Tools, Tips, and Workflows

Horizontal Accuracy Reporting in LP360

LP360, versions 2014.1 and above

B S A U | A W G

GeoCue Group Support
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In November 2014, the American Society for Photogrammetry and Remote Sensing (ASPRS) released an updated standard, Positional Accuracy Standards for Digital Geospatial Data, to tie together past experience with current industry practice of preparing data, but not plotting the resulting maps. The new standard provides guidelines for calculating both the vertical and the horizontal accuracy. Prior standards include the National Map Accuracy Standards (NMAS), which were developed in 1947, the 1990 ASPRS Accuracy Standards for Large-Scale Maps Standards and 2004 ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data. None of the previous standards was designed to address the current technologies available for LIDAR, orthoimagery or digital camera mapping. The 2014 ASPRS Standards, were therefore created to help address the new technology. The new standards focus on the higher level of accuracy that are currently available using the latest technology.

A portion of the updated 2014 ASPRS Standards addresses horizontal accuracy. Horizontal accuracy requires a known position (an identifiable marker) that is clearly defined within the data itself. For most airborne LIDAR data, the data is simply not dense enough to get any kind of clear features. Mobile and terrestrial LIDAR data, as well as photogrammetric elevation data and orthoimagery, can be readily used in a horizontal accuracy assessment. While the measurement and reporting of horizontal accuracies for airborne LIDAR data was removed from the final ASPRS Positional Accuracy Standards we have a seen a growing trend in the industry for a measured result as opposed to the estimated accuracy, based upon manufacturer's guidelines and the LIDAR Horizontal Error (Figure 1), that traditionally has accompanied a delivered airborne LIDAR dataset.

Horizontal Accuracy Statistics

Horizontal Accuracy is calculated using the root-mean-square-error (RMSE) statistic within the horizontal plane ($RMSE_x$, $RMSE_y$ and $RMSE_r$). RMSE (Equation 1) determines how much error exists between two different datasets.

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \hat{x}_i)^2}$$

Equation 1 - Root Mean Square Error

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Horizontal Airborne LIDAR Accuracy

According to the 2014 ASPRS Positional Accuracy Standards for Digital Geospatial Data, horizontal accuracy for airborne LIDAR data is calculated based off the Global Navigation Satellite System (GNSS), attitude (angular orientation) error (as derived from the INS) and flying altitude. Figure 1 provides a way to estimate the horizontal accuracy for LIDAR datasets, while Table 1 shows potential $RMSE_r$ values if the radial horizontal positional error of the GNSS is equal to 0.11314m (based on 0.08 m in either X or Y), and the IMU error is 0.00427 degree in roll, pitch and heading[1].

$$Lidar\ Horizontal\ Error\left(RMSE_r\right) = \sqrt{\left(GNSS\ positional\ error\right)^2 + \left(\frac{\tan(IMU\ error)}{0.55894170} x\ flying\ altitude\right)^2}$$

Figure 1 - Airborne LIDAR Horizontal Accuracy

Altitude (m)	Positional $RMSE_r$ (cm)	Altitude (m)	Positional $RMSE_r$ (cm)
500	13.1	3,000	41.6
1,000	17.5	3,500	48.0
1,500	23.0	4,000	54.5
2,000	29.0	4,500	61.1
2,500	35.2	5,000	67.6

Table 1 - Expected Horizontal Errors ($RMSE_r$) for LIDAR Data in Terms of Flying Altitude

Horizontal Accuracy for Geospatial Data

In order to determine horizontal accuracy for any data type, surveyed control points need to be collected in a manner to be visible within the provided dataset. Visible control could include: a painted ground marker (Figure 2), a large road arrow (Figure 3), painted cross walk lines (Figure 4), or any other identifiable and easily measured feature.

