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The HiRES airborne geophysical survey of the Isle of Wight: Logistics Report

Environmental Geoscience Baselines Programme

Internal Report IR/09/54

BRITISH GEOLOGICAL SURVEY

GEOPHYSICAL BASELINES

INTERNAL REPORT IR/09/54

The HiRES airborne geophysical survey of the Isle of Wight: Logistics Report

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Front cover

Coastal view across chalk cliffs, from survey aircraft

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Foreword

This report is a product of a project carried out by the British Geological Survey (BGS). The project is a HiRES airborne geophysical survey carried out by the Geophysical Baselines Team under the Environmental Geoscience Baselines Programme. The survey was intended to form a part of the then current revised mapping being undertaken within the Mesozoic and Tertiary Basins Team. The report provides a summary of the logistics of the HiRES airborne geophysical survey conducted in September and October 2008 across the Isle of Wight and part of the Lymington area.

Acknowledgements

The JAC survey team, including BGS operators, listed later in this report are thanked for their contributions to the successful HiRES survey project.

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Summary

This report provides a summary of the logistics of the HiRES airborne geophysical survey conducted in September and October 2008 across the Isle of Wight and part of the Lymington area. The survey was carried out by the Joint Airborne-Geoscience Capability (JAC) established between the Geological Survey of Finland (GTK) and British Geological Survey (BGS). The project is a HiRES survey carried out by the Geophysical Baselines Team under the Environmental Geoscience Baselines Programme.

The survey was conducted at high resolution (a flight line spacing of 200 m) and at low altitude (56m) rising to >200 m in the vicinity of conurbations. The three main data sets acquired are magnetic, radiometric (gamma ray spectrometry) and active frequency domain electromagnetic (AEM). The aim of the present report is to provide descriptions of the logistical and in-field processing elements of the survey operations.

1 Survey: Location and details

The Isle of Wight is England's largest island; situated off the south coast of Hampshire it offers a diverse range of geology for an area of its size (380 km^2). Between September and October 2008 the island was surveyed as part of the High Resolution Airborne Resource and Environment Surveys (HiRES) program. The primary aim of the survey was to determine the geophysical responses of specific geology, characteristic of much of southern England, in relation to geological map revision. The full survey area covered a total on- and off-shore area of 36 x 22 km which was investigated with flight lines spaced at 200 m and flown in a N-S direction, orthogonal to the major structural trends of the region. A nominal survey altitude of 56 m was adopted, but over the built environment a regulatory flight altitude of 240 m was required. The survey obtained over 4,500 line km of data and provided the first airborne EM (AEM) survey undertaken across southern England.

The geology of the Isle of Wight can be fairly evenly divided into a northern zone of tertiary sands, clays and limestones and a southern region of Cretaceous strata; divided by the E-W trending chalk beds of the late-Cretaceous (Figure 2). The island is of significant geological interest due to the nature of the reactivated Variscan thrust faulting causing near vertical bedding along a central monocline. Of primary interest to this study was a first chance to deploy AEM over a significant chalk deposit.

The airborne geophysical survey (Figure 1) was designed on the basis of the cost of a 4,500 line-km survey. Permitting of the survey was via the CAA and a programme of outreach to local authorities and the public took place in the month preceding the survey.

The idealised survey lines provided the parameters of the survey shown in Table 1.

Table 1. Summary of planned and completed flight lines and survey line-km.

	Direction	***Line separation (m)***	***Number of lines***	***Line-km***
Plan, 2008	180/360	200	191	4202
Actual	180/360	200	191	4505

The actual survey includes many excess line-km obtained from longer-than-ideal lines. Line numbers range from 001 to 1910 and increase in units of 10. Five additional flight lines (termed infill lines) were obtained providing 100 m line-spacing over a 5-km wide zone. The five additional lines have line numbers of 1235, 1245, 1255, 1265 and 1275.

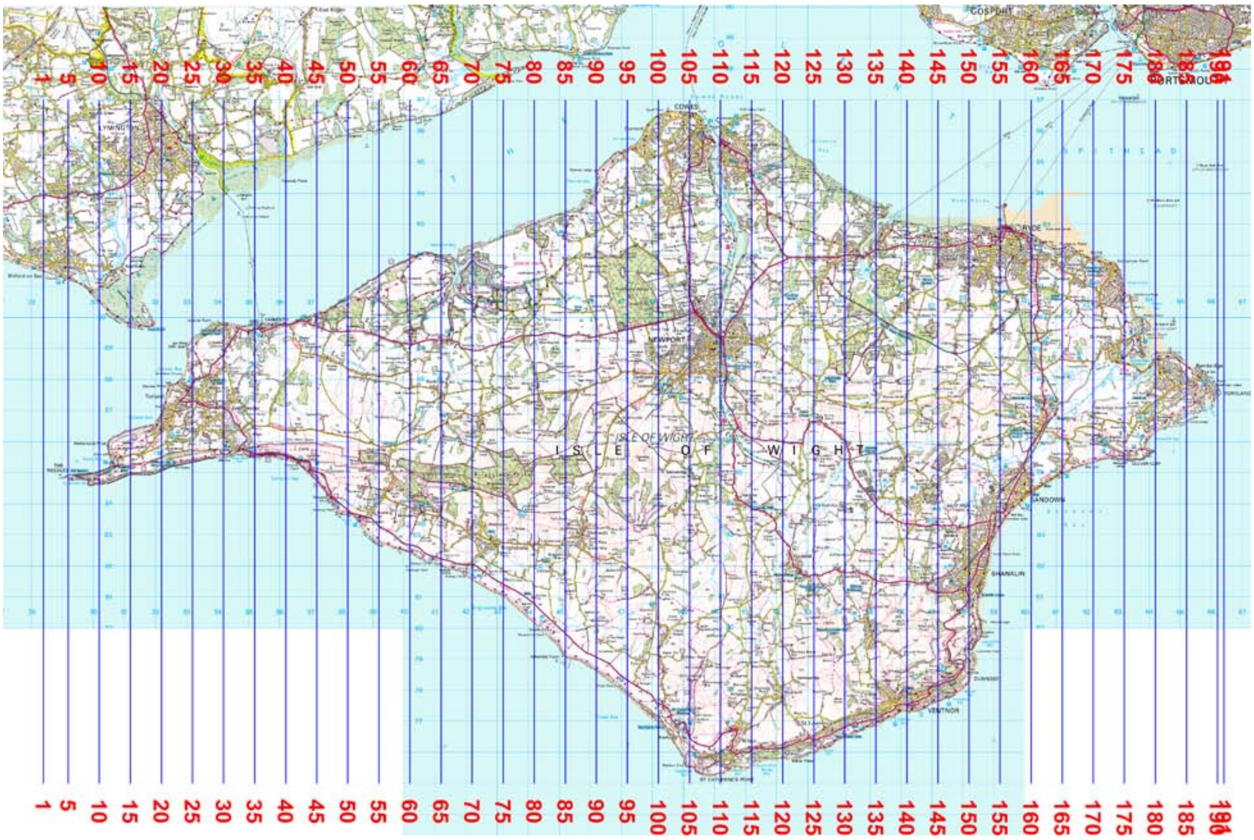


Figure 1. Flight line plan plotted over topographic map. Every fifth line is shown.

