UNITED STATES GEOLOGICAL SURVEY
ALASKA AEROMAGNETIC SURVEY
OPERATIONAL REPORT
Bettles, Alaska
Summer, 2008

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Two DVDs are located in the pockets at end of the main report.
See Appendix E for the list of files.

INTRODUCTION

The following report describes the aeromagnetic survey conducted by Excel Geophysics Inc. (Excel) for the United States Geological Survey (USGS). The survey area was located northwest of Bettles, Alaska in the Brooks Range. The project area covered the Howard Pass and the East half of the Misheguk Mountain quadrangles. The survey was conducted from June 10th 2008, to August 29th 2008, with a total of 9,661.3 miles (15,548.4 km) flown during this project. Figure 1 shows the survey location.

Figure 1: Survey Location - Howard Pass and East Half of Misheguk Mountain

EXCEL GEOPHYSICS

Excel Geophysics Inc. is a Canadian company specializing in the acquisition, processing and interpretation of gravity and magnetic data. Founded in 1989, Excel's head office is in High River, Alberta, with a staff of fifteen people. For airborne geophysical surveys, Excel Geophysics Inc. operates in a partnership with Aries Aviation Remote Sensing Inc. Both companies have decades of geophysical industry experience.

The working relationship between Excel Geophysics and Aries Aviation is a partnership in which all magnetic equipment is jointly owned by both companies. Aries Aviation provides the aircraft, pilots and mechanics to operate the aircraft, while Excel provides the geophysical expertise and project management of the survey. Excel also provides crew to operate the geophysical equipment and is responsible for collecting and processing data.

SAFETY

Each crewmember held current safety certifications in Emergency First Aid, H_2S awareness, and WHMIS. An emergency response plan, containing contact numbers and emergency procedures,

was distributed and explained to all field staff. Safety meetings were held by the field staff on a regular basis to identify any potential safety hazards.

Excel ensured that each member of the crew was equipped with appropriate outdoor wear and first-aid kit. The survey aircraft was maintained on a regular basis and was equipped with a satellite phone, first-aid supplies, fire extinguishers, and emergency beacons. No injuries, accidents or incidents occurred during the course of the survey.

EXCEL PERSONNEL

Excel Geophysics provided an experienced QA/QC geophysicist and two operators / technicians. In addition to the survey operation and data verification functions, the Excel staff were responsible for installation of the system and all related testing. Aries Aviation assigned two experienced pilots and a certified AME.

The geophysical personnel for this project included the following:

Excel Geophysics

Brian Jones, M.Sc., P.Geoph	President
Jessica Pugh, B.Sc.	VP Field Operations
Rob Folkersen, B.Sc. , P.Geoph	Field Operations Manager
Sheldon Kasper, B.Sc.	Technical Operations Manager
Andrew Befus, B.Sc.	Geophysical Operator/ Processor
Logan Turnidge	Geophysical Operator
Sobhi Alhashwa, B.Sc. , Geoph I.T.	Geophysical Data Processor

Aviation

Lloyd Kissack	General Manager
Rory Clayton	Pilot
Bob Harrity	Pilot
Chris Weaver	Pilot
Sebastian Baker	Aviation Maintenance Engineer
Brent Krizan	Aviation Maintenance Engineer

AEROMAGNETIC SURVEY PROCEDURES

This aeromagnetic survey was based in Bettles, Alaska. The survey area was located about 300 km northwest of Bettles, in the Brooks Range. The magnetic base stations were set up at the Ivotuk airstrip less than 10 km east of the project area. The following table outlines the main parameters of the aeromagnetic survey.

Table 1. Aeromagnetic Survey Parameters

General Survey Location	Northwest of Bettles Alaska Latitude: 68°N to 69°N Longitude: 156.0°W to 160.5°W
Survey Duration	June 10 to August 29, 2008
Flight Line Spacing	1 mile (1,600 m) North - South
Tie Line Spacing	5 miles (8 km) East - West
Total Line miles flown	9,661.3 miles (15,548.4 km)
Flying Height	1000 ft (304 m) Drape Above Ground
Base Magnetometer Location	Ivotuk Airstrip 68.48°N, 155.73°W
Type of Aircraft	Navajo PA – 31-310 (C-FFRY) Provided by Aries Aviation

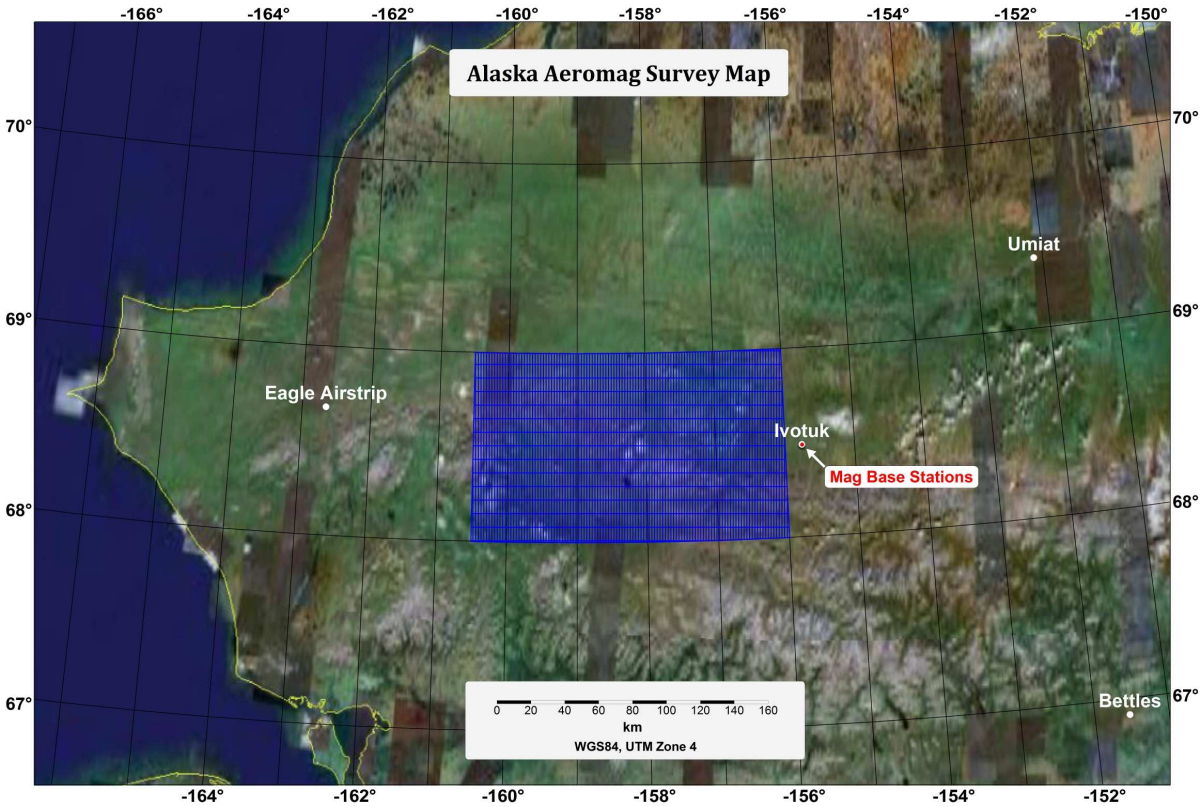

Figure 2: Survey Layout and Base Station Location Map

FLIGHT LOGS

The aircraft was flown from Springbank, Alberta to Bettles, Alaska on June 11th and June 12th 2008. An initial safety flight was conducted where the pilot identified any possible obstacles and evaluated the terrain for possible safety hazards. As well, an FOM flight and a calibration flight for the radar and barometric altimeters were performed prior to data collection. Production flights began on June 14th.

The weather conditions in Alaska during our survey caused significant delays and severely impacted production rates. The final day of data acquisition was August 24th, 2008. The flight logs are shown in Appendix B indicating flight lines, production times, and other relevant information.

INSTRUMENT CALIBRATIONS

Magnetometer

Two calibration flights were flown to define the compensation parameters for this project. Analysis of the calibration, results in a figure of merit value of 0.97 nT. The data are shown in Figure 3.

