FINAL REPORT

on

Data Acquisition and Processing

for the

Airborne Magnetic Survey

of

Taylor Mountains Area in Southwest Alaska

for

US Geological Survey

APS PO Box 25046
MS204A Denver Federal Center
Denver, Colorado 80225
USA

by

McPhar Geosurveys Ltd.

1256B Kerrisdale Blvd.
Newmarket, Ontario
Canada, L3Y 8Z9
Tel: (905) 830-6880
Fax: (905) 898-0336

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- GMAG Magnetometer Base Station

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- Biljana Milicevic, M.Sc.
- Hermann Mueller
- John R. Currie
- Kwame Barko, M.Sc.
- Manuel Vargas
- Timothy R. Borger
- Tonia Bojkova, M.Sc

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SUMMARY

An airborne high-resolution magnetic and coincidental horizontal magnetic gradiometer survey was completed over the Taylor Mountains area in southwest Alaska. The flying was undertaken by McPhar Geosurveys Ltd. on behalf of the United States Geological Survey (USGS). First tests and calibration flights were completed by April 7, 2004 and data acquisition was initiated on April 17, 2004. The final data acquisition and final test/calibrations flight was completed on May 31, 2004. A total of 8,971.15 line-miles of data were acquired during the survey.

Figure 1: Aeromagnetic Surveying in the Taylor Mountains, Alaska

1. INTRODUCTION

A detailed high-resolution fixed-wing magnetic and coincidental horizontal magnetic gradiometer survey was carried out during the period of April 7, 2004 through May 31, 2004 on behalf of the United States Geological Survey, hereinafter referred to as "USGS", by McPhar Geosurveys Ltd., hereinafter referred to as "McPhar", over the Taylor Mountains survey area in southwest Alaska (see Figure 1 on the last page).

Horizontal Magnetic Gradiometer data acquisition involves the use of differential GPS positioning and two high sensitivity magnetometers installed on the wing tips of a fixed-wing aircraft to measure the transverse horizontal magnetic gradient of Earth's magnetic field. In this instance the aircraft used was a Cessna C207 aircraft with USA registration N7384U. The magnetometers installed on the wingtips of this aircraft were separated from each other by a distance of 41 feet 11 inches (12.9 metres).

Mobilization of the aircraft, equipment and personnel to the survey base was completed on April 7, 2004. The initial flight tests and calibrations were completed on April 7, 2004, and the first survey flight was carried out on April 17, 2004. The last survey flight was carried out on May 31, 2004 and the final tests and calibration flights were completed on May 31, 2004.

Field operations were based out of the village of Koliganek, southwest Alaska.

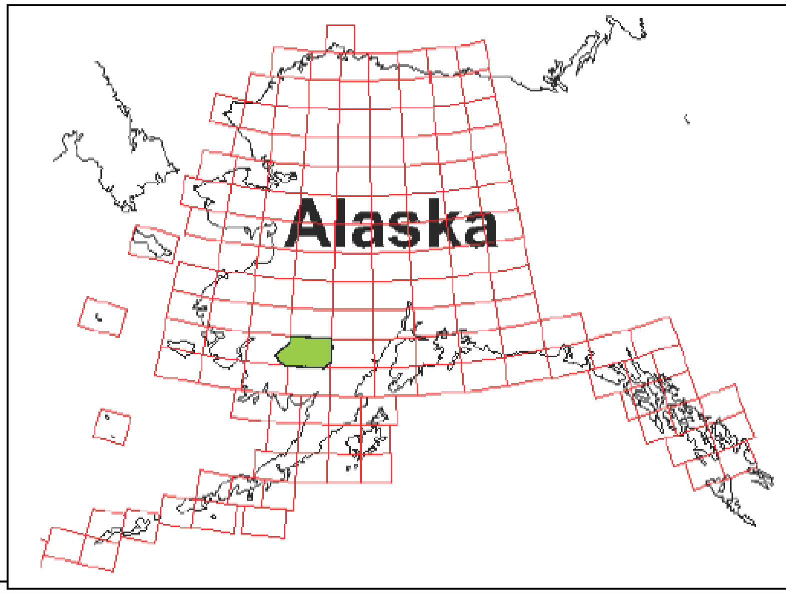
A 1:250,000 scale contour map and digital grid of the total magnetic field were produced, as well as a digital grid of the measured horizontal magnetic gradient and the radar altimeter (ground clearance) data.

