

TECHNICAL REPORT ON AN AIRBORNE MAGNETIC SURVEY OF THE LLEWELLYN AREA, BC & YT

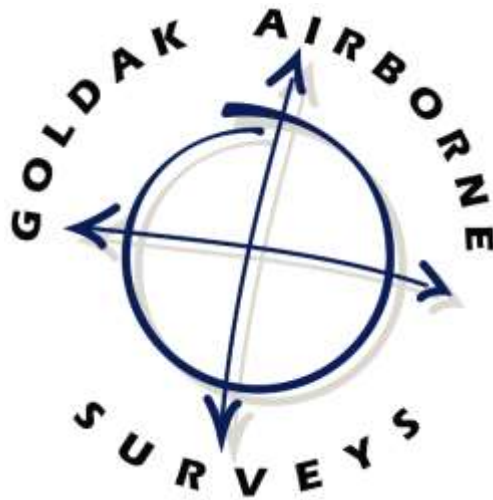
FOR

Geological Survey of Canada

BY

GOLDAK AIRBORNE SURVEYS

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1 INTRODUCTION

This report describes an airborne magnetic survey conducted in the Llewellyn area of BC and YT. This high sensitivity aeromagnetic spectrometric survey was carried out by Goldak Airborne Surveys (Goldak) on behalf of the Geological Survey of Canada (GSC) between March 10 and July 6, 2017.

Aircraft equipment operated included three cesium vapour magnetometers, a GPS/GLONASS real-time and post-corrected differential positioning system, a flight path recovery camera, a digital video titling and recording system, as well as radar and barometric altimeters. All data were recorded digitally in GEDAS binary file format.

Reference ground equipment included two GEM Systems GSM-19W Overhauser magnetometers and a Novatel 12 channel GPS/GLONASS base station which was set up at the base of operations for differential post-flight corrections.

Sixty-four flights (including test and calibration sorties) were required to complete the survey. A total of 32,035 line kilometres of high resolution magnetic collected, processed and compiled.

The traverse lines were flown at a spacing of 400 metres with control lines flown at a separation of 2400 metres. Nominal terrain clearance was specified at 150 metres above ground. The city of Whitehorse, YT was used as the base of operations throughout the entire survey.

All installations and equipment specifications are described in more detail in Section 4 of this report. Daily operational logs were kept and are included as Appendix B of this report.

2 SURVEY AREA LOCATION

The survey block was located in northern British Columbia approximately 160 km south of Whitehorse, YT with the midpoint roughly at 59° 45' N, 134° 45' W. The survey area contained 32,035 line kilometers of data (26,572 km of traverse lines and 5,463 km of control lines).



Figure 1 - Location of the Llewellyn survey area

The survey area was bounded by the following NAD83 geographic coordinates:

Latitude	Longitude
60.335556	-135.500556
60.333333	-134.000000
59.000000	-134.000278
59.000000	-134.398333
59.037222	-134.398056
59.082222	-134.442500
59.128056	-134.480000
59.128056	-134.566111
59.190278	-134.681667
59.247500	-134.702500
59.280278	-134.963056
59.345000	-135.030000
59.362222	-135.015556
59.381944	-135.010556
59.395278	-135.014722
59.422222	-135.066944
59.454722	-135.071111
59.474444	-135.026944
59.563611	-135.027222
59.623056	-135.113333
59.625000	-135.156111
59.663611	-135.214444
59.693611	-135.228611
59.701389	-135.253611
59.811111	-135.504722
60.335556	-135.500556

Table 1 – Llewellyn Survey Area Coordinates

The survey area also contained two zones where control line spacing was adjusted to 400 m, bounded by the following NAD83 geographic coordinates:

Zone 1		Zone 2	
Latitude	Longitude	Latitude	Longitude
60.266667	-134.233333	59.933333	-134.233333
60.266667	-134.000000	59.933333	-134.000000
60.116667	-134.000000	59.833333	-134.000000
60.116667	-134.283333	59.833333	-134.233333

Table 2 - Control line infill zones

3 CONTRACT SPECIFICATIONS

3.1 Line Spacing

Traverse Lines:

- bearing: N45°E
- spacing: 400 metres
- allowed min separation: 300 metres
- allowed max separation: 500 metres
- minimum overfly distance: 1000 metres

Control Lines:

- bearing: N135°E
- nominal spacing: 2400 metres
- minimum overfly distance: 1000 metres

Control Lines (infill zones):

- bearing: N135°E
- nominal spacing: 400 metres
- minimum overfly distance: 1000 metres

3.2 Altitude

Altitude control was accomplished via a smooth drape constructed using STRM elevation data.

Target nominal altitude: 150 m NTC (nominal terrain clearance)

Tolerance: a maximum 30 m difference between traverse lines and control lines. To accomplish this, actual height deviations from the drape surface were not to exceed an envelope of +/- 15 metres at all times.

3.3 Flying Speed

Target ground speed of the aircraft was in the range of 200 km/h and 270 km/h

3.4 Diurnal Specifications

Pulsations having periods of 1 minute or less shall not exceed 3 nT, In addition, micro-pulsations of a period of 15 seconds or less shall not exceed 0.5 nT.

3.5 Magnetic Noise

The magnetic noise was not to exceed 0.1 nT in the 4th digital difference.

All data was fully examined in the field and home office and was deemed to have met the above specifications.

4 AIRCRAFT AND EQUIPMENT

4.1 Aircraft

Type	Piper PA-31 Navajo
Registration	C-GJBB & C-GJBG
Cruise Range	1800 km
Cruising Speed	330 km/h
Typical Survey Speed	270 km/h
Survey Duration	6 hours plus reserve
Max Climb Gradient	13%
Max Descent Gradient	16%
Aviation Fuel	100 LL aviation gasoline
Fuel Consumption	150 litres per hour total
Oil Consumption	0.2 liters per hour total
Long Range Comm	Iridium satellite phone
Typical Figure of Merit	0.8
Tail Stinger	3 m composite
Wingtip Pods	1 m composite
Gradiometer Dimensions	14.783 m lateral / 9.754 m longitudinal

Two identically equipped Piper PA-31 Navajos, registrations C-GJBB and C-GJBG, owned and operated by Goldak Airborne Surveys, were used on this survey. The aircraft magnetometers are installed in the 3-meter stinger attached to the rear fuselage and in the 1-metre composite pods attached to each wing-tip. The attitude sensing fluxgate magnetometer is positioned at the midpoint of the stinger. The three magnetometers form a two-axis gradiometer.

Each aircraft has been extensively modified, both mechanically and electrically, to minimize the effects of maneuvering on the measured magnetic field. This aircraft has typical a Figure of Merit result of less than 0.7 nT as measured to Geological Survey of Canada (GSC) specification.



Figure 2 - Aircraft C-GJBB



Figure 3 - Aircraft C-GJBG

4.2 Airborne Systems

4.2.1 Data Acquisition System

Manufacturer:	Goldak Exploration Technology Ltd.
Type and Model Number:	GEDAS
Sampling Rate:	10 Hz
Data Format:	GEDAS binary

All magnetic and positioning data are processed and recorded digitally by our GEDAS system. The GEDAS is an industrial rack-mount Intel Pentium based PC computer with multiple hard-drives, IO ports and ADAC devices.

The GEDAS system records GNSS navigation records at 1Hz. Magnetic, radar altimeter and barometric altimeter data are recorded at 10 Hz. All data is tightly synchronized to GPS time with an accuracy of ± 1 millisecond. Each data packet, on arrival to the data system is stamped with a system time with a resolution of 1 millisecond. Data files are organized on a flight-by-flight basis in a proprietary binary format. The data can then imported directly into Geosoft® via a custom import routine.

4.2.2 Magnetometers and Compensation

Aircraft Magnetometers:

Manufacturer:	Geometrics
Type and Model Number:	Cesium G-822A
Range in nT:	20,000 to 90,000
Sensitivity in nT:	0.005
Sampling Rate:	10 Hz

Real-time Magnetic Compensator:

Manufacturer:	RMS Instruments
Type and Model Number:	AADCII or AARC
Range in nT:	20,000 to 100,000
Resolution in nT:	0.001
Sampling Rate:	20Hz

The airborne magnetometers used are a matched set of Geometrics G-822A optically pumped cesium vapour types with sensitivity of 0.005 nT. The magnetometer's Larmor signal is decoupled and counted by a RMS Instruments AADCII compensator, and data are produced at a rate of 10 Hz with a resolution of 0.001 nT. The data bandwidth is from 0 to 0.9 Hz with an internal noise level of less than 0.002 nT.

