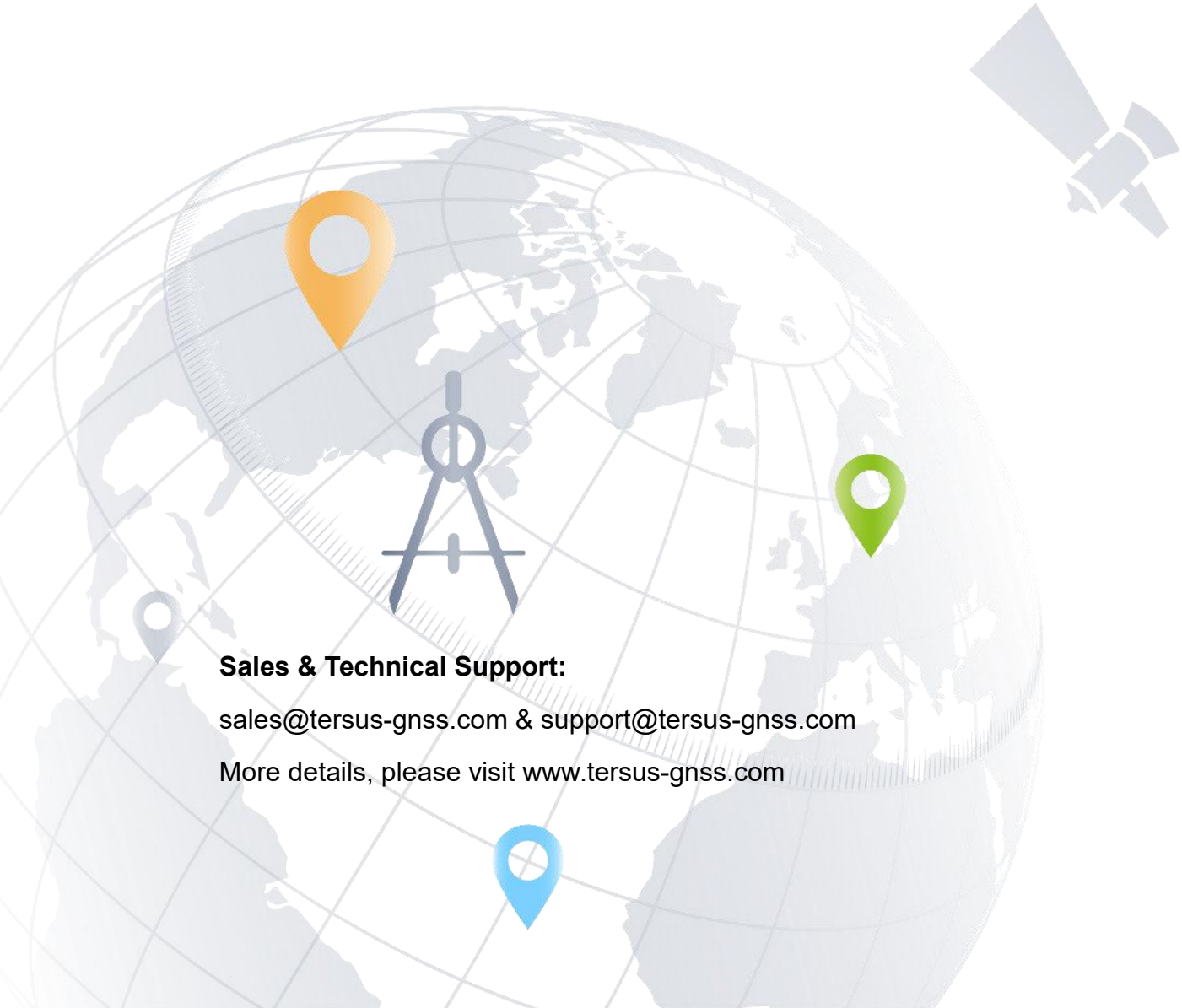
Application Note

Version V1.2-20190523

Aerial Survey Application by using Tersus GNSS UAV PPK Solution



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Revision History

Revision	Description	Date	Owner
1.0	Issued for Release	2018/07/16	MJF
1.1	Update with GeoPix software	2019/02/02	LC
1.2	Update cover photo	2019/05/23	LC

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1. Introduction

The Tersus Post-Processing Kinematic (PPK) solution includes one dual frequency GPS / GLONASS / BeiDou receiver BX316R, one AX3705 Helix Antenna and Tersus GeoPix software. They allow cm-level position referencing of OrthoMosaic photos and 3D models without the Ground Control Points (GCPs). It saves hours of mission planning and setup time for surveying.