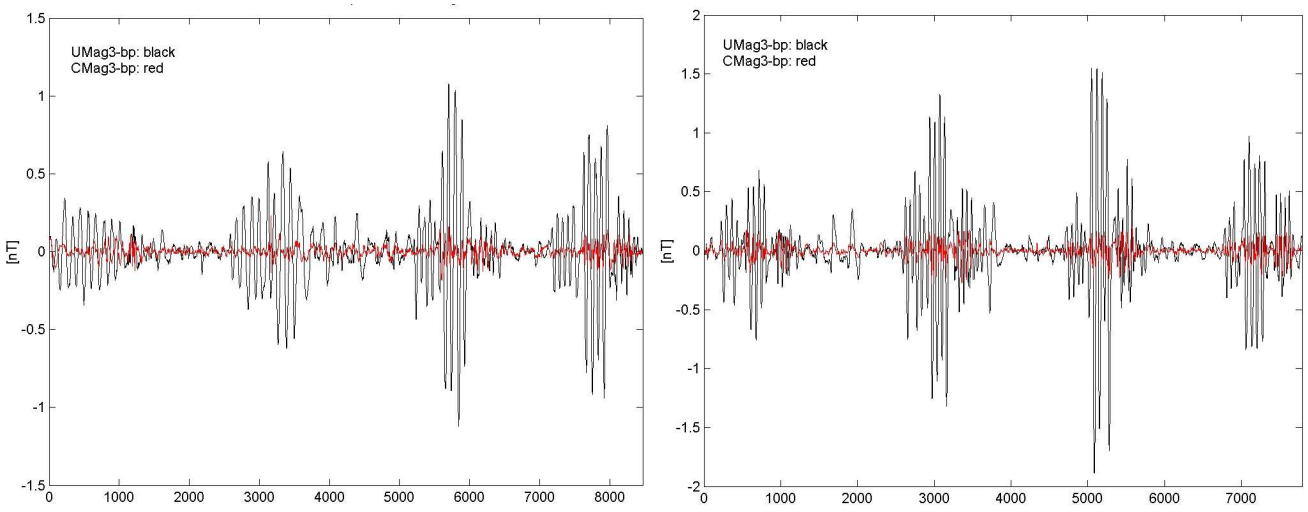

Figure 3: Calibration Flights

Radar Altimeter

The radar altimeter used is a TRT model ERT-011. This altimeter is setup for analog output, DC voltage, linear from 0 to 5000 ft. The manufacturer's equation was used to convert the voltage reading to the height above ground (shown below). Several test flights over the airport confirmed the manufacturer's calibration, as shown in Figure 4.

$$h = 60.96 \times V_{rad}$$

h – Height Above Ground (m).
V_{rad} - Radar Altimeter Voltage (V).

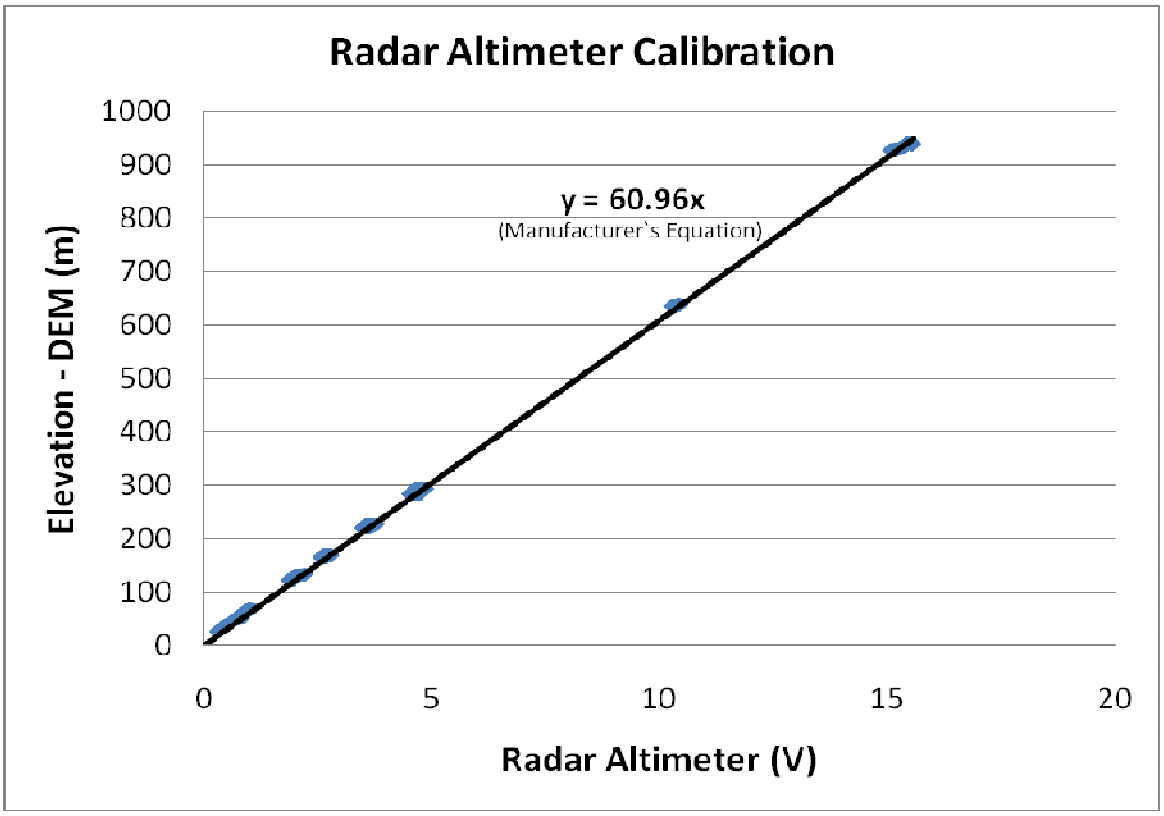

Figure 4: Radar Altimeter Confirmation Flight

The output of the radar altimeter is an analog voltage ranging from 0 to 30 Volts. This analog voltage is converted to a digital value and recorded by the RMS system. The RMS data recorder is restricted to a maximum voltage of 9.99 Volts which corresponds to a height of about 2000 ft or 610 m above ground. For surveys draped at 1000 ft, the 2000 ft altimeter range is usually adequate. However, for the present survey, several deep valleys were too narrow and sharp sided to be closely tracked by the draped survey, and the analog voltage output of the radar altimeter exceeded the recording limitation of the RMS system.

As soon as the USGS alerted us of this problem, a new external logging device capable of recording 0 - 30 V was installed in the plane. The data from this external logging device was used to replace any data which was out of range for the original system. This was an excellent solution to the problem. For 96.6% of the data, the recorded values from the radar altimeter were used. The remaining 3.4% of data, which radar altimeter data was missing for short segments, were scattered throughout the project area. The height above ground for these readings was calculated using the GPS elevation of the plane and the digital elevation model (DEM) for this area. Comparisons of the radar altimeter versus calculated height indicate this is an excellent solution which integrated seamlessly. The radar altimeter data is shown in the final data listing *Alaska-2008-AeromagData.txt*. The 3.4% of readings using a calculated height are indicated with a value of "99" in the voltage column.

Barometric Altimeter

A calibration flight was performed over the Bettles Airstrip on June 14th to calibrate the barometric altimeter. Figure 5 shows the results of the calibration for the barometric altimeter. The best fit line though the flown elevations and the output voltage determined the equation to calculate the pressure at each station. The average atmospheric pressure during each flight was taken from the data given by the weather station at Ambler, AK. The station elevation for each station was calculated from the following formulae.

$$h_m = \frac{\left(288 - 288 \times \left(\frac{P_{stn}}{P_a}\right)^{0.19026}\right)}{0.0065}$$

P_{stn} - *Pressure at Each Station (inHg).*
P_a - *Atmospheric Pressure (inHg).*
h_m - *Station Elevation (m).*
V_{baro} - *Barometric Altimeter Voltage (V).*