Compensation mathematically "corrects" the magnetic data for noise due to aircraft motion and heading. Prior to the survey, the aircraft is taken to an area of low magnetic gradient at a high altitude (7000' AGL +) and put through a series of rolls, pitches and yaws on each of the survey's cardinal headings. The data collected from these maneuvers can then be used to form a model of the aircraft's magnetic characteristics without the near influence of the local geology.

The remaining magnetic distortion is quantified by a term known as the Figure of Merit, or FOM. The Geological Survey of Canada uses a figure of merit of 1.5 or less as standard survey criteria.

Three compensation flights were completed over the course of the survey. The results of these flights are posted in Appendix A.

4.2.3 GNSS Positioning and Navigation

Navigation System:

Manufacturer	Goldak Exploration Technology Ltd.
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Type and Model Number	GENAV
Displays	10" Color LCD data display 3D Autodrape LCD pilot display

GNSS Receiver:

Manufacturer	Novatel
Type and Model Number:	OEMV dual-frequency ProPakV3 (x3)
System Resolution:	<1 meter
Overall accuracy:	3 m in real-time, <1m post-corrected
Number Channels:	120
Signal Tracking:	GPS L1, L2, L2C, L5 GLONASS L1, L2 Galileo E1, E5

The GNSS receiver in the survey aircraft was a GPS and GLONASS capable Novatel OEMV ProPakV3 12 channel dual-frequency differential unit that communicates directly with the GEDAS system. This unit is used for navigation purposes and also logs data for post-flight differential corrections.

GNSS signals can be affected by atmospheric and ionospheric effects which typically reduce the accuracy of the non-differential positioning to approximately 10 metres RMS. If a suitable stationary GPS receiver, on a known or assumed position, is used to record the apparent errors in the satellite range data, those errors can be used to correct the moving receiver in the aircraft to an accuracy of 1 meter RMS. This compensation process is called differential correction and can be applied to the moving receiver in real time for higher dynamic accuracy, or applied later to find out where the aircraft was with high accuracy. These are called real-time and post-corrected differential positioning respectively.

4.2.4 Radar Altimeters

Radar Altimeter 1:

Manufacturer	Thompson
Type and Model Number:	CFS 530A
Range:	0-8000 feet
Resolution:	1 meter
Accuracy:	2%

Radar Altimeter 2:

Manufacturer	Terra
Type and Model Number:	TRA3000 – TRI40
Range:	40-2500 feet
Resolution:	3 metres
Accuracy:	5-7%

4.2.5 Barometric Altimeter

Manufacturer:	Setra
Type and Model Number:	270
Range:	-1000 to 10,000 feet
Resolution:	1 meter

4.2.6 Visual Flight Path Recovery

Flight Path Camera:

Manufacturer:	Panasonic
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Model: GPKR402 HRSV
Lens: WV-LR4R5 4.5mm
Field of view at 300m AGL 317 x 396m

Video Titler:

Manufacturer: Horita
Model: SCT-50
Type: video overlay with 10Hz clock

Digital Video Recorder:

Manufacturer: Toronto Micro-Electronics
Model: MDVR301
Type: digital MPEG

The flight path was captured by a Panasonic GP-KR402 HRSV hi-resolution color video camera located in the lower rear fuselage of each aircraft. The video was recorded to a removable hard drive by a Toronto Micro Systems MDVR digital recorder, and then burned to dual layer DVD post flight.

4.3 Ground Systems

4.3.1 Magnetic Base Stations

Base Station Magnetometers:

Manufacturer: GEM Systems
Type and Model Number: Overhauser GSM-19W
Range in nT: 20,000 to 120,000
Sensitivity in nT: 0.01
Sampling Rate: 1 Hz (5 Hz maximum)

Base Station Data Loggers:

Manufacturer: Acumen
Type and Model Number: Data Bridge SDR-CF Serial Data Recorder
Media Type: Compact Flash



Figure 4 - Base Magnetometer Installation

For this survey two magnetic base stations were installed. Multiple stations are useful both as a hardware back up and to discern any cultural effects from either unit. In both installations the base station employed was a GEM Systems GSM19W Overhauser type proton precession magnetometer with GPS time base. Each setup was configured to log data both internally and externally to a compact flash card using an Acumen DataBridge SDR serial data recorder. The station closest to the base of operations was also equipped with a VHF radio link to the processing office so that diurnal conditions could be monitored in real time. Station BaseMag 1, which included the VHF radio link, was installed in a wooded area approximately 750 m from the Town and Mountain Hotel, Whitehorse. Station BaseMag 2 was installed near a quarry approximately 26 km outside of Whitehorse. The installation details are as follows:

Station	Latitude	Longitude	Elevation	Reference Value
BaseMag 1	60°43'25.2"	-135°02'48.7"	633 m	56400 nT
BaseMag 2	60°32'43.3"	-134°52'28.5"	758 m	56600 nT

Table 3 - Base Magnetometer Stations

4.3.2 GNSS Base Station

Base GNSS Receiver:

Manufacturer	Novatel
Type and Model Number:	OEMV dual-frequency ProPakV3 (x1)
System Resolution:	<1 meter
Overall accuracy:	3 m in real-time, <1m post-corrected

Number Channels: 120
 Signal Tracking: GPS L1, L2, L2C, L5
 GLONASS L1, L2
 Galileo E1, E5

The base station receiver unit, like the airborne units, was a GPS and GLONASS capable Novatel OEMV ProPakV3 whose data were logged by a battery-powered, industrial portable computer. A survey-grade GNSS base antenna designed to minimize multi-path errors was set up on the roof of the Town and Mountain Hotel, Whitehorse. The precise position of the antenna was determined by collecting 9 hours of data then submitting the data to the NRCan's online Precise Point Positioning (PPP) service. The following WGS84 coordinate was delivered:

Latitude	60°43'6.972"
Longitude	-135°03'22.6803"
Ellipsoidal Height	654.66 m

Table 4 - Base GNSS Position



Figure 5 - Base GNSS Antenna Installation

4.4 Field Office Systems

4.4.1 Field Data Verification, Logging and Plotting

Processing Computer:

Manufacturer: Lenovo
Type and Model Number: ThinkCentre / Intel i5 3.4 GHz

Data Logging Computers:

Manufacturer: Lenovo
Type and Model Number: ThinkPad / Intel i5 3.4 GHz

Plotters and Printers:

Manufacturer: Canon
Type and Model Number: Inkjet

Data backup:

Manufacturer: Sony
Type and Model Number: DVD+-R / CDRW
Manufacturer: Western Digital
Type and Model Number: 1.5 TB external HDD

4.4.2 Software

Manufacturer: Geosoft®
Function: Geophysical data processing
Type and Model Number: Oasis Montaj v 7.2

Manufacturer: Waypoint Consulting
Function: GPS post-processing
Type and Model Number: GrafNav v 8.50

Manufacturer: MatLab
Function: Geophysical data processing
Type and Model Number: 2015b

Manufacturer: Scott Hogg & Associates
Function: Offline Magnetic Compensation
Type and Model Number: CompCal v 1.1

5 PERSONNEL

The following Goldak personnel were involved in the Llewellyn project:

Ben Goldak	President / CEO / General manager
Glen Carson	Data processor / Map production
Brenda Doherty	Office administration / Finance
Daniel Leppington	Aircraft engineer
Jay Mathieson	Pilot
Dustin Biesenthal	Co-pilot
Rick Smith	Pilot
Mike Heit	Co-pilot:
Bill Heath	Field data processor

Table 5 - Project Personnel

6 DATA PROCESSING

6.1 Positioning Data and Altitude Data

Processing of the positioning data takes place in the field and is performed on a post-flight basis. The following procedures are included in positioning and altitude data processing:

1. The raw airborne GPS data are corrected using the corresponding GPS base station data and NovAtel® Inc.'s Waypoint® GrafNav® GNSS Post-Processing software suite.
2. The corrected GPS World Geodetic System 1984 (WGS84) longitude, latitude and altitude are merged into a Geosoft® database with aircraft flight data and re-projected to the local UTM Zone 8 NAD83 datum. Velocity is then calculated from the corrected positions. Corrected UTM co-ordinates are trimmed.
3. The primary radar altimeter data is lagged by 0.9 seconds and the secondary radar altimeter data is lagged by 3.0 seconds.
4. The digital elevation model is calculated by subtracting the radar altimeter data from the GPS altitude data.
5. Quality-control procedures described in section 7.2 are performed.

