LiDAR Quality Assessment Report

The USGS National Geospatial Technical Operations Center, Data Operations Branch is responsible for conducting reviews of all Light Detection and Ranging (LiDAR) point-cloud data and derived products delivered by a data supplier before it is approved for inclusion in the National Elevation Dataset and the Center for LiDAR Information Coordination and Knowledge. The USGS recognizes the complexity of LiDAR collection and processing performed by the data suppliers and has developed this Quality Assessment (QA) procedure to accommodate USGS collection and processing specifications with flexibility. The goal of this process is to assure LiDAR data are of sufficient quality for database population and scientific analysis. Concerns regarding the assessment of these data should be directed to the Chief, Data Operations Branch, 1400 Independence Road, Rolla, Missouri 65401 or NGTOCoperations@usgs.gov.

Materials Received:
7/24/2012

Project Type: NSDI Agreement

Project Description:

Project ID:
IN_Statewide-HowardCo_2011

Year of Collection: 2011

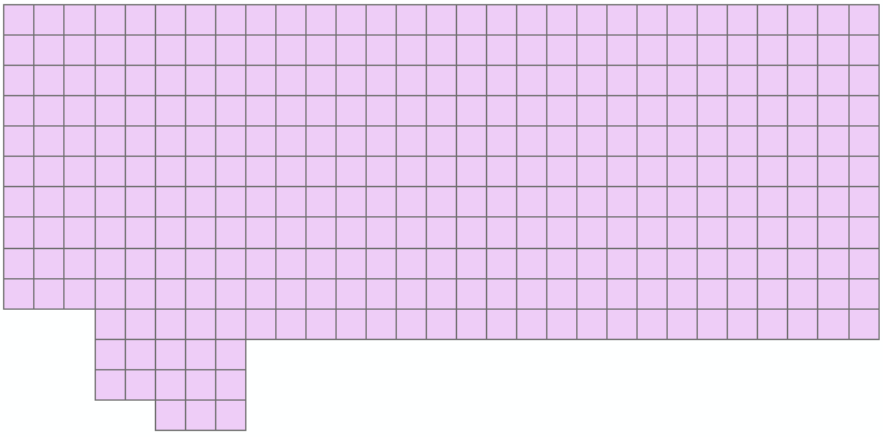
Project Alias(es):
Indiana Central Tier

Lot 1 of 1 lots.

Project Extent:
☑ Project Extent image?

Project Tiling Scheme:

☑ Project Tiling Scheme image?



Contractor:

Woolpert, Inc.

Applicable Specification:

V12, FEMA

Licensing Restrictions:

None

☐ Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
David Nail	NSDI Liaison	317-600-2722	dnail@usgs.gov

Project Deliverables

All project deliverables must be supplied according to collection and processing specifications. The USGS will postpone the QA process when any of the required deliverables are missing. When deliverables are missing, the Contracting Officer Technical Representative (COTR) will be contacted by the Elevation/Orthoimagery Section supervisor and informed of the problem. Processing will resume after the COTR has coordinated the deposition of remaining deliverables.

- ☑ Collection Report
- ☑ Survey Report
- ☑ Processing Report
- ☑ QA/QC Report
- ☑ Control and Calibration Points
- ☑ Project Shapefile/Geodatabase
- ☑ Project Tiling Scheme Shapefile/Gdb
- ☑ Control Point Shapefile/Gdb
- ☑ Breakline Shapefile/Gdb
- ☐ Project XML Metadata

Multi-File Deliverables

File Type	Quantity
☑ Swath LAS Files ☑ Required? ☐ XML Metadata?	see below
☐ Intensity Image Files ☐ Required?	
☑ Tiled LAS Files ☑ Required? ☑ XML Metadata?	329
☑ Breakline Files ☑ Required? ☑ XML Metadata?	2
☑ Bare-Earth DEM Files ☑ Required? ☑ XML Metadata?	329

