EARTHDATA

Turning Spatial Data into Knowledge

ELEVATION MAPPING

Hinds County, MS
Lidar

Final Project Report

15 January 2007

Prepared for

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INTRODUCTION

Mississippi Geographic Information, LLC (MGI) contracted EarthData International, Inc. (EarthData) to collect and deliver high quality topographic elevation point data derived from multiple return light detection and ranging (lidar) measurements for an area of approximately 879 square miles encompassing Hinds County in Mississippi.

1.1 Project Area

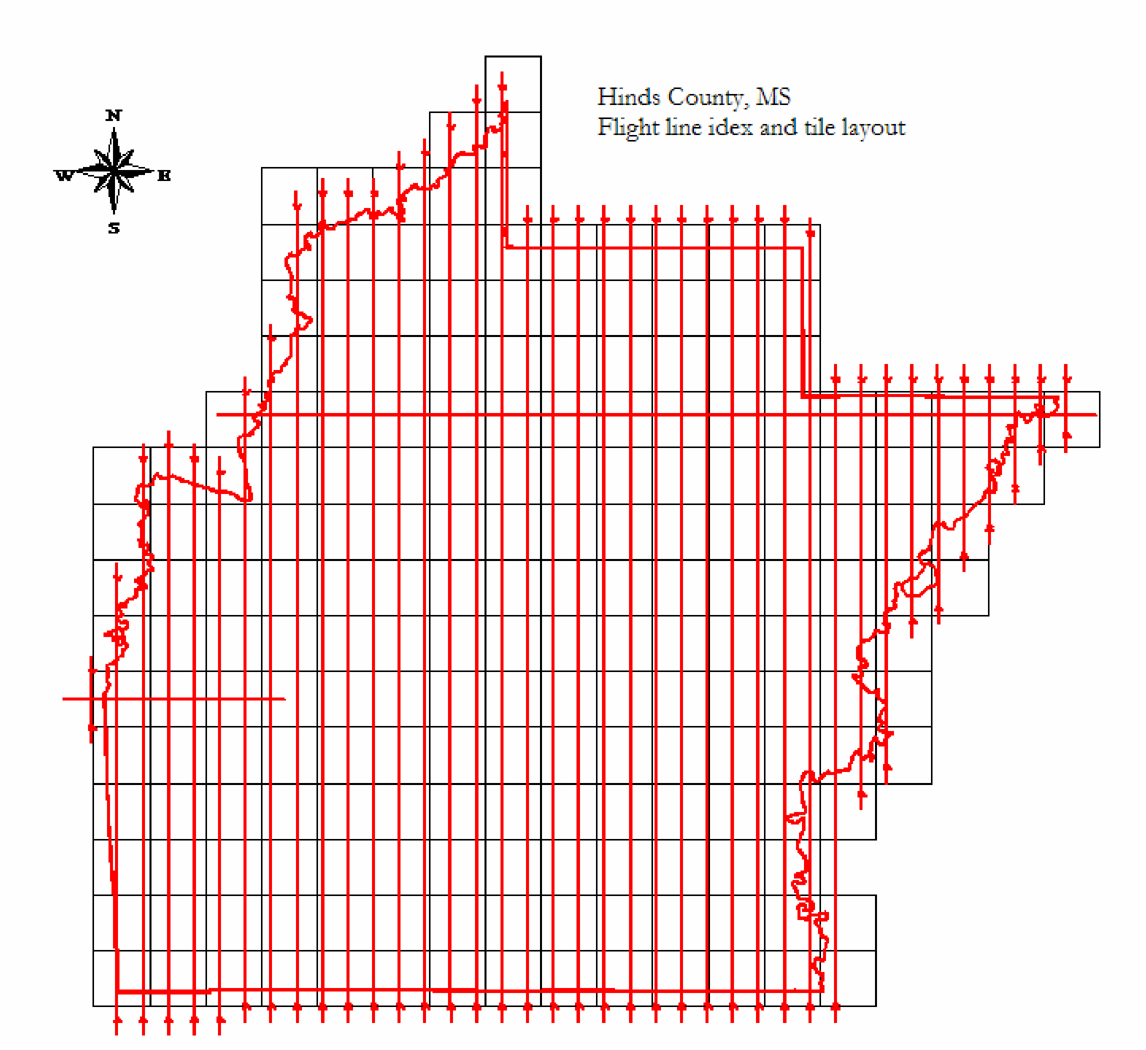

Figure 1 - Project Area

1.2 Purpose

The acquisition, processing, and delivery of bare earth lidar data, raw point cloud lidar data, lidar intensity data, and floodmap breaklines covering Hinds County, MS was a coordinated effort between EarthData and MGI to support MDEM and FEMA flood mapping requirements. Floodmap breaklines are intended to support DFIRM modeling and update only, and will be delivered to MDEQ for use on the DFIRM program.

