September 21, 2011

Ground Survey Report, Lidar Accuracy Report, & Project Report
New Madrid Seismic Zone
Northeast of Memphis, Tennessee
Contract Number: W91278-09D-0049/004
EN Project: C-10-026

Contact

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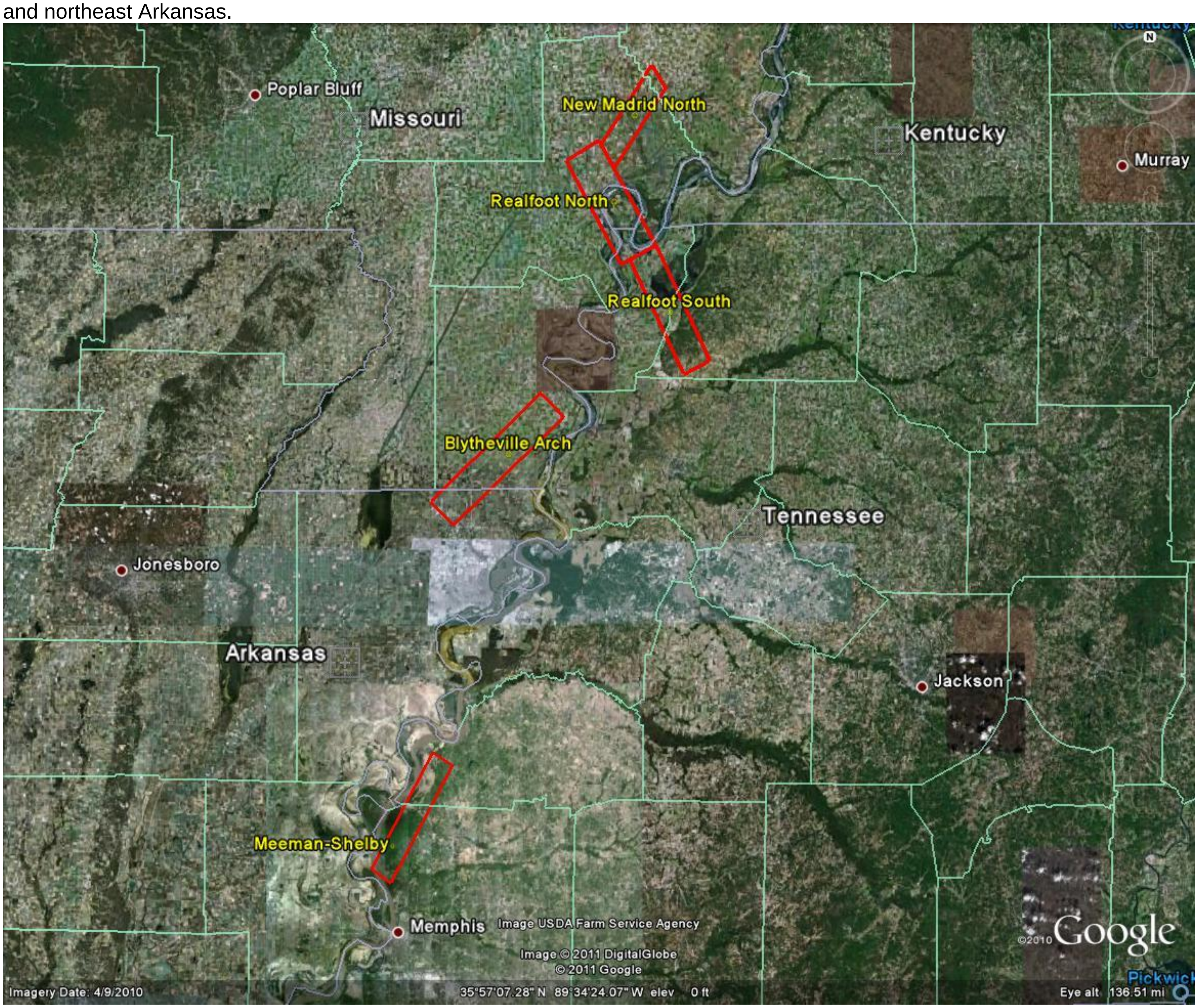
Location

Sites are located along the Mississippi River in southeast Missouri, southwest Kentucky, west Tennessee, and northeast Arkansas.



