

AERIAL TRIANGULATION REPORT



NOAA CONNECTICUT SHORELINE ORTHOIMAGERY PROGRAM

6-INCH PIXEL RESOLUTION

WOOLPERT PROJECT NUMBER: 76783

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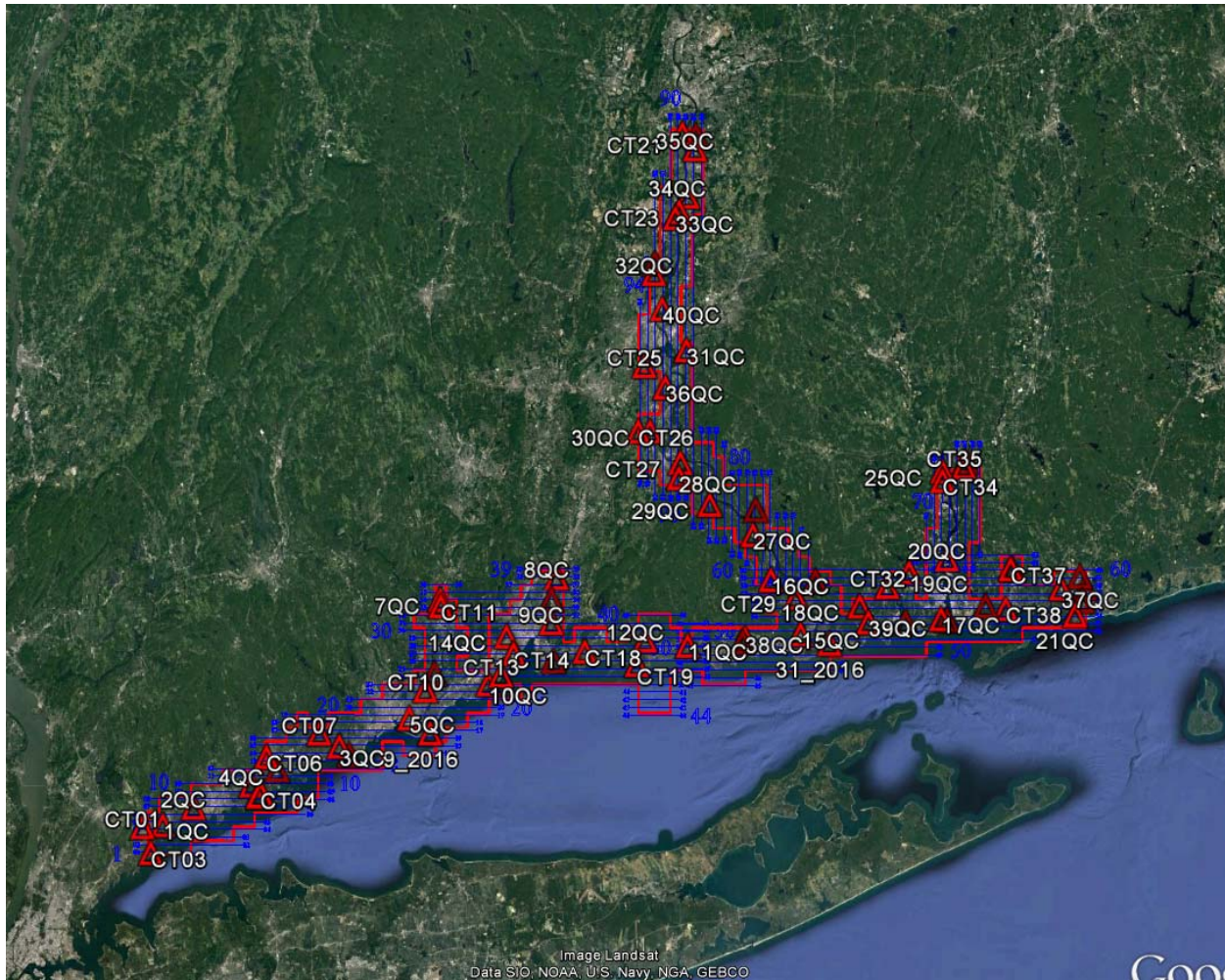
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INTRODUCTION

This report contains an outline of the photogrammetric aerial triangulation (AT) process that supported the NOAA Connecticut Shoreline 6-Inch Pixel Resolution Area.