The BX316R is a GNSS Post Processing Kinematic (PPK) receiver for accurate positioning. It can eliminate the datalink between the airplane and base station. All GNSS positioning data are stored on board in the BX316R PPK receiver, without a real-time data link with reference station. The BX316R is connected with hot shoe with the camera, we could get camera cm-level locations during the post-processing procedure after flight. The corrected image positions are directly added to the image EXIF using Tersus GeoPix software and can be imported to photogrammetric software packages.

Figure 1.1 Over looking at the area to be tested

The objective of the test is to validate the accuracy and precision of the BX316R UAV PPK solution.

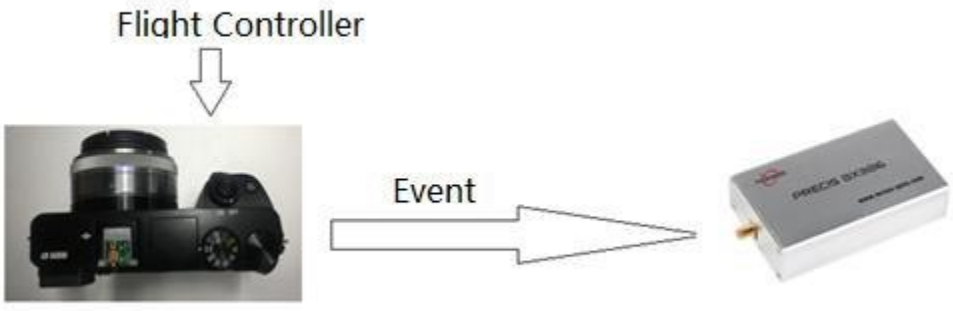

Figure 1.2 Connection of the BX316R with camera

2. Survey Area

The test site is located in Shanghai, China.

Figure 2.1 Location Map

Information about acquired data

Altitude: 120m

Average Ground Sampling Distance (GSD) 2.34 cm

Area Covered: 0.0239 km^2.

3. Equipment

The BX316R is a GNSS PPK receiver for cm-level positioning and accurate raw measurements output, which can be integrated with autopilots and inertial navigation units.

In parallel the BX316R receiver records the shutter events of the camera and logs the GNSS raw measurements information during flight on an on-board memory /SD card.

TY-M400 PPK drone carried the Sony A6000 camera with a 16mm wide angle lens providing a nominal Ground Sampling Distance (GSD) of 2.34cm at 120 meters.

4. Data Collection and Processing

The accuracy of UAV PPK system is validated by comparing the results of aerial surveys with precisely measured verification points (GCPs). The verification workflow includes following steps:

4.1 Surveying the Control Points

The majority of the control points were selected in the crosswalk line and it was very easy to find. All points were measured by a Tersus David GNSS survey grade receiver using RTK corrections from local QXWZ VRS. The ground survey produced a horizontal accuracy of 8mm and a vertical accuracy of 10mm. The details of David GNSS Receiver refers to website https://www.tersus-gnss.com/product/david-receiver .

Figure 4.1 Tersus David GNSS Receiver

Figure 4.2 Surveying the GCPs

	A	B	C	D
1	PT1	N31.167797774	E121.608650556	14.64
2	PT2	N31.167700728	E121.608525457	14.68
3	PT3	N31.167302628	E121.608790463	14.88
4	PT4	N31.166541293	E121.609156887	15.41
5	PT5	N31.166109647	E121.609612978	15.41
6	PT6	N31.165924077	E121.609393613	15.79
7	PT7	N31.166045672	E121.609189010	16.25
8	PT8	N31.167963353	E121.608392907	14.59
9	PT9	N31.168797698	E121.607966002	15.88
10	PT10	N31.168843687	E121.608021910	16