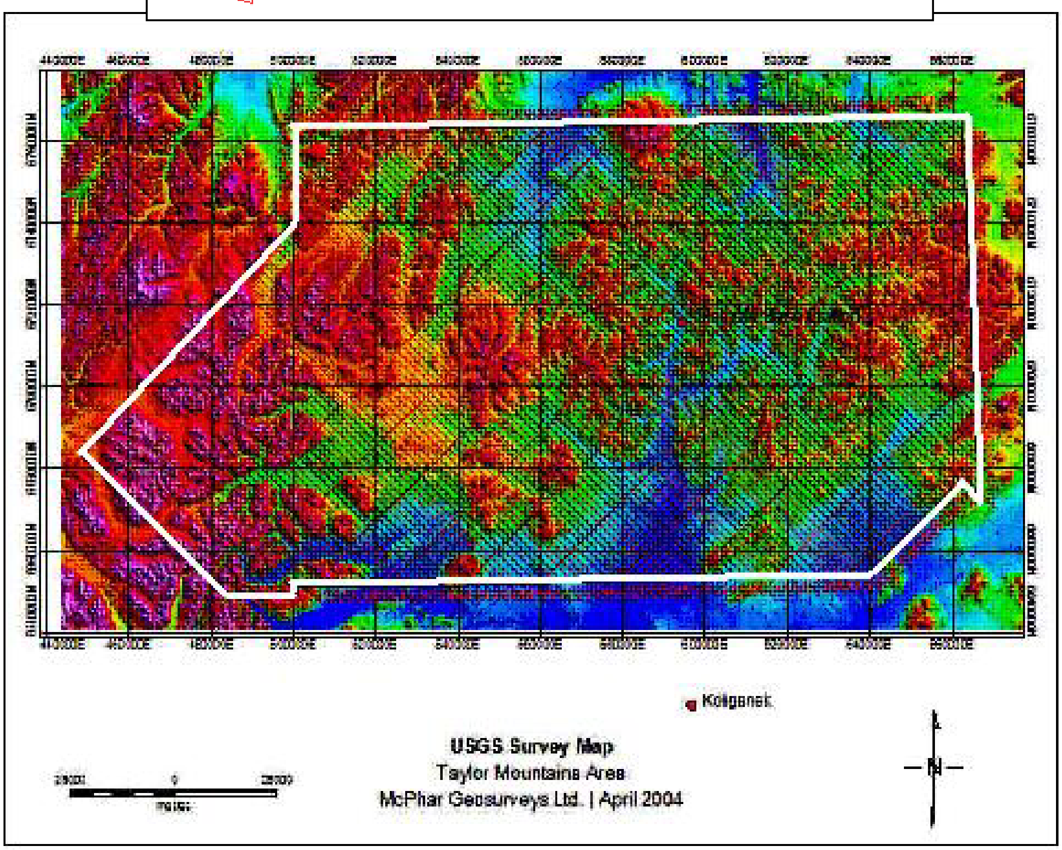
This report describes the data acquisition and processing procedures, parameters and delivered products for this survey.

2. SURVEY AREA

2.1 Outline of the Survey Area

The survey consisted of one block as outlined on the location maps below.





Figures 2 & 3: Location Maps – Taylor Mountains Area in Southwest Alaska – Figure 3 on Topographic Base

3. TECHNICAL SPECIFICATIONS

This section describes in detail the guidelines followed throughout the performance of the project.

3.1 Flight Specifications

Traverse Line Directions	NW – SE
Traverse Line Spacing	one (1) mile
Control Line Direction	NE – SW
Control Line Spacing	eight (8) miles
Terrain Clearance	nominally 1,000 feet
Line Miles	8,971.15
Average Sampling Interval	20 feet (6 metres)

3.2 Tolerances

Reflights were carried out at McPhar's expense whenever survey lines or part survey lines were noted in the field to be beyond the contractual tolerances. All reflights covered a minimum of two control lines. The tolerances observed were:

3.2.1 Navigation

- Deviations from the pre-planned (pre-flight) paths will not exceed 10% of the designated flight line spacing. Gaps between adjacent flight lines greater than 1.5 times the designated flight line spacing for more than 2 linear miles (3.2 km) will require fill-in lines.

3.2.2 Flight Height

- The maximum vertical deviations as indicated by the barometric altimeter will be ±200 feet (61 m) from the pre-planned draped flight surface except in areas where FAA regulations prevent flying at this height, and in areas of severe topography where the pilot's judgement will prevail.

3.2.3 Magnetic Diurnal

Survey data will not be acceptable when gathered during magnetic storms or short-term disturbances of magnetic activity at the magnetometer base station used, which exceeds the following:

- Monotonic changes in the magnetic field of 5 nT in any 5-minute period
- Pulsations having periods of 5 minutes or less shall not exceed 2 nT
- Pulsations having periods between 5 and 10 minutes shall not exceed 4 nT
- Pulsations having periods between 10 and 20 minutes shall not exceed 8 nT.

Survey data acquisition will be stopped altogether in the case of magnetic diurnal activity exceeding the above specifications.

3.2.4 Airborne Magnetometer Noise

The error envelope due to turbulence and the internal magnetometer noise will not exceed ±0.1 nT for more than 10% of any flight line. The magnetometer will be compensated for errors caused by the magnetic field of the aircraft such that maneuver noise will not exceed 3 nT for pitches or rolls of $\pm 20^{o}$ and heading changes will not cause a variation of more than 1 nT in the magnetic reading.

