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3D Accuracy

1

Introduction

2

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Usage in LiDAR applications

In LiDAR applications, GCPs are used for 2 reasons:

- **Determination of the accuracy**: this is performed by comparing the LiDAR point cloud and targets with known coordinates.
- **Global alignment of point cloud**: to improve the precision and the accuracy of the point cloud.

Notes:

- The precision is improved as the misalignment between lines are reduced.
- Accuracy is improved as the misalignment between the point cloud and GCPs is reduced.

3

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In comparing the Computed GCT Center and the coordinates of the GCP we can assess the deviation from the local point cloud to the GCP at the GCP location: Thus, we can compute the LiDAR point cloud accuracy.

GCP

- Monumented point for which geodesic coordinates are known with a controlled accuracy and precision.
- (may be provided by National Geodetic Authority or made by the user.)

GCT

- Device that defines a unique center

4

GCT types

5

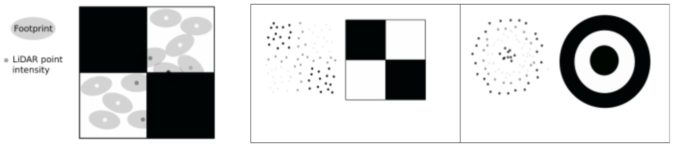
2D Ground Control Target types

Classic targets:

- CheckerBoard
- Concentric circle

Limitations:

- the estimation of the center is **dependent of the sampling of low and high intensity** (B&W) points over the target.
- Given the X,Y estimates of the center, the **Z value should be estimated by a spatial interpolation i**n a neighborhood of the estimated center.



6

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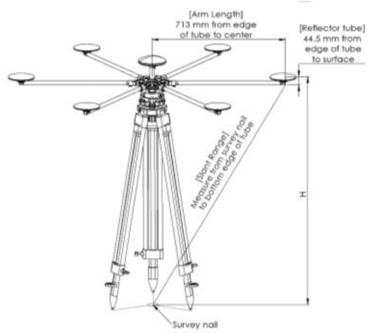
3D GCT (Accuracy Star)

Specs

- Arm length 70cm;
- Reflector diameter 14cm;
- Recommended installation height: at least 1,40m

Installation with GCP

- In placing a GNSS antenna at the center we can make an estimation of the 3D center. This point will play the role of reference coordinates of the GCP.
- Install the Accuracy Star over a survey nail or a monumented GCP by levelling the tripod. The vertical separation between the survey nail and a reference height of the Accuracy Star should be measured accurately (H Offset).



7

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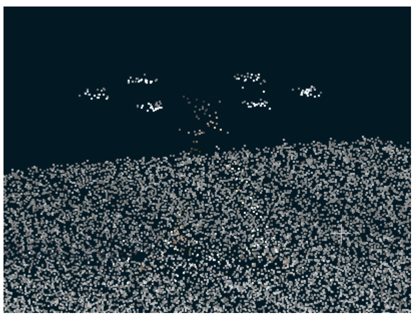
Advantages of Accuracy Star

- It is **accurate** since the hexagon geometry enables us to estimate the center from 3 to 6 clusters of points representing the reflectors. Redundancy in the hexagon observation makes the center estimate to be precise and robust.
  - The size and the separation of the reflectors has been optimized to enable a good detection for most UAV LiDAR flight configuration.
- It is **unbiased** since the redundancy of the six reflectors enables us to estimate the center in a robust way.
- The Z component comes from the vertical separation from the ground of the reflectors. It is important to install the Accuracy star at the highest possible elevation from the ground.



8

Best practices

9

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How many GCTs should I use?

It is recommended to deploy **at least 3 GCTs** to enable a possible rotation-translation transformation

Number of AS	1	2	3+
Translation	Yes	Yes	Yes
Rotation + Translation	No	No	**Yes**

Notes 1 GCT allows validation of the point cloud Accuracy and confirms that the dataset doesn't have major issues. The point cloud cannot be corrected (other than locally) but can be validated that it is within the expected accuracy range of the system

10

Where shoud I install my GCTs

- We recommend installing GCTs at locations where positioning uncertainty is higher, in order to have a conservative estimate of accuracy.
  - Example: for a long corridor survey, GCTs should be installed at the beginning and at the end of the corridor, to measure the effect of IMU heading bias along the corridor, especially if the UAV is flying at low speed.
- Accuracy can be assessed in
  - overlapping areas (intersections between lines)
  - non overlapping area (single line),
  - line by line.
- Discrepancy between different lines can give relevant information on the survey local accuracy and may help the user to understand some sources of errors that may depend on the lines
- If you have multiple flights in an area performed on the same day, you should use the same GCTs for all flights

11

Local versus global accuracy of the survey

- If interested in the global accuracy, accuracy assessment and accuracy enhancement should be performed with some AS distributed over the survey area.
- If interested only in local accuracy, the AS should be placed on the location of interest.

