Fugro Airborne Surveys

LOGISTICS AND PROCESSING REPORT
Airborne Magnetic and RESOLVE® Survey

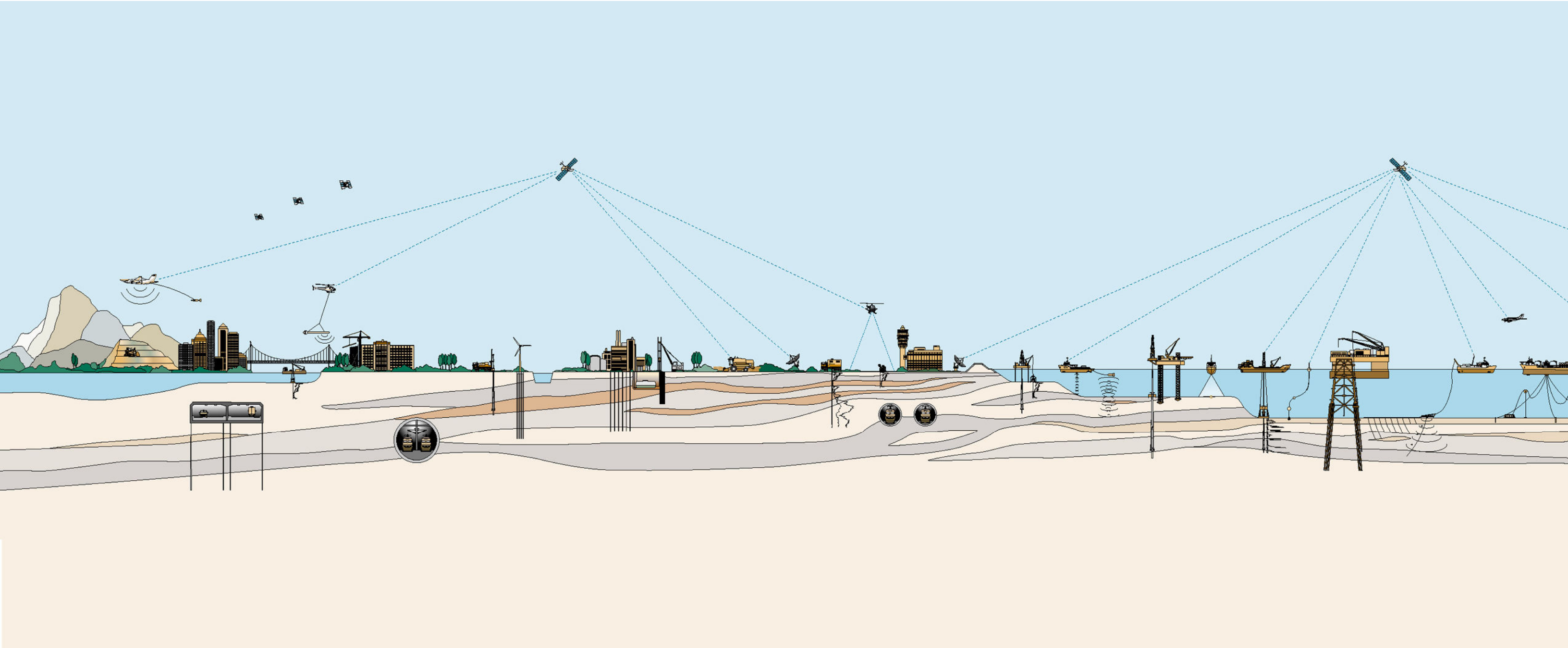
FORT YUKON AREA, ALASKA

&

FORT WAINWRIGHT HEM LINES

Job No. 10026 & 10039

United States Geological Survey



LOGISTICS AND PROCESSING REPORT
AIRBORNE MAGNETIC AND RESOLVE® SURVEY
FORT YUKON AREA, ALASKA,
&
FORT WAINWRIGHT HEM LINES

JOB NO. 10026
& 10039

Client: United States Geological Survey
BLDG 53, ENT S-1, Denver Federal Center
Denver, CO, U.S.A
80225

Date of Report: September, 2010

FUGRO AIRBORNE SURVEYS

Fugro Airborne Surveys was formed in early 2000 through the global merger of leading airborne geophysical survey companies: Geoterrex-Dighem, High-Sense Geophysics, and Questor of Canada; World Geoscience of Australia; and Geodass, and AOC of South Africa. Sial Geosciences of Canada joined the Fugro Airborne group in early 2001, and Spectra Exploration Geosciences followed thereafter. In mid 2001, Fugro acquired Tesla 10 and Kevron in Australia, and certain activities of Scintrex. Fugro also works with Lasa-Geomag located in Brazil, for surveys in South America. With a staff of over 400, Fugro Airborne Surveys now operates from 12 offices worldwide.

Fugro Airborne Surveys is a professional services company specializing in low level remote sensing technologies and collects, processes and interprets airborne geophysical data related to the subsurface of the earth and the sea bed. The data and map products produced have been an essential element of exploration programs for the mining and oil & gas industries for over 50 years. Engineers, scientists and others with a need to map the earth's subsurface geology use Fugro Airborne Surveys for environmental and engineering solutions. From mapping kimberlite pipes and oil and gas deposits to detecting water tables and unexploded ordnance, Fugro Airborne Surveys designs systems dedicated to specific targets and survey needs. State of the art geophysical systems and techniques ensure that clients receive the highest quality survey data and images.

Fugro Airborne Surveys acquires both time domain and frequency domain electromagnetic data as well as, magnetic, radiometric and gravity data from a wide range of fixed wing (airplane) and helicopter platforms. Depending on the geophysical mapping needs of the client, Fugro Airborne Surveys can field airborne systems capable of collecting one or more of these types of data concurrently. The company offers all data acquisition, processing, interpretation and final reporting services for each survey.

Fugro Airborne Surveys is a founding member of IAGSA, the International Airborne Geophysics Safety Association. Our quality management system has successfully achieved certification to the international standard *ISO 9001:2000 Quality Management Systems - Requirement*s

Survey Purpose

The Fort Yukon survey was flown to detect resistivity contrasts in and around the Fort Yukon area to evaluate the effectiveness of frequency domain electromagnetics to map permafrost. The Fort Wainwright HEM Lines were flown to allow comparison of resistivity depth data from airborne data with surface geophysics and borehole data

TABLE OF CONTENTS

SURVEY AREA DESCRIPTION **7**

Location of the Survey Area 7

Base Station Locations 9

SYSTEM INFORMATION **12**

Aircraft and Geophysical On-Board Equipment 14

Base Station Equipment 15

Contract Specifications 15

DATA PROCESSING **18**

Airborne Magnetics 19

Electromagnetics 19

Apparent Resistivity 20

FINAL PRODUCTS **21**

Digital Archives 21

Maps 21

Profile Plots 21

Report 21

APPENDICES

DATA ARCHIVE DESCRIPTION

SYSTEM TESTS

FLIGHT LOGS

Survey Area Description

Location of the Survey Area

The Fort Yukon Area, Alaska (Figure 2-1) was flown between June 3, 2010 and June 10, 2010, with Fort Yukon, Alaska as the base of operations. Lines were flown in a block at 350m spacing and have 10000 series line numbers. They were flown at an azimuth of 050 degrees and contain 841.9 line kilometres of traverse lines and 31.5 line kilometres of tie lines. There are two other groups of lines in the survey that start in the block and loop out to the north in the case of the 20000 series and in the south in the 30000 series. The north loop contains 487.5 line kilometres and the south loop contains 400.6 line kilometres. The complete survey totalled 1761.5 line kms

Figure 2- 1 Fort Yukon location map

Table 2-1 contains the coordinates of the corner points of the survey block.

Corner	Block	UTM Easting (m)	UTM Northing (m)
1	**10026-1**	580937	7390148
2	**Fort Yukon Block**	587205	7382679
3		564286	7363448
4		558019	7370917

Table 2- 1 Area Corners WGS84 UTM Zone 6N

The Fort Wainwright HEM lines consist of two orthogonal survey lines each approximately one kilometer in length. Both lines were flown five times. Each time at a different altitude.