Figure 4.3 Position of the GCPs Surveyed by Surveyor

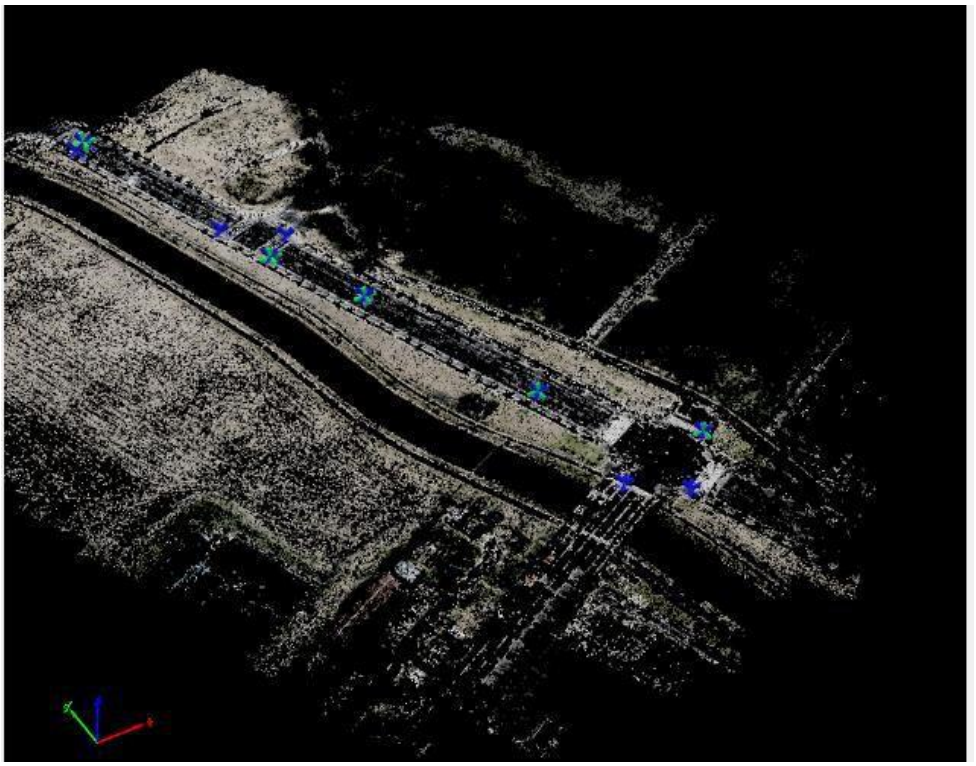

Figure 4.4 GCPs

4.2 Reference Base Station

The PPK does not need a real-time data link with a base station during a flight. However, GNSS raw data has to be recorded by base station in rate 1HZ. (We set the BX316R in the drone with 5HZ refresh rate)

Figure 4.5 Recording GNSS Data

4.3 Aerial Survey

- Flight altitudes: 120 meters
- Image overlap: 65% side lap 70%
- Camera settings: Auto/ shutter priority
- Camera lenses: 16mm wide angle lens
- Flight time: 7 minutes
- A total of 46 pictures have taken during the flight.

Figure 4.6 UAV with a camera

Figure 4.7 Arial Survey route

4.4 Post-Processing

After flight, camera's positions were produced by combining GNSS recordings of the aircraft with the corresponding information of the reference base station on the ground. We use the GeoPix software to process data in this test. Below figures has shown the positions of the camera after processing.

