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Accuracy Assessment of POS AVX 210 integrated with the Phase One iXU150

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Introduction

The Applanix POS AVX 210 is a GNSS-Inertial solution designed to reduce the cost and improve the efficiency of mapping with small and medium format cameras. The single rugged enclosure contains a precision GNSS receiver and inertial sensor components, logging capability, plug and play interface for mapping sensors as well as TrackAir's Flight Management System (FMS).

This paper presents results using a plug and play directly georeferenced aerial mapping system consisting of an Applanix POS AVX 210, a Phase One iXU 150 camera with an 80mm lens and the NanoTrack FMS to produce highly accurate orthorectified imagery without Ground Control Points (GCPs). A flight test was conducted by Applanix and GeoPixel Air on a manned platform over an airborne testing and calibration range north of Toronto, Ontario, Canada. Details of the test flight, processing methodology and results are outlined in the proceeding sections of this document.

Configuration

The configuration for the flight test (Figure 1) was as follows:

- The POS AVX 210 GNSS-Inertial System
- Phase One iXU 150 camera (50MP; image size of 8280 columns by 6208 rows and a detector size of 5.3 microns) with a 80mm lens
- NanoTrack FMS with Pilot display
- Aircraft: Cessna 172

Figure 1: POS AVX 210, NanoTrack & Phase One iXU 150 sensor

The Phase One iXU 150 camera and 80mm lens combination were terrestrially calibrated using Applanix' in-house camera calibration facility (Figure 2) for approximate focal length, principal point and lens distortion parameters using a process certified by the U.S. Geological Survey (USGS). The camera and lens combination were subsequently installed in a custom mount so that it was rigidly attached to the POS AVX 210 system. The mounting ensured that the stability of both the interior orientation and IMU bore-sight calibration over shock and vibration was maintained.

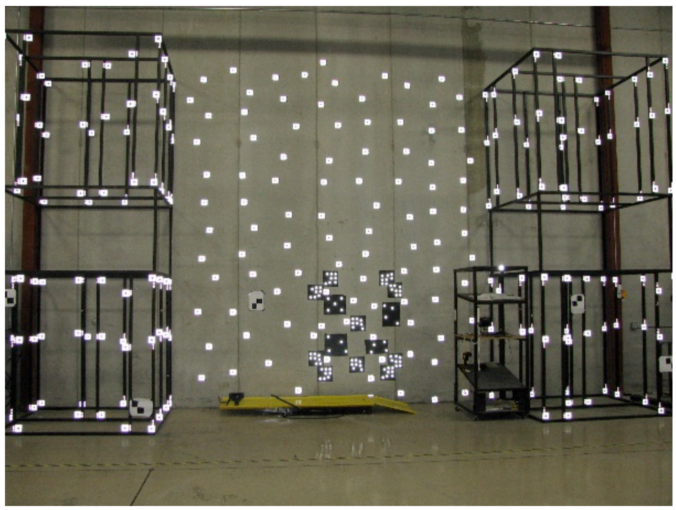

Figure 2: Applanix' in-house camera calibration facility

Test Description

On February 24, 2016, Applanix carried out a test flight of the system installed in a Cessna 172 operated by GeoPixel Air. The goals of this test flight included:

- Evaluation of the quality and performance of the Phase One iXU 150 camera with an 80 mm lens
- Assessment of the performance of the POS AVX 210 direct georeferencing system

The area mapped during the test was the Applanix Mount Albert test range in Ontario, Canada. It consisted of a square block, approximately 2km x 2km in size. A network of GCPs (Figure 3) are located within this test area. The test flight over this range was conducted with 4 North-South lines flown at 1100m AGL, resulting in a 7.2cm GSD and 4 East-West lines flown at 700m AGL, resulting in a 4.7cm GSD. The sidelap between strips was ~25% while the endlap within each strip was ~60%.

