



AIRBORNE LASER TERRAIN MAPPER

(ALTM)

Customer Performance Report

Model Number: 1225

Serial Number: 99D117

Client Name: CS1

Testing Period: May 2005

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Data processed by: The processing team

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SUMMARY

ALTM 1225 99D117 was flown on one occasion. Data collection altitudes ranged from 1000 m to 1220 m.

This report is made upon the request of LMSI/GRW Inc.

1 INTRODUCTION

The purpose of this ALTM System Report is to confirm that Optech ALTM 1225 99d117 meets all specifications and customer requirements at the time of delivery. It demonstrates that elevation and horizontal accuracy performance is within specification when the optimal GPS quality has been met also that other system outputs including first and last pulse capture and intensity measurement are performing as they should.

2 SYSTEM SPECIFICATION

This certifies that Optech ALTM 1225, bearing SN 99D117 complies with the specifications set forth in Table 1 below.

Table 1 *ALTM 1225 system specifications*

Nominal	
Operating altitude	400-1,200 m nominal
Elevation accuracy*	<15cm at 1000m ; 1 σ
Scan angle	Variable from 0 to $\pm 20^\circ$
Swath width	Variable from 0 to 0.68 altitude
Angle resolution	0.01°
Scan frequency	Variable based on scan angle ; e.g., 28 Hz for +/- 20 degree scan
Horizontal accuracy	+/- 1/2000 x altitude, 1 σ
Supported GPS receivers	Novatel Millenium
Laser repetition rate	25 kHz
Beam divergence	Dual divergence: Narrow (1.e) 0.2 mrad/ Wide (1/e) 0.8 mrad
Eyesafe range **	
Intensity	Records strength of returned laser pulse signals
Dual time interval meters	Simultaneous first and last return pulse signals provided for every laser shot
Laser classification	Class IV laser product (FDA CFR 21)
Power requirements	28 VDC @ 35A
Operating temperature	10-35°C
Humidity	0-95% non-condensing

Notes:

* To meet its stated accuracy, the ALTM must receive GPS data of sufficient quality. GPS data quality will be viable only when all of the following conditions are met:

- At least 4 satellites are in lock (tracked by the receiver) throughout the survey
- Elevation of the satellites is above 15°
- Geometry of the satellites is good (i.e. PDOP < 4)
- Aircraft stays within 30 km of the GPS base station.

If one or more of these conditions is not met, or if any source of electromagnetic interference causes the GPS receivers to repeatedly loose lock, the specified accuracy of the ALTM cannot be guaranteed.

3 INITIAL AND FINAL CALIBRATION PARAMETERS

Table 2 *Lab and Final Calibration Numbers.*

Parameter	Initial Lab Calibration Values	Final Calibration Values
<i>ALTM ID</i>	99D117	99D117
<i>ALTM Type</i>	1225	1225
<i>Time Correction (sec)</i>	0.00	
<i>TIM1</i>		
First Pulse (meters)	-0.425	-0.425
Last Pulse (meters)	N/A	N/A
<i>TIM2</i>		
First Pulse (meters)	N/A	N/A
Last Pulse (meters)	-0.306	-0.306
<i>Cross-flight Scanner</i>		
Offset (degrees)	-0.079	-0.079
Scale (no units)	1.003	1.003
Lag (degrees)	0.0000	0.0000
<i>IMU Corrections</i>		
Pitch	0.032	0.030
Roll	-0.007	-0.002
Heading	-0.001	-0.001

Table 3 *Horizontal analysis using final calibration numbers.*

Data Set	Diver. (mrad)	Attribute	Laser Freq. (kHz)	Pulse	Mean Difference (m)	Standard Deviation (m)	RMS (m)	Sample Size (# of Points)	Flight Altitude (m AGL)	GPS Stdev. (m)
Day 12505	0.3	Pitch	25	First	0.050	0.304	0.308	4	1060	0.035
				Last	-0.034	0.181	0.184	4	1060	
		Roll	25	First	-0.05	0.238	0.243	402	1060	
				Last	0.021	0.430	0.431	402	1060	

Table 4 *Vertical analysis using final calibration values.*

Data Set	Divergence (mrad)	Attribute	Laser Freq. (kHz)	Pulse	Mean Difference (m)	Stdev. (m)	RMS (m)	Sample Size (# of Points)	Flight Altitude (m AGL)
Day 12505 25x24x20	0.3	TIM1	25	First	0.023	0.049	0.054	187	1220
		TIM2		Last	0.032	0.056	0.065	187	
Day 12505 25x24x20	0.3	TIM1	25	First	-0.037	0.053	0.065	176	1220
		TIM2		Last	-0.030	0.061	0.068	176	