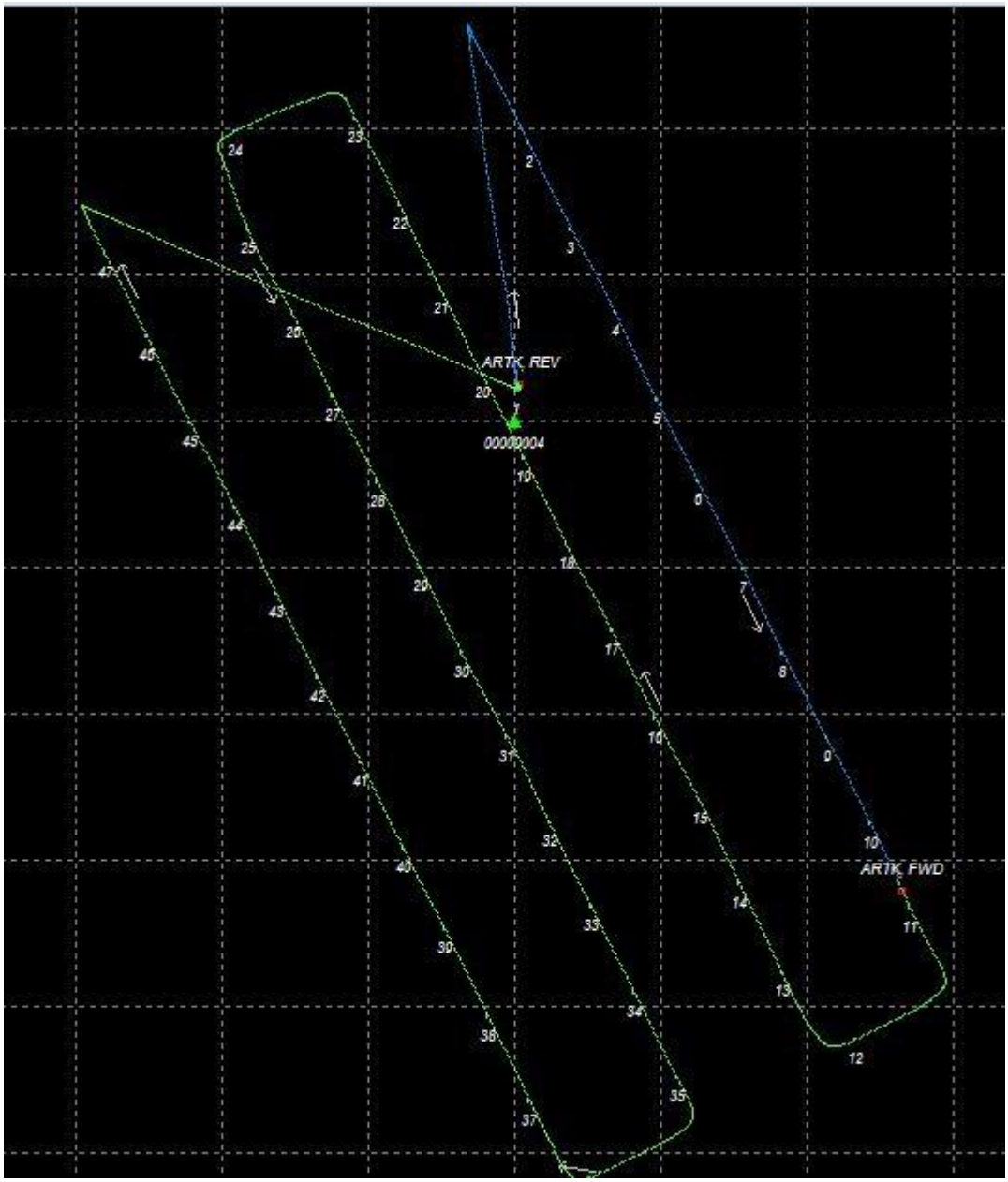

Figure 4.8 Positions image of the camera

Station	GPSTime (HMS)	UTCTime (sec)	Latitude (deg)	Longitude (deg)	H-Ell (m)	SDHori (m)	SDHeig (m)	Q
1	2:46:07.5	355550.56	31.167887311874	121.6086577505	15.023	0.013	0.019	1
2	2:48:10.6	355673.70	31.168648298215	121.6087038897	121.946	0.016	0.018	1
3	2:48:17.4	355680.41	31.168385685562	121.6088558278	122.020	0.015	0.017	1
4	2:48:23.8	355686.82	31.168129552340	121.6090128522	121.821	0.015	0.016	1
5	2:48:30.4	355693.47	31.167862185405	121.6091620347	121.780	0.015	0.015	1
6	2:48:36.8	355699.90	31.167609800215	121.6093117743	122.214	0.014	0.014	1
7	2:48:43.5	355706.55	31.167343547138	121.6094712171	123.224	0.010	0.013	1
8	2:48:50.1	355713.20	31.167083321424	121.6096167528	123.823	0.010	0.011	1
9	2:48:56.9	355719.95	31.166823238550	121.6097720325	123.975	0.010	0.010	1
10	2:49:03.5	355726.54	31.166558212682	121.6099321874	124.103	0.009	0.019	1
11	2:49:10.1	355733.19	31.166302227959	121.6100718174	123.327	0.009	0.015	1
12	2:49:25.9	355748.91	31.165899710139	121.6098742141	125.171	0.008	0.015	1
13	2:49:36.4	355759.45	31.166107488258	121.6096106069	125.384	0.009	0.015	1
14	2:49:43.3	355766.31	31.166375853918	121.6094603547	125.432	0.009	0.015	1
15	2:49:49.8	355772.85	31.166633844012	121.6093158516	125.545	0.009	0.015	1
16	2:49:56.1	355779.11	31.166882754394	121.6091600418	125.471	0.009	0.015	1
17	2:50:02.8	355785.83	31.167151789784	121.6090026778	125.273	0.009	0.015	1
18	2:50:09.4	355792.43	31.167415352338	121.6088402044	124.967	0.009	0.015	1
19	2:50:16.0	355799.05	31.167681598972	121.6086880231	124.959	0.009	0.015	1
20	2:50:22.5	355805.57	31.167939975085	121.6085351213	125.154	0.009	0.015	1
21	2:50:29.1	355812.11	31.168200035440	121.6083878265	125.631	0.008	0.015	1
22	2:50:35.7	355818.71	31.168460821914	121.6082392272	125.516	0.008	0.015	1
23	2:50:42.4	355825.43	31.168724574678	121.6080812040	125.274	0.008	0.015	1
