

**HYMAP MARK I AIRBORNE HYPERSPECTRAL
SCANNER DATA LOGISTICS REPORT
FOR EL 2855 LIVERPOOL**

Gerard Zaluski, P. Geo.
Geoscientist
Cameco Corporation
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1.0 INTRODUCTION

DeBeers Australia Exploration Ltd (formerly Stockdale Prospecting Pty Ltd) was contracted by Cameco Australia Pty Ltd to collect airborne hyperspectral scanner imagery over exploration projects in Arnhem Land using their Hymap Mark I in 2000. Data was collected over the Liverpool project on July 9, 2000.

The scanner, originally called the AMS scanner (airborne multispectral scanner), was built by Integrated Spectronics Pty Ltd in 1996 for DeBeers. This was the first of a series of scanners referred to as Hymap scanners and therefore, since being commercialized in 2001, it has been renamed Hymap Mark I. The instrument is a 96 channel whiskbroom scanner with an approximate 15 nm bandpass over the 500 to 2500 nm spectral range.

2.0 DATA ACQUISITION

The following data are an excerpt from the logistics report supplied by DeBeers Australia.

Survey Name: AMS-SURV0014O

Survey consisted of five (5) areas flown from Katherine
Arnhem Land Survey 0014O (Katherine)

Cameco A	(Area prefix CA36)	Strips 1-30 (Completed)	29Jun-7Jul00
Cameco B	(Area prefix CB37)	Strips 1-21 (Completed)	9Jul00
Cameco C	(Area prefix CC38)	Strips 1-16 (Completed)	9-11Jul00
Cameco D	(Area prefix CD35)	Strips 1-16 (Completed)	28Jun00
Cameco E	(Area prefix CE39)	Strips 1-4 (Completed)	11Jul00

Survey Duration: 28/06/00 – 12/08/99

Survey Customer: Cameco Australia Pty Ltd.

Aircraft Survey Operator: Kevron Aviation
10 Compass Road
Jandikot Airport Perth

2.1 Logistics

Upon clearing Australian Customs, the AMS to be transported to Integrated Spectronics, Sydney for maintenance and calibration. Problems had been reported with the stabilised platform and it was airfreighted to Christec, Melbourne for assessment. As the platform could not be repaired in time for the desired AMS deployment, Integrated Spectronics's spare platform and base was borrowed. Platform problems are attributed to electrical short-circuits caused by dust.

The AMS was installed in Kevron Aviation's VH-AZU, a Cessna 404 on the 23rd June at Sydney's Bankstown airport. Graham Wornes, who is experienced in photography surveying, piloted the aircraft throughout the deployment. When out-of hours, Graham Wornes was replaced by Alec Penberty or Tom Atikison both experienced survey pilots. Ground testing of the AMS indicated the touch-screen computer was unstable and the AMS interface software was loaded onto a Toshiba laptop to act as a backup if the touch-screen computer failed. The AMS was ferried to

Mt Isa the following day, 24th June. As supplies of liquid nitrogen were not available in Katherine, both dewiers were filled in Sydney and transported by Kevron via Mt Isa to the survey areas. Poor weather required a longer than expected stay in Katherine and liquid nitrogen was replenished during a visit to Darwin for repairs to the AMS.

Surveying was delayed two (2) days in Mt Isa due to a failed aircraft engine oil seal. Once repaired, the aircraft ferried to Katherine and base was set up in the Frontier Motel, 27th June. This delay and poor weather in Arnhem Land survey areas delayed surveying and our stay clashed with the Olympic Torch Relay. Accommodation was tight and the operations base was moved to the Knotts Crossing Motel on the 29th June. The SWIR2 dewier was not holding a vacuum and was pumped during down time. The AMS failed on 3rd July and was ferried to Darwin the following day for repairs. Integrated Spectronics traced the fault to the AMS's 5volt-power supply and the unit was replaced. The aircraft returned to Katherine the same day. Surveying was completed on the 12th July and the aircraft ferried to Kununurra for further surveying.