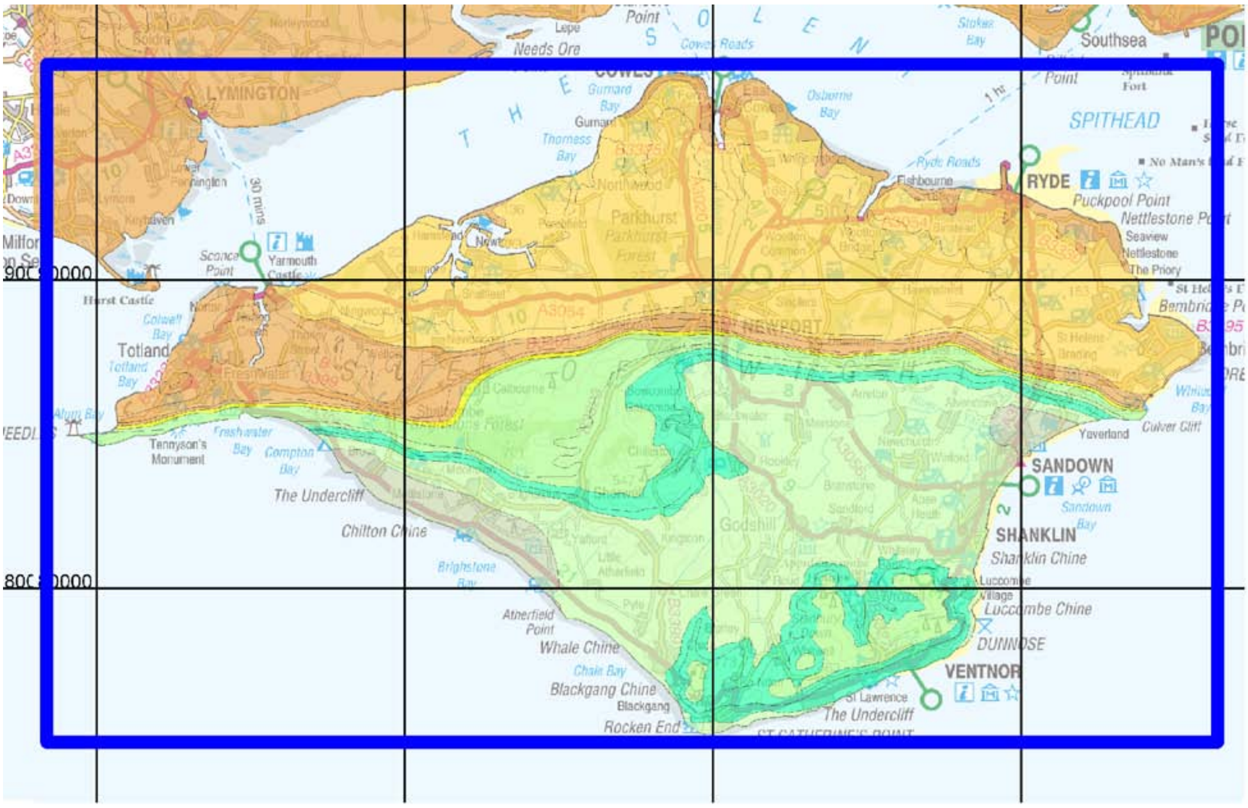


Figure 2. Survey rectangle (38 x 22km) plotted over 1:625k geology.

1.1 COORDINATE SYSTEM

The coordinate system used during acquisition and in in-field processing was WGS84 UTM Zone 30N. The preferred option of acquiring data in British National Grid was not available in the on-board software functionality.

1.2 REFLIGHT SPECIFICATIONS

Specific conditions for reflights due to technical reasons were according to the JAC internal Quality Manual. For this survey, the nominal reflight specifications applied were as follows:

i. Where ***flight line deviation*** is a maximum of 50 m or exceeds 30 m over a distance of 2 km (except where ground conditions dictated otherwise, for example to avoid radio-masts, etc).

ii. Where ***terrain clearance*** exceeds a maximum of 30 metres from the nominal survey height (56 m) or exceeds 15 m over a distance of 2 km.

iii. Where the ***sample separation*** exceeds 77 m i.e. an increase of 7m/s above the nominal maximum survey speed of 70 m/s.

The above conditions may be exceeded without a reflight where such constraints would breach air regulations, or in the opinion of the pilot, put the aircraft and crew at risk (e.g. wind farms).

1.3 SURVEY OPERATIONS

1.3.1 Survey Duration

The Twin-Otter ferry flight from Perpignan (France) to Bembridge airfield took place over 2 days (26-30 September 2008, including a weekend) and totalled 4 hrs 33 minutes (flight time).

The survey data acquisition was conducted between 26th September and 8th October 2008. The survey base was Bembridge airfield. Flight operations occupied a 5-6 day week. The operational chronology of data acquisition is provided in Table 2. The Table summarises the dates, the time duration and the number of lines accepted for each sortie. The survey comprised 12 operational flights on 7 operational days with Flight/Material numbers from 163 to 175. The return ferry flight (Bembridge-Pori) took place over 2 days (09 and 10 October) and took 7 hr 19 min.

Table 2. Survey duration. Times are Flight Times in UTC. Flight 147 is a compensation flight. Flight numbers do not increase if no data is acquired.

Flight No.	date	Out	Off	On	In	Duration	Lines
147	26/09/	06:36	07:02	9:58	10:00	2:56	0
147	26/09/	11:21	11:27	12:51	12:55	1:24	0
147	30/09/	08:12	08:20	8:33	08:36	0:13	0
148	30/09/	15:12	15:15	16:22	16:26	1:07	4
149	01/10/	09:29	09:34	10:00	10:02	0:26	0
149	01/10/	13:55	13:58	14:35	14:37	0:37	0
149	02/10/	07:18	07:23	11:40	11:42	4:17	29
150	02/10/	13:36	13:39	14:56	14:57	1:17	6
151	02/10/	15:44	15:47	17:47	17:48	2:00	14
152	03/10/	07:23	07:26	11:36	11:38	4:10	33
153	03/10/	14:09	14:12	17:42	17:44	3:30	25
154	04/10/	07:10	07:13	9:16	09:19	2:03	14
155	06/10/	13:26	13:29	17:34	17:37	4:05	30
156	08/10/	07:39	07:42	11:53	11:55	4:11	31
157	08/10/	13:16	13:21	16:25	16:27	3:04	22

1.3.2 Personnel

A list of personnel involved in the survey is provided in Table 3.