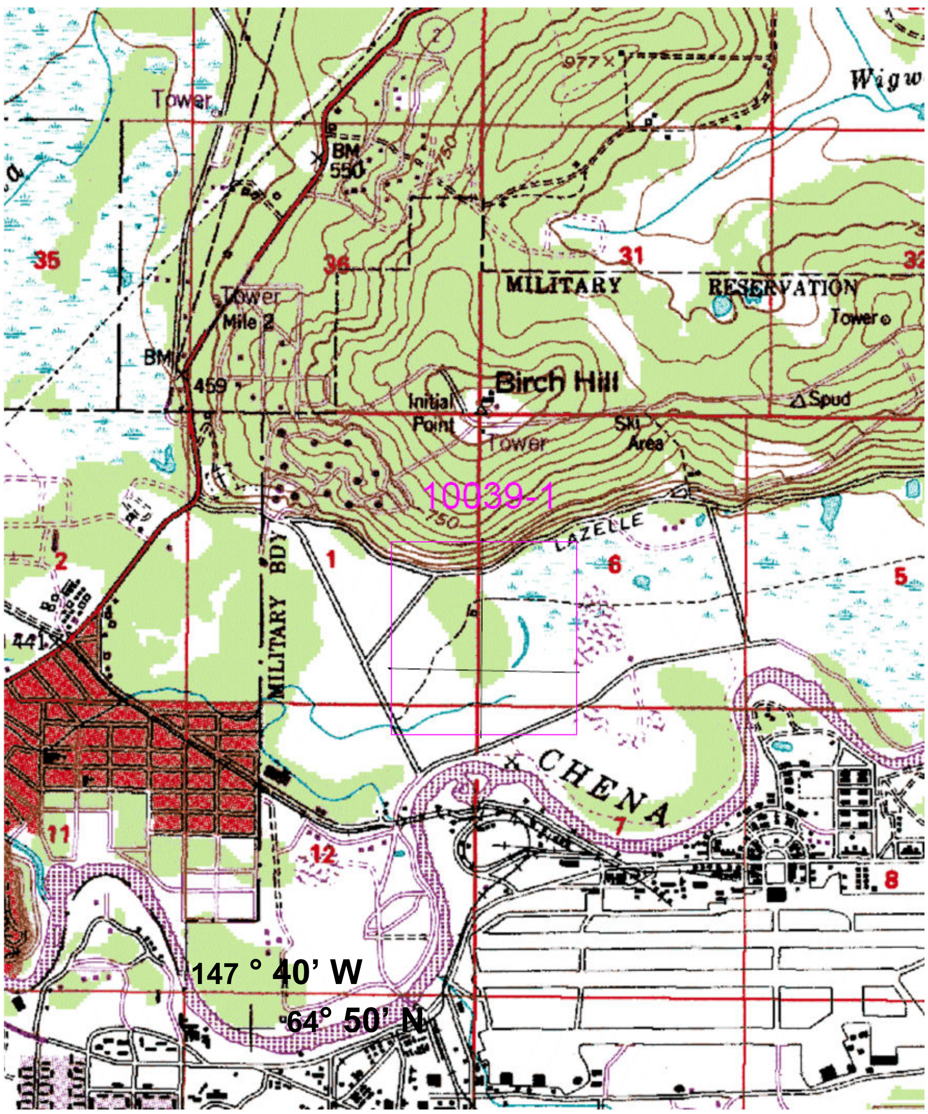


Figure 2- 2 Fort Wainwright location map

Table 2-2 contains the coordinates of the corner points of the Fort Wainwright survey lines.

	Line	UTM Easting (m)	UTM Northing (m)
Line Start	**10010**	469510	7191632
Line End		469518	7192702
Line Start	**10020**	469010	7191999
Line End		470041	7191976

Table 2-2 Area Corners WGS84 UTM Zone 6N

Base Station Locations

During the survey a base station GPS was set up to collect data to allow the post processing of the positional data for increased accuracy. The location of the GPS base station is recorded in Table 2-2.

Status	Location Name	WGS84 Latitude (deg-min-sec)	WGS84 Longitude (deg-min-sec)	WGS84 Elevation (m)	Date Setup	Date Torn Down
Primary	Gravel Pit	66 34 14.9546 N	145 14 53.5728 W	137.311	3-Jun-10	10-Jun-10

Table 2-2 GPS Base Station Location

Figure 2-2 Typical GPS Base Station Setup

Status	Location Name	WGS84 Latitude (deg-min-sec)	WGS84 Longitude (deg-min-sec)	WGS84 Elevation (m)	Date Setup	Date Torn Down
Primary	Gravel Pit	66 33 52.8744 N	145 12 07.851 W	132.472	3-Jun-10	10-Jun-10

Table 2-3 Magnetic Base Station Location

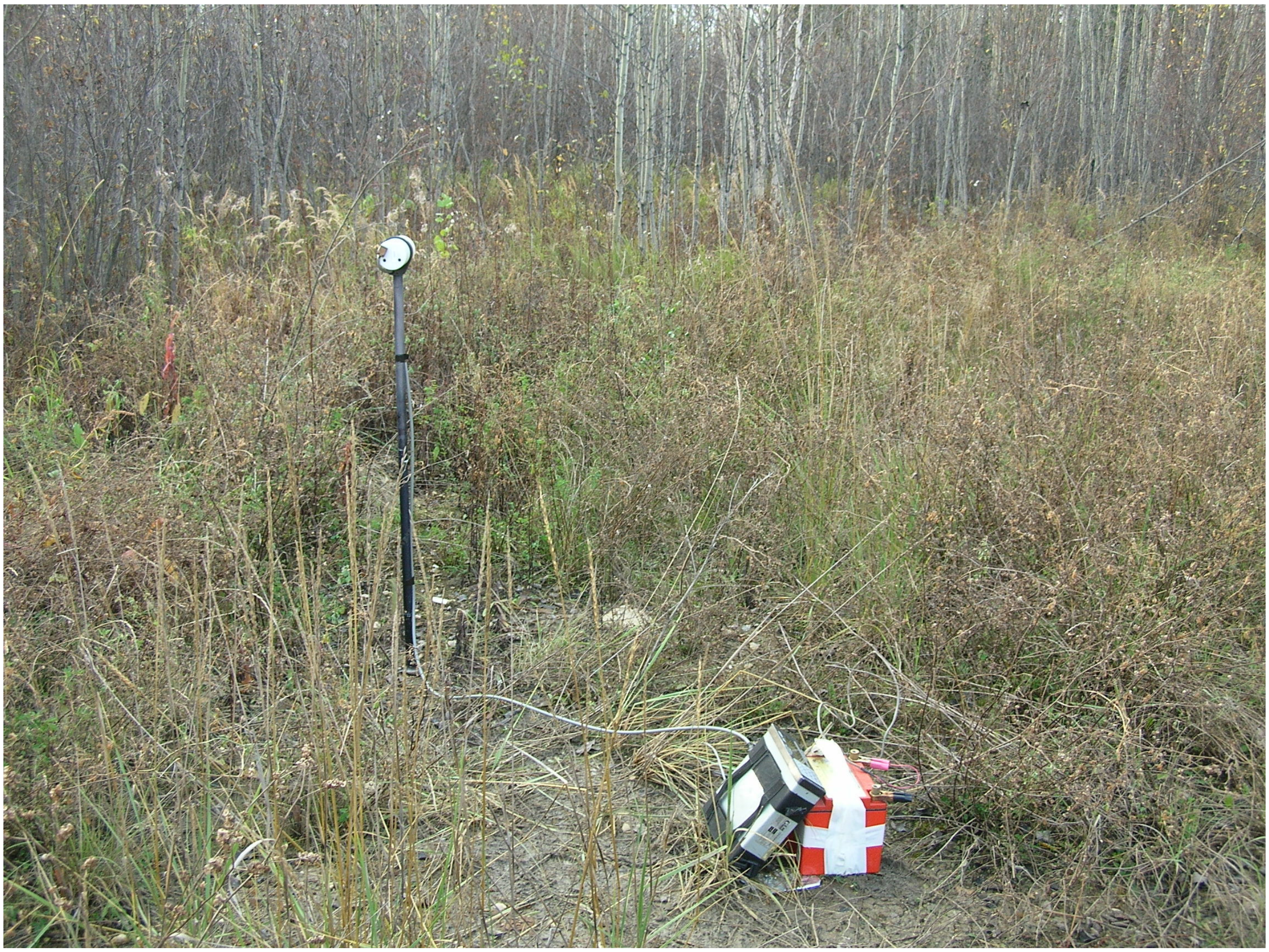


Figure 2-3 Typical Magnetic Base Station Setup

All the grids and maps have been produced with the following coordinate system.

