

**DE BEERS HYPERSPECTRAL SCANNER
DATA AND LOGISTICS REPORT**

**CAMECO SURVEY
ARHHEMLAND JUNE 2004**

**Dr M C Hussey and Mr M J Hornibrook
JUNE 2004**

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1.0 INTRODUCTION

De Beers Australia Exploration Ltd was contracted by Cameco Australia Pty Ltd to collect airborne hyperspectral scanner imagery over exploration projects in Arnhem Land using their hyperspectral scanner (DBHS) in June 2004. Data was collected over seven survey blocks between the 7th and 13th June 2004. The DBHS is an 96-channel whiskbroom scanner with an approximate 15nm band pass over the 530nm to 2500 nm spectral range.

2.0 DATA ACQUISITION

The following data are an excerpt from the logistics report:

Survey Name: Cameco_2004

Survey consisted of seven (7) areas flown from Jabiru and Katherine

Mann River	(Area prefix MMR)	Strips 1-10	08/6/04
Mann River	(Area prefix MMR)	Strips 11-12 (Completed)	10/6/04
Cadell	(Area prefix Cd)	Strips 1-13 (Completed)	08/6/04
Cadell	(Area prefix Cd)	Strips 12 (Repeat)	09/6/04
Wellington River	(Area prefix WNR)	Strips 1-08 (Completed)	09/6/04
Nablarlek	(Area prefix Nab)	Strips 7-12	10/6/04
Nablarlek	(Area prefix Nab)	Strips 1-12 (Complete with Repeat)	11/6/04
Nablarlek	(Area prefix Nab)	Strips 10-12 (Complete with Repeat)	12/6/04
Jabiru	(Area prefix Jab)	Strips 1-3(Complete)	10/6/04
Algoda	(Area prefix Alg)	Strips 1-2(Complete)	12/6/04
Manyallaluk	(Area prefix MMY)	Strips 1-6(Complete)	7/6/04
Manyallaluk	(Area prefix MMY)	Strips 1-12(Complete-reflown 1 to 6)	13/6/04

Aircraft Survey Operator: VHEE Aviation / Corporate Air
Airtourer Road
Canberra Airport ACT

2.1 Logistics

The DBHS was radiometrically calibrated in January 2004 and checked during ground testing on the 4th June 2004, prior to the survey, to ensure that the wavelength and radiance values had not changed. The system was judged to be operating normally and was installed in VHEE Aviation's VH-CSV, a Cessna 404 on the 5th June at Corporate Air's hanger at Canberra airport. Mr B Wood, a senior pilot experienced in photography surveying, commanded the aircraft. After a brief test flight, the DBHS was ferried to Alice Springs and then to Jabiru, the surveys base, arriving there on the 6th of June 2004..

As supplies of liquid nitrogen were not available in Jabiru, both dewers were filled in Canberra and transported to Jabiru. Surveying commenced on the 7th June and was completed by 13th of June 2004.

This survey took longer than expected due to persistent cloud in the area, several lines were flown more than once to collect optimal data. Cameco had been told that flying at this time of the year may be problematic, previous surveys have been completed later in the year.

2.2 Data Acquisition Summary

2.2.1 Day's Flying: 7th June 2004

Crew

B Wood (Pilot)

M. Hornibrook (Operator)

Pre Flight Testing

Infrasil Window Cleaned

Take Off @ 08:50am

Weather conditions: Clear 0/8 to <1/8

Days objective:

As many strips as possible from Cameco's Survey Areas

Flight Strip Summary

Ferry Time: 1hr 30mins

Survey Time: 2hr 00mins

Comment

Due to cloud cover at end of lines re-fly if possible.

AMS Operator Flight Strip Log**Survey ID** Cameco_2004:**Day's Flying** : 07/06/04**Area Local Solar Zone** : GMT +9.5**Pilot:** B. Wood **Operator:** : M.Hornibrook**Visibility:** 25 Km**Area Name** : Mann River**Sheet #** : 1 of 1**Solar Noon** =12:36**Take Off Time** : 9:05 AM-**Area Subcode** : MMY**Solar elevation @ noon** =55deg**Land Time:** 12:00 PM

