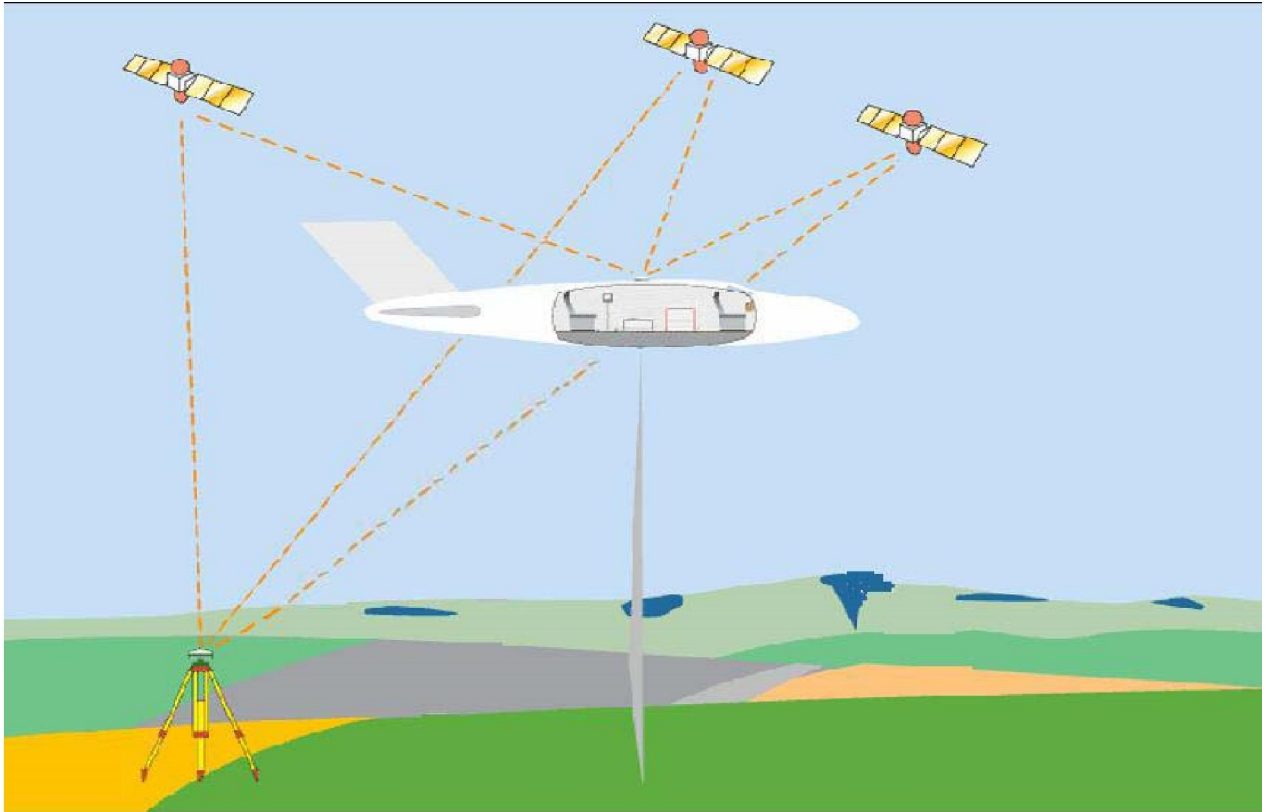


# ALS Calibration Certificate



*This certificate is valid for  
Calibration certificate issued on*

*Model*  
**ALS70-HP (High Performance)**  
**29 Jan 2016**

*Serial Number*  
**SN7232**  
Inspector

*by*

*Certificate and calibration data ID*

**SN7232\_160129\_ALS70\_HP\_SP3**  
**Cal Report**

Deanna Burton

Leica Geosystems AG  
Heinrich-Wild-Strasse  
9435 Heerbrugg  
Switzerland

**Leica**  
Geosystems

## Components of ALS70

Component	Device	Type	Serial Number
LS70	Laser Scanner		7232
IPAS	INS System	10 v3.0001	1508
IMU	Inertial Measurement Unit	CUS6-"uIRS"	56071262 (temp)
GPS	L12GVQ GPS+GNSS w Tightly Coupled	SPAN3.630	BZZ13020428
DL70	Data Logger	XP embedded	7232
GC70	Galvo Controller	"ALS_70" performance Combined	X 14032321 Y
SC70	System Controller		7232
Receivers	Optical Paths	2	17.02.14 009 F 1835 17.02.14 006 F 1830

## Calibrated Parameters

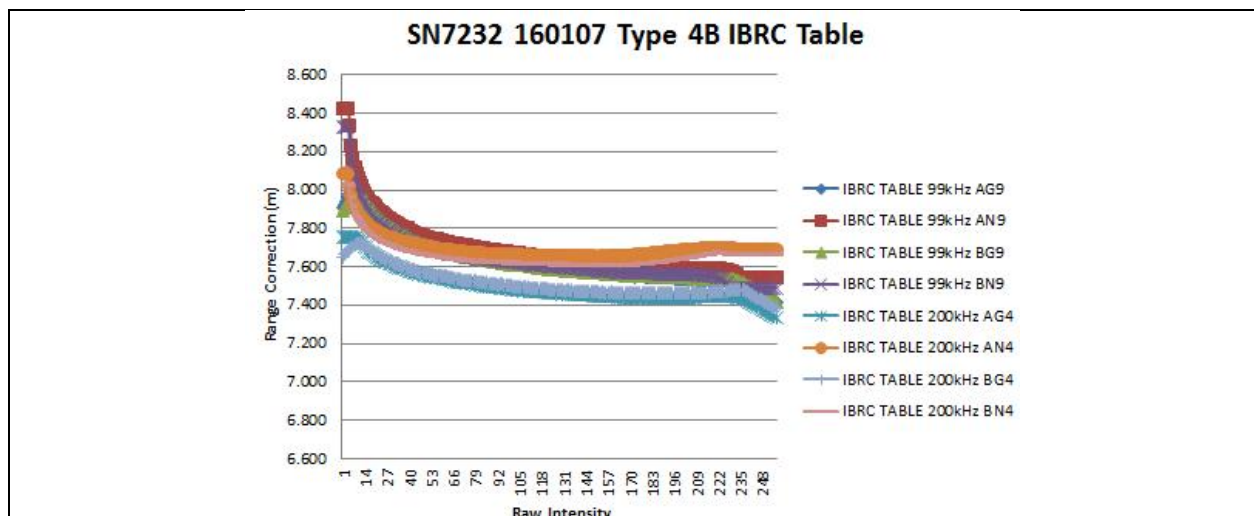
### Intensity based range correction (IBRC)

	Passed	Date	Inspector
<i>RIVIT (raw IBRC) measurements</i>	ok	07 Jan 16	Production
<i>IBRC table</i>	ok	21 Jan 16	Deanna Burton
<i>Integrated Range Offset (Mission Date)</i>	ok	29 Jan 16	Deanna Burton

File **SN7232\_HP\_IBRC\_Type4B\_160129.csv (Tz Split - Auto)**

Objective To correct for the effect of varying range based on return signal strength.

Note The range biases are in meters. The bias values derived from test data above and below the TPR are for intensity values of 0 (low intensity) to 255 (high intensity) in that order.



Intensity based range correction (IBRC) - curve

**Gain based intensity correction (GBIC) SP2. Intensity Scale Factors (SP3)**

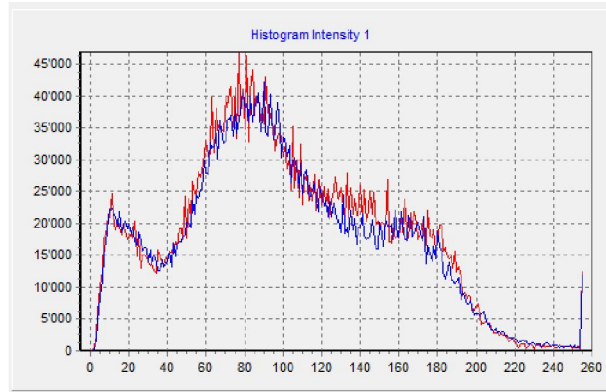
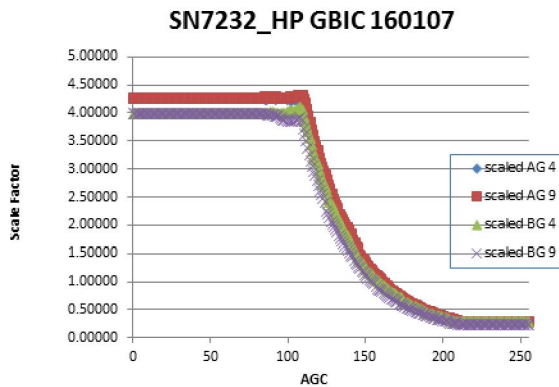
	Passed	Date	Inspector
GBIC (raw IBRC) measurements	ok	07 Jan 16	Production
SP2 - GBIC table	ok	21 Jan 16	Deanna Burton
SP3 - Intensity Scale Factors	Ok	21 Jan 16	Deanna Burton

File **SN7232\_GBIC\_Type3\_1\_160121.csv (Tz Split - Auto)**

Objective To correct for the effect of varying AGC value on intensity.

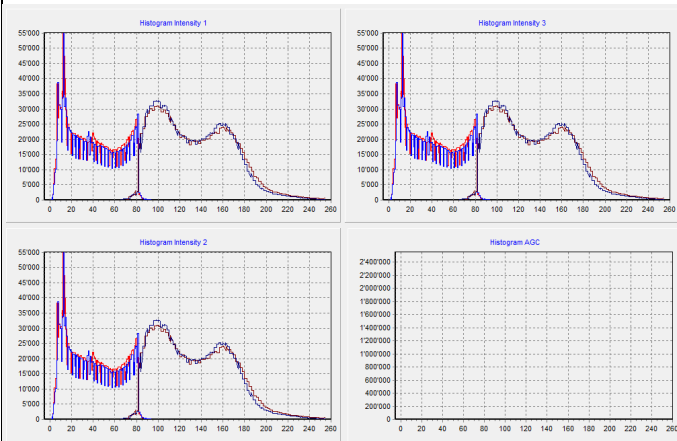
Note Correction factor values are unit less and are derived from test data through the range of AGC values.

**Gain based intensity correction (GBIC) curve and settings for SP2 operation**

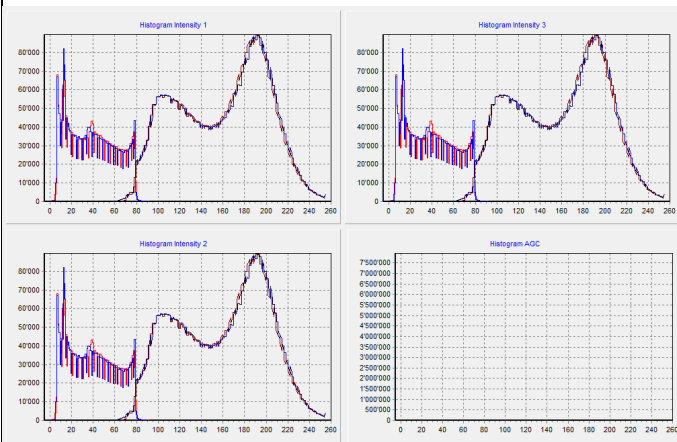


– GBIC Table can be optimized by customer

**Default Intensity Scale Factors for SP3 operation – 1300m line**



Below TPR (@ 131.5 kHz) 1000m AGL



Above TPR (@ 250 kHz) 400m AGL

**Intensity Corrections**

Apply Gain Based Intensity Correction (GBIC)

GBIC Input File: QC/SN7232/20160107\_IBRC\_GBIC/SN7232\_GBIC\_Type3\_1\_160121.csv Browse

Apply gain correction to Waveform data (only applies to GBIC correction)

Apply Intensity Scale Factors (ISF)

ISFs When Below Transition Pulse Rate				ISFs When Above or Equal Transition Pulse Rate			
	Slope	Offset		Slope	Offset		
AG	0.3648	0.0000	AG	0.3570	0.0000		
AN	2.1430	60.0000	AN	1.8720	59.0000		
BG	0.3700	0.0000	BG	0.3580	0.0000		
BN	2.0010	62.0000	BN	1.7870	61.0000		

Accept Cancel

**ALS70 Multi Channel System Options**

Channels to Process

- Gain Channel - Receiver A
- Non gain channel - Receiver A
- Gain Channel - Receiver B
- Non gain channel - Receiver B

Set Point Class of LAS record to channel ID

Gain Channel Selection Options

Output Gain and Non gain channel

Auto select Gain / Non gain channel (merge to Gain Channel)

Auto select Gain/ Non Gain (do not merge to Gain Channel)

Gain / Non Gain intensity threshold - Receiver A: 230

Gain / Non gain intensity threshold - Receiver B: 230

Note: Non gain channel will be used when intensity of gain channel is above the set value

NOTE: These options only apply to ALS70 data

*– Intensity Scale Factors can be optimized by customer*

**Flight and data processing**

	Passed	Date	Inspector
<i>Test flight – Locarno, Switzerland</i>	<i>ok</i>	<i>19 Jan 16</i>	<i>ADEN</i>
<i>Data Quality Check</i>	<i>ok</i>	<i>21 Jan 16</i>	<i>Deanna Burton</i>
<i>Calibration</i>	<i>ok</i>	<i>25 Jan 16</i>	<i>Deanna Burton</i>

File **SN7232\_160129\_Calibration.xml (for CloudPro)**  
 Objective To correct for systematic effects of this ALS System.  
 Validation A complete "on-site" calibration should be performed *after system delivery* to verify factory calibration and establish a final set of correction parameters.

**IPAS Processing – FCMS Guidance and Sensor Control Operation**

<b>Parameter [Units]</b>	<b>Value</b>
<i>IMU Type</i>	<i>CUS6-“uIRS”</i>
<i>IMU Lever Arm X [m]</i>	<i>-0.450</i>
<i>IMU Lever Arm Y [m]</i>	<i>0.159</i>
<i>IMU Lever Arm Z [m]</i>	<i>-0.169</i>
<i>Omega Rotation Angle</i>	<i>0.0000</i>
<i>Phi Rotation Angle</i>	<i>-90.0000</i>
<i>Kappa Rotation Angle</i>	<i>90.0000</i>
<b><i>(The distance from the IMU to the virtual PAV80 pivot point - the SOL trajectory position.)</i></b>	
<i>User Frame Lever Arm X [m]</i>	<i>-0.167</i>
<i>User Frame Lever Arm Y [m]</i>	<i>0.001</i>
<i>User Frame Lever Arm Z [m]</i>	<i>-0.175</i>
<b><i>(The distance from the virtual PAV80 pivot point - the SOL trajectory location to the ALS70 sensor mirror.)</i></b>	
<i>Test Airplane – (Locarno - Pilatus Porter)</i>	
<i>GPS Lever Arm X [m]</i>	<i>0.646</i>
<i>GPS Lever Arm Y [m]</i>	<i>0.371</i>
<i>GPS Lever Arm Z [m]</i>	<i>-1.370</i>
<b><i>(The distance from the virtual PAV80 pivot point - the SOL trajectory position to the airborne antenna ARP.)</i></b>	

***Required: IPAS Pro v2.01.02+ or IPAS TC v3.10+. IPAS SUP file required***

<b>ALS Calibration Summary – Key Parameters for use in the ALS Post Processor</b>		
Parameter (units)	Receiver A	Receiver B
<b>Scanner Correction</b>		
Encoder Offset (number of ticks/counts)	-10035	
Encoder Latency (microseconds)	0.513	
Torsion Constant (Nm/rad)	0	
Encoder Scale Factor (Ticks/counts per Rev)	8388608	
<b>POS Errors Entry</b>		
Roll Boresight (radians)	0.0102115457	0.0105095685
Pitch Boresight (radians)	-0.0015989720	-0.0047057120
Heading Boresight (radians)	-0.0013225155	-0.0012491918
Pitch Error Slope (radians/degree)	0	0
PPS Correction (uSec)	-1000	
IMU Latency (uSec) [Maintain in ALSPP]	0	
Forward Laser Angle (Degrees)	-0.98151	1.26153
Down Laser Angle (Degrees)	10	10
Forward Mirror Normal Angle (Degrees)	0.000	0.000
<b>Range Correction</b>		
Range Correction 1 ( Channel AG)	0.000	
Range Correction 2 ( Channel AN)	0.000	
Range Correction3 ( Channel BG)	0.000	
Range Correction 4 ( Channel BN)	0.000	
Equal to or Over TPR for Base Range	Check (Over TPR)	
Intensity Based Range Correction [IBRC]	<i>(text file specified above)</i>	
Transition Pulse Rate (Hz)	200000	
TPR Range Offset (meters)	0	
<b>Elevation Offset</b>	0	
<b>Intensity Correction</b>		
Correction Algorithm	No Normalization - use Raw	
Visibility (meters)	1000000	
Scale Factor	1	
<b>Waveform Processing</b>		
Trigger Delay - under TPR (pico seconds)	16375	
Trigger Delay - over TPR (pico seconds)	17764	
<b>GBIC Inputs</b>		
Optional Gain Based Intensity Correction [GBIC]	<i>(text file specified above)</i>	
<b>ALS70 Multi Channel Processing Options</b>		
	Receiver A	Receiver B
	Set Point Class..to channel ID is user option	
<b>Autoselect Gain/NonGain</b>	Merge or do not Merge is user option	
<b>Gain/NonGain Intensity Threshold</b>	220	220

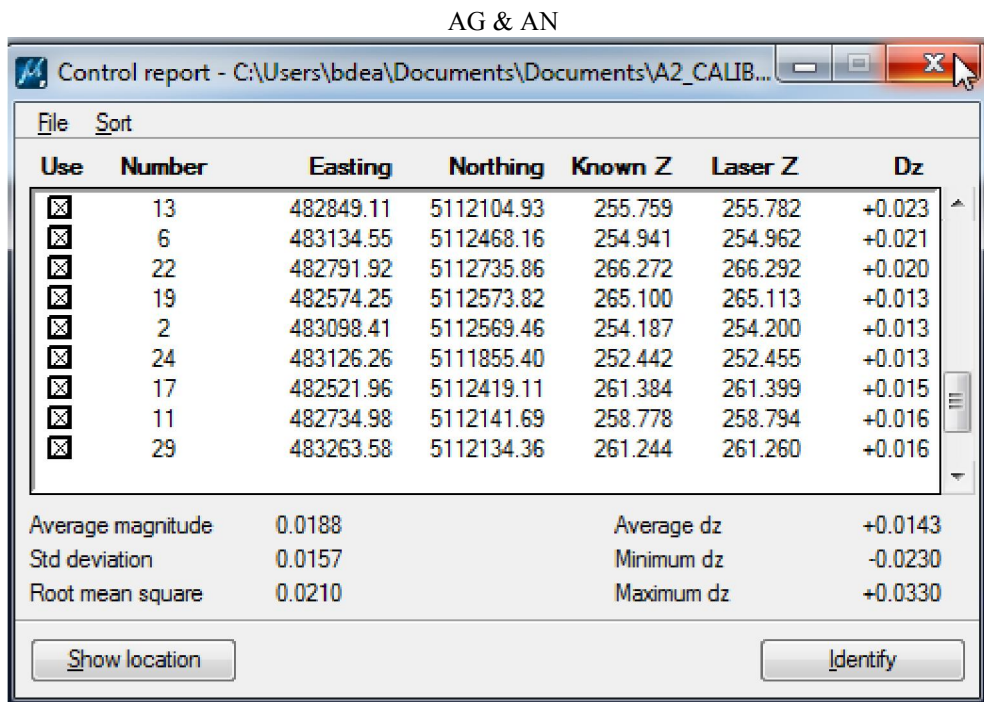
**Key parameters for input in TracGUI - Threshold Discriminator**

Threshold discriminator channel	Threshold setting	
	General Operation	Power line or other low altitude ( $\leq 400m$ AGL) applications
Discriminator AG	190 mv	110 mv
Discriminator AN	55 mv	55 mv
Discriminator BG	190 mv	110 mv
Discriminator BN	55 mv	55 mv

\*Threshold is set using TracGUI | Advanced Setup. Only change in consultation with Leica CSS, other than as shown above.

**Accuracy Check – 1300m AGL. 45 Deg FOV. 45 Hz SR. 200 kHz PR.**

	Avg Dz (m)	Std Dev (m)	Inspector
<i>Line 13mT19 Dz to Control.</i>			
<i>RangeOffset-LocarnoCity_UTMz32N_WGS84_120605.txt (31 Kinematic GNSS points)</i>			
<b>AG &amp; AN</b> (6 Outliers removed)	+0.014	0.016	
<b>BG &amp; BN</b> (24 Outliers removed)	+0.017	0.016	Deanna Burton
<b>Summary Calibration check</b>	ok		Deanna Burton



BG & BN

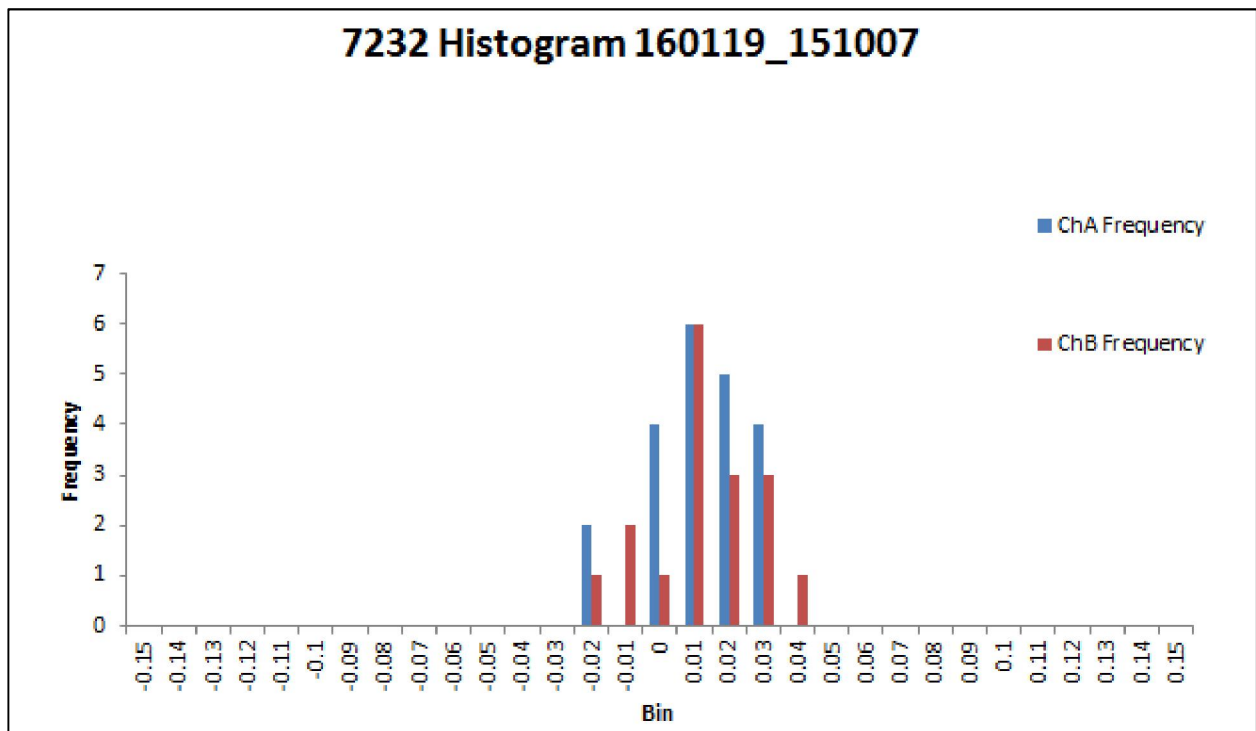
Control report - C:\Users\bdea\Documents\Documents\A2\_CALIB...