The information provided in this report summarizes the project, from project planning through final deliverable generation, and provides a final quality control evaluation of the project deliverables.

2 PROJECT OVERVIEW

This project includes the collection and processing of lidar data covering approximately 879 square miles over Hinds County, MS. Data was collected at a nominal four (4) meter post spacing between points. Hydro-enforced breaklines were produced for this project as well as lidar intensity images.

2.1 Project Plan

EarthData developed a project plan designed to provide MGI with comprehensive support and assurance of the successful completion of the project's requirements through a combination of program management, data management, and resource management as well as through the strengths of the EarthData team who contributed:

- Experienced technical staff.
- Proven experience integrating new technology and commercial off-the-shelf (COTS) solutions in the production environment.
- Experienced program management capabilities.
- Excellent working relationship with MGI contracting staff.

3 PROJECT DELIVERABLES/ACCURACY

The project deliverables listed below will provide MGI data to assist in their decision-making processes.

3.1 Products

Products Developed for MGI
Bare earth lidar data in ASCII format and LAS format
Raw point cloud lidar data in LAS format
Lidar intensity data in TIF format
Floodmap breaklines in ESRI shapefile format
Digital flightline index in ESRI-compatible format
Survey control report
FGDC-compliant metadata

3.2 Data Accuracy Requirements

Data Accuracy
Lidar data collected at a nominal four (4) meter spacing between points
All data was referenced to MS State Plane West Zone, NAD83, NAVD88, US Survey foot
Lidar has been collected and processed in accordance with FEMA guidance as published in Appendix A, February 2002.
Lidar points have been processed to meets guidance published by FEMA. When compared to GPS survey grade points in generally flat, open, non-vegetated areas, at least 95% of the positions have an error less than or equal to 37 cm (equivalent to root mean square error of 18.5 cm if errors were normally distributed)

4 PROJECT PLANNING

EarthData's program management process has been documented and is conducted in accordance with ISO 9001 requirements. Mrs. Jordan monitored progress against schedule through internal production meetings which facilitate communications between project managers and key project personnel. She prepared monthly written reports that were submitted to MGI to track the status of the program and to note milestones and/or issues that required resolution.

5 LIDAR AND AIRBORNE GPS/IMU DATA ACQUISITION

All lidar data collected for this project was acquired using the Leica ALS-50 lidar system. The ALS-50 instrument has an operating ceiling of 15,000' AMT and is equipped with a with a 50 kHz thermal infrared laser that delivers a ground point spacing between 1 and 8 meters.

The ALS-50 system has the ability to detect and record up to 3 return signals for each transmit pulse. The system is also equipped with two intensity cards that record the reflective energy of each returning pulse.

All data is written to removable hard disk drives through a SCSI connection for post-mission processing. Data from both the laser subsystem and the positioning subsystem are tagged with the GPS 1 PPS clock, and the laser data stream also contains the GPS time word for subsequent time matching and processing.

To support this project EarthData Aviation Division acquired ALS-50 lidar data over Hinds County, MS. Data was acquired on April 11 and 12, 2006 using its aircraft with tail number N62912. Lidar data was captured using an ALS-50 lidar system, including an inertial measuring unit (IMU) and a dual frequency GPS receiver.

5.1 Lidar Data Acquisition

The area of interest was flown at an altitude of 2,896 meters (9,500 feet) above mean terrain. Data was collected at a nominal four-meter point spacing. The ALS-50 collection specifications follow:

Sensor Collection Parameters	
Flying Height	2,896 m AMT
Target Airspeed	160 knots
Laser Pulse Rate	32,900 Hz
Field of View	45 degrees
Scan Rate	18 Hz
Average Swath Width	2398.82 meters

5.2 Airborne GPS Data Acquisition

The concept of airborne GPS is to precisely locate the lidar sensor in space at a defined moment in time. Airborne GPS control is accomplished through the simultaneous observation of five or more satellites in the GPS constellation using a receiver that is permanently mounted in the aircraft and multiple ground receivers that are located over known control points that are in the vicinity of the project area. As the aircraft traverses the flight lines, the GPS system logs observations in 1-second epochs. After the flight is completed, the data logged from the roving receiver, the stationary receiver(s), and the time pulses are post-processed and the position of the camera is defined to an accuracy of 3-10 cm.