$$P_{stn} = 2.9894 \times V_{baro} + 17.389$$

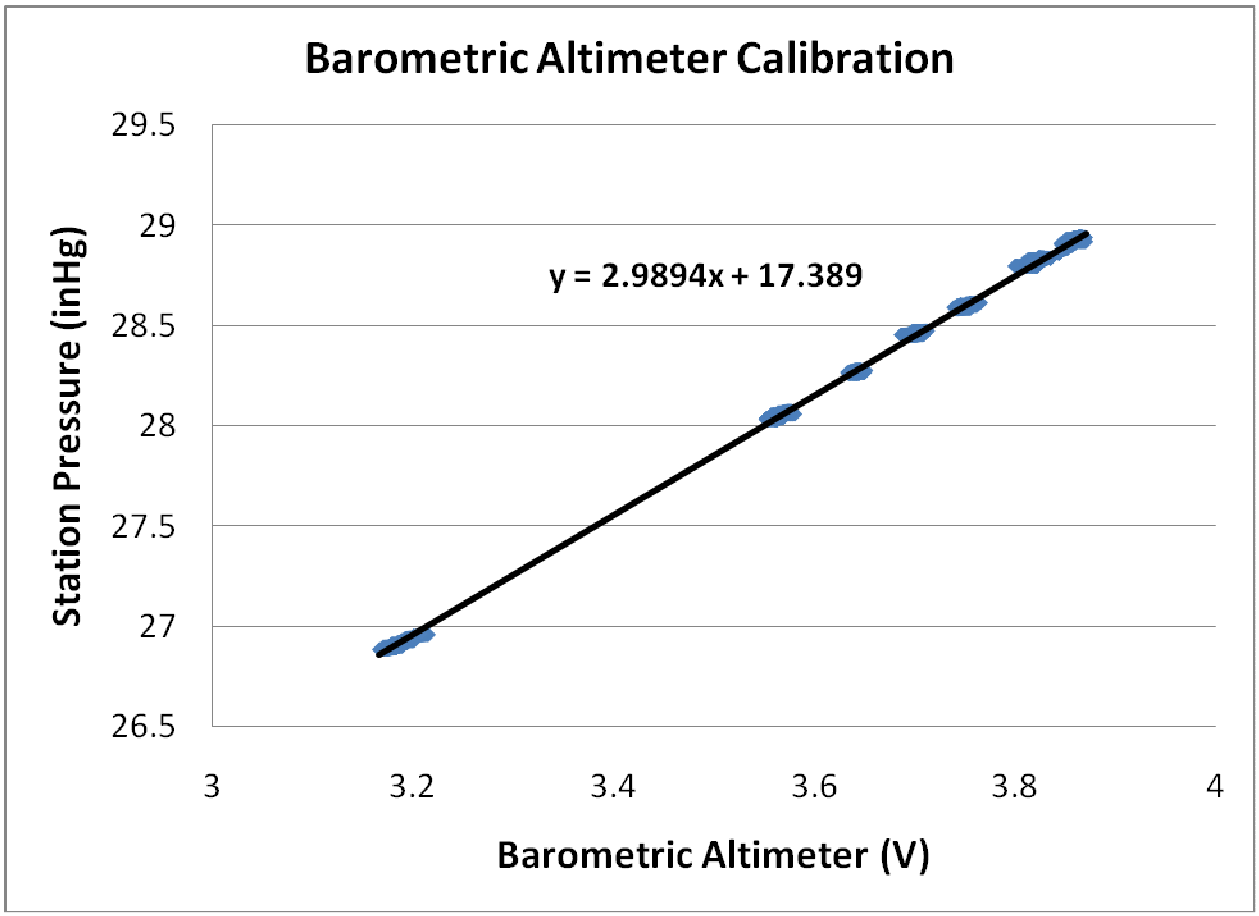

Figure 5: Pressure Versus Voltage Output from the Barometric Altimeter

EQUIPMENT USED

Survey Aircraft

The aircraft used for this survey was a PA-31-310 Navajo (registration C-FFRY), twin engine fixed wing aircraft. The turbocharged twin engine (300 HP each) configuration provided a service ceiling of 26,300 ft (15,800 ft on one engine), 1,395 fpm climb (ISA), and 1,750 ft take off distance over a 50 ft obstacle. The aircraft is capable of performing drape flight and has been specifically modified for geophysical survey work to be magnetically "quiet". The aircraft has been equipped with long range fuel tanks (Nyack) for 7 + hours duration, and is configured with a certified tail stinger, equipment rack and survey power modifications. The aircraft is capable of climb and descent gradients of 6.5%. Survey operations were conducted at an aircraft speed of 120 NM/hr (~210 km/hr).

Survey Equipment

The survey aircraft was equipped with the following instrumentation:

- Three *Geometrics G-822A* high-sensitivity cesium magnetometers installed in the tail boom and wingtip pods.
- A three component *fluxgate magnetometer*.
- *AARC500 compensator and DGR33A Data Acquisition System* from RMS Instruments, including a front-end magnetometer processor with ±0.32 pT resolution and less than ±0.1 pT internal system noise.
- *Novatel GPS receiver* with dual frequency GPS antenna. Uses real-time correction to provide aircraft positioning in real-time.
- *AG-NAV2 navigation equipment* capable of using a 3D preplanned flight path and real time GPS positioning for navigation.
- *Radar altimeter* TRT model ERT-011.
- *Sony DFW-X710* camera featuring a 1/3" CCD that delivers uncompressed, high-resolution, digital color images and features an easy-to-use asynchronous electronic shutter function with an exposure range from 1/100,000 to 17.5 seconds.
- *Setra Model 276 barometric pressure transducer* with a SETRACERAM sensor.

Video

The Sony DFW-X710 video camera was mounted in the center of the plane with a clear view of the ground. Photos were recorded every second and tagged with a GPS position. All video and GPS files are included on the attached DVD.

Navigation System

The onboard GPS unit was a Novatel OEMV GNSS receiver with a dual frequency antenna. The Novatel received CDGPS differential corrections to provide an accuracy of 0.5 m. The onboard navigation system was the AG-NAV2 system which uses the differential GPS data received from the Novatel GPS unit. The Novatel system monitors the GPS satellite signals, calculates corrections, and transmits this corrected “differential” information to the AG-NAV2. Pictures and performance specifications for each of the Novatel and AG-NAV2 units can be seen in Figures 6 to 9.

Figure 6: Novatel OEMV GNSS Receiver

PERFORMANCE *(Subject To GPS System Characteristics)*

Position Accuracy [a]	Standalone:	
	L1 only	1.8 m RMS
	L1/L2	1.5 m RMS
	WAAS:	
	L1 only	1.2 m RMS
	L1/L2	0.9 m RMS
	DGPS	0.45 m RMS
	RT-20	0.20 m RMS
	RT-2	0.01 m + 1 ppm RMS
	CDGPS:	
	L1 only	1.0 m RMS
	L1/L2	0.5 m RMS
	OmniSTAR:	
	VBS	0.7 m RMS (OEMV-1 and OEMV-3 only)
	XP	0.15 m RMS (OEMV-3 only)
	HP	0.10 m RMS (OEMV-3 only)
	Post Processed	5 mm + 1 ppm RMS
Time To First Fix	Hot: 30 s (Almanac and recent ephemeris saved and approximate position)	
	Warm: 40 s (Almanac, approximate position and time, no recent ephemeris)	
	Cold: 50 s (No almanac or ephemeris and no approximate position or time)	
Reacquisition	0.5 s L1 (typical)	
	1.0 s L2 (typical)	(OEMV-2 and OEMV-3 only)
Data Rates	Raw Measurements:	20 Hz
	Computed Position:	20 Hz
	OmniSTAR HP Position:	20 Hz (OEMV-3 only)
Time Accuracy [a b]	20 ns RMS	
Velocity Accuracy	0.03 m/s RMS	
Measurement Precision	C/A code phase	6 cm RMS
	L1 carrier phase:	
	Differential	0.75 mm RMS
	L2 P code	25 cm RMS (OEMV-2 and OEMV-3 only)
	L2 carrier phase:	
	Differential	2 mm RMS (OEMV-2 and OEMV-3 only)
Dynamics	Velocity	515 m/s [c]
	Height	18,288 m [c]

a. Typical values. Performance specifications are subject to GPS system characteristics, U.S. DOD operational degradation, ionospheric and tropospheric conditions, satellite geometry, baseline length and multipath effects.
b. Time accuracy does not include biases due to RF or antenna delay.
c. In accordance with export licensing.

Figure 7: Performance Specs for the Novatel OMEV GNSS Receiver

Figure 8: AG-NAV2 Onboard Navigation System

TECHNICAL SPECIFICATIONS:

***AG-NAV*® 2 Moving Map Display (Computer Unit):**

Processor	Pentium
Data Storage:	60MB Solid State HDD, 1.44MB FDD
I/O ports:	3 RS 232 serial ports, lightbar, remote controls, DGPS
Display:	VGA 640x480 transflective monochrome LCD with keypad, contrast and brightness control (Colour Display Optional)
Control:	Operation via remote 5-position thumb switch
Power Supply:	10-30V DC
Operating Temp:	0°C to 50°C (32°F to 120°F)
Storage Temp:	-20°C to 70°C (-5°F to 155°F)
Dimensions:	22 x 16 x 10cm (8.5" x 6" x 4")
Weight:	2.5kg (5 lb)

Differential Signal Sources:
-Omnistar - World-wide L-Band satellite differential signal coverage
-Landstar - L-Band satellite differential signal coverage
-Coast Guard beacon (where available).
-WAAS – Wide Area Augmentation System

Steering Indicators: (see also Optional Lightbars)

Large Brightbar:

Display:	24 left/right, 10 status ultra bright LED lights with 2 discrete data display areas
Main Features:	Direction, approach, in/out area, two Discrete user selectable data display areas
Mounting:	Outside
Dimensions:	35 x 6 x 15cm (13.5" x 2.25" x 6")
Weight:	1.5kg (3.5 lb) with mounting hardware

Pilot Indicator Display:

Display:	Two line, 40 character LCD, with backlight
Main Features:	Cross-track or angle-of-intercept, spray on/off, four discrete user selectable data display areas
Mounting:	Inside only, for use in helicopters and short-nosed aircraft
Dimensions:	22 x 4 x 6cm (8.5" x 1.5" x 1")
Weight:	0.25kg (8oz)

Figure 9: Performance Specs for the AG-NAV2 Navigation System

Ground Magnetometer

Excel set up two remote reading GSM-19 Overhauser magnetometers about 9 km east of the project area at the Ivotuk airstrip to continuously monitor the magnetic field throughout the project. The GSM-19 has a resolution of 0.01 nT and 0.2 nT absolute accuracy over its full temperature range. Synchronization was maintained through GPS time. The base station unit is shown in Figure 10.

