

AERIAL TRIANGULATION REPORT



**VOLUSIA COUNTY, FLORIDA
TASK ORDER 1**

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WOOLPERT PROJECT #64919

December 2006

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DECEMBER 2006**

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Introduction

This report contains an outline of the photogrammetric aerial triangulation (AT) process that supported the 2006 Digital Orthophoto Image Maps Project for Volusia County, Florida.

Project Area

The project area encompasses approximately $\pm 1,427$ square miles within Volusia County, Florida.

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 two Leica ADS40 digital sensors. A total of five (5) missions were completed for the entire project on the following days:

Julian Day	Date
045	February 14, 2006
059	February 28, 2006
060	March 1, 2006
064	March 5, 2006
074	March 15, 2006

Sensor Description

All data was acquired using two Leica ADS40 digital sensors with serial numbers 30026 and 30028. Both the FCIR and RGB bands were acquired simultaneously. The maximum acquisition ground sampling distance was 0.66-foot with the final deliverable pixels being produced at 0.5-foot. The band configuration is outlined below:

BLUE NADIR	GREENF16	PANB14
GREEN NADIR	REDF14	PANF28
RED NADIR	NIRF18	

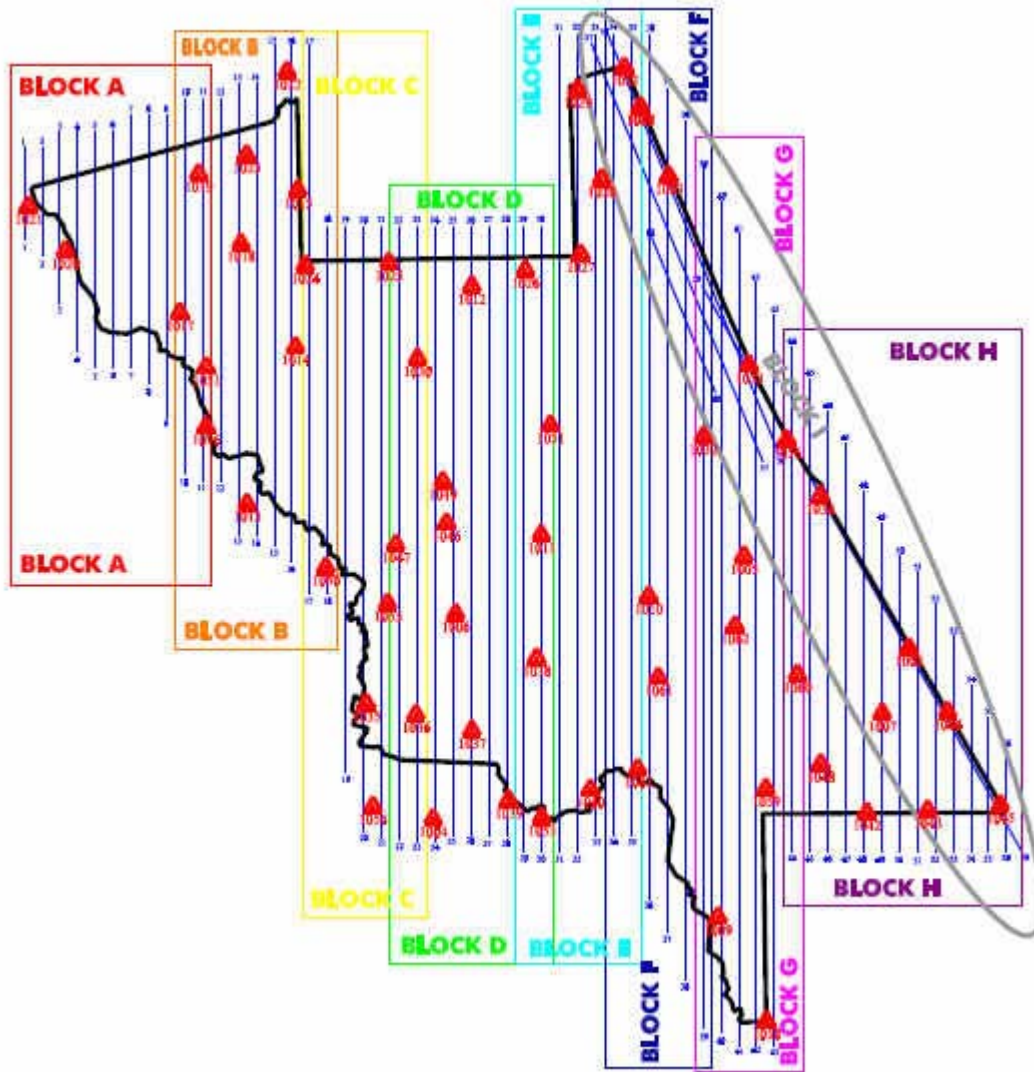
Processing Software

The software utilized for the digital image processing and aerial triangulation, developed by Leica GeoSystems, was: LPS 9.0, ORIMA 9.0a, CAP-A 7.12 and GPro 3.1.

Processing Methodology

The project area was divided up into nine (9) aerial triangulation blocks (see Diagram “A” shown below). Each block was created using Leica’s GPro software and is based on project specifications, control point locations and a suitable number of lines for our blocks. Each block had a good distribution of control points within its boundaries.

Diagram “A”



Every band for the required flight lines is added to the project applying the processed position and orientation data. This creates metadata files and an orientation data file for each band giving the imagery its raw position and orientation.