EarthData's airborne GPS system is designed to allow on-the-fly initialization, which means that the aircraft does not have to start and end each mission over a known survey point. More importantly, the aircraft receiver can re-initialize during flight should satellite reception be lost. During the lidar collection mission, the stationary receiver and roving receiver acquire GPS observations in 1-second intervals or epochs, which are then merged during post mission processing and quality control.

During airborne data collection, an additional GPS receiver was in constant operation over a temporary control point set by EarthData at Hawkins Airport. During the data acquisition, the receiver collected phase data at an epoch rate of 1 Hz.

5.3 GPS Data Processing

All GPS phase data was post processed with continuous kinematic survey techniques using "On the Fly" (OTF) integer ambiguity resolution. The GPS data was processed with forward and reverse processing algorithms. The results from each process, using the data collected at the airport, were combined to yield a single fixed integer phase differential solution of the aircraft trajectory.

5.4 Project Acquisition Areas

The bounding coordinates provided below represent rectangles covering the total area in which the project is located.

Bounding Coordinates	
Westernmost Longitude:	-90.737872
Easternmost Longitude:	-90.036490
Northernmost Latitude:	32.601207
Southernmost Latitude:	32.039824

6 CONTROL

6.1 Ground Control and GPS Base Stations

Waggoner Engineering, Inc. was contracted by EarthData to perform a geodetic control survey in support of lidar mapping of Hinds County, MS. The survey consisted of 16 lidar control points in Hinds County, MS. The map below in figure 2 shows the location of the project area.