Figure 10: GSM-19 Base Magnetometer

The survey area was extremely remote; over 300 km from the nearest town Bettles, AK, where the crew was based. The base stations were designed to operate unmanned in order to have them located close to the project area. The magnetic base station system was setup with batteries attached to a solar panel power source which maintained power for the entire duration of the survey. The systems were set to automatically upload data to the field computers and transmit the data to the Excel office in High River by connecting every six hours to an ftp site via satellite modem. This remote setup allowed data to be sent on a daily basis with no operator on site. The set up of the base magnetometer systems are shown in Figure 11. The base stations were visited by the survey crew periodically to maintain and create data backups. After retrieving the data in the office from the ftp site, the data were examined for magnetic storms and anomalies.

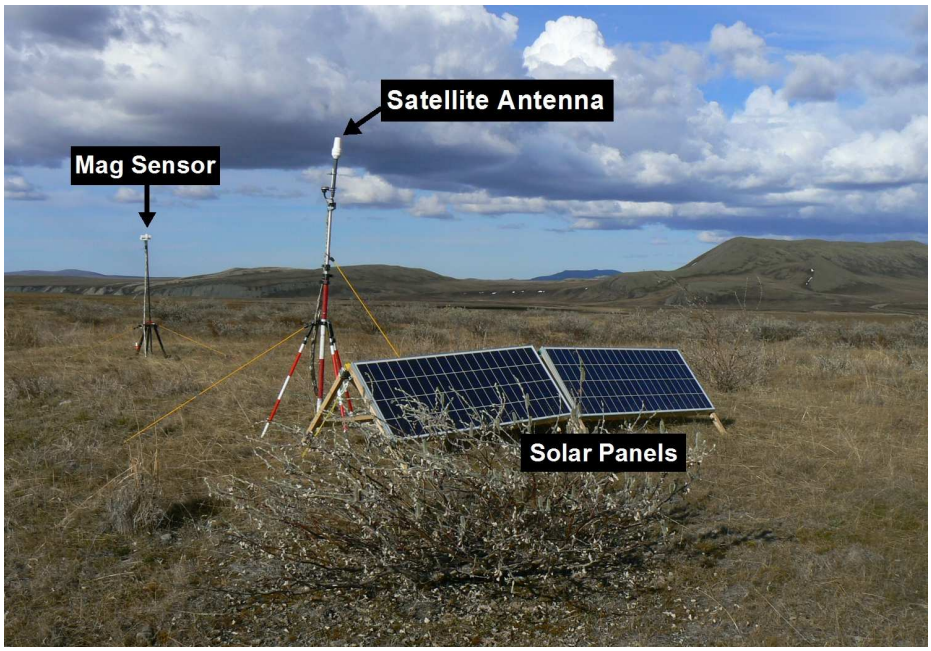

Figure 11: Setup of the GSM- 19 Base Magnetometers at Ivotuk

Four neighboring permanent magnetometer stations were monitored in addition to Excel's two base stations setup at Ivotuk. These permanent base stations were operated by the Geophysical Institute at the University of Alaska. The K-Index recorded at CIGO (near Fairbanks, AK) was also monitored to track magnetic activity. Figure 12 shows the location of the Excel base stations relative to the four neighboring sites (Bettles, Fort Yukon, Poker Flat, and CIGO).

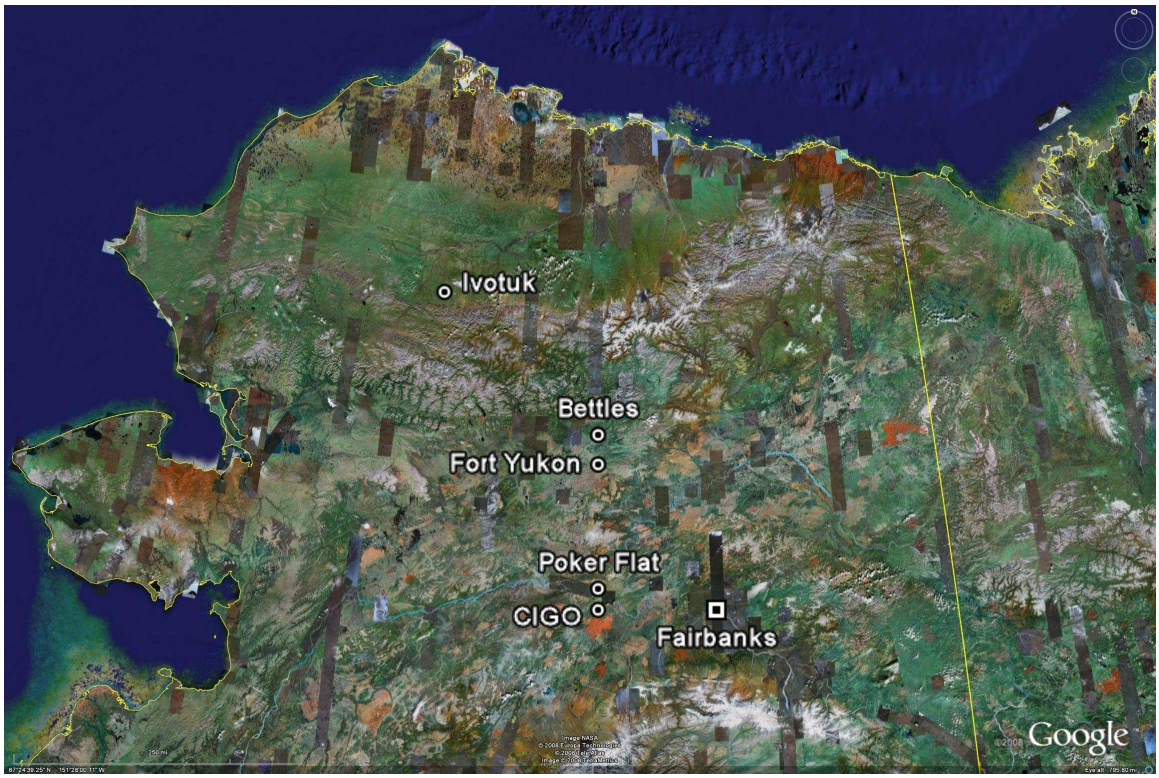

Figure 12: Location of Permanent Magnetic Stations

A study comparing the Excel base station data to the published data from the Geophysical Institute base magnetometers shows that the data have the same general trends. If the magnetic field is relatively stable, all base stations show low magnetic activity. If there is high magnetic activity and/or storms, all the base stations show the increased activity. The K-Index also peaks during high magnetic activity periods. Figure 13 shows a sample of data collected by the magnetometers along with the K-Index.