Additional Deliverables

Errors, Anomalies, Other Issues to document? ◉ Yes ○ No

"Scope of Services" report references USGS NGP Base LiDAR Specification, version 12 which lists swath las files as a required deliverable, and the "Airborne LiDAR Report" included las v1.2 raw unclassified point cloud as a final deliverable, however no swath las files were delivered to reviewer at NGTOC. Reviewer at NGTOC contacted David Nail on 9/28/12 and again on 12/11/12 requesting delivery of swath las files. Swath files received by reviewer at NGTOC on 1/28/13. Not consistently projected, corrections requested 2/11/13. Corrected swath las files received at NGTOC on 4/2/13. Swath not organized by county, all Indiana Central Tier swath will be delivered to EROS at once as pre-approved my Michael Steuck on 2/5/13. Multiple issues with swath las file headers, additional swath corrections requested 5/2/13, on 8/8/13 reviewer was notified that no corrections will be delivered to NGTOC. Please see swath las review section below for additional details.

"Airborne LiDAR Report" lists independent control points used to test vertical accuracy in shapefile format as a required deliverable, however, no control points were delivered to reviewer at NGTOC. Reviewer at NGTOC contacted David Nail on 9/28/12 and again on 12/11/12 requesting delivery of control point shapefile. All available checkpoints received 3/18/13.

No project level xml metadata delivered to reviewer at NGTOC. Reviewer read all delivered xml metadata files and determined the best use xml metadata. Reviewer at NGTOC renamed the file BESTUSE.XML and copied it to the Metadata-Documents folder.

The delivered "Airborne LiDAR Task Order Report" lists the dates of acquisition on pages 2-8 and 2-9. Woolpert reported the last date of acquisition as April 20, 2011. The xml metadata delivered with the project lists the dates of acquisition with the last date of acquisition being April 30, 2011. The reviewer contacted NSDI Liaison David Nail on 09/27/2012 requesting the correct dates of acquisition. On 10/24/2012 James Sparks replied that the correct dates are in the metadata, there was a typo in the report. The correct dates of acquisition are 03/13/2011-04/30/2011.

Project Geographic Information

Areal Extent:

295

Sq Mi

Grid Size:

5

U.S. Feet

Tile Size:

5000x5000

U.S. feet

Nominal Pulse Spacing:

1.5

meters

Vertical Datum: NAVD88 U.S. feet

Horizontal Datum: NAD83 U.S. feet

Project Projection/Coordinate Reference System: Indiana State Plane East (1302) U.S. feet.

This Projection Coordinate Reference System is consistent across the following deliverables:

- [x] Project Shapefile/Geodatabase
- [x] Project Tiling Scheme Shapefile/Gdb
- [x] Checkpoints Shapefile/Geodatabase
- [ ] Project XML Metadata File
- [ ] Swath LAS XML Metadata File
- [x] Classified LAS XML Metadata File
- [x] Breaklines XML Metadata File
- [x] Bare-Earth DEM XML Metadata File
- [ ] Swath LAS Files
- [x] Classified LAS Files
- [x] Breaklines Files
- [x] Bare-Earth DEM Files

Project XML Metadata CRS

No project xml metadata delivered to reviewer at NGTOC

Swath LAS XML Metadata CRS

No swath las xml metadata delivered to reviewer at NGTOC

Swath LAS Files CRS

Swath las delivered in WGS84 UTM 16N

Review Cycle

This section documents who performed the QA Review on a project as well as when QA reviews were started, actions passed, received, and completed.

Reviewer:
H. Boggs

Review Start Date:
11/30/2012

Action to Contractor Date	Issue Description	Return Date
2/11/2013	Corrections required. Swath las not consistently projected.	4/2/2013
5/2/2013	Corrections requested for swath las, classified las, and DEMs.	8/8/2013
8/30/2013	Multiple corrections completed at NGTOC.	10/17/2013

Review Complete: 11/19/2013

Metadata Review

Provided metadata files have been parsed using 'mp' metadata parser. Any errors generated by the parser are documented below for reference and/or corrective action.

The Project XML Metadata file parsed witherrors.