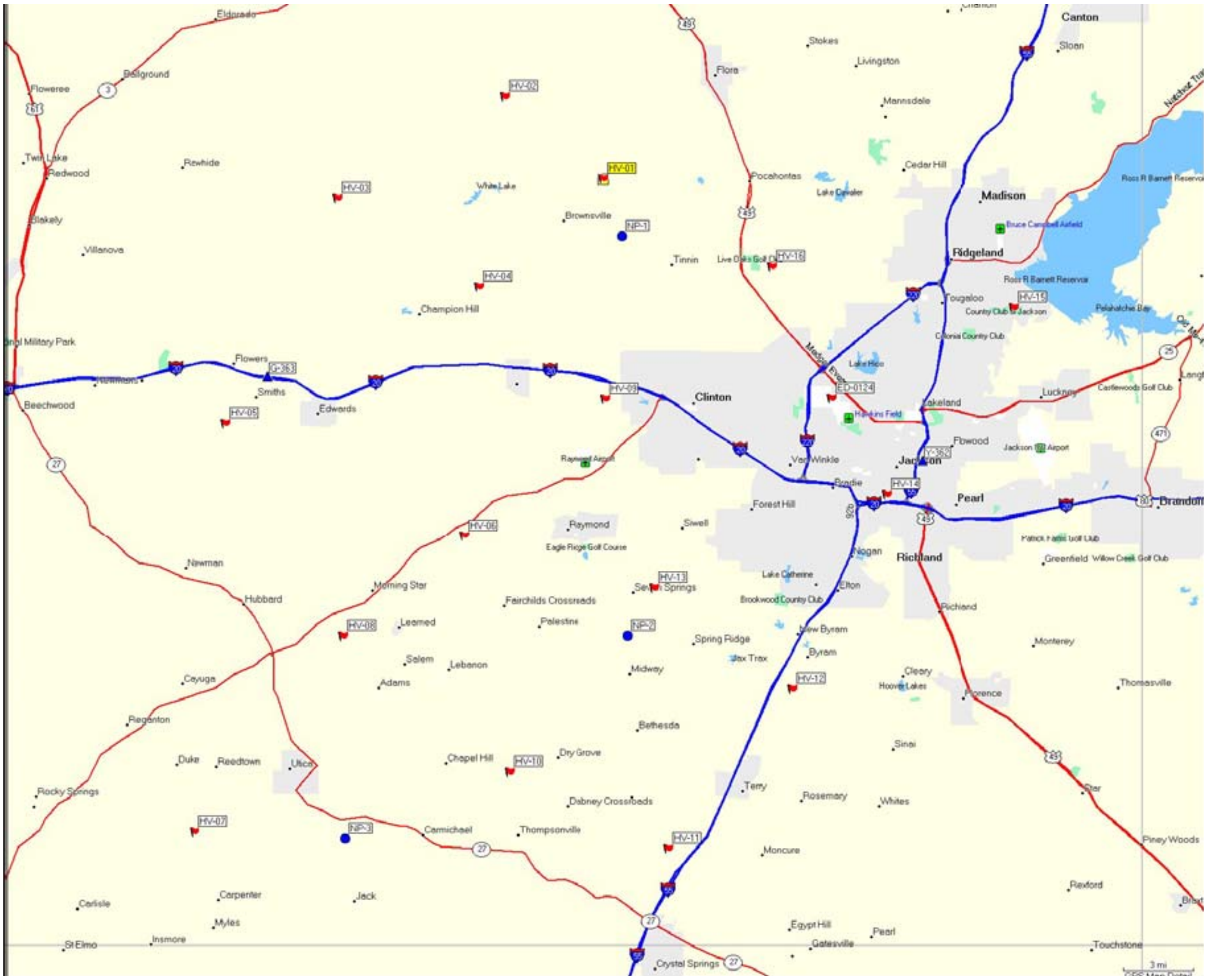

Figure 2 - Project Area Survey

The following table lists the horizontal and vertical control utilized for the primary network. The horizontal datum was the North American Datum of 1983 (NAD83). The vertical datum was the North American Vertical Datum of 1988 (NAVD88).

GPS Point	Description
HV-01	Nail set in open yard on Hwy 22 North, Hinds Co
HV-02	Nail set in edge of dirt road in open field on East Cox Ferry Road
HV-03	Nail Set in an open pasture
HV-04	Nail set in ground in open field behind mobile home off of Butler Road
HV-05	Nail set in ground in open field approx. 400 feet from center of garage
HV-06	Nail set in ground off of Ratcliff Drive, west of median
HV-07	Nail set in the center of Paul Gallows Road
HV-08	Nail set in ground in open field off of Morrison Cemetery Road
HV-09	Nail set in ground in open field 70'± off of asphalt road
HV-10	Nail set in gravel drive off of Prentis Crump Road
HV-11	Nail set in ground at intersection of Haley Road and Limestone Cove

GPS Point	Description
HV-12	Nail set in ground at PSW (Proler Steel Works) in front of office
HV-13	Nail set in ground edge of Seven Springs Road
HV-14	Ground shot at South Jackson Sub-Station
HV-15	Ground shot at Country Club of Jackson Golf Course
HV-16	Nail set in ground at dirt road
ED0124	Nail set in ground at Hawkins Field

7 LIDAR PROCESSING

7.1 Lidar Data Processing Production Steps

EarthData has developed a unique method for processing lidar data to identify and remove elevation points falling on vegetation, buildings, and other aboveground features. The algorithms for filtering data were utilized within EarthData's proprietary software and commercial software written by TerraSolid. This software suite of tools provides efficient processing for small to large-scale projects and has been incorporated into ISO 9001 compliant production work flows.

7.1.1 Point Cloud

The following is a step-by-step breakdown of the process utilized to produce variably-spaced point cloud data sets.

Step 1 Processing of the lidar data begins with refinement of the initial boresight alignment parameters provided in the ALS processor by Leica. The technician also verifies that there are no voids, and that the data covers the entire project area. Calibration is accomplished using the tri-directional flight lines over the project airport, which is generally flat and free of major obstructions, trees or brush. Two overlapping bi-directional lines are flown along the length of the runway, and the cross flight line is perpendicular to both. All three lines are examined to ensure that they agree, within expected system tolerances, in the overlapping areas. The technician will review flight lines and locate the areas that contained systematic errors or distortions that were introduced by the lidar sensor.

Step 2 Systematic distortions highlighted in step 1 were removed and the data was re-inspected. Corrections and adjustments can involve the application of angular deflection or compensation for curvature of the ground surface that can be introduced by crossing from on type of land cover to another.

Step 3 All flight lines are processed with the refined calibration parameters obtained thru steps 1 and 2. All flight lines are examined to ensure that they agree, within expected system tolerances, in the overlapping areas (side lap).

Step 4 The lidar data for each flight line was trimmed in batch for the removal of the overlap areas between flight lines. The data was checked against a control network to ensure that vertical requirements were maintained. Conversion to the client-specified datum and projections were then completed. The lidar flight line data sets were then segmented into adjoining tiles for batch processing and data management.

Step 5 The data was then edited for Blunder removal.

Step 6 The data was separated into a variably-spaced point cloud in LAS file format, and EarthData .EBN (binary) format for bare earth production of ASCII deliverables and left in LAS format for bare earth production of LAS deliverables.

