delair-tech
AIRBORNE SENSORING

White paper

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DT26X
DT-3BANDS XL
APXL

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Introduction

The purpose of this document is to show the benefit of a precision GNSS/IMU on the accuracy of products obtained by photogrammetry (DSM, DTM, orthophotography, stereoscopic restitution, 3D model).

The benefit of this precision GNSS/IMU combination will be to minimise or eliminate the need for work on the ground such as the establishment of a reference base and/or control points.

Let us examine the following case study, that we carried out in June 2015.

Vector and Payload

Vector

For this acquisition, we used the DT26X, whose main specifications are:

- ◊ Up to 2.5 h of endurance
- ◊ 3.3 m wingspan
- ◊ 1.6 m length
- ◊ 50 km/h cruising speed
- ◊ Possibility of carrying loads up to 4 kg

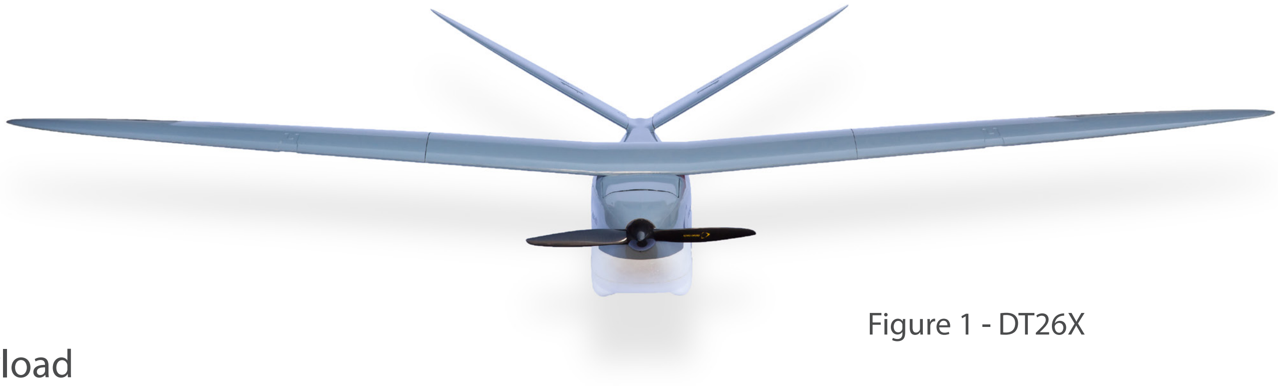

Figure 1 - DT26X

Payload

Photographic sensor

This consists of a Sony Alpha 7 R and a Sony 35 mm fixed lens (Ref: SEL35F28Z).
Its characteristics are:

- ◊ Sensor installed in landscape mode in the drone's direction of flight
- ◊ 4.9 microns (physical size of the pixels), ensuring good image quality
- ◊ 4912 x 7360 pixels, i.e. a 24 x 36 mm sensor (full format)
- ◊ Fixed, stable lens
- ◊ 1 s maximum frame rate
- ◊ At 150 m, coverage on the ground of 103 x 105 m and a pixel on the ground of 2.1 cm

GNSS/IMU

After reviewing the existing solutions, we contacted a specialist in the field. Applanix has been recognised in the aerial mapping field for many years, and our choice was guided towards the APX-15 UAV.
The position and attitude characteristics, once the data have been post-processed with POSPac software, are:

- ◊ 2 to 5 cm in position
- ◊ 0.025° in pitch and roll
- ◊ 0.08° in heading

This system is autonomous, i.e. its results can be obtained without establishing any base on the ground, thanks to the permanent network used by Applanix for post-processing calculation of navigation.

Calibration field

We selected our test zone in an area where we were able to place many points for validating our results. We chose a zone that we normally use to test our drones.

It measures 300 x 350 m.

We placed 15 points, including 11 plates for which we measured the centre and one of the corners, and 4 surveyor nails that we placed on the road (with a painted cross to ensure correct identification).

These control points were measured with a Trimble R10 coupled with the Teria network guaranteeing accuracy to the order of 2-3 cm.

