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:
11/30/2012

Project ID:
SD_MtRushmore-RileyPass_2012

Project Alias(es):
Mount Rushmore NM and Riley Pass, Cu...

Project Type: GPSC

Project Description:

This task order is for Planning, Acquisition, processing, and derivative products of lidar data to be collected at a nominal pulse spacing (NPS) of **0.5 meters (4 PPSM)**. The Mount Rushmore National Monument, area exclusive of the remaining Park extent, shall be collected at **0.35 meters NPS (7.52 PPSM)**, single pass. Specifications listed below are based on the ***"U.S. Geological Survey National Geospatial Program Base Lidar*** Specification, Version 13 (ILMF)."
This task is for a high resolution data set of lidar covering approximately 32 square miles in South Dakota. The areas of interest include the Mount Rushmore National Monument and Riley Pass of the North Cave Hills Unit of Custer National Forest. *This data shall be used to support analysis of disturbed lands for mining reclamation, develop hydrologic models, vegetation monitoring, and recreation planning.*

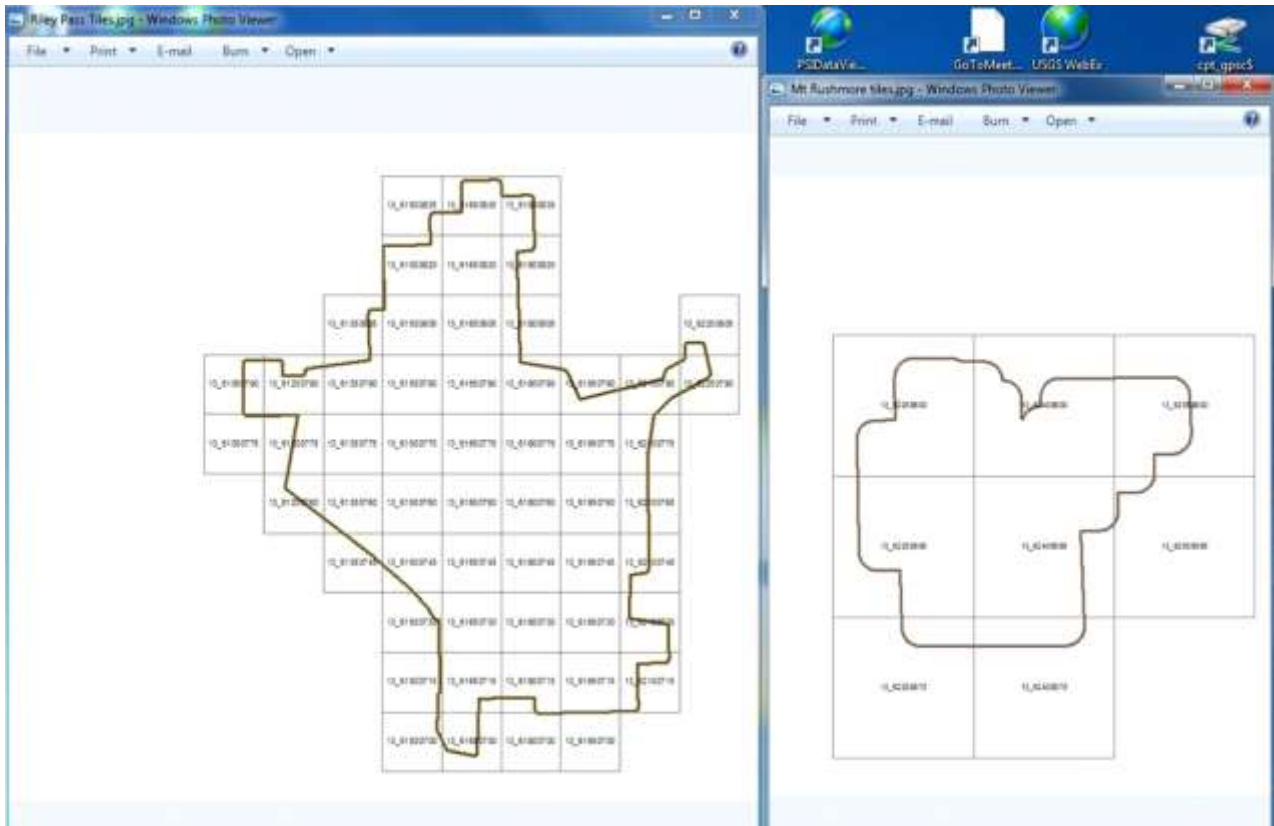Year of Collection: August 28-29, 2012

Lot 1 of 1 lots.

