correction of temporal variations of the Earth magnetic field, running during the whole duration of the job
- A single frequency DGPS base station used for differential post-processing

Before beginning the survey, equipments were tested on the ground to ensure that the acquisition parameters were within the contract specifications. After completion of the survey, the equipments specifications have been checked again.

During the data acquisition, quality controls were carried out on the data on a daily basis by the Novatem's data processor to ensure that the quality remained within specifications.

4.1 MAGNETOMETERS

4.1.1 AIRBORNE MAGNETOMETERS

Two scalars sensors manufactured by *GEOMETRICS*, measure the total field, synchronised with GPS data, every 0.1 seconds (10 Hz). These magnetometers provide higher sensitivities and minimal heading errors.

SPECIFICATION	
Sampling rate	10 Hz
Accuracy	0.1 nT
Sensitivity	< 0.0005 nT/ $\sqrt{\text{Hz}}$ rms
Resolution	0.00001 nT
Operating range	20 000 to 100 000 nT
'Heading error'	\pm 0.15 nT

4.1.2 FLUXGATES

The magnetic noises of the aircraft (permanent and induced magnetization, plus eddy currents) are measured in real time and corrected during post-processing. The compensation software uses the vectorial magnetic components, from high sampling rate fluxgates, which use a 24 bits digital convertor.

SPECIFICATIONS	
Magnetic noise	< 0.3 nT
Resolution	± 0.1 nT
Operating range	± 65 µT
Sampling rate	125 measures/sec
Axis orthogonality	Better than ± 0.2°

4.1.3 BASE STATION MAGNETOMETER

A GSM-19 GEM systems total field magnetic sensor, with a sampling interval of 1 second was used to record the diurnal variation of the magnetic field at the base-station location. The GSM-19 is a portable high-sensitivity Overhäuser effect magnetometer using its own GPS.

SPECIFICATIONS	
Sampling rate	1 Hz
Accuracy	0.2 nT
Resolution	0.01 nT

4.2 LASER ALTIMETER

The ground clearance of the aircraft is measured thanks to high precision laser altimeter manufactured by *Optech*. The flight height is measured 10 times per second with an approximate accuracy of 1 centimetre and a resolution of one millimetre. The last pulse received by the acquisition system is used to measure the height through clouds or snow. No calibration is required on the field.

SPECIFICATIONS	
Sampling rate	10 Hz (100 Hz max)
Accuracy	1 cm
Resolution	1 mm
Colour	904 nm (I.R.)
Divergence	0.3°

4.3 GPS NAVIGATION EQUIPMENT

The navigation system is based on a DGPS *Novatel ProPack V3* receptor, using the differential corrections from CDGPS network. The navigation computer relays the indications in real time to a

bargraph and a screen installed in front of the pilot inside the cockpit. The coordinates of the flight lines are pre-programmed, and compared in real time with the trajectory given by the DGPS, so that the pilot is able to constantly correct his track.

SPECIFICATIONS	
Sampling rate	10 Hz
WAAS L1/L2	0.8 m
CDGPS	0.7m
Reacquisition of L1 signal	0.5 s
Reacquisition of L2 signal	1 s
Time accuracy	20 ns

4.4 ACQUISITION EQUIPMENT, DATA RECORDING AND IN-FLIGHT CONTROLS

The acquisition system developed by *Novatem Inc.* is based on an onboard computer which records and synchronizes DGPS and magnetometric data in real time. All the data are recorded on the flash disk of the computer with a sampling rate of 10 measures per second. Each instrument is inspected in real time by the onboard computer. The pilot is informed that the equipment is working properly by light indicators that switch from green to red when any of the quality parameters goes under the specifications.

4.5 DIGITAL COLOUR CAMERA

A *Panasonic Toughbook CF29* connected both to the *Prosilica GC 1020C* wide angle digital Camera, and to the DGPS system for inserting a timestamp, records a picture of the terrain under the aircraft every second. These images available upon request enable to identify magnetic anomalies caused by human activities.

SPECIFICATIONS	
CCD	Sony ICX204 AK Colour
Image resolution	1024 x 768 pixels
Sampling rate	1 Hz

4.6 INERTIAL MEASUREMENT UNIT (IMU)

An inertial Measurement Unit (IMU) was used to measure the attitude angles of the aircraft, necessary for the correction of the magnetic gradients. The three attitude angles (roll, pitch, yaw) are measured with an accuracy of 0.001 degree at a very high sampling rate (between 100 and 600 Hz) and brought down to the same rate than the other measures (10Hz). Besides the IMU provides a continuous real time positioning of centimetric precision, even in case of GPS signal loss.