6.2 Magnetic Data

6.2.1 Initial Field Processing

Processing of the magnetic data begins in the field where the raw magnetic, positioning and altitude data from the aircraft acquisition systems is first imported into a Geosoft® Oasis montaj™ database on a line basis. The magnetic base station data, logged during the corresponding flight time, were then merged with the flight data for display and quality control checks.

1. A system latency correction, determined from the pre-survey lag test of 0.4 seconds for the tail magnetometer data and 0.3 seconds for the wing-tip magnetometer data, is then applied.
2. A diurnal correction derived from the local magnetic base station data is applied to account for temporal variations in the total magnetic field.
3. Quality-control procedures described in section 7.2 are performed.

6.2.2 Filtering

High frequency noise that was induced by aircraft movement and not removed through the magnetic compensation process, generally less than 2 seconds in wavelength and 0.1 nT in amplitude, was removed by generating a correction profile from a combination of high-pass and low-pass filters of the total field data for each sensor. This correction profile was then in-turn subtracted from the total field data

6.2.3 Height Correction

The height correction was accomplished by upward and downward continuation of the magnetic data (MAGHFCOR) at the original altitude (GPSALT) on a smooth drape (SURFACE) along the traverse lines and tie lines by using a Taylor series method (see Pilkington and Boulanger, Geophysics, vol 82., 2017, page J12). To the first order, this altitude correction (ALTCOR) is the difference between the altitude and the drape ($\text{drapeZ} = \text{GPSALT} - \text{SURFACE}$) multiplied by the first vertical derivative (VG1): $\text{ALTCOR} = \text{drapeZ} * \text{VG1}$. The altitude correction ALTCOR was calculated at the second order with the first and second vertical derivatives (VG1 and VG2) using the GX developed by Regis Dumont (Taylor.GX).

6.2.4 Control-Line Levelling

The intention of control-line levelling is to apply a smoothly-varying function to the measured data, which results in nearly identical values at the intersections of traverse and control lines. The most significant component of the correction is to accommodate the diurnal variation of the magnetic field. Other sources of error are altitude errors, GPS positioning errors and system drift.

Levelling of the total field data consists of the following steps:

1. Calculation of the positions of the survey-line–control-line intersection points and the extraction of mismatch values of the magnetic data between the line and control lines at these points.
2. An iterative application of corrections, based of best-fit, first-order linear trends of mismatch values (with outliers removed), on the traverse and control lines until the resulting corrections approach zero.
3. An iterative application of long-wavelength corrections on traverse and control lines determined by applying median and low-pass filters to the remaining intersection mismatches (with outliers removed) and then using Akima spline interpolation between the now-filtered intersection mismatch values. This enhances and isolates correction “features” that span several intersections. The lengths of the filters are based on the traverse-line–control-line intersection separations. In this case, the initial filter lengths spanned 10 control-line intersections on survey lines and 50 survey-line intersections on control lines. The number of intersections spanned is reduced in increments to an appropriate minimum until the correction approaches zero.
4. Manual inspection of the remaining intersection mismatches and reducing it to zero (where appropriate) by applying the necessary corrections to either the survey or tie lines. Special attention is paid to ensuring that the overall correction profiles are as smooth as possible and that there is no line-to-line correlation in the correction profiles, which implies a misapplied correction.
5. Construction of pseudo-tie lines to generate an intra-tie-line correction profile that is then added to the total correction profile.
6. The second vertical derivative of the total field grid is analyzed to ensure that the corrections are sufficient and appropriate. Features that appear along the survey lines in the second vertical derivative may be the result of over-correction or under-correction. In either case, the solution is to revise the correction profile at those intersections.

6.2.5 Calculation and Removal of the International Geomagnetic Reference Field

The International Geomagnetic Reference Field (IGRF) was calculated using the 2015 model year with a constant date of May 8, 2017 (roughly the mid-point of the survey) as the reference date. A constant altitude of 1950 m, the mean altitude over the course of the survey, was specified as the elevation. This value was subtracted from the tie-line levelled data to obtain the residual magnetic field data.

6.2.6 Calculation of the Vertical Derivative Grid

The first vertical derivative grid was calculated directly from the gradient-enhanced residual magnetic intensity grid using the Geosoft MagMap grid processing suite.

7 QUALITY CONTROL

7.1 Tests and Calibrations

The full results of the tests and calibrations described below can be found in Appendix A.

a) Compensation Figure of Merit

Aircraft movements induce spurious magnetic fields, which are removed from the magnetic data by the compensator. The efficiency of this removal can be evaluated by conducting a test called a Figure of Merit (FOM). The aircraft flies a series of 3 manoeuvres of $\pm 10^\circ$ rolls, $\pm 5^\circ$ pitches and $\pm 5^\circ$ yaws in each of the traverse- and control-line directions in a magnetically quiet zone (low magnetic gradient). The peak-to-peak amplitudes of the responses obtained on the magnetometer compensated channel are determined for each of the 3 manoeuvre types and for each of the 4 directions. The 12 values are then summed giving the Figure of Merit.

Compensation figure of merit tests were performed by both aircraft after their initial arrival on site and before survey operations commenced. In addition, the calibration and tests were repeated after any significant change to the aircraft or its systems which may have altered its magnetic properties.

In all calibration and subsequent tests performed by the aircraft, the resultant figures of merit for the tail and wing-tip sensors were below the specified threshold of 1.5 nT.

b) Heading Test

To verify system accuracy and acceptable heading error a heading test was performed over the GSC Meanook calibration range. The aircraft performed 3 passes in each cardinal direction directly over a predefined point and the aircraft measured total field was compared between opposing passes.

For all tests performed the calculated heading errors were minimal.

c) Lag Test

To verify the magnetic system latency, the survey aircraft conducted lag tests. These tests involve flying multiple passes in each of the 4 cardinal headings over a known magnetic feature and comparing the position of the observed magnetic peaks with the known position of the target.

The aircraft flew this test over a tower located 22 km southwest of Saskatoon, Saskatchewan prior to survey commencement.

The calculated system latencies from this tests were determined to be consistent with previous tests performed by this aircraft.

d) Radar Altimeter Calibration

The radar altimeter calibration and verification were performed by acquiring altitude data from several passes of increasing altitude over the runway at the Saskatoon airport. The radar altimeters of both aircraft were confirmed to have a linear relationship with and within acceptable range of the GPS height.

7.2 Daily Field Quality Control

a) Positioning Data

In a Geosoft® Oasis montaj™ database, the corrected GPS data are inspected for gaps and positioning error as indicated by anomalous velocity changes or vertical offsets. The real-time positions are compared to the post-corrected positions for integrity check.

Flight path is examined to detect horizontal deviations that exceed tolerances. Computed velocity is inspected and confirmed to be within tolerances.

The radar altimeter and barometric altimeter data are inspected for anomalous conditions. The computed digital elevation model is compared against known topographical data. Vertical navigation is checked for deviations from the pre-determined flight surface that exceed tolerances.

b) Magnetic Data

Goldak Airborne Surveys' data acquisition system is designed to allow the second pilot to monitor data quality at all times. Both pilots have been trained to operate the equipment and recognize data problems. Automated systems are also in place to draw their attention to anomalous conditions. In addition, the field processor is continually monitoring the magnetic base station via radio link to be on the alert for poor diurnal conditions. The field processor maintains scheduled communication with the aircraft for flight-following purposes and to update the flight crew on weather and diurnal conditions.

After a survey flight, the magnetic and measured gradient data are inspected on a line-by-line basis for gaps, spikes and other anomalous conditions. Magnetic noise levels are monitored using the fourth digital difference and visually. The magnetic base station data are examined for deviations that exceed the contract stated peak-to-peak magnitude and chord lengths. Reflights are assigned where necessary.

A frequency domain plot of the uncompensated and compensated magnetic data is generated through fast Fourier transform on a line-by-line basis and inspected. Through this, the general ongoing performance of the magnetic compensation can be evaluated and any aircraft system-induced magnetic noise can be easily discerned.

Grids of the total field and vertical derivative data, along with flight path plots, are examined daily to visually compare the correlation of data between lines and across flights.

7.3 Quality Control in the Home Office

a) Review of field processed data

At the home office, the results of the field processing are reviewed at regular intervals throughout the survey and following completion.

b) Review of the final processed data

The results of the levelling of the magnetic data are reviewed on a line-by-line basis through inspection of the total correction profile and intersection mismatch values. Final grid products are visually and statistically inspected for overall quality and validity.