Project Extent:
☑ Project Extent image?
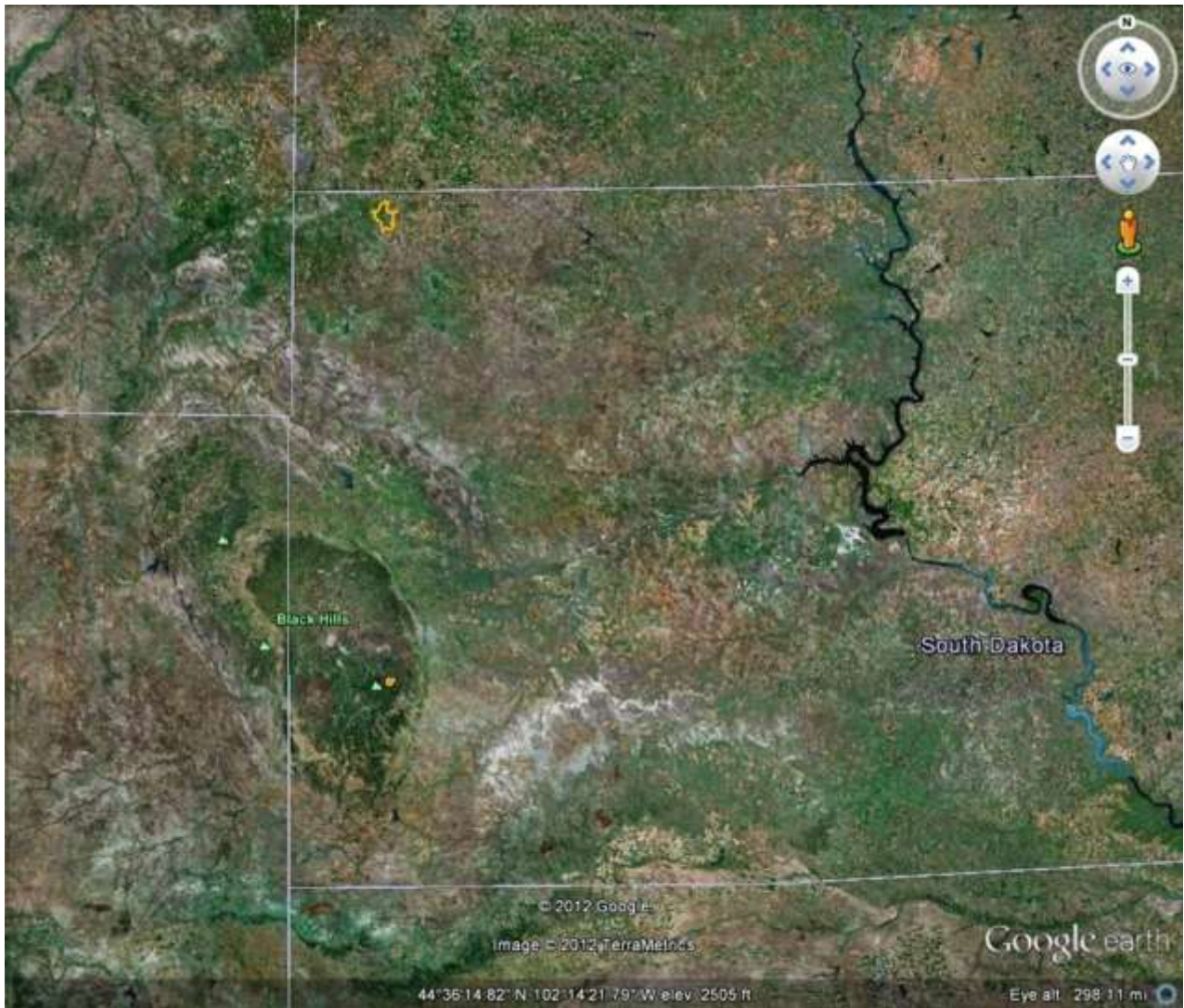
Project Tiling Scheme:
☑ Project Tiling Scheme image?