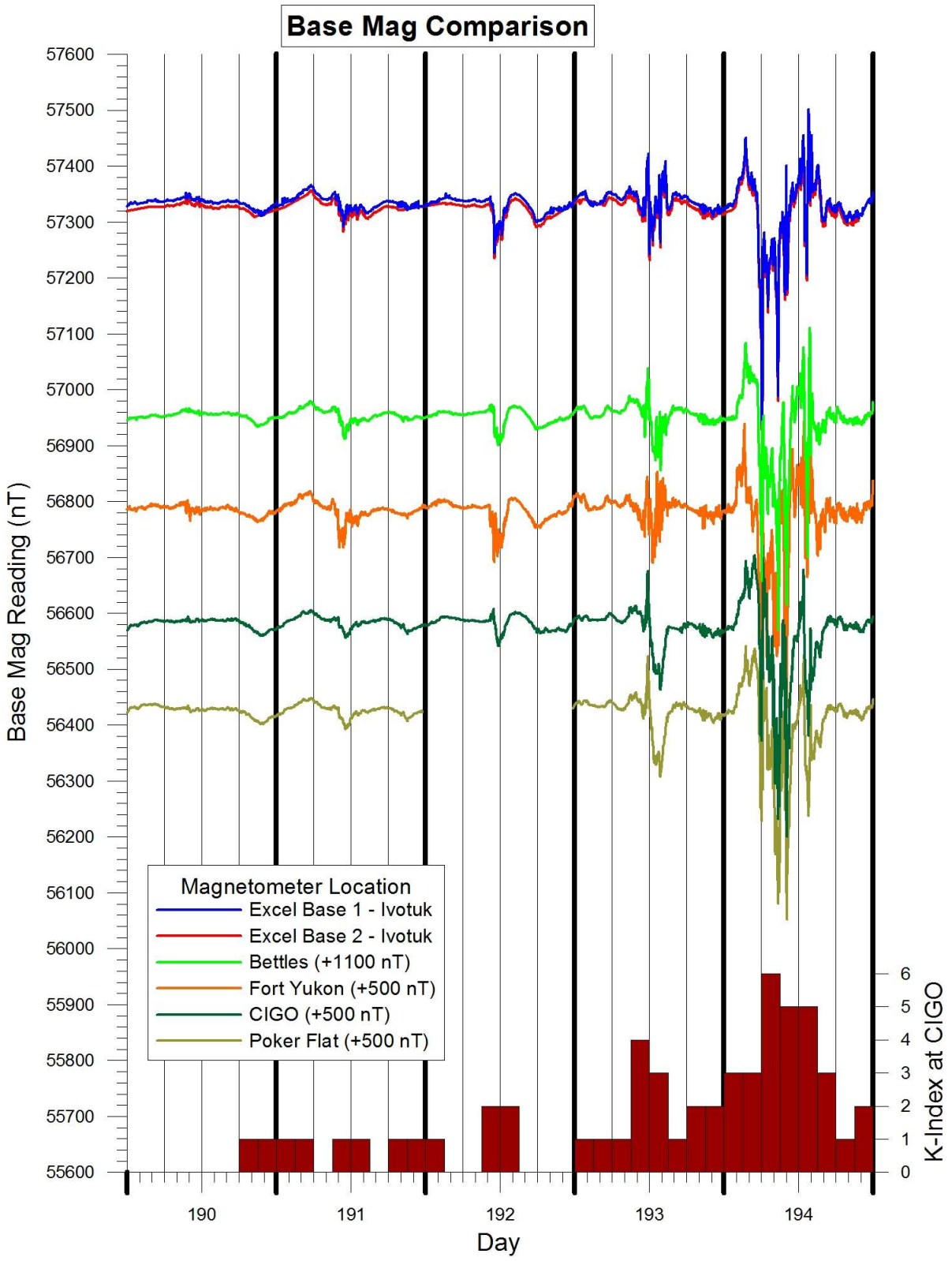

Figure 13: Comparison of Magnetic Data from Different Magnetometers

The remote magnetic base station systems provide not only magnetic and time readings but data quality measures of which only the highest quality data were used for processing. Minor concerns were noted in some of the base station files where the data quality would drop during the day for brief periods of time (typically less than 15 minutes). Investigations determined that the source of the interference was the solar array inverters. This problem was corrected by disabling the voltage chopper circuit of the battery charger. The voltage chopper operated intermittently only when the batteries were approaching complete charge under full sunlight. Chopping was not applied early in the charge procedures when full solar power was applied to the batteries, and once fully charged, the solar arrays were turned completely off. The chopper related magnetic noise was intermittent and limited in duration. Numerous samples of good magnetic data occurred throughout these limited windows.

If the surrounding permanent magnetometer stations all indicated that the magnetic field was quiet and stable (well within the survey specifications for monotonic and periodic changes), then the diurnals were interpolated during these periods with interference. Otherwise, the noisy intervals were reflown. All interpolated diurnal values are flagged in the data listings. Typically, the interpolation interval was less than one minute. The maximum interpolated interval was 15 minutes. This problem did not affect any data acquired after July 10, 2008.

DATA AQUISITION AND PROCESSING PROCEDURES

Magnetic Data Reduction

Ground magnetometer data were collected at one second intervals during airborne data acquisition in order to monitor magnetic diurnal. Preliminary processing for onsite quality control was performed as each flight was completed. The ground magnetometer data were plotted and checked for evidence of magnetic storms or short term anomalous magnetic activity. Approximately, 25% of the lines were repeated for this survey. Most of these reflights were due to magnetic diurnal activity beyond the survey specifications.

A datum of 57,270 nT was chosen for the survey and was subtracted from the base magnetometer data. The base data were then combined with the airborne magnetometer data using GPS time to synchronize the two data sets. The airborne magnetic data were recorded at an interval of 0.05 seconds (20 Hz). The base station data, which were recorded at an interval of one second, were interpolated to match the airborne sample rate. The airborne magnetometer data were corrected for diurnal variations by subtracting the base magnetometer value corrected for the datum. The ground magnetometer data were filtered using a sixth-order, 45-point Savitzky-Golay low pass smoothing filter before diurnal subtraction to remove data spikes. The raw, filtered and final values for each reading are included in the data listing. The International Geomagnetic Reference Field 2005 was calculated for each reading and removed.

Once the airborne data had been corrected for diurnal and had the IGRF-2005 removed, they were filtered using a sixth-order, 67-point Savitzky-Golay low pass filter. Finally, the airborne data were leveled using a proprietary program. Final micro-leveling techniques were then applied to the data to remove minor residual variations.

The semi-automated magnetic data leveling system used includes:

1. Tabulation of magnetic data at flight line/tie line intersections, along with flight altitude data;
2. Network analysis of intersection data, based on minimizing the root mean square of the differences and closure errors, to obtain suggested leveling adjustments;
3. Manual analysis of computer suggested corrections, based on magnetic gradients at the intersections and the flight altitude differences;
4. Application of leveling corrections; and
5. Revision of leveling corrections using imaging techniques.

The diurnal and leveling corrections for each data reading are included in the data listing.

The total field magnetic data grid was created using a kriging algorithm.

DATA QUALITY

The leveling corrections applied to the dataset were reasonable. The standard deviation of the corrections is 2.85 nT. This agreement in the line intersections indicates high quality navigation and excellent magnetic data quality. Figure 14 shows a histogram of the leveling corrections applied.

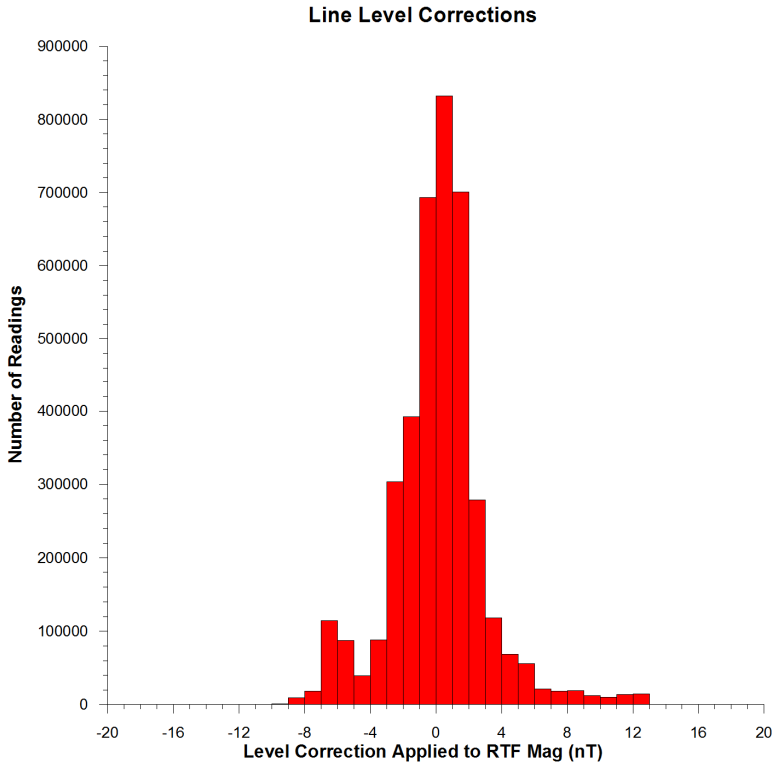

Figure 14: Histogram of Level Corrections

The horizontal distances between the flown elevations and the pre-planned line layout were well within the survey specifications for the entire survey. Figure 15 displays a histogram of the difference in vertical distance between the flown elevations and the pre-planned draped survey (actual – planned). The specified vertical difference for this survey was 0 ± 61m. 97.6% of the data is within this specification. For the remaining 2.4% of the data it was neccessary to deviate from the preplanned drape due to significant terrain changes and the rugged nature of the area. Pilots discrecion was used to safely navigate these rugged areas with steep terrain.