4.7 FIELD COMPUTERS

Two laptops dedicated to field measurements enable to perform a quality control of the data and plot the navigation path and the raw measures, immediately after the flights.

5 DATA PROCESSING

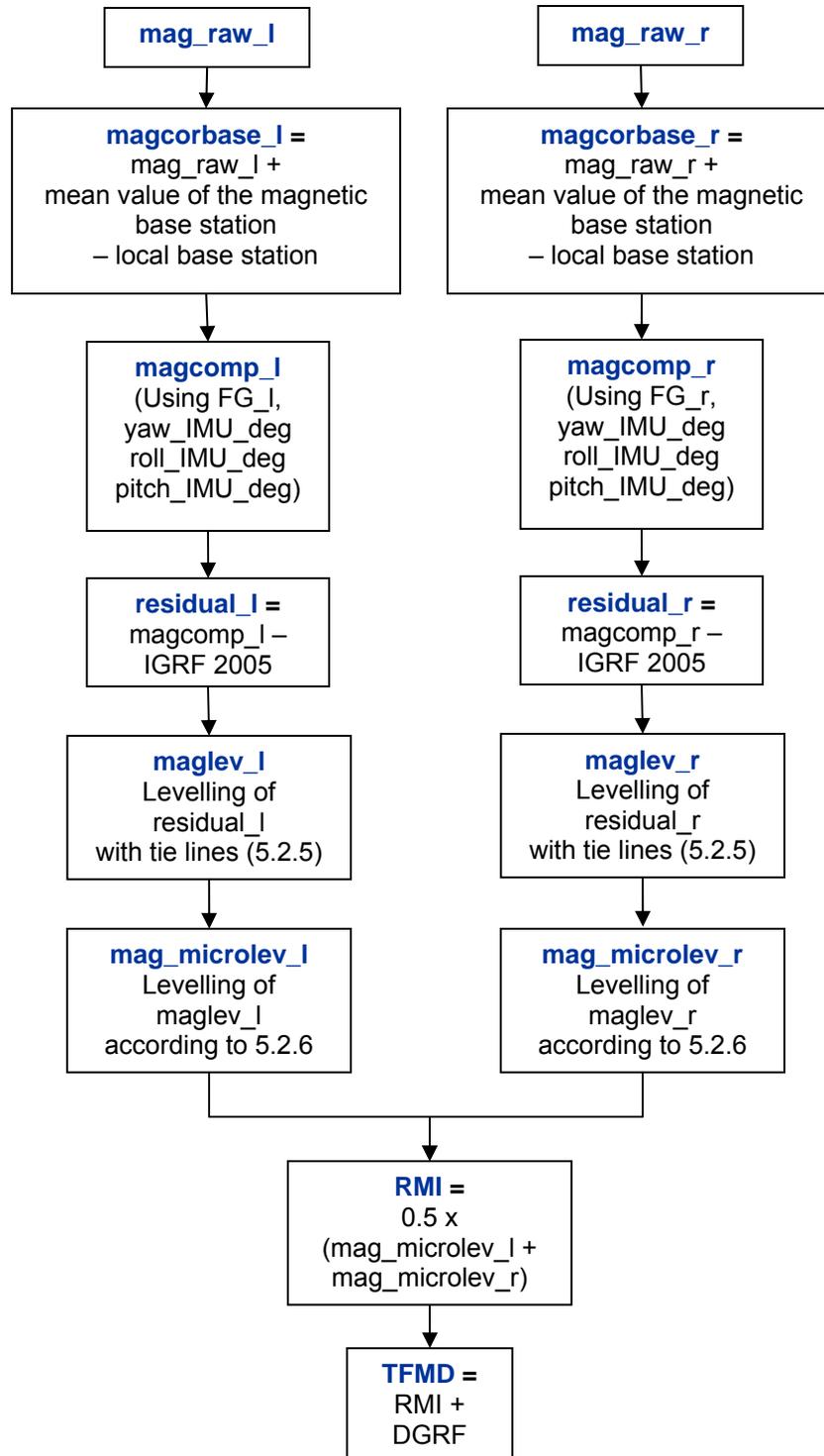


Figure 9 : Total field processing diagram

5.1 FLIGHT PATH RECOVERY

The successive positions delivered by the DGPS system are firstly converted to UTM rectangular coordinates. The sampling frequency of the magnetometers being higher than the differential positioning, the position of the magnetic samples are recalculated by the acquisition system between the DGPS positions.