12

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Specific to Accuracy Stars

- For Accuracy Stars, the accuracy assessment is **independent of the nature of the underlying terrain :** An Accuracy Star over a flat/gentle slope area or wet/dry or high/low reflectance will give the same information; It is given by its own reflectors and not by the terrain.

- For Accuracy Stars, the accuracy assessment **only depends on the flight conditions**:
  - Height, Speed -> parameters affecting point density
  - Motion (long constant heading at low speed, angular rates, etc…)

13

How-to

14

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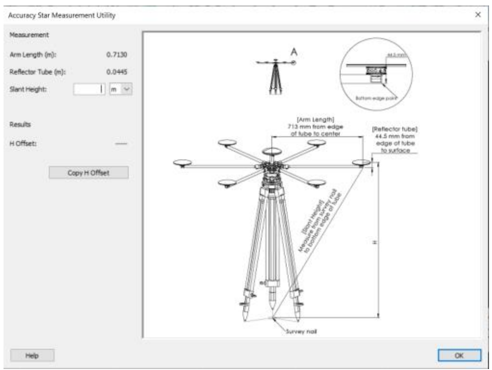
Measure Accuracy Stars in the field



15

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Processing workflow

1. Import GCP
2. Auto Find
3. Solve
4. Apply Correction
5. Verification

Example

Payload: TV516

Flight Height: 75m

Flight Speed : 5 m/s

16

Step 1. Import Ground Control Points (from txt)

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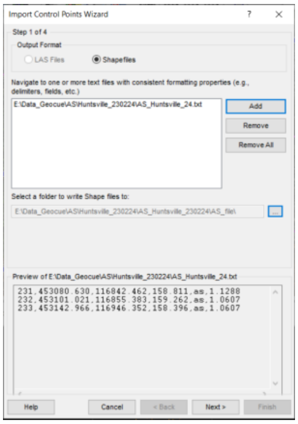

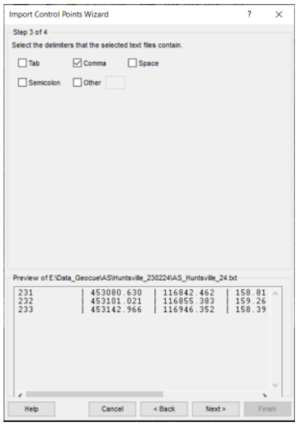

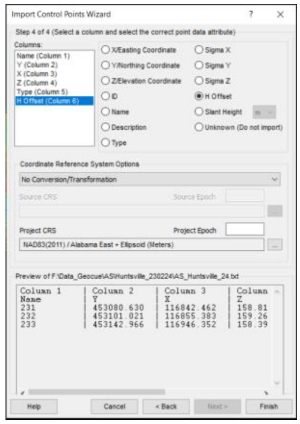

17

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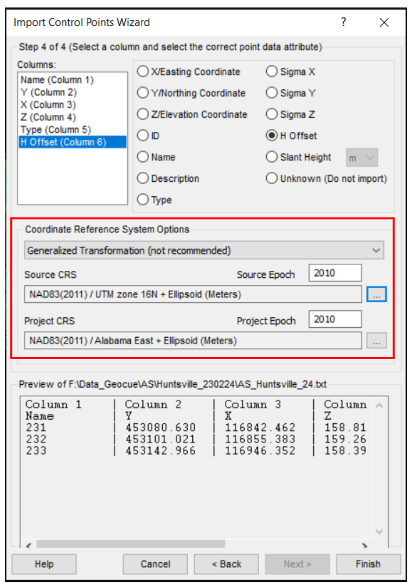
GCPs can be transformed during import if they are in a different CRS

- **Projection/Vertical Change Only**
  - Applies no datum transformation
- **Transform from ITRF2014 Geographic Coordinates**
- **Generalized Transformation**
  - Applies both datum and epoch transformations



18

Step 1. Import Ground Control Points (from shp)