4. SURVEY OPERATIONS

4.1 Operations Base

Survey operations were based from Koliganek in southwest Alaska. Permission was gained to use a building beside the airstrip in which to house the magnetic and GPS base stations. The GPS base station antenna was positioned on the roof of this building, and the magnetic base station sensor was stationed approximately 30 m away from the building.

McPhar's personnel at the crew residence undertook Quality Control and Preliminary Data Processing in Koliganek.

4.2 Diurnal Conditions

Magnetic diurnal conditions were varied throughout the survey. A total of eleven days were lost to production during the project due to magnetic diurnal conditions being out of specifications.

4.3 Other Survey Conditions

Weather conditions during the survey were variable. Temperatures varied from a few degrees above zero Celsius on some days to as low as -20^{o}C on others. Many days were lost due to bad weather throughout the survey because of rain and/or snow, fog and poor visibility.

A total of four (4) days were lost to production for either aircraft or equipment maintenance.

In Appendix 2 may be found the daily and weekly reports for the project, which describe in more detail the weather and diurnal magnetic conditions for each day throughout the survey.

4.4 Navigation

The nominal data acquisition speed was approximately 220 kilometres per hour. Scan rates for the magnetic data acquisition was 0.1 second, 1.0 second for the radar and barometric altimeters, and 1.0 second for the GPS navigation/positioning system. Therefore, there is a magnetic value recorded about every 20 feet (6 metres) and a position fix each 65 yards (60 metres) along the flight track.

Navigation was assisted by a GPS receiver system that reports GPS co-ordinates as WGS-84 latitude & longitude and directs the pilot over the pre-programmed three-dimensional (3D) survey grid. The x-y-z position of the aircraft as reported by the GPS system was recorded together with the terrain clearance as reported by the radar altimeter and the pressure altitude observed by the barometric altimeter.

Vertical navigation along flight lines was established using the radar altimeter. The nominal terrain clearance during normal survey flying was 1,000 feet. However, due to rugged terrain in some areas, and the pilot's judgment of safe flying conditions in these areas, this terrain clearance was not possible 100% of the time.

The final vertical and horizontal survey positions were differentially corrected post flight, computed using the data from the onboard GPS receiver and the GPS base station receiver, to a precision of approximately 1.5 m.

4.4.1 Flight Line Elevation Design

As a smooth acquisition surface was considered to be critical to the success of this program, McPhar pre-determined the flight line elevation variations and designed the acquisition altitude for each flight line in order to obtain optimum responses from the survey. The critical elements in the design of the flight surface were the safety of the data acquisition operation, the (median) performance parameters of the survey aircraft for climb/descent rates and the desire to drape as closely as possible to the specified 1,000 feet survey altitude. The preplot of this survey was, therefore, designed to encompass not only the standard XY location of each line, but also the Z component. To prepare the preplot, a digital topographic grid of the survey area using a sample density of points with a maximum spacing of thirty metres was used. The preplot was prepared using a climb gradient for the aircraft of 100 m/km. The preplot survey design was stored as the on-board navigation information for the pilot to fly with, using radar altimeter and, where possible, real-time differentially corrected GPS height for vertical control, and GPS positions for horizontal control. As a backup, a geodetic quality dual-frequency GPS system was operated onboard the aircraft, and these data were post-flight differentially corrected using data acquired by a base station GPS receiver. Final aircraft position was based on corrected differential GPS in X, Y and Z and the radar altimeter.

Prior to the start of survey operations, McPhar provided a copy of the proposed 3D navigation flight plan to the USGS's supervisor for approval.

4.5 Geodetic & Mapping Parameters

The following geodetic and mapping parameters were observed throughout the data acquisition phase.

Length unit	m
Projection	UTM zone 5N
Type	Transverse Mercator
Lat0, Lon0, SF, FE, FN	0, -153, 0.9996, 500000, 0
Datum	WGS84
Ellipsoid	WGS84
Majax, Eccen, PrimeMer	6378137, 0.08181919084,0
Local datum transform	WGS84 World

4.6 Quality Control & Field Processing

McPhar ensures Quality Control by using a team concept. The instrumentation onboard the survey aircraft permits basic quality control procedures. The team concept is continued at the Survey Base where a McPhar geophysicist undertakes a more comprehensive QC analysis of the data, and performs preliminary data processing. The data is then given a second, and more complete review, where in all the systems onboard the aircraft are tested for compliance to the survey's specifications. Any problematic or unacceptable data is identified and flagged for reflying by the survey crew. On a daily basis, this preliminary processed data is sent to McPhar's data processing centre, where other geophysicists commence the Final Data Processing work.

On this project, the survey data was transferred to portable magnetic media on a flight-by-flight basis, and then copied to the field data processing workstation. In-field data processing included differential correction of the airborne GPS data using Waypoint Navigation's GrafNav software, reduction of the data to Geosoft GDB database format, post-flight compensation of the magnetometer data using McPhar's CCMAG software, and inspection of all data for adherence to contract specifications. Survey lines which showed excessive deviation after differential correction, or which were considered to be of inferior quality, for whatever reason, were reflown.