Every effort was made to keep a constant altitude and to fly the best drapage surface possible. However, the pilots' ability to fly lines with high precision is mainly a function of weather conditions. Considering the request to make the survey late fall and during the whole winter, the team had to face very bad meteorological conditions. For the Indian Head and Gros Morne survey areas, rough topography in conjunction with strong winds from the shore made the navigation particularly difficult. Reflights were done when the horizontal deviation exceeded the specifications and for unusable data. However, for safety reasons we have only reflighted the unusable lines which would not have been possible to correct during post-processing. Otherwise some lines of the Deer Lake block, flown to a higher altitude for safety reasons, but still in the horizontal tolerance, were kept anyways in order to minimize the duration of the survey. Those lines were considered as usable data after correction and levelling since they are sporadic.

The details of the reflights are specified in the logbook attached to this report.

5.2 PROCESSING OF MAGNETIC DATA

The data collected in flight were edited daily and archived in *Geosoft Oasis Montaj* databases. Profiles were then plotted and controlled. Firstly, the raw data are corrected from temporal variations (magnetic base station). Then, the directional variations due to the intrinsic « heading error » are removed. Using the vectorial information from the fluxgate magnetometers and the information from the IMU, magnetic measurements are corrected from the perturbation due to the aircraft (compensation). Finally, a levelling is applied using the tie-lines in order to remove the residual errors caused by variation in the aircraft height.

5.2.1 DIURNAL CORRECTION

The data collected at the three base stations were edited, archived in an ASCII file and then linearly interpolated at the time of data acquisition. The base stations being fixed and far away from any magnetic variations induced by human activities, the variations recorded are precisely the temporal variations mainly caused by solar activity (diurnal variation, pulsation ...).

Corrections are calculated after removing the constant at the base station, obtained by averaging the measures for all the calm days of the survey. The variations around this average value are subtracted to the value of the magnetic field measured in flight. See appendix C for details about the locations and average values used for processing.

5.2.2 LAG CORRECTION

Residual errors of positioning, generated by the delay of time (lag) between the instant when the position is measured and that of its recording, generate a systematic offset in the position of the recorded magnetometer values, depending on the flight direction. The results of the lag tests carried out prior to surveying showed that the lag time between the geophysical data and the DGPS unit is not noticeable. The conception of the acquisition system, which separately assigns a timestamp from the GPS, or "tag" to each instrument, renders the time lag negligible. Therefore no lag correction was applied to the data.

5.2.3 REMAINING CORRECTIONS

Another source of error, known as “heading error”, is intrinsic to optically pumped magnetometers: the absolute value of the magnetic field delivered by the magnetometer depends on the orientation of the sensor (position of the sensor compared to the surrounding magnetic field lines). This error - around ± 0.1 nT for Potassium vapour optically pumped magnetometers – is a constant for a given direction (it may thus vary along a profile depending on the wind or the topography). Simple high altitude tests carried out prior to the survey, enable to determine these directional constants. The corrections obtained are applied to the data during processing.

5.2.4 COMPENSATION AND LEVELLING

The magnetic data are compensated using the measurements from APS fluxgates in addition with the inertial measurements and proprietary software of *Novatem Inc.* in order to remove the magnetic noise caused by the variations of attitude of the aircraft. High altitudes Figure Of Merite (FOM) is done over an area of low magnetic variations to calculate coefficients that were used for compensation.

A 3 by 3 rotation matrix, whose coefficients are included in the data base, was also applied for the coordinate system transformation from the moving reference frame of the aircraft to the fixed terrestrial magnetic reference frame.

The rotation matrix terms are defined as follow:

$$\begin{aligned} \text{rot_term11} &= \cos(r) \cdot \cos(y) \\ \text{rot_term12} &= \cos(r) \cdot \sin(y) \\ \text{rot_term13} &= -\sin(r) \\ \text{rot_term21} &= \sin(p) \cdot \sin(r) \cdot \cos(p) - \cos(p) \cdot \sin(r) \\ \text{rot_term22} &= \sin(p) \cdot \sin(r) \cdot \sin(y) + \cos(p) \cdot \cos(y) \\ \text{rot_term23} &= \cos(r) \cdot \sin(p) \\ \text{rot_term31} &= \cos(p) \cdot \sin(r) \cdot \cos(y) + \sin(p) \cdot \sin(y) \\ \text{rot_term32} &= \cos(p) \cdot \sin(r) \cdot \sin(y) - \sin(p) \cdot \cos(y) \\ \text{rot_term33} &= \cos(r) \cdot \cos(p) \end{aligned}$$