Projection:	Universal Transverse Mercator (UTM Zone 6N)
Datum:	NAD83
Central meridian:	147° East/West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.9996
Dx,Dy,Dz:	0,0,0

The field crew for the survey were as follows;

Data Processor:	Mitch Jackson
Pilots:	Glen Charbonneau
Electronics Operator:	Manu Chaudry
Engineer:	Will Harper

System Information

Figure 3-1 Resolve Em system

The Resolve EM system is composed of a 90 foot cable which tows a 30 foot bird containing the EM transmitter and receiver coils, five coplanar and one coaxial, laser altimeter and gps antenna. The helicopter has a tail boom mounted GPS antenna for in flight navigation as well as a radar altimeter, barometric altimeter, video camera and data acquisition system. The magnetometer was mounted on the trailing end of the bird to reduce noise in the magnetic data.

Aircraft and Geophysical On-Board Equipment

Aircraft:	AS350-B3 Helicopter
Operator:	Great Slave Helicopters
Registration:	C-GBDA
Average Survey Speed:	55 knots / 65 mph / 30 m/s
Magnetometer:	Scintrex CS-3 single cell cesium vapour, slung below the helicopter, sensitivity = 0.01 nT[1], sampling rate = 0.1 s, ambient range 20,000 to 100,000 nT. The general noise envelope was kept below 0.5 nT. The nominal sensor height was ~75 m above ground.
Electromagnetic System:	A RESOLVE electromagnetic (EM) system will be employed. The RESOLVE system is a unique system with horizontal coplanar coils capable of measuring the EM response at five frequencies and one coaxial coil. The frequency range is between approximately 400 Hz and 140 kHz with the six operational frequencies logarithmically spaced.

The following nominal configuration and frequencies will be employed:

Nominal Frequency	Coil Orientation	Coil Separation (m)	Actual Running Frequency (Hz)	Channels	Sensitivity (ppm)
390 Hz	Horizontal coplanar	7.93	378	I,Q	0.12
3,300 Hz	Vertical coaxial	9.06	3260	I,Q	0.24
1,800 Hz	Horizontal coplanar	7.90	1843	I,Q	0.12
8,200 Hz	Horizontal coplanar	7.94	8180	I,Q	0.24
40,000 Hz	Horizontal coplanar	7.95	40650	I,Q	0.44
140,000 Hz	Horizontal coplanar	7.93	128510	I,Q	0.44

Table 3-1 EM System Information

A total of twelve EM channels of information will be sampled at 0.1 second intervals or approximately every 4 metres along the survey line, with a time constant of 0.2 seconds. Additionally, there are two spheric/powerline channels for noise monitoring.

1 One nanotesla (nT) is the S.I. equivalent of one gamma.

Digital Acquisition:	Fugro Airborne Surveys Helidas.
Barometric Altimeter:	Motorola MPX4115AP analog pressure sensor with a pressure sensitivity of 150mV/kPa and a 10 Hz sample interval mounted in the helicopter.
Radar Altimeter:	Honeywell or Sperry, RT 300 or AT220 short pulse modulation 4.3 GHz, sensitivity 1 ft, range 0 to 2500 ft, 10 Hz recording interval mounted in the helicopter.
Laser Altimeter:	Optech first pulse last pulse, accuracy 2%, sensitivity 1 ft, range 0 to 2500 ft, 10 Hz sample rate mounted in the EM loop.
Camera:	Panasonic WVCL322 Colour Video Camera
Electronic Navigation:	NovAtel OEMV-4 Dual Frequency, 1 sec recording interval, with an accuracy of ±0.6m using SBAS. Antenna mounted on the tail of the helicopter.
Sensor Positional Data:	NovAtel OEMV-4 Dual Frequency, 1 sec recording interval, with an accuracy of ±0.6m using SBAS. Antenna mounted on the EM bird.

Base Station Equipment

Magnetometer:	Scintrex CS-2 single cell cesium vapour, mounted in a magnetically quiet area, measuring the total intensity of the earth's magnetic field in units of 0.01 nT at 1 Hz, within a noise envelope of 0.20 nT.
GPS Receiver:	NovAtel OEMV-2, 1 sec recording interval, with an accuracy of ±0.6m using SBAS.
Data Logger:	CF1, SBBS (single board base station).

Contract Specifications

The Survey Area is comprised of one (1) block located over the Fort Yukon, Alaska. Flight lines will be flown at an azimuth of (050°/230°) at 350 metre flight line intervals. Two additional loops were flown, the Upper Yukon loop to the north and the Shennjek Porcupine loop to the south. The total survey area encompasses approximately 1774 line kilometres as detailed in Table 3-2.

BLOCK	LINES		FLIGHT	LINE	MEASURED	CONTRACT
	FROM	TO	DIRECTION	SPACING	LINE km	LINE km
1	10010	10290	NE-SW (50°)	350 metres	867.6	
Main Area	19010	19030	NW-SE (140°)	14500 metres	30.3	897.9
2a-2k Upper Yukon	20010	20110	varies		479.6	479.6
3a-3i Shennjek Porcupine -	30010	30090	varies		396.5	396.5

Table 3-2 Flight Block Summary

Optimum Survey Elevations for the helicopter and instrumentation during normal survey flying are:

Helicopter	60 metres
Magnetometer	35 metres
RESOLVE EM Sensor	35 metres

Survey Elevations will not deviate by more than +/-20% over a distance of 2 km from the contracted elevation.

Survey Elevations is defined as the measurement of the helicopter radar altimeter to the tallest obstacle in the helicopter path. An obstacle is any structure or object which will impede the path of the helicopter to the ground and is not limited to and includes tree canopy, towers and power lines.

Survey Elevations may vary based on the pilot's judgement of safe flying conditions around man-made structures or in rugged terrain.

Electromagnetics

RESOLVE EM

Reflights will result when the drift of the EM channels exceeds the specified limits. The tolerances by frequency and coil orientation are:

Frequency	Coil orientation	Drift limits (ppm/hr)
390 Hz	horizontal coplanar	20.0
1,800 Hz	horizontal coplanar	30.0
3,300 Hz	vertical coaxial	40.0
8,200 Hz	horizontal coplanar	60.0
40,000 Hz	horizontal coplanar	80.0
137,000 Hz	horizontal coplanar	100.0

Table 3-3 EM Drift limits

Spheric pulses may occur having strong peaks but narrow widths. The EM data are considered acceptable when their occurrence is less than 10 spheric events exceeding the stated noise specification for a given frequency per 100 samples continuously over a distance of 2,000 metres.

Airborne High Sensitivity Magnetometer

The non-normalized 4^{th} difference will not exceed 1.6 nT over a continuous distance of 1 kilometre excluding areas where this specification is exceeded due to natural anomalies.

Ground Base Station Magnetometer

For acceptance of the magnetic data, non-linear variations in the magnetic diurnal should not exceed 10 nT per minute.

Data Processing

Field

All digital data were verified for validity and continuity. The data from the aircraft and base station were transferred to the field PC's hard disk. Basic statistics were generated for each parameter recorded, these included: the minimum, maximum, and mean values; the standard deviation; and any null values located. Data were checked in the field by the FUGRO AIRBORNE SURVEYS field geophysicist for adherence to the survey specifications as outlined in the contract. Any failure to meet the survey specifications resulted in a reflight of the line or portion of the line unless aircraft safety was at risk or the client's on site representative approved the data.

Flight Path Recovery

The quality of the GPS navigation was controlled on a daily basis by recovering the flight path of the aircraft and ensuring it met the standards in the contract. The bird positional data were then corrected using the raw ranges from the base station to create improved models of clock error, atmospheric error, satellite orbit, and selective availability. These models are used to improve the conversion of aircraft raw ranges to differentially corrected sensor position. The x and y positional data are presented in NAD83 UTM Zone 6N and the gps height data are relative to the EGM96-World geoid so that the heights are orthometric or relative to mean sea level.

To check the quality of the positional data the speed of the bird is calculated using the differentially corrected x, y and z data. Any sharp changes in the speed are used to flag possible problems with the positional data. Where speed jumps occur the data are inspected to determine the source of the error. The erroneous data are deleted and splined if less than two seconds in length. If the error is greater than two seconds the raw data are examined and if acceptable may be shifted and used to replace the bad data. The gps z component is the most common source of error. When it shows problems that cannot be corrected by recalculating the differential correction the barometric altimeter is used as a guide to assist in making the appropriate correction.