4.7 Survey Statistics and Weekly Operations Reports

The aeromagnetic survey entailed a total of 42 flights, of which 36 were production flights or "re-flights". The first production flight was on April 7, 2004, with the last production flight on May 31, 2004. The balance of the flights were either test and/or calibration flights or flights that were aborted for bad weather or aircraft or equipment problems. Re-flights of data found unacceptable were carried out as processing of the dataset progressed.

4.7.1 Daily and Weekly Operations Reports

Daily Operations Reports commencing with Report #1 dated April 7, 2004 and finishing with Report #55 of May 31, 2004 may be found in Appendix 2.

Weekly Operations Reports commencing with the week ending April 11, 2004 and finishing with the week ending June 6, 2004 are provided in Appendix 2.

These reports provide detailed information on the daily happenings during the survey.

5. AIRCRAFT AND EQUIPMENT

5.1 The Aircraft

The survey was flown using a Cessna C207 aircraft, with registration number N7384U (see Figures 4, 5 and 6), provided by TransNorthern LLC of Anchorage, Alaska. The aircraft has been modified as a geophysical survey platform, and features dual wingtip pods for the two cesium magnetometers. The Cessna C207 will reliably acquire aeromagnetic data at nominal survey airspeed of 120 knots (220 kph), and is capable of exceeding a climb gradient of 120 m/km.

The installation of the geophysical and ancillary equipment was carried out by McPhar's personnel at TransNorthern's facilities at Anchorage Airport, Alaska, with final adjustments, calibration and testing completed at the survey base, Koliganek, after the completion of mobilization.

Figures 4, 5 & 6: Cessna C-207 Survey Aircraft, N7348U, at Koliganek

5.1.1 Aircraft Details

Aircraft Model:	-	Cessna C-207
Aircraft Registration:	-	USA, N7384U
Engines:	-	300 hp, six cylinder Continental IO52OF
Propellers:	-	McCauley Mod no D3A34C404
Fuel Type & Capacity:	-	AVGAS, 88 US gallons
Range: Survey Configuration:	-	5.3 hours
Aircraft Gross Weight:	-	3,600 lb.

The Cessna C207 is fully described in Appendix 3.

5.2 The Survey Instrumentation

5.2.1 Survey System Overview

The instrumentation installed in the aircraft included:

- Two (2) Geometrics G822A airborne cesium magnetometers
- Billingsley TFM-100 3-component fluxgate magnetometer
- Pico Envirotec AGIS-100 Data Acquisition System with imbedded GPS Navigation Computer and 3D Pilot Steering Indicator
- Pico Envirotec MMS-4 Multi-channel Cesium Magnetometer Processor
- NovAtel Performance GPS receiver
- NovAtel MiLLennium 24-channel, geodetic quality, L1/L2 GPS Navigation Receiver and antenna
- Terra TRA-3000/TRI-30 radar altimeter
- Setra model 276 Barometric Pressure Altimeter
- Dev-Tech Geo-iMAGE Lite Digital Imaging System and Sony digital camera
- Instrumentation Rack and Power Distribution System

The Base Stations and Ground Support Equipment comprised:

- Field Workstation comprising a Pentium 4, 2.6 GHz PC, a full suite of QC and data processing software and a colour inkjet printer.
- A McPhar "Fieldworks" Cesium Magnetometer/GPS Base Station comprising a Scintrex H8 Cesium Magnetometer, a NovAtel MiLLennium GPS receiver and a PC-based datalogger (for use at the survey base).
- A Pico Envirotec GMAG Base Station, complete with a Scintrex H8 Cesium Magnetometer, a Magellan GPS Receiver and datalogger, and solar panel power supply (for remote locations) Synchronization of each of the two base stations described above with the airborne system was via GPS time. Post-survey differential corrections were made using a program called GrafNav™.
- A complement of spare parts and test equipment were maintained at the survey base.

5.2.2 Airborne Magnetometers

Two Geometrics G822A optically pumped cesium vapor magnetic field sensors, mounted in wingtip pods, were utilized on this survey. The sensitivity of these magnetic sensors is 0.001 nanoTesla (nT) at a sampling interval of 0.05 second.

Figure 7: G822A Cesium Magnetometer

A cesium vapor magnetic sensor is in essence a miniature atomic absorption unit, which produces a signal whose frequency (Larmor frequency) is proportional to the intensity of the ambient magnetic field. The unit consists of three main elements: a cesium vapor lamp; an absorption cell; and a photosensitive diode.

These three units are all mounted along a common optical axis within the sensor housing. The electronic support system is mounted approximately three metres from the sensor, and transmits the Larmor signal to a counter in the data acquisition system that converts the signal to magnetic field strength as nanoTeslas.

The G822A magnetometer is described in Appendix 3.