24	2:50:54.6	355837.67	31.168685244715	121.6076473933	124.245	0.008	0.015	1
25	2:51:04.8	355847.85	31.168382978301	121.6076963684	123.639	0.008	0.015	1
26	2:51:11.6	355854.63	31.168125613693	121.6078566037	123.678	0.008	0.015	1
27	2:51:17.9	355860.93	31.167871624036	121.6080007613	124.078	0.008	0.015	1
28	2:51:24.6	355867.63	31.167608525995	121.6081621681	123.693	0.008	0.014	1
29	2:51:31.1	355874.15	31.167347207026	121.6083135824	123.837	0.008	0.014	1
30	2:51:37.7	355880.71	31.167083427697	121.6084647898	123.688	0.008	0.014	1
31	2:51:44.3	355887.35	31.166823788432	121.6086286915	123.243	0.008	0.014	1
32	2:51:50.7	355893.73	31.166566912973	121.6087773070	123.893	0.008	0.014	1
33	2:51:57.3	355900.31	31.166307643966	121.6089282533	124.069	0.008	0.014	1
34	2:52:03.8	355906.89	31.166040405166	121.6090853835	123.552	0.008	0.014	1
35	2:52:10.3	355913.33	31.165784802410	121.6092348851	123.389	0.008	0.014	1
36	2:52:23.1	355926.13	31.165490592000	121.6089587278	125.262	0.008	0.014	1
37	2:52:33.8	355936.85	31.165709637908	121.6087088177	125.748	0.008	0.014	1
38	2:52:40.5	355943.55	31.165969609827	121.6085585066	125.530	0.008	0.014	1
39	2:52:47.3	355950.35	31.166237156024	121.6084041979	125.100	0.008	0.014	1
40	2:52:53.5	355956.51	31.166483505610	121.6082559184	125.233	0.008	0.014	1
41	2:53:00.2	355963.23	31.166750622248	121.6081004749	125.139	0.008	0.014	1
42	2:53:06.6	355969.65	31.167008361425	121.6079486258	125.163	0.008	0.014	1
43	2:53:13.2	355976.21	31.167267865924	121.6077993373	125.336	0.008	0.014	1
44	2:53:19.8	355982.81	31.167530935558	121.6076498528	124.668	0.008	0.014	1
45	2:53:26.4	355989.45	31.167793336119	121.6074883746	124.662	0.008	0.014	1
46	2:53:33.0	355996.01	31.168055422712	121.6073356116	124.739	0.008	0.014	1

Figure 4.9 Positions data of the camera

We try to show two results, one is with 4 GCPs, and the other one is without GCP.

A: With 4 GCPs

We just use the 4 Control points to process the Photogrammetric by Agisoft PhotoScan software.