With $r = \text{roll_IMU_deg}$
 $p = -\text{pitch_IMU_deg}$
 $y = \text{yaw_IMU_deg} - 90$

5.2.5 TRADITIONAL MAGNETIC LEVELLING

A standard levelling procedure, based on the differences observed at the intersections between lines and tie-lines, was applied using *Oasis Montaj™*. This procedure is based on the differences at the crossing points between the line and tie-lines.

Several tests are applied, by using Shift correction, Tilt correction, Spline correction or Tensioned correction. The correction yielding the best results was only carefully applied at the intersections where conditions permitted.

5.2.6 NOVATEM'S MAGNETIC LEVELLING

The previous procedure is well adapted to fixed-wing surveys where the drape surface is smooth. In areas of higher topographical gradients, the discrepancies between lines flown in opposite directions are higher, especially on top of hills and over valleys and consequently corrugation is higher. As the direction of the wind is not the same for the Lines and for the Tie-lines, it is thus very difficult for the pilot to follow the draped surface in the same manner for the Line and for the Tie-lines. Even if the navigation appears close to the draped surface, local discrepancies are generally shown, which are

usually well correlated with the top of the mounts and the low of the valleys. The traditional levelling generally fails because the corrections are not only a shift or a tilt, but a local wavelength (local clearance variation). Moreover, the wavelength varies depending both on the topography, the relative speed of the aircraft, the direction of the wind, etc..., and so the Spline parameters should vary locally.

The Novatem levelling is based on a frequency approach in order to level only frequencies measured at the crossing-points. Having identified the frequencies to level, these frequencies are removed, levelled and then added. This is equivalent to remove a corrugated base level; to correct it using local corrections, and then to add it. This procedure is not a microlevelling in the sense of the “Geosoft Microlevelling” as the corrections are only applied to a base level, without any modification to the highest frequencies.

Finally, the vertical gradient, calculated from a convolution, is used to bring the anomaly closer from the vertical of the magnetic source. However, this technique reinforces the small wavelengths and might create artefacts.

5.2.8 CULTURAL NOISE NOTIFICATION

The presence of high voltage power lines, and urbanized or industrial areas, within the survey region creates magnetic anomalies, which can sometimes lead to erroneous interpretations. Thanks to the pictures continuously taken during the survey, it is possible to precisely identify sources of cultural noise.

5.2.9 MAGNETIC ANOMALIES (RESIDUAL MAGNETIC INTENSITY) AND TFMD (TOTAL FIELD MAGNETIC DATA)

The residual magnetic intensity is first calculated for each of the left and right magnetometers from the compensated left and right fields by the removing the 2005 IGRF, calculated for the altitude and the date of each measurement.

The Total Field Magnetic Data (TFMD) is then reconstructed from the Residual Magnetic Intensity (RMI) using a Definitive Geomagnetic Reference Field (DGRF) calculated for the mean period of the survey, i.e. 2009 January, 15th.

5.2.10 MEASURED LONGITUDINAL GRADIENT

The longitudinal gradient refers to the gradient calculated along the direction of the lines. It is defined as follow:

$$GRADIENT_{longitudinal} = \frac{dRMI / dt}{speed_GPS}$$

RMI, the final Micro-levelled mean residual magnetic field, was used instead of each individual magnetometer in order to remove the influence of lateral variations.

The longitudinal gradient so defined, is attitude independent and always referenced to the track axis of the aircraft. Therefore it is not necessary to rotationally correct this longitudinal gradient, even in the event of “crab flying”.

5.2.11 MEASURED TRANSVERSE GRADIENT

The transverse gradient refers to the gradient measured perpendicular to the axis of the plane. It is obtained by computing the difference between the right and left magnetometers, which is then divided by the distance between the two magnetometers (11m).