Altitude Data

For laser altimeter data values less than 5 metres and greater than 200 metres are replaced by dummies, next an Alfatrim median filter used to eliminate the highest and lowest values from the statistical distribution of a 13 point sample window for the data are then Akima splined where the gaps are fewer than 3 seconds. If the gaps exceed 30 values they are manually filled with radar altimeter data that is shifted to match the laser level. The laser altimeter data are then subtracted from the GPS elevation to create a digital terrain model that is gridded and consulted in conjunction with profiles of the laser altimeter and flight path video to detect any spurious points.

Radar altimeter data is despiked by applying a one and a half second median and smoothed using a one and a half second hanning filter. Likes the laser altimeter data the radar altimeter data are then subtracted from the GPS elevation to create a digital terrain model that is gridded and consulted in conjunction with profiles of the radar altimeter and flight path video to detect any spurious points.
Barometric altimeter data is smoothed with a 5 second hanning filter.

Base Station Diurnal Magnetics

The raw diurnal data sampled at 1 Hz and are imported into a database. The data are filtered with a 21 second median filter and then a 21 second hanning filter to remove spikes and smooth short wavelength variations. A non linear variation is then calculated and a flag channel is created to indicate where the variation exceeds the survey tolerance. Acceptable diurnal data are interpolated to a 10 Hz sample rate and the local regional field value calculated from the average of the first day's diurnal data is removed to leave the diurnal variation. This diurnal variation is then ready to be used in the processing of the airborne magnetic data.

Airborne Magnetics

Residual Magnetic Intensity

The TMI data collected in flight were profiled on screen along with a fourth difference channel calculated from the TMI. Spikes were removed manually where indicated by the fourth difference. The magnetic data collected on flights 4, 5 and 6 had long wavelength noise with a period of ten or eleven seconds and amplitude of around 3 nT. It did not exceed the fourth difference threshold but line to line variations of 3nT in quiet areas with the 50m line spacing result in a noisy grid. Attempts to filter out the noise resulted in the reduction or elimination of real magnetic signal and so the filtering attempt was abandoned. Flights 4, 5 and 6 covered most of block one and so the block one magnetic data should not be used. Grids are provided at the client's request. The problem was noted in the field and the magnetic sensor was moved to the rear of the bird. Flights 7 and 8 did not show the noise and block two data has been used to create the RMI and CVG maps. The northern third of this block was covered by flight 5 and the magnetic data is noticeably poorer there. The despiked data were corrected for lag by 8 scans. The diurnal variation that was extracted from the filtered ground station data was removed from the despiked and lagged TMI. The IGRF calculated for the specific survey location, time and altitude of the sensor, is removed from the resultant TMI to obtain the RMI. The RMI could not be conventionally tie line leveled as the north south line noise would be incorporated into the east west data. Instead the correction values of each east west line's set of intersections were summed and averaged and applied as a zero order polynomial to shift the east west lines and remove offsets. Manual corrections were then applied and microleveling was also carried out. The final RMI grid was filtered with a five point hanning for presentation.

Magnetic First Vertical Derivative

The first vertical derivative was calculated in the frequency domain from the final gridded RMI values to enhance subtleties related to geological structures. It was also shadowed and referred to during the leveling of the RMI.

Electromagnetics

EM data are processed at the recorded sample rate of 10 Hz. Profiles of the data were examined on a flight by flight basis on screen to check in-fight calibrations and high altitude background removal. A lag of 10 scans was applied and then first a median and then a hanning filter were used to reduce noise to acceptable levels. Flights were then displayed and corrected for drift. Following that individual lines were displayed and further leveling corrections were applied while referencing the calculated apparent resistivity. The inphase and quadrature channels of block one were microlevelled to remove some small leveling errors in resistive areas. A three point hanning filter was applied to the grids to smooth them for presentation.

Apparent Resistivity

The apparent resistivities in ohm•m are generated from the in-phase and quadrature EM components for all of the coplanar frequencies, using a pseudo-layer half-space model. The inputs to the resistivity algorithm are the in-phase and quadrature amplitudes of the secondary field. The algorithm calculates the apparent resistivity in ohm-m, and the apparent height of the bird above the conductive source. Any difference between the apparent height and the true height, as measured by the radar altimeter, is called the pseudo-layer and reflects the difference between the real geology and a homogeneous halfspace. This difference is often attributed to the presence of a highly resistive upper layer. Any errors in the altimeter reading, caused by heavy tree cover, are included in the pseudo-layer and do not affect the resistivity calculation. The apparent depth estimates, however, will reflect the altimeter errors. Apparent resistivities calculated in this manner may differ from those calculated using other models.

In areas where the effects of magnetic permeability or dielectric permittivity have suppressed the in-phase responses, the calculated resistivities will be erroneously high. Various algorithms and inversion techniques can be used to partially correct for the effects of permeability and permittivity.

Apparent resistivity maps portray all of the information for a given frequency over the entire survey area. The preliminary apparent resistivity maps and images are carefully inspected to identify any lines or line segments that might require base level adjustments. If required, manual level adjustments are carried out to eliminate or minimize resistivity differences that can be attributed, in part, to changes in operating temperatures. These leveling adjustments are usually very subtle, and do not result in the degradation of discrete anomalies.

Final Products

Digital Archives

Line and grid data in the form of an ASCII text file (*.xyz), Geosoft database (*.gdb) and Geosoft grids (*.grd) have been written to DVD. The formats and layouts of these archives are further described in Appendix E (Data Archive Description). Hardcopies of all maps have been created as outlined below.

Maps

Scale:	1:10,000
Parameters:	Residual Magnetic Intensity, Block 2 only
	First Vertical Derivative of the Residual Magnetic Intensity Block 2 only
	Calculated Resistivity Depth Slice at 5m below topographic surface
	Calculated Resistivity Depth Slice at 10m below topographic surface
	Calculated Resistivity Depth Slice at 20m below topographic surface
	Calculated Resistivity Depth Slice at 50m below topographic surface
	Calculated Resistivity Depth Slice at 75m below topographic surface
Media/Copies:	2 Paper

Profile Plots

Scale:	1:10,000
Parameters:	Differential Resistivity sections for lines chosen in consultation with the client comprising approximately 10% of the survey size in line kilometres.
Media/Copies:	digital PDF of Each Line

Report

Media/Copies:	1 digital (PDF format)

Appendix A

Data Archive Description

Data Archive Description:

Reference #   CDVD00575

Number of DVD's: 1

Archive Date   20-June-2010

Job # 10026   Archive Date   13-September-2010

This archive contains the final data archive and grids of a RESOLVE EM, magnetic
FUGRO AIRBORNE SURVEYS CORP. on behalf of the USGS over the Fort Yukon area, Alaska.
The suffix -1 to filenames denotes the 10000 series lines which were flown over
a block at 300m spacing. The suffix -2 denotes the 20000 and 30000 series lines
flown in various directions.

Projection information

All the grids and sections have been produced with the following coordinate system.

Projection:	Universal Transverse Mercator (UTM Zone 6N)
Datum:	NAD83
Central meridian:	147 West
False Easting:	500000 metres
False Northing:	0 metres
Scale factor:	0.9996
Conversion to WGS84	
Dx,Dy,Dz:	0,0,0
Grid Origin x,y:	557970, 7363510
Cell size dx,dy:	70,70
Rotation:	0

\README.txt -	This archive
\GRIDS	Grids in Geosoft float (.grd) format with accompanying .GI files
CVG-1.GRD	- Calculated Vertical Gradient from Residual Magnetic Field Block 1
MAG-1.GRD	- Residual Magnetic Field Block 1
DTM-1.GRD	- Digital Terrain Model ALTG-ALTL Block 1
LASER-1.GRD	- Laser altitude of bird Block 1
RES400-1.GRD	- Apparent Resistivity 400 Hz coplanar block 1
RES1800-1.GRD	- Apparent Resistivity 1800 Hz coplanar block 1

RES8200-1.GRD	- Apparent Resistivity 8200 Hz coplanar block 1
RES40k-1.GRD	- Apparent Resistivity 40k Hz coplanar block 1
RES140k-1.GRD	- Apparent Resistivity 140k Hz coplanar block 1
RES400-2.GRD	- Apparent Resistivity 400 Hz coplanar block 2
RES1800-2.GRD	- Apparent Resistivity 1800 Hz coplanar block 2
RES8200-2.GRD	- Apparent Resistivity 8200 Hz coplanar block 2
RES40k-2.GRD	- Apparent Resistivity 40k Hz coplanar block 2
RES140k-2.GRD	- Apparent Resistivity 140k Hz coplanar block 2