5.2.3 Magnetic Compensation

Compensation for the orientation and movement of the aircraft in the Earth's ambient magnetic field was undertaken using a McPhar proprietary program called "CCMAG" installed on the Field Workstation. The Larmor frequency output of the cesium magnetometer sensor installed in the wingtip pod on the aircraft was processed by the MMS-4 high precision frequency counter as a part of the AGIS-100 data acquisition system with a resolution of 0.001nT at a sampling rate of 20 times per second. The attitude and motion of the aircraft in flight, with respect to the Earth's magnetic field, was monitored by a Billingsley three-component fluxgate magnetometer. The output from this 3-axis fluxgate magnetometer, or attitude sensor, was then used in the proprietary processing of the raw magnetic data to produce magnetic data compensated for the orientation and motion of the aircraft in the Earth's magnetic field.

The CCMAG post-flight compensation program and the Billingsley TFM-100 3-axis magnetometer are described in Appendix 3.

5.2.4 The Base Station Magnetometers

Two base station magnetometers were used during this project. Both utilized high-sensitivity cesium vapor magnetometers and were time-synchronised with the airborne system using GPS time.

The magnetometer system used at the survey base was a McPhar "Fieldworks" system, comprised of a Scintrex H8 cesium vapor magnetometer, a NovAtel Millennium dual-frequency GPS receiver, a 28 volt power supply and a notebook PC datalogger. The resolution of this magnetometer was 0.001nT and it sampled at 1 Hz.

The magnetometer system that was used at remote field sites (the USGS contract required that "*One or more continuously recording ground magnetometers shall be located within 50 miles (80 km) of all survey points"*) was a Pico Envirotec GMAG Magnetometer Base Station comprised of a Scintrex H8 cesium vapor magnetometer, a Magellan GPS receiver, 28-volt power supplies with solar panels and a datalogger.

A pamphlet describing the GMAG Magnetometer can be found in Appendix 3.

Figure 8: The Fieldworks Magnetometer Base Station at Koliganek

Figure 9: The "Remote" Magnetometer Base Station – showing solar panels and service aircraft

Figure 10: Data was retrieved from the remote site location approximately every 72 hours by light aircraft equipped with "tundra-tires"

5.2.5 Altimeters

A Terra TRA-3000 radar altimeter system recorded the ground clearance to an accuracy of less than 1 metre (about 3 ft), over a range of 40 ft to 2,500 ft.

A Setra 276 barometric altimeter/pressure transducer measured the barometric pressure, from which the elevation of the aircraft above sea level was calculated. This barometric altimeter has an accuracy of ±0.02% and a resolution of 0.5 metres.

The altimeters were interfaced to the data acquisition system with an output repetition rate of 0.1 second, and were digitally recorded.

The Altimeters are further described in Appendix 3.

5.2.6 The GPS NAVSTAR Satellite Navigation System

Two navigation/positioning systems were used on the aircraft. One was an OmniSTAR/GPS receiver, and the second was a NovAtel MiLLennium-ProPak dual-frequency GPS receiver.

A pilot steering indicator, providing steering instructions to the pilot in three dimensions, was installed on top of the cockpit dashboard. This indicator was connected to the AGIS-100 data acquisition system receiving information from the GPS system and the radar altimeter.

A GPS ground base station, comprising a NovAtel MiLLennium GPS receiver, installed at the airport in Koliganek recorded GPS data on a Notebook PC-datalogger that was used for post-flight differential corrections (using GrafNav software). The GPS receivers are fully described in Appendix 3.

5.2.7 Data Acquisition/Recording System

A PC-based AGIS-100 data acquisition system (DAS) was used to record the geophysical and navigation data on board the aircraft. Data was simultaneously recorded on hard disk (and later copied to a flashcard) at a repetition rate of 0.1 second for post-flight computer processing. The five main functions fulfilled by the DAS are: 1) system control and monitoring; 2) data acquisition; 3) real-time data processing; 4) navigation; and 5) data playback and analysis.

The AGIS-100 is a fully PC-compatible microcomputer. All data collection routines, checking, buffering, recording and verification are software controlled for maximum flexibility. A modular concept is used for both the software and the hardware to allow for future expandability. The sensors used with AGIS-100 may include radiometric, magnetic and electromagnetic. Data being recorded is monitored on a colour LCD display as pseudo-analog traces to verify quality and functionality of the data being recorded. The AGIS-100 is fully described in Appendix 3.

Figure 11: AGIS-100 Data Acquisition System in the Cessna C207 aircraft

5.2.8 Field Computer Workstations

A Data Processing Field Workstation (FWS), a dedicated PC- based notebook computer for use at the technical base in the field, was used on this project. The FWS is designed for use with Geosoft Oasis/Montaj Data Processing Software. The FWS has a data replot capability, and may be used to produce pseudo-analog charts from the recorded digital data within less than 12 hours after the completion of a survey flight, if this is necessary. It is also capable of processing and imaging all the geophysical and navigation data acquired during the survey, producing semi-final, preliminary-levelled maps.