In normal survey conditions, roll and pitch angles are small enough to have only a limited influence on the measured transverse gradient. Nevertheless, depending on the wind direction the drift angle referred to as the “crab angle”, can be significant. It is thus necessary to rotate the measured

transverse gradient perpendicular to the track axis. The rotationally corrected transverse gradient is defined as follow:

$$TRANS_GRAD_{track} = LONGI_GRAD_{track} \times \tan(drift) + \frac{TRANS_GRAD_{heading}}{\cos(drift)}$$

With: drift = track - yaw_IMU_deg

The transverse gradient only provides local information, which is thus subject to long wavelength artefacts when represented in grid. A levelling procedure, based on the differences observed at the intersections between the transverse gradient along the lines and longitudinal gradient along the tie-lines, was applied using *Oasis Montaj™*, in order to remove the line to line errors.

Finally a microlevelling, similar to the frequency approach used for the total magnetic field, was applied to the levelled data in order to remove the remaining line to line features.

5.2.12 GRADIENT-ENHANCED TOTAL FIELD – GETF

The transverse and longitudinal measured gradients were used to reconstruct the Magnetic Total Field, using a method of integration. This method reinforces the short wavelengths which are better described in the measured gradients compared to the Total Field measurements. These transformations use a Novatem's proprietary suite of software (LEMM) mainly dedicated to the Potential Field transformations in the Fourier Domain. The measured transverse and longitudinal gradients are respectively integrated by the Hilbert Transform and the sum of the two integrations is then high pass filtered and added to the low pass Total Field filtered. In order to avoid Gibbs effects, the filtering is made directly on the measured profiles.

5.2.13 GRADIENT-ENHANCED VERTICAL GRADIENT – GEVG (SEE APPENDIX E)

Since the Gradient-Enhanced Vertical Gradient is calculated from measured gradients, it naturally reinforces short wavelengths and filters out long wavelengths. So the main difference between the GEVG and the Vertical Gradient calculated from the measured Total Field is a reinforcement of the shortest wavelengths (shallow sources) and an attenuation of the longest wavelengths (deep sources).

6 DELIVRABLES

6.1 DIGITAL DATA (DVD)

A digital version of the numerical data (databases), the maps and the report was archived on a DVD. One set is included with each report.

A. Magnetic database (MAG#_FINAL, MAGBASE):

Data were archived in the *Geosoft Oasis Montaj* (*.gdb) format and in an ASCII format (*.XYZ) which can be read by most editors. The channels of these files are as follow:

Field	Description	Units
line	Line number	
time.UTC	Universal Time Coordinated (seconds after midnight)	sec
fiducial	fiducial	sec
X	Easting UTM zone 21N, NAD83	m
Y	Northing UTM zone 21N, NAD83	m
raw_alt_GPS	Raw DGPS altitude, WGS84	m
alt_GPS	DGPS altitude post-processed, computed over WGS84	m
raw_lat	Raw latitude DGPS recorded	degrees
raw_long	Raw longitude DGPS recorded	degrees
lat	Latitude DGPS post-processed, WGS84	degrees
long	Longitude DGPS post-processed, WGS84	degrees
drape	Altitude of the draping surface used for the navigation	m
clearance_laser	Flight height above ground level	m
DEM	Digital Elevation Model : alt_GPS-clearance	m
rot_term11	Rotation matrix – term 1,1	
rot_term12	Rotation matrix – term 1,2	
rot_term13	Rotation matrix – term 1,3	
rot_term21	Rotation matrix – term 2,1	
rot_term22	Rotation matrix – term 2,2	
rot_term23	Rotation matrix – term 2,3	
rot_term31	Rotation matrix – term 3,1	
rot_term32	Rotation matrix – term 3,2	
rot_term33	Rotation matrix – term 3,3	
yaw_IMU_deg	Yaw angle from IMU: left handed rotation around z-axis. Degrees clockwise from North	degrees
roll_IMU_deg	Roll angle from IMU: right handed rotation from local level around y-axis	degrees
pitch_IMU_deg	Pitch angle from IMU: right handed rotation from local level around x-axis	degrees
speed_GPS	Aircraft speed as measured by the DGPS	m/s