Table 3. List of project personnel.

Position	*Name*	*Affiliation*
Project Manager/ Geophysicist	Dr. David Beamish	BGS
Geophysicist/ Party Chief	Dr Rob Cuss	BGS
Operator	Mr Ed Haslam	BGS
Operator	Ms Helen Taylor	BGS
Flight Crew		
Captain	Capt Raimo Vartiainen	FAA
Pilot	Mr Mika Raivonen	FAA
Navigator	Mr Esa Tiainen	FAA
FAA a/c Engineer	Mr Jussi Jarvinen	FAA

1.3.3 Flying instructions and restrictions

Permitting for the survey was conducted through the CAA. David Grove (Airspace Utilisation Section) provided the Airspace Utilisation Notice. The authorities allowed a survey height of 185 feet rising to 800 feet msd in relation to structures.

1.3.4 Technical and quality control

The survey geophysicist carries out daily technical quality control. The main emphasis of the technical quality control is related to flight path deviation and flight elevation. Quite often these specifications are exceeded due to safety reasons and piloting decisions. In these cases re-flights are not issued. Table 4 summarises the statistical data of the technical parameters. The figures are calculated using the final radiometric data.

Table 4. Statistics for technical parameters (radar and laser altitude and flying speed). Results are calculated using all the data including exceptions.

	Mean	Standard deviation	Min	Max
Radar altitude (m)	62.98	26.83	23.5	246.6
Laser altitude (m)	63.88	28.18	25.0	287.0
Speed (m/s)	59.93	6.5	38.0	79.0

The survey acquired 191 lines of data at 200 m intervals. Five additional flight lines (1235, 1245, 1255, 1265 and 1275) were acquired to obtain a zone of 100 m sampling. Line 1340 was extended ~4.6 km to the south to allow coverage across a regional maximum. Including the additional 5 lines, the raw (untrimmed) data points obtained were:

Radiometric data: 74,441 data points

Electromagnetic data: 297,176 data points

Magnetic data: 742,646 data points

2 Equipment

The airborne survey equipment used on the survey comprises a geophysically equipped de Havilland Twin-Otter aircraft (OH-KOG). The aircraft is owned by the NERC/BGS and the geophysical equipment is owned by the JAC/GTK. The BGS and GTK undertake airborne geophysical survey work in a partnership venture known as the Joint Airborne geoscience Capability (JAC). The aircraft is operated by the Finnish Aviation Academy (FAA) based in Pori, Finland.

A background to the development of the geophysical equipment used by the JAC is given by Hautaniemi et al. (2005). The main components of the geophysical measurement system are summarised below.

Table 5. Outline specification of the main geophysical systems.

Electromagnetic system	GTK AEM-05 four frequency
Aircraft Magnetometer	2 Scintrex CS-2 caesium vapour sensors, located at the left wingtip and nose stinger
Magnetic Compensator	RMS Instruments Automatic Aeromagnetic Digital Compensator (AADCII)
Gamma-ray spectrometer	Exploranium GR-820/3 gamma-ray spectrometer 256-channels, self-calibrating
Altimeter	Collins radar altimeter
Navigation/data location system	Real time DGPS based on Ashtech GG-24 GPS+GLONASS receiver, when RDS signal available
Data acquisition system	GTK proprietary: control unit including server, power unit, alarm box, Local Area Network

Standard ancillary equipment includes an external temperature sensor and barometric height sensor and a power-line (50/60 Hz) sensor (housed in the nose of the aircraft). Details of these devices are included in section 2.2.

Figure 3. Survey flight in vicinity of the Needles.

2.1 AIRCRAFT

The aircraft used in the survey is a fixed-wing, twin-engine DHC-6/300 Twin Otter (registration sign OH-KOG, registered in Finland).

Table 6. Specifications of survey aircraft OH-KOG.

Normal flight speed	210-220 km/h
Rate of climb	7.5 m/s
Total flight hours	About 16000 hours to date
Landings	About 8000 landings to date

The aircraft was built in Canada in 1979 and has been in use since 1980 for aerogeophysical measurements. During the manufacturing of the Twin Otter several modifications were made to its electrical systems in order to reduce the electrical noise levels. The aircraft offers several major advantages in terms of utility and cost, including excellent performance reserves, low-speed handling characteristics and operational flexibility allowing the use of unsupervised and unpaved air strips.

2.2 GEOPHYSICAL EQUIPMENT

Magnetics

- Two Scintrex CS-2 Caesium magnetometers, one at the left wingtip and one at the nose stinger
- Automatic compensation unit RMS AADCII
- Sampling rate of 10 Hz

Electromagnetic four-frequency unit

- Model AEM-05, vertical-coplanar coil configuration
- Frequencies in use: 912 Hz, 3005 Hz, 11962 Hz and 24510 Hz
- Coil separation of 21.4 meters
- Sampling rate of 4 Hz

Gamma-ray spectrometer

- Exploranium GR-820/3
- Two sets of NaI crystals, each containing four downward looking and one upward looking package
- Total volume 42 litres
- Sampling rate of 1 Hz

Navigation system:

- Ashtech GG24 (24-channel GPS + Glonass receiver)
- Accuracy 7 m / 16 m (50% / 95 %)
- Real time DGPS when differential signal available
- Sampling rate 1 Hz

Altitude

- Collins radar altimeter
- Resolution 0.1 m, accuracy 0.5 m
- Sampling rate of 10 Hz

Auxiliary equipment

- Digital camera
- Riegl laser altimeter
- Barometer, thermometer, accelerometer

Base station equipment

- Scintrex CS-2 sensor for magnetic recording
- Ashtech Ranger GPS receiver for DGPS correction
- Picodas MEP-7110 magnetometer

2.3 GROUND-BASED EQUIPMENT

Ground-based equipment comprises a base magnetometer and a GPS station. The primary base station records magnetic and GPS data prior to, during, and after each flight. The data from this station are used to post process the airborne data. The base magnetic data are used to correct diurnal variations of the airborne magnetic field records. The base GPS records are used to perform differential processing of the airborne GPS recordings.

The magnetic data are logged at 1-second intervals and displayed on a base station laptop that controls data acquisition. The continuous display of the base station data (rolling screen) provides a capability for monitoring the magnetic disturbance conditions that might lead to a reflight condition.