Flight Strip ID	Strip Type	Day's Pass No.	Tape No.	Alt ASL (ft)	Cloud Cover	Track	Ground Speed	Est. Drift	Scan Rate	Local Time	GMT Time	Strip Length (Kms)	Strip Length (Lines)
MMY	Prod	1	01	9,200ft	0/8	N-S	150kts	1°R	12.0	9:33	9:33	20.77	4154
MMY	Prod	2	01	9,200ft	0/8	S-N	150kts	2°L	12.0	9:50	9:50	21.64	4328
MMY	Prod	3	01	9,200ft	<0/8	N-S	150kts	4°R	12.0	10:02	10:02	25.61	5122
MMY	Prod	4	01	9,200ft	<1/8	S-N	150kts	2°L	12.0	10:10	10:10	22.19	4439
MMY	Prod	5	01	9,200ft	<1/8	N-S	150kts	4°R	12.0	10:22	10:22	22.75	4550
MMY	Prod	6	01	9,200ft	<1/8	S-N	150kts	2°L	12.0	10:33	10:33	22.40	4480

Key to Strip Types

Ground	A Test Image taken on the Ground
Test	Airborne Test Image - A Non-Production Survey Strip Image
Prod	Airborne Production Survey Strip Image
Dark	Airborne Strip Dark Image (ie AMS shutter on)
UnConf	Unconfigured / extraneous Strip

Key to Strip Acquisition Mode

Inst	Instant Survey
Auto	Preplanned Automatic Survey
Palm	Palmtop

2.2.2 Day's Flying: 8th June 2004

Crew *B Wood (Pilot)*

M. Hornibrook (Operator)

Pre Flight Testing

Infrasil Window Cleaned

Take Off @ 09:05am

Weather conditions: Clear 0/8 to <1/8 cloud

Days objective:

As many strips as possible from Cameco's Survey Areas

Flight Strip Summary

Ferry Time: 1hr 18mins

Survey Time: 1hr 34mins

AMS Operator Flight Strip Log**Visibility:** 25 Km**Survey ID** Cameco_2004:**Area Name** : Mann River Area **Subcode** : MMR**Day's Flying** : 08/06/04 **Sheet #** : 1 of 1**Area Local Solar Zone** : GMT +9.5**Solar Noon** =12:37 **Local Time****Solar elevation** @noon=55deg**Pilot:** B. Wood **Operator:** : M.Hornibrook**Take Off Time** : 9:05 AM-**Land Time:** 12:00 PM

Flight Strip ID	Strip Type	Day's Pass No.	Tape No.	Alt ASL (ft)	Cloud Cover	Track	Ground Speed	Est. Drift	Scan Rate	Local Time	GMT Time	Strip Length (Kms)	Strip Length (Lines)
MMR01	Prod	1	02	9,200ft	0/8	N-S	150kts	5°R	12.0	9:44	0:14	19.57	3166
MMR02	Prod	2	02	9,200ft	0/8	S-N	150kts	5°L	12.0	9:55	0:25	19.57	3222
MMR03	Prod	3	02	9,200ft	0/8	N-S	150kts	5°R	12.0	10:05	0:35	19.57	2174
MMR04	Prod	4	02	9,200ft	0/8	S-N	150kts	6°L	12.0	10:15	0:45	19.57	3276
MMR04	Prod	5	02	9,200ft	<1/8	N-S	150kts	6°R	12.0	10:25	0:55	19.57	3327
MMR06	Prod	6	02	9,200ft	<1/8	S-N	150kts	6°L	12.0	10:35	1:05	19.57	3249
MMR07	Prod	7	02	9,200ft	<1/8	N-S	150kts	6°R	12.0	10:44	1:14	19.57	3128
MMR08	Prod	8	02	9,200ft	<1/8	S-N	150kts	6°L	12.0	10:54	1:24	19.57	3314
MMR09	Prod	9	02	9,200ft	<1/8	N-S	150kts	6°R	12.0	11:04	1:34	19.57	3268
MMR10	Prod	10	02	9,200ft	<1/8	S-N	150kts	6°L	12.0	11:13	1:43	19.57	3234

Key to Strip Types

Ground	A Test Image taken on the Ground
Test	Airborne Test Image - A Non-Production Survey Strip Image
Prod	Airborne Production Survey Strip Image
Dark	Airborne Strip Dark Image (ie AMS shutter on)
UnConf	Unconfigured / extraneous Strip

Key to Strip Acquisition Mode

Inst	Instant Survey
Auto	Preplanned Automatic Survey
Palm	Palmtop

2.2.3 Day's Flying: 09 June, 2002

Crew

B Wood (Pilot)

M. Hornibrook (Operator)

Pre Flight Testing

Infrasil Window Cleaned

Take Off @ 09:15am

Weather conditions: Clear 0/8 to <1/8

Days objective:

As many strips as possible from Cameco's survey areas

Flight Strip Summary

Ferry Time: 0hr 45mins

Survey Time: 2hr 09 mins

AMS Operator Flight Strip Log**Survey ID :** Cameco_2004**Day's Flying :** 09/06/04**Area Local Solar Zone :** GMT \pm 9.**Pilot:** B. Wood**Operator :** M.Hornibrook**Visibility:** 25 Km**Area Name :** Cadell & Wellington Range Area**Sheet # :** 1/2**Solar Noon =** 12:37 : **Local Time****Solar elevation @noon=**55deg**Take Off Time :** 9:00 am **Land Time:** 13:15 pm**Subcode :** WRN/ Cd

Flight Strip ID	Strip Type	Day's Pass No.	Tape No.	Alt ASL (ft)	Cloud Cover	Track	Ground Speed	Est. Drift	Scan Rate	Local Time	GMTTime	Strip Length (Kms)	Strip Length (Lines)
Cd101	Prod	1	03	8,800ft	0/8	N-S	150kts	4°R	12.0	9:30	0:00	20.89	3387
Cd102S	"	2	03	8,800ft	0/8	S-N	150kts	4°L	12.0	9:39	Aborted	DAS	
Cd102N	"	3	03										
Cd103	"	4	03	8,800ft	0/8	N-S	150kts	4°R	12.0	9:49	0:19	20.89	3300
Cd104	"	5	03	8,800ft	0/8	S-N	155kts	4°L	12.5	9:58	0:28	20.89	3146
Cd105	"	6	03	8,800ft	0/8	N-S	150kts	4°R	12.0	10:07	0:37	20.89	3447
Cd106	"	7	02	8,800ft	0/8	S-N	155kts	4°L	12.5	10:17	0:47	20.89	3203
Cd107	"	8	02	8,800ft	0/8	N-S	150kts	4°R	12.0	10:27	0:57	20.89	3403
Cd108	"	9	02	8,800ft	0/8	S-N	155kts	4°L	12.5	10:36	1:06	20.89	3023
Cd109	"	10	02	8,800ft	0/8	N-S	150kts	4°R	12.0	10:45	1:15	20.89	3448
Cd110	"	11	02	8,800ft	0/8	S-N	155kts	4°L	12.5	10:54	1:24	20.89	3201
Cd111	"	12	02	8,800ft	<1/8	N-S	150kts	4°R	12.0	11:03	1:33	20.89	3415
Cd112	"	13	02	8,800ft	<1/8	S-N	155kts	4°L	12.5	11:12	1:42	20.89	3440
Cd113	"	14	02	8,800ft	<1/8	N-S	150kts	4°R	12.0	11:21	1:51	20.89	3524

AMS Operator Flight Strip Log

Survey ID : Cameco_2004

Day's Flying : 09/06/04

Area Local Solar Zone : GMT ±9.

Pilot: B. Wood Operator : M.Hornibrook

Visibility: 25 Km

Area Name : Cadell & Wellington Range Area

Sheet # : 2/2

Solar Noon = 12:37 : Local Time

Solar elevation @noon=55deg

Take Off Time : 9:00 am Land Time: 13:15 pm

Subcode : WRN/ Cdl

Flight Strip ID	Strip Type	Day's Pass No.	Tape No.	Alt ASL (ft)	Cloud Cover	Track	Ground Speed	Est. Drift	Scan Rate	Local Time	GMT Time	Strip Length (Kms)	Strip Length (Lines)
Cd102 (Repeat)	Prod	15	02	8,800ft	<1/8	S-N	155kts	4°L	12.5	11:35	2:05	20.89	3199
WNR08	"	16	03	8,500ft	<1/8	S-N	155kts	4°L	12.5	11:50	2:20	24.83	4056
WNR07	"	17	03	8,500ft	<1/8	N-S	150kts	4°R	12.0	12:01	2:31	24.84	4255
WNR06	"	18	03	8,500ft	<1/8	S-N	155kts	4°L	12.5	12:07	2:37	24.85	3823
WNR05	"	19	03	8,500ft	<1/8	N-S	150kts	4°R	12.0	12:20	2:50	26.25	4341
WNR04	"	20	03	8,500ft	<1/8	S-N	155kts	4°L	12.5	12:30	3:00	26.29	4152
WNR03	"	21	03	8,500ft	<1/8	N-S	150kts	4°R	12.0	12:40	3:10	26.34	4534
WNR02	"	22	03	8,500ft	<1/8	S-N	155kts	4°L	12.5	12:52	3:22	13.01	2068
WNR01	"	23	03	8,500ft	<1/8	N-S	150kts	4°R	12.0	12:59	3:29	13.01	2265

Key to Strip Types

Ground	A Test Image taken on the Ground
Test	Airborne Test Image - A Non-Production Survey Strip Image
Prod	Airborne Production Survey Strip Image
Dark	Airborne Strip Dark Image (ie AMS shutter on)
UnConf	Unconfigured / extraneous Strip

Key to Strip Acquisition Mode

Inst	Instant Survey
Auto	Preplanned Automatic Survey
Palm	Palmtop

2.2.4 Day's Flying: 10th June 2004

Crew

B Wood (Pilot)

M. Hornibrook (Operator)

Pre Flight Testing

Infrasil Window Cleaned

Take Off @ 08:50am

Weather conditions: Clear 0/8 to <1/8

Days objective:

As many strips as possible from Cameco's Survey Areas

Flight Strip Summary

Ferry Time: 1hr 30mins

Survey Time: 2hr 00mins

AMS Operator Flight Strip Log**Survey ID** Cameco_2004:**Day's Flying** : 10/06/04**Area Local Solar Zone** : GMT +9.5**Pilot:** B. Wood **Operator:** : M.Hornibrook**Visibility:** 25 Km**Area Name** : Narbarlek**Sheet #** : 1 of 1**Solar Noon** =12:37**Take Off Time** : 9:05 AM-**Area Subcode** :Nab**Solar elevation @ noon** =54deg**Land Time:** 11:50 PM

Flight Strip ID	Strip Type	Day's Pass No.	Tape No.	Alt ASL (ft)	Cloud Cover	Track	Ground Speed	Est. Drift	Scan Rate	Local Time	GMT Time	Strip Length (Kms)	Strip Length (Lines)
Nab12	Prod	1	04	8,700ft	1/8	S-N	155kts	4°L	12:5	9:35		18.66	3016
Nab11	“	2	04	8,700ft	<1/8	N-S	150kts	4°R	12:0	9:44		18.61	2969
Nab10	“	3	04	8,700ft	1/8	S-N	155kts	4°L	12:5	9:53		18.57	3013
Nab09	“	4	04	8,700ft	<1/8	N-S	150kts	4°R	12:0	10:01		18.50	2907
Nab08	“	5	04	8,700ft	1/8	S-N	155kts	4°L	12:5	10:11		18.59	3021
Nab07	“	6	04	8,700ft	1/8	N-S	155kts	4°R	12:25	10:19		18.67	3323
RGR01	“	7	04	6,400ft	0/8	N-S	130kts	5°R	12:5	11:10	1:40	14.87	3201
RGR02	“	8	04	6,400ft	0/8	S-N	130kts	5°L	12:5	11:19	1:49	14.87	2763
RGR03	“	9	04	6,400ft	0/8	N-S	130kts	5°R	12:5	11:27	1:57	14.87	2844
RGR04	“	10	04	6,400ft	0/8	S-N	130kts	5°L	12:5	11:36	2:06	14.87	2862

Key to Strip Types

Ground	A Test Image taken on the Ground
Test	Airborne Test Image - A Non-Production Survey Strip Image
Prod	Airborne Production Survey Strip Image
Dark	Airborne Strip Dark Image (ie AMS shutter on)
UnConf	Unconfigured / extraneous Strip

Key to Strip Acquisition Mode

Inst	Instant Survey
Auto	Preplanned Automatic Survey
Palm	Palmtop

2.2.5 Day's Flying: 11th June 2004

Crew

B Wood (Pilot)

M. Hornibrook (Operator)

Pre Flight Testing

Infrasil Window Cleaned

Take Off @ 08:50am

Weather conditions: Clear 0/8 to <1/8

Days objective:

As many strips as possible from Cameco's Survey Areas

Flight Strip Summary

Ferry Time: 00hr 33mins

Survey Time: 04hr 12mins

Comment

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AMS Operator Flight Strip Log**Survey ID** Cameco_2004:**Day's Flying :** 11/06/04**Area Local Solar Zone :** GMT +9.5**Pilot:** B. Wood**Operator:** : M.Hornibrook**Visibility:** 25 Km**Area Name :** Narbarlek/Mann River/Jabiru**Sheet # :** 1/1**Solar Noon** =12:37**Take Off Time :** 9:05 AM-**Area Subcode :** Nab/MMR/Jab**Solar elevation @ noon** =54deg**Land Time:** 13:20 PM

Flight Strip ID	Strip Type	Day's Pass No.	Tape No.	Alt ASL (ft)	Cloud Cover	Track	Ground Speed	Est. Drift		Local Time	GMT Time	Strip Length (Kms)	Strip Length (Lines)
Nab12R	Prod	1	05	8,700ft	0/8	S-N	155kts	5°L	12:5	9:25		18.66	2922
Nab11R	"	2	05	8,700ft	0/8	N-S	150kts	5°R	12:0	9:33		18.61	3115
Nab10R	"	3	05	8,700ft	0/8	S-N	155kts	5°L	12:5	9:42		18.57	3055
Nab09R	"	4	05	8,700ft	0/8	N-S	150kts	5°R	12:0	9:51	0:21	18.5	3273
Nab08R	"	5	05	8,700ft	0/8	S-N	155kts	5°L	12:5	10:00	0:30	18.59	3014
Nab07R	"	6	05	8,700ft	0/8	N-S	150kts	5°R	12:0	10:09	0:39	18.67	3400
Nab06	"	7	05	8,700ft	0/8	S-N	155kts	5°L	12:5	10:19	0:49	21.42	3419
Nab05	"	8	05	8,700ft	0/8	N-S	150kts	5°R	12:0	10:28	0:58	21.34	3711
Nab04	"	9	05	8,700ft	0/8	S-N	155kts	5°L	12:5	10:38	1:08	18.64	2991
Nab03	"	10	05	8,700ft	0/8	N-S	150kts	5°R	12:0	10:47	1:17	9.19	1631
Nab02	"	11	05	8,700ft	0/8	S-N	155kts	5°L	12:5	10:54	1:24	9.09	1564
Nab01	"	12	05	8,700ft	0/8	N-S	150kts	5°R	12:0	11:01	1:31	8.99	1658
MMR11	"	13	05	9,200ft	<1/8	N-S	150kts	5°R	12:0	11:28	1:58	19.58	3219
MMR12	"	14	05	9,200ft	<1/8	S-N	155kts	5°L	12:5	11:36	2:06	19.58	3020
Jab01	Prod	15	05	8,500ft	0/8	S-N	155kts	5°L	12:5	12:08	2:38	25.48	3928
Jab02	"	16	05	8,500ft	0/8	N-S	150kts	5°R	12:0	12:18	2:48	25.48	4469
Jab03	"	17	05	8,500ft	0/8	S-N	155kts	5°L	12:5	12:29	2:59	25.48	3949
NabL01	"	18	05	6,500ft	0/8	S-N	130kts	5°L	12:5	12:56	3:26	6.08	1235
NabL02	"	19	05	6,500ft	0/8	N-S	130kts	5°R	12:5	12:58	3:28	6.08	1521
NabL01R	"	20	05	6,500ft	0/8	N-S	130kts	5°R	12:5	13:07	3:37	6.08	1568

2.2.6 Day's Flying: 12th June 2004

Crew

B Wood (Pilot)

M. Hornibrook (Operator)

Pre Flight Testing

Infrasil Window Cleaned

Take Off @ 08:50am

Weather conditions: Clear 0/8 to <1/8

Days objective:

As many strips as possible from Cameco's Survey Areas

Flight Strip Summary

Ferry Time: 01hr 00mins

Survey Time: 02hr 00mins

Comment

.

AMS Operator Flight Strip Log**Survey ID** Cameco_2004:**Day's Flying** : 11/06/04**Area Local Solar Zone** : GMT +9.5**Pilot:** B. Wood **Operator:** M.Hornibrook**Visibility:** 25 Km**Area Name** : Narbarlek/Algoda**Sheet #** : 1/1**Solar Noon** =12:37**Take Off Time** : 10:15 AM-**Area Subcode** : Nab/Alg**Solar elevation @ noon** =54deg**Land Time:** 13:45 PM

Flight Strip ID	Strip Type	Day's Pass No.	Tape No.	Alt ASL (ft)	Cloud Cover	Track	Ground Speed	Est. Drift	Scan Rate	Local Time	GMT Time	Strip Length (Kms)	Strip Length (Lines)
Nab12R1	Prod	1	06	8,700ft	0/8	S-N	155kts	5°L	12:5	10:48	1:18	18.66	2970
Nab11R1	“	2	06	8,700ft	<1/8	N-S	150kts	5°R	12:0	10:57	1:27	18.61	2853
Nab10R1	“	3	06	8,700ft	<1/8	S-N	155kts	5°L	12:5	11:06	1:36	18.57	2963
Alg02	“	4	06	8,500ft	<1/8	S-N	155kts	5°L	12:5	11:29	1:59	13.02	2143
Alg01	“	5	06	8,500ft	<1/8	N-S	155kts	5°R	12:5	11:37	2:07	13.02	2220
RJ01	“	6	06	6,500ft	0/8	N-S	130kts	2°L	12:5	12:35	3:05	11.99	2606
RJ02	“	7	06	6,500ft	0/8	S-N	130kts	2°R	12:5	12:43	3:13	11.99	2383

Key to Strip Types

Ground	A Test Image taken on the Ground
Test	Airborne Test Image - A Non-Production Survey Strip Image
Prod	Airborne Production Survey Strip Image
Dark	Airborne Strip Dark Image (ie AMS shutter on)
UnConf	Unconfigured / extraneous Strip

Key to Strip Acquisition Mode

Inst	Instant Survey
Auto	Preplanned Automatic Survey
Palm	Palmtop

2.2.7 Day's Flying: 13th June 2004

Crew

B Wood (Pilot)

M. Hornibrook (Operator)

Pre Flight Testing

Infrasil Window Cleaned

Take Off @ 08:50am

Weather conditions: Clear <1/8

Days objective:

As many strips as possible from Cameco's Survey Areas

Flight Strip Summary

Ferry Time: 01hr 00mins

Survey Time: 02hr 00mins

Comment

.

AMS Operator Flight Strip Log

Survey ID Cameco_2004:

Visibility: 25 Km

Area Name : Manyallaluk

Area Subcode : MMY

Day's Flying : 11/06/04

Sheet # : 1/1

Area Local Solar Zone : GMT +9.5

Solar Noon =12:37

Solar elevation @ noon =54deg

Pilot: B. Wood

Operator: M.Hornibrook

Take Off Time : 09:45AM

Land Time: 12:45 PM

Flight Strip ID	Strip Type	Day's Pass No.	Tape No.	Alt ASL (ft)	Cloud Cover	Track	Ground Speed	Est. Drift	Scan Rate	Local Time	GMT Time	Strip Length (Kms)	Strip Length (Lines)
MMY01R	Prod	1	07	9,300ft	<1/8	N-S	155kts	5°R	12:5	10:16	0:48	27.85	4282
MMY02R	"	2	07	9,300ft	<1/8	S-N	155kts	6°L	12:5	10:26	0:56	27.85	4291
MMY03R	"	3	07	9,300ft	<1/8	N-S	155kts	6°R	12:5	10:36	1:06	27.85	4498
MMY04R	"	4	07	9,300ft	<1/8	S-N	155kts	6°L	12:5	10:46	1:16	27.85	4359
MMY05R	"	5	07	9,300ft	<1/8	N-S	155kts	6°R	12:5	10:56	1:26	27.85	4479
MMY06R	"	6	07	9,300ft	<1/8	S-N	155kts	6°L	12:5	11:06	1:36	27.85	4315
MMY07	"	7	07	9,300ft	<1/8	N-S	155kts	6°S	12:5	11:15	1:45	27.85	4508
MMY08	"	8	07	9,300ft	<1/8	S-N	155kts	6°L	12:5	11:25	1:55	27.85	4298
MMY09	"	9	07	9,300ft	<1/8	N-S	155kts	6°R	12:5	11:37	2:07	27.85	4586
MMY10	"	10	07	9,300ft	<1/8	S-N	155kts	6°L	12:5	11:47	2:17	27.85	4289
MMY11	"	11	07	9,300ft	<1/8	N-S	155kts	6°R	12:5	11:56	2:26	27.85	5403
MMY12	"	12	07	9,300ft	<1/8	S-N	155kts	6°L	12:5	12:06	2:36	27.85	4295
MMY08R	"	13	07	9,300ft	<1/8	N-S	155kts	6°R	12:5	12:17	2:47	27.85	4562

Key to Strip Types

Ground	A Test Image taken on the Ground
Test	Airborne Test Image - A Non-Production Survey Strip Image
Prod	Airborne Production Survey Strip Image
Dark	Airborne Strip Dark Image (ie AMS shutter on)
UnConf	Unconfigured / extraneous Strip

Key to Strip Acquisition Mode

Inst	Instant Survey
Auto	Preplanned Automatic Survey
Palm	Palmtop

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 integer, BIL data file with an ASCII header file). DBHS stores the intensity of light reflected from the surface of the earth as digital numbers (DN). The intensity recorded is the net effect of the wavelength dependent atmospheric absorption 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 non-reflecting surface. It represents system voltages and electronic noise. It is additive and band dependent.