Field	Description	Units
FG_l	Total Magnetic Field from Left Flux-Gate components	nanoteslas
FGX_l	Left Flux-Gate X component	nanoteslas
FGY_l	Left Flux-Gate Y component	nanoteslas
FGZ_l	Left Flux-Gate Z component	nanoteslas
FG_r	Total Magnetic Field from Right Flux-Gate components	nanoteslas
FGX_r	Right Flux-Gate X component	nanoteslas
FGY_r	Right Flux-Gate Y component	nanoteslas
FGZ_r	Right Flux-Gate Z component	nanoteslas
mag_raw_l	Left raw uncompensated mag	nanoteslas
mag_raw_r	Right raw uncompensated mag	nanoteslas
DeerLake_base	Magnetic base station low pass filtered on 5 points	nanoteslas
magcorbase_l	Left raw uncompensated mag base corrected	nanoteslas
magcorbase_r	Right raw uncompensated mag base corrected	nanoteslas
magcomp_l	Left base corrected compensated mag	nanoteslas
magcomp_r	Right base corrected compensated mag	nanoteslas
DGRF	Definitive Geomagnetic Reference Field (DGRF, 2009 January, 15 th) used for TFMD : RMI = TFMD - IGRF	nanoteslas
residual_l	Left residual : local IGRF (versus alt_GPS) removed from magcomp_l	nanoteslas
residual_r	Right residual: local IGRF (versus alt_GPS) removed from magcomp_r	nanoteslas
maglev_l	Levelled left residual	nanoteslas
maglev_r	Levelled right residual	nanoteslas
mag_microlev_l	Micro-levelled left residual	nanoteslas
mag_microlev_r	Micro-levelled right residual	nanoteslas
RMI	Residual Magnetic Intensity: RMI = TFMD – IGRF Final Micro-levelled mean residual magnetic field	nanoteslas
TFMD	Total Field Magnetic Data: TFMD = RMI + IGRF	nanoteslas
grad_longitudinal	Magnetic longitudinal gradient	nanoteslas/m
grad_transverse_raw	Raw magnetic transversal gradient	nanoteslas/m
drift	Drift	degrees
grad_trans_rot_corrected	Rotated transversal gradient	nanoteslas/m
grad_trans_rot_corrected_lev	Levelled rotated transversal gradient	nanoteslas/m
grad_trans_final	Micro-levelled rotated transversal gradient	Nanoteslas/m
GETF	Gradient Enhanced Total Field	nanoteslas
GEVG	Gradient Enhanced Vertical Gradient	nanoteslas/m
date	Date of the survey flight	ddmmyyyy
flight	Flight number	

NB: Opening the databases using *C08072_DVD-V2.gpf* will display the channels in the order of this table.

B. Grids

The grids of the magnetic field were calculated using the minimum curvature algorithm. The construction parameters of these grids are specified in Appendix D.

6.2 MAPS

Data are represented on colour shaded maps and contours at the scale of 1:50 000. Maps were produced using projected coordinates system NAD83, UTM Zone 21N. Hydrology background was used to locate lakes and rivers.

The numerical data for each of the following maps are included in the DVD-ROM. The following table describes the maps and their associated number:

INDIAN HEAD

Map Description	Open File	Map number
Residual Magnetic Field, Flat Bay – Main Gut Map Area, 12B/07 (east) and 12B/08 (west)	012B/0581	2009-55
First Vertical Derivative of the Residual Magnetic Field, Flat Bay - Main Gut Map Area, 12B/07 (east) and 12B/08 (west)	012B/0581	2009-56
Residual Magnetic Field, Harry's River - Stephenville Map Area, 12B/09 (west) and 12B/10 (east)	012B/0581	2009-57
First Vertical Derivative of the Residual Magnetic Field, Harry's River - Stephenville Map Area, 12B/09 (west) and 12B/10 (east)	012B/0581	2009-58
Residual Magnetic Field, Shag Island – Serpentine Map Area, 12B/15 (east) and 12B/16 (west)	012B/0581	2009-59
First Vertical Derivative of the Residual Magnetic Field, Shag Island – Serpentine Map Area, 12B/15 (east) and 12B/16 (west)	012B/0581	2009-60

DEER LAKE

Map Description	Open File	Map number
Residual Magnetic Field, Corner Brook – Rainy Lake Map Area, 12A/13 (east) and 12A/14 (west)	NFLD/3075	2009-61
First Vertical Derivative of the Residual Magnetic Field, Corner Brook – Rainy Lake Map Area, 12A/13 (east) and 12A/14 (west)	NFLD/3075	2009-62
Residual Magnetic Field, The Topsails – Deer Lake Map Area, 12H/02 (west) and 12H/03 (east)	NFLD/3075	2009-63
First Vertical Derivative of the Residual Magnetic Field, The Topsails – Deer Lake Map Area, 12H/02 (west) and 12H/03 (east)	NFLD/3075	2009-64
Residual Magnetic Field, Deer lake - Pasadena Map Area, 12H/03 (west) and 12H/04 (east)	NFLD/3075	2009-65
First Vertical Derivative of the Residual Magnetic Field, Deer lake - Pasadena Map Area, 12H/03 (west) and 12H/04 (east)	NFLD/3075	2009-66
Residual Magnetic Field, Cormack - Sheffield Lake Map Area, 12H/06 (east) and 12H/07 (west)	NFLD/3075	2009-67
First Vertical Derivative of the Residual Magnetic Field, Cormack - Sheffield Lake Map Area, 12H/06 (east) and 12H/07 (west)	NFLD/3075	2009-68
Residual Magnetic Field, Hampden Map Area, 12H/10	NFLD/3075	2009-69
First Vertical Derivative of the Residual Magnetic Field, Hampden Map Area, 12H/10	NFLD/3075	2009-70