8 FINAL PRODUCTS

8.1 Digital Profile Data

A database containing the magnetic profile data was delivered in Geosoft® .GDB format. The fields included are as follows:

Channel Name	Description	Format	Units	Sample Rate
LINE	Line number	I6	-	0.1
TIME	UTC time (seconds after midnight)	F8.1	sec	0.1
FIDCOUNT	Acquisition System time increment	F7.1	sec	
LONG	Longitude (WGS84)	F12.6	deg	0.1
LAT	Latitude (WGS84)	F10.6	deg	0.1
EASTING	Easting (NAD83, UTM zone 8N)	F10.2	m	0.1
NORTHING	Northing (NAD83, UTM zone 8N)	F11.2	m	0.1
SURFACE	Ideal Surface altitude (drape)	F8.2	m	0.1
RALTRAW	Raw Primary Radar Altimeter, before corrections	F8.2	m	0.1
RALT	Final Radar Altimeter, lagged, with corrections	F8.2	m	0.1
BALTRAW	Raw Barometric altimeter not corrected for drift and lag	F8.2	m	0.1
BALT	Barometric altimeter corrected for drift and lag	F8.2	m	0.1
GPSALTR	Uncorrected GPS Altitude (real-time)	F8.2	m	0.1
GPSALT	Differentially Corrected GPS Altitude	F8.2	m	0.1
DEMRAW	Raw digital Elevation Model (GPSALT - RALT - 3.5)	F8.2	m	0.1
DEMLEV	Levelled digital Elevation Model	F8.2	m	0.1
MAGUNCOM	Raw uncompensated, unlagged Lower Tail Mag	F9.2	nT	0.1
MAGCOM	Raw compensated, unlagged Lower Tail Mag	F9.2	nT	0.1
MAGRAW	Raw compensated, lagged Lower Tail Mag	F9.2	nT	0.1
MAGHFCOR	High-frequency noise removal correction to Mag	F8.4	nT	0.1
ALTCOR	Altitude correction to Mag	F7.2	nT	0.1
DIURNRAW	Raw Basemag1	F9.2	nT	0.1
DIUR2RAW	Raw Basemag2	F9.2	nT	0.1
DIURNAL	Basemag1	F9.2	nT	0.1
DIURNAL2	Basemag2	F9.2	nT	0.1
MAGTLCOR	Tie-line levelling corrections to Mag	F7.2	nT	0.1
SRVMGLEV	Final tie-line levelled mag	F9.2	nT	0.1
IGRF	IGRF correction calculated at altitude of 1950 m, date: 2017.35	F9.2	nT	0.1
SRVMGRES	Levelled residual magnetic field	F9.2	nT	0.1
FLUXLONG	Longitudinal Vector Mag (fluxgate)	F10.2	nT	0.1
FLUXTRAN	Transverse Vector Mag (fluxgate)	F10.2	nT	0.1
FLUXVERT	Vertical Vector Mag (fluxgate)	F10.2	nT	0.1
PITCH	Aircraft pitch (nose up +ve)	F7.2	deg	0.1
ROLL	Aircraft roll (left wing up +ve)	F7.2	deg	0.1
AZIMUTH	Aircraft heading	F7.2	deg	0.1
AIRCRAFT	Aircraft registration number	A4	-	0.1
DATE	Local date (YYYYMMDD)	I9	-	0.1
FLIGHT	Flight number	I3	-	
LINETYPE	Line type (L=traverse Line, T=Tie)	A2	-	
LINENAME	Line name (Line type + Line number)	A7	-	

$$\text{SRVMGLEV} = \text{MAGRAW} + \text{ALTCOR} - \text{MAGHFCOR} - \text{MAGTLCOR}$$

Table 6 - Final Magnetic Database Channels

8.2 Maps

1:100,000 scale, UTM Zone 8N, NAD83 datum maps were delivered digitally in Geosoft .MAP and Adobe .PDF formats.

Six map sheets were produced with the following themes and open file reference:

GSC Open File	BCGS / YGS Open File	Grid Layer	Vector Layers
8287	2017-2 Sheet 1 of 2	Residual total magnetic field	Magnetic contours & topographic base
8288	2017-4 Sheet 1 of 2	Residual total magnetic field	Magnetic contours & topographic base
8289	2017-61	Residual total magnetic field	Magnetic contours & topographic base
8290	2017-2 Sheet 2 of 2	First vertical derivative of the magnetic field	Flight path & topographic base
8291	2017-4 Sheet 2 of 2	First vertical derivative of the magnetic field	Flight path & topographic base
8292	2017-62	First vertical derivative of the magnetic field	Flight path & topographic base

Table 7 - Final 1:100,000 Scale Maps

8.3 Gridded Data

Grids in UTM Zone 8N, NAD83 datum coordinates of the following data were delivered in Geosoft .GRD format:

Data	Grid Name	Cell Size
Residual total magnetic field	SRVMGRES	100
Total magnetic field	SRVMGLEV	100
First vertical derivative of the magnetic field	SRVMGRES_VG1	100
Second vertical derivative of the magnetic field	SRVMGRES_VG2	100
Levelled digital topography	DEMLEV	100

Table 8 - Final Grids

8.4 Flight Path Video

Flight path video for this survey was supplied on external HDD, archived by flight, in a proprietary format. Software required to view the video is included on each disc. Times, positions, direction and speed are overlain on the tape for detailed flight path recovery if required.

9 STATEMENT OF ASSURANCE

I, Ben Goldak of the city of Saskatoon, Saskatchewan, certify that:

I am President of Goldak Airborne Surveys Ltd.

I hold a B.Sc. Adv. in Computer Science from the University of Saskatchewan.

I have been active in the field of geophysics since 1980.

I have supervised the work referred to in this report and find it was performed with regards to best practices in the industry.

All final data were of high quality, adhered to contract specifications, and final products were delivered as required by NRCan.



Ben Goldak

President

Goldak Airborne Surveys

September, 2017

Date

APPENDIX A – TEST AND CALIBRATION RESULTS

A.1 Compensation Figures of Merit

Compensation / Figure of Merit Test Analysis

Project	Llewellyn
Flight	10
Aircraft	C-GJBB
Date	2017-03-04
Julian Day	63

Pilot	Mathieson
Copilot	Heit
Processor	Heath

Test Summary

MB FOM	0.94

Test Location	Whitehorse
Reason for Comp / FOM	Project Start

Air Time	1.2
Test Time	0.4
Ferry Time	0.8

RMS ADCII Compensator Statistics

	Uncomp Std Dev	Comp Std Dev	IR	Solution Norm
Left Wing M1	1.95E+00	4.23E-02	46	55.3
Right Wing M2	2.10E+00	4.31E-02	48.7	55.8
Tail Top M3				
Tail Lower M4	2.55E-01	2.11E-02	12.1	14.7
Lateral Grad G1	2.53E+00	1.05E-01	24.1	38.5
Long Grad G2	1.01E+01	9.00E-01	112.6	64.6
Vert Grad G3				
Memory Slot	13			

FOM Analysis

Bottom Tail Magnetometer (MBc)					
	North	East	South	West	Sum
Pitch	0.1	0.11	0.09	0.08	0.38
Roll	0.09	0.08	0.04	0.04	0.25
Yaw	0.06	0.09	0.09	0.07	0.31
Sum	0.25	0.28	0.22	0.19	0.94

Table 9 - C-GJBB Initial Compensation Figure of Merit

Compensation / Figure of Merit Test Analysis

Project	Llewellyn
Flight	9
Aircraft	C-GJBG
Date	2017-03-04
Julian Day	63

Pilot	Mathieson
Copilot	Heit
Processor	Heath

Test Summary

MB FOM	0.62

Test Location	Whitehorse
Reason for Comp / FOM	Project Start

Air Time	1.4
Test Time	0.6
Ferry Time	0.8

RMS AACII Compensator Statistics

	Uncomp Std Dev	Comp Std Dev	IR	Solution Norm
Left Wing M1	1.41E+00	3.48E-02	41.4	44.7
Right Wing M2	8.44E-01	2.18E-02	38.8	40.2
Tail Top M3				
Tail Lower M4	1.34E-01	1.57E-02	8.5	14.4
Lateral Grad G1	1.03E+00	1.11E-01	92.7	67.1
Long Grad G2	3.36E+00	5.38E-02	62.5	33.9
Vert Grad G3				
Memory Slot	10			

FOM Analysis

Bottom Tail Magnetometer (MBc)					
	North	East	South	West	Sum
Pitch	0.08	0.1	0.08	0.08	0.34
Roll	0.02	0.02	0.02	0.04	0.10
Yaw	0.05	0.04	0.05	0.04	0.18
Sum	0.15	0.16	0.15	0.16	0.62