Field survey & GPS

Dates

Field survey was performed between April 22, 2010 and April 27, 2010.

Methods and Procedures

Using N.G.S. datasheets, Metro recovered known monumentation to be used to establish the primary control network. Static G.P.S methods were applied to establish three (3) primary control points. (Control Points LBC1, CT3, and CT8) These three primary control points were occupied simultaneously with G.P.S. receivers while static G.P.S. rovers occupied N.G.S. monuments. Each N.G.S. monument had a two hour static G.P.S session. There were a total of five (5) known positions occupied to establish the Primary G.P.S. Network.

Ground control points were established utilizing Static G.P.S. methods. The three primary control points were occupied simultaneously with G.P.S. receivers while static G.P.S. rovers occupied the ground control points. Each ground control point had a one hour static G.P.S session. There were a total of nine (9) ground control points occupied to establish a secondary G.P.S. Network.

Azimuth marks were also occupied during the secondary network survey to be used for the collection of test points within vegetation categories.

Static G.P.S. data was processed and adjusted using Trimble Geomatics Office software.

Final horizontal datum is U.T.M. 16, WGS84 and vertical datum is WGS84 ellipsoid.

Equipment used for the G.P.S. surveys were Trimble 4000 series receivers and Trimble R8 receivers.

Static G.P.S. data files were uploaded to OPUS. The coordinate values determined from the OPUS solutions for the ground control points were compared to the coordinate values determined from the static surveys. See the following table for Q.C. results.

Static Survey Solution					OPUS Solution				Meters		
Point	North	East	Elev		Point	North	East	Elev	N. Res	E. Res	Z. Res.
LBC1	4064217.562	275705.296	65.254		LBC1	4064217.556	275705.297	65.285	0.006	-0.001	-0.031
CT3	4057501.302	274676.715	61.305		CT3	4057501.292	274676.717	61.319	0.010	-0.002	-0.014
CT8	4073475.511	282702.765	63.705		CT8	4073475.513	282702.751	63.716	-0.002	0.014	-0.011
SP3 2000	4067859.449	303389.268	70.638		SP3 2000	4067859.421	303389.243	70.667	0.028	0.025	-0.029
KEWANE	4061515.029	271046.636	65.555		KEWANE	4061515.039	271046.615	65.630	-0.010	0.021	-0.075
SIK A	4085983.091	271340.179	66.472		SIK A	4085983.095	271340.227	66.540	-0.004	-0.048	-0.068

Collection of Test Points

Test points were collected using conventional surveying methods in two different areas on this project. Using the control points established during the G.P.S. surveys, test points were collected at these two locations for “bare earth”, “low grass”, “crops”, “tall grass” and “asphalt” categories.

Conventional survey data was collected using a Leica Robotic TCRA 1105 total station with TDS Pro field surveying software on board. The field data files were post processed using Terramodel surveying software.

The vertical accuracy reports for the varying surface classifications were generated using independent check points.

