Wantman Group, Inc. (WGI)

FireFLY6 Pro RTK Accuracy Assessment

The Wantman Group Inc. (WGI), is an engineering and survey firm based in Florida with office in 7 states. WGI has a history of implementing leading edge technology to better facilitate our client needs. Adding an RTK UAS to our fleet was a practical leap on our UAS roadmap.

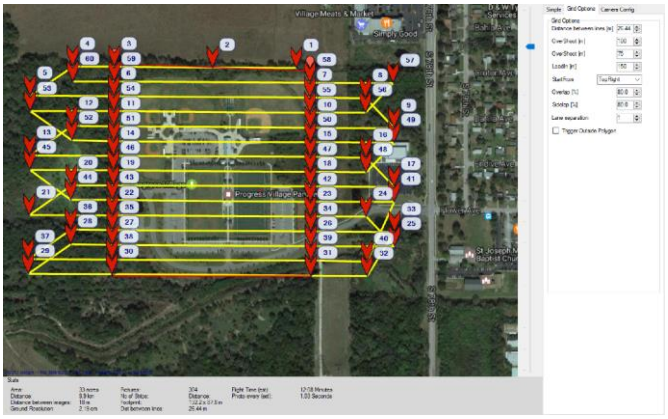
We received our FireFly 6 Pro RTK UAS months earlier and immediately began running it through numerous test at our bore site location in Tampa. As part of our UAS Program we established a bore site with 20 photo identifiable points that have been leveled through to @ .02'. We typically use this location as a baseline to test the accuracy of new hardware and software. With the RTK UAS, our goal was to determine the optimum altitudes, and overlap that would provide the highest quality imagery and the most benefit from our new RTK solution.

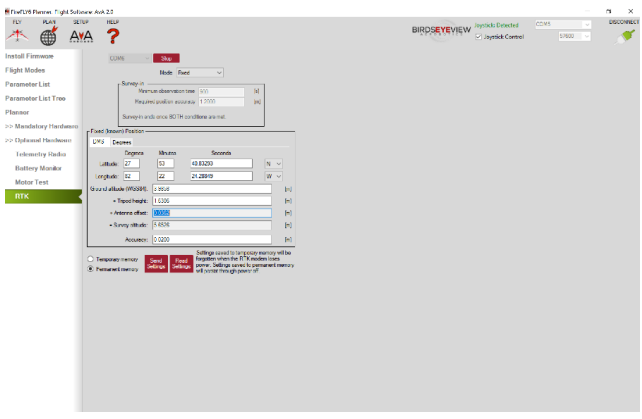
Below are the parameters used in testing and the test results.

Single Pass Method

System: FireFLY6 Pro RTK
Flying Height: 90m (295') AGL
Mission Plan: Traditional E - W
Overlap: 80/80
Camera: Sony A600 24 Mega Pixel
Processing Software: SimActive
Validation Software: QGIS

One mission was flown to create a grid pattern of imagery, our RTK Receiver was set to Fixed Mode over point 112, the coordinates and height information were added and allowed to collect data until it gained a fixed position.