The FWS was used to accomplish the following:

- **Quality Control/Digital Data Verification** - flight data quality and completeness were assured by both statistical and graphical means on a daily basis
- **Flight Path Plots** - flight path plots were generated from the GPS satellite data to verify the completeness and accuracy of each day's flying
- **Preliminary Maps -** the Geosoft software system permitted preliminary maps of the Horizontal Magnetic Gradiometer data to be quickly and efficiently created for noise and coherency checks.

One workstation was dedicated to the project, a PC-compatible PENTIUM Notebook microcomputer, a Pentium Centrino 1.6 GHz processor, 1 GB of memory and 60 GB hard disk drive. Data was backed up and stored on CD-ROM on a regular basis. The FWS is fully described in Appendix 3.

Figure 12: Pentium IV Field Workstation

The Montaj software is designed for airborne data editing, compilation, processing and plotting. The software reads the portable data media from the airborne system, checks for gaps, spikes or other defects and permits the data to be edited where necessary. The base station GPS/magnetometer data is checked, edited, processed and then merged with the airborne data. GPS flight path plots are created and plotted for both flight planning and flight path verification. Multi-channel stacked profiles of the recorded and edited data may be produced on a dot-matrix printer or plotter, as required. The software can also be used to carry out flight path recovery, magnetic levelling, filtering, gridding and contouring of data, imaging of gridded data and plotted to any desired map scale and map layout should the facilities be available.

5.2.9 Geo-iMAGe Lite Colour Digital Imaging System

The primary focus of this digital video imaging system is to replace the traditional 8-mm "VCR" with a digital picture recording mechanism. Any standard CD-ROM may be used to view the frame or frames of choice on a computer, using any variety of commercial imagery software, such as ER-MAPPER.

To record digital imagery of the ground over which the aircraft flew, a Dev-Tech Geo-iMAGe-Lite Colour Digital Imaging System, comprised of the following, was provided:

- Stand alone rack mountable mini-computer system, Pentium III 1.0 GHz clock speed c/w 256 MB RAM memory, 20 GB HDD, LCD TFT screen, keyboard and mouse.
- Windows 2000 Professional Operating System and custom software to enable acquisition of .JPG video frames at a resolution of up to 800 x 600 pixel x 256 colours.
- User selectable frame acquisition rate controlled by 1 PPS signal from GPS receiver - from 1 frame to 5 frames per second.
- Sony digital colour video camera with 1/3 inch CCD video element.
- 2.8- to 4-mm focal length auto-iris lens for low-level video acquisition (47^{o} to 96^{o} viewing angle).

5.2.10 Spares

A normal compliment of spare parts, tools, back-up software, and necessary test instrumentation was kept available in the field office.

6. INSTRUMENT CHECKS AND CALIBRATIONS

6.1 Airborne Magnetometer System Tests and Calibrations

6.1.1 Maneuver Noise

As the magnetometer system's sensors, installed in the wingtip pods, are still within the magnetic effect of the aircraft structure, tests were conducted at regular intervals to determine the effects of aircraft roll, pitch and yaw. These tests were carried out at high altitude over an area of low magnetic gradient by carrying out $\pm 10^{o}$ rolls, $\pm 5^{o}$ pitches and $\pm 5^{o}$ yaw maneuvers flown over periods of 4-5 seconds in the same directions as the flight and tie lines. A compensated Figure-of-Merit (FOM) for the aircraft was calculated by summing the peak-to-peak amplitudes of the twelve magnetic signatures. For both sensors the FOM was determined at the commencement of flight operations on flight #1 on April 7, 2004, and flight #20 on May 6, 2004 and again at the end of the survey, flight #55 on May 31, 2004. The FOM on Flight #1 was determined to be 0.739 nT for sensor MAG1, and 0.572 nT for sensor MAG2. On flight #20 MAG1 was 0.86 nT and MAG2 0.94 nT and finally on flight #42 the sensor MAG1 was determined to be 1.45 nT and sensor MAG2 was 1.05 nT. Detailed information about these FOM tests is provided in Appendix 1.

6.1.2 Magnetic Heading Effect

The magnetic heading effect was determined by flying a cloverleaf pattern oriented in the same direction as the survey lines and tie lines on several occasions. At least two passes in each direction were flown over a recognizable feature on the ground in order to obtain sufficient statistical information to estimate the heading error. The heading error was determined before the survey on April 7, 2004, and on May 31, 2004.