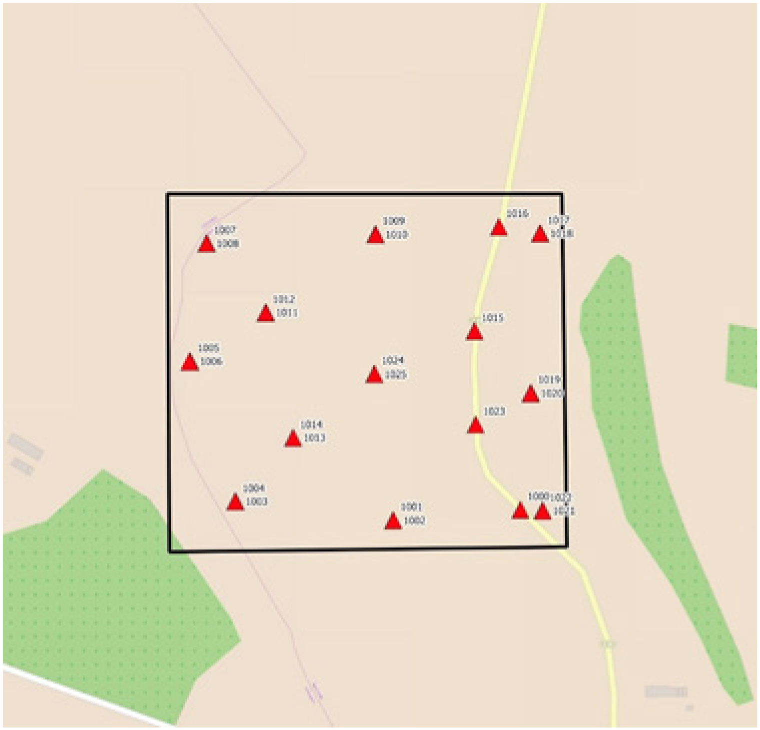

Figure 2 - Calibration field and control points - copyright OSM

Operating mode

In order to resolve any ambiguities (concerning the camera, lens, distortion and the principal point of autocollimation, as well as the angles related to the set-up between the Applanix map and the camera), a 90° cross-flight at two heights in relation to the ground was performed.
The "lever arms" between the GPS antenna and the IMU and between the IMU and the camera were known because of the way it was set up and thanks to the CAD drawing of the payload.
The North/South axes were flown at 150 m above the ground and the East/West axes at a height of 120 m.
Side coverage of the axes was set at 80% in order to increase the overlap of images and obtain more autocorrelation points.

The photogrammetry software used was UASMaster, which enables good control of tie points and control points. The data were also processed with PIX4D and Correlator3D, with consistent and similar results.