Contractor:

Aerometric, Inc.

Applicable Specification:

V13

Licensing Restrictions:

Monument_Special_Raw and Monument_Special_Classified data are for National Park Service use only and will not be included in the deliverables to EROS.

☐ Third Party Performed QA?

Project Points of Contact:

POC Name	Type	Primary Phone	E-Mail
Gail Dunn	CPT	573.308.3756	gdunn@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   ☑ Project Shapefile/Geodatabase
☑ Survey Report   ☑ Project Tiling Scheme Shapefile/Gdb
☑ Processing Report   ☑ Control Point Shapefile/Gdb
☑ QA/QC Report   ☑ Breakline Shapefile/Gdb
☑ Control and Calibration Points   ☑ Project XML Metadata

Multi-File Deliverables

File Type	Quantity
☑ Swath LAS Files ☑ Required? ☑ XML Metadata?	58
☑ Intensity Image Files ☑ Required?	126
☑ Tiled LAS Files ☑ Required? ☑ XML Metadata?	53
☑ Breakline Files ☑ Required? ☑ XML Metadata?	2
☑ Bare-Earth DEM Files ☑ Required? ☑ XML Metadata?	63

Additional Deliverables

	Item
☑	1.0-m Hydro-enforced DEMs - 63 files
☑	Hydro-enforced breaklines - 2 files
☑	Special classification scheme for landcovers 3-5 and 16 - 9 files
☑	1-Foot Contours - 63 files
☑	1.0-m DSM - 63 files

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

Main level files such as metadata, control, report and shapefiles are shared by both Mount Rushmore and Riley Pass AOIs. The report does not state the vertical accuracy of the raw and the bare-earth DEM that I can tell. The DEM metadata reports values in the <attraccr> tags. I am supplying SAMPLE reporting information for the contractor's review and editing purposes.

Project Geographic Information

Areal Extent:

32

Sq Mi

Grid Size:

1

meters

Tile Size:

1500

 meters

Nominal Pulse Spacing:

0.5

 meters

Vertical Datum: NAVD88 meters

Horizontal Datum: NAD83 meters

Project Projection/Coordinate Reference System: UTM Zone 13 N meters.

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

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

Project Shapefile/Geodatabase CRS

Riley Pass boundary shapefile is Geographics. This was the initial spec but later chan...

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:

L. Lansbery

Review Start Date:

12/20/2012

Action to Contractor Date	Issue Description	Return Date
12/26/2012	No errors in DEM. Swath files are incomplete, metadata issues outlined at bottom of report	1/15/2013

Review Complete:

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 without errors.

The Swath LAS XML Metadata file parsed without errors.

The Classified LAS XML Metadata file parsed without errors.

The Breakline XML Metadata file parsed without errors.