PROJECT AREA

The project area is defined within this report as NOAA Connecticut Shoreline 6-Inch Pixel Resolution Area



PURPOSE OF AERIAL TRIANGULATION

Aerial triangulation is a method of ground control extension or densification performed mathematically and in conjunction with a limited number of ground control points, Airborne GPS data, and inertial measurement data to control aerial imagery such that it may be utilized to measure 3D information about features on or above the ground.

DATES OF IMAGE ACQUISITION

Aerial imagery was acquired using the Leica ADS81 and ADS27 digital sensors. A total of ten (10) missions were completed for the entire project area as follows:

Julian Day	Imagery Flights	Sensor(s)	Date
208	40-44, 58-70	Sh101	July 26 th , 2016
209	36, 45-52	Sh101	July 27 th , 2016
212	86-87, 94	Sh101	July 30 th , 2016
216	53-57, 89-93	Sh101	August 3 th , 2016
217	71-80, 86-89	Sh101	August 4 th , 2016
218	81-82	Sh101	August 5 th , 2016
220	30-39, 82-85	Sh101	August 7 th , 2016
221	3-14	Sh101	August 8 th , 2016
222	15-25, 88-91	Sh101	August 9 th , 2016
237	1-2, 26-29	Sh101	August 24 th , 2016

SENSOR DESCRIPTION

All data was acquired using the Leica ADS81 digital sensor, serial number 101. The Leica ADS80 series records all objects, with equal resolution as a 12-bit image, in panchromatic from three different viewing angles as well as additional viewing angles in RGB and FCIR images. These views are below the aircraft at nadir, and simultaneously ranging between 27 degrees forward and 16 degrees backward.

The maximum acquisition ground sampling distance was 0.447-foot with the final deliverable pixels being produced at 0.5-foot.

The band configurations are as outlined:

Sensor #101		
Calibration Date: January 25, 2012		
BLUE NADIR	NIR NADIR	PANF02
GREEN NADIR	PANB14	
RED NADIR	PANF27	

PROCESSING SOFTWARE

Leica GeoSystem's XPro software program was used to perform image processing and aerial triangulation.

PROCESSING METHODOLOGY

The NOAA Connecticut Shoreline 6-Inch Pixel Resolution Area was created using Leica GeoSystem's XPro software. The software settings are based on the project specifications, a sequential grouping of flights lines and the appropriate distribution of survey control points for block processing. The block processing utilizes all the bands and applies the raw position and orientation data and creates a metadata file.

The aerial triangulation process uses only the Level 0 (zero) panchromatic imagery bands; PANB14, PANF27, and PANF02. The AT process is similar to conventional operations, where the Level 0 panchromatic imagery is passed through Automatic Point Measurement, the resulting tie points and ground control is adjusted using CAP-A and ORIMA software. Blunders are removed and the block is analyzed for weak network areas, and if required, manual points are added. The final adjustment output consists of precise orientation data files for each band, calibration parameters and metadata.

The imagery is rectified to a digital elevation model (DEM) which removes any relief displacement which may be present. During this processing stage, set the ground sampling distance (GSD), select optional 8 bit or 16 bit imagery and apply a total tonal curve (TTC). The ortho-rectified imagery is commonly referred to as Level 2 imagery.

INDIVIDUAL BLOCK RESULTS

Ground Control used in Triangulation

Ground Control Used in Triangulation			
Point ID	X ft	Y ft	Z ft
9_2016	900711.8	617520.2	22.17
20_2016	1070247	666893.3	9.78
28_2016	1077447	738344.2	133.71
24_2016	1022688	871499.7	145.65
31_2016	1117591	665989	29.7
CT01	743864.3	566380	154.97
CT03	748360.7	552345.3	8.47
CT04	808199.8	584301.6	5.94
CT05	817498.3	597586.1	7.87
CT06	811629.4	604614.3	130.07
CT07	840388.5	617358.7	209.16
CT08	856677	605808.5	5.42
CT10	898080.6	640777.7	61.52
CT11	906513.8	686295.5	120.21
CT13	939182.1	648895.8	30.18
CT14	945978.8	660480.5	17.08
CT17	966600.5	689853.9	20.28
CT18	984658.6	661714.1	19.03