The aerial triangulation process uses only the Level 0 panchromatic imagery bands PANB14, PANF28, and GRNN00 which are created by GPro. The aerial triangulation 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 can now be rectified to a DEM which removes any relief displacement which may be present. During this processing stage, we can set the required ground sampling distance (GSD), 8 bit or 16 bit imagery, and apply a tonal curve. The ortho-rectified imagery is commonly referred to as Level 2 imagery.

Ground Control used in Triangulation

Florida State Plane, East Zone				
GPS Station Name	Designation	Grid Northing (US Feet)	Grid Easting (US Feet)	Target Elevation (US Feet)
1002	79 78 A10	1671437.91	711774.92	9.65
1003	79 78 A73 RM 1	1817901.07	637251.54	15.07
1004	EVERGREEN RM NO 1	1618356.32	564122.76	50.99
1005	FL GPS 38	1699958.51	660568.29	29.38
1006	VOL 42	1682057.47	571098.17	49.78
1007	OAK 2	1651189.69	703482.04	14.21
1008	OTOS	1839253.63	628387.79	18.15
1009	V002	1587872.75	652501.58	11.65
1010	V006	1687590.13	630957.19	46.82
1011	VO11	1706551.92	597640.10	40.15
1012	VO13	1783773.91	576112.33	36.28
1013	V026	1716245.52	506339.15	43.67
1014	V027	1764842.54	521429.45	44.55
1015	V028	1813466.24	522150.10	22.45
1016	V030	1740091.86	493647.26	4.75
1017	V032	1775493.86	485516.98	2.07
1018	V033	1797030.45	504493.00	33.03
1019	V035	1818578.46	491332.94	40.36
1020	V039	1794746.77	450025.58	51.54
1021	VOL 01	1808497.45	438460.41	41.48
1022	VOL 02	1850395.08	518786.74	5.57
1023	VOL 03	1824413.41	506186.41	38.02
1024	VOL 04	1790143.52	524436.16	47.05
1025	VOL 05	1791009.71	550337.48	28.91
1026	VOL 06	1788738.94	592755.84	38.62
1027	VOL 07	1793634.31	609905.30	23.47
1028	VOL 08	1816999.78	616344.41	28.58
1029	VOL 09	1844735.13	608966.90	27.86
1030	VOL 10	1761291.38	559292.92	42.96
1031	VOL 11	1740556.59	600451.79	39.64
1032	VOL 12	1736998.16	647957.02	25.81
1033	VOL 13	1759207.63	662178.90	15.99
1034	VOL 14	1718587.20	684200.91	7.56
1035	VOL 15	1654164.90	543415.66	20.77