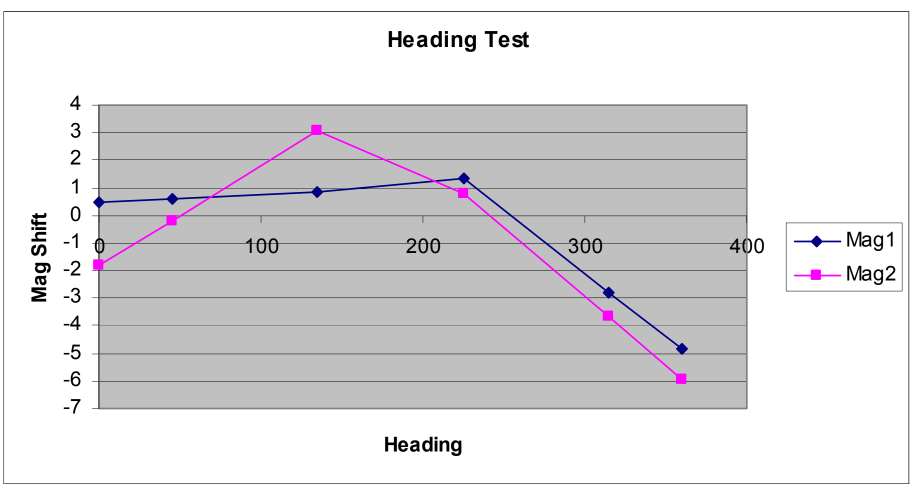


Figure 13: Heading Error Test Results – flight 42, May 31, 2004

Results of these Magnetic Heading tests are provided in Appendix 1.

6.1.3 Lag Tests

Lag tests were performed on April 7, 2004 to ascertain the time difference between the recorded magnetometer readings and the output of the GPS System. Test flights were flown in two directions at survey altitude across distinct anomalies on several occasions during survey operations.

6.1.4 GPS Checks & Tests

In addition to carefully selecting a suitable area for the positioning of the base stations, care was also taken to ensure that the base station GPS antenna maintained a maximum field-of-view to the NAVSTAR satellites, and did not become obstructed due to movement and placement of airport equipment.

6.1.5 Altimeter Calibration Checks

Checks of the radar and barometric altimeter calibration were undertaken at regular intervals during the survey. The calibration was determined by comparing the radar altitude with the Differential GPS altitude and readings from the barometric altimeter during flights at predetermined altitudes. Altimeter calibrations for the start and end of the survey April 7, 2004 and May 20, 2004 are provided in Appendix 1.

6.1.6 Other Daily Checks

The validity of data on all system channels were checked at the start and end of each survey flight, together with the synchronization of each of the systems (airborne and ground).

7. DATA PROCESSING

Daily quality control, initial processing and archiving of the data were done on-site at the base of operations in Koliganek, Alaska. The final data processing, map generation and report writing was undertaken at the offices of McPhar Geosurveys Ltd. in Newmarket, Ontario, Canada.

7.1 Flight Path Compilation

The flight path was derived from differentially corrected GPS positions using the airborne and static GPS data. Differential GPS data editing and processing was accomplished using the GrafNav GPS processing system as developed by WayPoint Navigation, Inc. A position was calculated each 1.0 second (approximately each 60 metres along the flight path) to an accuracy of better than ±1.5 metre. These position data were merged into magnetic and ancillary data in the Geosoft GDB database.

7.2 Base Station Magnetic Data

The magnetometer data from the two base stations was edited, plotted and merged into the GDB database on a daily basis.

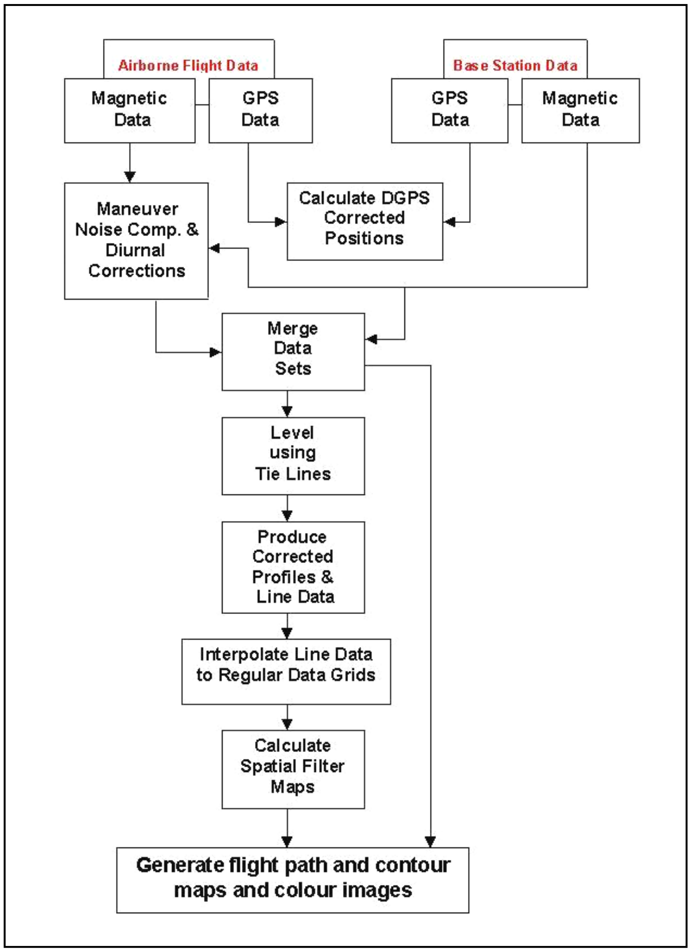


Figure 14: Data Processing Flow Chart

7.3 Measured Horizontal Gradient

In order to obtain values of the measured Horizontal Gradient in nanoTesla/metre, values recorded by the two wing tip magnetometers were subtracted (after applying all necessary corrections), always in the same direction, and the result was divided by the distance between the sensors (12.9 m).