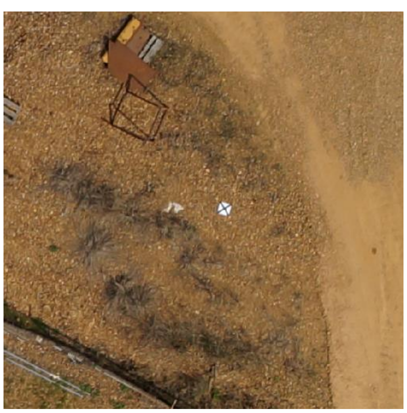

Figure 2 - Painted Ground Marker

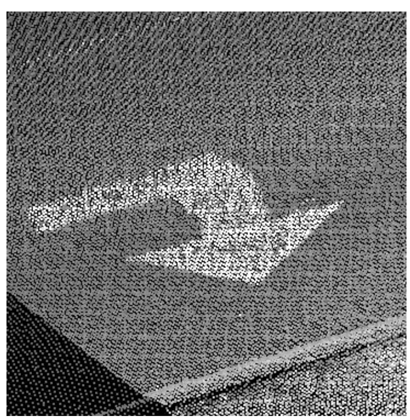

Figure 3 - Painted Road Arrow

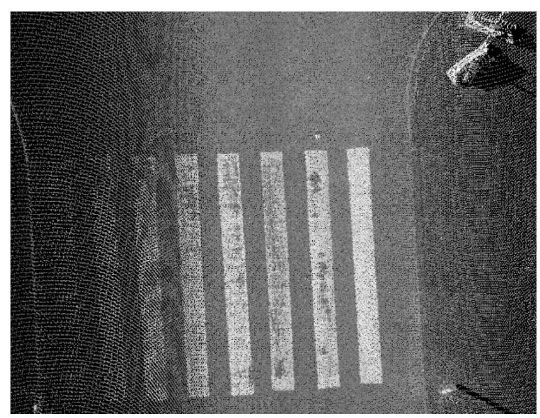

Figure 4 - Painted Cross Walk Lines

[1] (American Society for Photogrammetry and Remote Sensing, 2014)

The identifiable markers and the surveyed control are used in conjunction to determine the horizontal accuracy of the data. Table 2 comes from the 2014 ASPRS Positional Accuracy Standards for Digital Geospatial Data and specifies the horizontal accuracy standards for digital data: digital orthoimagery, digital planimetric data and scaled planimetric maps. The updated standard defines the horizontal accuracy with respect to $RMSE_x$ and $RMSE_y$ whereas the legacy standards used numerical ranks for accuracy classes that were tied to the map scale. For example: Class 1, Class 2, etc.

Horizontal Accuracy Class	Absolute Accuracy			Orthoimagery Mosaic Seamline Mismatch (cm)
	RMSEx and RMSEy (cm)	RMSEr (cm)	Horizontal Accuracy at 95% Confidence Level (cm)	
X-cm	≤*X*	≤1.414**X*	≤2.448**X*	≤2**X*

Table 2 – Horizontal Accuracy Standards for Geospatial Data

Relative Horizontal Accuracy

Prior to determining absolute horizontal accuracy, it is necessary to verify relative horizontal accuracy. If the difference between the images is too high then determining overall horizontal accuracy is going to be mute. The relative accuracy is assessed determining the orthoimage mosaic seamline mismatch value (Table 3). Introduced in LP360 version 2014.1 was an option within the Control Report dialog to measure and determine the horizontal accuracy. Measure Mode is an interactive tool, which allows a user to specify where the control point is located within the visible dataset.

1. Load the rectified orthoimagery and LIDAR data into LP360
2. Locate an overlap area between two images
3. Use LP360's Point Cloud Task to create a new Conflation task
    a. Use Tool Geometry to create new check points
    b. Conflation Method Summarize Z using Surface Z value
    c. Specify an output location that will be appended, to allow for the collection of multiple samples
4. Select two images with overlapping areas and turn off one of the images
5. In the currently active image identify known features, such as intersections between sidewalks and driveways Figure 5, and place a "check point" at that known location
6. Unload the active image and load the overlapping image
7. Open the Control Report Dialog
8. Specify Z Probe Location to be from Measured X,Y
9. Select Measure Mode to invoke the measure mode and specify within the image the measured location of the "check point"
10. The XYZ information is then determined by the program and displayed within the Control Points dialog (Figure 6)
11. Repeat across the project area including frame to frame and line to line assessments

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The planimetric statistics will be used to determine the maximum orthoimage mosaic seamline based upon the accuracy class of the data as determined by the 2014 ASPRS Positional Accuracy Standards for Digital Geospatial Data (Table 3).

