

---

# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

---

## Collection and Processing Report Summary

### Collection:

Kucera International was awarded the task of planning, collecting, processing, and delivering lidar data products to USGS v1.2 standards in Marion County, Indiana.

Flying the total project required 3 missions and a total of 39 lines with 875 miles flown. A summary of the per missions flight progress, flight date, and line numbers can be found in Table 1. The missions were flown on March 11, 12, and 18, 2016.

Data was captured onto 600GB Solid State Drives. As the data was captured, a database of the file was sent by the crew to the office to be examined for coverage and sensor errors. After every set of missions, the raw captured data was also copied to two external drives. One drive to remain with the crew, the other to be sent to the office for processing. The drives being sent to the office were sent after every 24 hour period where there was any collection accomplished.

### Processing:

At the office the data was quickly extracted in order to QC data for transfer or data corruption errors and to review for obvious data gaps and improper coverage. The GPS/INS is processed to finality during this time, at which point the data was output in its proper format per flight strip and prepared for initial production steps. Airborne GPS was processed using base stations in Inertial Explorer software suite together with TerraTec's TerraPOS software. TerraPOS relies on Precise Point Positioning, rather than base stations, for the processing of a final accurate trajectory and can also make use of GLONASS satellites. Inertial Explorer blends the GPS trajectory with the IMU data to create a final trajectory file that is used to initially georeference the lidar data. After data output, it was cut into efficient, manageable tiles and misalignment calibrations were computed on the mission data itself. The data was checked line to line and corrected individually per mission using these mission specific computed misalignments, and afterward checked for accurate and expected results. During this calibration process QC of the data was performed as well.

After calibration the mission data sets were checked for matching horizontally and vertically and further corrections applied if necessary. Typically just a small vertical adjustment is needed. The data was also checked against control for reasonable accuracy, to check for obvious and large blunders that would prevent further work on the data.

Classification of the data then proceeded on the entire block. Data classification was handled mainly by TerraScan and LP360. The data was run through the classification process on an arbitrary 10000ft X 10000ft tile layout to create more efficient files sizes with which to work. Editing and QC work was handled in TerraScan, LP360, ArcGIS 10, after which the data was cut to the final project tiles and final data products were generated.

Finally the data was edited, checked against control one more time, and checked one last time for classification/editing blunders. At the end the data was cut to Client tiles and prepared for delivery of specified data products, such as Hydro DEM, SEM etc.

## Sensor Parameters

---



---

# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

---

**Vendor:** Kucera International  
**Sensor:** ALS70 SN7232, ALS70 SN7108  
**GPS/IMU:** GPS/uIRS 200Hz

## ALS70 Sensor Parameters

Altitude AMSL (ft)	6500
Recommended Ground Speed (knots)	150
Field of View (FOV) (degrees)	38
Scan Rate Setting used (SR) (Hz)	53.3
Laser Pulse Rate used (Hz)	289600
Recommended Laser Power (%)	100
Full Swath Width (ft)	4000
Minimum Sidelap (%)	20%
Maximum Point Spacing Across Track (m)	1.15
Maximum Point Spacing Along Track (m)	1.4
Average Point Density (points/sq meter)	2.5
Average Point Spacing (ft)	2.0
Illuminated Footprint Diameter (ft)	1.4

## Survey Control - Collection, Processing, and Adjustment Report

- The establishment and positioning of ground control for the support of LiDAR operations and USGS v1.2 type land type class accuracy evaluations.
- The lidar adjustment/calibration and accuracy as a result of the lidar control points.
- Both lidar control and USGS v1.2 checkpoint point listings.
- Preliminary collection and processing summary.

### Lidar Control/Checkpoints:

As per requirements for USGS QL2 data, checkpoints in NVA and VVA areas were surveyed and compared to the lidar. A total of 33 VVA, and 32 NVA were surveyed.

Field work for the surveying was begun and completed the week of August 8-13, 2016, and performed by Steven A. Wood, IN PLS, CP using Leica geodetic grade dual frequency GPS receivers collecting static observations and processed using local CORS and NGS monument. Weather conditions had minimal or no effort on data collection throughout this period of time. Point locations were chosen by Kucera International and minimal changes to point locations were necessary.