7.4 Corrections to the Magnetic Data

The processing of the Taylor Mountains data involved post-flight compensation for the movement and orientation of the aircraft in the Earth's magnetic field. This corrected dataset was used to generate the initial grids and served as a base for all further processing and analysis. After reviewing the base mag corrected profiles and grids, a decision was made to apply the base station correction to the tie lines only, and further deal with the removal of diurnal variations from the traverse line data by applying the tie line levelling procedure.

7.4.1 Additional corrections applied to profile data

After applying the above-mentioned initial corrections to the profile data there were still some line-direction-related noise present on the calculated grids. To remove this noise, microleveling was applied. Its main purpose is to remove from the data remaining line-direction-related noise. The microleveling technique consists of applying directional and high-pass filters to the resulting grid, which leaves signal with noise-only in the line direction. In order to differentiate between the two of them, the grid is extracted to the profile database, and an amplitude limit and a filter length are determined, so that the final error channel reflects only noise present on the grid without removing or changing geological signal. This error channel is then subtracted from the initial data channel in order to get the final microleveled channel. The resulting grid is then free of line-direction-related noise.

This method was applied to the Total Magnetic Field and Digital Elevation Model Channels. These channels were then subjected to further gridding and spatial filtering.

7.4.2 Gridding

The corrected magnetic line data from each grid was interpolated between survey lines using a random point gridding method to yield x-y grid values for a standard grid cell size of 1/5th of the line spacing. Generally the Minimum Curvature algorithm (MINC) is used to interpolate values onto a regular spaced grid.

8. DELIVERABLE PRODUCTS

8.1 Maps

Two copies of the magnetic field contour map are presented at 1:250,000 scale with UTM registration in black and white, on Mylar.

8.2 Report

This report covers data acquisition and processing, and is provided in two hard copies plus a digital archive in *Microsoft Word* format.

8.3 Digital Archives

Files:	Raw and final processed profile data, and final magnetic grid.
Format:	The ASCII format is used for profiles, and an ASCII Universal Grid Exchange Format (GXF) is used for grids. A full format description is included in the appendix.
Media:	CD-ROM.
Copies:	Two.

9. ONSITE PERSONNEL

The following personnel were onsite crew on the project in Alaska, based out of Koliganek:

		Days Onsite
Data Processor/QC Geophysicist:	Kwame Barko	55
Technician/Operator:	Herman Mueller	55
Pilot:	Rory Brumbaugh	55

9.1 Diary of Personnel Movements

April 7	Crew arrived in Port Alsworth
May 19	Base Station moved from Port Alsworth to Koliganek
May 31	De-mobilization of aircraft, equipment and personnel from Taylor Mountains

9.2 Data Processing Personnel

The following personnel were involved in the Final Data Processing at McPhar's office in Newmarket:

Biljana Milicevic, M.Sc.	Senior Geophysicist / Data Processor
Tonia Bojkova, M.Sc.	Geophysicist / Data Processor

McPhar Geosurveys Ltd.

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Biljana Milicevic, M.Sc.
Senior Geophysicist

APPENDICES

APPENDIX 1 **General - Calibration and Test Results, etc.**

- FOM Calculations
  - April 7, 2004
  - May 6, 2004
  - May 31, 2004
- Altimeter Calibrations
  - April 7, 2004
  - May 20, 2004
- Magnetic Heading Tests
  - April 7, 2004
  - May 6, 2004
  - May 31, 2004
- Processed Database Channel names & Grid Descriptions

APPENDIX 2 **Daily Reports & Weekly Reports**

APPENDIX 3 **Equipment Description**

- Cessna C207 Aircraft
- Geometrics G822A Airborne Cesium Magnetometer
- Billingsley Triaxial Fluxgate Magnetometer
- CCMag Magnetic Compensation Software
- NovAtel Performance GPS receiver
- NovAtel MiLLennium GPS receiver
- Pico Envirotec AGIS-100 Data Acquisition System
- Terra TRA-3000 Radar Altimeter
- Setra 276 Barometric Altimeter
- FWS Field Workstations
- Geosoft Montaj Processing Software
- Waypoint Navigation GrafNav GPS Processing Software
- Geo-iMAGe Lite Colour Digital Imaging System
- GMAG Magnetometer Base Station

APPENDIX 4 **Personnel Resumes**

- Biljana Milicevic, M.Sc.
- Hermann Mueller
- John R. Currie
- Kwame Barko, M.Sc.
- Manuel Vargas
- Timothy R. Borger
- Tonia Bojkova, M.Sc

APPENDIX 5 **Page Sized Map**

APPENDIX 6 **Remote Base Magnetometer Station**

- Report on the Remote Base Station Magnetometer Station
- Report on the Second Remote Base Station Magnetometer

APPENDIX 7 **Flight Logs & Digital Media**