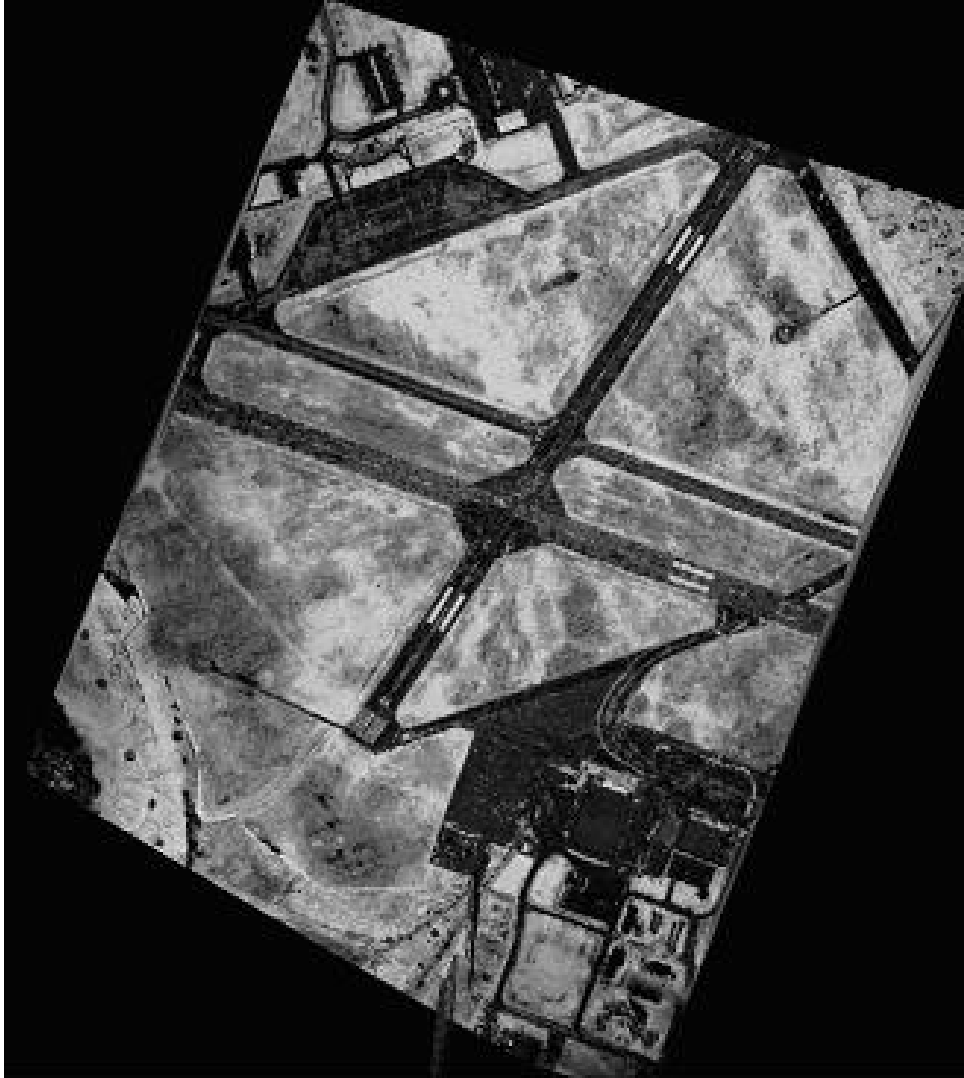


Figure 1 *Intensity image of Oshawa Airport, Oshawa, Canada. Data collected at 1000 m agl.*

The intensity image was inspected to ensure that there is no “banding” of the image due to the recording of different intensities from forward and backward scans. This test ensures that the alignment of the lidar receiver is optimized.

The analysis from 12505 indicates that 99D117 has scan line to scan line banding within specification.

Table 5 *Intensity Banding with flying height & scanner parameters.*

Flight Date	Aircraft Height (agl) Scanner Parameters	Inbound	Outbound	% (n-m)/n
12505	25 x 24 x 20 1220 m	60.52	62.35	2.88
12505	25 x 24 x 20 1220 m	44.0	43.7	0.68
12505	25 x 24 x 20 1220 m	63	64.1	1.71

3.1.1 Ranging Capabilities

Tests performed over the runway revealed average dropout rates. Dropouts are a function of the lack of a return signal for the outgoing pulse (Table 6). Results below are from a single flight. The data was reviewed to determine the percentage of dropouts.

Table 6 *ALTM dropout rates given varying altitudes.*

Flight Date	Aircraft Height (agl m)	Dropouts (%)
12505	1050m	0.19
12505	1050m	0.13
12505	1050m	1.19
12505	1000m	0.10
12505	1000m	0.41
12505	1000m	0.09
12505	1200m	0.23
12505	1200m	0.65

3.1.2 First/Last Pulse Feature Discrimination

The ALTM 99D117 simultaneously records the first and last returns of a given pulse. To test this feature data was collected over the calibration building. The processed data confirmed that the system is capable of collecting ground and canopy hits from a single outgoing pulse for the ground and the top of the building (Table 7). These tests indicate that this feature is functioning correctly.

Table 7 *Sample of ASCII output file containing GPS time, last pulse (E, N, Z) and first pulse (E, N, Z). Note the higher elevation value for the first pulse returns, indicating a hit on the top of the building.*

```

245464.964280 17624000.97 4873272.06 226.36 65 17624000.97 4873272.06 226.36 65
245464.964320 17624000.81 4873272.05 226.44 40 17624000.81 4873272.05 226.38 40
245464.964360 17624000.65 4873272.04 226.38 45 17624000.65 4873272.04 226.37 45
245464.964400 17624000.65 4873272.03 226.37 66 17624000.65 4873272.03 226.36 66
245464.964440 17624000.49 4873272.02 226.37 80 17624000.49 4873272.02 226.36 80
245464.964480 17624000.17 4873272.01 226.37 75 17624000.17 4873272.01 226.39 75
245464.964520 17624000.01 4873272.00 226.41 60 17623999.96 4873272.19 237.37 4
245464.964560 17623999.85 4873271.99 226.41 25 17623999.80 4873272.18 237.48 75
245464.964600 17623999.65 4873272.17 237.58 171 17623999.65 4873272.17 237.59 171
245464.964640 17623999.65 4873272.17 237.36 160 17623999.65 4873272.17 237.35 160
245464.964680 17623999.33 4873272.14 237.14 148 17623999.33 4873272.14 237.11 148
245464.964720 17623999.18 4873272.13 237.13 172 17623999.18 4873272.13 237.12 172
245464.964760 17623998.86 4873272.12 237.11 352 17623998.86 4873272.12 237.11 352
245464.964800 17623999.02 4873272.12 237.16 384 17623999.02 4873272.12 237.11 384
245464.964840 17623998.86 4873272.11 237.11 288 17623998.86 4873272.11 237.10 288
245464.964880 17623998.55 4873272.09 237.15 256 17623998.55 4873272.09 237.11 256
245464.964920 17623998.39 4873272.08 237.12 320 17623998.39 4873272.08 237.09 320

```

4 APPENDIX A:

4.1 GPS Eccentricity Values

The following measurements are valid only for the N111 (client's aircraft), when using the Novatel aircraft antenna. Note: The "User to GPS Antenna" offsets were calculated by summing the internal "User to Reference Point" measurements (determined at Optech) with the surveyed relative position of the GPS airborne antenna to the sensor head (i.e. "Reference Point to GPS Antenna").

Reference Point to GPS Antenna	
X	0.472 m
Y	0.006 m
Z	-0.886 m

User (Scanner Mirror) to GPS Antenna (POS/AV)	
X	0.421 m
Y	-0.021 m
Z	-1.386 m

4.2 Sensor Head Constants

The following measurements were calculated in the lab at Optech and will remain constant.

User Frame to IMU Misalignment (POS/AV)	
X	-0.075 degrees
Y	-0.015 degrees
Z	0.110 degrees

User to IMU Lever Arm (POS/AV)	
X	-0.101 m
Y	-0.005 m
Z	-0.111 m

User to Reference Point	
X	-0.051 m
Y	-0.027 m
Z	-0.500 m

5 APPENDIX B:

5.1 IP Addresses

IP Addresses	
Laptop IP address	192.9.202.99
Laptop Subnet Mask	255.255.255.0
POS IP Address	192.9.202.40
POS version	3.00

6 APPENDIX C:

6.1 Base Station GPS Antenna

Monument Description:		
Date (M/D/Y): 06/1/2005	GPS Receiver Type: Novatel Antenna Type: Novatel	Epoch Interval: Elevation Mask: 0 degrees Observation Type: Static
Observation Coordinate: N 43 51 28.59620 Station1: Buttonville E 79 22 10.29498 H 165.913		

7 APPENDIX D:

7.1 Hardware constants

IntensityK= 32.0
LastPulseConstant= 390192
ScannerCounts= 4096
ScannerMaxAngle= 40
SkippedLaserSecs= 0
TimestampIncrement= 10

7.2 Calibration File

AltmSerialNo= 99D117;
ImuType= LN200A1;
ImuRate= 50;
ScannerScale= 1.0008;
ScannerOffset= -0.079;
FirstPulseRange= -0.425;
LastPulseRange= -0.306;
IMURoll= -0.002;
IMUPitch= 0.030;
IMUHeading= -0.001;
UserToImuEx= -0.075;
UserToImuEy= -0.015;
UserToImuEz= 0.110;
UserToImuDx= -0.101;
UserToImuDy= -0.005;
UserToImuDz= -0.111;
UserToRefDx= -0.051;
UserToRefDy= -0.027;
UserToRefDz= -0.500;

7.3 Intensity Table

0	3	-0.04
4	16	-0.05
17	23	-0.04
24	42	-0.03
43	73	-0.02
74	99	-0.01
100	129	0.00
130	152	0.01
153	154	0.00
155	156	-0.01
157	166	-0.02
167	175	-0.03
176	199	-0.02
200	385	-0.01
386	475	0
476	540	0.01
541	635	0.02
636	720	0.03
721	1008	0.04
1009	1200	0.03
1201	1328	0.02
1329	1424	0.01
1425	2928	0
2929	3408	0.01
3409	3632	0.02
3633	3920	0.01
3921	8391	0.02