GNSS Survey Report

New York Statewide
LiDAR Acquisition
Lot 19

Erie-Genesee-Livingston
Ground Control and Check Point
Survey Report

AXIS Geospatial, LLC
28640 Mary's Court, Suite 200
Easton, Maryland 21601
Axis Project Number 13367-1916

Date: 08/01/2019
Revised: 08/22/2019

NY19-Erie Genesee Livingston LiDAR Primary Ground Control Folder Explanation and Inventory

NY19 Erie Genesee Livingston – GNSS Survey Report- This is the primary file forming the narrative of the survey report and contains descriptions of work areas, methodologies employed and contains a listing of final coordinate values and a coordinate analysis of our positioning vs. published NGS.

The deliverables are grouped into three subdirectories as follows:

Primary Control Reports- Contains individual year and project reports

Data Set – Contains an Excel Spreadsheet and a Shape File for Primary Control Points

Checkpoints –

Tables – Contains Excel Spreadsheets of points in various projections

Data – Contains Excel Spreadsheets and Shape Files for Checkpoints

Pictures – Contains photos (correlated by Point ID) of each Checkpoint

GNSS Survey Report Narrative

August 21, 2019

State of New York
Office of Information Technology Services,
GIS Program Office
10B Airline Drive
Albany, NY 12235

Attn : Tim Ruhren, Program Manager

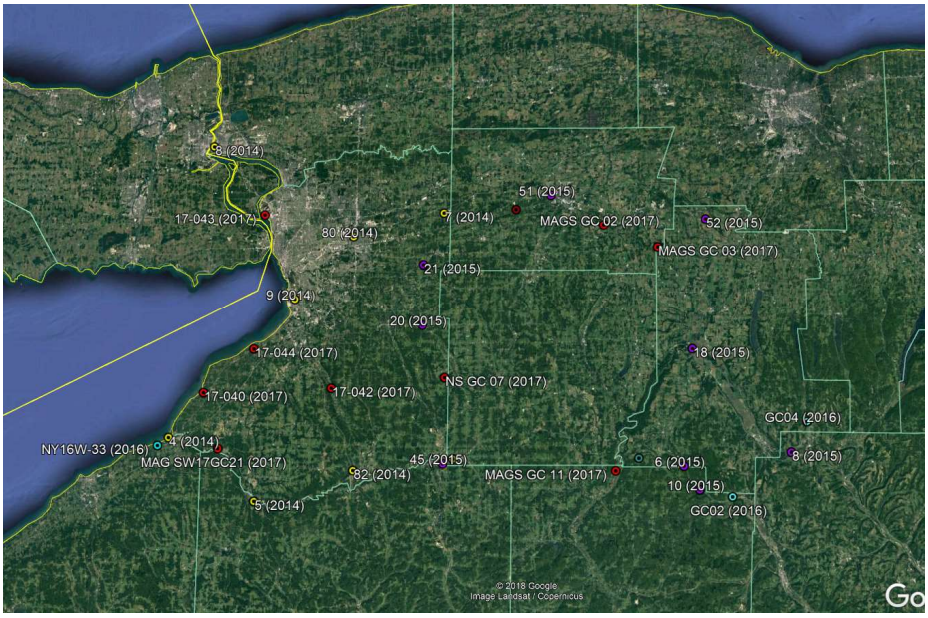
Re: GNSS Survey Control Report-Primary Control/Check Point Survey
Axis Project # 13367-1916, Lot 19 LiDAR Project Area, New York
NY Contract #C300036

Please find enclosed a series of reports, diagrams and other supporting information that forms the formal GNSS Survey Report for the referenced project. Additionally, we have included a narrative of the methodology, techniques and technical details about the equipment and technology utilized to execute the project.

Project Datum
All horizontal point data in this report is provided in the Albers equal-area conic projection (Albers) in metric units. All vertical data in this report is provided in North American Vertical Datum of 1988 (NAVD 88) in metric units, unless stated otherwise. Data was originally presented in either New York State Plane (NYSP) or Universal Transverse Mercator (UTM) projections in previous reports. To convert the data, AXIS utilized both ArcGIS and European Petroleum Survey Group's (EPSG) online data conversion tool (https://epsg.io/6350). The data was imported into ArcGIS in NYSP and exported in Albers, then again imported in UTM and exported out Albers. The results from each were compared and were found to be acceptable. The data was then entered into the EPSG website in ALBERS and converted to Latitude and Longitude for each point. The Latitude and Longitude were then converted to NYSP datum and compared to the original data submitted. Axis found the data conversions successful with no unacceptable deviations.