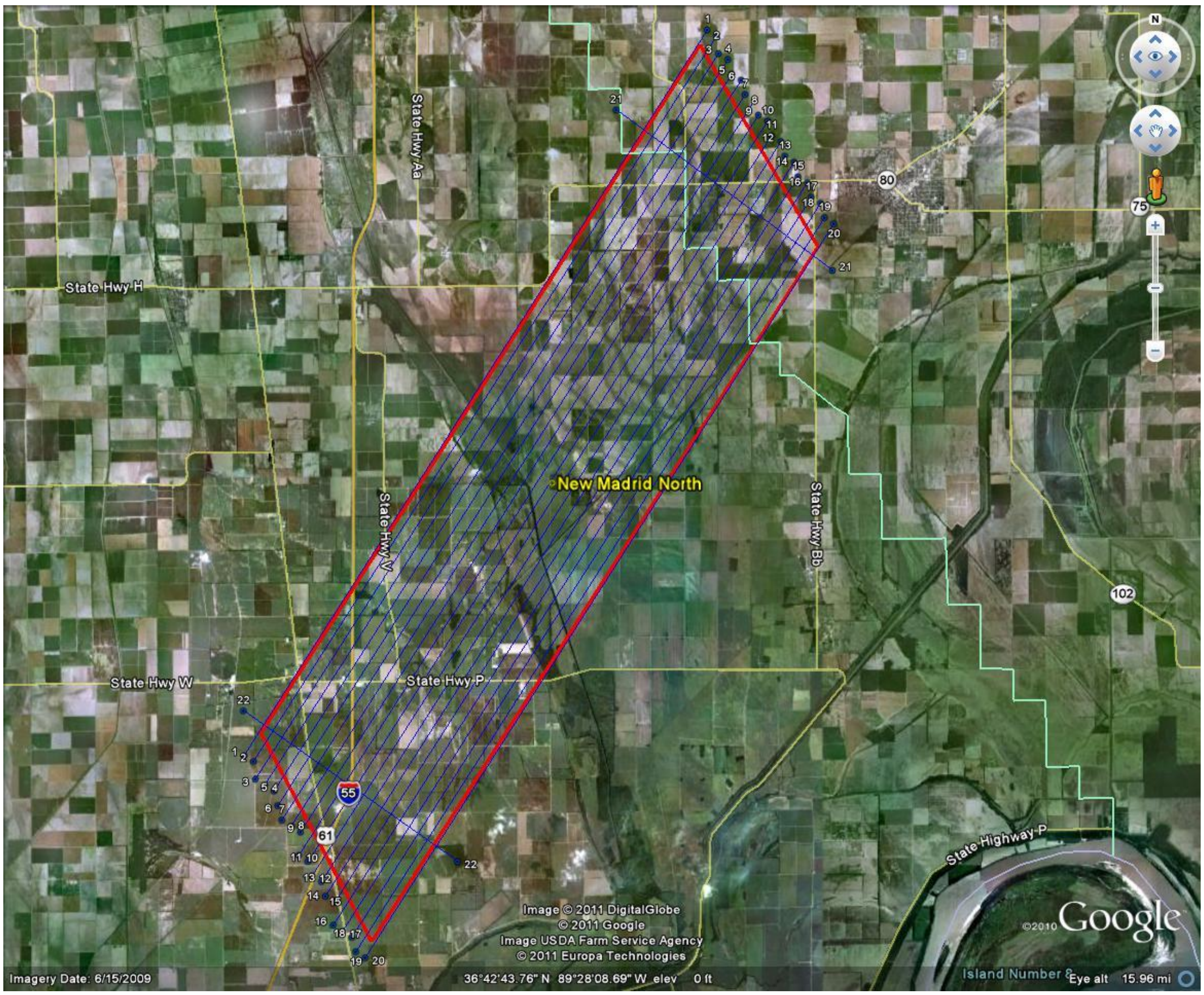
The following reports reflect the accuracy by comparing the field surveyed Check Point elevations (independent) to the LiDAR generated DEM (test)..

Collection of LiDAR

Receivers were setup on established project control points and GPS observations were collected during the flight. The flight took place when the PDOP was below 3 on the dates of: July 7th, 2010 & September 29th, 2010.

The Harrier 56/G3 LiDAR Sensor mounted in our Commander 500B fixed wing airplane was used on this project with the following parameters:

Flight Height: 488m (AGL)
Flight Speed: 113 knots
Scanner Pulse Rate: 180 kHz
Sidelap: 51.0 %
Viewing Angle: 60 deg
Swath Width: 560m
Point Density: 4.1 pts/sqm



Positional Information for the flight was captured during flight. The airborne GPS data was processed for the flight positional information. The GPS and Applanix IMU data was processed using Industry Standard software and procedures using Applanix PosPac 4.2 processed forward and backward for a Smoothed Best Estimate Trajectory (SBET) file**.** Laser Ranging data was processed with Rianaylse 5.01.The SBET file was merged with the laser ranging data using TOPIT 1.0 to produce a raw LAS 1.2 file. All data was processed to U.T.M. 16, WGS84 and vertical datum WGS84.

Classification

A TerraScan project was created allowing LAS files to be tiled into manageable sizes. The bald earth was extracted from the raw LiDAR points using Terrascan software. The vegetation removal process was performed by building an iterative surface model. This surface model was generated using three main parameters: Building size (processing footprint), Iteration angle and Iteration distance.

The initial model was based upon low points selected by a roaming window and were assumed to be ground points. The size of this roaming window is determined by the building size parameter. These low points were triangulated and the remaining points evaluated and subsequently added to the model when meeting the Iteration angle and distance constraints. This process was repeated until no additional points were added within iteration.