3.2 Calibration – Radiometric, Spectral 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 scaled by this band constant and a multiplier has been applied so that the data is stored as a 16-bit un-signed integer. The radiometric scaling factors applied, along with the band centers and bandwidths 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 multiplier 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).

Whilst the DBHS radiance data is spectrally and radiometrically calibrated, the spectra are distorted by atmospheric absorption and scattering. The Atmospheric Correction Now (ACORN: Analytical Imaging and Geophysics LLC) software has been used to determine a subset of atmospheric properties present in the DBHS radiance data. ACORN uses radiative transfer calculations (mode 1) and the calibrated hyperspectral data (with artefact suppression) to correct for the atmosphere. ACORN output is apparent surface reflectance. The atmosphere is suppressed and mineral absorption features are now recognisable. Reflectance is unit-less.

5.0 GEOMETRIC CORRECTION

The scanner data is collected along flight-lines oriented approximately north-south, and flown either south-north or north-south. Variations in the aircraft orientation, speed and altitude during image acquisition result in spatial distortions of the images, even though the scanner is mounted in a tri-axial, gyrostabilised platform that compensates for some of these motion effects. A C-migits INS/GPS unit is attached to scanner and it provides data that can be used to remove these distortions which would otherwise result in positional errors of several hundred metres. Using these data with the appropriate software permits geo-correction to be completed without the need for control point picking and depending on terrain variation can reduce positional errors to below 100m.

Software developed for De Beers by xq37 Pty Ltd is used for this correction process and works in two modes, extracting the required parameters from the log files produced for each strip. One program corrects the image data using a ray-tracing algorithm (xqInertia), it can incorporate digital terrain information to improve the correction. The other program (INSlocate) derives a set of control points from the log file with the frequency and location of the control points being specifiable (usually six points every fifth line). This control point file can then be used in map rectification programs contained within image processing systems, such as ENVI and ER Mapper, to warp the image strips to the desired map projection. This program does not utilise digital terrain data. These control points can then be used to geometrically correct any image that result from information extraction and enhancement processing. Once the data strips have been geometrically corrected they can be mosaiced together using programs available within standard image processing systems.

5.1 Geometric Correction Products and Mosaicing Procedures

Delivered with these data are the following files:

- *-**INS.txt** – Nadir pixel co-ordinates, altitude, roll, pitch and heading values from the C-migits unit
- *-**ccx** – Colour composite image for bands at wavelengths 2201nm, 941nm and 537nm in red, green and blue respectively.
- ccx_w** – Colour composite cross track shading corrected and warped to UTM zone 53 WGS-84 pixel size 6m using xqInertia.
- *-**GCP.pts** – control points file (ENVI compatible) produced by INSlocate, 6 points per line every 5th line

INSlocate been used to create the GCP's. However, it has been determined that the GPS data from the C-migits have an offset applied to them. It is possible to determine this offset relative to adjacent strips and this has been done and using these offsets, below, the GCP's have been calculated:

No DEM has been used in this calculation of offsets and so the average ground elevation plus 50m has been used to create GCP's.

From main menu open - **Map**
Open - **Registration**
Open - **Warp from GCP's Image to Map**
Select - **GCP.pts file for strip**
Select - **Projection (UTM*)**
Select - **Datum (WGS-84*)**
Select - **Units (Metres)**
Select - **Zone (53 – S)**
Select - **Pixel size (6*)**
Open - **Input image file**
Apply

Repeat procedure for each strip.

The rectified strips can then be mosaiced in ENVI as follows:

From main menu open - **Map**
Open - **Mosaicking**
Open - **Georeferenced**
Select - **Import**
Select - **Import file with feathering**
Select - **File**
Enter – **Edge Feathering Distance – 10pixels***
Enter – **Cutline Feathering Distance – 5 pixels***
Enter – **Background data value to ignore – 0**
Repeat for each strip to be added
Apply

This procedure has been used to produce the colour composite mosaic's delivered with the data from this survey,

*These are suggested values than can be varied if desired.

Another method of producing GCP's that incorporates will be applied to this data but this will require a new program AMS2SAT which is currently being debugged. This will be applied to these data as soon as possible and should result in a more accurate geometric correction. The procedure will be:

6.0 DATA ARCHIVING

The data is collected on DLT tapes and each day's surveys are backed up onto a duplicate DLT. After this backup the pre-processing software is run and the resultant ENVI image format radiance corrected data and all ancillary files are backup up onto DLT tape. All DLT tapes produced by this process have been retained at the premises of DBAE in Bassendean, WA. They will not be accessed or distributed to other parties expect at the written request of Cameco. If Cameco so requires these tapes will sent to Cameco and no copies of the data (raw or processed) will be retained by DBAE.