For the test flight, the relevant flight plan was created beforehand and uploaded into the NanoTrack FMS. After take-off, the aircraft pilot followed the instructions of the FMS to ensure that the planned mission parameters were being followed. The captured images and POS AVX 210 raw sensor data was subsequently downloaded for processing and analysis.

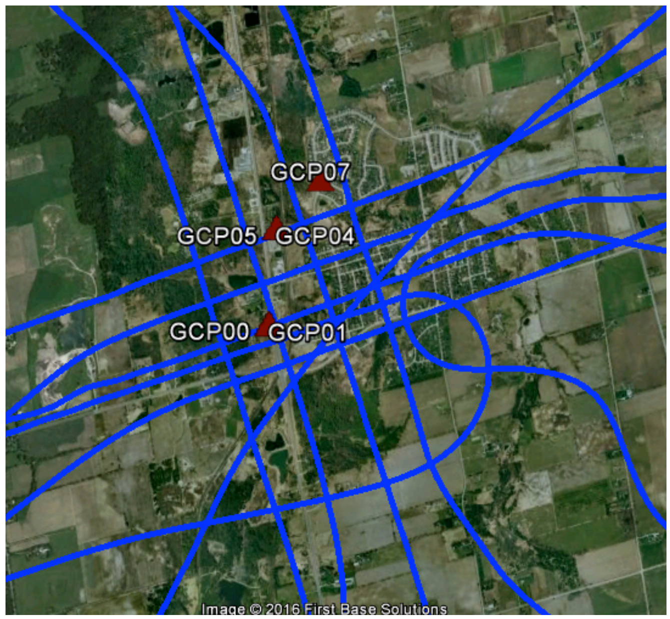

Figure 3: GCP distribution for the block

Processing Methodology

The GNSS-Inertial data collected by the POS AVX 210 was post-processed in POSPac MMS version 7 in Single Base mode, using a base station located within the project area (Figure 4 & 5). This base station operates continuously, and its position was precisely determined by processing a number of 24-hour sessions using the Trimble CenterPoint RTX Post Processing service.

