KUCERA INTERNATIONAL INC.

GEOGRAPHIC INFORMATION PROFESSIONALS / PHOTOGRAMMETRISTS

Aerotriangulation Report
Ramsey County, MN
2009

This report summarizes the aerotriangulation (AT) results of 0.5' GSD (Ground Sample Distance) color digital aerial photography captured for Ramsey County, MN. The photography was acquired using a Leica ADS40 digital camera, sensor head 30104. Mission date was April 14th, 2009. The photography consisted of 20 flight lines and covered Ramsey County its entirety.

The AT referenced the NAD83(86) State Plane Coordinate System, Minnesota South Zone (2203). The vertical reference datum used was NAVD88(Geoid03). The measurement units used were US survey feet.

The AT project was set up as one sub-block. The sub-block was controlled with a combination of airborne GPS/INS data and ground-based control points. The airborne GPS data was post-processed using TerraTecAS TerraPos v1.3.2 and Applanix POSGNSS v4.4. Inertial navigation system (INS) data was coupled with the processed GPS data using Leica IPAS Pro v1.33. APM (Automated Point Matching) measurements were generated to tie image strips and bands within strips together relatively using Leica GPro v3.3.1. Upon completion of APM, AT processing was performed using Leica ORIMA/CAP-A v9.1. Controls are measured and bundle adjustments are run using the controls to define the datum. Throughout an adjustment's iterations, statistical measures are used to detect and remove blunders in the APM and to refine the image coordinate measurements, ending with a final adjustment to the block of photography. After each adjustment, the resulting block statistics are thoroughly analyzed. These statistics provide a check on the quality of automatic and manual point measurements, ground controls, GPS/INS data, and the resulting exterior orientation parameters. This process ultimately produces a refined, final adjustment for the block of photography meeting all standards for photography at the scale it was flown.

There were 20 control points supplied for the project. All controls were measurable and used in the AT.

The achieved results for each component of the AT are included in the table below. These values are taken or computed from the block printouts. Sigma0 is a measure of the overall adjustment. GPS and IMU RMS reflect the remaining random errors in those components. Tie point RMS values reflect the average accuracy which was achieved at all terrain points. Control point RMS values reflect an average movement of the controls and is computed from the residuals of all control points. Control points define the datum for the blocks and, because

of their importance, a more informative table containing all control points in US survey feet is also included.

The block printout for the AT block is not included within this report. Its length and formatting does not lend itself to proper viewing here. However, it is included along with this report and is best viewed in WordPad or NotePad with the wordwrap feature turned off.