7.1.2 Bare earth

The following is a step-by-step breakdown of the process utilized to produce variably-spaced bare earth data sets.

Step 1 Processing of the lidar data begins with refinement of the initial boresight alignment parameters provided by EarthData Aviation Division in the LITES configuration file delivered with the raw data. The technician also verifies that there are no voids, and that the data covers the entire project area. Calibration is accomplished using the tri-directional flight lines over the project airport, which is generally flat and free of major obstructions, trees or brush. Two overlapping bi-directional lines are flown along the length of the runway, and the cross flight line is perpendicular to both. All three lines are examined to ensure that they agree, within expected system tolerances, in the overlapping areas. The technician will review flight lines and locate the areas that contained systematic errors or distortions that were introduced by the lidar sensor.

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4a. Sins and Fins (first and only and last of many) points are extracted from the point cloud and are used for bare earth classification.

Step 5 The initial batch-processing run removed 75% to 95% of points falling on vegetation. The algorithm also removed points that fell on the edge of hard features such as structures, elevated roadways and bridges. In addition, points not classified as ground are coded as above ground. Thus the lidar data was classified into two thematic layers that can be analyzed separately or together. Sub-classification of the above ground layer to intermediate canopy, top of canopy, building, etc was not required for this project.

Step 6 The data was processed interactively by the technician using lidar editing tools. During this final phase the technician generated a TIN based on a desired thematic layers to evaluate the automated classification performed in step 5. This allowed the technician to quickly re-classify points from one layer to another and recreate the TIN surface to see the effects of edits. The use of geo-referenced images was toggled on or off to aid the technician in identifying problem areas. The data was also examined with an automated profiling tool to aid the technician in the reclassification.

Step 7 The final bare earth products were written to LAS and ASCII formats for delivery. The files were written to DVD.

7.1.3 Generation of Lidar Intensity Images

Lidar intensity images were produced for the corresponding tiles of lidar points. Intensity images are generated through the use of a DOS-driven proprietary program called "eebnstif.exe". The program allows a user to select the desired pixel size of the resultant intensity image and will both extract the intensity value from each lidar and resample the data to the selected pixel size. Eebntif outputs the intensity images in .TIF format with associated .TFW files for the tiles.

Several samples at different pixel resolutions are generated and the lead technician selects the sample that is the most aesthetically pleasing and yields the most interpretability. From past experience on other projects, EarthData has found that the pixel resolution usually selected is one that closely mirrors the post spacing of the source lidar. In some cases, however, re-sampling to a tighter pixel resolution has yielded better results. For this project, the best resolution was a 12' (foot) pixel which is close to the nominal post spacing of the lidar data.

Once all of the intensity images were generated, the lead technician examined all of the images with the zoom and dynamic pan tools for normalcy, continuity, and coverage.

The lidar intensity data were delivered in TIF format. The files were written to DVD.

7.1.4 Generation of Hydro-Breaklines

<u>**Technical Note on Breaklines:</u> It should be noted that the breaklines developed for use in the H&H modeling should not be confused with traditional stereo-graphic or field survey derived breaklines. The elevation component of the 3D streamlines (breaklines) is derived from the lowest adjacent bare earth lidar point and adjusted to ensure that the streams flow downstream. The best elevation that can be derived for the 3D streamlines will be the water surface elevation on the date that the lidar data was acquired. The elevations in the 3D streamlines will not represent the underwater elevations for streams due to the fact that lidar data cannot collect bathymetry information.

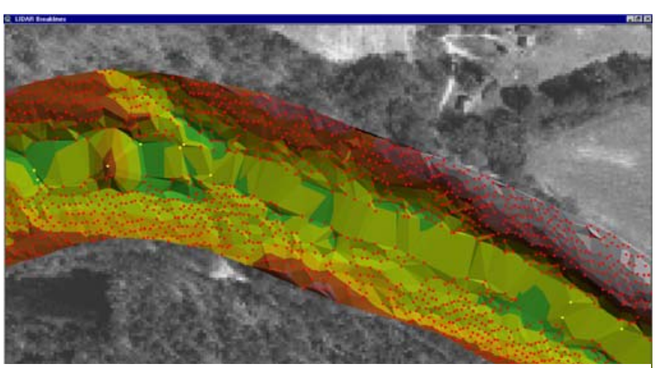


Figure 3: lidar TIN without breaklines

Watershed Concepts and EarthData have done considerable research generating breaklines from lidar data. Current H&H modeling practices rely heavily on mass points and breaklines to create a realistic TIN surface for hydrologic and hydraulic modeling. Lidar data consists only of points, which are not suited to defining sharp breaks on terrain. The problem is most pronounced across stream channels, where lidar is not able to define the stream banks clearly. Furthermore lidar does not reflect off water, therefore no reliable elevation points will exist within the stream channel itself. The TIN surface generated from lidar data alone is unsuitable for H&H modeling, as can be seen in figure 3.