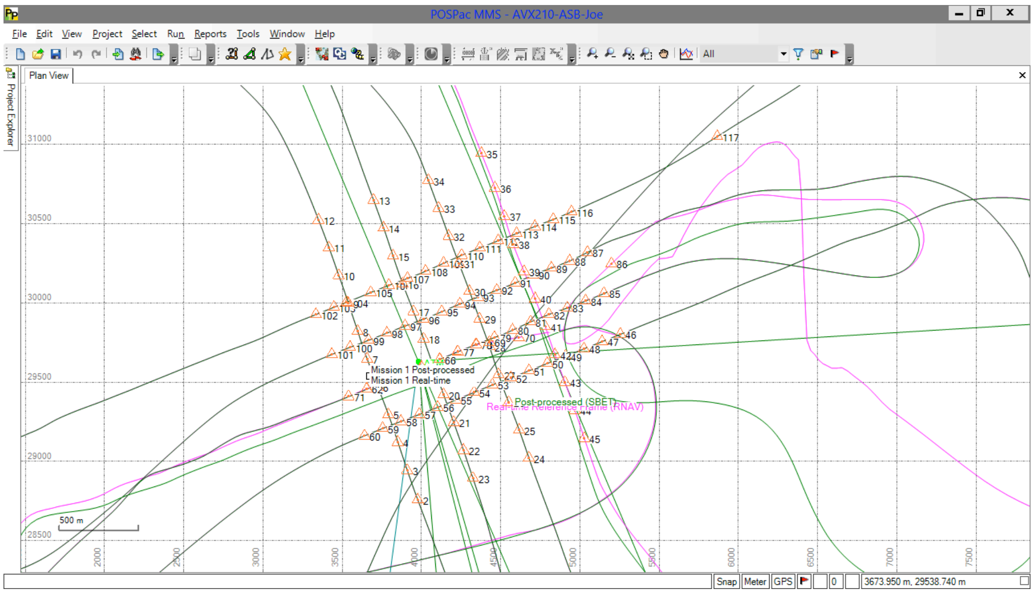

Figure 4: POS AVX 210 trajectory with photo centers

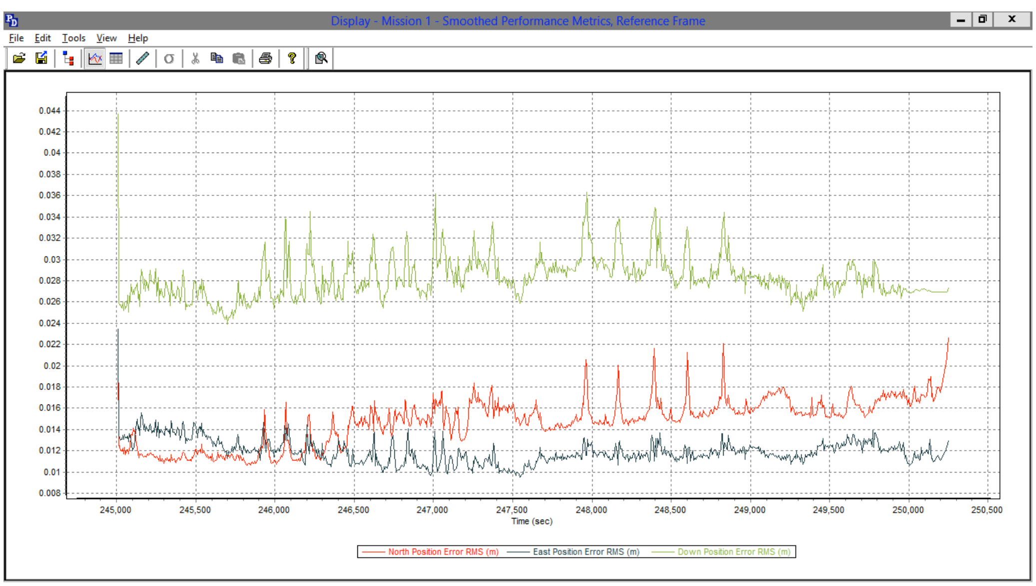

Figure 5: POSPac trajectory RMS estimate

The mission data was processed through the Applanix Calibration and Quality Control application (CalQC) - bundle adjustment software. First, tie points were extracted using the a priori EO from POSPac MMS and the approximate camera interior orientation from the terrestrial calibration. The tie-points and a priori EO were then run in a bundle adjustment where the IMU-camera misalignment (boresight) angles were estimated and the focal length and principal point offsets refined from their approximate values using the Integrated Sensor Orientation (ISO) approach. Lens distortion parameters were held fixed. A single 3-dimensional control point was used as part of the bundle adjustment (Figure 6) to perform quality control on the focal length. The refined camera parameters, updated EO and boresight estimates were subsequently used to generate the final map products.