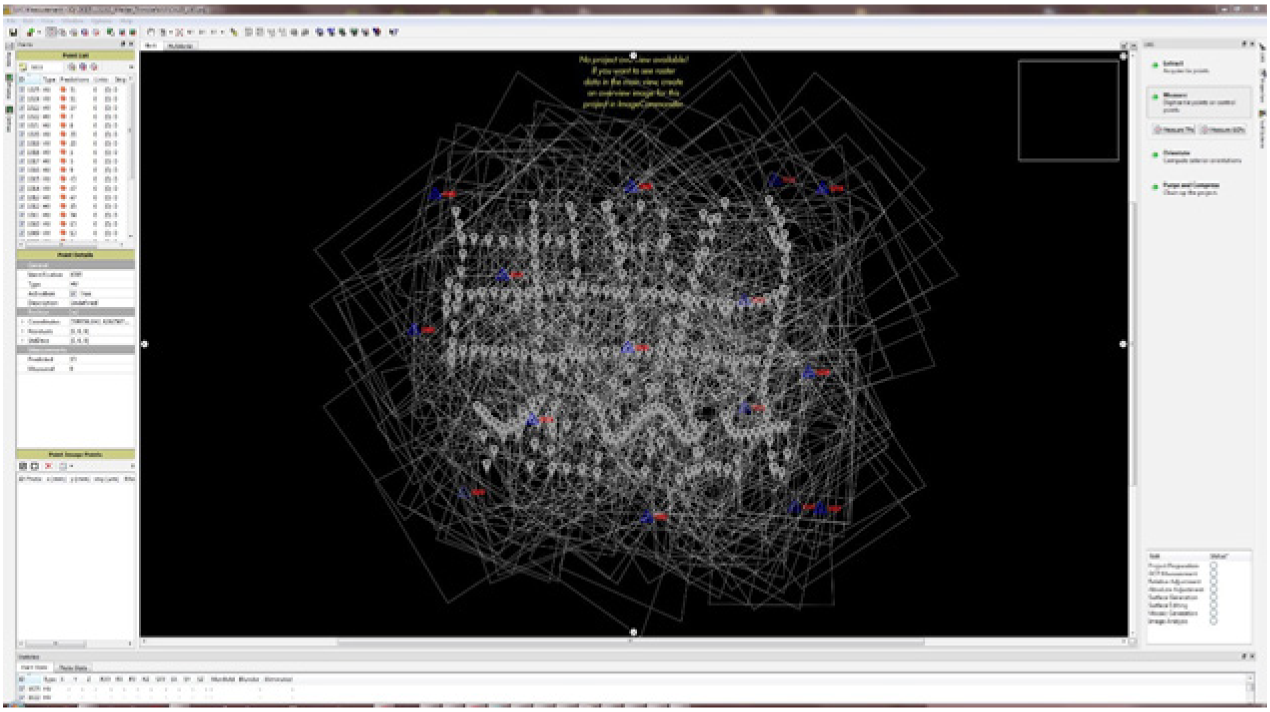

Figure 3 - UAS - Master

Acquisition

The flight took place on 5 June 2015 in difficult conditions, both in terms of wind and thermal turbulence. Despite these difficult conditions, the flight went ahead without any problem.
It was difficult to maintain the axis because of the wind, but overlaps of 80% enabled the study to take place.

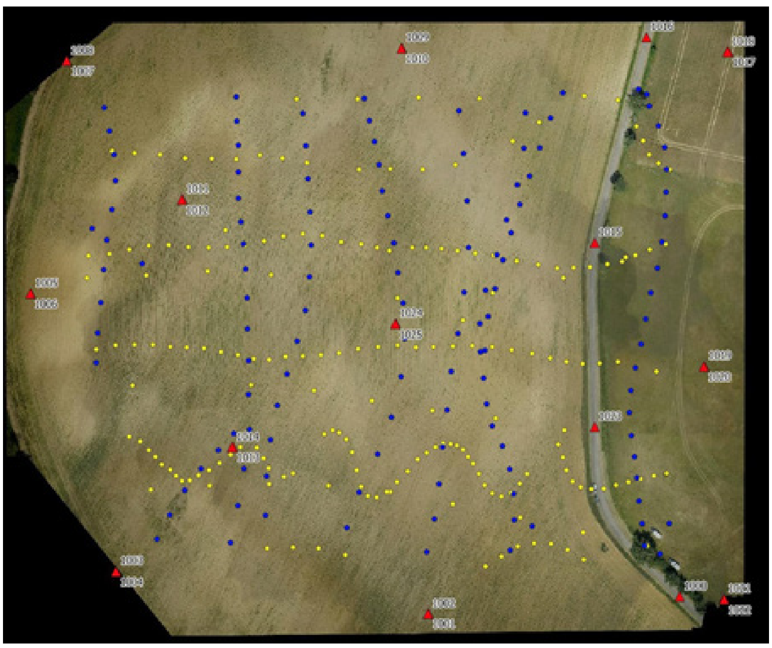

Figure 4 - Calibration field

control points

center of images acquired

Aerotriangulation

After the flight, the Applanix navigation data were post-processed using POSPac software in order to be able to integrate the lever arms, and the time delay that was evaluated in the laboratory.

All data are in Lambert-93 Projection and in IGN69 for altimetry.