Watershed Concepts engineers have studied the sensitivity of the 100-year flood boundary to the definition of stream channel geometry. The surface created with both lidar points and breaklines improves channel definitions for hydraulic cross section takeoffs and better defines the stream invert. It is not necessary to create breaklines on the top and bottom of stream banks; minor modifications to the cross sections and stream inverts can be made based on field survey data as necessary. In the 100-year flood, most of the flooded cross sectional area occurs in the overbank; therefore creating a more refined channel definition from the lidar data is not cost effective. The lidar TIN is used simply as the basis for the overbank definition.

Our research indicates that breaklines are required at the stream centerline for smaller streams with widths less than 50 feet. For larger streams (widths greater than 50 feet, breaklines are needed on the left and right water edge lines. Collection of photography and stereo compilation of the breaklines is not cost-effective for this purpose. Watershed Concepts and EarthData have developed techniques to synthesize 3D breaklines using digital orthophotos and lidar data. These breaklines can be digitized in 2D from orthophotos, approximating the stream bank in areas of significant tree overhang. A bounding polygon, created from the edge of bank lines, is used to remove all points within the channel. Automatic processes assign elevations to the vertices of the centerline based on surrounding lidar points. The lines are then smoothed to ensure a continuous downhill flow. Edge-of-bank vertices are adjusted vertically to match the stream centerline vertices. A new TIN can then be created from the remaining lidar points and newly created breaklines. The new TIN clearly defines the stream channel, as shown in Figure 4.

For this project, breaklines were generated in the matter described above for all streams draining greater than approximately one square mile. 2D lines defining the centerline and banks of those streams were manually digitized into ArcView shape file format from 2005 imagery. The streamlines were then processed against the bare earth lidar as described above. The new 3D lines were then viewed in profile to correct any anomalous vertices or remove errant points from the lidar DTM, which cause unrealistic "spikes" or "dips" in the breakline.

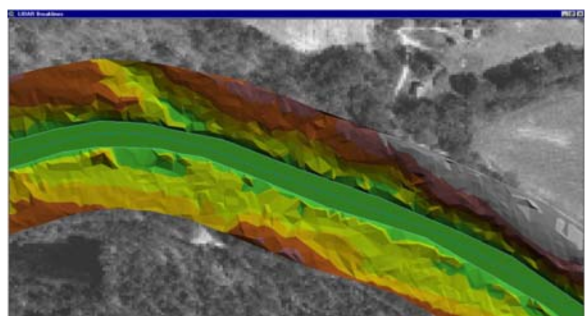


Figure 4: lidar TIN with breaklines

8 QUALITY ASSURANCE/QUALITY CONTROL PLAN

EarthData is committed to achieving an error-free production environment so that MGI can have full confidence in EarthData's ability to provide products and services on time and first time right. To achieve this goal, EarthData has implemented an ISO 9001-certified quality management system (QMS) that encompasses, enhances, controls, and standardizes production processes and quality control (QC) activities to ensure that products and services meet or exceed the client's requirements and expectations.

As a result, both manual and automated QC activities have been integrated throughout the production process as an effective method for identifying errors early in the production process, instead of reviewing only the final deliverable. These QC techniques detect failures in the system and then, through corrective action reviews and routines, link QC and quality assurance (QA) practices.

EarthData's approach to quality for the MGI project includes detailed quality procedures and plans based on project specifications and industry standards. This approach is designed to:

- Ensure that all data products meet or exceed the client's expectations for quality and accuracy
- Ensure high first-time acceptance rates – on time – by incorporating QA and QC throughout the production lifecycle, not just final deliverables
- Minimize client's responsibility and administrative burden for ensuring that all data products meet their expectations and the expectations of their users'

EarthData has developed an excellent reputation for providing our clients with high quality products and services that meet their specific needs. Earth has been ISO 9001 certified since 15 April 2000.