Following the data setup, the manual quality control of the surface was accomplished. This process consisted of visually examining the LiDAR points within Terrascan and correcting errors that occurred during the automated process. These corrections include verifying that all non ground elements are removed from the ground model and that all small terrain undulations such as road beds, retaining walls, dikes, rock cuts and hill tops are present within the model. This process was done with the help of hill shades, contours, profiles and cross-sections.

The tile size utilized in TerraScan for this project was 1 km2 x 1 km2. Basic classification to extract ground, low-medium-high vegetation and buildings, was run on each individual flight lines in a macro mode. An "Output Control Report" was generated for each individual flight line, using the field run truing points to analyze any adjustment needs. Surface to surface comparison (from flight line to flight line) was generated in the overlapping areas of the flight lines using "colorized isopachs" with a vertical scale of .5' above and below. Cross sections were cut in designated areas (at cross strips and at mid point of flight lines where overlap occurs) to inspect the flight lines before, during and after the calibration of flight lines. Once the initial assessment was completed TerraMatch was utilized to solve for **dz** on individual lines for calibrating the strips vertically to all of the truing points. Again, at the designated cross sections, the data was assessed and evaluated for vertical matching between flight lines. No further calibration was needed vertically, and the data set was inspected for the horizontal including: roll, pitch and heading between flight lines. Another surface to surface comparison was generated in the overlapping areas of the flight lines using "colorized isopachs" with a vertical scale of .5' above and below for verification. The vertical accuracy reports for the varying surface classifications were generated using independent check points.

The following reports reflect the accuracy by comparing the field surveyed Check Point elevations (independent) to the LiDAR generated DEM (test).

Vertical Accuracy Statistic Worksheet 35951

Bare Earth

A Point number	B Point description	C z (independent)	D z (test)	E diff in z	F (diff in z)^2
212	CULTIV-FIELD	63.75	63.79	-0.03	0.0012
213	CULTIV-FIELD	63.75	63.75	0.00	0.0000
214	CULTIV-FIELD	63.66	63.64	0.01	0.0002
215	CULTIV-FIELD	63.51	63.51	-0.01	0.0000
216	CULTIV-FIELD	63.50	63.53	-0.03	0.0009
217	CULTIV-FIELD	63.62	63.67	-0.05	0.0025
218	CULTIV-FIELD	63.66	63.65	0.01	0.0001
219	CULTIV-FIELD	63.69	63.68	0.01	0.0002
220	CULTIV-FIELD	63.76	63.78	-0.01	0.0002
221	CULTIV-FIELD	64.00	64.00	0.00	0.0000
222	CULTIV-FIELD	63.85	63.90	-0.05	0.0022
223	CULTIV-FIELD	63.90	63.96	-0.06	0.0031
224	CULTIV-FIELD	63.71	63.72	-0.02	0.0003
225	CULTIV-FIELD	63.68	63.68	-0.01	0.0000
226	CULTIV-FIELD	63.64	63.68	-0.04	0.0018
227	CULTIV-FIELD	63.69	63.66	0.03	0.0009
				sum	0.013642
				average	0.00085263
				RMSE	0.02919974
				NSSDA	0.0572315

2 Sigma

Vertical Accuracy Statistic Worksheet 35951

Low Grass

A Point number	B Point description	C z (independent)	D z (test)	E diff in z	F (diff in z)^2
200	LOWGRASS	63.69	63.73	-0.04	0.0019
201	LOWGRASS	64.09	64.13	-0.04	0.0018
202	LOWGRASS	64.70	64.76	-0.06	0.0035
203	LOWGRASS	64.42	64.46	-0.05	0.0023
204	LOWGRASS	64.14	64.15	-0.01	0.0001