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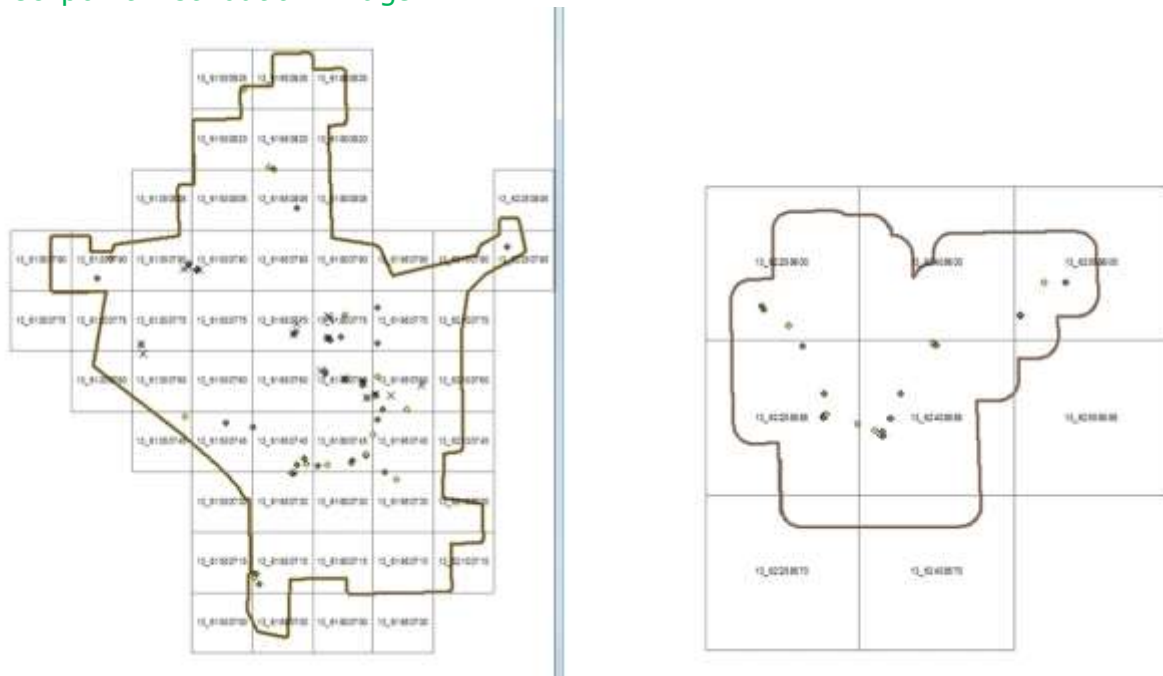
The following land cover classes are represented in this dataset (uncheck any that do not apply):

☑ Bare Earth

☑ 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 was able to locate independent checkpoints for this analysis. USGS accepts the quality of the checkpoint data for these LiDAR datasets.

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

☐ Image?

The Riley Pass AOI contains QC checkpoints for Mine Bluff areas per Customer requirement. There are Urban points in the Rushmore area, but not enough to meet 10% representation requirement, project wide.

From page 11 of project report: "A field survey was performed by AreoMetric Inc between September 20 and September 30, 2012. Twenty-seven (27) check points to be used to evaluate airborne LiDAR data were measured in various land coverage categories throughout the Mount Rushmore area. In the Riley Pass area, eighty-four (84) ground survey check points were made."

☐ Image?

Mine Bluff check points were included in the deliverables and an SVA was calculated by the reviewer. A value of 6.6 cm was attained using 17 check points.

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: centimeters

Required FVA Value is 18.2 centimeters or less.
Target SVA Value is 26.8 centimeters or less.
Required CVA Value is 26.8 centimeters or less.

The reported FVA of the LAS Swath data is 08.31 centimeters .

The reported FVA of the Bare-Earth DEM data is 09.10 centimeters .
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	10.80	centimeters
Brush Lands and Low Trees	11.20	centimeters
Forested Areas Fully Covered by Trees	11.90	centimeters
Urban Areas with Dense Man-Made Structu...	09.10	centimeters

The reported CVA of this data set is: 11.30 centimeters .

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
☑ Separate folder for LAS swath files
☑ Each swath files <= 2GB
☐ *If specified, *.wdp files for full waveform have been provided