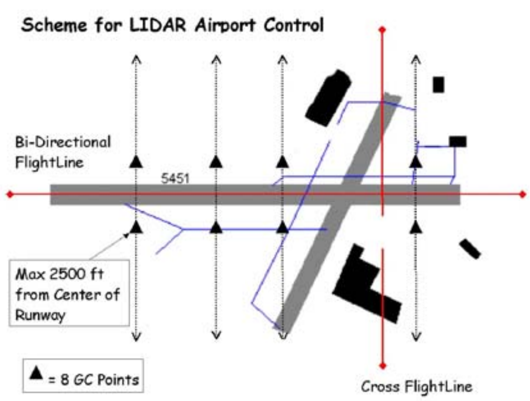
EarthData has very detailed processes and production workflows that govern each phase of production, from data acquisition through to processing and product finishing.

8.1 Quality Control of the Airborne GPS and IMU Data for Lidar

The performance and accuracy of the lidar/IMU system is tested and validated for each data capture sortie through a process called *boresight determination*. EarthData uses a permanent control field at the Hagerstown airport or establishes a control field in the vicinity of the project site and lidar data is obtained, processed and inspected to verify that all components (GPS, IMU and the lidar instrument) are operating correctly. The boresight determination is based on lidar data collected over a local airport located in the proximity of the project area.

8.1.1 IMU Boresight Determination

EarthData conducts a boresight determination prior to each data collection sortie to model and synchronize the outputs of the inertial measurement unit (IMU) and the lidar instrument. The goal of the boresight is to determine the level of compensation that must be applied to the dataset to remove systematic distortion during lidar post-processing. The following are the steps included in a boresight determination:



Step 1 At the start of each acquisition mission, lidar data is acquired over the local airfield where the crew establishes its base station at the altitude, swath width, and post spacing to be used for the project. The test area is covered by three overlapping flight lines. Two parallel lines cover the area in opposing directions with 100% overlap; the third line crosses perpendicular to the two principal lines.

Step 2 The vertical data from the 2 lines overlapping by 100% are processed using ArcView to color code differences in the elevation values of identical points in each of the lines to determine if there is any yaw or pitch in the lidar/IMU system. The perpendicular line is used to detect bowing or warping in the lidar sensor that occurs within each swath.

Step 3 The technician records the measurements of the boresight determination and calculates any offsets that must be applied to the IMU data during the initial processing.

8.1.2 Field Quality Control of Lidar Data

Raw lidar data consists of time events and mirror scan angles which must be transformed into georeferenced elevation points. The following list describes the step-by-step process used to ensure that the lidar, GPS and IMU data is compliant with project specifications:

Step 1 At the earliest opportunity post-mission, the airborne GPS is processed and passed through quality control. The GPS phase data is processed using continuous kinematic survey techniques, which yields a positional accuracy of 10 centimeters.

Step 2 The IMU data is then processed to integrate the inertial measurements and the precise phase differential GPS positions. This data is combined with the measurements of the angle of the scanning mirror in relationship to the IMU. Now the geodetic position and the orientation (omega, phi, and kappa) of the scan mirror can be calculated for at any point in the mission.

Step 3 The time and ranging data collected by the lidar instrument is then processed in conjunction with the known sensor position and orientation to calculate a three-dimensional ground coordinate for each pulse using GPS time as the common link between the two data sets. Processing of the lidar data is performed using EarthData's proprietary software, LITES.

Several transformations of the data are needed to complete this process. These transformations are performed between several different Cartesian coordinate systems called frames. The initial processing acts as a comprehensive quality control review of the lidar and associated positional data to ensure that the resulting elevation model will be compliant with the requirements of MGI.

Step 4 Using the LITES software, the technician specifies which portions of the lidar and/or intensity data are extracted for subsequent vegetation classification and processing. Lidar data has been checked for georeferencing and is output in a binary format designed by EarthData to increase the efficiency of processing.

8.2 QC Process for Lidar Data

EarthData has incorporated quality control processes into each component of the lidar acquisition and processing workflow. Some of the key components are described below:

The correct operation of the lidar instrument as well as the GPS/IMU subsystems are validated prior to each data collection sortie through the IMU boresight process. Calibration data for the boresight is acquired at the local airport where the aircrew is based. Lidar data for the boresight is acquired in several overlapping directions, normally over the airport runways, which is processed and measured. The results of this processing provide the technician with important information to model the combined GPS/IMU information, which determines the accuracy of the location of the lidar point data.