Figure 5 - Check Point Intersection of Sidewalk and Driveway

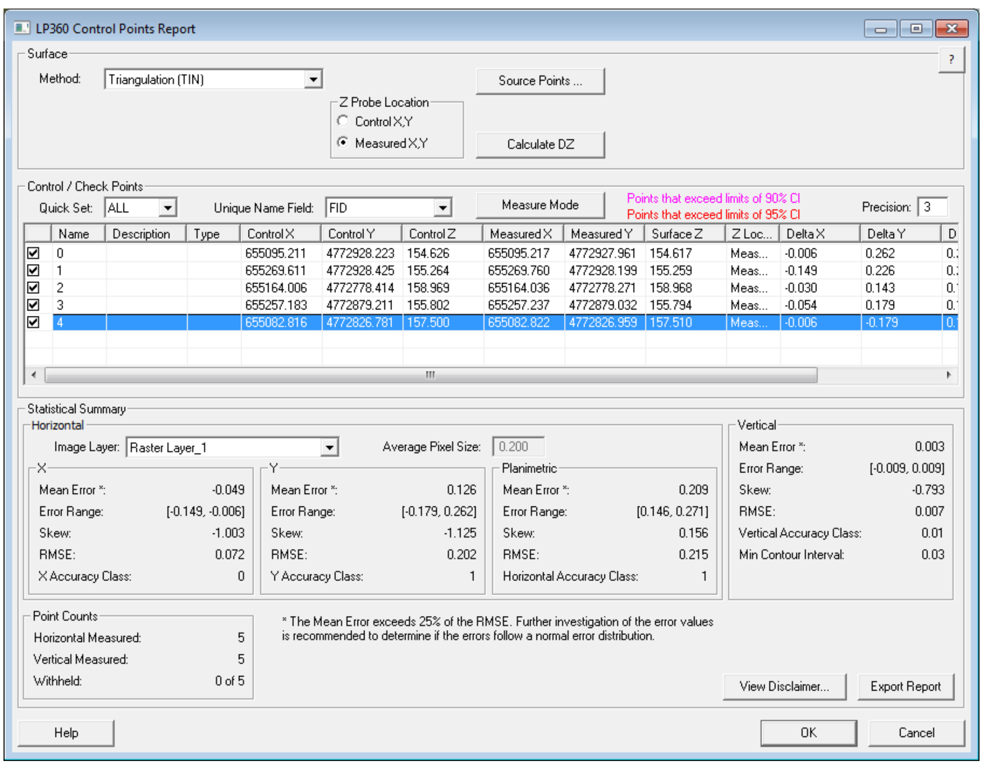

Figure 6 - Measured XY and Statistical Summary

Absolute Horizontal Accuracy in LP360

The Measure Mode can also be used to determine absolute horizontal accuracy.

1. Load the digital geospatial data and surveyed control into LP360
2. Open the Control Report dialog
3. Select Measure Mode to invoke the measurement mode, which involves a single left-click on the image or LIDAR data (Figure 7)
4. The XYZ information is then determined by the program and displayed within the Control Points dialog (Figure 8).