Ground Control Used in Triangulation			
Point ID	X ft	Y ft	Z ft
CT19	1012883	654559	6.26
CT21	1037684	941826.6	55.58
CT22	1044984	940732.1	129.83
CT23	1035870	899417.5	40.35
CT25	1017007	816051.3	168.89
CT26	1013654	780652.4	27.91
CT27	1036583	763667.9	69.69
CT29	1099219	690938.9	7.81
CT30	1109858	699797.4	41.78
CT32	1149007	696747.1	81.54
CT33	1158902	677529.6	41.47
CT34	1179029	754139.5	135.62
CT35	1190764	761609.6	106.02
CT36	1181563	678613.8	15.54
CT37	1216160	706246	41.8
CT38	1213485	684800.1	7.43
CT39	1256678	695992.7	112.53
CT40	1255282	689103.4	75.96

AT Block Statistical Data

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
20_2016	-0.00262	-0.00230	0.00098
24_2016	-0.00394	-0.00328	0.00033
28_2016	-0.00197	-0.00262	0.00000
31_2016	-0.00394	-0.00033	0.00066
9_2016	-0.00262	-0.00131	0.00000
CT01	-0.00098	-0.00066	0.00033
CT03	-0.00098	0.00164	0.00000
CT04	-0.00295	0.00098	0.00098
CT05	0.00295	0.00131	-0.00066
CT06	-0.00164	0.00033	0.00000
CT07	0.00230	-0.00033	-0.00033
CT08	0.00000	0.00033	0.00000
CT10	0.00098	-0.00066	-0.00033
CT11	-0.00098	-0.00033	-0.00033
CT13	0.00066	0.00000	0.00000
CT14	0.00197	-0.00131	0.00033
CT17	0.00033	0.00131	0.00000
CT18	-0.00295	-0.00066	0.00033
CT19	0.00033	0.00000	-0.00033
CT21	-0.00098	0.00000	0.00033

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
CT22	0.00066	0.00033	0.00000
CT23	0.00295	0.00361	0.00066
CT25	0.00230	0.00000	-0.00098
CT26	0.00262	0.00164	-0.00033
CT27	-0.00197	0.00197	-0.00033
CT29	0.00098	-0.00033	0.00000
CT30	-0.00164	0.00000	0.00000
CT32	0.00328	0.00262	0.00000
CT33	0.00033	-0.00525	-0.00098
CT34	0.00262	0.00197	0.00066
CT35	-0.00033	-0.00098	-0.00033
CT36	0.00164	0.00295	0.00098
CT37	0.00262	-0.00098	0.00033
CT38	0.00164	-0.00033	-0.00066
CT39	-0.00131	-0.00131	-0.00066
CT40	0.00098	0.00197	0.00098

Summary

The final RMSE (Root Mean Square Error) residuals on the ground control points are as follows:

	X	Y	Z
RMS	0.00178	0.00128	0.00039
RMS P	0.00218		

The RMSE P values meets or exceeds where designated the ASPRS Class 1 & Class II Accuracy Standards for DOI mapping at 1"=100' scale.

QC Results

The NOAA Connecticut Shoreline QC Point Horizontal Accuracy Static Worksheet listed below shows quality-controlled point checks and analysis.

Point number	Point description	x (Survey)	x (AT)	diff in x	(diff in x) ²	y (Survey)	y (AT)	diff in y	(diff in y) ²	(diff in x) ² + (diff in y) ²
1QC	PID	754985.230	754984.6214	0.609	0.370	567532.400	567531.5703	0.830	0.688	1.059
2QC	PID	771731.480	771730.7351	0.745	0.555	577078.010	577077.3548	0.655	0.429	0.984
3QC	PID	851276.660	851275.5481	1.112	1.236	610376.080	610375.151	0.929	0.863	2.099
4QC	PID	803330.390	803329.6186	0.771	0.595	589244.520	589243.6419	0.878	0.771	1.366
5QC	PID	889357.160	889356.4074	0.753	0.566	625613.880	625613.7144	0.166	0.027	0.594
6QC	PID	903005.200	903004.3459	0.854	0.729	649836.130	649835.5174	0.613	0.375	1.105
7QC	PID	906206.730	906206.1216	0.608	0.370	689658.550	689658.2788	0.271	0.074	0.444
8QC	PID	969427.220	969426.6176	0.602	0.363	701645.770	701644.7568	1.013	1.026	1.389
9QC	PID	966450.080	966449.5869	0.493	0.243	677227.710	677227.256	0.454	0.206	0.449