The base LiDAR ground control points referenced were Marion County photo-identifiable surveyed in 2009 for the IMAGIS lidar collection. A total of 23 points were used as the base georeferencing of the Marion County lidar dataset and the listing is included in this report (Table 2 and 3).



---

# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

---

Local CORS stations INMT, INPL as well as two other surveyor established base points (SW\_BASE, VVA\_F5Base) were incorporated in both the BASE network and LiDAR control points. Post processing was performed with Spectrum GPS vector software. Only “Fixed” ambiguity resolved vectors were accepted. All data was processed utilizing the NGS “Precise” final orbit ephemeris.

Additionally, Base point raw data was submitted through OPUS to obtain a CORS referenced position and orthometric height as a check to fully constrained least squares adjustment.

All checkpoints and lidar control points were positioned utilizing geodetic grade dual frequency Ashtech and Trimble GPS receivers in a “Static” mode. A minimum of sixty (60) minutes of occupation time was taken at LiDAR check locations. GPS receivers were set at BASE points throughout data collections periods with BASE spacing to ensure that no new locations, either LiDAR control or FEMA vegetation, were more than forty (40) kilometers from any BASE point.

Local CORS stations *ICT4*, *ICT5*, *HVLK*, and *NEAP* were incorporated in both the BASE network and LiDAR control points. Post processing was performed with Spectrum GPS vector software. Only “Fixed” ambiguity resolved vectors were accepted. All data was processed utilizing the NGS “Precise” final orbit ephemeris.

Additionally, base point raw data was submitted through OPUS to obtain a CORS referenced position and orthometric height as a check to fully constrained least squares adjustment.

Processed vectors were entered into the StarNet Least Squares adjustment program holding the referenced CORS and all existing NGS control, both horizontal and vertical. The adjusted results reference the GRS-80 ellipsoid while incorporating the 2009 NGS Geoid to achieve NAVD88 orthometric heights. The result provides horizontal accuracy of 2<sup>nd</sup> Order Class I (1:50,000) and vertical accuracy of 2<sup>nd</sup> Order (+/- 0.06’). The geodetic positions were transformed into UTM Zone 14N, units in meters.

## **Accuracy requirements:**

Land cover classes:

NVA:

- Clear or open, bare earth, low grass; for example, sand, rock, dirt, plowed fields, lawns, golf courses
- Urban areas; for example, tall, dense man-made structures

VVA:

- Tall grass, tall weeds, and crops; for example, hay, corn, and wheat fields
- Brush lands and short trees; for example, chaparrals, mesquite
- Forested areas, fully covered by trees; for example, hardwoods, conifers, mixed forests



---

## **MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT**

---

Check points for NVA assessments shall be surveyed in clear, open areas (which typically produce only single lidar returns), devoid of vegetation and other vertical artifacts (such as boulders, large riser pipes, and vehicles). Ground that has been plowed or otherwise disturbed is not acceptable.

Check points for VVA assessments shall be surveyed in vegetated areas (typically characterized by multiple return lidar).



# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

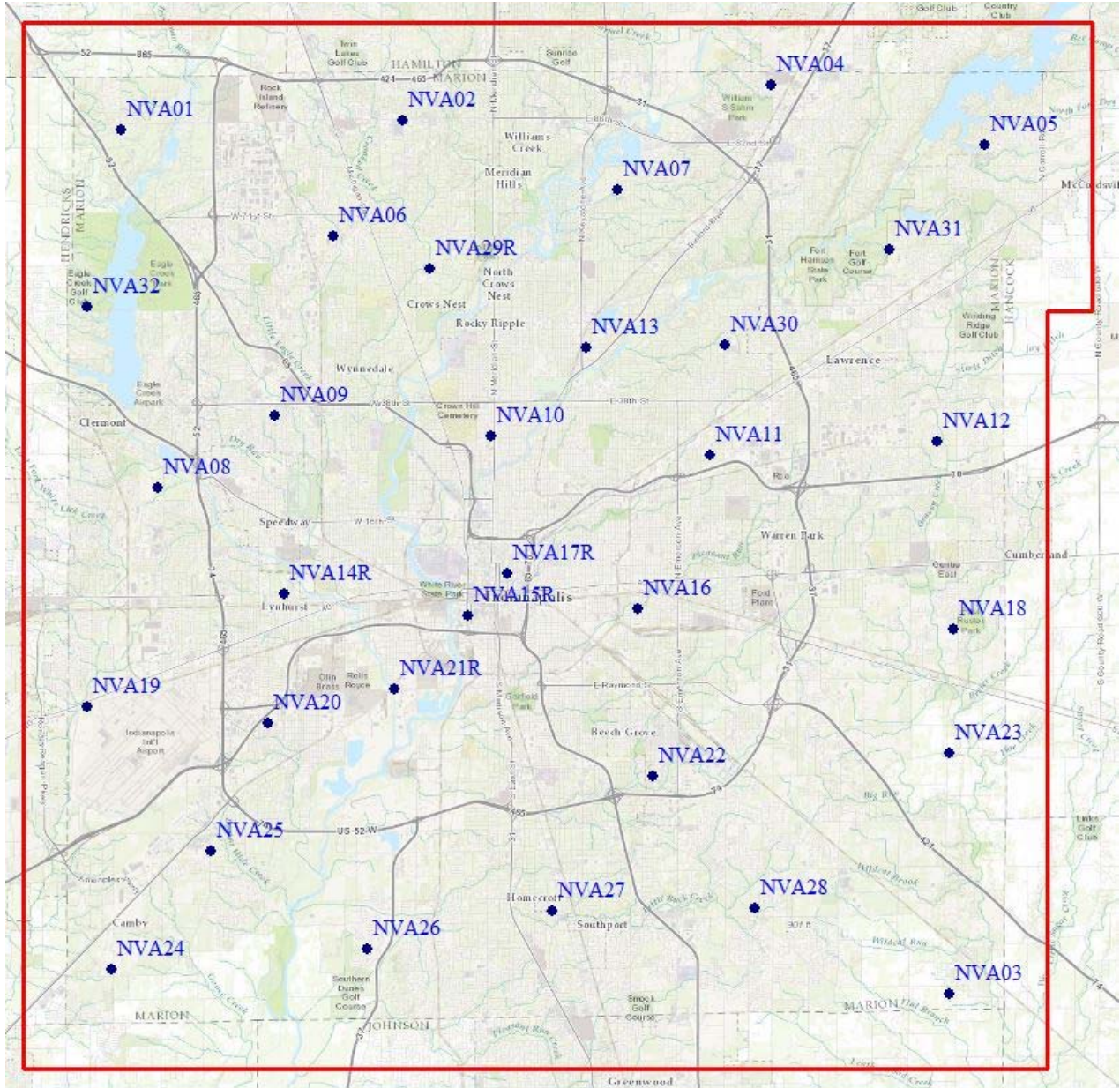
## Control Points for Land Cover Class NVA:

Number	Easting	Northing	Elevation	LiDAR Elevation	Dz
NVA04	221451.530	1702887.729	806.309	806.610	0.301
NVA15R	187472.457	1643254.588	700.257	700.550	0.293
NVA02	180094.797	1698970.856	835.635	835.840	0.205
NVA14R	166732.926	1645738.927	727.789	727.960	0.171
NVA29R	183149.617	1682341.156	779.384	779.540	0.156
NVA22	208191.504	1625261.834	803.472	803.610	0.138
NVA13	200783.534	1673404.554	734.371	734.500	0.129
NVA01	148464.963	1697820.317	884.009	884.110	0.101
NVA05	245556.101	1696215.774	825.760	825.850	0.090
NVA31	234731.124	1684425.266	843.600	843.690	0.090
NVA09	165744.678	1665779.986	753.729	753.810	0.081
NVA07	204211.020	1691099.435	727.194	727.270	0.076
NVA08	152577.073	1657641.765	777.266	777.340	0.074
NVA32	144700.227	1678041.695	859.732	859.790	0.058
NVA12	240097.658	1662823.072	843.423	843.470	0.047
NVA20	164934.344	1631191.121	725.053	725.100	0.047
NVA30	216375.832	1673724.177	837.206	837.250	0.044
NVA17R	191917.047	1648090.444	716.627	716.670	0.043
NVA23	241589.834	1627843.012	822.219	822.200	-0.019
NVA11	214681.337	1661410.881	838.490	838.470	-0.020
NVA24	147404.816	1603623.305	794.537	794.510	-0.027
NVA10	190088.848	1663434.723	730.031	730.000	-0.031
NVA21R	179168.715	1635018.358	686.784	686.730	-0.054
NVA06	172288.189	1685959.790	809.243	809.180	-0.063
NVA28	219606.065	1610474.477	848.639	848.570	-0.069
NVA26	176171.968	1605823.237	671.532	671.460	-0.072
NVA27	196865.382	1610190.397	755.684	755.590	-0.094
NVA25	158558.860	1616871.333	749.483	749.370	-0.113
NVA19	144698.533	1633080.522	755.280	755.150	-0.130
NVA18	241958.164	1641764.279	836.415	836.260	-0.155
NVA16	206513.139	1644148.830	768.641	768.400	-0.241
NVA03	241549.627	1600867.097	789.836	789.560	-0.276
<b>Average Dz</b>					0.024
<b>Minimum Dz</b>					-0.276
<b>Maximum Dz</b>					0.301
<b>Average Magnitude</b>					0.110
<b>RMS</b>					0.135
<b>STD</b>					0.134



# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

## Control Map for NVA Points:

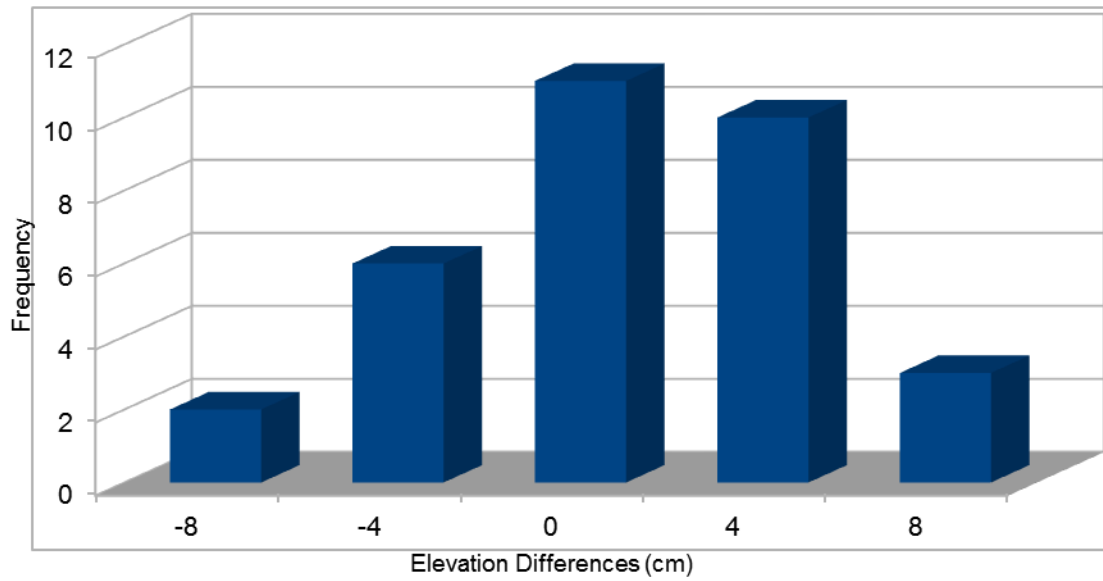


---

# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

---

Elevation Differences Histogram (NVA)



# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

## Control Points for Land Cover Class VVA:

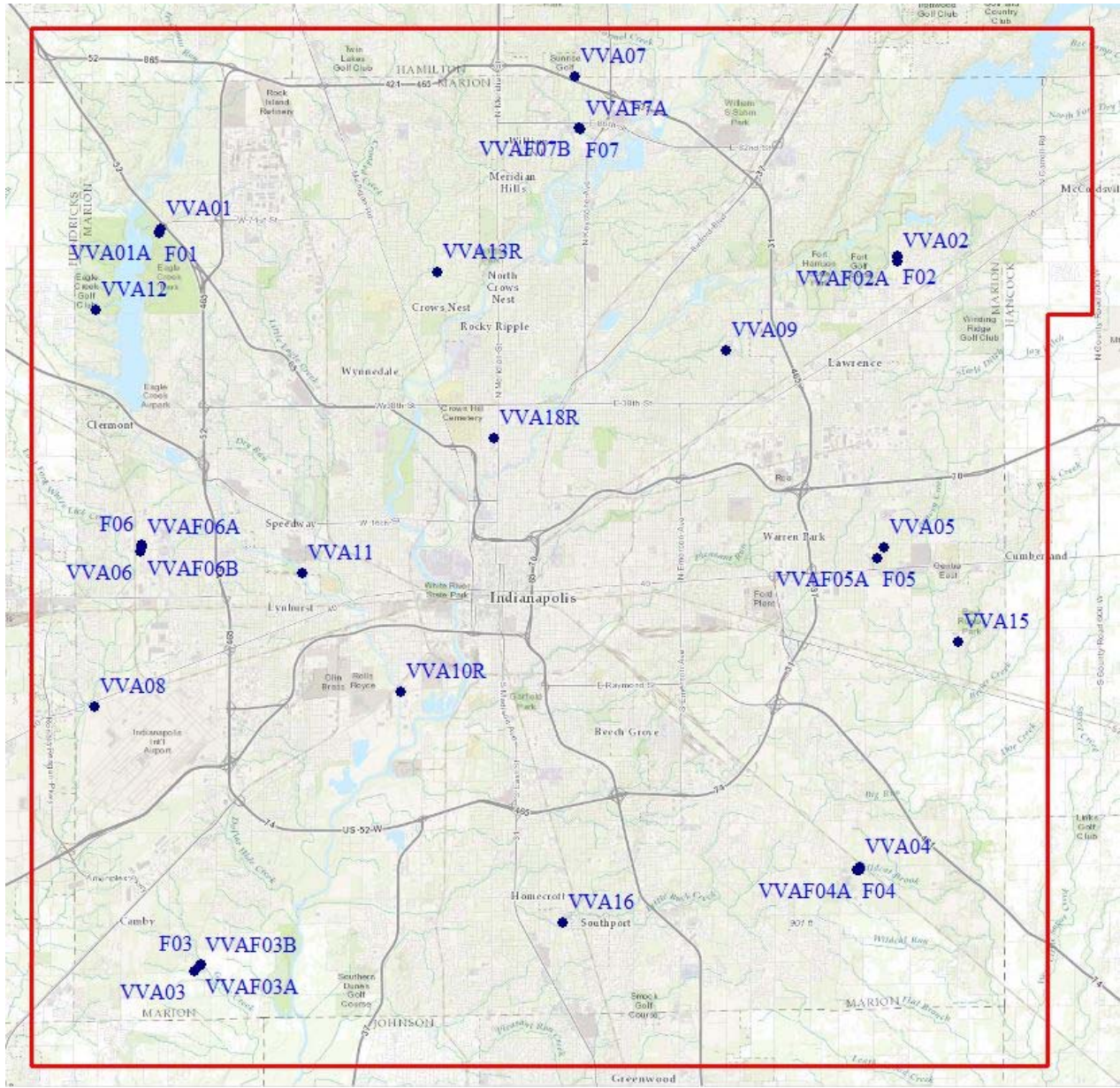
Number	Easting	Northing	Elevation	LiDAR Elevation	Dz
VVA01	152075.665	1687205.975	826.925	827.360	0.435
VVA02	235487.427	1683586.575	843.500	843.890	0.390
VVA05	234062.371	1651148.615	856.971	857.350	0.379
F02	235585.652	1684108.764	843.000	843.280	0.280
VVAF06A	149960.349	1651060.213	780.346	780.620	0.274
VVA13R	183480.273	1682371.261	782.958	783.230	0.272
VVA07	199086.386	1704476.909	793.716	793.970	0.254
VVA01A	151930.048	1686825.988	842.960	843.190	0.230
VVAF7A	199632.249	1698473.233	761.529	761.720	0.191
VVA09	216156.672	1673373.009	835.995	836.180	0.185
VVA11	168235.524	1648194.745	713.227	713.390	0.163
F01	151890.208	1686690.525	847.450	847.590	0.140
VVA04	231305.758	1614932.618	833.867	834.000	0.133
VVAF05A	233243.693	1649891.205	851.925	852.050	0.125
VVA16	197616.470	1608576.174	744.486	744.600	0.114
VVA06	149754.765	1650666.605	779.894	779.990	0.096