No project xml metadata file delivered to reviewer at NGTOC. Reviewer read all delivered xml metadata files and determined the best use xml metadata. Reviewer at NGTOC renamed the file BESTUSE.XML and copied it to the Metadata-Documents folder.

The Classified LAS XML Metadata file parsed withouterrors.

The Breakline XML Metadata file parsed withouterrors.

The Bare-Earth DEM XML Metadata file parsed without errors.

Project QA/QC Report Review

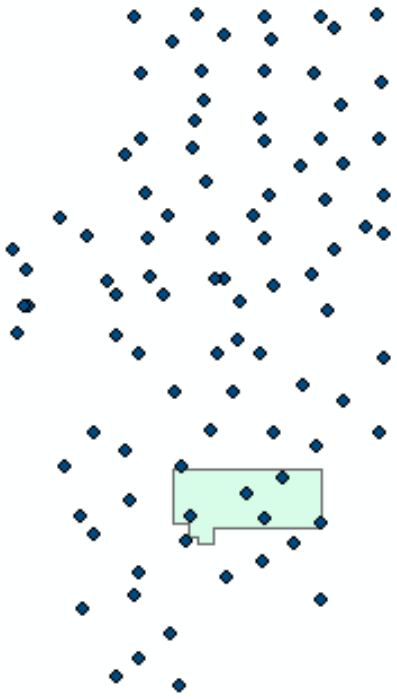
ASPRS recommends that checkpoint surveys be used to verify the vertical accuracy of LiDAR data sets. Checkpoints are to be collected by an independent survey firm licensed in the particular state(s) where the project is located. While subjective, checkpoints should be well distributed throughout the dataset. National Standards for Spatial Data Accuracy (NSSDA) guidance states that checkpoints may be distributed more densely in the vicinity of important features and more sparsely in areas that are of little or no interest. Checkpoints should be distributed so that points are spaced at intervals of at least ten percent of the diagonal distance across the dataset and at least twenty percent of the points are located in each quadrant of the dataset.

NSSDA and ASPRS require that a minimum of twenty checkpoints (thirty is preferred) are collected for each major land cover category represented in the LiDAR data. Checkpoints should be selected on flat terrain, or on uniformly sloping terrain in all directions from each checkpoint. They should not be selected near severe breaks in slope, such as bridge abutments, edges of roads, or near river bluffs. Checkpoints are an important component of the USGS QA process. There is the presumption that the checkpoint surveys are error free and the discrepancies are attributable to the LiDAR dataset supplied.

For this dataset, USGS checked the spatial distribution of checkpoints with an emphasis on the bare-earth (open terrain) points; the number of points per class; the methodology used to collect these points; and the relationship between the data supplier and checkpoint collector. When independent control data are available, USGS has incorporated this into the analysis.

Checkpoint Shapefile or Geodatabase:

☑ Checkpoint Distribution Image?



The following land cover classes are represented in this dataset (uncheck any that do not apply):

- [x] Bare Earth
- [x] Tall Weeds and Crops
- [ ] Brush Lands and Low Trees
- [ ] Forested Areas Fully Covered by Trees
- [ ] Urban Areas with Dense Man-Made Structures

There are a minimum of 20 checkpoints for each land cover class represented. Points within each class are uniformly distributed throughout the dataset. USGS wasable to locate independent checkpoints for this analysis. USGS acceptsthe quality of the checkpoint data for these LiDAR datasets.

Errors, Anomalies, Other Issues to document? (•) Yes ( ) No

- [ ] Image?

"Airborne LiDAR Report" lists independent control points used to test vertical accuracy in shapefile format as a required deliverable, however, no control points were delivered to reviewer at NGTOC. Reviewer at NGTOC contacted David Nail on 9/28/12 and again on 12/11/12 requesting delivery of control point shapefile. All available checkpoints delivered to NGTOC on 2/11/13, and 3/19/13.

- [ ] Image?

Task Order requires that the data collected meet the NSSDA accuracy standards. The task order requires FVA and CVA assessment (but does not require SVA) and references USGS Base Spec v12. The reviewer has determined USGS Base Spec v12 does not mention SVA or CVA.