Use	Number	Easting	Northing	Known Z	Laser Z	Dz
<input checked="" type="checkbox"/>	9	482626.19	5112318.22	259.437	259.457	+0.020
<input checked="" type="checkbox"/>	7	482597.34	5112370.34	259.651	259.684	+0.033
<input checked="" type="checkbox"/>	11	482734.98	5112141.69	258.778	258.801	+0.023
<input checked="" type="checkbox"/>	30	483374.03	5112197.19	259.076	259.100	+0.024
<input checked="" type="checkbox"/>	19	482574.25	5112573.82	265.100	265.126	+0.026
<input checked="" type="checkbox"/>	24	483126.26	5111855.40	252.442	252.470	+0.028
<input checked="" type="checkbox"/>	14	482819.53	5112366.58	256.920	256.948	+0.028
<input checked="" type="checkbox"/>	4	483096.99	5112487.67	254.938	254.965	+0.027
<input checked="" type="checkbox"/>	13	482849.11	5112104.93	255.759	255.786	+0.027

Average magnitude	0.0219	Average dz	+0.0175
Std deviation	0.0163	Minimum dz	-0.0190
Root mean square	0.0237	Maximum dz	+0.0400

**Multi-line accuracy to control, in a tabular format.  
Demonstrates detail of two channels data comparison to control.**



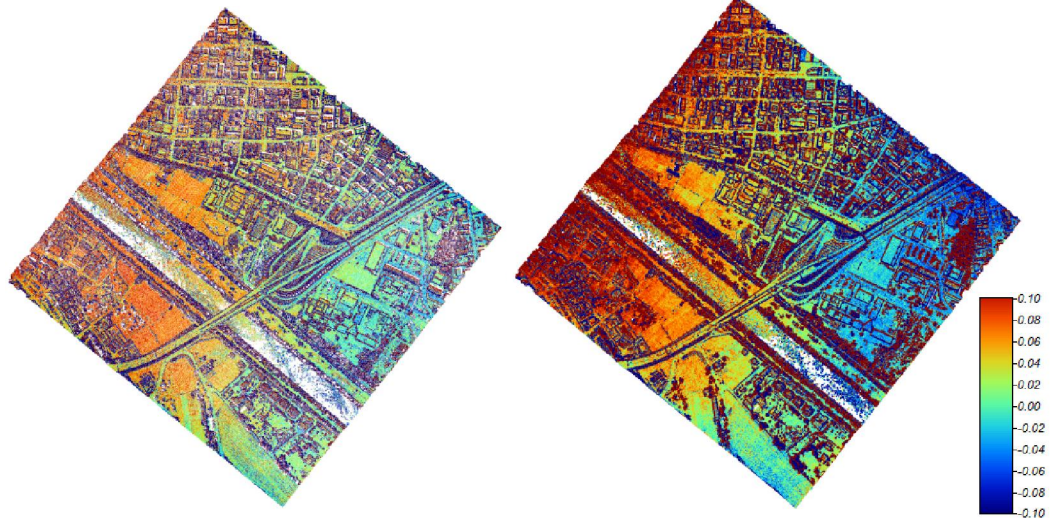
**Single Line Comparison of ChA (AG&AN) and ChB (BG&BN) to control.  
Compares ChA and ChB to control graphically.**



Line 13mT19 – 13mOPCaT1	1300m	+-0.100 m Color Scheme	
Ground TIN Subtraction perpendicular line check	ok		Deanna Burton

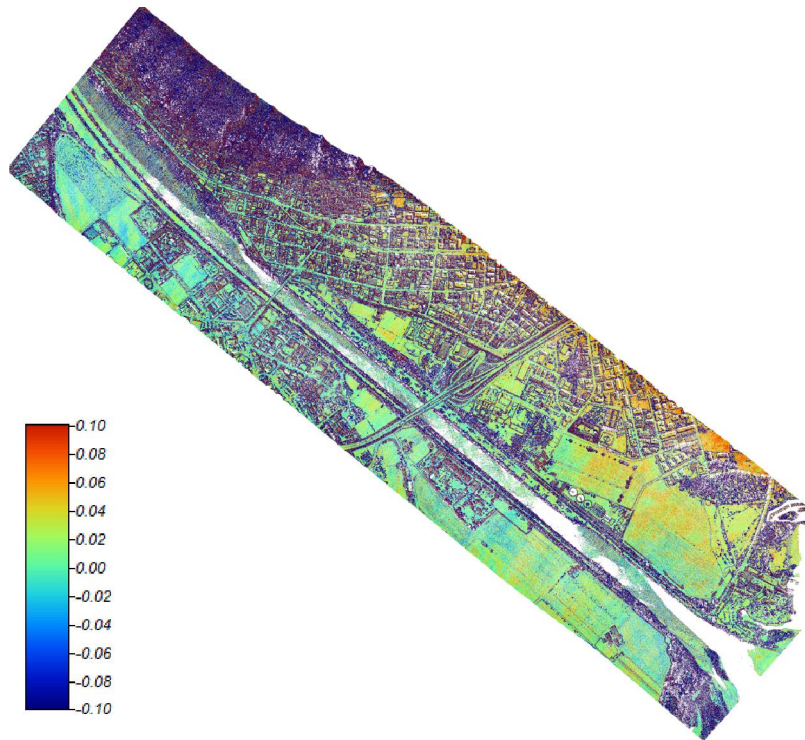
AG&AN Channel

BG&BN Channel



Perpendicular flight lines, surface subtraction, for ChA (left pic) and ChB (right pic).  
Demonstrates calibration accuracy.

Line 13mT19	1300m	+-0.100 m Color Scheme	
Ground TIN Subtraction Channel A - Channel B	ok		Deanna Burton



Subtraction of the two channels for a single line.  
Establishes Channel matching of merged ChA (AG&AN) with ChB (BG&BN)

**Nominal Laser Characteristics**

	Value
<i>Beam diameter (1/e and 1/e<sup>2</sup>, mm)</i>	5.6, 8.0
<i>Beam divergence (1/e and 1/e<sup>2</sup>, mr)</i>	0.15, 0.22
<i>Pulse width (maximum, Full Width Half Max, ns)</i>	9
<i>Maximum single-pulse energy (mJ)</i>	0.2
<i>Emitted wavelength (nm)</i>	1064

**Inspection****Inspectors**

<i>Name</i>	<b>Deanna Burton</b>
<i>Position</i>	Airborne Systems Support
<i>Name</i>	<b>Bernhard Riedl</b>
<i>Position</i>	Production Manager - Hardware