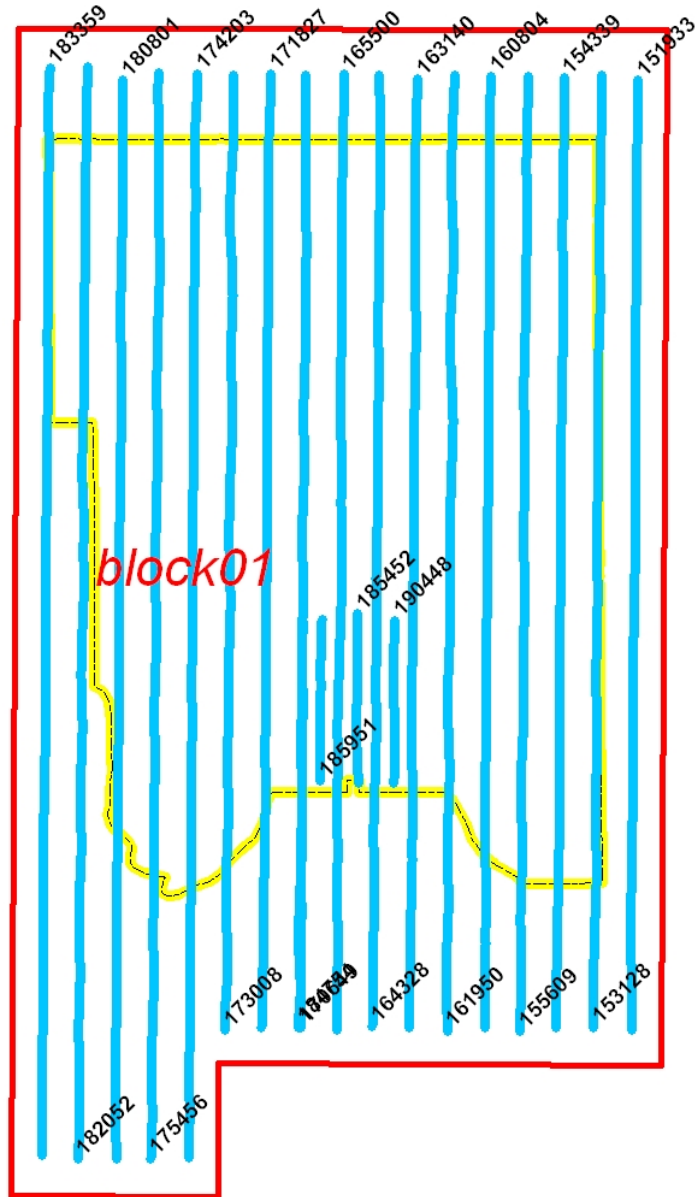|	Block01
Sigma0 (mm)	2.9
GPS RMS X (m)	0.009
GPS RMS Y (m)	0.010
GPS RMS Z (m)	0.014
IMU RMS O (deg)	0.0013
IMU RMS P (deg)	0.0012
IMU RMS K (deg)	0.0045
Tie points RMS X (m)	0.0716
Tie points RMS Y (m)	0.0518
Tie points RMS Z (m)	0.1557
Control Points RMS X (m)	0.0326
Control Points RMS Y (m)	0.0287
Control Points RMS Z (m)	0.0274

AT Control Residuals   Ramsey County, MN

Horizontal datum: NAD83(86), Ramsey Coordinate System
Vertical datum: NAVD 88 (Geoid03)
Unit: US Survey Foot

Block01

| Type	PT ID	INPUT CONTROL X	Y	Z	ADJUSTED CONTROL X	Y	Z		Res. X	Res. Y	Res. Z
Full	CP_01	540177.910	221607.160	912.200	540178.001	221607.151	912.263		0.091	-0.009	0.063
Full	CP_02	556903.710	221554.260	886.700	556903.722	221554.374	886.691		0.012	0.114	-0.009
Full	CP_03	573891.980	221538.760	906.900	573891.944	221538.867	906.912		-0.036	0.107	0.012
Full	CP_04	592401.420	221528.040	919.600	592401.513	221527.933	919.324		0.093	-0.107	-0.276
Full	CP_05	600852.420	221530.120	941.400	600852.356	221529.851	941.293		-0.064	-0.269	-0.107
Full	CP_07	540434.870	189209.730	957.300	540434.674	189209.681	957.274		-0.196	-0.049	-0.026
Full	CP_08	553215.560	189261.900	926.400	553215.308	189261.920	926.408		-0.252	0.020	0.008
Full	CP_09	571617.120	192003.670	924.700	571617.165	192003.765	924.603		0.045	0.095	-0.097
Full	CP_10	589869.880	188490.760	912.900	589869.898	188490.779	912.841		0.018	0.019	-0.059
Full	CP_13	545590.200	164462.440	909.100	545590.161	164462.384	909.206		-0.039	-0.056	0.106
Full	CP_14	557243.330	163146.520	934.000	557243.384	163146.434	933.960		0.054	-0.086	-0.040
Full	CP_15	577685.180	163521.060	814.300	577685.023	163521.038	814.319		-0.157	-0.022	0.019
Full	CP_16	592015.810	162907.960	935.400	592015.808	162907.919	935.215		-0.002	-0.041	-0.185
Full	CP_17	603138.010	173600.300	1011.200	603138.056	173600.232	1011.225		0.046	-0.068	0.025
Full	CP_22	549806.530	137680.670	808.700	549806.544	137680.683	808.743		0.014	0.013	0.043
Full	CP_24	566576.490	136487.660	820.000	566576.467	136487.736	819.974		-0.023	0.076	-0.026
Full	CP_25	590747.480	136228.630	708.600	590747.616	136228.709	708.604		0.136	0.079	0.004
Full	CP_26	603493.910	136571.490	984.700	603494.123	136571.483	984.759		0.213	-0.007	0.059
Full	CP_21-09	540455.011	141699.231	836.572	540455.053	141699.359	836.551		0.042	0.128	-0.021
Full	CP_23-09	557038.479	135314.491	764.139	557038.513	135314.552	764.183		0.034	0.061	0.044
								RMSE	**0.106**	**0.092**	**0.090**