The following products were sent to Cameco on DVD on the

26th June 2004:

- Radiance data and reflectance corrected data with Dark Current and log-files.
- Image and data products as described in section 5.1
- Files showing Channel number with Wavelength band centre (nm), band centre (nm) and radiance scaling factor
- Files showing Offset for Geometric Corrections

APPENDIX 1

DBHS 2004 Band Wavelength, FWHM and Radiance Offsets.

Band	Wavelength	Bandwidth	DN_rad mult
1	525.75	13.53	0.6522969
2	539.43	16.05	0.1609052
3	554.92	16.45	0.07021
4	570.61	17.05	0.0420878
5	586.78	16.9	0.0288915
6	602.94	16.65	0.022475
7	618.79	16.15	0.0185009
8	634.93	16.85	0.0155364
9	651.19	16.55	0.0138324
10	667.15	16.05	0.0122149
11	682.89	16.1	0.0110746
12	698.71	16.6	0.0103613
13	714.57	15.95	0.0098702
14	730.12	15.95	0.0094964
15	745.69	16.05	0.0092349
16	761.3	15.95	0.0092068
17	776.8	15.45	0.0093033
18	792.08	15.45	0.0092866
19	807.64	15.85	0.0092077
20	823.18	15.5	0.0089942
21	838.26	15.35	0.0089171
22	853.42	15.45	0.0090689
23	868.66	15.5	0.0094977
24	883.8	15.15	0.01069
25	898.69	15.3	0.0112874
26	913.75	15.45	0.0116591
27	928.7	15.4	0.0117469
28	943.42	15.15	0.0127644
29	958.02	15.45	0.0143425
30	972.81	15.85	0.0172337
31	987.53	15.7	0.020448
32	1001.67	14.85	0.0245382
33	1427.54	16.85	0.9641486
34	1427.54	16.85	0.0055519
35	1441.15	17.1	0.0047384
36	1441.15	17.1	0.0047384
37	1482.61	15.75	0.0038857
38	1482.61	15.75	0.0033161
39	1497.02	10.95	0.0028967
40	1510	15.2	0.0026744
41	1523.41	15.1	0.0025613
42	1536.88	15.6	0.0024276
43	1550.43	15.7	0.0022657
44	1563.69	15.35	0.0021013
45	1576.67	15.6	0.001995
46	1589.61	16.05	0.001935
47	1602.53	16.05	0.0019361
48	1615.3	16	0.0019433
49	1628.05	16.2	0.0019244
50	1640.73	16.3	0.0018697
51	1653.34	15.85	0.0018109

52	1665.55	15.5	0.0017797
53	1677.73	15.75	0.0017726
54	1689.97	16.05	0.0017847
55	1702.19	15.6	0.0018029
56	1714.17	15.3	0.0018161
57	1726.07	15.3	0.0018145
58	1749.92	15.15	0.0017865
59	1749.92	15.15	0.0018137
60	1761.57	14.75	0.0018203
61	1773.02	14.65	0.0018486
62	1784.6	14.95	0.00193
63	1796.05	14.6	0.0020409
64	1807.41	13.65	0.002227
65	1955.8	22.2	0.001173
66	1975.5	21.7	0.0010018
67	1994.8	21.5	0.000891
68	2014.2	21.9	0.0008092
69	2033.7	22.1	0.0007584
70	2053.1	21.8	0.000731
71	2072.1	21.8	0.0007331
72	2090.5	21.5	0.00073
73	2108.9	21.4	0.0007204
74	2127.4	21.5	0.0007267
75	2145.9	22	0.0007199
76	2164.3	21.5	0.0007293
77	2181.9	20.5	0.0007527
78	2198.9	21.2	0.0007815
79	2217.9	21.1	0.0007966
80	2235.3	20.5	0.0008106
81	2253.3	21.9	0.0008082
82	2270.9	20.4	0.0008148
83	2288.2	20.5	0.0008164
84	2305	20	0.0008351
85	2321.7	20.2	0.0008476
86	2338.5	20.7	0.0008591
87	2355.6	21.1	0.0008464
88	2372.4	20.6	0.0008418
89	2388.9	20.3	0.0008398
90	2405.1	19.8	0.0008531
91	2421.2	19.8	0.0008785
92	2437.3	19.9	0.0008967
93	2453.5	20.4	0.0009244
94	2469.4	21	0.0009731
95	2485.4	20.2	0.0011028
96	2500.2	19.3	0.001513