GROS MORNE

Map Description	Open File	Map number
Residual Magnetic Field, Gros Morne Map Area, 12H/12	NFLD/3076	2009-71
First Vertical Derivative of the Residual Magnetic Field, Gros Morne Map Area, 12H/12	NFLD/3076	2009-72
Residual Magnetic Field, St. Paul's Inlet Map Area, 12H/13 and part of 12H/14	NFLD/3076	2009-73
First Vertical Derivative of the Residual Magnetic Field, St. Paul's Inlet Map Area, 12H/13 and part of 12H/14	NFLD/3076	2009-74
Residual Magnetic Field, Indian Lookout - Portland Creek Map Area, 12I/03 (west) and 12I/04 (east)	NFLD/3076	2009-75
First Vertical Derivative of the Residual Magnetic Field, Indian Lookout - Portland Creek Map Area, 12I/03 (west) and 12I/04 (east)	NFLD/3076	2009-76
Residual Magnetic Field, Bellburns Map Area, 12I/05	NFLD/3076	2009-77
First Vertical Derivative of the Residual Magnetic Field, Bellburns Map Area, 12I/05	NFLD/3076	2009-78
Residual Magnetic Field, Bellburns Map Area, 12I/06 and part of 12I/07	NFLD/3076	2009-79
First Vertical Derivative of the Residual Magnetic Field, Bellburns Map Area, 12I/06 and part of 12I/07	NFLD/3076	2009-80
Residual Magnetic Field, Torrent River Map Area, 12I/10	NFLD/3076	2009-81
First Vertical Derivative of the Residual Magnetic Field, Torrent River Map Area, 12I/10	NFLD/3076	2009-82
Residual Magnetic Field, Port Saunders Map Area, 12I/11	NFLD/3076	2009-83
First Vertical Derivative of the Residual Magnetic Field, Port Saunders Map Area, 12I/11	NFLD/3076	2009-84
Residual Magnetic Field, St. John Island - Castors River Map Area, 12I/14 (east) and NTS 12I/15 (west)	NFLD/3076	2009-85
First Vertical Derivative of the Residual Magnetic Field, St. John Island - Castors River Map Area, 12I/14 (east) and NTS 12I/15 (west)	NFLD/3076	2009-86

Table 4 : Map types and associated drawing numbers

8 SUMMARY

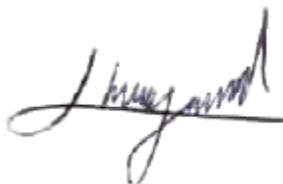
An airborne magnetic geophysical survey was flown for the Newfoundland and Labrador Department of Natural Resources – Energy Branch and Nalcor Energy from October 2008 to May 2009. The West Coast project was composed of three Blocks; referred to as Indian Head, Deer Lake and Gros Morne located on the west coast of Newfoundland, CANADA.

The final paper products consist of 32 maps at a scale of 1: 50 000. The final maps represent the residual magnetic field and the first vertical derivative. All these maps are included in a separate series of printed volumes, to be examined in conjunction with the report. The digital products consist of raw and final databases, metadata files, final grid files and maps. The digital data are included on DVD attached with the printed maps.

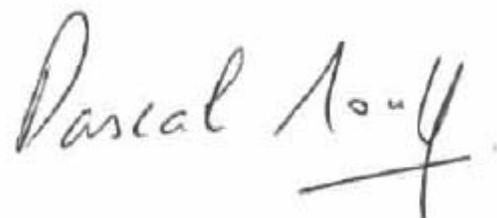
This report was written by Olivier Savignet, Jr. Eng. and Jérémie Largeaud, Jr. Eng. and was verified and approved by Pascal Mouge, Ph. D.



Olivier Savignet, Jr. Eng.