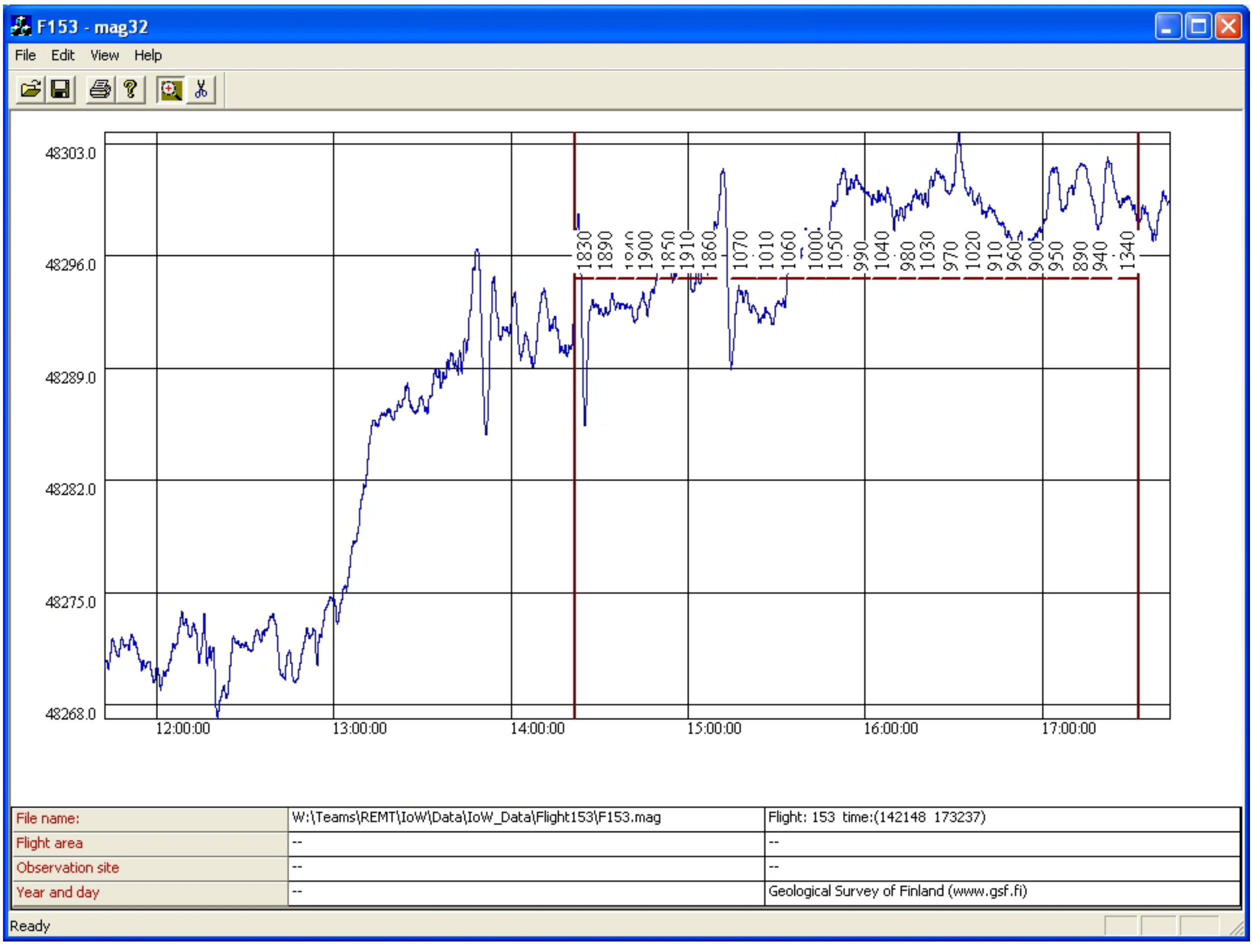


Figure 4. Base magnetic station data recording of Flight 153, showing overlay of Line numbers. Time is UT.

Base station operations and precise locations are summarised below.

Table 7. Summary of primary base station used during the survey.

Primary Base Station	Private ground (orchard)
Start Date (Julian Day)	25/09/2008 (162)
End date (Julian Day)	08/10/2008 (175)
Geographic Latitude (North)	50:41:22.08104
Geographic Longitude (West)	1:6:7.4852
Elevation (m)	48.58988

The precise coordinates of the GPS base station (given above) were determined using a differential correction with the Sandown station of the GPS permanent reference station network. During field processing a magnetic base level of 48300 nT was applied to the magnetic data.

3 Calibration Data

3.1 MAGNETIC COMPENSATION

The effect caused by the movements of the aircraft is removed/diminished automatically during the flight by use of compensation data. During the compensation flight the aircraft flies at 3 km altitude in the two flight line directions and the directions perpendicular to those and performs pitch (±5º), roll (±10º) and yaw (±5º) manoeuvres along each direction. After recording, the magnetic effects of all twelve movements, the AADCII compensator (RMS Instruments) computes the compensation coefficients, and stores the results to provide real-time corrections during the actual survey.

The effectiveness of the compensation is verified by a Figure-Of-Merit (FOM) survey immediately after the compensation during the same flight. The same movements are repeated and the new compensation parameter file is utilized. All three compensated movement effects are summarized in all four directions, and the FOM parameter is thus the sum of these 12 peak-to-peak anomaly values of the compensated magnetic field. The compensated FOM values are a judgement of the peak/trough amplitudes observed during each manoeuvre.

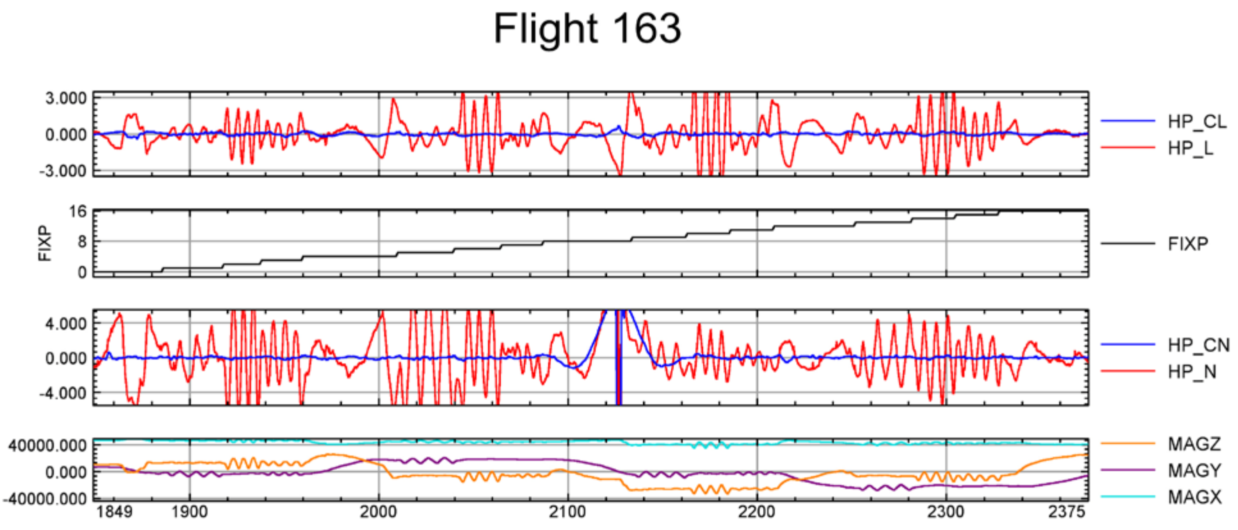


Figure 5. The profiles of magnetometer compensation data for the 4x3 =12 set of manoeuvres. Upper panel: Uncompensated (red) and compensated (blue) Left magnetometer. Second panel: Fixed point information. Third panel: Uncompensated (red) and compensated (blue) Nose magnetometer. Lower panel: Fluxgate magnetometer data.