☐ Image?

The task order on page 2-5 reads, "Woolpert will not be using land use category test areas. Woolpert will use 20 test points per LiDAR acquisition block." Howard County is located in Block 2, there are 4 blocks comprising the central tier of Indiana flown in 2011. On page 2-6 of the task order, CVA testing requirements are detailed. The reviewer has determined that CVA for the entire central tier of Indiana (including multiple other counties) was not calculated, rather, FVA testing was done one each block and again on the entire central tier. Woolpert reported overall accuracy of the central tier as 0.393 feet (11cm) vertical accuracy at the 95% confidence level.

☐ Image?

Vertical accuracy assessment was calculated by comparison of the LiDAR bare earth points to the ground surveyed QA/QC points. FVA of Howard County is reported to be 0.241 feet (7.3 cm).

Accuracy values are reported in terms of Fundamental Vertical Accuracy (FVA), Supplemental Vertical Accuracy(s) (SVA), and Consolidated Vertical Accuracy (CVA).

Accuracy values are reported in: U.S. feet

Required FVA Value is 0.98 U.S. feet or less.
Target SVA Value is N/A U.S. feet or less.
Required CVA Value is N/A U.S. feet or less.

The reported FVA of the LAS Swath data is **N/A** U.S. feet.

The reported FVA of the Bare-Earth DEM data is **N/A** U.S. feet.

SVA are required for each land cover type present in the data set with the exception of

bare-earth. SVA is calculated and reported as a 95th Percentile Error.

Land Cover Type	SVA Value	Units
Tall Weeds and Crops	N/A	U.S. feet
Brush Lands and Low Trees		N/A
Forested Areas Fully Covered by Trees		N/A
Urban Areas with Dense Man-Made Structu...		N/A

The reported CVA of this data set is: **see above** U.S. feet.

LAS Swath File Review

LAS swath files or raw unclassified LiDAR data are reviewed to assess the quality control used by the data supplier during collection. Furthermore, LAS swath data are checked for positional accuracy. The data supplier should have calculated the Fundamental Vertical Accuracy using ground control checkpoints measured in clear open terrain. The following was determined for LAS swath data for this project:

LAS Version

(•) LAS 1.2 ( ) LAS1.3 ( ) LAS 1.4

Swath File Characteristics

- [x] Separate folder for LAS swath files
- [x] Each swath files <= 2GB
- [ ] *If specified, *.wdp files for full waveform have been provided

The reported FVA of the LAS swath data is N/A U.S. feet.

Based on this review, the USGS accepts the LAS swath file data.

Errors, Anomalies, Other Issues to document? (•) Yes ( ) No

- [ ] Image?

"Scope of Services" report references USGS NGP Base LiDAR Specification, version

12 which lists swath las files as a required deliverable, and the "Airborne LiDAR Report" included las v1.2 raw unclassified point cloud as a final deliverable, however no swath las files were delivered to reviewer at NGTOC. Reviewer at NGTOC contacted David Nail on 9/28/12 and again on 12/11/12 requesting delivery of swath las files.

☐ Image?

Swath las files initially received by reviewer at NGTOC on 1/28/13, corrections requested 2/11/13 as many swath las files found to be missing projection information.

☐ Image?

First correction cycle received by reviewer at NGTOC on 4/2/13.

☐ Image?

Additional corrections requested 5/2/13 as many swath las files did not meet the las specifications version 1.2 which is referenced in the USGS Base Specification draft v12. Prior to acceptance, all swath las files must be fully compliant LAS format v1.2. Point source count field not properly populated, unique file source ID not assigned to each file, point source not set identical to file source prior to processing, two delivered swath las files contain NO returns, two delivered swath las files did not contain projection information in their headers, a handful of swath las files remain unprojected, and the system ID field is required yet many delivered swath las files did not contain any information regarding system ID. On 8/8/13 reviewer was notified that no corrections will be delivered to NGTOC.