\LINEDATA\FORT WAINWRIGHTGeosoft format databases - Fort Wainwright Area

ARC_Wainwright_LTlines.gdb- Geosoft format database of Traverse and Tie line final archive data channels described below

ARC_Wainwright_Slines.gdb- Geosoft format database of S Type (turn around) lines archive data channels described below

\LINEDATA\FORT YUKON Geosoft format databases - Fort Yukon Area

ARC_Yukon_LTlines.gdb	- Geosoft format database of Traverse and Tie line final archive data channels described below
ARC_Yukon_Slines.gdb	- Geosoft format database of S Type (turn around) lines archive data channels described below

\PDF\Sections PDF format files of differential/Sengpiel profile sections

ProfL10010.pdf	Profiles of lines L10010 and L10020
ProfL10030.pdf	Profiles of lines L10030 and L10040
ProfL10050.pdf	Profiles of lines L10050 and L10060
ProfL10061.pdf	Profiles of lines L10061 and L10070
ProfL10072.pdf	Profiles of lines L10072 and L10073
ProfL10074.pdf	Profiles of lines L10074 and L10080
ProfL10082.pdf	Profiles of lines L10082 and L10090
ProfL10092.pdf	Profiles of lines L10092 and L10100
ProfL10102.pdf	Profiles of lines L10102 and L10110
ProfL10111.pdf	Profiles of lines L10111 and L10120
ProfL10123.pdf	Profiles of lines L10123 and L10130
ProfL10132.pdf	Profiles of lines L10132 and L10140
ProfL10142.pdf	Profiles of lines L10142 and L10150
ProfL10152.pdf	Profiles of lines L10152 and L10160
ProfL10161.pdf	Profiles of lines L10161 and L10171
ProfL10180.pdf	Profiles of lines L10180 and L10190
ProfL10200.pdf	Profiles of lines L10200 and L10210
ProfL10220.pdf	Profiles of lines L10220 and L10230

ProfL10240.pdf	Profiles of lines L10240 and L10250
ProfL10260.pdf	Profiles of lines L10260 and L10270
ProfL10280.pdf	Profiles of lines L10280
ProfL20010.pdf	Profiles of lines L20010 and L20020
ProfL20021.pdf	Profiles of lines L20021 and L20030
ProfL20040.pdf	Profiles of lines L20040 and L20041
ProfL20042.pdf	Profiles of lines L20042 and L20050
ProfL20060.pdf	Profiles of lines L20060 and L20070
ProfL20080.pdf	Profiles of lines L20080 and L20090
ProfL20100.pdf	Profiles of lines L20100 and L20110
ProfL30010.pdf	Profiles of lines L30010 and L30011
ProfL30020.pdf	Profiles of lines L30020 and L30030
ProfL30040.pdf	Profiles of lines L30040 and L30041
ProfL30050.pdf	Profiles of lines L30050 and L30060
ProfL30061.pdf	Profiles of lines L30061 and L30070
ProfL30080.pdf	Profiles of lines L30080 and L30090
ProfL30091.pdf	Profiles of lines L30091
ProfT19010.pdf	Profiles of lines L19010 and L19011
ProfT19020.pdf	Profiles of lines L19020

\Report Logistics and interpretation report in Word format

10026rep.doc

Fugro GDB Archive Summary for Fort Yukon Data

ARC_Yukon_LTlines.gdb

# Channel	Units	Description
1 LINE		Line number
2 FLIGHT		flight number
3 FID		fiducial increment
4 LONG		degrees longitude NAD 83
5 LAT		degrees latitude NAD83
6 X	m	easting NAD83 UTM zone 6N
7 Y	m	northing NAD83 UTM zone 6N
8 YEAR		YYYYDDD Day of year
9 TIME		Time of day HHMMSS.SS

10 ALTR	m	Radar altitude of bird measured from heli minus 27.74m cable length
11 ALTB	m	Barometric altitude of helicopter
12 ALTG	m	GPS measured orthometric bird height
13 ALTL	m	EM bird altitude from laser altimeter
14 DTM	m	Orthographic corrected terrain elevation ALTG-ALTL
15 CPI400_RAW	ppm	coplanar inphase 378 Hz - raw unprocessed
16 CPQ400_RAW	ppm	coplanar quadrature 378 Hz - raw unprocessed
17 CPI180_RAW	ppm	coplanar inphase 1843 Hz - raw unprocessed
18 CPQ1800_RAW	ppm	coplanar quadrature 1843 Hz - raw unprocessed
19 CXI3300_RAW	ppm	coaxial inphase 3260 Hz - raw unprocessed
20 CXQ3300_RAW	ppm	coaxial quadrature 3260 Hz - raw unprocessed
21 CPI8200_RAW	ppm	coplanar inphase 8180 Hz - raw unprocessed
22 CPQ8200_RAW	ppm	coplanar quadrature 8180 Hz - raw unprocessed
23 CPI40K_RAW	ppm	coplanar inphase 40650 Hz - raw unprocessed
24 CPQ40K_RAW	ppm	coplanar quadrature 40650 Hz - raw unprocessed
25 CPI140K_RAW	ppm	coplanar inphase 128510 Hz - raw unprocessed
26 CPQ140K_RAW	ppm	coplanar quadrature 128510 Hz - raw unprocessed
27 CPI400_LAG	ppm	coplanar inphase 378 Hz - phase, gain, background and lag corrected
28 CPQ400_LAG	ppm	coplanar quadrature 378 Hz - phase, gain, background and lag corrected
29 CPI1800_LAG	ppm	coplanar inphase 1843 Hz - phase, gain, background and lag corrected
30 CPQ1800_LAG	ppm	coplanar quadrature 1843 Hz - phase, gain, background and lag corrected
31 CXI3300_LAG	ppm	coaxial inphase 3260 Hz - phase, gain, background and lag corrected
32 CXQ3300_LAG	ppm	coaxial quadrature 3260 Hz - phase, gain, background and lag corrected
33 CPI8200_LAG	ppm	coplanar inphase 8180 Hz - phase, gain, background and lag corrected
34 CPQ8200_LAG	ppm	coplanar quadrature 8180 Hz - phase, gain, background and lag corrected
35 CPI40K_LAG	ppm	coplanar inphase 40650 Hz - phase, gain, background and lag corrected
36 CPQ40K_LAG	ppm	coplanar quadrature 40650 Hz - phase, gain, background and lag corrected
37 CPI140K_LAG	ppm	coplanar inphase 128510 Hz - phase, gain, background and lag corrected
38 CPQ140K_LAG	ppm	coplanar quadrature 128510 Hz - phase, gain, background and lag corrected
39 CPI400_LLEV	ppm	coplanar inphase 378 Hz - smoothed and leveled
40 CPQ400_LLEV	ppm	coplanar quadrature 378 Hz - smoothed and leveled
41 CPI1800_LLEV	ppm	coplanar inphase 1843 Hz - smoothed and leveled
42 CPQ1800_LLEV	ppm	coplanar quadrature 1843 Hz - smoothed and leveled
43 CXI3300_LLEV	ppm	coaxial inphase 3260 Hz - smoothed and leveled
44 CXQ3300_LLEV	ppm	coaxial quadrature 3260 Hz - smoothed and leveled
45 CPI8200_LLEV	ppm	coplanar inphase 8180 Hz - smoothed and leveled
46 CPQ8200_LLEV	ppm	coplanar quadrature 8180 Hz - smoothed and leveled
47 CPI40K_LLEV	ppm	coplanar inphase 40650 Hz - smoothed and leveled
48 CPQ40K_LLEV	ppm	coplanar quadrature 40650 Hz - smoothed and leveled
49 CPI140K_LLEV	ppm	coplanar inphase 128510 Hz - smoothed and leveled
50 CPQ140K_LLEV	ppm	coplanar quadrature 128510 Hz - smoothed and leveled
51 APRHO400	ohm•m	apparent resistivity - 378 Hz