The location of the compensation flight was just offshore of the survey area. The area was located on the basis of low magnetic gradient. The FOM parameters of each direction and each movement are summarised below.

Table 8. Figure of merit calculations for magnetic data (Flight 163).

	Nose				Fids		Left				Nose		Left		Ratios	
Leg	HPCRmax	HPCRmin	HPRmax	HPRmin	Fid1	Fid2	HPCLmax	HPCLmin	HPLmax	HPLmin	Comp	Non-comp	Comp	Non-comp	Ratio N	Ratio L
1	0.24	-0.15	2.62	-2.72	1899.2	1903.8	0.05	-0.08	0.8245	-0.7	0.39	5.34	0.12	1.52	13.69	12.60
2	0.52	-0.11	8.32	-6.98	1930.7	1932.9	0.04	-0.05	1.83	-2.46	0.63	15.30	0.10	4.29	24.27	42.98
3	-0.03	-0.05	4.28	-3.13	1946.6	1949.6	-0.01	-0.18	0.8957	-1.256	0.02	7.41	0.17	2.15	312.43	12.42
5	0.24	-0.17	9.11	-6.52	2022	2026.2	0.09	0.00	0.4946	-0.923	0.41	15.63	0.08	1.42	38.14	16.93
6	0.09	-0.13	5.71	-4.55	2052.8	2056.8	0.04	-0.06	3.14	-3.18	0.22	10.25	0.10	6.32	46.04	63.38
7	0.34	-0.04	1.57	-1.81	2075.8	2078.8	-0.02	-0.08	0.87	-1.03	0.38	3.38	0.06	1.90	8.93	30.21
9	-0.45	-0.91	1.64	-2.47	2153.5	2157.6	0.21	0.11	0.79	-1.121	0.46	4.11	0.10	1.91	8.88	18.66
10	0.44	0.12	3.89	-1.85	2169.2	2173	0.07	-0.12	4.86	-4.86	0.32	5.75	0.19	9.72	17.94	50.79
11	0.15	-0.07	0.70	-0.87	2199	2203.1	0.11	-0.08	1.56	-1.05	0.22	1.58	0.19	2.60	7.05	13.79
13	0.14	-0.02	3.82	-2.47	2267.8	2272.7	0.13	0.02	0.79	-1.17	0.16	6.29	0.11	1.96	40.33	17.73
14	0.19	-0.18	4.05	-4.95	2291.5	2294.8	0.02	-0.05	3.26	-3.37	0.37	9.00	0.07	6.63	24.19	91.41
15	0.04	-0.23	2.73	-2.28	2314.8	2318.2	-0.08	-0.15	1.75	-2.15	0.27	5.01	0.07	3.90	18.29	55.71

The figures of merit (FOM) are 1.38 (Left) and 3.86 (Nose). The ratios of uncompensated to compensated data are 23.05 (Left) and 32.22 (Nose)

3.2 RADIOMETRIC CALIBRATION DATA

As noted previously the radiometric instrument employed is the Exploranium GR-820 with 256-channels. The commonly adopted standard in carrying out airborne gamma-ray measurements is to calibrate and process the data in a manner presented in AGSO and IEAE reference manuals (Grasty and Minty, 1995; IAEA, 1991). The radiometric system was calibrated prior to the survey using locations and calibration ranges in Finland that have been used for over 25 years. The following sections summarise the calibrations that were performed prior to this survey.

3.2.1 Cosmic and background coefficients

To determine the aircraft and cosmic background, a test flight was carried out over the sea near the base airport, at flight surfaces from 5000 to 10000 ft. Linear regression from the mean counts in each channel and equivalent cosmic channel count rate provide the constant and linear coefficients. The constant represents the background radiation from the aircraft and the linear coefficient is used to calculate the varying part of background radiation because of cosmic radiation.
The cosmic coefficients were found to be:

cos_tot	52.57 (0.870)	Total counts
cos_kal	6.05 (0.039)	Potassium

cos_ura	3.1 (0.031)	Uranium
cos_tho	0.0 (0.039)	Thorium
cos_Ur	0.33 (0.008)	Uranium upward

The numbers in parentheses are the linear coefficients.

3.2.2 Stripping ratios

The stripping ratios were determining using 4 transportable calibration pads (1m x 1m x 0.3m) prior to the survey season in Pori, Finland. Each pad was measured for 10 minutes and the stripping ratios were calculated using the Padwin program provided by the manufacturer of the pads. The calculated values are very close to the manufacturer's and IAEA's ideal values.

The results of the calibration are:

TH INTO U (ALPHA = A23/A33)	0.2408 (0.0629)
TH INTO K (BETA = A13/A33)	0.4071 (0.1330)
U INTO K (GAMMA = A12/A22)	0.7327 (0.1760)
U INTO TH (A = A32/A22)	0.0453 (0.0638)
K INTO TH (B = A31/A11)	-0.0031 (0.0342)
K INTO U (G = A21/A11)	0.0032 (0.0335)

The numbers in parentheses are estimated standard deviations.

3.2.3 Height attenuation

For determining height attenuation, a series of heights from 100 to 800 ft was used to take measurements near Porvoo, Finland. This test line has been used for more than 25 years. Background and stripping corrections were applied and the attenuation was calculated using the logarithmic values of corrected Tot, K, U and Th, and flight altitude.

The attenuation coefficients were calculated as:

K	0.008437
U	0.005381
Th	0.006920
Total counts	0.006774

3.2.4 Concentration coefficients

The same Porvoo test line was used to determine the system sensitivities. This same line has been measured for more than 25 years using the same aircraft (OH-KOG). The sensitivity parameters have been applied yearly to the radiometric data measured. Comparisons have been made also between different areas measured during different years to find out the possible variations. The variations are mostly due to different methods used earlier for sensitivity determining, e.g. pads, runway. Over the last few years the sensitivity parameters have varied by just a few percent.