2.2 Day's Flying: 09 July, 2000

2.2.1 Data Acquisition Summary

Crew

G. Wornes (Pilot)
M. Hornibrook (Operator)

Pre Flight Testing

Infrasil Window Cleaned
Take Off @ 08:58am
Weather conditions: Scattered Cumulus.

Days objective:

As many strips as possible from Cameco Area B (CB38)

Flight Strip Summary

Ferry Time:	1hr 52 mins	Ferry Km:	531km
Survey Time:	5hr 16 mins	Survey Km:	712km

AMS Operator Flight Strip Log

Survey ID : 00140

Day's Flying : 09-07-00

Pilot: G. Wornes

Operator: M. Hornibrook

Sheet # : 1 of 2

Survey Name : Arnhem Land, NT

Take Off Time:- 08:58am

Area Name : Cameco B, C

Area Subcode : C

Land Time:- 15:58pm

Flight Strip ID	Strip Type	Acq Mode	Tape Pass #	Tape #	Alt (ft ASL)	Cloud Cover	Ground Track	Ground Speed	Est. Drift	Scan Rate (lines/sec)	Time Local
CB3701	Prod	Inst.	1	10	9,200	<1/8	S-N	150kts	1°L	12	9:50
CB3702	Prod	Inst.	2	10	9,200	<1/8	N-S	150kts	1°R	12	10:02
CB3703	Prod	Inst.	3	10	9,200	<1/8	S-N	150kts	1°L	12	10:14
CB3704	Prod	Inst.	4	10	9,200	<1/8	N-S	150kts	1°R	12	10:27
CB3705	Prod	Inst.	5	10	9,200	<1/8	S-N	150kts	1°L	12	10:39
CB3706	Prod	Inst.	6	10	9,200	<1/8	N-S	150kts	1°R	12	10:51
CB3707	Prod	Inst.	7	10	9,200	<1/8	S-N	150kts	1°L	12	11:03
CB3708	Prod	Inst.	8	10	9,200	<1/8	S-N	150kts	1°R	12	11:15
CB3709	Prod	Inst.	9	10	9,200	<1/8	N-S	150kts	1°L	12	11:27
CB3710	Prod	Inst.	10	10	9,200	<1/8	S-N	150kts	1°R	12	11:39
CB3711	Prod	Inst.	11	10	9,200	<1/8	N-S	150kts	1°L	12	11:51
CB3712	Prod	Inst.	12	10	9,200	<1/8	S-N	150kts	1°R	12	12:03
CB3713	Prod	Inst.	13	10	9,200	<1/8	N-S	150kts	1°L	12	12:15
CB3714	Prod	Inst.	14	10	9,200	<1/8	S-N	150kts	1°R	12	12:26

Key to Strip Types

Ground	A Test Image taken on the Ground	Inst	Instant Survey
Test	Airborne Test Image - A Non-Production Survey Strip Image	Auto	Preplanned Automatic Survey
Prod	Airborne Production Survey Strip Image	Palm	ISPL Palmtop
Dark	Airborne Strip Dark Image (ie AMS shutter on)		
UnConf	Unconfigured / Extraneous Strip		

Key to Strip Acquisition Mode

AMS Operator Flight Strip Log

Survey ID : 00140

Day's Flying : 09-07-00

Pilot: G. Wornes

Operator: M. Hornibrook

Sheet # : 2 of 2

Survey Name : Arnhem Land, NT

Take Off Time:- 08:58am

Area Name : Cameco B, C

Area Subcode : C

Land Time:- 15:58pm

Flight Strip ID	Strip Type	Acq Mode	Tape Pass #	Tape #	Alt (ft ASL)	Cloud Cover	Ground Track	Ground Speed	Est. Drift	Scan Rate (lines/sec)	Time Local
CB3715	Prod	Inst.	15	10	9,200	<1/8	S-N	150kts	1°L	12	12:38
CB3716	Prod	Inst.	16	10	9,200	<1/8	N-S	150kts	1°R	12	12:50
CB3717	Prod	Inst.	17	10	9,200	<1/8	S-N	150kts	1°L	12	13:02
CB3718	Prod	Inst.	18	10	9,200	<1/8	N-S	150kts	1°R	12	13:14
CB3719	Prod	Inst.	19	10	9,200	<1/8	S-N	150kts	1°L	12	13:26
CB3720	Prod	Inst.	20	10	9,200	<1/8	N-S	150kts	1°R	12	13:38
CB3721	Prod	Inst.	21	10	9,200	<1/8	S-N	150kts	1°L	12	13:50
CC3816	Prod	Inst.	22	10	9,200	<1/8	S-N	150kts	2°L	12	14:10
CC3815	Prod	Inst.	23	10	9,200	<1/8	N-S	150kts	0°	12	14:20
CC3814	Prod	Inst.	24	10	9,200	<1/8	S-N	150kts	0°	12	14:30
CC3813	Prod	Inst.	25	10	9,200	<1/8	N-S	150kts	0°	12	14:39
CC3812	Prod	Inst.	26	10	9,200	<1/8	S-N	150kts	0°	12	14:49
CC3811	Prod	Inst.	27	10	9,200	<1/8	N-S	150kts	0°	12	15:01

Key to Strip Types

Ground	A Test Image taken on the Ground	Inst	Instant Survey
Test	Airborne Test Image - A Non-Production Survey Strip Image	Auto	Preplanned Automatic Survey
Prod	Airborne Production Survey Strip Image	Palm	ISPL Palmtop
Dark	Airborne Strip Dark Image (ie AMS shutter on)		
UnConf	Unconfigured / Extraneous Strip		

Key to Strip Acquisition Mode

3.0 SYSTEM CORRECTIONS

The following information was supplied by M. Hornibrook of Spectral Geology Pty Ltd, the instrument operator during the acquisition of the data. The collected scanner data are stored on a DLT flight tape and converted to ENVI compatible image files (16-bit signed integer, BIL data file with an ASCII header file). The Hymap Mark I scanner stores the intensity of light reflected from the surface of the earth as digital numbers (DN). This intensity recorded is the net effect of the wavelength dependent atmospheric absorptions and scattering, solar irradiance, light scattered back from the earth surface, and background voltages from the scanner electronics. Pre-processing involves two corrections.

3.1 Dark Current Subtraction

This correction removes the “zero light” spectrum in all image pixels, the DN values registered from the scanner while imaging a totally non-reflecting surface. It represents system voltages and electronic noise. It is additive and band dependent.

3.2 Spectral Calibration and Scaling

The scanner is calibrated using a standard light source so the response of each detector is known. Every pixel of each band has been multiplied by this band constant and a scaling factor has been applied so that the data is stored as a 16-bit signed integer. The scaling factors applied, along with the band centers and band widths are shown in Appendix I.

4.0 DATA UNITS

The pre-processing corrections described above have already been applied so that the data as supplied are in radiance units of microwatts/cm²/steradian/nm before the scaling factor of 1000 is applied to convert to 16-bit integer. (In other words, the DN values as present in the raw image are in units of milliwatts/cm²/steradian/nm).

5.0 GEOMETRIC CORRECTION

The scanner data is collected in flightlines oriented approximately north-south or south-north. Variations in the orientation of the scanner during image acquisition result in spatial distortions of the resulting images. Although the use of a GPS during data acquisition allows for semiautomated georeferencing, the distortions inherent in airborne scanner data collected without a three-axis, gyrostabilized platform limit the accuracy of the predicted locations to about 70 m.

A series of Cameco proprietary computer programs were written to extract the GPS information from the data acquisition logs, interpolate values for each image scan line, and build an input

geometry file compatible with the Input Geometry File format of ENVI (Research Systems Inc). Using this information, a Geometry Lookup Table based georeferencing was performed in ENVI 3.4. The 96 channel, calibrated radiance image datasets were then georeferenced using this procedure to the AMG53 projection, AGD66 datum. A background (null value of -9999) was used. Each image was then trimmed to the project boundary and saved as a 16-bit signed integer, binary, BIL raster with an ENVI header file (ASCII). This may be used directly in ENVI, or, for other software, the ASCII header can be read to derive the image parameters.

6.0 DATA ARCHIVING

The georeferenced data for each flightline (along with the ENVI headers) were compressed using WinZip 7.0 to create a zip archive. These were burned to CD.

Appendix I AMS Scanner Calibration (June, 2000)

AMS Scanner Calibration

channel	band center (nm)	band width (nm)	scaling factor
1	528.8	15	0.2187388
2	544.5	15.1	0.0964191
3	560	15.7	0.05439
4	576.2	16.4	0.0381713
5	592.5	16.3	0.0288962
6	608.6	15.9	0.0241933
7	624.8	16.2	0.020821
8	641.1	16.3	0.0178537
9	657.3	15.9	0.0161357
10	673.2	15.8	0.0144726
11	689.1	16.2	0.0137461
12	705	15.9	0.0132264
13	720.7	15.8	0.0127527
14	736.3	15.9	0.0125341
15	752	15.9	0.0124181
16	767.6	15.3	0.0124807
17	783	15.4	0.0126923
18	798.5	15.6	0.0126947
19	814.2	15.2	0.0126209
20	829.4	14.9	0.0124978
21	844.6	15.1	0.0125965
22	859.9	15.1	0.0132149
23	875.1	14.9	0.0140147
24	890.1	14.6	0.0159221
25	905.2	15	0.0168792
26	920.3	14.8	0.0176643
27	935.1	14.8	0.0180798
28	949.7	14.6	0.0200258
29	964.5	15.2	0.0233239
30	979.4	14.8	0.0292491
31	993.9	15	0.0358352
32	1008	14.5	0.0442234
33	1405	17	0.0137815
34	1417.8	17.4	0.0109487
35	1430.9	17.3	0.0089907
36	1444.2	17.8	0.0078032
37	1457.8	17.2	0.0069688
38	1471.6	17.1	0.0062565
39	1485.2	16.6	0.0055986
40	1498.6	16.7	0.0050245
41	1511.9	16.2	0.004649
42	1525.1	16.1	0.0044496
43	1538.2	16.5	0.0042568
44	1551.6	16.8	0.0039987
45	1564.6	16.4	0.0037469
46	1577.2	16.3	0.0035668
47	1589.7	16.5	0.003506
48	1602.5	16.8	0.0034952
49	1615.2	16.6	0.0034831
50	1627.7	16.4	0.0034345

AMS Scanner Calibration (continued)

channel	band center (nm)	band width (nm)	scaling factor
51	1640.1	16.4	0.0033218
52	1652.4	16.1	0.0031886
53	1664.6	16	0.0031256
54	1676.5	15.7	0.0030432
55	1688.6	15	0.0029854
56	1700.7	14.8	0.0030502
57	1712.7	15.4	0.0030841
58	1724.3	14.9	0.0030649
59	1736.3	15.1	0.0030275
60	1748.1	15.1	0.0030244
61	1759.7	14.7	0.0030443
62	1771.2	14.3	0.0030934
63	1782.7	14.4	0.0031784
64	1794.2	14.3	0.0033066
65	1958.3	21.8	0.0014476
66	1976.9	21	0.0012799
67	1995.6	21	0.0011694
68	2014	21	0.0010855
69	2032.5	21.6	0.0010301
70	2051.1	21.2	0.0010009
71	2069.4	20.8	0.00101
72	2087.4	20.7	0.0010105
73	2105.2	20.1	0.0009997
74	2122.9	20.4	0.0010081
75	2140.6	20.7	0.0009949
76	2158.4	20.5	0.0009992
77	2175.7	19.8	0.0010218
78	2192.4	19	0.001057
79	2209.9	20.4	0.0010821
80	2227.4	19.5	0.0011053
81	2244.5	19.7	0.0011057
82	2261.8	19.6	0.0011139
83	2278.9	19.1	0.0011085
84	2295.4	18.8	0.001128
85	2311.9	18.7	0.001148
86	2328.2	18.6	0.0011725
87	2344.4	18.7	0.0011633
88	2360.9	19.1	0.0011517
89	2377.5	18.6	0.0011349
90	2393.4	17.8	0.0011392
91	2409.4	17.8	0.0011646
92	2425	17.7	0.0011886
93	2440.8	17.8	0.0012284
94	2456.5	17.6	0.0012873
95	2472.4	18.1	0.00145
96	2488.2	16.9	0.0018624