52 APRHO1800	ohm•m	apparent resistivity - 1843 Hz
53 APRHO8200	ohm•m	apparent resistivity - 8180 kHz
54 APRHO40K	ohm•m	apparent resistivity - 40650 Hz
55 APRHO140K	ohm•m	apparent resistivity - 128510 Hz
56 PSDEP400	m	apparent depth - 378 Hz
57 PSDEP1800	m	apparent depth - 1843 Hz
58 PSDEP8200	m	apparent depth - 8180 Hz
59 PSDEP40K	m	apparent depth - 40650 Hz
60 PSDEP140K	m	apparent depth - 128510 Hz
61 CENTDEP400	m	centroid depth - 378 Hz
62 CENTDEP1800	m	centroid depth - 1843 Hz
63 CENTDEP8200	m	centroid depth - 8180 kHz
64 CENTDEP40K	m	centroid depth - 40650 Hz
65 CENTDEP140K	m	centroid depth - 128510 Hz
66 DIFFRHO400	ohm•m	differential resistivity - 378 Hz
67 DIFFRHO1800	ohm•m	differential resistivity - 1843 Hz
68 DIFFRHO8200	ohm•m	differential resistivity - 8180 kHz
69 DIFFRHO40K	ohm•m	differential resistivity - 40650 Hz
70 DIFFRHO140K	ohm•m	differential resistivity - 128510 Hz
71 DIFFDEP400	m	differential depth - 378 Hz
72 DIFFDEP1800	m	differential depth - 1843 Hz
73 DIFFDEP8200	m	differential depth - 8180 Hz
74 DIFFDEP40K	m	differential depth - 40650 Hz
75 DIFFDEP140K	m	differential depth - 128510 Hz
76 SF		spherics monitor
77 HZ60		60 Hz powerline monitor
78 DIURNAL	nT	Base magnetometer total field magnetics
79 MAGR	nT	Uncorrected total field magnetics
80 MAG	nT	Total field magnetics lagged and corrected for diurnal
81 MAGLEV	nT	Leveled magnetic data
82 MAGIGRF	nT	Leveled and IGRF removed magnetic data
83 GroundProfile		Corresponding ground data profile line number

Fugro GDB Archive Summary

ARC_Yukon_Slines.gdb

# Channel	Units	Description
1 LINE		Line number
2 FLIGHT		flight number
3 FID		fiducial increment

4 LONG	degrees	longitude NAD 83
5 LAT	degrees	latitude NAD83
6 X	m	easting NAD83 UTM zone 6N
7 Y	m	northing NAD83 UTM zone 6N
8 YEAR		YYYYDDD Day of year
9 TIME		Time of day HHMMSS.SS
10 ALTR	m	Radar altitude of bird measured from heli minus 27.74m cable length
11 ALTB	m	Barometric altitude of helicopter
12 ALTG	m	GPS measured orthometric bird height
13 ALTL	m	EM bird altitude from laser altimeter
14 CPI400_RAW	ppm	coplanar inphase 378 Hz - raw unprocessed
15 CPQ400_RAW	ppm	coplanar quadrature 378 Hz - raw unprocessed
16 CPI180_RAW	ppm	coplanar inphase 1843 Hz - raw unprocessed
17 CPQ1800_RAW	ppm	coplanar quadrature 1843 Hz - raw unprocessed
18 CXI3300_RAW	ppm	coaxial inphase 3260 Hz - raw unprocessed
19 CXQ3300_RAW	ppm	coaxial quadrature 3260 Hz - raw unprocessed
20 CPI8200_RAW	ppm	coplanar inphase 8180 Hz - raw unprocessed
21 CPQ8200_RAW	ppm	coplanar quadrature 8180 Hz - raw unprocessed
22 CPI40K_RAW	ppm	coplanar inphase 40650 Hz - raw unprocessed
23 CPQ40K_RAW	ppm	coplanar quadrature 40650 Hz - raw unprocessed
24 CPI140K_RAW	ppm	coplanar inphase 128510 Hz - raw unprocessed
25 CPQ140K_RAW	ppm	coplanar quadrature 128510 Hz - raw unprocessed
26 CPI400_LAG	ppm	coplanar inphase 378 Hz - phase, gain, background and lag corrected
27 CPQ400_LAG	ppm	coplanar quadrature 378 Hz - phase, gain, background and lag corrected
28 CPI1800_LAG	ppm	coplanar inphase 1843 Hz - phase, gain, background and lag corrected
29 CPQ1800_LAG	ppm	coplanar quadrature 1843 Hz - phase, gain, background and lag corrected
30 CXI3300_LAG	ppm	coaxial inphase 3260 Hz - phase, gain, background and lag corrected
31 CXQ3300_LAG	ppm	coaxial quadrature 3260 Hz - phase, gain, background and lag corrected
32 CPI8200_LAG	ppm	coplanar inphase 8180 Hz - phase, gain, background and lag corrected
33 CPQ8200_LAG	ppm	coplanar quadrature 8180 Hz - phase, gain, background and lag corrected
34 CPI40K_LAG	ppm	coplanar inphase 40650 Hz - phase, gain, background and lag corrected
35 CPQ40K_LAG	ppm	coplanar quadrature 40650 Hz - phase, gain, background and lag corrected
36 CPI140K_LAG	ppm	coplanar inphase 128510 Hz - phase, gain, background and lag corrected
37 CPQ140K_LAG	ppm	coplanar quadrature 128510 Hz - phase, gain, background and lag corrected
38 SF		spherics monitor
39 HZ60		60 Hz powerline monitor
40 DIURNAL	nT	Base magnetometer total field magnetics
41 MAGR	nT	Uncorrected total field magnetics

Fugro GDB Archive Summary for Fort Wainwright Data

ARC-Wainwright_Llines.gdb

#	Channel	Units	Description
1	LINE		Line number
2	FLIGHT		flight number
3	FID		fiducial increment
4	LONG	degrees	longitude NAD 83
5	LAT	degrees	latitude NAD83
6	X	m	easting NAD83 UTM zone 6N
7	Y	m	northing NAD83 UTM zone 6N
8	YEAR		YYYYDDD Day of year
9	TIME		Time of day HHMMSS.SS
10	ALTR	m	Radar altitude of bird measured from heli minus 27.74m cable length
11	ALTB	m	Barometric altitude of helicopter
12	ALTG	m	GPS measured orthometric bird height
13	ALTL	m	EM bird altitude from laser altimeter
14	DTM	m	Orthographic corrected terrain elevation ALTG-ALTL
15	CPI400_RAW	ppm	coplanar inphase 378 Hz - raw unprocessed
16	CPQ400_RAW	ppm	coplanar quadrature 378 Hz - raw unprocessed
17	CPI180_RAW	ppm	coplanar inphase 1843 Hz - raw unprocessed
18	CPQ1800_RAW	ppm	coplanar quadrature 1843 Hz - raw unprocessed
19	CXI3300_RAW	ppm	coaxial inphase 3260 Hz - raw unprocessed
20	CXQ3300_RAW	ppm	coaxial quadrature 3260 Hz - raw unprocessed
21	CPI8200_RAW	ppm	coplanar inphase 8180 Hz - raw unprocessed
22	CPQ8200_RAW	ppm	coplanar quadrature 8180 Hz - raw unprocessed
23	CPI40K_RAW	ppm	coplanar inphase 40650 Hz - raw unprocessed
24	CPQ40K_RAW	ppm	coplanar quadrature 40650 Hz - raw unprocessed
25	CPI140K_RAW	ppm	coplanar inphase 128510 Hz - raw unprocessed
26	CPQ140K_RAW	ppm	coplanar quadrature 128510 Hz - raw unprocessed
27	CPI400_LAG	ppm	coplanar inphase 378 Hz - phase, gain, background and lag corrected
28	CPQ400_LAG	ppm	coplanar quadrature 378 Hz - phase, gain, background and lag corrected
29	CPI1800_LAG	ppm	coplanar inphase 1843 Hz - phase, gain, background and lag corrected
30	CPQ1800_LAG	ppm	coplanar quadrature 1843 Hz - phase, gain, background and lag corrected
31	CXI3300_LAG	ppm	coaxial inphase 3260 Hz - phase, gain, background and lag corrected
32	CXQ3300_LAG	ppm	coaxial quadrature 3260 Hz - phase, gain, background and lag corrected
33	CPI8200_LAG	ppm	coplanar inphase 8180 Hz - phase, gain, background and lag corrected
34	CPQ8200_LAG	ppm	coplanar quadrature 8180 Hz - phase, gain, background and lag corrected
35	CPI40K_LAG	ppm	coplanar inphase 40650 Hz - phase, gain, background and lag corrected
36	CPQ40K_LAG	ppm	coplanar quadrature 40650 Hz - phase, gain, background and lag corrected