All the corrections were made to the radiometric test flight data and the concentrations were compared to earlier measurements and new sensitivity parameters were calculated as:

K	0.0082	%K/(pulses/s)
U	0.0700	ppm eU/(pulses/s)
Th	0.1221	ppm eTh/(pulses/s)

3.2.5 Resolution of the spectrometer

The Spectrometer resolution was measured with a Cs-137 source in Pori, Finland. Background was also measured and after a background correction, the Cs peak was measured and the FWHM (Full Width at Half Maximum) determined. The FWHM is across 5.0 channels, each with an energy of 12.1 keV, which makes 60.5 keV. Thus we obtain a spectrometer resolution of

R = 100*60.5 keV/662 keV = 9.14 **%**

Individual crystals were measured at Helsinki-Vantaa airport. The downward looking spectra were stabilized using K-40 and the upward looking spectra with Cs-137. The results are given as Crystal Number with %Resolution in parentheses:

D1(7.4%), D2(11.0%), D3(7.5%), D4(6.1%), D5(5.3%), D6(5.9%), D7(5.9%), D8(5.4%), U13(9.5%), U14(7.9%)

D refers to downward and U to upward.

3.3 ELECTROMAGNETIC CALIBRATIONS

3.3.1 Coefficient Calibration

The calibration of the JAC AEM-05 system used in the survey is described by Hautaniemi et al. (2005) and Leväniemi et al. (2009). The EM calibration coefficients for 2008 were (1.562, 0.0) at 912 Hz, (1.714, 0.0) at 3005 Hz, (1.928, 0.0) at 11962 Hz and (2.124, 0.0) at 24510 Hz.

The EM system was calibrated by flying a test line over the sea (Gulf of Finland) prior to the survey season, at different heights from 25 to 100 m. The conductivity of the sea was measured by a CTD sensor at 4 different points along the test line, from the surface to the sea bottom. The conductivity of the sea was estimated by a model, which contains layers with a different conductivity for each layer.

The theoretical responses of the airborne EM to the model described above were calculated using the Leroi-air program developed by AMIRA. Non-linear optimization was used to obtain a best fit to a complex, scalar coefficient. The coefficients obtained at each frequency enables measured units to be converted to coupling ratios (Hs/Hp, meaning secondary over primary) in ppm (parts per million)

An example of the coefficient calculation (3005 Hz) is shown in the Figures below.

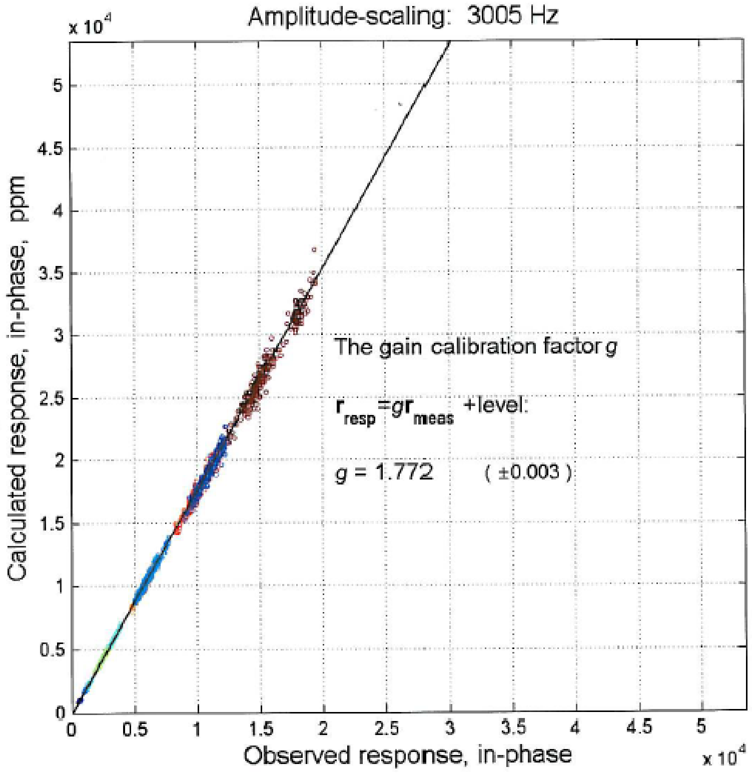


Figure 6. EM optimisation results for the Real component calibration at 3005 Hz.

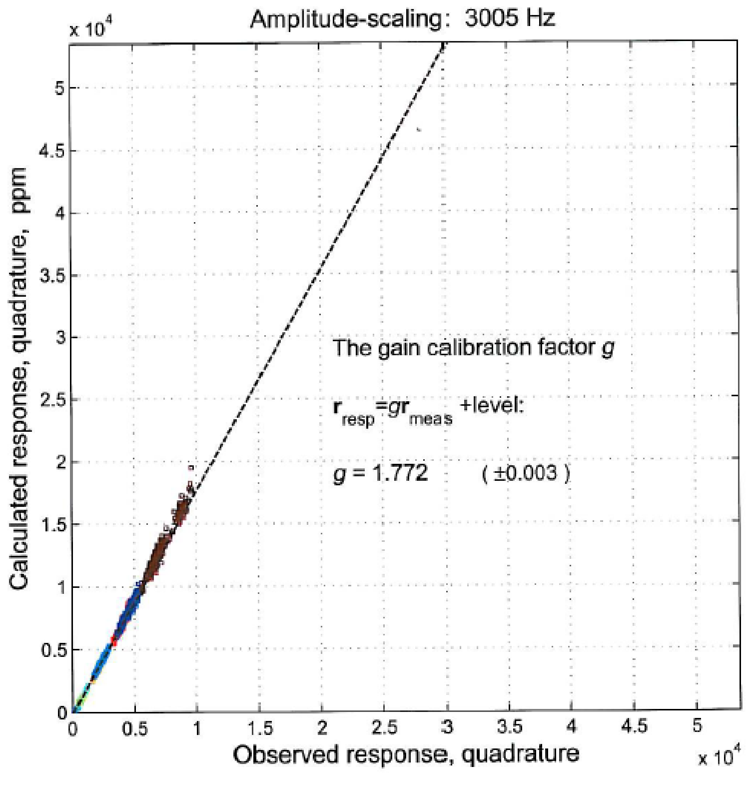


Figure 7. EM optimisation results for the Imaginary component calibration at 3005 Hz.

3.3.2 EM System orthogonality

The phase shift between in-phase (real) and quadrature (imaginary) components is checked and adjusted at the beginning and end of each survey flight. The test is undertaken at an 'out-of-ground-effect' elevation (e.g. >300 m) over the landmass (i.e. not over the sea). As the phase shift is 90 degrees, there should not be any trace in the quadrature component as an artificial signal is applied to in-phase component and vice versa. This procedure is done separately on each frequency to in-phase and quadrature components. At the end of each survey flight this same procedure is repeated to check for any possible phase drift during the flight. An example of the calibration pulses observed at the start of a flight is shown below..