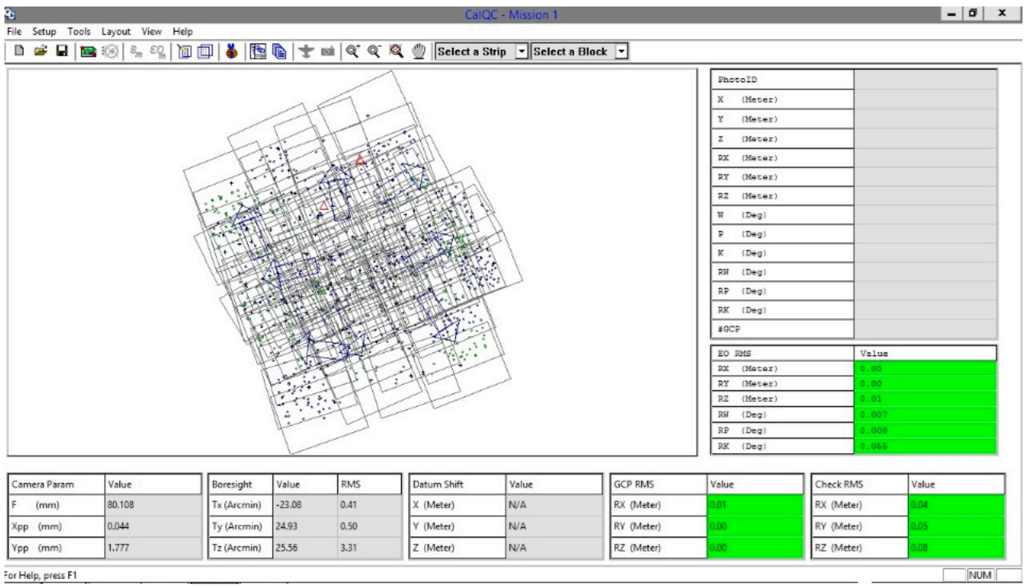

Figure 6: CalQC bundle adjustment project

Accuracy Assessment

A map view of the directly georeferenced orthorectified imagery is shown in Figure 7:

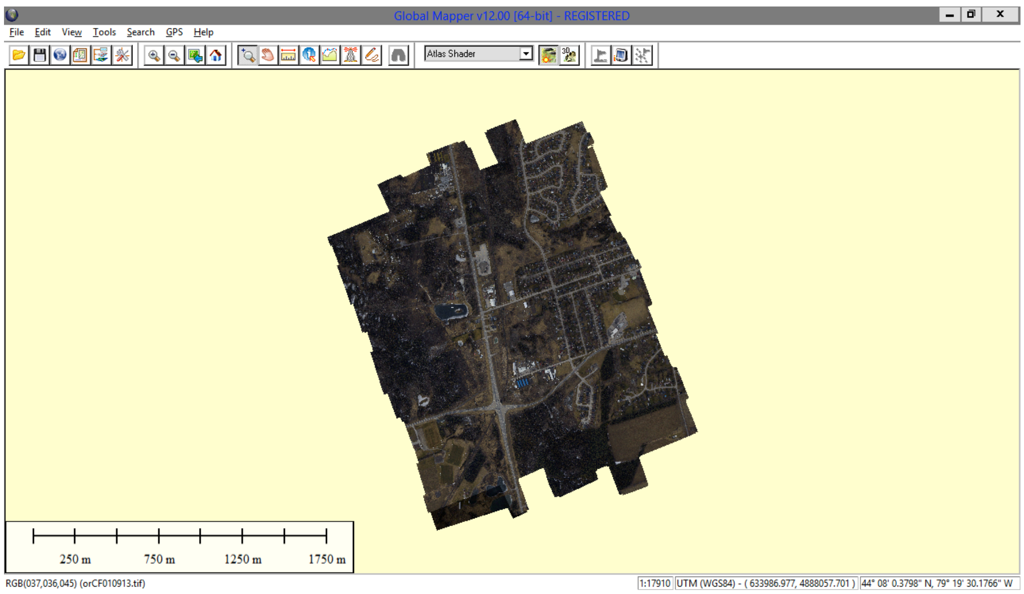

Figure 7: Orthophotos Displayed in Global Mapper

The Inpho photogrammetric software package (version 6.1) was used to develop only the 4 strip higher elevation orthoimages. The photos were imported into an Inpho project (Figure 8), with updated focal length, principal point offsets, estimated boresight angles and adjusted EO resulting from the CalQC bundle adjustment.