The reported FVA of the LAS swath data is 08.31 centimeters .
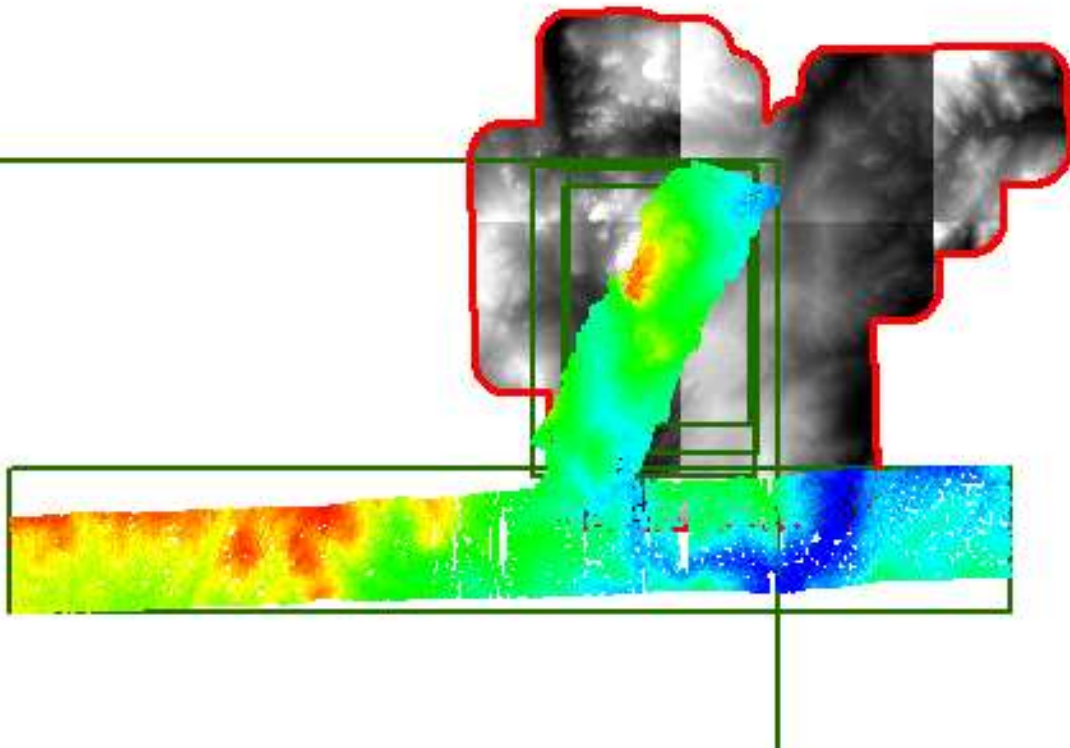
Based on this review, the USGS does not accept at this time the LAS swath file data.

◉ Yes ○ No

☐ Image?

The Mount Rushmore folder contains additional coverage of the monument area that is extra data for the customer

☑ Image?

Do not have a complete delivery of swath files for Mt. Rushmore area. The

Rushmore_Raw_Strips are the E-W swath row and the Monument_Special_Raw are the swath files oriented NE-SW. The swath data does not cover the DEM area and an FVA of the swath cannot be checked at NGTOC at this time.

Vendor fixed this issue 1/17/2013 See picture at bottom of this section. FVA was calculated on the swath data with a result of 7.9 cm. Text file of report is located in the NGTOC_Created_Metadata folder.

☑ Image?

Resulting shapefile from Point Cloud Statistics on the raw .las for Mt. Rushmore. The large box showing is from the 17.las file (Monument_Special_Raw) which has a point in the lower left corner (see picture below).