Table 10 - C-GJBG Initial Compensation Figure of Merit

Compensation / Figure of Merit Test Analysis

Project	Llewellyn
Flight	48
Aircraft	C-GJBB
Date	2017-05-02
Julian Day	122

Pilot	Mathieson
Copilot	Smith
Processor	Heath

Test Summary

MB FOM	0.6

Test Location	Whitehorse
Reason for Comp / FOM	update solution

Air Time	1.3
Test Time	0.5
Ferry Time	0.8

RMS AACII Compensator Statistics

	Uncomp Std Dev	Comp Std Dev	IR	Solution Norm
Left Wing M1	1.74E+00	3.08E-02	56.6	45
Right Wing M2	2.15E+00	3.66E-02	58.7	56.7
Tail Lower M3	2.76E-01	1.44E-02	19.2	15.6
Tail Top M4				
Lateral Grad G1	3.55E+00	7.30E-02	48.6	41.4
Long Grad G2	9.65E+00	8.55E-01	112.9	64.2
Vert Grad G3				
Memory Slot	2			

FOM Analysis

Bottom Tail Magnetometer (MBc)					
	North	East	South	West	Sum
Pitch	0.09	0.08	0.07	0.07	0.31
Roll	0.04	0.02	0.03	0.02	0.11
Yaw	0.05	0.04	0.06	0.03	0.18
Sum	0.18	0.14	0.16	0.12	0.60

Table 11 - C-GJBB Updated Compensation Figure of Merit

Compensation / Figure of Merit Test Analysis

Project	Llewellyn
Flight	52
Aircraft	C-GJBG
Date	2017-05-07
Julian Day	127

Pilot	Mathieson
Copilot	Smith
Processor	Heath

Test Summary

MB FOM	0.62

Test Location	Whitehorse
Reason for Comp / FOM	update solution

Air Time	1.2
Test Time	0.4
Ferry Time	0.8

RMS AACII Compensator Statistics

	Uncomp Std Dev	Comp Std Dev	IR	Solution Norm
Left Wing M1	1.31E+00	3.27E-02	40.1	42.2
Right Wing M2	9.26E-01	2.60E-02	35.6	41.7
Tail Top M3				
Tail Lower M4	1.602.1	1.46E-02	11	14.9
Lateral Grad G1	8.75E+00	9.70E-02	90.2	63
Long Grad G2	3.65E+00	5.60E+00	65.2	34.4
Vert Grad G3				
Memory Slot	11			

FOM Analysis

Bottom Tail Magnetometer (MBc)					
	North	East	South	West	Sum
Pitch	0.05	0.11	0.09	0.07	0.32
Roll	0.02	0.07	0.03	0.03	0.15
Yaw	0.04	0.03	0.06	0.02	0.15
Sum	0.11	0.21	0.18	0.12	0.62

Table 12 - C-GJBG Updated Compensation Figure of Merit

A.2 Radar Altimeter Calibrations

Radar Altimeter Calibration Analysis

Project	Llewellyn
Flight	5
Aircraft	C-GJBB
Date	2017-02-23
Julian Day	54

Pilot	Mathieson
Copilot	Heit
Processor	Heath

Radar Stack Summary

Runway Height	501.5
Tail Height	3.5

Test Location	
Radar 1 Type	Thompson-CFS ERT160
Radar 2 Type	Terra TRA-30

Radar 1 Scale Factor	1.000
Radar 2 Scale Factor	1.025

Radar Stack Analysis

PASS (ft)	GPSAlt	RAIt 1	RAIt 2	Hgt AGL	RAIt 1 Scale	RAIt 2 Scale
1	642.84	136.97	135.15	137.84	1.006	1.020
2	944.82	440.3	426.57	439.82	0.999	1.031
3	1252.42	748.83		747.42	0.998	
4	1546.1	1043.73		1041.1	0.997	
5	1853.61	1352.2		1348.61	0.997	

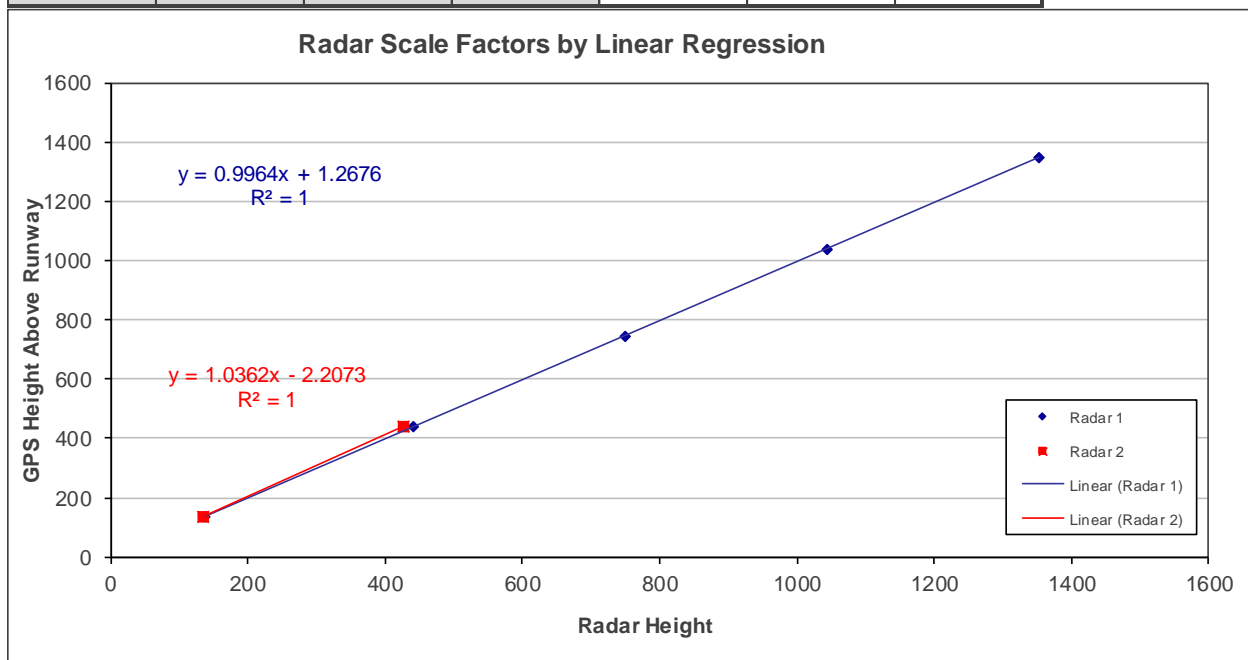


Table 13 - C-GJBB Radar Altimeter Calibration

Radar Altimeter Calibration Analysis

Project	Llewellyn
Flight	2
Aircraft	C-GJBG
Date	2017-02-23
Julian Day	54

Pilot	Mathieson
Copilot	Heit
Processor	Heath

Radar Stack Summary

Runway Height	501.5
Tail Height	3.5

Test Location	Saskatoon 15/33
Radar 1 Type	Thompson-CFS ERT160
Radar 2 Type	Terra TRA-30

Radar 1 Scale Factor	1.003
Radar 2 Scale Factor	1.026

Radar Stack Analysis

PASS (ft)	GPSAlt	RAIt 1	RAIt 2	Hgt AGL	RAIt 1 Scale	RAIt 2 Scale
1	629.25	122.77	120.28	124.25	1.012	1.033
2	951.08	445.22	436.98	446.08	1.002	1.021
3	1254.61	749.17	730.99	749.61	1.001	1.025
4	1550.07	1044.62		1045.07	1.000	
5	1854.62	1350.37		1349.62	0.999	

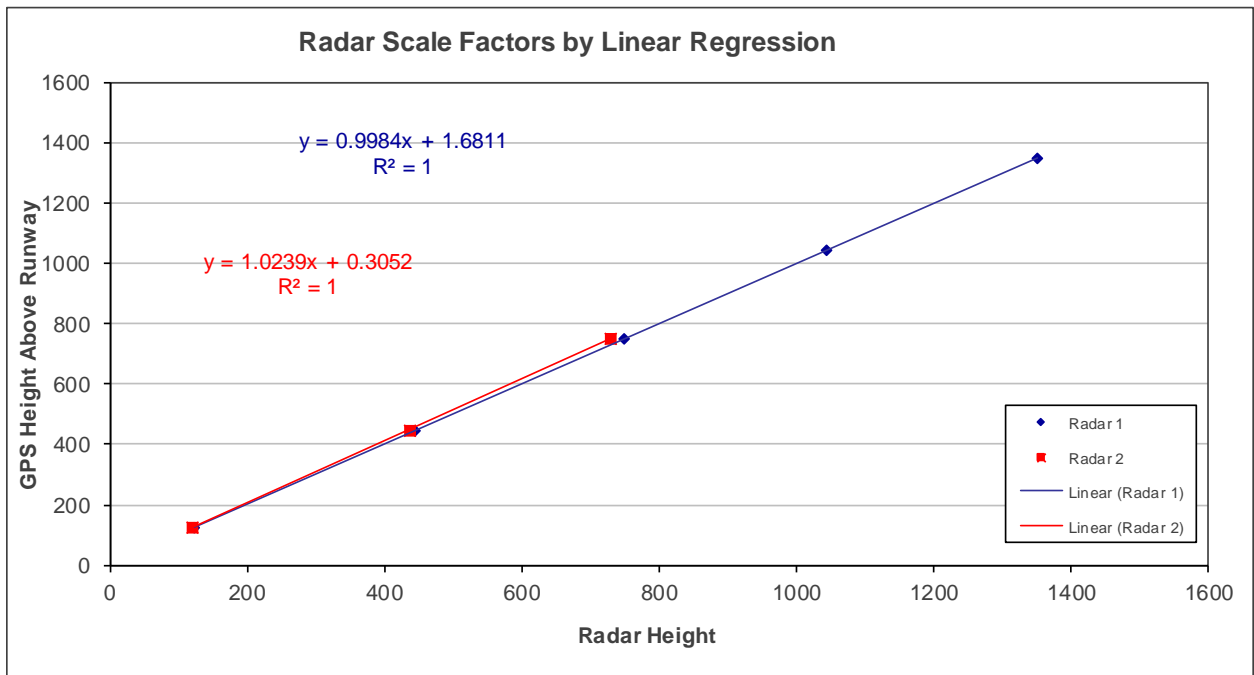


Table 14 - C-GJBG Radar Altimeter Calibration

A.4 Lag Tests

Lag Test Analysis

Project	Llewellyn
Flight	6
Aircraft	C-GJBB
Date	2017-02-23
Julian Day	54

Pilot	Mathieson
Copilot	Heit
Processor	Heath

Lag Test Summary

MB Average Lag	0.4

Test Location	Tower 22 km SW of YXE
Feature Easting	370599
Feature Northing	5767237

Air Time	
Test Time	
Ferry Time	

Lag Test Analysis

Bottom Tail Magnetometer (MB)						
Pass	Direction	Peak X	Peak Y	Velocity	From Tower	Lag
1	N	370609	5767270	83.15285713	34.48	0.41
2	S	370594	5767198	80.72868378	39.32	0.49
3	N	370606	5767271	80.80085498	34.71	0.43
4	S	370587	5767201	80.56752029	37.95	0.47
5	N	370607	5767270	81.60307016	33.96	0.42
6	S	370587	5767202	81.58774944	37.00	0.45
7	W	370572	5767244	78.66122874	27.89	0.35
8	E	370634	5767232	83.13119637	35.36	0.43
9	W	370568	5767244	76.52634318	31.78	0.42
10	E	370634	5767232	83.32376113	35.36	0.42
11	W	370572	5767245	77.06645851	28.16	0.37
12	E	370629	5767231	83.51997838	30.59	0.37

Table 17 - C-GJBB Lag Test

Lag Test Analysis

Project	Llewellyn
Flight	3
Aircraft	C-GJBG
Date	2017-02-23
Julian Day	54

Pilot	Mathieson
Copilot	Heit
Processor	Heath

Lag Test Summary

MB Average Lag	0.4
MR Average Lag	
ML Average Lag	
MT Average Lag	

Test Location	Tower 22 km SW of YXE
Feature Easting	370599
Feature Northing	5767237

Air Time	
Test Time	
Ferry Time	

Lag Test Analysis

Bottom Tail Magnetometer (MB)						
Pass	Direction	Peak X	Peak Y	Velocity	From Tower	Lag
1	N	370603	5767271	86.06	33.86	0.39
2	S	370591	5767198	87.80	39.69	0.45
3	N	370605	5767270	84.01	33.96	0.40
4	S	370591	5767203	87.10	34.74	0.40
5	N	370606	5767265	84.03	29.04	0.35
6	S	370587	5767205	86.58	34.60	0.40
7	W	370567	5767246	85.17	33.44	0.39
8	E	370637	5767230	88.99	38.46	0.43
9	W	370566	5767247	83.12	34.27	0.41
10	E	370638	5767230	89.78	40.00	0.45
11	W	370564	5767245	82.80	36.00	0.43
12	E	370636	5767230	84.93	37.28	0.44

Table 18 - C-GJBG Lag Test

APPENDIX B – OPERATIONS REPORTS

Goldak Airborne Surveys Operations Report

GSC - Llewellyn

February 27 to March 05
2017

Aircraft and Crew		
Aircraft:	C-GJBB	C-GJBG
Pilot:	Mathieson	Smith
Copilot:	Heit	Beisnthal
Processor:	Heath	
Base:	Town and Mountain Inn - Whitehorse	
Contact:	306-290-3881	

Summary	
Project Total	31785
Remaining	31785
Flown this week	
Flown to date	0

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment	
Mon February 27	7	C-GJBG											Meanook Test
		C-GJBG											Vehicle arrives in Whitehosre
Tues February 28		C-GJBB											JBG Arrives in Whitehosre
		C-GJBG											
Wed March 01		C-GJBB								100			2 Basemags, Base GPS set up
		C-GJBG											snow, low cloud
Thurs March 02	8	C-GJBB								100			JBB leaves Saskatoon. Flies Meanook
		C-GJBG											Snow low cloud in Whitehosre
Fri March 03		C-GJBB								100	75		Snow Low Cloud, active diurnal
		C-GJBG											
Sat March 04	9	C-GJBG	0.8	0.6		1.4							JBG Comp => Tail 0.62
	10	C-GJBB	0.8	0.4		1.2							JBB Comp => Tail 0.94
	11	C-GJBG	1.1			1.1							Aborted, poor visibility in block
Sun March 05		C-GJBB								100			Low Cloud
		C-GJBG								100			

Weekly Total	2.7	1	0	3.7	0	0	0
Total to Date	2.7	1	0	3.7	0	0	0

Goldak Airborne Surveys Operations Report

GSC - Llewellyn

March 06 to March 12
2017

Aircraft and Crew		
Aircraft:	C-GJBB	C-GJBG
Pilot:	Mathieson	Smith
Copilot:	Biesenthal	Heit
Processor:	Heath	
Base:	Whitehosre	
Contact:	306-290-3881	

Summary	
Project Total	31785
Remaining	29548
Flown this week	2237
Flown to date	2237

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment	
Mon March 06	12	C-GJBG	0.4			0.4				100	75		Block clouded over. Diurnal spotty all day
	13	C-GJBB	0.4			0.4				100	75		
Tues March 07	14	C-GJBG	0.5		0.8	1.3	84	84					Block in cloud
	15	C-GJBB	0.6		0.7	1.3	86	86					Block in cloud
Wed March 08		C-GJBB								100			Block in cloud
		C-GJBG											
Thurs March 09	16	C-GJBG	0.5			0.5				90			Block in cloud
	17	C-GJBB	0.6			0.6				90			
Fri March 10	18	C-GJBG	0.4		4.5	4.9	792	792					
	19	C-GJBB	0.4		4.6	5.0	1164	1149	15				
Sat March 11	20	C-GJBG	1.1		0.5	1.6	77	77		90			Block in cloud
	21	C-GJBB	0.9		0.7	1.6	49	49		90			
Sun March 12		C-GJBB								100			Low overcast
		C-GJBG								100			

Weekly Total	5.8	0	11.8	17.6	2252	2237	15
Total to Date	8.5	1	11.8	21.3	2252	2237	15

Goldak Airborne Surveys Operations Report

GSC - Llewellyn

March 13 to March 19
2017

Aircraft and Crew		
Aircraft:	C-GJBG	C-GJBB
Pilot:	Mathieson	Smith
Copilot:	Biesenthal	Heit
Processor:	Heath	
Base:	Town and Mountain, Whitehorse	
Contact:	306-290-3881	

Summary	
Project Total	31785
Remaining	28644
Flown this week	814
Flown to date	3141