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- Must be in the same CRS as your LAS
- Must contain an attribute field for the Height Offset, ‘HOffset’
- Must contain an attribute field for the target type, ‘Type’

19

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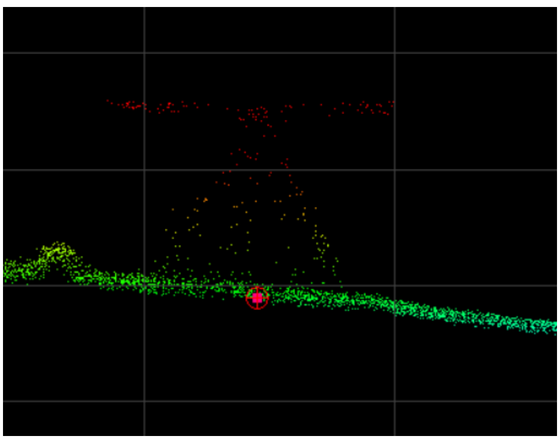

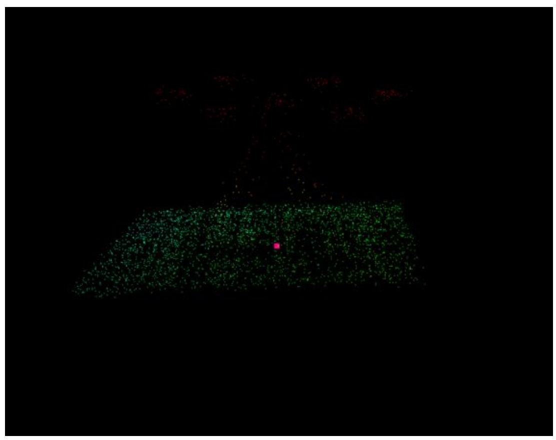

20

Step 2. Auto Find

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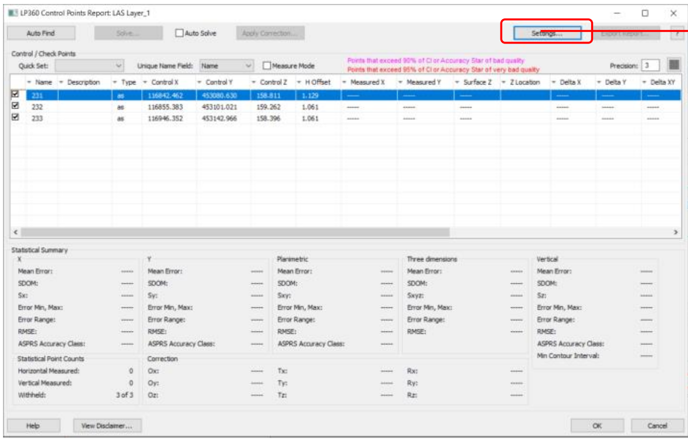
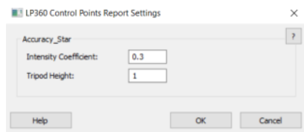
- Find the Accuracy Stars on the point cloud and compare to GCPs

Notes
3D Accuracy will be run on the Active LAS Layer





Intensity Coefficient: the proportion of points that will be used based on intensity.

Tripod Height: the approximate measure from the ground to the base of the tripod where is installed the AS.

21

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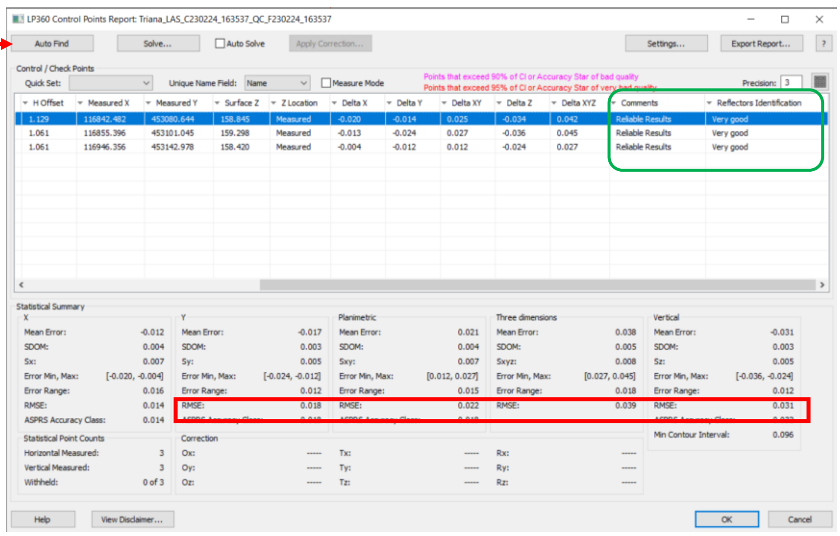
- Calculate DX, DY, DXY, DZ, DXYZ
- Calculate statistics
- Generates comments on results of the Auto Find