Not corrected by vendor 1/17/2013. Per CPT - This data is not a task order requirement, it is extra data delivered by vendor. Therefore, this does not affect the recommendation of the data for NED. Vendor will be made aware of issue, but this special swath data will be delivered as is.
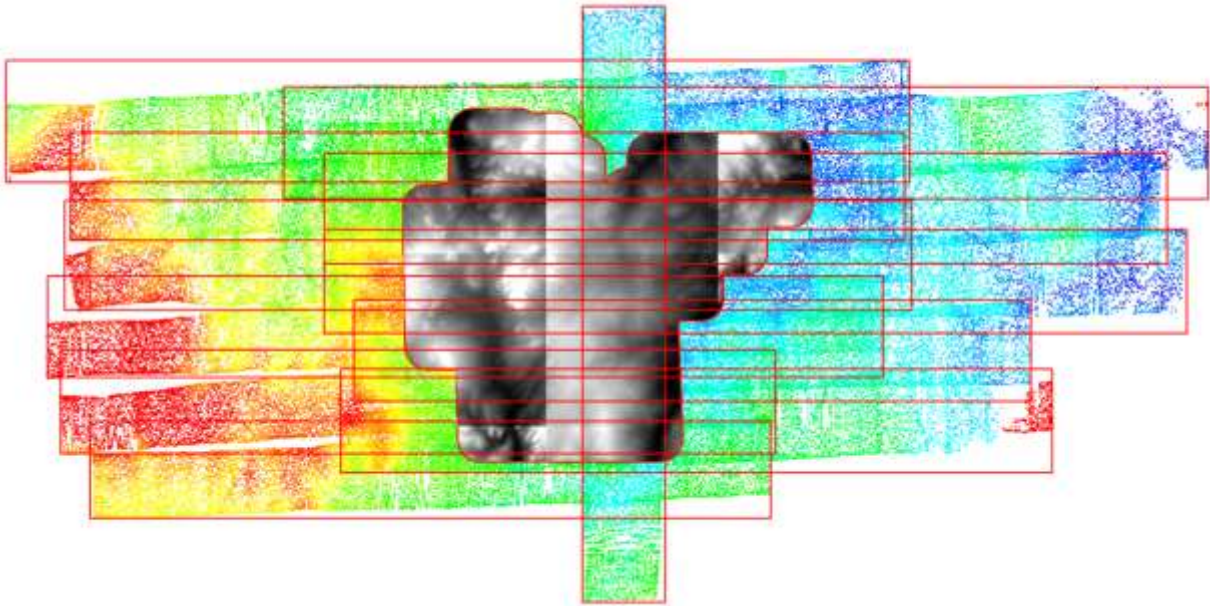
This data will not be included in the deliverables to EROS. The data is for the National Park Service use only

☑ Image?

In the 17.las file of the Monument_Special_Raw folder is a point far from the monument area of collection.

☑ Image?

The Swath data for Mt. Rushmore area loads correctly. Shown here with the DEM data. **Vendor fixed issue with swath data (Rushmore_Raw_Strips). 1/17/2013

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
- ☑ Separate folder for Classified LAS tile files
- ☑ Classified LAS tile files conform to Project Tiling Scheme
- ☑ Quantity of Classified LAS tile files conforms to Project Tiling Scheme
- ☑ Classified LAS tile files do not overlap
- ☐ 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?

Additional classifications in this data set.
☑ 3 - Tall weeds and crops (low vegetation)
☑ 4 - Brush lands and low trees (medium vegetation)
☑ 5 - Forested areas fully covered by trees
☑ 6 - Urban area with dense man-made structures

☑ 16 - Is to be used for Overstory Trees (16 feet or greater)

Based on this review, the USGS <u>accepts</u> the classified LAS tile file data.

No Class 8 was used per the Point Cloud Stats table (task order C.1.d. (ii)(g)) ◉ Yes
○ No

☐ Image?

Breakline File Review

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

Breakline File Characteristics
☑ Separate folder for breakline files
☑ All breaklines captured as PolylineZ or PolygonZ features
☑ No missing or misplaced breaklines

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

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

☐ Image for error?

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
☑ Separate folder for bare-earth DEM files
☑ DEM files conform to Project Tiling Scheme
☑ Quantity of DEM files conforms to Project Tiling Scheme
☑ DEM files do not overlap
☐ DEM files are uniform in size
☑ DEM files properly edge match
☑ Independent check points are well distributed

All accuracy values reported in centimeters .

Reported Accuracies

		Fundamental Vertical Accuracy	Supplemental	Consolidated

Land Cover Category	# of Points	@95% Confidence Interval ($Accuracy_z$) Required FVA = 18.2 or less.	Vertical Accuracy @95th Percentile Error Target SVA = 26.8 or less.	Vertical Accuracy @95th Percentile Error Required CVA = 26.8 or less.
Open Terrain	24	9.10		
Tall Weeds and Crops	21		10.80	
Brush Lands and Low Trees	21		11.20	
Forested Areas Fully Covered by Trees	21		11.90	
Urban Areas with Dense Man-Made Structures	5		09.10	
Consolidated	92			11.30

☑ QA performed Accuracy Calculations?