VVA15	242368.564	1640388.255	834.860	834.940	0.080
VVA08	144645.139	1633039.046	755.095	755.170	0.075
VVAF03B	156581.338	1603722.770	716.139	716.200	0.061
VVAF04A	231249.777	1614635.380	828.132	828.150	0.018
VVAF07B	199550.196	1698629.496	762.124	762.140	0.016
VVA03	155994.176	1603199.477	712.746	712.760	0.014
VVAF03A	156607.962	1603811.936	714.744	714.740	-0.004
VVAF06B	149980.905	1651158.015	780.404	780.400	-0.004
VVA10R	179300.769	1634720.520	689.606	689.580	-0.026
VVA18R	189911.762	1663426.591	729.286	729.250	-0.036
VVAF02A	235588.297	1684038.614	844.507	844.470	-0.037
F06	149986.036	1651384.367	779.380	779.320	-0.060
F05	233216.087	1649949.565	855.440	855.380	-0.060
F04	230965.165	1614551.165	827.180	827.100	-0.080
F07	199570.946	1698474.378	763.320	763.210	-0.110
F03	156709.209	1603820.135	715.930	715.780	-0.150
VVA12	144782.132	1678017.982	859.619	859.430	-0.189
<b>Average Dz</b>					0.096
<b>Minimum Dz</b>					-0.189
<b>Maximum Dz</b>					0.435
<b>Average Magnitude</b>					0.142
<b>RMS</b>					0.183
<b>STD</b>					0.158