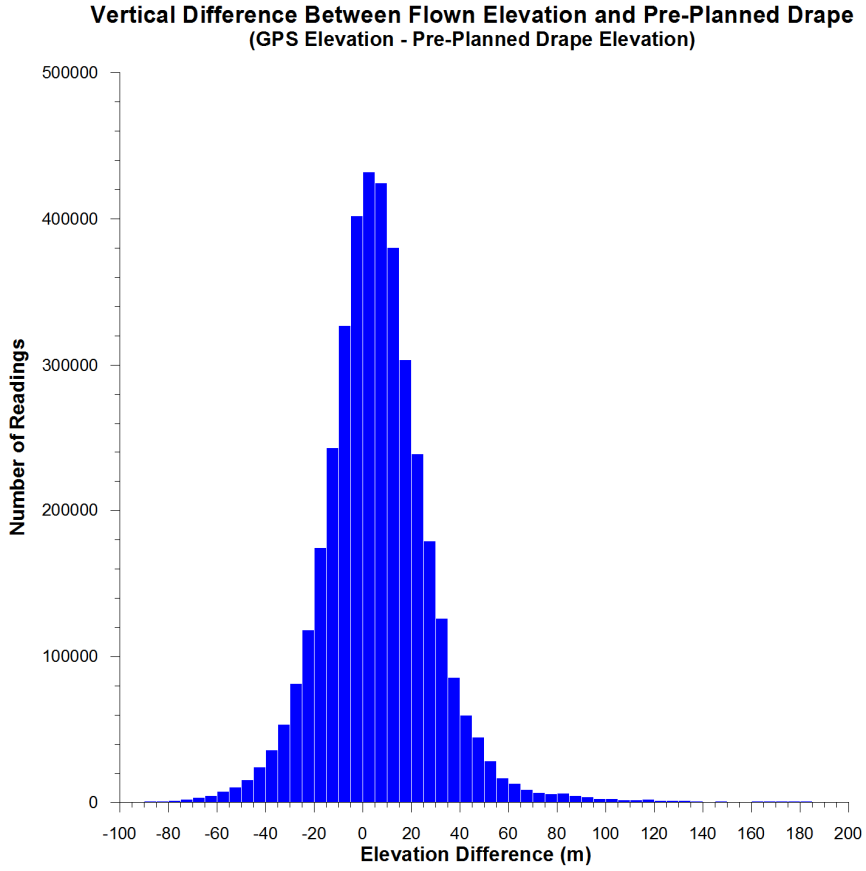

Figure 15: Distance Between Flown and Pre-Planned Drape Elevation

SUMMARY

No incidents or accidents occurred on this project. Weather was the major obstacle to overcome throughout this survey. Cloud cover and fog caused significantly more weather days than expected. The crew was stationed in Bettles for almost three months and was grounded for more than 68% of the time due to weather. This completely destroyed the economics of this project. Magnetic storms in comparison posed only minor concerns. The rugged terrain and remote location of the survey were anticipated and were not a factor in production.

APPENDIX A - PROJECTION AND DATUM CONVERSION METHODS

The coordinate system used for mapping purposes is UTM Zone 4 (WGS 84). Parameters for the coordinate system are shown in Table 3

Table 2. UTM Zone 4 Mapping Parameters

Project Mapping System	
Datum	NAD 83
Ellipsoid	WGS 84
Latitude of Origin	Equator, 0º
Central Meridian	159º W
Grid Projection	UTM Zone 4
Scale Factor	0.9996
False Easting	500,000.0 m
False Northing	0.0 m

Ellipsoids:	WGS 84
Semi-major axis	6,378,137.0 m
Semi-minor axis	6,356,752.3 m

Data was collected as WGS 84 coordinates. The NADCON transformation was used to convert these data from WGS 84 to NAD 27.

APPENDIX B – FLIGHT LOGS

Table 3. Flight Logs

Date	Flight No.	Line	Line Start Time	Line Start Position (UTM)	Line End Time	Line End Position (UTM)	Wheels Up	Wheels Down
06/14/08	ALTIM001	ALT	Altimeter Calibration Flight				N/A	N/A
06/14/08	FOM00002	FOM	FOM Flight				N/A	N/A
06/14/08	COMPB002	COMP	Compensation Box Flight				N/A	N/A
06/14/08	AK14JUN1	1180	1151	7537848	1159	7568965	N/A	N/A
06/14/08	AK14JUN2	1170	1443	7544554	1453	North	1339	1753
		1160	1502	North	1521	South		
		1150	1523	South	1543	North		
		1140	1547	North	1612	South		
		1130	1614	South	1634	North		
		1120	1638	North	1702	7542488		
06/15/08	AK15JUN1	3140	1046	East	1100	561900	0937	1323
		3130	1106	569700	1116	East		
		1110	1124	North	1138	758300		
		1100	1146	758700	1200	North		
		1090	1205	North	1216	760100		
06/17/08	Weather Check						0853	N/A
06/19/08	AK19JUN1	3120	1104	East	1141	West	0927	1754
		3130	1145	West	1211	East		
		3140	1214	569400	1241	West		
		3110	1249	461900	1321	East		
06/20/08	FOM00003	FOM	FOM Flight				0930	N/A
06/21/08	AK21JUN1	1110	1044	7586600	1052	South	0940	1401
		1100	1055	South	1105	7588000		
		1090	1108	7601000	1117	South		
		1080	1120	South	1141	North		
		1070	1144	North	1230	South		
		1060	1235	North	1303	South		
06/23/08	AK23JUN1	1050	1215	South	1238	North	0943	1455
		1040	1241	North	1302	7562000		
		1000	1309	South	1331	North		
		0990	1333	North	1352	7569900		
		0920	1401	South	1422	North		
		0910	1424	North	1448	South		
06/24/08	AK24JUN1	1040	1035	763400	1041	760400	0935	1237
		3100	1050	East	1108	517000		
		3090	1113	530700	1135	East		
06/25/08	Weather Check						0930	N/A
06/27/08	Weather Check						1935	N/A

Date	Flight No.	Line	Line Start Time	Line Start Position (UTM)	Line End Time	Line End Position (UTM)	Wheels Up	Wheels Down
06/29/08	AK29JUN1	1040	1247	South	1258	North	1031	1556
		0990	1310	North	1319	South		
		1010	1324	South	1343	North		
		1020	1345	North	1409	South		
		1030	1411	South	1435	North		
		0980	1438	North	1509	South		
06/29/08	AK29JUN2	3010	1743	East	1821	West	1650	2100
		0020	1829	South	1842	North		
		0030	1853	North	1916	South		
		3020	1924	West	2000	East		
07/02/08	AK02JUL1	3030	1041	East	1118	West	0952	1423
		0040	1127	South	1151	North		
		0050	1153	North	1216	South		
		0060	1218	South	1241	North		
		3110	1252	West	1305	East		
07/02/08	AK02JUL2	0880	1806	South	1829	North	1630	2046
		0890	1832	North	1856	South		
		0950	1904	South	1928	North		
		0960	1930	North	1952	South		
07/03/08	AK03JUL1	3040	1130	East	1211	West	1043	1514
		0070	1220	South	1244	North		
		0080	1246	North	1309	South		
		0090	1311	South	1335	North		
07/03/08	AK03JUL2	3050	1720	East	1755	West	1624	2115
		0100	1808	South	1831	North		
		0110	1835	North	1857	South		
		0120	1900	South	1923	North		
		0130	1926	North	1948	South		
07/04/08	AK04JUL1	3060	1040	East	1116	West	0948	1428
		0140	1129	South	1152	North		
		0150	1155	North	1218	South		
		0160	1220	South	1243	North		
		0170	1246	North	1309	South		
07/06/08	AK06JUL1	0180	0827	South	0851	North	0657	1123
		0190	0854	North	0916	South		
		0200	0918	South	0942	North		
		0210	0945	North	1008	South		
07/07/08	AK07JUL2	0220	0820	South	0851	North	0709	1157
		0230	0853	North	0918	South		
		0240	0921	South	0943	North		
		0250	0946	North	1011	South		
		0260	1014	South	1035	North		

Date	Flight No.	Line	Line Start Time	Line Start Position (UTM)	Line End Time	Line End Position (UTM)	Wheels Up	Wheels Down
07/08/08	AK08JUL1	3070	0840	East	0921	West	0714	1204
		0270	0939	North	1005	South		
		0280	1007	South	1028	North		
		0290	1030	North	1056	South		
07/09/08	**Weather Check**						0921	1023
07/09/08	**Weather Check**						1604	1711
07/10/08	AK10JUL1	1070	0919	South	0942	North	0743	1157
		1060	0945	North	1010	South		
		0900	1017	South	1022	7570000		
		0900	1026	7587000	1040	North		
		0870	1043	North	1101	7580000		
07/10/08	AK10JUL2	0300	1800	South	1822	North	1638	2052
		0310	1824	North	1848	South		
		0320	1850	South	1912	North		
		0330	1914	North	1938	South		
07/15/08	**Weather Check**						1329	1424
07/20/08	**Weather Check**						0208	255
07/23/08	AK23JUL1	0540	0820	7538192	0830	7592574	0811	1046
07/24/08	AK24JUL1	0340	0639	South	0703	North	0526	1021
		0350	0705	North	0729	South		
		0360	0731	South	0754	North		
		0370	0757	North	0820	South		
		0380	0822	South	0845	North		
		0390	0848	North	0911	South		
07/24/08	AK24JUL2	0860	1344	7666777	1409	South	1106	1618
		0850	1412	South	1435	North		
		0840	1438	North	1503	South		
		0870	1505	South	1516	North		
		0900	1519	North	1524	7558651		
07/25/08	AK25JUL1	3080	0702	East	0742	West	0611	1111
		3090	0745	West	0804	532000		
		3100	0806	531000	0825	West		
		0400	0843	North	0908	South		
		0410	0910	South	0931	North		
		0420	0933	North	0959	South		