37 CPI140K_LAG	ppm	coplanar inphase 128510 Hz - phase, gain, background and lag corrected
38 CPQ140K_LAG	ppm	coplanar quadrature 128510 Hz - phase, gain, background and lag corrected
39 CPI400_LLEV	ppm	coplanar inphase 378 Hz - smoothed and leveled
40 CPQ400_LLEV	ppm	coplanar quadrature 378 Hz - smoothed and leveled
41 CPI1800_LLEV	ppm	coplanar inphase 1843 Hz - smoothed and leveled
42 CPQ1800_LLEV	ppm	coplanar quadrature 1843 Hz - smoothed and leveled
43 CXI3300_LLEV	ppm	coaxial inphase 3260 Hz - smoothed and leveled
44 CXQ3300_LLEV	ppm	coaxial quadrature 3260 Hz - smoothed and leveled
45 CPI8200_LLEV	ppm	coplanar inphase 8180 Hz - smoothed and leveled
46 CPQ8200_LLEV	ppm	coplanar quadrature 8180 Hz - smoothed and leveled
47 CPI40K_LLEV	ppm	coplanar inphase 40650 Hz - smoothed and leveled
48 CPQ40K_LLEV	ppm	coplanar quadrature 40650 Hz - smoothed and leveled
49 CPI140K_LLEV	ppm	coplanar inphase 128510 Hz - smoothed and leveled
50 CPQ140K_LLEV	ppm	coplanar quadrature 128510 Hz - smoothed and leveled
51 APRHO400	ohm•m	apparent resistivity - 378 Hz
52 APRHO1800	ohm•m	apparent resistivity - 1843 Hz
53 APRHO8200	ohm•m	apparent resistivity - 8180 kHz
54 APRHO40K	ohm•m	apparent resistivity - 40650 Hz
55 APRHO140K	ohm•m	apparent resistivity - 128510 Hz
56 PSDEP400	m	apparent depth - 378 Hz
57 PSDEP1800	m	apparent depth - 1843 Hz
58 PSDEP8200	m	apparent depth - 8180 Hz
59 PSDEP40K	m	apparent depth - 40650 Hz
60 PSDEP140K	m	apparent depth - 128510 Hz
61 CENTDEP400	m	centroid depth - 378 Hz
62 CENTDEP1800	m	centroid depth - 1843 Hz
63 CENTDEP8200	m	centroid depth - 8180 kHz
64 CENTDEP40K	m	centroid depth - 40650 Hz
65 CENTDEP140K	m	centroid depth - 128510 Hz
66 DIFFRHO400	ohm•m	differential resistivity - 378 Hz
67 DIFFRHO1800	ohm•m	differential resistivity - 1843 Hz
68 DIFFRHO8200	ohm•m	differential resistivity - 8180 kHz
69 DIFFRHO40K	ohm•m	differential resistivity - 40650 Hz
70 DIFFRHO140K	ohm•m	differential resistivity - 128510 Hz
71 DIFFDEP400	m	differential depth - 378 Hz
72 DIFFDEP1800	m	differential depth - 1843 Hz
73 DIFFDEP8200	m	differential depth - 8180 Hz
74 DIFFDEP40K	m	differential depth - 40650 Hz
75 DIFFDEP140K	m	differential depth - 128510 Hz
76 SF		spherics monitor
77 HZ60		60 Hz powerline monitor
78 MAGR	nT	Uncorrected total field magnetics

Fugro GDB Archive Summary

ARC_Wainwright_Slines.gdb

# Channel	Units	Description
1 LINE		Line number
2 FLIGHT		flight number
3 FID		fiducial increment
4 LONG	degrees	longitude NAD 83
5 LAT	degrees	latitude NAD83
6 X	m	easting NAD83 UTM zone 6N
7 Y	m	northing NAD83 UTM zone 6N
8 YEAR		YYYYDDD Day of year
9 TIME		Time of day HHMMSS.SS
10 ALTR	m	Radar altitude of bird measured from heli minus 27.74m cable length
11 ALTB	m	Barometric altitude of helicopter
12 ALTG	m	GPS measured orthometric bird height
13 ALTL	m	EM bird altitude from laser altimeter
14 CPI400_RAW	ppm	coplanar inphase 378 Hz - raw unprocessed
15 CPQ400_RAW	ppm	coplanar quadrature 378 Hz - raw unprocessed
16 CPI180_RAW	ppm	coplanar inphase 1843 Hz - raw unprocessed
17 CPQ1800_RAW	ppm	coplanar quadrature 1843 Hz - raw unprocessed
18 CXI3300_RAW	ppm	coaxial inphase 3260 Hz - raw unprocessed
19 CXQ3300_RAW	ppm	coaxial quadrature 3260 Hz - raw unprocessed
20 CPI8200_RAW	ppm	coplanar inphase 8180 Hz - raw unprocessed
21 CPQ8200_RAW	ppm	coplanar quadrature 8180 Hz - raw unprocessed
22 CPI40K_RAW	ppm	coplanar inphase 40650 Hz - raw unprocessed
23 CPQ40K_RAW	ppm	coplanar quadrature 40650 Hz - raw unprocessed
24 CPI140K_RAW	ppm	coplanar inphase 128510 Hz - raw unprocessed
25 CPQ140K_RAW	ppm	coplanar quadrature 128510 Hz - raw unprocessed
26 CPI400_LAG	ppm	coplanar inphase 378 Hz - phase, gain, background and lag corrected
27 CPQ400_LAG	ppm	coplanar quadrature 378 Hz - phase, gain, background and lag corrected
28 CPI1800_LAG	ppm	coplanar inphase 1843 Hz - phase, gain, background and lag corrected
29 CPQ1800_LAG	ppm	coplanar quadrature 1843 Hz - phase, gain, background and lag corrected
30 CXI3300_LAG	ppm	coaxial inphase 3260 Hz - phase, gain, background and lag corrected
31 CXQ3300_LAG	ppm	coaxial quadrature 3260 Hz - phase, gain, background and lag corrected
32 CPI8200_LAG	ppm	coplanar inphase 8180 Hz - phase, gain, background and lag corrected
33 CPQ8200_LAG	ppm	coplanar quadrature 8180 Hz - phase, gain, background and lag corrected
34 CPI40K_LAG	ppm	coplanar inphase 40650 Hz - phase, gain, background and lag corrected
35 CPQ40K_LAG	ppm	coplanar quadrature 40650 Hz - phase, gain, background and lag corrected
36 CPI140K_LAG	ppm	coplanar inphase 128510 Hz - phase, gain, background and lag corrected

37 CPQ140K_LAG	ppm	coplanar quadrature 128510 Hz - phase, gain, background and lag corrected
38 SF		spherics monitor
39 HZ60		60 Hz powerline monitor
40 MAGR	nT	Uncorrected total field magnetics

Fugro Airborne Surveys Corp.
2505 Meadowvale Boulevard
Mississauga, Ontario
Canada L5N 5S2
Phone +1 905 812 0212
Fax +1 905 812 1504
Website www.fugroairborne.com

Appendix B

System Tests

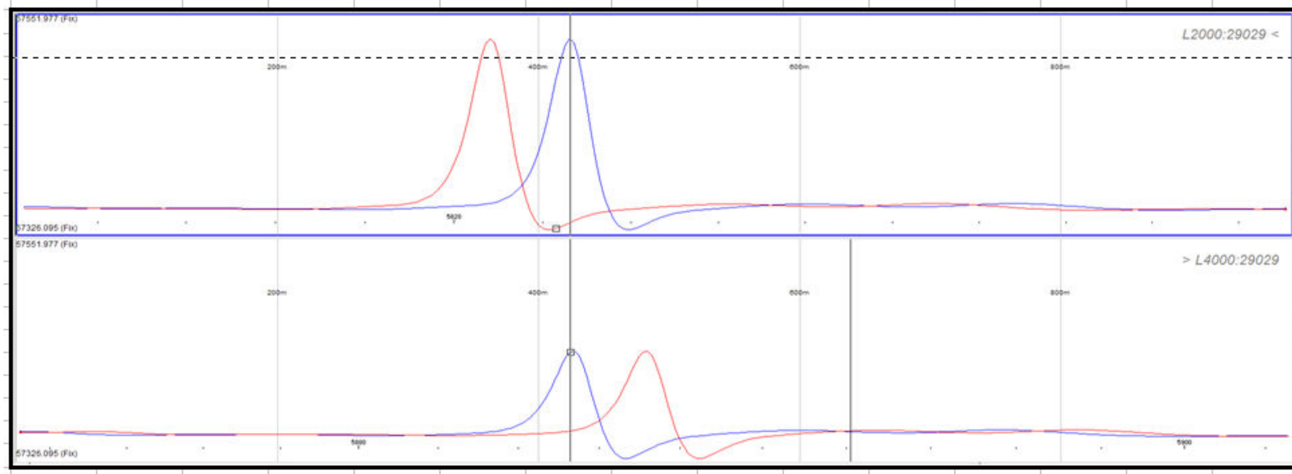
Lag test

LAG TEST

Job Number:	10026	**Survey Type:**	HFEM / MAGNETICS
Date Flown:	9-Jun-10	**Helicopter Registration:**	C-GBDA
Flight Number:	29029	**Database Name:**	100609 - Lag Test.gdb