Point number	Point description	x (Survey)	x (AT)	diff in x	(diff in x) ²	y (Survey)	y (AT)	diff in y	(diff in y) ²	(diff in x) ² + (diff in y) ²
10QC	PID	932338.640	932338.0169	0.623	0.388	644128.920	644128.3869	0.533	0.284	0.672
11QC	PID	1040531.830	1040531.803	0.027	0.001	664939.430	664938.906	0.524	0.275	0.275
12QC	PID	1017427.370	1017426.922	0.448	0.200	667812.370	667812.1398	0.230	0.053	0.253
13QC	PID	967628.420	967627.6723	0.748	0.559	656633.230	656632.8963	0.334	0.111	0.670
14QC	PID	942166.130	942165.298	0.832	0.692	669861.190	669861.2409	-0.051	0.003	0.695
15QC	PID	1101868.070	1101867.77	0.300	0.090	671145.540	671144.584	0.956	0.914	1.004
16QC	PID	1085727.760	1085726.671	1.089	1.187	700461.630	700460.8882	0.742	0.550	1.737
17QC	PID	1178334.040	1178332.808	1.232	1.518	679327.060	679327.7045	-0.645	0.415	1.933
18QC	PID	1134008.910	1134007.69	1.220	1.487	686162.890	686162.5236	0.366	0.134	1.622
19QC	PID	1160885.820	1160884.628	1.192	1.420	704669.390	704668.4994	0.891	0.793	2.214
20QC	PID	1181450.810	1181449.888	0.922	0.849	711662.510	711661.791	0.719	0.517	1.366
21QC	PID	1251366.330	1251365.166	1.164	1.356	681451.130	681450.5568	0.573	0.329	1.684
22QC	PID	1253980.800	1253979.206	1.594	2.541	702339.910	702339.311	0.599	0.359	2.900
23QC	PID	1217243.490	1217242.147	1.343	1.804	706242.860	706241.8407	1.019	1.039	2.843
24QC	PID	1202540.420	1202539.008	1.412	1.994	686355.350	686355.01	0.340	0.116	2.110
25QC	PID	1179047.860	1179046.625	1.235	1.526	759094.320	759093.2592	1.061	1.125	2.651
26QC	PID	1191708.960	1191707.22	1.740	3.027	764409.280	764408.4113	0.869	0.755	3.781
27QC	PID	1075994.780	1075993.147	1.633	2.667	724735.930	724735.0519	0.878	0.771	3.438
28QC	PID	1035724.190	1035723.27	0.920	0.846	755516.790	755515.7426	1.047	1.097	1.943
29QC	PID	1052479.260	1052478.578	0.682	0.465	741093.700	741092.5412	1.159	1.343	1.808
30QC	PID	1020102.460	1020101.295	1.165	1.358	780641.410	780640.6811	0.729	0.531	1.889
31QC	PID	1039867.880	1039866.894	0.986	0.972	824532.330	824531.5845	0.746	0.556	1.528
32QC	PID	1022201.210	1022201.269	-0.059	0.003	865920.570	865920.2108	0.359	0.129	0.132
33QC	PID	1033782.810	1033781.918	0.892	0.795	896124.450	896123.8305	0.620	0.384	1.179
34QC	PID	1040410.640	1040409.114	1.526	2.329	907690.170	907688.705	1.465	2.146	4.475
35QC	PID	1044554.730	1044553.52	1.210	1.465	933322.410	933321.5758	0.834	0.696	2.161
36QC	PID	1028413.920	1028413.337	0.583	0.340	804435.290	804434.2918	0.998	0.996	1.337
37QC	PID	1243681.040	1243679.613	1.427	2.035	695814.080	695813.7408	0.339	0.115	2.150
38QC	PID	1071699.570	1071698.791	0.779	0.607	668632.600	668632.0061	0.594	0.353	0.960
39QC	PID	1138775.040	1138773.95	1.090	1.187	677571.090	677570.6739	0.416	0.173	1.361
40QC	PID	1026746.380	1026746.05	0.330	0.109	846887.460	846887.2617	0.198	0.039	0.148
									sum	62.411
									average	1.560
									RMSE	1.249
									NSSDA	2.162



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