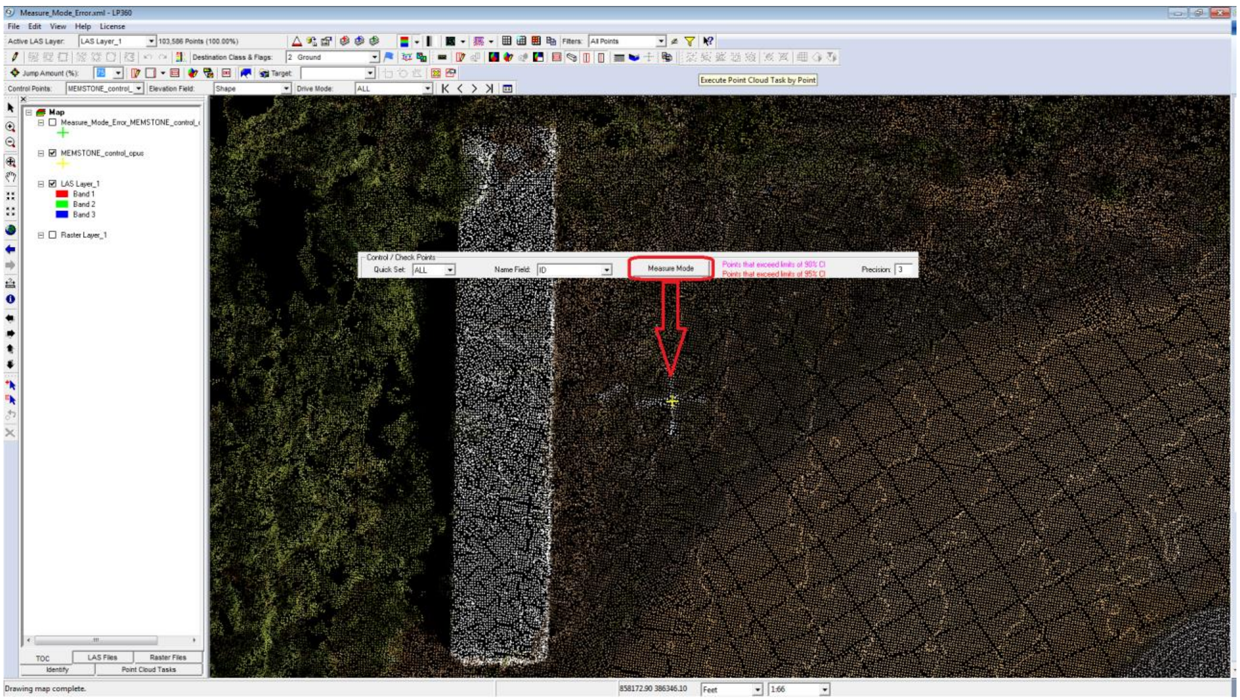

Figure 7 - Measure Mode Tool in LP360

Control / Check Points
Quick Set: ALL
Name Field: ID
Measure Mode
Points that exceed limits of 90% CI
Points that exceed limits of 95% CI
Precision: 3

	Name	Description	T...	Control X	Control Y	Control Z	Measured X	Measured Y	Surface Z	Z Loc...	Delta X	Delta Y	Delta XY	Delta Z
☑	10		FC	858165.760	386319.533	364.045	858165.744	386319.554	364.064	Meas...	0.016	-0.021	0.026	-0.019
☑	11		FC	858864.423	386246.675	358.184	858864.413	386246.678	358.127	Meas...	0.010	-0.003	0.011	0.057
☑	12		FC	858847.166	385922.431	356.950	858847.120	385922.452	356.899	Meas...	0.047	-0.021	0.051	0.051
☑	13		FC	859057.448	385422.155	369.736	859057.432	385422.165	369.715	Meas...	0.016	-0.010	0.019	0.021
☑	14		FC	858521.758	385640.820	357.857	858521.773	385640.778	357.854	Meas...	-0.016	0.042	0.044	0.002
☑	16		FC	858753.624	385090.079	360.984	858753.608	385090.079	360.985	Meas...	0.016	0.000	0.016	-0.001
☑	17		FC	858201.154	385260.977	361.421	858201.160	385260.967	361.389	Meas...	-0.005	0.010	0.012	0.032
☑	18		FC	858193.526	385708.975	358.851	858193.562	385708.985	358.903	Meas...	-0.036	-0.010	0.038	-0.052
☑	19		FC	858371.624	385920.084	360.135	858371.661	385920.094	360.106	Meas...	-0.036	-0.010	0.038	0.029
☑	3		FK	858337.969	386255.801	362.417	858337.985	386255.801	362.367	Meas...	-0.016	0.000	0.016	0.050
☑	15		FK	858641.019	385344.482	354.761	858640.993	385344.461	354.629	Meas...	0.026	0.021	0.033	0.131