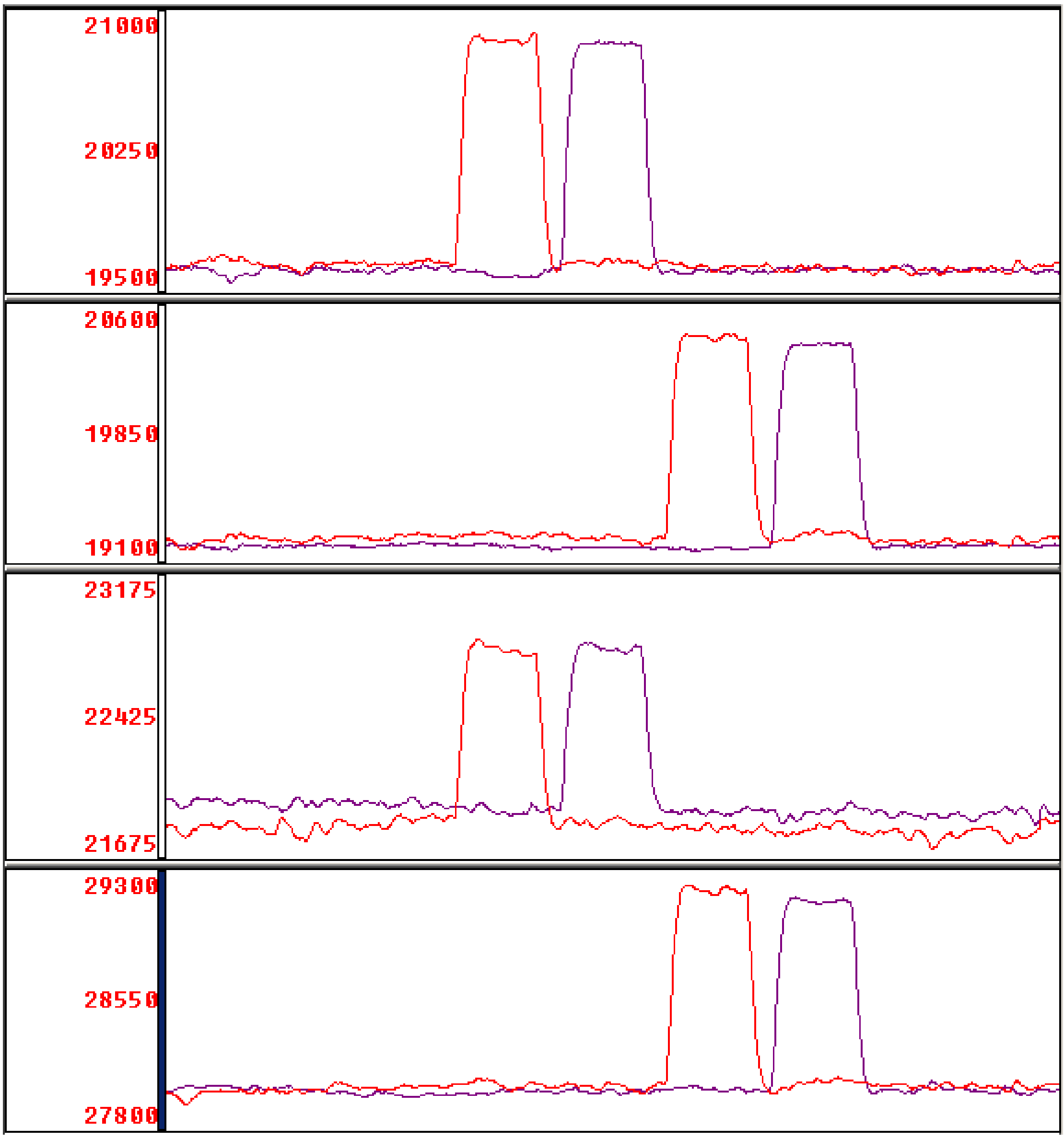


Figure 8. The orthogonality test for Real and Imaginary components of the Twin Otter EM configuration. Panels show the frequencies in increasing order from top to bottom with Real component in red and imaginary component in magenta.

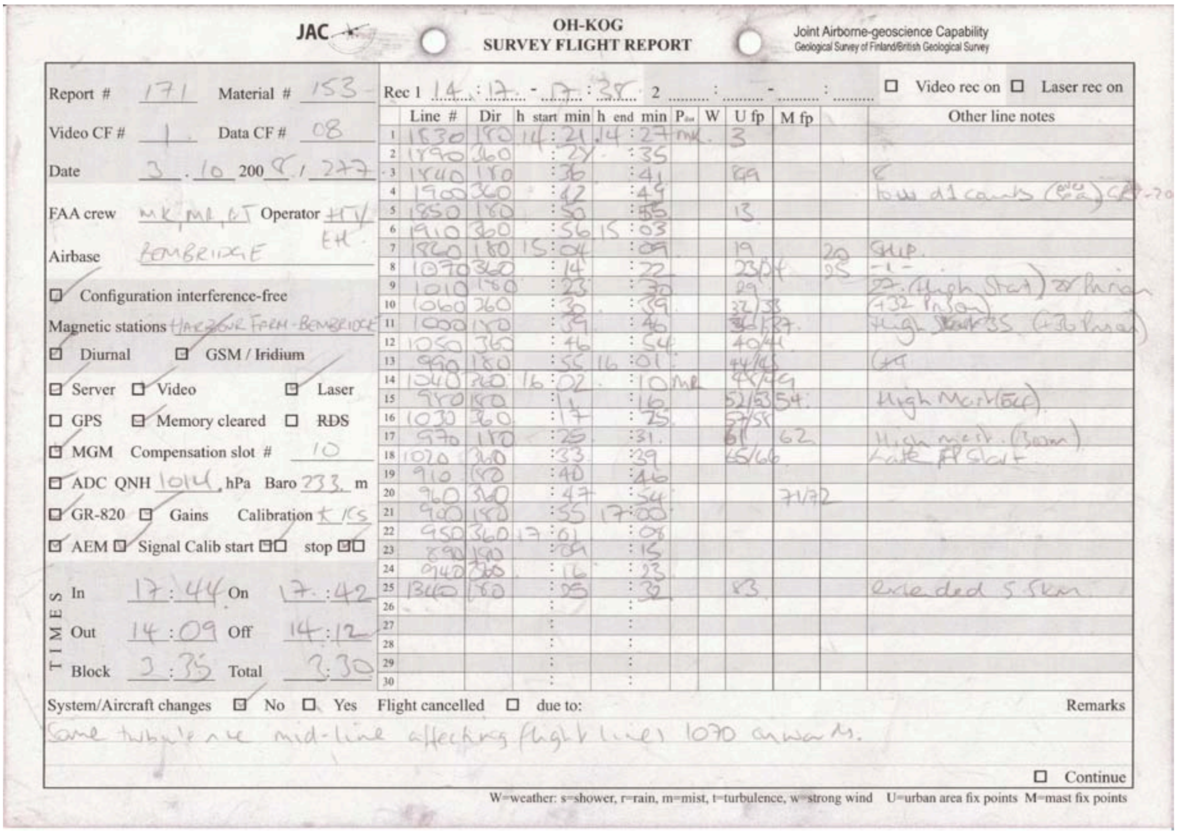
4 Data handling, QC procedures and Processing

The data handling and QC procedures used by the JAC are fully described by Hautaniemi et al., (2005).