Calculated Accuracies

Land Cover Category	# of Points	Fundamental Vertical Accuracy @95% Confidence Interval ($Accuracy_z$) Required FVA = 18.2 or less.	Supplemental Vertical Accuracy @95th Percentile Error Target SVA = 26.8 or less.	Consolidated Vertical Accuracy @95th Percentile Error Required CVA = 26.8 or less.
Open Terrain	24	14.2		
Tall Weeds and Crops	21		15.0	
Brush Lands and Low Trees	21		14.0	
Forested Areas Fully Covered by Trees	21		12.0	
Urban Areas with Dense Man-Made Structures	5		03.8	
Consolidated	92			15.0

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 <u>accepts</u> the bare-earth DEM files.

Bare-Earth DEM Anomalies, Errors, Other Issues

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

None.

Based on this review, the deliverables provided <u>meet</u> the Task Order requirements.

Internal Note:

Note there is an extra SVA category for Mine Bluff Areas for which there are 17 points that would bring the total number of CVA to 109 points. An initial review reveals that shapefiles, breaklines, metadata and the project report are combined for both AOIs. I will request that all but the project report be split into the individual AOI for the end Customer. The vertical accuracy reporting in the metadata does not follow V13 spec and there is no report of the DEM FVA. The hydro-enforced DEM should be delivered in ESRI Grid per task order requirement (Vendor re-delivered enforced DEMs as arcgrids). The lift metadata does not report the FVA of the TIN derived from the raw swath data, but the DEM metadata does. The hydro-enforced and hydro-flattened DEM share a metadata file. There should really be a metadata file for each product with a unique process description for each. The project report does not address the FVA, CVA or SVAs of the DEM or raw swath TIN. Note that the hydro-flattened breaklines do not seem to follow the outline of some water bodies from imagery though they appear to follow the intensity imagery. This topic will be brought up for discussion with the contractor.

Contours were to be delivered as 1-Ft though the data was UTM/Meters. Files which were to be delivered in feature class for the customer are the hydro-enforced breaklines, contours, DSM. The Hydro-enforced DEM was to be delivered as ESRI Grid.

NGTOC Reviewer: There are two areas to the project and each has their own respective folders within the Project folder: SD_RileyPass_2012 and SD_MtRushmore_2012. Some documents are duplicated within the two folders. Vertical accuracy was calculated on the entire project area and the same report is included in both Mt. Rushmore and Riley Pass. Final_To_NED images were created for Riley Pass and Mt. Rushmore areas separately as well as one image for the entire project area.

The swath files are incomplete and need to be re-delivered. A check of the FVA of the swath TIN cannot be completed without complete swath files. **Vendor fixed this error with the Rushmore_Raw_Strips and FVA was calculated at NGTOC for the swath data. In the Monument_Special_Raw data there is an outlier point as shown in the LAS Swath File Review Section of this report - this was not part of the deliverable per the task order and is extra data provided by vendor. Please see comments under the error picture.**

As noted above in the report, the Monument special raw and classified data are for the National Park Service use only and will not be included in the deliverables to EROS.

A review was completed on the Hydro-Flattened DEMs only. The Hydro-Enforced DEMs were not reviewed as part of this task order. **The Hydro-Enforced DEMs were re-delivered in ESRI Grid format as required by the task order.

Vertical Accuracy: From page 22 of the Project Report it states that "
In the Rushmore area five check points of Urban ground cover category were collected near the monument visitor facilities. Urban ground cover does not comprise 10 percent of the project area." There were 7 points provided, however, pts 506 & 507 were used as control points and not included in the vertical accuracy testing (pg 197-198 of project report). Additionally for the mine bluff points: "In the Riley Pass area the ground cover type, 'Mine Bluffs' is assessed by seventeen ground

This is the end of the report.