Figure 8 - Measure Mode Collected XYZ Values in Control Report Dialog

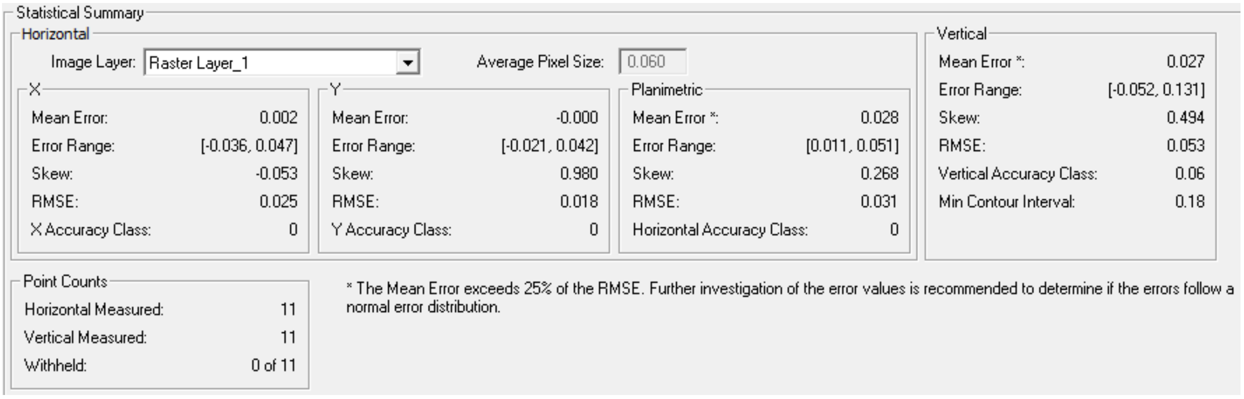

Figure 9 - Horizontal and Vertical Statistical Summaries

The statistical summary information is located in the lower pane of the Control Report Dialog (Figure 9). Export this information to a text file using the Export Report button for incorporation into your final project report.

Note: When using LP360 for Standalone, the Image Layer and Average Pixel Size is automatically selected for the user. If using LP360 for ArcGIS, this information will need to be populated by the user.

The horizontal accuracy consists of three separate statistics: X, Y and Planimetric. Each set contains five different statistics: Mean Error, Error Range, Skew, RMSE and Accuracy Class.

- **Mean Error** is equal to the sum of the vertical errors divided by the number of errors.
- **Error Range** is the minimum and maximum vertical error used in the calculation of the mean error.
- **Skew** is the measure of the symmetry in the error distribution.
- **RMSE** is the root mean square error for the compared data points calculated using Equation 1.
- **Accuracy Class** is the Horizontal Accuracy Class for $RMSE_x$, $RMSE_y$ or $RMSE_r$ in cm based upon the 2014 ASPRS Positional Accuracy Standards for Digital Geospatial Data (Table 3).

Horizontal Accuracy Class $RMSE_x$ and $RMSE_y$ (cm)	$RMSE_r$ (cm)	Orthoimage Mosaic Seamline Maximum Mismatch (cm)	Horizontal Accuracy at the 95% Confidence Level (cm)
0.63	0.9	1.3	1.5
1.25	1.8	2.5	3.1
2.50	3.5	5.0	6.1
5.00	7.1	10.0	12.2
7.50	10.6	15.0	18.4
10.00	14.1	20.0	24.5
12.50	17.7	25.0	30.6
15.00	21.2	30.0	36.7
17.50	24.7	35.0	42.8
20.00	28.3	40.0	49.0
22.50	31.8	45.0	55.1
25.00	35.4	50.0	61.2

Table 3 - Common Horizontal Accuracy Classes According to the 2014 ASPRS Specifications

Conclusion

Horizontal Accuracy for digital geospatial data has differed over the years. The latest specification put forth by the ASPRS provides new guidelines for horizontal accuracy based upon the latest technologies. LP360's Control Report can be used to determine the horizontal accuracies using the Measure Mode Tool located within. For additional information concerning measuring and reporting of horizontal accuracy in LP360 please contact the LP360 Support Team at support@lp360.com.