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes	
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment		Crew
Mon March 13		C-GJBG												Snow low viz in Whitehorse
		C-GJBB												
Tues March 14		C-GJBG												Snow low viz in Whitehorse
		C-GJBB												
Wed March 15		C-GJBG												Block in cloud, Whitehorse mainly clear
		C-GJBB												
Thurs March 16		C-GJBG												Snow in Whitehorse. Block in cloud
		C-GJBB												
Fri March 17		C-GJBG												Snow in Whitehorse Block in cloud
		C-GJBB												
Sat March 18		C-GJBG												Snow in Whitehorse in AM, block in cloud
		C-GJBB												
Sun March 19	22	C-GJBG	0.4		3.2	3.6	338	338						Block clouded in as flights progressed
	23	C-GJBB	0.8		2.8	3.6	573	476	97	40				

Weekly Total	1.2	0	6	7.2	911	814	97
Total to Date	9.7	1	17.8	28.5	3163	3141	22

Goldak Airborne Surveys Operations Report

GSC - Llewellyn

March 20 to March 26
2017

Aircraft and Crew		
Aircraft:	C-GJBG	C-GJBB
Pilot:	Mathieson	Smith
Copilot:	Heit	Biesenthal
Processor:	Heath	
Base:	Town and Mountain Inn Whitehorse	
Contact:	306-290-3881	

Summary	
Project Total	31785
Remaining	26583
Flown this week	2151
Flown to date	5202

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes	
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment		Crew
Mon March 20		C-GJBG												Block in cloud
		C-GJBB												
Tues March 21		C-GJBG								50	50			Weather looked possible in AM, however diurnal was extremely active. By the time diurnal settled cloud moved in to block
		C-GJBB												
Wed March 22		C-GJBG								100				snow, low cloud
		C-GJBB												
Thurs March 23		C-GJBG								100				Low cloud
		C-GJBB												
Fri March 24		C-GJBG								100				Snow, low visibility
		C-GJBB												
Sat March 25		C-GJBG								100				Snow in Whitehorse in AM, cleared but block remained in cloud
		C-GJBB												
Sun March 26	24	C-GJBG	0.7		5.5	6.2	1160	1160						Compensation Flight
	25	C-GJBB	1.2			1.2								
	26	C-GJBB	0.8		3.7	4.5	991	991						

Weekly Total	2.7	0	9.2	11.9	2151	2151	0
Total to Date	12.4	1	27	40.4	5314	5202	112

Goldak Airborne Surveys Operations Report

GSC - Llewellyn
 March 27 to April 02
 2017

Aircraft and Crew
 Aircraft: C-GJBB C-GJBG
 Pilot: Mathieson Smith
 Copilot: Heit Biesenthal
 Processor: Heath
 Base: Town and Mountain Hotel Whitehorse
 Contact: 306-290-3881

Summary	
Project Total	31785
Remaining	26383
Flown this week	90
Flown to date	5402

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment	
Mon March 27		C-GJBB								100	100		Weather and diurnal bad all day
		C-GJBG											
Tues March 28	27	C-GJBG	1.0		0.6	1.6	57	57		90			Block Clouded in
	28	C-GJBB	1.2		0.6	1.8	33	33					
Wed March 29		C-GJBB								100	25		Diurnal active until 10:30 am. Block Clouded in
		C-GJBG											
Thurs March 30	29	C-GJBG	1.0		0.4	1.4	81		81	90			Block Clouded in
	30	C-GJBB	1.1		0.3	1.4	29		29				
Fri March 31		C-GJBB								100			Low cloud, high winds, turbulence
		C-GJBG											
Sat April 01		C-GJBB								100			Low cloud
		C-GJBG											
Sun April 02		C-GJBB								100			Low Cloud, high winds
		C-GJBG											

Weekly Total	4.3	0	1.9	6.2	200	90	110
Total to Date	16.7	1	28.9	46.6	5514	5402	112

Goldak Airborne Surveys Operations Report

GSC - Llewellyn
 April 03 to April 09
 2017

Aircraft and Crew
 Aircraft: C-GJBB C-GJBG
 Pilot: Mathieson Smith
 Copilot: Heit Biesenthal
 Processor: Heath
 Base: Town and Mountain Hotel, Whitehorse
 Contact: 306-290-3881

Summary	
Project Total	31785
Remaining	23509
Flown this week	2984
Flown to date	8276

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes	
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment		Crew
Mon April 03		C-GJBB												Low cloud, high upper winds
		C-GJBG												
Tues April 04		C-GJBB												Low cloud, high upper winds
		C-GJBG												
Wed April 05		C-GJBB												Low Cloud
		C-GJBG												
Thurs April 06	31	C-GJBB	0.9		1.0	1.9	73	49	24	90				Most of block clouded...encountered severe turbulence in the one clear area
		C-GJBG												
Fri April 07	32	C-GJBB	0.4		5.3	5.7	1327	1327						
		C-GJBG												
Sat April 08	33	C-GJBB	0.4		5.5	5.9	1354	1330	24					
		C-GJBG												
Sun April 09	34	C-GJBB	0.5		1.3	1.8	305	278	27	60				Low cloud and turbulence shortend flight
		C-GJBG												

Weekly Total	2.2	0	13.1	15.3	3059	2984	75
Total to Date	18.9	1	42	61.9	8573	8276	297

Goldak Airborne Surveys Operations Report

GSC - Llewellyn
 April 10 to April 16
 2017

Aircraft and Crew
 Aircraft: C-GJBB
 Pilot: Mathieson
 Copilot: Smith
 Processor: Heath
 Base: Town and Mountain Hotel, Whitehorse
 Contact: 306-290-3881

Summary	
Project Total	31785
Remaining	17647
Flown this week	5862
Flown to date	14138

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)				Notes	
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment	Crew		
Mon April 10	35	C-GJBB	0.6		5.1	5.7	1198	1198							
Tues April 11	36	C-GJBB	0.5		5.4	5.9	1427	1427							
Wed April 12	37	C-GJBB	1.7			1.7	100	88	12					encountered severe turbulence in block	
Thurs April 13		C-GJBB								100				cloud, winds throughout	
Fri April 14	38	C-GJBB	0.5		4.3	4.8	1156	1156							
Sat April 15	39	C-GJBB	0.5		5.4	5.9	1421	1421							
Sun April 16	40	C-GJBB	0.5		3.1	3.6	572	572		50				Part of block clouded, clear portion became too turbulent.	

Weekly Total	4.3	0	23.3	27.6	5874	5862	12
Total to Date	23.2	1	65.3	89.5	14447	14138	309

Goldak Airborne Surveys Operations Report

GSC - Llewellyn
 April 17 to April 23
 2017

Aircraft and Crew
 Aircraft: C-GJBB
 Pilot: Mathieson
 Copilot: Smith
 Processor: Heath
 Base: Town and Mountain Hotel, Whitehorse
 Contact: 306-290-3881

Summary	
Project Total	31785
Remaining	16234
Flown this week	1413
Flown to date	15551

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes	
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment		Crew
Mon April 17		C-GJBB												Cloud
Tues April 18	41	C-GJBB	0.9		0.6	1.5	96	88		80				encountered cloud and turbulence in the area
Wed April 19		C-GJBB								100				Cloud
Thurs April 20		C-GJBB								100				Cloud
Fri April 21		C-GJBB								100				Cloud
Sat April 22		C-GJBB								50	90			Bad diurnal throughout the day. Weather favourable in the AM
Sun April 23	42	C-GJBB	0.6		5.1	5.7	1325	1325			40			Stormy diurnal until 11:00 local. Unsettled afterwards.