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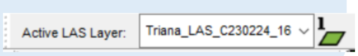

22

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Comment (on noise & density)

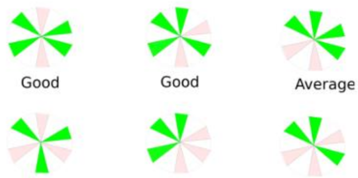
- Reliable Results
- Noise Warning
- Noise Alert
- Low Density Warning
- Low Density Alert
- Not Useable
- Not Enough Points
- Not Enough Detected Reflector Points

Reflector Identification

≥ 5 Very good

= 4

= 3



≤ 2 Very bad

23

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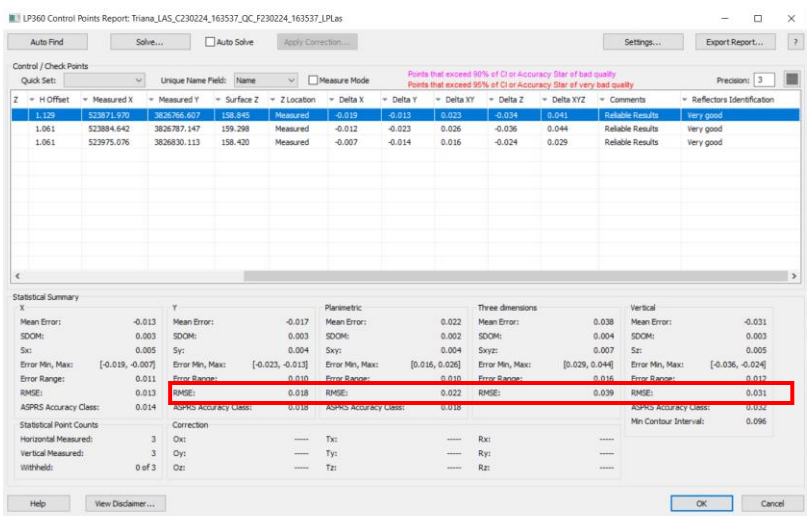
Example with GCP transformed from US State Plane to UTM during import

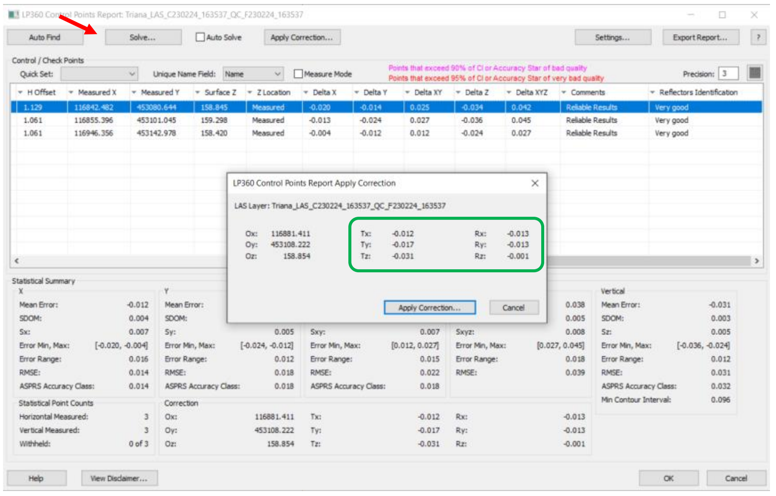
- Results are **identical** to dataset without transformation



24

Step 3. Solve

- Calculates translation
- Calculates rotation (if at least 3 AS)
- Auto Solve will automatically recalculate if you check/uncheck GCP in the list