Jérémie Largeaud, Jr. Eng.



Pascal Mouge, PhD.

APPENDICES

APPENDIX A : SURVEY GEODETIC PARAMETERS

The table below presents the geodetic parameters used for the plane positioning. These parameters were applied in all subsequent coordinate transformations.

Local Datum transform:	NAD 83
Ellipsoid:	GRS 1980
Projection:	UTM
Zone:	21 N
Lat0, Lon0,	0, -57
False Easting:	500 000
False Northing:	0
Scale factor:	0.9996
Major Axis, Inverse flattening, Prime Meridian	6378137,298.25722,0
WGS84 to NAD83 Conversion Method:	Molodensky

APPENDIX B : COORDINATES OF THE VERTICES OF THE BLOCKS

Projection: North American Datum 1983 (GRS80) ; Universal Transverse Mercator ; zone 21N

Coordinates of the vertices, in metres, delimiting the Block **INDIAN HEAD**

X (Easting)	Y (Northing)
384520	5415940
408670	5395000
404670	5391270
410830	5384970
402545	5378065
409240	5371600
401070	5364420
391270	5364420
373540	5382380
375640	5387910
374195	5394600
384520	5415940

Coordinates of the vertices, in metres, delimiting the Block **DEER LAKE**

X (Easting)	Y (Northing)
461395	5407410
478935	5423610
494685	5441065
515295	5457080
504370	5466720
513950	5483960
504810	5491480
502170	5483460
493350	5469705
476840	5450510
464760	5449070
457675	5442905
454950	5437030
454125	5425005
452510	5413785
461395	5407410

Coordinates of the vertices, in metres, delimiting the Block **GROS MORNE**

X (Easting)	Y (Northing)
443820	5536770
437610	5526970
428455	5503090
447480	5497800
464820	5531120
469570	5529920
470930	5542920
479330	5561165
486285	5573765
495920	5581220
517750	5625685
495695	5631735
489200	5625730
471170	5618520
470070	5616220
476575	5611040
471060	5604870
443820	5536770

APPENDIX C : BASE STATIONS SPECIFICATIONS**2008**

BASE STATION 1
HAWKE'S BAY
INSTALLED: 01-10-08
S/N: 8082873
COORDINATES: 050.6134124 -057.1380635
MEAN VALUE UNTIL 17-10-08: 53064.248 nT

BASE STATION 2
COW HEAD
INSTALLED: 30-09-08
S/N: 8082874
COORDONNÉES: 049.9141997 -057.7855598
MEAN VALUE UNTIL 17-10-08: 53210.944 nT

BASE STATION 3
STEADY BROOK 2 (STEADY BROOK FALL)
INSTALLED: 07-10-08
S/N: 6082063
COORDINATES: 048.9465832 -057.8213265
MEAN VALUE UNTIL 17-10-08: 52911.016 nT

2009

BASE STATION 1
HAWKE'S BAY
INSTALLED: 17-01-09
S/N: 8082873
COORDINATES: 049.2508604 -057.4556954
MEAN VALUE UNTIL 15-05-09: 53222.743 nT

BASE STATION 2
COW HEAD
INSTALLED: 20-01-09
S/N: 8082874
COORDONNÉES: 049.9141997 -057.7855598
MEAN VALUE UNTIL 15-05-09: 53181.089 nT

BASE STATION 3
CORMACK
INSTALLED: 21-01-09
S/N: 6082063
COORDINATES: 048.9823510 -057.8357327
MEAN VALUE UNTIL 15-05-09: 53094.301 nT

APPENDIX D : GRIDS CONSTRUCTION PARAMETERS

The following table summarizes the construction parameters of the grids:

INDIAN HEAD

Type of elements	FLOAT
Separation between two points along X, in m:	50
Separation between two points along Y, in m:	50
Number of points along X:	884
Number of points along Y:	1025
Origin of the grid:	X = 366 700 Y= 5 364 400
Azimuth:	0

DEER LAKE

Type of elements	FLOAT
Separation between two points along X, in m:	50
Separation between two points along Y, in m:	50
Number of points along X:	1491
Number of points along Y:	1681
Origin of the grid:	X = 440 750 Y= 5 407 400
Azimuth:	0

GROS MORNE

Type of elements	FLOAT
Separation between two points along X, in m:	50
Separation between two points along Y, in m:	50
Number of points along X:	2206
Number of points along Y:	2675
Origin of the grid:	X = 407 500 Y= 5 498 000
Azimuth:	0