205	LOWGRASS	64.50	64.56	-0.06	0.0031
206	LOWGRASS	65.52	65.52	0.00	0.0000
207	LOWGRASS	65.41	65.46	-0.05	0.0023
208	LOWGRASS	65.74	65.80	-0.06	0.0032
209	LOWGRASS	65.63	65.69	-0.05	0.0030
210	LOWGRASS	65.84	65.81	0.03	0.0010
211	LOWGRASS	65.12	65.15	-0.03	0.0010
284	LOWGRASS	61.08	61.12	-0.04	0.0019
285	LOWGRASS	61.20	61.26	-0.06	0.0034
286	LOWGRASS	61.16	61.22	-0.06	0.0037
287	LOWGRASS	61.10	61.16	-0.06	0.0032
288	LOWGRASS	61.04	61.05	-0.01	0.0001
289	LOWGRASS	61.07	61.11	-0.05	0.0021
290	LOWGRASS	61.08	61.14	-0.06	0.0042
291	LOWGRASS	61.03	61.07	-0.04	0.0016
292	LOWGRASS	61.06	61.10	-0.04	0.0015
293	LOWGRASS	61.00	61.03	-0.03	0.0010
294	LOWGRASS	60.99	61.03	-0.05	0.0020
295	LOWGRASS	61.06	61.11	-0.05	0.0022
296	LOWGRASS	61.04	61.09	-0.06	0.0034
297	LOWGRASS	61.08	61.13	-0.05	0.0025
298	LOWGRASS	61.04	61.07	-0.03	0.0008
299	LOWGRASS	61.00	61.04	-0.04	0.0018
				sum	0.0588330
				average	0.002101179
				RMSE	0.045838614
				NSSDA	0.089843684 2 Sigma

Vertical Accuracy Statistic Worksheet 35951

Tall Grass

A Point number	**B** Point description	**C** z (independent)	**D** z (test)	**E** diff in z	**F** (diff in z)^2
272	TALL-GRASS	61.38	61.45	-0.07	0.0045
273	TALL-GRASS	61.42	61.48	-0.05	0.0027
274	TALL-GRASS	61.43	61.49	-0.07	0.0042
275	TALL-GRASS	61.43	61.49	-0.06	0.0041
276	TALL-GRASS	61.42	61.48	-0.07	0.0045
277	TALL-GRASS	61.44	61.50	-0.05	0.0030
278	TALL-GRASS	61.15	61.21	-0.07	0.0046
279	TALL-GRASS	61.17	61.18	-0.01	0.0001
280	TALL-GRASS	61.21	61.17	0.04	0.0018
281	TALL-GRASS	61.23	61.20	0.03	0.0008
282	TALL-GRASS	61.26	61.25	0.01	0.0002
283	TALL-GRASS	61.21	61.26	-0.04	0.0018
				sum	0.032233
				average	0.00268608
				RMSE	0.05182744

NSSDA	0.10158178	2 Sigma

Vertical Accuracy Statistic Worksheet 35951

Asphalt

A Point number	B Point description	C z (independent)	D z (test)	E diff in z	F (diff in z)^2	
228	CLRD-ASP	63.968	64.046	-0.078	0.0061	
229	CLRD-ASP	63.920	64.001	-0.081	0.0066	
230	CLRD-ASP	63.910	64.002	-0.092	0.0085	
231	CLRD-ASP	63.878	63.967	-0.089	0.0079	
232	CLRD-ASP	63.925	63.938	-0.013	0.0002	
233	CLRD-ASP	63.858	63.914	-0.056	0.0031	
234	CLRD-ASP	63.803	63.853	-0.050	0.0025	
235	CLRD-ASP	63.633	63.699	-0.066	0.0044	
236	CLRD-ASP	63.490	63.540	-0.050	0.0025	
237	CLRD-ASP	63.344	63.403	-0.059	0.0035	
262	CLRD-ASP	61.487	61.534	-0.047	0.0022	
263	CLRD-ASP	61.476	61.534	-0.058	0.0034	
264	CLRD-ASP	61.478	61.523	-0.045	0.0020	
265	CLRD-ASP	61.471	61.495	-0.024	0.0006	
266	CLRD-ASP	61.468	61.522	-0.054	0.0029	
267	CLRD-ASP	61.496	61.518	-0.022	0.0005	
268	CLRD-ASP	61.470	61.486	-0.016	0.0003	
269	CLRD-ASP	61.491	61.513	-0.022	0.0005	
270	CLRD-ASP	61.507	61.526	-0.019	0.0004	
271	CLRD-ASP	61.468	61.495	-0.027	0.0007	
				sum	0.058576	
				average	0.0029288	
				RMSE	0.05411839	
				NSSDA	0.10607204	2 Sigma