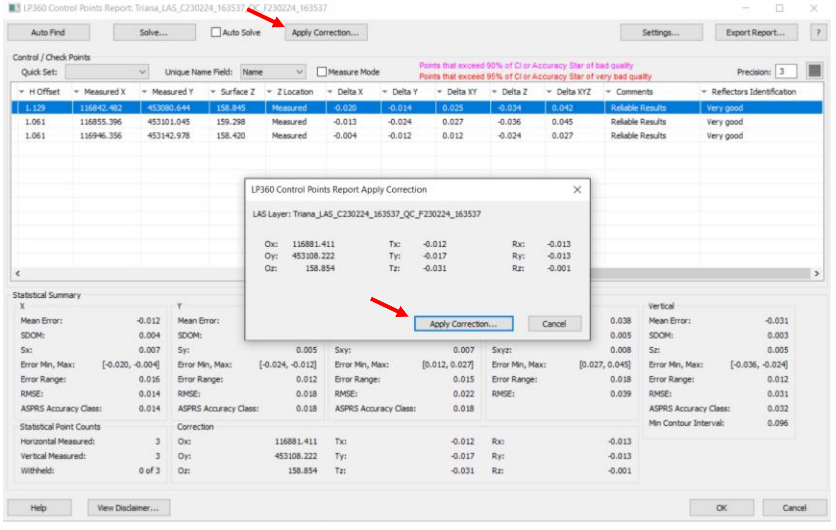
Notes

If the translation is combined to a rotation, the rotation is defined from an origin point (Ox, Oy, Oz). Therefore, the translation is also relative to this origin point.

25

Step 4. Apply correction

- Apply correction will apply the translation and rotation on the point cloud and create a new LAS layer.



26

Step 5. Verification

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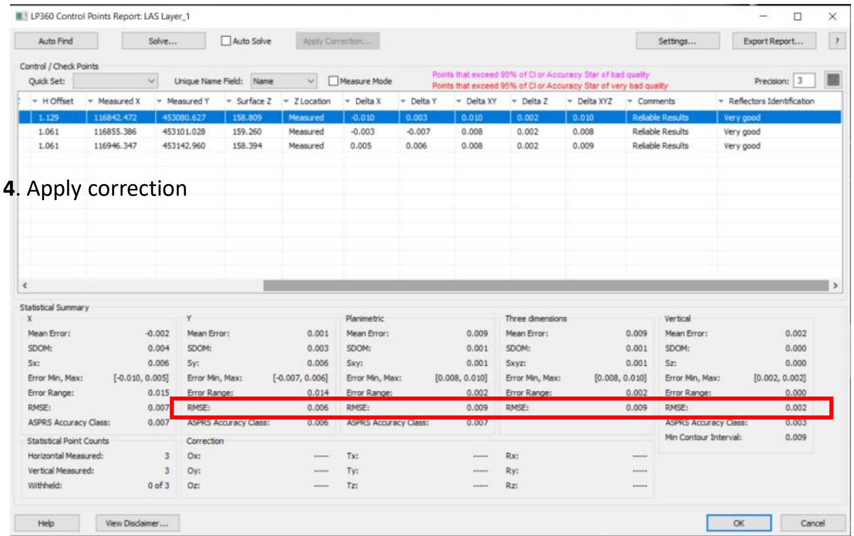
Run Auto Find on the new LAS layer

Step 4. Apply correction



27

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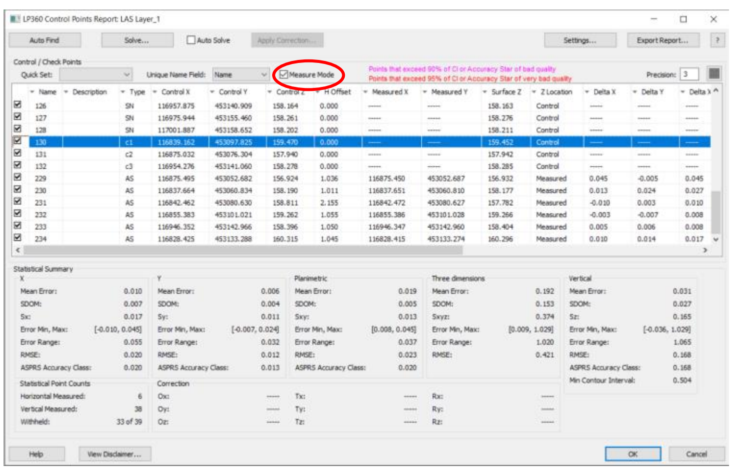
Additional workflow

You can also mix Accuracy Stars with checkerboards by manually selecting the checkerboard's planimetric center in the point cloud using Measure Mode.



28