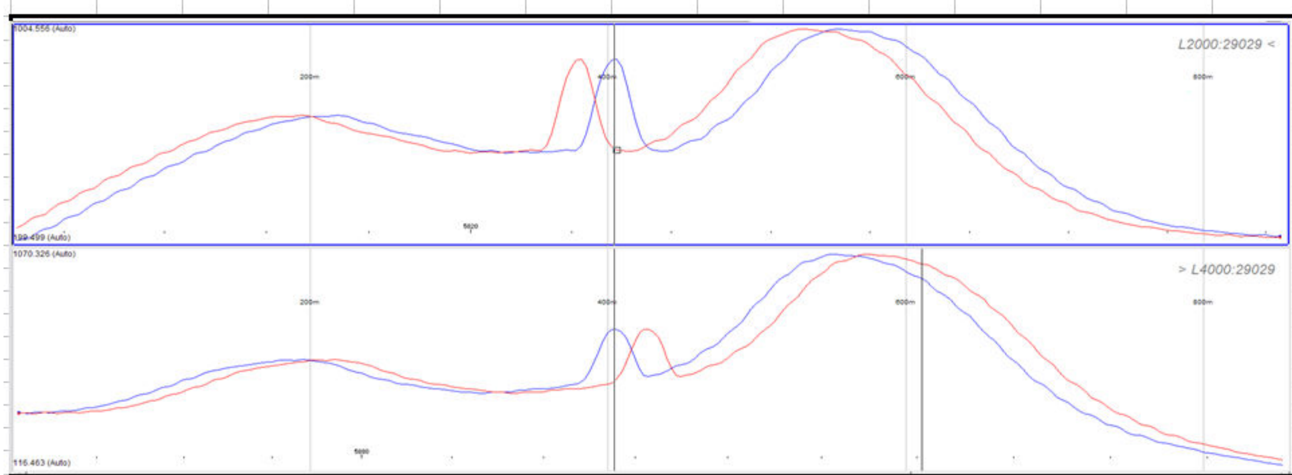
Mag Channel Prior to Applying Lag:	MAG1U
Mag Channel After Applying Lag:	MAG1U_L

Mag Lag Value Applied:	18



EM Channel Prior to Applying Lag:	EM1I
EM Channel After Applying Lag:	EM1I_L

EM Lag Value Applied:	7

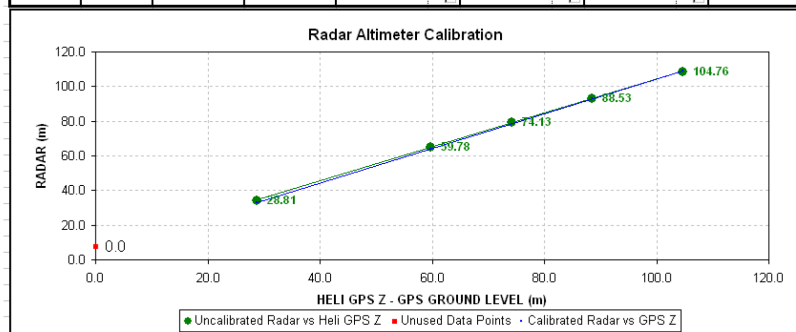


Altimeter test

ALTIMETER CALIBRATION

Job Number:	10026	Survey Type:	HFEM / MAGNETICS	Radar Altimeter:	Honeywell or Sperry RT300 / AT220
Date Flown:	4-Jun-10	Helicopter Reg:	BDA	Laser Altimeter:	Optech ADMGPA100
Flight Number:	29013	Database Name:	Alt Test.gdb	Barometric Pressure Sensor:	Motorola MPX4115AP

LINE	TARGET RADAR (ft)	ZHG_HELI	ZHG_BIRD	ALTRAD_FT	Use Data Point	ALTLASFP_M	Use Data Point	ALTLASLP_M	Use Data Point	ALTBAR_M	Use Data Point	HELI GPS Z MINUS GROUND GPS LEVEL (m)	BIRD GPS Z MINUS GROUND GPS LEVEL (m)	UNCALIBRATED RADAR (m)	CALIBRATED RADAR (m)	BAROMETRIC MINUS GROUND GPS LEVEL (m)
0	0	141.6	138.8	24.5	☐		☑		☑	71.3	☑	0.0	0.0	7.5	5.7	-70.3
100	100	170.4	138.8	112.2	☑		☑		☑	89.4	☑	28.8	0.0	34.2	33.0	-52.2
200	200	201.4	169.6	213.3	☑		☑	31.4	☑	103.1	☑	59.8	30.8	65.0	64.4	-38.6
250	250	215.7	183.9	260.0	☑		☑	46.1	☑	107.7	☑	74.1	45.1	79.3	79.0	-33.9
300	300	230.1	198.3	304.6	☑		☑	60.1	☑	114.3	☑	88.5	59.6	92.8	92.8	-27.3
350	350	246.4	214.4	356.7	☑		☑	76.6	☑	121.7	☑	104.8	75.6	108.7	109.0	-20.0
					☑		☑		☑		☑					
					☑		☑		☑		☑					
					☐		☐		☐		☐					
					☐		☐		☐		☐					
					☐		☐		☐		☐					

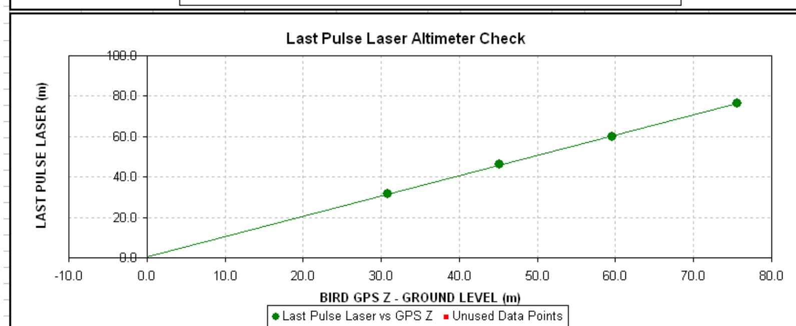


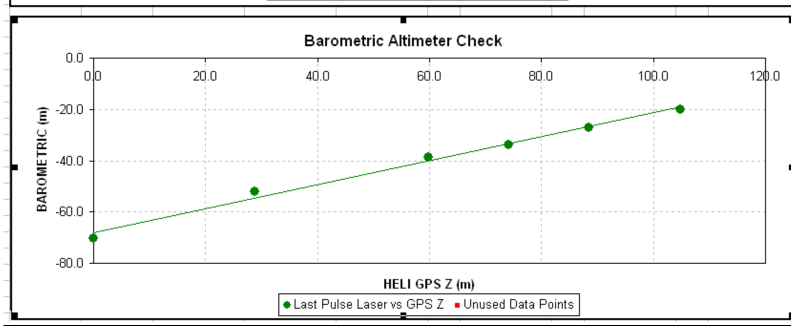
Summary of Radar Altimeter Calibration Test

Scale factor to apply = 1.02
Offset factor to apply = -6.22 m = -20.40 ft

The following equation should be used to calibrate the raw radar altimeter data (Note: ALTRAD_R is in feet and the offset applied, -20.40 is in feet):

ALTRAD_C = 1.02 * ALTRAD_R - 20.40





Appendix C

Flight Logs