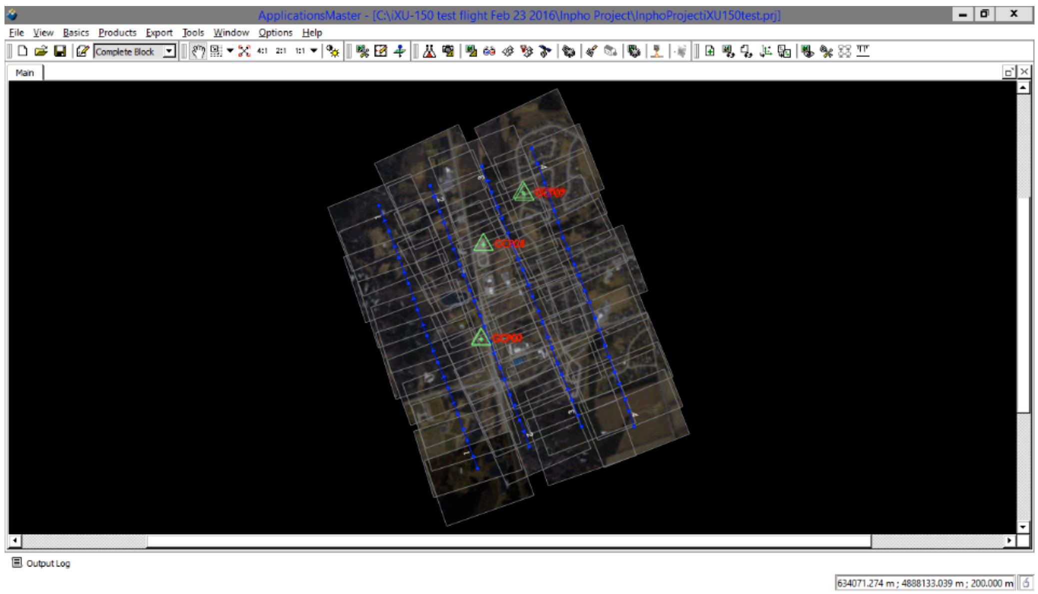

Figure 8: 4 strip high altitude block

First, a 10m Digital Terrain Model (DTM) was extracted using Inpho MATCH-T DSM version 6.1. Using this DTM, the raw images were then orthorectified at a GSD of 7.2cm using Inpho OrthoMaster version 6.1.

The map accuracy was evaluated by comparing the Check Point positions in the orthomosaic product against their surveyed positions.

The estimated map accuracy values (Table 1) are summarized below.

	Survey Check Point Values		Ortho Map-derived values		Residuals (Errors)	
Point ID	E	N	E	N	dE	dN
GCP00	634286.072	4887825.337	634286.122	4887825.353	-0.05	-0.02
GCP01	634289.511	4887818.891	634289.618	4887818.847	-0.11	0.04
GCP04	634303.360	4888454.039	634303.375	4888454.039	-0.02	0.00
GCP05	634302.261	4888453.930	634302.362	4888453.759	-0.10	0.17
GCP07	634576.545	4888788.707	634576.428	4888788.835	0.12	-0.13
Number of Points					5	5
Mean Error					-0.031	0.014
Standard Deviation (m)					0.091	0.108
RMSE (m)					0.087	0.098
RMSEr (m)					0.131	SQRT(RMSEx2 + RMSEy2)
RMSEr (Pixels)					1.8	
NSSDA Horizontal Accuracyr (ACCr) at 95% Confidence Level					0.227	RMSEr × 1.7308

Table 1: 4 Strip higher altitude ISO Accuracy Results

From the above results, it can be seen that the accuracy of the POS AVX 210 and stability of the Phase One iXU 150 camera with the 80mm lens are sufficient to produce orthomap products to an accuracy of 1.8x GSD RMS.

Conclusion

The test outlined in this document demonstrates the feasibility of using a directly georeferencing solution such as the POS AVX 210 and the Phase One iXU 150 camera to generate highly efficient, accurate and cost effective Directly Georeferenced map products. Accuracies achieved were at the 1.8 pixel level RMS for the ortho products.

Direct Georeferencing and ISO eliminate the need for dense GCPs and allow the capture of image data with minimal sidelap to increase data acquisition and processing efficiencies. The processing time required to create map products compared to traditional AT techniques is greatly reduced thereby increasing productivity.