Step 1

◊ Importing of images, importing of navigation data from POSPac, importing of control points by putting them into verification points (they were not used during the aerotriangulation calculations however we have statistical values on these points).
◊ Creation of automatic tie points up to the maximum level.
◊ Verification of control points.
◊ Adjustment of the unit with calibration of the camera.

The results of this step are fully satisfactory and may be sufficient for direct georeferencing (with precision of around 15-20 cm).

◊ Horizontal residuals control points in [meter]

ID	rx	ry		
1000	0.026	0.209	check	point
1001	0.189	0.198	check	point
1003	0.378	0.265	check	point
1005	0.436	0.097	check	point
1007	0.471	-0.079	check	point
1009	0.316	-0.092	check	point
1011	0.369	0.015	check	point
1013	0.316	0.116	check	point
1015	0.109	-0.061	check	point
1016	0.165	-0.16	check	point
1017	0.088	-0.184	check	point
1019	0.077	-0.008	check	point
1021	-0.048	0.249	check	point
1023	0.124	0.086	check	point
1024	0.222	0.035	check	point

◊ Vertical residuals control points in [meter]

ID	rz		
1000	0.29	check	point
1001	0.183	check	point
1003	0.086	check	point
1005	0.089	check	point
1007	0.019	check	point
1009	0.071	check	point
1011	0.111	check	point
1013	0.14	check	point
1015	0.327	check	point
1016	0.21	check	point
1017	0.203	check	point
1019	0.214	check	point
1021	0.34	check	point
1023	0.328	check	point
1024	0.23	check	point

	x	y	z
average	0.216	0.046	0.189
standard deviation	0.158	0.145	0.102

Step 2

To see the contribution of the control points on our calibration field, five control points (four at the edges and one in the centre) were activated for further adjustment of the unit and here is the excellent result (with an accuracy of about 3 cm in planimetry and 6 in altimetry).

◊ Horizontal residuals control points in [meter]

ID	rx	ry		
1000	0.024	-0.001	check	point
1001	0.018	-0.031	check	point
1003	-0.004	0.004		
1005	-0.048	0.02	check	point
1007	-0.001	-0.001		
1009	0.058	0.049	check	point
1011	-0.018	0.023	check	point
1013	-0.003	-0.033	check	point
1015	0.015	-0.021	check	point
1016	0.063	0.019	check	point
1017	0.003	-0.002		
1019	0.085	-0.043	check	point
1021	0.003	0.006		
1023	0.053	-0.005	check	point
1024	0	-0.006		

◊ Vertical redisuals control points in [meter]

ID	rz		
1000	0.026	check	point
1001	0.004	check	point
1003	0		
1005	0.024	check	point
1007	-0.002		
1009	-0.163	check	point
1011	-0.033	check	point
1013	-0.007	check	point
1015	0.034	check	point
1016	-0.065	check	point
1017	0		
1019	-0.1	check	point
1021	0.001		
1023	0.053	check	point
1024	0.003		

	x	y	z
average	0.017	-0.001	-0.015
standard deviation	0.035	0.024	0.056

Conclusion

We have seen here that if you are seeking an accurate solution without any control points, it is possible to obtain precision of the order of 15 cm by performing a suitable flight.

To obtain even greater precision, a few control points bring the precision down from the decimetre to the centimetre level.

A solution that can be implemented and that limits the GCP installation time is, during a corridor flight, to create a small calibration field with five control points close to the drone's ground station and to create three axes: two at 120 m and the third oriented at 90° and at 150 m, and to carry out acquisition of the site afterwards.
Once in the office, all ambiguities concerning camera settings or angles between the GNSS/IMU and the camera are resolved, and the navigation is recalculated by integrating the parameters observed from the "mini" calibration. In this case a result with centimetre precision should be obtained with a minimum of work on the ground.

This GNSS/IMU solution is integrated in our DT18, in order to offer an identical solution in terms of precision. Further testing will be carried out shortly, in particular with the tested solution described above.

Figure 5 - Ortophoto