LAS Tile File Review

Classified LAS tile files are used to build digital terrain models using the points classified as ground. Therefore, it is important that the classified LAS are of sufficient quality to ensure that the derivative product accurately represents the landscape that was measured. The following was determined for classified LAS files for this project:

Classified LAS Tile File Characteristics

- [x] Separate folder for Classified LAS tile files
- [x] Classified LAS tile files conform to Project Tiling Scheme
- [x] Quantity of Classified LAS tile files conforms to Project Tiling Scheme
- [x] Classified LAS tile files do not overlap
- [x] Classified LAS tile files are uniform in size
- [ ] Classified LAS tile files have no points classified as '12'

- [ ] Point classifications are limited to the standard values listed below:

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
7	Noise (low or high, manually identified, if needed)
9	Water
10	Ignored ground (breakline proximity)
11	Withheld (if the "Withheld" bit is not implemented in processing software)

- [ ] Buy up?

Based on this review, the USGS accepts the classified LAS tile file data.

Errors, Anomalies, Other Issues to document? (•) Yes ( ) No

- [ ] Image?

Task order does not match "LiDAR Task Order Report" or delivered .las files regarding classification scheme. Task Order lists 1, 2, 7, 9, 10 and 13. LiDAR Task Order Report lists 1, 2, 7, 9, 10, 12, and 13. The delivered classified las tiles include class 12 in the classification scheme. On 8/8/13 reviewer was notified that no corrections will be delivered to NGTOC.

Breakline File Review

Breaklines are vector feature classes that are used to hydro-flatten the bare earth Digital Elevation Models.

Breakline File Characteristics

- [x] Separate folder for breakline files
- [x] All breaklines captured as PolylineZ or PolygonZ features
- [x] No missing or misplaced breaklines

Based on this review, the USGS accepts the breakline files.

Errors, Anomalies, Other Issues to document? ○ Yes ◉ No

None.

Bare-Earth DEM Tile File Review

The derived bare-earth DEM file receives a review of the vertical accuracies provided by the data supplier, vertical accuracies calculated by USGS using supplied and independent checkpoints, and a manual check of the appearance of the DEM layer.

Bare-Earth DEM files provided in the following format: Erdas Imagine *.img

Bare-Earth DEM Tile File Characteristics

- [x] Separate folder for bare-earth DEM files
- [x] DEM files conform to Project Tiling Scheme
- [x] Quantity of DEM files conforms to Project Tiling Scheme
- [x] DEM files do not overlap
- [x] DEM files are uniform in size

☑ DEM files properly edge match
☑ Independent check points are well distributed

All accuracy values reported in U.S. feet.

Reported Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval ($Accuracy_z$) Required FVA = 0.98 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = N/A or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = N/A or less.
Open Terrain	25	N/A		
Tall Weeds and Crops			N/A	
Brush Lands and Low Trees				
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures				
Consolidated	25			see above

☑ QA performed Accuracy Calculations?

Calculated Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval ($Accuracy_z$) Required FVA = 0.98 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = N/A or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = N/A or less.
Open Terrain	26	0.547		
Tall Weeds and Crops				
Brush Lands and Low Trees				
Forested Areas Fully Covered by Trees				
Urban Areas with Dense Man-Made Structures				

Consolidated	26			N/A

Based on this review, the USGS recommends the bare-earth DEM files for inclusion in the 1/3 Arc-Second National Elevation Dataset.

Based on this review, the USGS accepts the bare-earth DEM files.

Bare-Earth DEM Anomalies, Errors, Other Issues

Errors, Anomalies, Other Issues to document? (•) Yes ( ) No

☑ Image?

One waterbody greater than 2 acres that was not hydroflattened was identified by the reviewer. This is the only error that requires correction. It is located in DEM tile in2011_02051905_12.img. Reviewer created a shapefile documenting the location of this error found in the delivered DEMs named errors.shp. On 8/8/13 reviewer was notified that no corrections will be delivered to NGTOC. Corrections performed in house, accepted 11/19/13.

Internal Note:

This is the end of the report.

QA Form V1.4 12OCT11.xsn