## Control Map for VVA Points:





# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

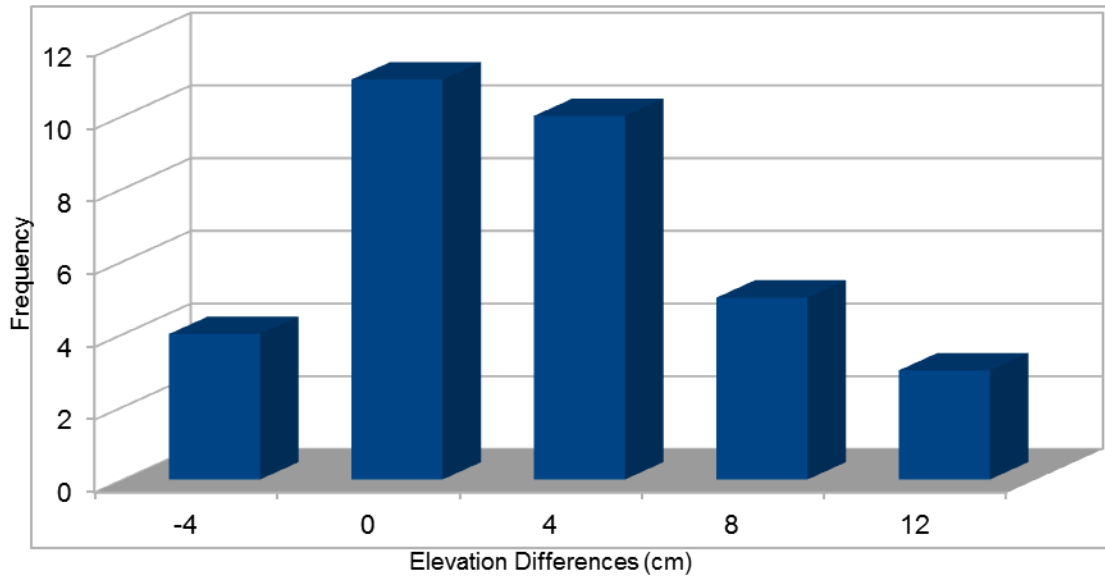


---

# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

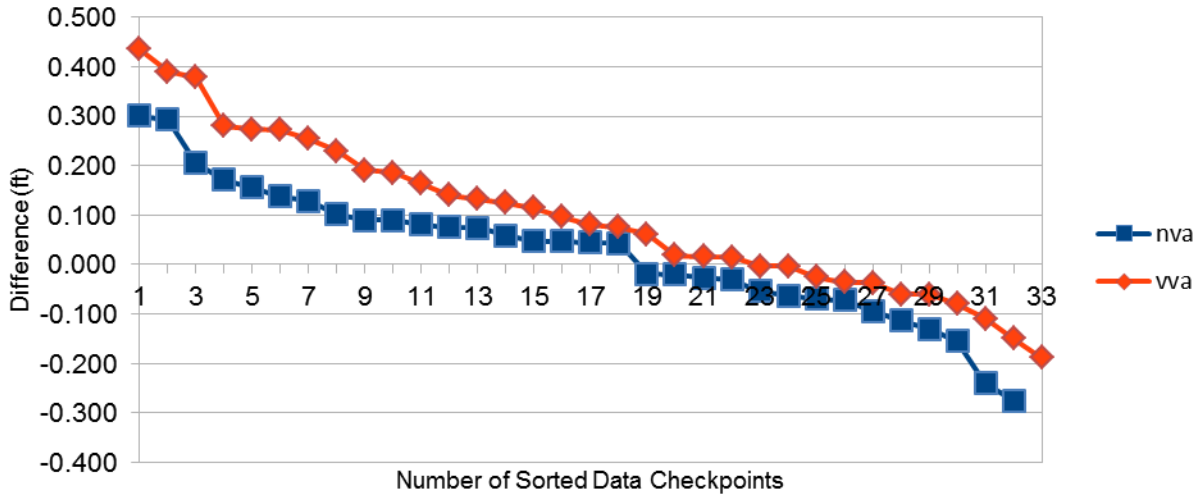
---

Elevation Differences Histogram (VVA)