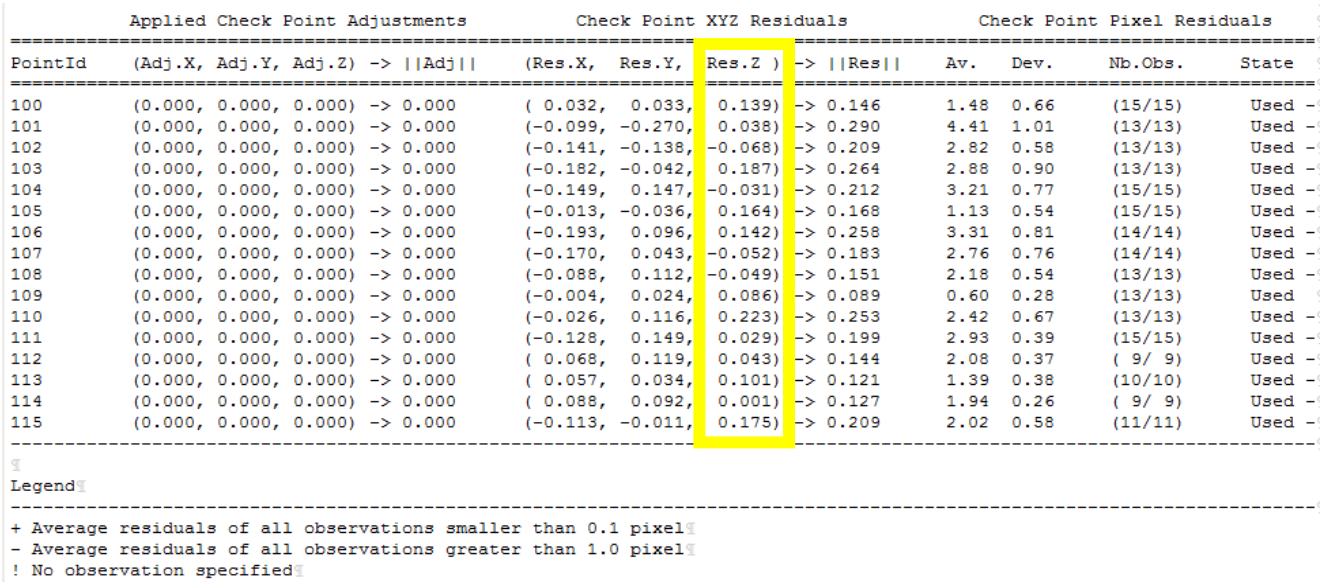


Using NSSDA Accuracy Reporting Guidelines: The Elevation Model (DTM) meets NSSDA Half-Foot Contour Vertical Accuracy*

NSSDA Half-Foot Contour - Vertical Accuracy Assessment				
Reference: FGDC's Geospatial Positioning Accuracy Standards				
National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998				
FireFLY6 Pro RTK Fixed Mode Test - Single Pass Pattern 90m (300') 80/80 OL				
QC Point Number	**QA/QC Points as Surveyed Elevation (ft)**	**Elevation Points as Measured Elevation (ft)**	**Δz (ft)**	**Δz^2 (ft^2)**
100	13.558	13.697	0.139	0.019
101	13.652	13.690	0.038	0.001
102	14.617	14.549	-0.068	0.005
103	14.426	14.613	0.187	0.035
104	14.430	14.399	-0.031	0.001
105	15.244	15.408	0.164	0.027
106	15.648	15.790	0.142	0.020
107	15.683	15.631	-0.052	0.003
108	15.106	15.057	-0.049	0.002
109	14.230	14.316	0.086	0.007
110	14.475	14.698	0.223	0.050
111	15.113	15.142	0.029	0.001
112	13.077	13.120	0.043	0.002
113	13.515	13.616	0.101	0.010
114	13.127	13.128	0.001	0.000
115	13.909	14.084	0.175	0.031
Point Count			Sum of Squares	0.214
16	**Half-Foot Contour Vertical Accuracy Acceptance Criteria**		MSE	0.013
	RMSEz should = 0.15 ft or less		**RMSEz**	**0.116**
	NSSDA ACCURACYr must = 0.3 ft or less at 95% confidence level		**NSSDA ACCURACYv (ft)**	**0.227**
	The relationship of the RMSE values and the 95 percent confidence intervals is as follows:			
	Vertical Accuracy = 1.9600 x RMSEz			
	Where RMSEz is the RMSE of the vertical differences			

* Elevations were derived from a comparison of field surveyed spot elevations and Photo Identifiable check points with the surface (DTM) created in SimActive.

SimActive Report us d to populate NSSDA spreadsheet.



	Applied Check Point Adjustments	Check Point XYZ Residuals			Check Point Pixel Residuals			
PointId	(Adj.X, Adj.Y, Adj.Z) -> ||Adj||	(Res.X,	Res.Y,	Res.Z) -> ||Res||	Av.	Dev.	Nb.Obs.	State
100	(0.000, 0.000, 0.000) -> 0.000	(0.032,	0.033,	0.139) -> 0.146	1.48	0.66	(15/15)	Used
101	(0.000, 0.000, 0.000) -> 0.000	(-0.099,	-0.270,	0.038) -> 0.290	4.41	1.01	(13/13)	Used
102	(0.000, 0.000, 0.000) -> 0.000	(-0.141,	-0.138,	-0.068) -> 0.209	2.82	0.58	(13/13)	Used
103	(0.000, 0.000, 0.000) -> 0.000	(-0.182,	-0.042,	0.187) -> 0.264	2.88	0.90	(13/13)	Used
104	(0.000, 0.000, 0.000) -> 0.000	(-0.149,	0.147,	-0.031) -> 0.212	3.21	0.77	(15/15)	Used
105	(0.000, 0.000, 0.000) -> 0.000	(-0.013,	-0.036,	0.164) -> 0.168	1.13	0.54	(15/15)	Used
106	(0.000, 0.000, 0.000) -> 0.000	(-0.193,	0.096,	0.142) -> 0.258	3.31	0.81	(14/14)	Used
107	(0.000, 0.000, 0.000) -> 0.000	(-0.170,	0.043,	-0.052) -> 0.183	2.76	0.76	(14/14)	Used
108	(0.000, 0.000, 0.000) -> 0.000	(-0.088,	0.112,	-0.049) -> 0.151	2.18	0.54	(13/13)	Used
109	(0.000, 0.000, 0.000) -> 0.000	(-0.004,	0.024,	0.086) -> 0.089	0.60	0.28	(13/13)	Used
110	(0.000, 0.000, 0.000) -> 0.000	(-0.026,	0.116,	0.223) -> 0.253	2.42	0.67	(13/13)	Used
111	(0.000, 0.000, 0.000) -> 0.000	(-0.128,	0.149,	0.029) -> 0.199	2.93	0.39	(15/15)	Used
112	(0.000, 0.000, 0.000) -> 0.000	(0.068,	0.119,	0.043) -> 0.144	2.08	0.37	(9/ 9)	Used
113	(0.000, 0.000, 0.000) -> 0.000	(0.057,	0.034,	0.101) -> 0.121	1.39	0.38	(10/10)	Used
114	(0.000, 0.000, 0.000) -> 0.000	(0.088,	0.092,	0.001) -> 0.127	1.94	0.26	(9/ 9)	Used
115	(0.000, 0.000, 0.000) -> 0.000	(-0.113,	-0.011,	0.175) -> 0.209	2.02	0.58	(11/11)	Used

Legend

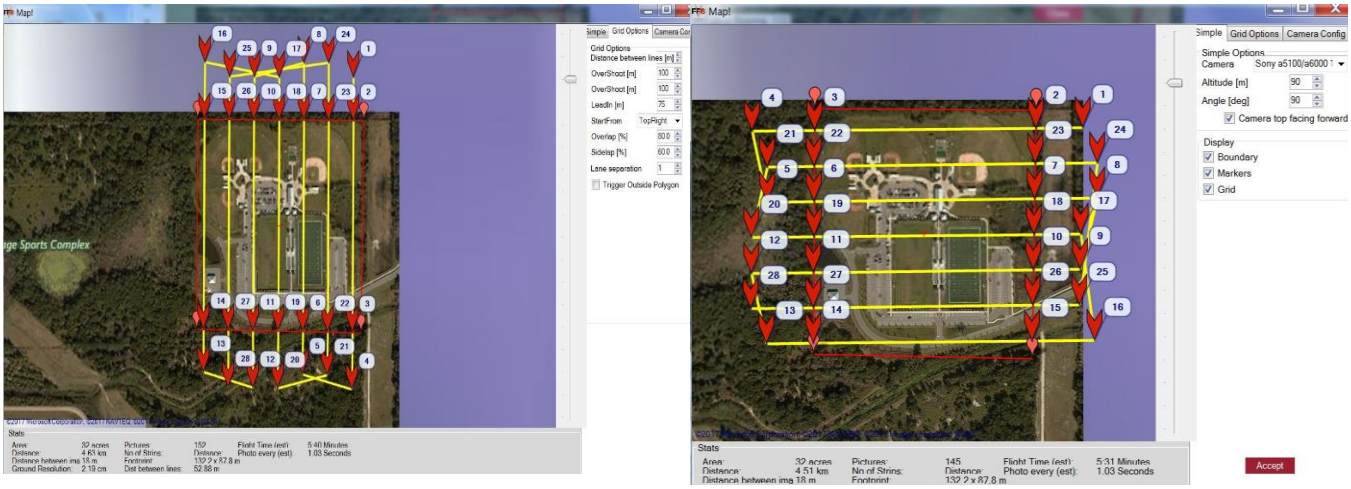
\+ Average residuals of all observations smaller than 0.1 pixel
\- Average residuals of all observations greater than 1.0 pixel
! No observation specified

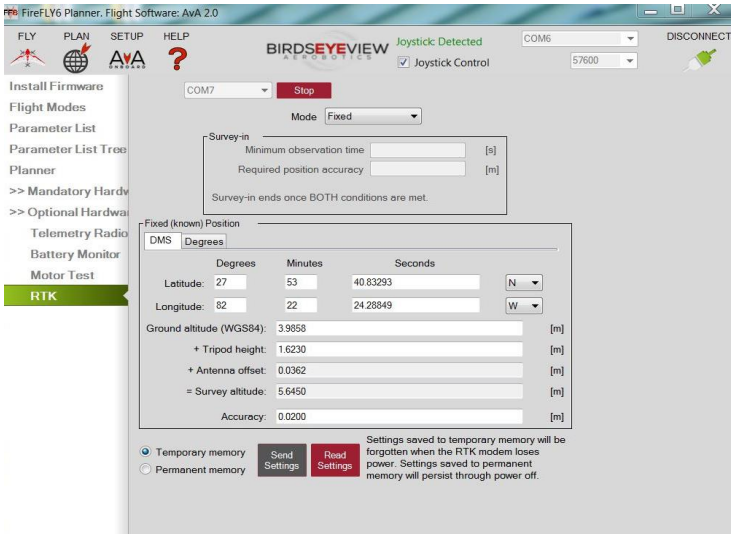
Grid Pattern Method

It was suggested that a “grid pattern” method might yield better results, so we tested this as well.

System: FireFLY6 Pro RTK
Flying Height: 90m (295’) AGL
Mission Plan: Grid pattern, Flights N – S and E - W
Overlap: 80/60
Camera: Sony A600 24 Mega Pixel
Processing Software: SimActive
Validation Software: QGIS

Two missions were flown to create a grid pattern of imagery, Our RTK Receiver was set to Fixed Mode over point 112, the coordinates and height information were added and allowed to collect data until it gained a fixed position.





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NSSDA Half-Foot Contour - Vertical Accuracy Assessment				
Reference: FGDC's Geospatial Positioning Accuracy Standards				
National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998				
FireFLY6 Pro RTK Fixed Mode Test - Cross Flight Pattern 90m (300') 80/60 OL				
QC Point Number	**QA/QC Points as Surveyed Elevation (ft)**	**Elevation Points as Measured Elevation (ft)**	**Δz (ft)**	**Δz^2 (ft^2)**
100	13.558	13.609	0.051	0.003
101	13.652	13.627	-0.025	0.001
102	14.617	14.674	0.057	0.003
103	14.426	14.441	0.015	0.000
104	14.430	14.524	0.094	0.009
105	15.244	15.211	-0.033	0.001
106	15.648	15.685	0.037	0.001
107	15.683	15.736	0.053	0.003
108	15.106	15.213	0.107	0.011
109	14.230	14.300	0.070	0.005
110	14.475	14.724	0.249	0.062
111	15.113	15.158	0.045	0.002
112	13.077	13.287	0.210	0.044
113	13.515	13.390	-0.125	0.016
114	13.127	13.345	0.218	0.048
115	13.909	13.835	-0.074	0.005
Point Count			Sum of Squares	0.214
16	**Half-Foot Contour Vertical Accuracy Acceptance Criteria**		MSE	0.013
	RMSEz should = 0.15 ft or less		**RMSEz**	**0.116**
	NSSDA ACCURACYr must = 0.3 ft or less at 95% confidence level		**NSSDA ACCURACYv (ft)**	**0.227**
	The relationship of the RMSE values and the 95 percent confidence intervals is as follows:			
	Vertical Accuracy = 1.9600 x RMSEz			
	Where RMSEz is the RMSE of the vertical differences			

* Elevations were derived from a comparison of field surveyed spot elevations and Photo Identifiable check points with the surface (DTM) created in SimActive.

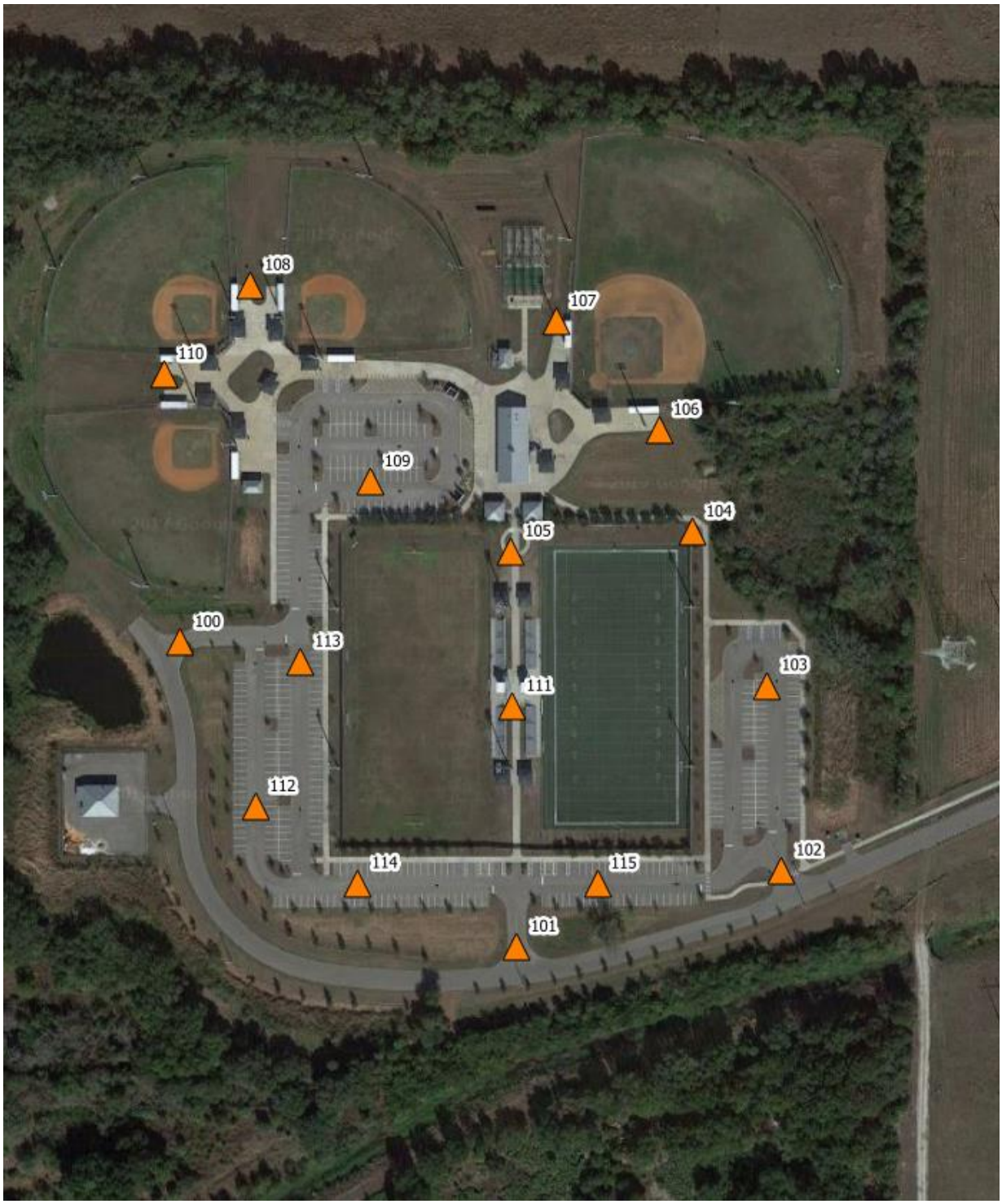
SimActive Report used to populate NSSDA spreadsheet.

	Applied Check Point Adjustments	Check Point XYZ Residuals		Check Point Pixel Residuals			
PointId	(Adj.X, Adj.Y, Adj.Z) -> ||Adj||	(Res.X, Res.Y, Res.Z)	-> ||Res||	Av.	Dev.	Nb.Obs.	State
100	(0.000, 0.000, 0.000) -> 0.000	(-0.105, -0.015, 0.051)	-> 0.118	1.67	0.44	(14/14)	Used -
101	(0.000, 0.000, 0.000) -> 0.000	(-0.051, -0.168, -0.025)	-> 0.177	2.77	0.57	(15/15)	Used -
102	(0.000, 0.000, 0.000) -> 0.000	(-0.019, -0.054, 0.057)	-> 0.081	1.05	0.55	(11/11)	Used -
103	(0.000, 0.000, 0.000) -> 0.000	(-0.112, -0.064, 0.015)	-> 0.130	1.97	0.41	(12/12)	Used -
104	(0.000, 0.000, 0.000) -> 0.000	(-0.079, 0.041, 0.094)	-> 0.129	1.62	0.60	(15/15)	Used -
105	(0.000, 0.000, 0.000) -> 0.000	(-0.039, -0.050, -0.033)	-> 0.071	1.08	0.39	(15/15)	Used -
106	(0.000, 0.000, 0.000) -> 0.000	(-0.169, 0.071, 0.037)	-> 0.187	2.86	0.55	(14/14)	Used -
107	(0.000, 0.000, 0.000) -> 0.000	(-0.192, -0.014, 0.053)	-> 0.200	2.88	0.54	(14/14)	Used -
108	(0.000, 0.000, 0.000) -> 0.000	(-0.203, 0.039, 0.107)	-> 0.233	3.15	0.58	(15/15)	Used -
109	(0.000, 0.000, 0.000) -> 0.000	(0.050, 0.003, 0.070)	-> 0.086	0.98	0.48	(13/13)	Used
110	(0.000, 0.000, 0.000) -> 0.000	(-0.102, 0.110, 0.249)	-> 0.291	2.34	1.09	(15/15)	Used -
111	(0.000, 0.000, 0.000) -> 0.000	(-0.104, 0.171, 0.045)	-> 0.205	3.16	0.78	(15/15)	Used -
112	(0.000, 0.000, 0.000) -> 0.000	(-0.079, 0.135, 0.210)	-> 0.262	2.20	1.05	(15/15)	Used -
113	(0.000, 0.000, 0.000) -> 0.000	(-0.037, 0.059, -0.125)	-> 0.143	1.44	0.57	(15/15)	Used -
114	(0.000, 0.000, 0.000) -> 0.000	(-0.101, 0.153, 0.218)	-> 0.285	3.00	1.04	(15/15)	Used -
115	(0.000, 0.000, 0.000) -> 0.000	(-0.062, 0.062, -0.074)	-> 0.115	1.53	0.60	(15/15)	Used -

Legend

+ Average residuals of all observations smaller than 0.1 pixel
- Average residuals of all observations greater than 1.0 pixel
! No observation specified

Check Point Distribution



Conclusion

Prior to acquisition the base station provided was set on point 112. As offset was measured to count for the RTK units height above the point and input into mission planners RTK set up page. The RTK unit soaked for approximately 10 minutes before giving us the recommended 3D fix @ 1.4 cm. Once the 3D fix was acquired, the missions were run. After field verification, the imagery was processed in back in our office with SimActive. WGI worked with SimActive in developing a workflow to ingest RTK derived image positions. After reading the images and creating the tie points, a bundle adjustment was performed. All Check Points were withheld during this process and compared with the solution upon completion.

The results were very good in both scenarios, in fact pretty much identical. It is our opinion that the grid pattern is unnecessary, with regard to the RTK solution.

We have since run many similar test and recommend the following as best practices when using the FireFly 6 Pro RTK.

- Higher is better, the RTK seems to hold a better solution the higher up you are. This was only tested to 120m/400ft. In addition our deliverables are typically topographic maps derived from imagery. Given the quality of sensors Sony's A6000 (24 megapixel) and A7R (36 megapixel), one can typically meet desired accuracies at our FAA mandated ceiling.
- Grid patterns do not improve overall results with regard to the FireFLY 6 Pro RTK. Time is money and this method doubles your time in acquisition and processing with no verified benefit. There may be some cases where it's of value for other reasons, but don't expect it to improve the RTK solution.
- Overlap is important. 80/80 OL/SL yield the best results, but at 80/60 OL/SL we achieve similar results. If time allows, go with the 80/80.
- Always include plenty of photo identifiable check points.
    1. To validate your results and
    2. As insurance in the event you're RTK fails.