Florida State Plane, East Zone				
GPS Station Name	Designation	Grid Northing (US Feet)	Grid Easting (US Feet)	Target Elevation (US Feet)
1036	VOL 16	1650792.77	558778.90	55.18
1037	VOL 17	1645818.69	576144.42	8.47
1038	VOL 18	1668287.00	596229.01	32.88
1039	VOL 19 PID	1624200.54	587563.86	9.57
1040	VOL 20	1627574.21	612922.36	8.61
1041	VOL 21	1633893.65	627641.34	8.11
1042	VOL 22	1620386.21	698706.94	8.59
1043	VOL 23	1621131.92	717551.22	11.71
1044	VOL 24	1651650.41	723766.37	17.61
1045	VOL 25	1622717.16	740117.76	3.06
1046	VOL 26	1710184.57	568280.24	79.70
1047	VOL 27	1703546.10	552544.54	79.83
1048	VOL 28	1635458.69	684392.43	57.17
1049	VOL 29	1723137.12	567105.19	67.43
1050	VOL 30	1696451.04	530841.30	20.18
1051	VOL 31	1758593.24	493619.26	24.44
1052	VOL 32	1851657.77	623466.80	15.36
1053	VOL 33	1618765.10	597809.14	7.20
1054	VOL 34	1622248.13	545458.87	98.43
1055	VOL 35	1685273.40	550011.00	22.38
1056	VOL 36	1736062.49	673888.97	15.42
1057	VOL 37	1839261.62	628408.05	15.52
1058	VOL 38	1555591.18	667523.57	8.04
1059	VOL 39	1627829.81	667374.08	25.68
1060	VOL 40	1663248.14	677134.66	27.87
1061	VOL 41	1662313.48	634010.69	26.05
1062	VOL 44	1678352.80	657810.25	26.04
1063	VOL 33 PID	1618791.35	597887.59	6.98

Accuracy Requirements

The aerial triangulation accuracy requirement (National Map Accuracy Standards/American Society of Photogrammetry and Remote Sensing Class I) at the quality control checkpoints is as follows:

- Horizontal = flying height/10,000 or 0.66-foot RMSE
- Vertical = flying height/9,000 or 0.73-foot RMSE
- Maximum allowable error is 3*RMSE

The average aircraft flying height during imagery acquisition was 6,600-feet above ground level.

Quality Control Checks

The points indicated below were withheld from the adjustment for quality control checking purposes, and all points (including these quality control points) were used in the **final** adjustment.

Block A

Quality Control Points			
Point ID	X ft	Y ft	Z ft
1017	-0.105	-0.149	-0.039

Block B

Quality Control Points			
Point ID	X ft	Y ft	Z ft
1018	0.071	0.056	0.047

Block C

Quality Control Points			
Point ID	X ft	Y ft	Z ft
1055	-0.128	-0.168	0.070

Block D

Quality Control Points			
Point ID	X ft	Y ft	Z ft
1049	-0.171	0.226	-0.060

Block E

Quality Control Points			
Point ID	X ft	Y ft	Z ft
1028	-0.117	-0.038	-0.164

Block F

Quality Control Points			
Point ID	X ft	Y ft	Z ft
1061	0.095	0.313	-0.127

Block G

Quality Control Points			
Point ID	X ft	Y ft	Z ft
1005	0.005	-0.088	0.048

Block H

Quality Control Points			
Point ID	X ft	Y ft	Z ft
1007	-0.061	-0.270	-0.054

Block I

Quality Control Points			
Point ID	X ft	Y ft	Z ft
1056	0.029	0.123	0.106

Ground Control Withheld

No ground control points were withheld for this project.

AT Block Statistical Summaries

Block A

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1016	0.064	-0.039	0.030
1017	-0.095	-0.080	-0.013
1019	0.020	-0.080	0.010
1020	-0.032	0.044	-0.031
1021	-0.022	0.169	-0.025
1051	0.065	-0.014	0.029

Block B

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1013	-0.131	0.193	0.034
1014	0.127	0.000	0.016
1015	0.007	-0.102	0.027
1016	-0.005	-0.025	-0.011
1017	-0.158	0.052	0.026
1018	0.063	0.052	0.007
1019	-0.047	0.023	0.005
1022	0.138	-0.166	-0.094
1023	0.007	-0.173	0.047
1024	-0.049	-0.052	0.007
1050	0.075	0.127	-0.047
1051	-0.028	0.070	-0.016

Block C

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1015	-0.021	-0.010	0.032
1024	-0.020	-0.034	-0.003
1025	-0.155	-0.193	0.034
1030	0.115	0.095	-0.010
1035	0.010	0.147	-0.030
1036	0.063	0.158	-0.015
1047	0.063	-0.204	-0.033
1050	0.056	0.170	-0.028
1054	0.000	0.031	-0.005
1055	-0.111	-0.163	0.058

Block D

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1004	-0.083	0.014	0.009
1006	0.009	-0.046	-0.006
1011	0.149	-0.042	0.006
1012	-0.065	0.061	0.015
1025	-0.206	-0.052	0.145
1026	-0.015	-0.136	-0.016
1030	0.044	0.080	-0.009
1031	0.160	-0.066	0.063
1036	-0.024	0.231	-0.020
1037	-0.118	0.143	-0.036

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1038	0.144	-0.094	0.027
1039	0.016	0.009	0.004
1046	-0.058	-0.039	-0.017
1047	-0.117	-0.195	0.037
1049	-0.147	0.210	-0.005
1063	0.011	-0.013	-0.005

Block E

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1008	0.175	-0.056	0.110
1011	-0.139	0.130	-0.029
1026	-0.218	0.113	0.010
1027	0.149	-0.095	0.046
1028	-0.073	-0.032	-0.141
1029	0.041	-0.032	0.026
1031	-0.144	-0.016	0.039
1038	-0.239	0.046	-0.181
1040	0.077	-0.227	-0.050
1041	0.199	-0.038	0.039
1052	0.185	0.004	0.068
1053	-0.053	0.110	0.002
1057	0.224	-0.003	0.094
1063	-0.185	0.098	-0.033

Block F

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1003	0.190	-0.150	0.048
1008	0.069	-0.106	0.059
1010	-0.126	0.265	-0.048
1028	-0.197	-0.115	0.135
1032	0.187	-0.274	0.048
1041	-0.140	0.041	-0.075
1052	-0.040	-0.089	-0.040
1057	0.014	0.134	-0.042
1061	0.043	0.293	-0.084

Block G

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1005	0.003	-0.069	0.019
1009	-0.062	-0.057	-0.005
1032	-0.042	0.022	0.024
1033	0.134	-0.005	-0.003
1058	-0.086	0.076	0.002
1059	-0.013	0.043	0.022
1062	0.067	-0.010	-0.012

Block H

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1002	0.021	-0.065	0.010
1007	-0.036	-0.256	-0.004
1034	0.052	-0.025	0.046
1042	-0.005	0.151	0.024
1043	-0.036	-0.026	-0.055
1044	-0.031	0.011	-0.049
1045	-0.047	0.070	-0.027
1048	0.016	-0.036	0.027
1056	0.013	0.101	-0.010
1060	0.053	0.076	0.028

Block I

Control Point Residuals			
Point ID	X ft	Y ft	Z ft
1002	-0.077	-0.098	-0.051
1003	0.072	0.068	-0.005
1008	-0.026	0.147	-0.035
1033	0.145	-0.010	0.039
1034	-0.114	-0.154	0.008
1044	-0.018	-0.148	-0.023
1045	-0.029	-0.077	-0.040
1052	0.025	0.111	0.021
1056	0.011	0.075	0.081
1057	0.009	0.086	0.006

Summary

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

	X	Y	Z
RMS XYZ	0.102	0.115	0.048
RMS P	0.154		

The RMSE values fall well within the MTS/NMAS requirements for DOI mapping at 1"=200' scale and DTM/contours at 0.3-foot RMSE vertical accuracy or the RMSE P values fall well within the industry and National Map Accuracy Standards for DOI mapping at 1"=100' scale and DTM/contours at a 0.46-foot RMSE vertical accuracy.

THIS REPORT IS NOT VALID WITHOUT THE SIGNATURE AND RAISED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER.

Surveyor and Mapper in Responsible Charge:

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THIS PHOTOGRAMMETRIC MAPPING DATA AND REPORT IS CERTIFIED TO SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT AS MEETING OR EXCEEDING, IN QUALITY AND PRECISION, THE STANDARDS APPLICABLE FOR THIS WORK, AS SET FORTH IN CHAPTER 61G17-6, FLORIDA ADMINISTRATIVE CODE.

Christopher M. O'Neill, CP, PSM
Professional Surveyor and Mapper No. LS-0006497

Date

Seal