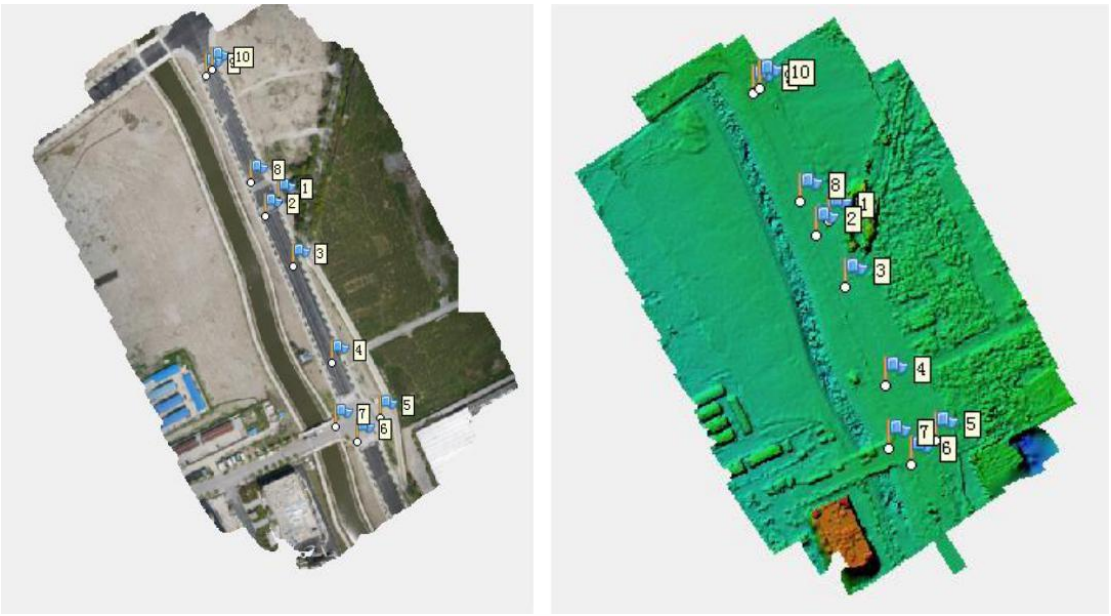

Figure 4.10 DOM and DEM

B: <u>Without Control Points we use the Smart 3D Capture Software to get 3D model.</u>

Figure 4.11 3D Model

5. Results

The figure below contains the full list of errors for each point, with Photoscan with 4 GCPs.

		Control Points			Photoscan with 4 GCPs			Accurancy		
		X	Y	Z	X	Y	Z	X	Y	Z
3	PT2	367388.4	3449021	14.68	367388.4	3449021	14.76	0.0321	0.0076	-0.08
4	PT3	367413.1	3448977	14.88	367413	3448977	15	0.07	0.0345	-0.12
5	PT4	367446.9	3448892	15.41	367446.9	3448892	15.49	-0.0221	0.0641	-0.08
6	PT5	367489.8	3448843	15.41	367489.7	3448844	15.47	0.0605	-0.0344	-0.06
7	PT6	367468.6	3448823	15.79	367468.6	3448823	15.88	0.0581	-0.0406	-0.09
8	PT7	367449.3	3448837	16.25	367449.3	3448837	16.37	-0.0454	0.0676	-0.12
9	PT8	367376.1	3449050	14.59	367376.1	3449050	14.68	-0.0333	-0.0322	-0.09
10	PT9	367336.6	3449143	15.88	367336.6	3449143	15.95	-0.0475	-0.0648	-0.07
11	PT10	367342	3449148	16	367342	3449148	16.07	-0.025	-0.0621	-0.07

Figure 5.1 The Accuracy of PPK with 4 GCPs

The figure below contains the full list of errors for each point, with Smart 3D, No GCPs.

A	B	C	D	E	F	G	H	I	J
	Control Points			smart3D no GCP			Accurancy		
	X	Y	Z	X	Y	Z	X	Y	Z
PT2	367388.4	3449021	14.68	367388.5	3449021	14.89	-0.1479	0.1176	-0.21
PT3	367413.1	3448977	14.88	367413.2	3448977	15.13	-0.1148	0.1345	-0.25
PT4	367446.9	3448892	15.41	367447	3448892	15.69	-0.0721	0.0951	-0.28
PT5	367489.8	3448843	15.41	367489.7	3448843	15.66	0.0705	0.1156	-0.25
PT6	367468.6	3448823	15.79	367468.6	3448823	16.01	0.0881	0.1694	-0.22
PT7	367449.3	3448837	16.25	367449.3	3448837	16.58	0.0346	0.1576	-0.33
PT8	367376.1	3449050	14.59	367376.2	3449050	14.81	-0.1133	0.0578	-0.22
PT9	367336.6	3449143	15.88	367336.7	3449143	15.88	-0.1575	0.1352	0
PT10	367342	3449148	16	367342	3449148	16.2	-0.086	0.1469	-0.2

Figure 5.2 The Accuracy of PPK without GCPs

6. Conclusion

Result 1 shows that we could reduce a lot of the GCPs with BX316R PPK receiver.

Result 2 shows that the accuracies are 8cm (horizontal) and 20cm (vertical) without the use of any ground control.

Our test have shown that the BX316R PPK solution is an efficient and reliable system for high accuracy aerial surveys without or use less of physical Ground Control Points. Our PPK workflow allows to easily combine high-resolution aerial images with high-precision GNSS data during the post-processing phase and to create high-quality OrthoMosaic and digital surface models.

7. Terminology

Abbreviation	Definition
DSM	Digital Surface Model
GCP	Ground Control Point
GIS	Geo-Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning Systems
PPK	Post Processing Kinematic
RTK	Real-Time Kinematic
UAV	Unmanned Aerial Vehicle
VRS	Virtual Reference Station

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