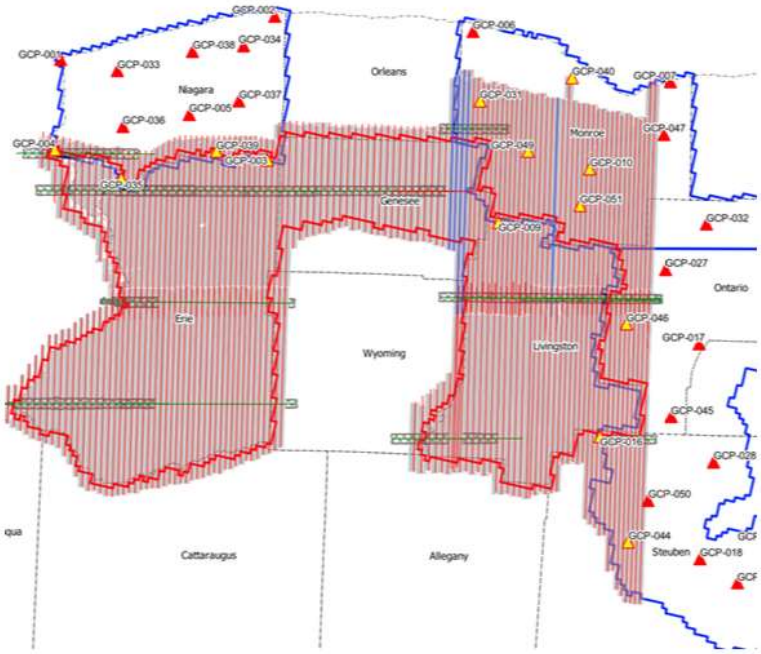
Primary Control
Primary Control for this project is a compilation of points utilized from previous New York Statewide LiDAR Acquisition Project Areas and the NY FEMA R2 Central 2018 D19. The point data can be found in the folders specified on Page 2 of this report.

New York Statewide LiDAR Acquisition Project Areas Ground Control utilized:



Description	SOURCE	SOURCE YEAR	Northing	Easting	Ortho Ht (M)
4	NY Statewide LiDAR Aquisition	2014	2295490.354	1368778.204	176.175
5	NY Statewide LiDAR Aquisition	2014	2286489.083	1388045.639	254.895
6	NY Statewide LiDAR Aquisition	2014	2302130.971	1424797.862	444.748
7	NY Statewide LiDAR Aquisition	2014	2350282.953	1413376.265	249.364
82	NY Statewide LiDAR Aquisition	2014	2296153.835	1405936.572	419.360
80	NY Statewide LiDAR Aquisition	2014	2342108.620	1396493.183	214.090
8	NY Statewide LiDAR Aquisition	2014	2354859.033	1364930.610	182.305
9	NY Statewide LiDAR Aquisition	2014	2327398.227	1387546.187	177.857
51	NY Statewide LiDAR Aquisition	2015	2357963.530	1433753.184	270.946
52	NY Statewide LiDAR Aquisition	2015	2359107.721	1465151.393	204.881
6	NY Statewide LiDAR Aquisition	2015	2309437.132	1469710.322	402.760
8	NY Statewide LiDAR Aquisition	2015	2316159.856	1489995.312	426.578
10	NY Statewide LiDAR Aquisition	2015	2305466.074	1473600.718	402.992
18	NY Statewide LiDAR Aquisition	2015	2332674.439	1467203.111	173.715
20	NY Statewide LiDAR Aquisition	2015	2327110.101	1413627.530	274.153
21	NY Statewide LiDAR Aquisition	2015	2339146.928	1411400.356	261.242
45	NY Statewide LiDAR Aquisition	2015	2300847.346	1423009.941	433.036
GC01	NY Statewide LiDAR Aquisition	2016	2309285.660	1460722.272	483.967
GC02	NY Statewide LiDAR Aquisition	2016	2305329.070	1480156.804	402.847
GC04	NY Statewide LiDAR Aquisition	2016	2322679.207	1491996.266	431.111
NY16W-33	NY Statewide LiDAR Aquisition	2016	2293540.840	1366975.672	198.939
17-040	NY Statewide LiDAR Aquisition	2017	2305531.811	1373670.747	181.162
17-042	NY Statewide LiDAR Aquisition	2017	2311261.877	1398423.089	277.033
17-043	NY Statewide LiDAR Aquisition	2017	2343051.354	1378032.600	177.867
17-044	NY Statewide LiDAR Aquisition	2017	2315990.380	1381664.065	214.473
MAG SW17GC21	NY Statewide LiDAR Aquisition	2017	2295239.139	1378833.291	193.221
mags gc 01	NY Statewide LiDAR Aquisition	2017	2353752.506	1427422.491	271.982
mags gc 02	NY Statewide LiDAR Aquisition	2017	2354003.822	1445284.105	282.041
MAGS GC 03	NY Statewide LiDAR Aquisition	2017	2351664.083	1456743.866	280.668
MAGS GC 11	NY Statewide LiDAR Aquisition	2017	2305967.942	1456696.568	352.311
NS GC 07	NY Statewide LiDAR Aquisition	2017	2317625.620	1420047.955	420.368