Date	Flight No.	Line	Line Start Time	Line Start Position (UTM)	Line End Time	Line End Position (UTM)	Wheels Up	Wheels Down
07/25/08	AK25JUL2	0680	1432	7535848	1457	North	1324	1823
		0670	1458	North	1528	South		
		0660	1530	South	1554	North		
		0650	1555	North	1624	South		
		0640	1626	South	1650	North		
		0630	1652	North	1721	7540651		
07/30/08	AK30JUL1	0820	1810	7543428	1835	North	1709	2210
		0830	1836	North	1901	South		
		0930	1903	South	1928	North		
		0940	1931	North	1956	South		
		0970	1959	South	2020	7658411		
08/03/08	**Weather Check**						1235	1537
08/07/08	AK07AUG1	0430	1038	South	1101	North	0929	1415
		0440	1103	North	1127	South		
		0450	1129	South	1152	North		
		0460	1154	North	1217	South		
		0470	1220	South	1243	North		
		0480	1245	North	1307	South		
08/07/08	AK07AUG2	0810	1832	7662403	1855	South	1544	2135
		0800	1857	South	1921	North		
		0790	1922	North	1945	South		
		0780	1947	South	2012	North		
		0770	2013	North	2029	7586000		
		0770	2031	7576000	2036	7543083		
08/08/08	AK08AUG1	0490	1136	South	1147	7596000	1029	1337
		3050	1209	North	1227	5223000		
08/13/08	CB000003	COMP	**Compensation Box Flight**				0930	1152
08/16/08	**Weather Check**						1912	1923
08/18/08	AUG18CAL	ALT	**Altimeter Calibration Flight**				1258	1451
08/20/08	AK20AUG1	0490	0716	South	0739	North	0605	1053
		0500	0741	North	0805	South		
		0510	0807	South	0831	North		
		0520	0832	North	0856	South		
		0530	0858	South	0921	North		
		0540	0923	North	0946	South		

Date	Flight No.	Line	Line Start Time	Line Start Position (UTM)	Line End Time	Line End Position (UTM)	Wheels Up	Wheels Down
08/20/08	AK20AUG2	0550	1245	South	1310	North	1140	1625
		0560	1312	North	1336	South		
		0570	1337	South	1400	North		
		0580	1402	North	1426	South		
		0590	1428	South	1457	North		
		0600	1453	North	1517	South		
08/21/08	AK21AUG1	0610	0713	South	0737	North	0618	1033
		0620	0739	North	0803	South		
		0690	0806	South	0831	North		
		0700	0832	North	0856	South		
		0710	0857	South	0921	North		
		0720	0923	North	0946	South		
08/21/08	AK21AUG2	0730	1226	7539905	1257	North	1125	1554
		0740	1253	North	1316	South		
		0750	1317	South	1343	North		
		0760	1344	North	1407	South		
		0770	1409	South	1422	North		
		1120	1440	7660956	1504	7541715		
08/22/08	AK22AUG1	3050	0725	522502	0749	624435	636	1058
		1180	0800	South	0807	North		
		1170	0813	North	0824	South		
		1160	0826	South	0844	North		
		1150	0852	North	0916	South		
		1140	0917	South	0941	North		
		1130	0943	North	1006	South		
08/22/08	AK22AUG2	3080	1241	West	1317	East	1138	1655
		170	1332	South	1357	North		
		340	1404	North	1427	South		
		350	1429	South	1454	North		
		3140	1506	West	1547	East		
08/23/08	AK23AUG1	1100	0750	South	0814	North	0658	1055
		1030	0817	North	0841	South		
		1020	0843	South	0907	North		
		980	0909	North	0933	South		
		990	0937	7545037	0944	7581999		
		1040	0956	7579999	1003	7545137		
08/24/08	AK24AUG1	3110	0957	East	1040	West	0852	1410
		370	1053	North	1117	South		
		360	1119	South	1142	North		
		3130	1157	North	1233	South		
		1010	1240	North	1305	South		
08/24/08	AK24AUG2	3120	1558	East	1640	West	1453	1822
		30	1646	North	1710	South		
		20	1715	South	1726	North		

APPENDIX C – LENGTH OF SURVEY LINES

Table 4. Length of Survey Lines

Line No.	Distance (km)	Distance (mi)	Line No.	Distance (km)	Distance (mi)
20	66.99	41.63	*350*	112.54	69.93
30	112.56	69.94	*360*	112.52	69.92
40	112.58	69.95	*370*	112.52	69.92
50	112.58	69.96	*380*	112.52	69.92
60	112.58	69.95	*390*	112.49	69.90
70	112.56	69.94	*400*	112.52	69.92
80	112.57	69.95	*410*	112.53	69.92
90	112.58	69.95	*420*	112.18	69.71
100	112.55	69.94	*430*	112.52	69.92
110	112.56	69.94	*440*	112.51	69.91
120	112.56	69.94	*450*	112.51	69.91
130	112.59	69.96	*460*	112.51	69.91
140	112.55	69.94	*470*	112.55	69.94
150	112.55	69.94	*480*	112.36	69.82
160	112.56	69.94	*490*	112.50	69.90
170	112.55	69.94	*500*	112.50	69.90
180	112.55	69.93	*510*	112.50	69.91
190	112.54	69.93	*520*	112.50	69.90
200	112.55	69.94	*530*	112.50	69.90
210	112.54	69.93	*540*	112.44	69.87
220	112.54	69.93	*550*	112.50	69.90
230	112.54	69.93	*560*	112.50	69.91
240	112.54	69.93	*570*	112.50	69.90
250	112.54	69.93	*580*	112.50	69.90
260	112.54	69.93	*590*	112.50	69.90
270	112.54	69.93	*600*	112.50	69.90
280	112.54	69.93	*610*	112.50	69.90
290	112.55	69.93	*620*	112.50	69.90
300	112.82	70.10	*630*	112.51	69.91
310	112.57	69.95	*640*	112.51	69.91
320	112.68	70.02	*650*	112.52	69.91
330	112.36	69.82	*660*	112.51	69.91
340	112.53	69.92	*670*	112.51	69.91

Line No.	Distance (km)	Distance (mi)	Line No.	Distance (km)	Distance (mi)
680	112.49	69.90	*1030*	112.45	69.87
690	112.49	69.90	*1040*	112.51	69.91
700	112.49	69.89	*1050*	112.46	69.88
710	112.49	69.90	*1060*	112.45	69.87
720	111.97	69.58	*1070*	112.45	69.87
730	112.49	69.89	*1080*	112.46	69.88
740	112.48	69.89	*1090*	112.45	69.88
750	112.49	69.90	*1100*	112.44	69.86
760	112.48	69.89	*1110*	112.64	69.99
770	112.52	69.92	*1120*	112.44	69.87
780	112.48	69.89	*1130*	112.24	69.74
790	112.48	69.89	*1140*	112.44	69.87
800	112.49	69.90	*1150*	112.43	69.86
810	112.47	69.89	*1160*	84.64	52.59
820	112.48	69.89	*1170*	53.62	33.32
830	112.48	69.89	*1180*	30.97	19.24
840	112.48	69.89	*3010*	189.24	117.59
850	112.47	69.89	*3020*	188.72	117.26
860	112.47	69.88	*3030*	188.13	116.90
870	112.47	69.88	*3040*	187.59	116.56
880	112.47	69.89	*3050*	187.09	116.25
890	112.47	69.89	*3060*	186.46	115.86
900	112.55	69.94	*3070*	185.95	115.54
910	112.48	69.89	*3080*	185.38	115.19
920	112.49	69.90	*3090*	185.38	115.19
930	112.47	69.89	*3100*	184.35	114.55
940	112.51	69.91	*3110*	183.74	114.17
950	112.47	69.88	*3120*	183.27	113.88
960	112.46	69.88	*3130*	182.64	113.49
970	112.50	69.90	*3140*	182.23	113.23
980	112.45	69.87	**TOTAL**	**15548.40**	**9661.33**
990	112.48	69.89			
1000	112.47	69.88			
1010	112.09	69.65			
1020	112.44	69.87			

APPENDIX D – SAMPLE LISTING OF DATA FILES

Aeromagnetic Data

Alaska-2008-AeromagData.txt

Line	Flight Direction (Degrees From North)	Longitude (WGS-84)	Latitude (WGS-84)	Longitude (NAD-27)	Latitude (NAD-27)
20	0	-160.46108	67.99591	-160.45741	67.99642
20	0	-160.46107	67.99595	-160.45740	67.99646
20	0	-160.46107	67.99599	-160.45740	67.99650

UTMx (m ,WGS-84, Zone 4N)	UTMy (m, WGS-84, Zone 4N)	UTMx (m, NAD-27, Zone 4N)	UTMy (m, NAD-27, Zone 4N)	Fiducial
438913.9	7543130.6	439066.0	7543001.2	72818685
438914.2	7543134.8	439066.3	7543005.3	72818735
438914.5	7543138.9	439066.6	7543009.5	72818785

Year/Julian Date (YYYY/DDD, GMT)	Time (HHMMSS.SS, GMT)	Radar Altimeter Reading (V)	Height Above Ground (Radar Altimeter, m)
2008/238	011152.35	5.64	344.1
2008/238	011152.40	5.64	343.9
2008/238	011152.45	5.64	343.8

Barometric Altimeter Reading (V)	Barometric Altitude (m)	GPS Elevation (m)	Base Mag Reading (nT)	Filter Applied to Base Mag (nT)
3.31	660.0	657.4	57340.48	0.00
3.31	660.9	657.5	57340.48	0.00
3.30	661.6	657.7	57340.48	0.00

Base Mag Filtered (nT)	Diurnal (nT)	IGRF-2005 Value (nT)	Raw Uncompensated Mag (nT)	Compensated, Uncorrected Mag (nT)
57340.48	70.48	56891.08	56779.76	56814.14
57340.48	70.48	56891.09	56779.77	56814.15
57340.48	70.48	56891.09	56779.77	56814.16

Mag, Diurnal Corrected (nT)	Residual Total Field Mag (Diurnal & IGRF Corrected, nT)	Filter Applied to RTF Mag (nT)
56743.66	-147.42	0.00
56743.67	-147.41	0.00
56743.68	-147.41	0.00

Level Correction Applied to RTF Mag (nT)	Final Mag Value (Residual Total Field, After Filtering & Leveling, nT)
3.10	-144.32
3.10	-144.31
3.10	-144.31

Base Magnetometer Data

MagBase-167-AK15JUN1.txt

Year/Julian Date (YYYY/DDD, GMT)	Time (HHMMSS, GMT)	Base Magnetometer Value (nT)	Reading/Interpolated
2008/167	180000	57264.52	RDG
2008/167	180001	57264.56	RDG
2008/167	180002	57264.62	RDG

APPENDIX E - LIST OF FILES SUPPLIED

2 DVDs

DVD 1 - Final Data

A. Final Report
1. USGS Alaska Aeromag 2008 Operational Report.pdf
2. Explanatory Text of Operational Report.pdf

B. Aeromag Data
1. Alaska-2008-AeromagData.txt
2. Alaska-2008-AeromagData-ReadMe.txt

C. Aeromag Grids
1. Alaska-2008-AeromagMap.gxf
2. Alaska-2008-AeromagMap-Uncompressed.gxf
3. Alaska-2008-RadarAltimeterValues.gxf
4. Alaska-2008-RadarAltimeterValues-Uncompressed.gxf
5. Alaska-2008-AeromagGrids-ReadMe.txt

D. Maps
1. Alaska-2008-AeromagMap.jpg
2. Alaska-2008-AeromagMap-Color.jpg
3. Alaska-2008-AeromagMap-8kmResidual.jpg
4. Alaska-2008-RadarAltimeterMap.jpg

DVD 2 - Raw Data

A. Aeromag Raw Data
1. AK14JUN1.dat
2. AK14JUN2.dat
3. AK15JUN1.dat
4. AK19JUN1.dat
5. AK21JUN1.dat
6. AK23JUN1.dat
7. AK24JUN1.dat
8. AK29JUN1.dat
9. AK29JUN2.dat
10. AK02JUL1.dat
11. AK02JUL2.dat
12. AK03JUL1.dat
13. AK03JUL2.dat
14. AK04JUL1.dat
15. AK06JUL1.dat
16. AK07JUL1.dat
17. AK08JUL1.dat

18. AK10JUL1.dat
19. AK10JUL2.dat
20. AK23JUL1.dat
21. AK24JUL1.dat
22. AK24JUL2.dat
23. AK25JUL1.dat
24. AK25JUL2.dat
25. AK30JUL1.dat
26. AK07AUG1.dat
27. AK07AUG2.dat
28. AK08AUG1.dat
29. AK20AUG1.dat
30. AK20AUG2.dat
31. AK21AUG1.dat
32. AK21AUG2.dat
33. AK22AUG1.dat
34. AK22AUG2.dat
35. AK23AUG1.dat
36. AK24AUG1.dat
37. AK24AUG2.dat
38. FOM00002.dat
39. FOM00003.dat
40. COMPB002.dat
41. CB000003.dat
42. ALTIM001.dat
43. AUG18CAL.dat

B. Base Magnetometer Data

1. MagBase-166-ALTIM001-FOM00002-COMPB002-AK14JUN1.txt
2. MagBase-166&167-AK14JUN2.txt
3. MagBase-167-AK15JUN1.txt
4. MagBase-171-AK19JUN1.txt
5. MagBase-172-FOM00003.txt
6. MagBase-173-AK21JUN1.txt
7. MagBase-175-AK23JUN1.txt
8. MagBase-176-AK24JUN1.txt
9. MagBase-181-AK29JUN1.txt
10. MagBase-182-AK29JUN2.txt
11. MagBase-184-AK02JUL1.txt
12. MagBase-185-AK02JUL2.txt
13. MagBase-185-AK03JUL1.txt
14. MagBase-186-AK03JUL2.txt
15. MagBase-186-AK04JUL1.txt
16. MagBase-188-AK06JUL1.txt
17. MagBase-189-AK07JUL1.txt
18. MagBase-190-AK08JUL1.txt
19. MagBase-192-AK10JUL1.txt
20. MagBase-193-AK10JUL2.txt
21. MagBase-205-AK23JUL1.txt

22. MagBase-206-AK24JUL1.txt
23. MagBase-206-AK24JUL2.txt
24. MagBase-207-AK25JUL1.txt
25. MagBase-207&208-AK25JUL2.txt
26. MagBase-213-AK30JUL1.txt
27. MagBase-220-AK07AUG1.txt
28. MagBase-221-AK07AUG2.txt
29. MagBase-221-AK08AUG1.txt
30. MagBase-226-CB000003.txt
31. MagBase-231-AUG18CAL.txt
32. MagBase-233-AK20AUG1.txt
33. MagBase-233-AK20AUG2.txt
34. MagBase-234-AK21AUG1.txt
35. MagBase-234-AK21AUG2.txt
36. MagBase-235-AK22AUG1.txt
37. MagBase-235&236-AK22AUG2.txt
38. MagBase-236-AK23AUG1.txt
39. MagBase-237-AK24AUG1.txt
40. MagBase-237&238-AK24AUG2.txt

QC Check Images

1. MagBase-166-ALTIM001-FOM00002-COMPB002-AK14JUN1.jpg
2. MagBase-166&167-AK14JUN2.jpg
3. MagBase-167-AK15JUN1.jpg
4. MagBase-171-AK19JUN1.jpg
5. MagBase-172-FOM00003.jpg
6. MagBase-173-AK21JUN1.jpg
7. MagBase-175-AK23JUN1.jpg
8. MagBase-176-AK24JUN1.jpg
9. MagBase-181-AK29JUN1.jpg
10. MagBase-182-AK29JUN2,txt
11. MagBase-184-AK02JUL1.jpg
12. MagBase-185-AK02JUL2.jpg
13. MagBase-185-AK03JUL1.jpg
14. MagBase-186-AK03JUL2.jpg
15. MagBase-186-AK04JUL1.jpg
16. MagBase-188-AK06JUL1.jpg
17. MagBase-189-AK07JUL1.jpg
18. MagBase-190-AK08JUL1.jpg
19. MagBase-192-AK10JUL1.jpg
20. MagBase-193-AK10JUL2.jpg
21. MagBase-205-AK23JUL1.jpg
22. MagBase-206-AK24JUL1.jpg
23. MagBase-206-AK24JUL2.jpg
24. MagBase-207-AK25JUL1.jpg
25. MagBase-207&208-AK25JUL2.jpg
26. MagBase-213-AK30JUL1.jpg
27. MagBase-220-AK07AUG1.jpg
28. MagBase-221-AK07AUG2.jpg

29. MagBase-221-AK08AUG1.jpg
30. MagBase-226-CB000003.jpg
31. MagBase-231-AUG18CAL.jpg
32. MagBase-233-AK20AUG1.jpg
33. MagBase-233-AK20AUG2.jpg
34. MagBase-234-AK21AUG1.jpg
35. MagBase-234-AK21AUG2.jpg
36. MagBase-235-AK22AUG1.jpg
37. MagBase-235&236-AK22AUG2.jpg
38. MagBase-236-AK23AUG1.jpg
39. MagBase-237-AK24AUG1.jpg
40. MagBase-237&238-AK24AUG2.jpg

C. Video

Digital Camera Recordings

Files are sorted by flight then by line number.

There are two files for each photo.

1. Image of the picture (.jpg)
2. Coordinates and time of picture in GPGGA format (.geo)

HARDCOPY MAPS PROVIDED

1. Alaska 2008 Aeromagnetic Survey Residual Total Field Magnetic Map
2. Alaska 2008 Aeromagnetic Survey Residual Total Field Magnetic Map (Color Version)
3. Alaska 2008 Aeromagnetic Survey Residual Total Field 8 km Residual Magnetic Map
4. Alaska 2008 Aeromagnetic Survey Height Above Ground Radar Altimeter Map