During data acquisition, the on-board GPS flight management system eliminates the need for re-flights due to insufficient or improper coverage. EarthData incorporates one or more crossing lines that are acquired perpendicular to the main flight acquisition plan. The data from the crossing line provides the technician with the ability to review selected points on the ground from two different vantage points. The use of crossing lines identifies systematic distortion in the lidar elevation data caused by the lidar sensor. Further, the crossing line provides the means to model any distortion and to apply a correction factor to ensure that the elevation data meets FEMA requirements.

Once post-processing commences, existing ground control and elevation data are used to verify the accuracy of the lidar data. Coverage and edge-match of the data is confirmed a second time using cross flight lines. Finally, the bare-ground DEM is checked against the intensity data and/or digital orthophotography to verify that no artifacts are introduced during post-processing.

EarthData has developed proprietary processes to identify and to remove systematic distortion in the lidar data that may be introduced by the lidar sensor. Data processing routines for distortion removal are fully documented in accordance with ISO 9001 requirements.

EarthData received ISO 9001 certification on 15 April 2000. All production process development complies with the ISO 9001:2000 standard that require all production processes be documented and address all aspects of quality control and that all of the required steps be implemented for the project. All processes are internally audited on an on-going basis.

Every phase of production has a quality assurance plan that includes checklists, independent review, automated quality routines for data validation, reports, and interactive quality steps.

9 POSITIONAL ACCURACY EVALUATION

9.1 Positional Accuracy

9.1.1 Vertical Positional Accuracy Report

Compliance with the accuracy requirements was ensured by comparing GPS ground control points against the processed dataset. Tests consisted of visual checks and the use of EarthData proprietary software (CheckDEM).

- CheckDEM is a program designed to compare a list of controls against DEM file(s) and therefore to check the accuracy of the DEM file(s). For each control point, first, the program selects all the DEM points that fall into a given radius from the position of the control point. Second, the program calculates a weighted average of the DEM points to interpolate an elevation at the position of the control point. And last, the program computes the difference between the elevation of the control point and the interpolated elevation. After all the control points have been checked, the program computes several statistics on the differences between controls and interpolated DEM elevations. The statistics include RMSE, Standard Deviation, Minimum Difference, Maximum Difference, and Mean Difference. In the output report, the program prints out elevation differences for every control points and the statistics.

9.1.1.1 Accuracy Report of Hinds County, Mississippi

Project Name: Hinds
Control File: control_utm.txt
Date: Wed Sep 27 09:41:42 2006
Radius: 5.000

LAS File(s) Processed:
170155.las
171553.las
172959.las
174455.las
175908.las
181144.las
182250.las
183350.las
184438.las
185550.las
190347.las
190633.las
190813.las
191423.las
191957.las
192548.las
193200.las
193857.las
194608.las
195011.las
195532.las
200556.las
201409.las
201729.las
203008.las
203053.las
204507.las
205904.las
211311.las
212732.las
214126.las
215515.las
220913.las
222318.las
223725.las
225120.las
230704.las
232256.las
233838.las

Full Point Set

Root Mean Square Error = 0.070
Standard Deviation = 0.073
Minimum Difference = -0.104
Maximum Difference = 0.153
Mean Difference = 0.004
Total Control Points = 13
Num Valid Control Pts = 13

Three Sigma Point Set

Root Mean Square Error = 0.070
Standard Deviation = 0.073
Minimum Difference = -0.104
Maximum Difference = 0.153
Mean Difference = 0.004
Total Control Points = 13
Num Valid Control Pts = 13
Num Outside 3 Sigma = 0

Point differences (control minus surface):
HV-01 : -0.104
HV-02 : -0.093
HV-03 : 0.002
HV-04 : 0.007
HV-06 : -0.023
HV-07 : 0.083
HV-08 : 0.070
HV-10 : 0.046
HV-11 : 0.024
HV-12 : -0.020
HV-14 : -0.075
HV-15 : 0.153
HV-16 : -0.016

10 METADATA

Project level metadata was produced to FGDC compliant standards and contain sufficient detail to ensure the data or data product can be fully understood for future use and for posterity.

11 DISSEMINATION AND ARCHIVING

Data was delivered to MGI on DVD and CD media.

An extra copy of all deliverables has been created until notice is received from MGI that the data has been accepted. A copy of the final digital version will be stored on a file server using the data organization schema developed for this project. All data can be quickly accessed and retrieved should the need arise.

All data produced under this project has been supplied to MGI without restriction.

12 CONCLUSION

This program has been a success through a partnership that connotes end-to-end collaboration in achieving the end project objectives. EarthData worked with personnel from MGI to ensure that the data produced through this project will support MDEM and FEMA flood mapping requirements.