The geophysical and avionic data acquired during each flight is monitored by a geophysical operator as shown Figure 9. The geophysical operator monitors all the instruments and the data being acquired using a laptop computer. Each instrument is connected to a dedicated microprocessor. The microprocessor controls data transfer to a Local Area Network (LAN). A GPS-based synchronisation pulse is provided through the LAN at a frequency of 40 Hz.

Figure 9. Geophysical operator and main instrument rack on OH-KOG.

The operator is responsible for maintaining the flight logs, which summarise all the required parameters for each survey flight. An example log from Flight 153 of the survey is shown below. Any noteworthy factors (e.g. urban fly-high conditions) and exceptions are digitally logged using a fixed-point (FP) number data channel that ties the operator's notes to the recorded data stream. Fixed points also define on-line and off-line conditions.



JAC

OH-KOG
SURVEY FLIGHT REPORT

Joint Airborne-geoscience Capability
Geological Survey of Finland/British Geological Survey

Report # 171 Material # 153

Video CF # 1 Data CF # 08

Date 3 . 10 . 2008 / 277

FAA crew MK, MR, AJ Operator HV, EH

Airbase PEMBRIDGE

☐ Configuration interference-free

Magnetic stations HARZOVR FARM - PEMBRIDGE

☑ Diurnal ☑ GSM / Iridium

☑ Server ☑ Video ☑ Laser

☐ GPS ☑ Memory cleared ☐ RDS

☑ MGM Compensation slot # 10

☑ ADC QNH 1014 hPa Baro 233 m

☑ GR-820 ☑ Gains Calibration K/Cs

☑ AEM ☑ Signal Calib start ☑☐ stop ☑☐

TIMES In 17:44 On 17:42

Out 14:09 Off 14:12

Block 3:35 Total 3:30

Rec 1 14 : 17 - 17 : 38 2 ....:.... - ....:.... ☐ Video rec on ☐ Laser rec on

	Line #	Dir	h start	min	h end	min	P	W	U fp	M fp		Other line notes
1	1830	180	14	21	14	27	mk		3			
2	1890	360		28		35						
3	1840	180		36		41			89			8
4	1900	360		42		49						low d1 counts
5	1850	180		50		55			13			
6	1910	360		56	15	03						
7	1860	180	15	04		09			19		20	Ship.
8	1070	360		14		22			23/24		25	-1-
9	1010	180		23		30			29			27 (High Start)
10	1060	360		30		39			32/33			(+32 Pylon)
11	1000	180		39		46			36/37			High Start 35 (+36 Pylon)
12	1050	360		46		54			40/41			
13	990	180		55	16	01			44/45			
14	1040	360	16	02		10	MR		48/49			
15	980	180		11		16			52/53	54		High Mast
16	1030	360		17		25			57/58			
17	970	180		25		31			61	62		High mast. (300m)
18	1020	360		33		39			65/66			Late FP Start
19	910	180		40		46						
20	960	360		47		54				71/72		
21	900	180		55	17	00						
22	950	360	17	01		08						
23	890	180		09		15						
24	940	360		16		23						
25	1340	180		25		32			83			Extended 5.5km
26				:		:						
27				:		:						
28				:		:						
29				:		:						
30				:		:						

System/Aircraft changes ☑ No ☐ Yes Flight cancelled ☐ due to: Remarks

Some turbulence mid-line affecting flight lines 1070 onwards.

☐ Continue

W=weather: s=shower, r=rain, m=mist, t=turbulence, w=strong wind U=urban area fix points M=mast fix points

Figure 10. Example Flight log (Flight number 153) from the survey.

4.1 QC AND FIELD PROCESSING

The basic processing of the recorded data is undertaken immediately after each flight and before the start of the next flight.

In the first stage the data is examined for any apparent errors such as file corruption or significant data errors. An example of this is shown below in Figure 11.. After this, the data profiles are examined more carefully. Standard processing and QC involves the use of fourth differences in the magnetic and electromagnetic channels. The appearance, quality and noise levels of all data components together with EM calibrations, drift levels and noise peaks are examined.

Figure 11. Example of the initial QC using ALKU2005 (Flight 155).

Base station magnetic and GPS data are also checked. For magnetic data this means comparing the recorded data against specification conditions for reflights. The GPS data are checked for any recording gaps or low-quality data.

Although the final levelling of the EM data is performed after the whole area has been surveyed, preliminary levelling is carried out at this stage. This initial levelling step, carried out in the field, is important in that it allows for a greater degree of QC on the EM coupling ratios acquired.

After all these processing steps, further programs are then applied for the calibration and the application of methodological corrections to the geophysical data. These procedures provide an initial, but still preliminary, set of text files (termed .xyz) for each flight and for each of the three geophysical data sets. These data sets are finally assembled into a Geosoft database for further QC assessments according to those required by the survey specifications.

The outcome of the application of the procedures mentioned above, together with the DGPS corrections, result in flight-line by flight-line xyz text files for each geophysical parameter. These are transferred to Geosoft databases where further QC control is applied. Altitude deviation is checked statistically and also by plotting colour profiles. The line paths are compared to the specified line paths and the flight path deviation is analysed. Sampling intervals and survey speed are also checked.

Average radiometric spectra and the main energy windows are plotted for each line. This allows an assessment of any spectral drift. Spectral stability and overall functioning of the spectrometer is controlled during the survey in real-time (geophysical operator), together with the initial QC and line-based spectral inspection.

Processed data for each successive flight are appended to the survey area databases. Geophysical parameters, errors and noise levels of all measurements are examined on a line-by-line basis.

Geophysical parameters are also interpolated to grids and examined. All these grids are preliminary but they form useful updated summaries of the behaviour of the survey data.

4.2 FINAL PROCESSING

Final processing of all the data is carried out only after all survey lines have been acquired and accepted. The final processing does not form part of this logistics report. The procedures applied to the data are described by Hautaniemi et al. (2005). The final levelled EM data are then used to calculate apparent resistivity and depth according to a half-space model (Hautaniemi et al., 2005, Leväniemi et al., 2009).

5 References

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