Ramsey County MN - AT Block Layout

block01

Legend:
- AT block
- 041409_3547G_SH104_scan-on
- Ramsey Co

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0 0.5 1   2   3   4   5
Miles
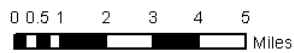
Ramsey County MN - AT Control Layout
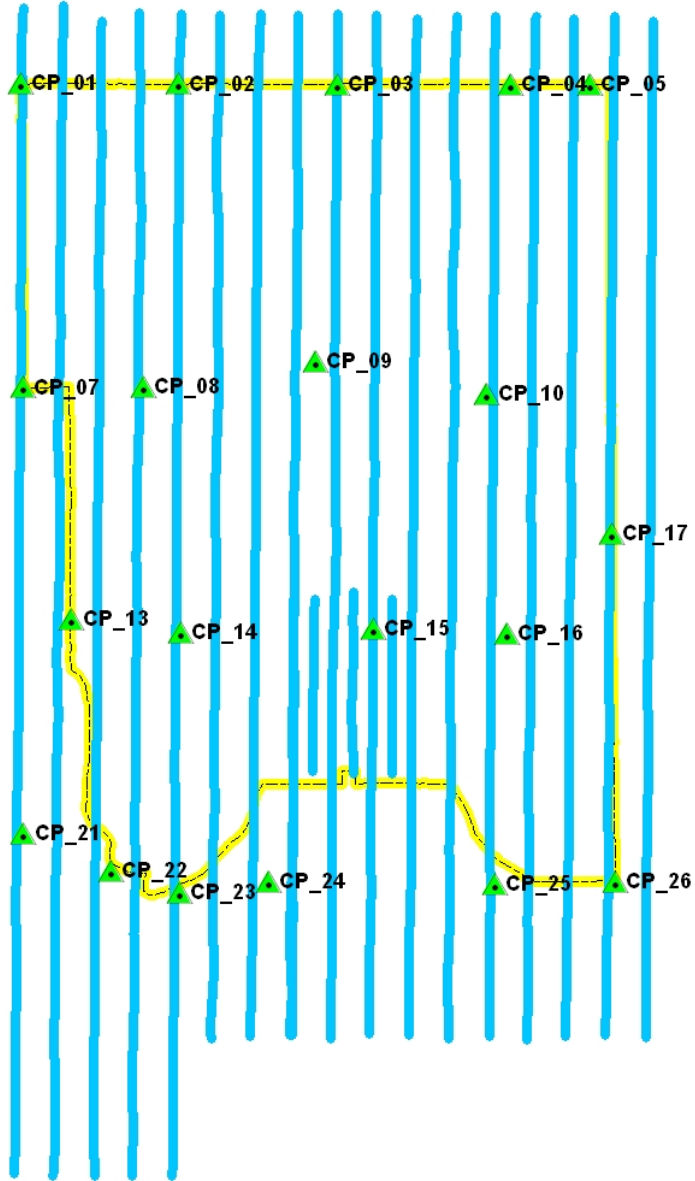
Control point
041409_3547G_SH104_scan-on
Ramsey Co

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0 0.5 1   2   3   4   5
Miles