Weekly Total	1.5	0	5.7	7.2	1421	1413	0
Total to Date	24.7	1	71	96.7	15868	15551	309

Goldak Airborne Surveys Operations Report

GSC - Llewellyn
 April 24 to April 30
 2017

Aircraft and Crew
 Aircraft: C-GJBB C-GJBG
 Pilot: Mathieson
 Copilot: Smith
 Processor: Heath
 Base: Town and Mountain Hotel, Whitehorse
 Contact: 309-290-3881

Summary	
Project Total	31785
Remaining	12132
Flown this week	4102
Flown to date	19653

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment	
Mon April 24	43	C-GJBB	0.9		4.9	5.8	951	951		100			
		C-GJBG											
Tues April 25	44	C-GJBB	0.7		3.3	4.0	721	721		25	25		Diurnal early in the morning, clear by 9 am. Turbulence picked up shortening flight.
		C-GJBG											
Wed April 26	45	C-GJBB	0.6		5.1	5.7	1173	1173					
		C-GJBG											
Thurs April 27		C-GJBB								100			JBB receiving scheduled maintenance
		C-GJBG											
Fri April 28		C-GJBB								100			JBB receiving scheduled maintenance
		C-GJBG											
Sat April 29	46	C-GJBG	0.6		3.5	4.1	714	714					Flight shortened due to turbulence
		C-GJBG											JBB receiving scheduled maintenance
Sun April 30	47	C-GJBB	0.6		2.8	3.4	543	543		40			Cloud and turbulence
		C-GJBG											JBG grounded => Oil Leak

Weekly Total	3.4	0	19.6	23	4102	4102	0
Total to Date	28.1	1	90.6	119.7	19970	19653	309

Goldak Airborne Surveys Operations Report

GSC - Llewellyn

May 01 to May 07
2017

Aircraft and Crew	
Aircraft:	C-GJBB C-GJBG
Pilot:	Mathieson
Copilot:	Smith
Processor:	Heath
Base:	Town and Mountain Hotel, Whitehorse
Contact:	306-290-3881

Summary	
Project Total	31785
Remaining	9635
Flown this week	2497
Flown to date	22150

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes	
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment		Crew
Mon May 01		C-GJBB												Cloudy
		C-GJBG												
Tues May 02	48	C-GJBB	0.8	0.5	1.3					80				COMP flight Passed. Survey block not workable
		C-GJBG												
Wed May 03		C-GJBB												Cloudy
		C-GJBG												
Thurs May 04	49	C-GJBB	0.7		0.1	0.8	16		16	100				Windy, Turbulent.. Could not hold line
		C-GJBG												
Fri May 05	50	C-GJBB	0.7		4.0	4.7	1057	1057						
		C-GJBG												
Sat May 06	51	C-GJBB	0.8		5.4	6.2	1427	1427						JBB flat tire on landing
		C-GJBG												
Sun May 07	52	C-GJBG	0.8	0.4	1.2									Comp Flight West side of block fogged in, tired infill line - too rough
	53	C-GJBG	0.5		0.1	0.6	13	13	90					

Weekly Total	4.3	0.9	9.6	14.8	2513	2497	16
Total to Date	32.4	1.9	100.2	134.5	22483	22150	325

Goldak Airborne Surveys Operations Report

GSC - Llewellyn
 May 15 to May 21
 2017

Aircraft and Crew
 Aircraft: C-GJBB C-GJBG
 Pilot: Mathieson
 Copilot: Smith
 Processor: Heath
 Base: Town and Mountain Hotel, Whitehorse
 Contact: 306-290-3881

Summary	
Project Total	31785
Remaining	7200
Flown this week	2435
Flown to date	24585

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)				Notes	
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment	Crew		
Mon May 15	54	C-GJBG	0.6		1.9	2.5	165	165							
		C-GJBG													
Tues May 16	55	C-GJBG	0.7		4.5	5.2	1044	916	128		10			Large diurnal pulsations stated shortly after take off, lasted 30 mins	
		C-GJBG													
Wed May 17	56	C-GJBB	0.7		5.5	6.2	1224	1224							
		C-GJBG													
Thurs May 18	57	C-GJBB	1.1		1.4	2.5	130	130							
		C-GJBG													
Fri May 19	58	C-GJBG	1.3			1.3					100			No clear area in the block	
		C-GJBG													
Sat May 20		C-GJBB								100	50			Low cloud, rain. Active diurnal in am	
		C-GJBG													
Sun May 21		C-GJBB								100				Low cloud	
		C-GJBG													

Weekly Total	4.4	0	13.3	17.7	2563	2435	128
Total to Date	36.8	1.9	113.5	152.2	25046	24585	453

Goldak Airborne Surveys Operations Report

GSC - Llewellyn

May 29 to June 04
2017

Aircraft and Crew	
Aircraft:	C-GJBB C-GJBG
Pilot:	Mathieson
Copilot:	Smith
Processor:	Heath
Base:	Town and Mountain Hotel, Whitehorse
Contact:	306-290-3881

Summary	
Project Total	31785
Remaining	3246
Flown this week	1228
Flown to date	28539

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)				Notes	
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment	Crew		
Mon May 29		C-GJBB													block in cloud
		C-GJBG													
Tues May 30		62 C-GJBB	1.4			1.4									block not workable
		C-GJBG													
Wed May 31		C-GJBB													block in cloud
		C-GJBG													
Thurs June 01		C-GJBB													block in cloud
		C-GJBG													
Fri June 02		C-GJBB													block in cloud
		C-GJBG													
Sat June 03		C-GJBB													block in cloud
		C-GJBG													
Sun June 04		63 C-GJBB	0.8		4.9	5.7	1228	1228							
		C-GJBG													

Weekly Total	2.2	0	4.9	7.1	1228	1228	0
Total to Date	41.3	1.9	129.8	173	29020	28539	473

Goldak Airborne Surveys Operations Report

GSC - Llewellyn
 June 05 to June 11
 2017

Aircraft and Crew
 Aircraft: C-GJBB C-GJBG
 Pilot: Mathieson
 Copilot: Smith
 Processor: Heath
 Base: Town and Mountain Hotel, Whitehorse
 Contact: 306-290-3881

Summary	
Project Total	31785
Remaining	2553.4
Flown this week	693
Flown to date	29231.6

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)			Notes		
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment		Crew	
Mon June 05		C-GJBB											100		block in cloud
		C-GJBG													
Tues June 06		C-GJBB											100		block in cloud
		C-GJBG													
Wed June 07		C-GJBB											100		block in cloud
		C-GJBG													
Thurs June 08		C-GJBB											100		high upper winds and turbulence
		C-GJBG													
Fri June 09		64 C-GJBB	0.7		3.0	3.7	673	673							block in cloud
		C-GJBG													
Sat June 10		C-GJBB											100		
		C-GJBG													
Sun June 11		65 C-GJBB	0.6		0.8	1.4	57	20	37	90					one part line, part refight segment. Block cloudy, turbulent
		C-GJBG													

Weekly Total	1.3	0	3.8	5.1	730	692.6	37.4
Total to Date	42.6	1.9	133.6	178.1	29750	29231.6	510.4

Goldak Airborne Surveys Operations Report

GSC - Llewellyn
 June 12 to June 18
 2017

Aircraft and Crew
 Aircraft: C-GJBB C-GJBG
 Pilot: Mathieson
 Copilot: Smith
 Processor: Heath
 Base: Town and Mountain Hotel, Whitehorse
 Contact: 306-290-3881

Summary	
Project Total	31785
Remaining	722.4
Flown this week	1831
Flown to date	31062.6

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)				Notes							
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment	Crew								
Mon June 12		C-GJBB																			
		C-GJBG																			
Tues June 13		C-GJBB																			
		C-GJBG																			
Wed June 14		66 C-GJBB	0.9		3.1	4.0	698	698													
		C-GJBG																			
Thurs June 15		C-GJBB																			
		C-GJBG																			
Fri June 16		C-GJBB																			
		C-GJBG																			
Sat June 17		C-GJBB																			
		C-GJBG																			
Sun June 18		67 C-GJBB	0.6		4.8	5.4	1133	1133													
		C-GJBG																			

Weekly Total	1.5	0	7.9	9.4	1831	1831	0
Total to Date	44.1	1.9	141.5	187.5	31581	31062.6	510.4

Goldak Airborne Surveys Operations Report

GSC - Llewellyn
 June 19 to June 25
 2017

Aircraft and Crew
 Aircraft: C-GJBB C-GJBG
 Pilot: Mathieson
 Copilot: Smith
 Processor: Heath
 Base: Town and MountainHotel, Whitehorse
 Contact: 306-290-3881

Summary
 Project Total 31785
 Remaining -536.6
 Flown this week 1259
 Flown to date 32321.6

	Flight	Aircraft	Flight Times (h)				Production (km)			Unservicability (%)				Notes
			Ferry	Test	Survey	Total	Flown	Accepted	Rejected	Weather	Diurnal	Equipment	Crew	
Mon June 19	68	C-GJBB	1.2		0.4	1.6	119	119		80				turbulence ended flight
		C-GJBG												
Tues June 20		C-GJBB								100				low cloud
		C-GJBG												
Wed June 21		C-GJBB								100				low cloud
		C-GJBG												
Thurs June 22		C-GJBB								100				low cloud
		C-GJBG												
Fri June 23	69	C-GJBB	0.7		4.7	5.4	1140	1140						
		C-GJBG												
Sat June 24		C-GJBB								100				low cloud
		C-GJBG												
Sun June 25		C-GJBB								100				low cloud
		C-GJBG												

Weekly Total	1.9	0	5.1	7	1259	1259	0
Total to Date	46	1.9	146.6	194.5	32840	32321.6	510.4