NY FEMA R2 Central 2018 D19 Project Ground Control utilized:



Description	SOURCE	SOURCE YEAR	Northing	Easting	Ortho Ht (M)
GCP-003	NY FEMA R2 Central 2018 D19	2018	2362087.812	1409392.744	186.593
GCP-004	NY FEMA R2 Central 2018 D19	2018	2354100.789	1364380.301	170.080
GCP-009	NY FEMA R2 Central 2018 D19	2018	2360072.696	1460965.068	215.118
GCP-010	NY FEMA R2 Central 2018 D19	2018	2375877.134	1477604.847	160.227
GCP-016	NY FEMA R2 Central 2018 D19	2018	2319378.704	1492663.942	418.349
GCP-031	NY FEMA R2 Central 2018 D19	2018	2385023.804	1451156.107	158.982
GCP-035	NY FEMA R2 Central 2018 D19	2018	2351231.887	1379667.045	175.191
GCP-039	NY FEMA R2 Central 2018 D19	2018	2361512.810	1398239.153	180.503
GCP-040	NY FEMA R2 Central 2018 D19	2018	2394412.873	1469418.444	82.545
GCP-044	NY FEMA R2 Central 2018 D19	2018	2298404.523	1503743.574	502.644
GCP-046	NY FEMA R2 Central 2018 D19	2018	2344603.068	1492710.042	286.480
GCP-049	NY FEMA R2 Central 2018 D19	2018	2376644.735	1463790.916	177.554
GCP-051	NY FEMA R2 Central 2018 D19	2018	2367620.497	1477266.346	207.422

Process Summary
AXIS GeoSpatial, LLC was authorized to collect airborne LiDAR data for the area of Lot 19. Based on mission planning by the project Certified Photogrammetrist, a map was provided to me for evaluation and GNSS Survey planning which contained the planned flight lines, the proposed ground control points and proposed check points. Based on previously collected control, available local control, the site's proximity to high order NYSNet CORS stations and the number and related geometry of surrounding Real-time Network base stations, as well as the numerous benefits of using a Real-time Network positioning solution, AXIS decided to utilize the existing ground control previously used for New York Statewide LiDAR Acquisition. AXIS then moved forward with mobilization for the project and configuration of my equipment to utilize the New York NYSNet Real-time GNSS Network to collect the check points.

Check Point Survey
Following USGS specifications (LiDAR Base Specification; Techniques and Methods, 11-B4, Page 8) citing the Positional Accuracy Standards for Digital Geospatial Data (American Society for Photogrammetry and Remote Sensing, 2014, Table C.1 Recommended Number of Checkpoints Based on Area, Page A19, Axis determined the number of Quality Check (QC) points required. For this project, a minimum of seventy-six (76) Non-vegetated Vertical Accuracy (NVA) points were required and a minimum of fifty-nine (59) Vegetated Vertical Accuracy (VVA) points were required. The QC surveys were conducted as separate, fully independent mobilizations. Axis proposed and received approval for the check point sites, distributed across the work area. While in the field Axis collected a total of 214 QC points, 111 NVA points and 103 VVA points.

At each site, a GNSS control pair was set using the approved methodology for GNSS control points. Once the observation sequences were completed and satisfactory positions obtained, Axis personnel used a Leica MS-50 robotic instrument to make terrestrial measurements to the second control point as well as the desired QC points. Each QC point was located using a two face (direct/indirect) measurement sequence. The angles and distances were then averaged and used to calculate each Check Point. Points were then documented with two digital photographs, detailing ground and general site conditions. Positions were recorded for the NVA and VVA check points, with attention given to randomize locations across each site as much as reasonably possible. This combined GNSS/robotic approach has several benefits, the first being reduced numbers of time intensive GNSS observations. By setting only two inter-visible GNSS control points, and performing the actual QC observations with the robot, dozens of control points can be located quickly, with very little error in positioning, across the site, without being hampered by the lack of GNSS observability in wooded areas.

Real-time Network Positioning
Coordinates for the Check Point Survey were determined using the Real-time Network (RTN) NYSNet, verified with the measurements to monuments found in the National Geodetic Survey Control Point database. The use of an RTN for geodetic control involves the collection and correction of ionospheric, tropospheric, satellite clock errors and orbital errors from multiple permanent control points surrounding the observation site, resulting in high precision positional data, based on correction data from all the surrounding stations, and a positioning vector measurement from an optimized base station, generally the closest to the rover. The control points of this network are NY State Continuously Operating Reference Stations, NYSNet CORS Stations and National Geodetic Survey Continuously Operating Reference Stations or NGS CORS, and the resulting measurement vectors between the GNSS receiver and network station are direct measurements to existing, high order physical monuments, which have been vetted, documented and distributed by the State of New York and the National Geodetic Survey from their online control databases. Additional measurement data was also collected during the survey fieldwork to other high order, local national geodetic survey monuments as a supplemental verification of positioning quality.

A real-time reference frame-based positioning system by its very nature will not always match published positions of ground control points, regardless of their adjustment status, due to their original measurement methodology and accuracy classification, time passage since original observation, exposure to the elements, forces of nature and the deliberate or accidental injury to their integrity by man.

The project area contains a fairly well distributed, GNSS observable NGS control point framework, and control check in was conducted to points within the immediate project area.

NYSNet RTN and NGS Control Stations:

Primary RTN Control Stations:

NYSNet NYMX/RTCM REF 0039	WARSAW
NYSNet NYNS/RTCM REF 0033	DANSVILLE
NYSNet NYWL/RTCM REF 0032	PITTSFORD
NYSNet NYCL/RTCM REF 0035	LOCKPORT
NYSNet NYMX/RTCM REF 0007	BATAVIA
NYSNet NYNS/RTCM REF 0034	SALAMANCA
NYSNet NYWL/RTCM REF 0017	FREDONIA
NYSNet NYCL/RTCM REF 0008	HAMBURG

NGS Control Stations:

JAVA	AE2167	RECOVERED AS DESCRIBED
WES GAL 1	NC1475	RECOVERED AS DESCRIBED
C 161	NB1390	RECOVERED AS DESCRIBED

Fieldwork Mobilization Dates: June 03,2019 – June 19,2019

RTN Field Equipment

GNSS receiver technical data: Leica GS-15- Geodetic GNSS receiver/antenna (GPS L1/L2/L2C/L5 and L1/L2 GLONASS frequencies), Serial #1505760 firmware v. 6.13
Leica CS-20- Serial #2490713 Controller firmware/Captivate v. 2.2

Leica GS-14- Geodetic GNSS receiver/antenna (GPS L1/L2/L2C and L1/L2 GLONASS frequencies), Serial # 2806875 firmware v. 6.13
Leica CS-35- Serial # 5GTSA86661 Controller firmware/Captivate v. 2.2

Field procedure/methodology: GNSS- Multiple, redundant, multi-set observations with offset occupation times and individual ambiguity resolutions, using NYSNet real-time network with an I-Max network correction configuration for both GPS and GLONASS satellites.

Field Equipment Adjustment/Calibration/Field Checks
Laser plummets were field checked at each setup, using the precise level plate level bubble and a two-position check routine. Rotation of a laser plummet will immediately reveal any defect in the internal structure or alignment of the laser.

Instrument heights were measured using a device called a height hook, which makes a direct, vertical reading of the instrument height without concern for slant height or other problems. The height hook reading is made in millimeters, which offers an exact, high precision measurement.

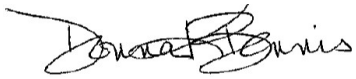
No change or adjustment to any field equipment was necessary throughout the duration of this project.

Office Software
The GNSS receiver and its controller hardware interface via field software called Leica SmartWorx, which provides a user interface and workflows for collecting data, analyzing datasets, selecting results and performing other calculations, including QA/QC analysis, exporting of data and reports and organizing project data. Office software used is the full suite of Leica Geo Office, Version 8.4 (current) and Leica Infinity Version 3.0.1 (current), which provide an interface for downloading data, generating reports and performing calculations, analyzing data, and organizing and printing project reports. Additional analysis was performed using Microsoft Excel 2010, AutoCAD Civil 3D 2016, AutoCAD Map 2016, ArcGIS, and the Google Earth extension of Leica Infinity.

Statistical Analysis & Quality Reporting
A table showing the statistical analysis and positional quality of the NGS control points is available in the Control Analysis worksheet Table starting on page 9 of this report.

Responsible Charge

The field work and GNSS computations for this project were conducted under the supervision of a Professional Land Surveyor, following NYDOT Photogrammetric Control Procedures, National Geodetic Survey Guidelines for GNSS Surveying using Real Time Kinematic and Real Time Networks and FGDC Guidelines for GPS Positioning. Report prepared by:



_____ Date: 08-01-2019

Donna K Bennis, PLS
Delaware Professional Land Surveyor # S6-0000623
Pennsylvania Land Surveyor # SU075237

LOT 19; NGS QA Control Analysis Worksheet				
Horizontal Datum:	UTM 17/UTM 18			
Vertical Datum:	North American Vertical Datum of 1988 derived using Geoid 12B			
Units:	Meters			
Axis Geospatial Survey Points- RTN				
Pt#	Northing	Easting	Ortho Ht.	Code
1002 (17)	4726376.504	709777.129	332.863	JAVA
1001 (17)	4744493.379	681973.679	193.477	WES GAL 1
1005 (18)	4741700.263	270850.833	263.794	C 161
NGS Datasheet Values				
PID	Northing	Easting	Ortho Ht.	Name
AE2167	4726376.525	709777.127	332.841	JAVA
NC1475	4744493.361	681973.642	193.485	WES GAL 1
NB1390	4741700.248	270850.837	263.887	C 161
Comparison Matrix (RTN Dataset vs. NGS Published Data)				
	▲ Northing	▲ Easting	▲ Height	
1002 VS. AE2167	-0.021	0.002	0.022	
1001 VS. NC1475	0.018	0.037	-0.008	
1005 VS. NB1390	0.015	-0.004	-0.093	
	0.018	**0.018**	**0.049**	Std. Dev.
	-0.021	**0.037**	**-0.093**	Max.
	0.015	**0.002**	**-0.008**	Min.
	0.004	**0.011**	**-0.026**	Average

LOT 19; NGS QA Control Analysis Worksheet				
Horizontal Datum:	NY SP WEST			
Vertical Datum:	North American Vertical Datum of 1988 derived using Geoid 12B			
Units:	METERS			
Axis Geospatial Survey Points- RTN				
Pt#	Northing	Easting	Ortho Ht.	Code
1002	295552.486	361718.177	332.863	JAVA
1001	314455.518	334448.558	193.477	WES GAL 1
1005	310535.895	413927.154	263.794	C 161
NGS Datasheet Values				
PID	Northing	Easting	Ortho Ht.	Name
AE2167	295552.507	361718.175	332.841	JAVA
NC1475	314455.501	334448.520	193.485	WES GAL 1
NB1390	310535.880	413927.159	263.887	C 161
Comparison Matrix (RTN Dataset vs. NGS Published Data)				
	▲ Northing	▲ Easting	▲ Height	
1002 VS. AE2167	-0.021	0.002	0.022	
1001 VS. NC1475	0.017	0.038	-0.008	
1005 VS. NB1390	0.015	-0.005	-0.093	
	0.019	**0.019**	**0.049**	Std. Dev.
	-0.021	**0.038**	**-0.093**	Max.
	0.015	**-0.002**	**-0.008**	Min.
	0.004	**0.012**	**-0.026**	Average