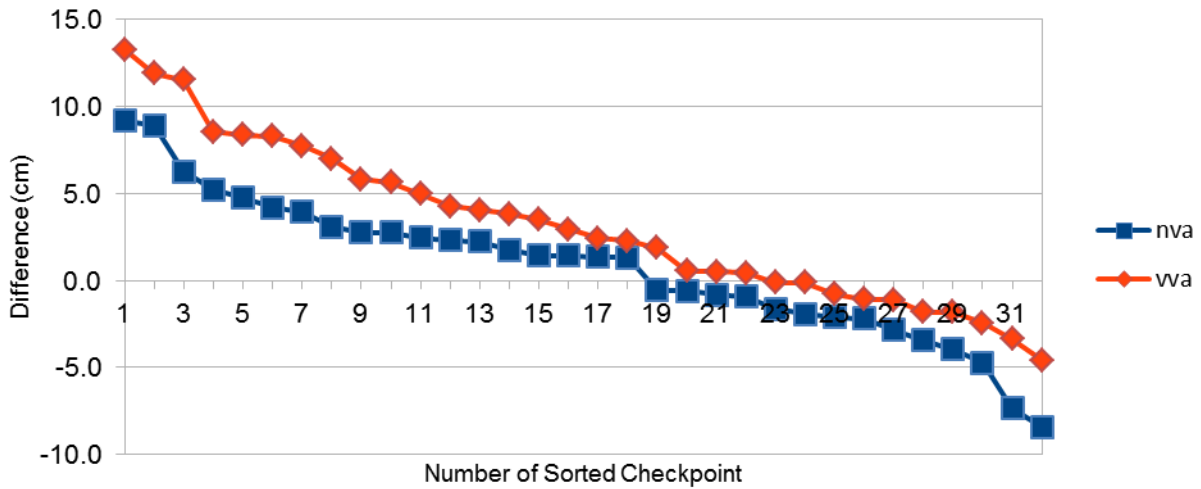


# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

Elevation Differences



Elevation Differences



---

**MARION COUNTY, INDIANA LIDAR PROJECT  
LIDAR COLLECTION, CONTROL / CHECKPOINT  
AND LIDAR ADJUSTMENT REPORT**

---

**Mission Summary**

<b>Mission</b>	<b>Start Date</b>	<b>Aircraft</b>	<b>Sensor</b>	<b>Duration</b>	<b>Lines</b>	<b># of Lines</b>
Mission 1	03/11/2016	N35834	SN7232	4:55 hrs	20101-20120	20
Mission 2	03/12/2016	N35834	SN7232	2:39 hrs	20201-20206	6
Mission 3	03/18/2016	350GB	SN7108	6:45 hrs	40301-40313	13



**MARION COUNTY, INDIANA LIDAR PROJECT  
LIDAR COLLECTION, CONTROL / CHECKPOINT  
AND LIDAR ADJUSTMENT REPORT**

**Marion County, Indiana 2009 Ground Control Points**

<b>Number</b>	<b>Easting</b>	<b>Northing</b>	<b>Elevation</b>	<b>LiDAR Elevation</b>	<b>Dz</b>
MA-05	189414.655	1703356.701	830.040	830.480	0.440
MA-03	238037.237	1707282.805	825.760	825.920	0.160
MA-17	206929.252	1646997.610	793.060	793.170	0.110
MA-10	146056.927	1646682.167	783.110	783.190	0.080
MA-01	240664.861	1668151.092	837.130	837.190	0.060
MA-09	152624.986	1669642.661	811.830	811.890	0.060
MA-21	169241.122	1624257.888	688.900	688.940	0.040
MA-19	189458.941	1678020.168	713.540	713.570	0.030
MA-16	243320.722	1638506.244	828.040	828.060	0.020
MA-07	143072.788	1704373.025	909.610	909.560	-0.050
MA-08	138937.460	1682459.036	888.640	888.570	-0.070
MA-04	199376.155	1696277.226	758.270	758.170	-0.100
MA-02	246569.081	1691898.948	826.170	826.060	-0.110
MA-11	177383.148	1655518.220	716.730	716.620	-0.110
MA-18	213790.142	1672770.871	821.450	821.340	-0.110
MA-06	162969.360	1696222.151	877.500	877.370	-0.130
MA-20	138933.221	1619663.799	743.200	743.020	-0.180
MA-14	221660.106	1610955.863	853.270	853.040	-0.230
MA-15	219678.151	1630199.788	847.650	847.410	-0.240
MA-12	185701.304	1650963.306	703.580	703.330	-0.250
MA-23	190095.059	1621476.359	709.100	708.780	-0.320
MA-22	183201.428	1606442.857	690.320	689.960	-0.360
MA-13	192838.506	1643340.669	730.100	removed	*
<b>Average Dz</b>					-0.057
<b>Minimum Dz</b>					-0.360
<b>Maximum Dz</b>					0.440
<b>Average Magnitude</b>					0.148
<b>RMS</b>					0.185
<b>STD</b>					0.180



# MARION COUNTY, INDIANA LIDAR PROJECT LIDAR COLLECTION, CONTROL / CHECKPOINT AND LIDAR ADJUSTMENT REPORT

## Control Map for 2009 Marion County Points:

