FANAVEGEN BRANNSTASJON
RAPPORT GEOMATIKKARBEID

Oppdragsnavn	**Fanavegen brannstasjon**
Prosjekt nr.	**1350017214-003**
Mottaker	**Bergen kommune, Etat for utbygging v/Tor Milde**
Dokument type	**Rapport**
Versjon	**1**
Dato	**06.08.2018**
Utført av	**Gudmund Obrestad**
Kontrollert av	**HST**
Godkjent av	

Bakgrunn

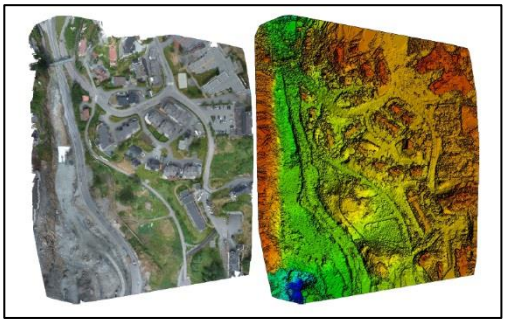
Bakgrunnen for arbeidet er at Rambøll har hatt oppdrag med en reguleringsendring for etablering av ny brannstasjon på stedet, for Fana bydel, Bergen. Planen forutsetter tilrettelegging av tomten med sprenging og utplanering. Oppdragsgiver Etat for utbygging bestilte derfor et tilleggsarbeid for å masseberegne dette.

Beskrivelse av geomatikkarbeid utført i prosjektet

Drone:

Drone ble benyttet til å fotografere arealet slik at det ved hjelp av bildeinformasjon kunne lages en georeferert 3D modell. Dronen flyr i et forhåndsprogrammert mønster på kryss og tvers i en høyde på 50 meter, slik at bildene overlapper hverandre. Alle bildene settes sammen til et heldekkende bilde som det kan genereres punktsky av og overføres til programvare som lager grunnlag for volumberegninger av det fotograferte arealet. Landmålere fra Anko ble leid inn for å markere punkt på bakken etter plan fra oss.

Punktsky og ortofoto:



Bildene fra droneflyving ble matet inn i programmet Pix4d, hvor man laster inn punkt fra landmåler. Ved å fortelle programmet hvor man finner igjen de ulike landmålte punktene i bildene, kan kameraposisjoner bli beregnet, og ut fra det kan en punktsky og et ortofoto bli generert som ligger korrekt plassert i verden. Bakkeoppløsningen på ortofoto er 2,13 cm, dvs at en pixel i bildet utgjør 2,13 cm på bakken. Separat rapport fra denne prosessen legges ved.

Terrengmodell:
Punktskyen fra Pix4d ble behandlet i Terrascan og Terramodeller, hvor man fjerner støy fra punktskyen og finner bakkepunkt. Disse punktene brukes så til å generere en triangulert terrengmodell, som man må ha for å kunne masseberegne.
Ut fra rapporten fra Pix4d kan vi anta at nøyaktigheten på terrengmodell er rundt tre til seks cm, forutsatt at kjentpunkt har blitt målt inn korrekt

Masseberegning:
Det var området innenfor den stiplede linjen på bildet vi beregnet.
Masser er beregnet fra terrengmodell fra droneflyving, og kote 42,15.
All masse regnes som jord, dvs at vi ikke bruker noen utvidelseskoeffisient.
Det oppgis seperate volumangivelser for volumer over og under angitt kote.
Selve beregningen ble gjort i Inroads, som er et tillegg til Microstation.



Resultat masseberegning:
Skjæring : 16343 m³
Fylling: 1558 m³

Det leveres separat rapport på denne beregningen.

Referanserammer:
Alle data blir levert i UTM32 med høydereferanse NN2000

Følgende data blir levert
Masseberegning:
Rapport
Avgrensing for masseberegning som .dwg
Beregningsgrunnlaget med terreng og tomt som .dwg

Fra drone:
Rapport fra Pix4D
Ortofoto i .jpg format.
Ubehandlet punktsky i .las format

Terrengmodell:
Terreng i .dwg format

Quality Report

Generated with Pix4Dmapper Pro version 4.2.27

Important: Click on the different icons for:

Help to analyze the results in the Quality Report

Additional information about the sections

Click here for additional tips to analyze the Quality Report

Summary

Project	bergen run 1
Processed	2018-06-16 18:45:33
Camera Model Name(s)	FC330_3.6_4000x3000 (RGB)
Average Ground Sampling Distance (GSD)	2.13 cm / 0.84 in
Area Covered	0.084 km^2 / 8.3934 ha / 0.03 sq. mi. / 20.7512 acres
Time for Initial Processing (without report)	28m:52s

Quality Check

Images	median of 34768 keypoints per image	✓
Dataset	504 out of 504 images calibrated (100%), 3 images disabled	✓
Camera Optimization	4.08% relative difference between initial and optimized internal camera parameters	✓
Matching	median of 7299.2 matches per calibrated image	✓
Georeferencing	yes, 10 GCPs (10 3D), mean RMS error = 0.05 m	⚠

Preview

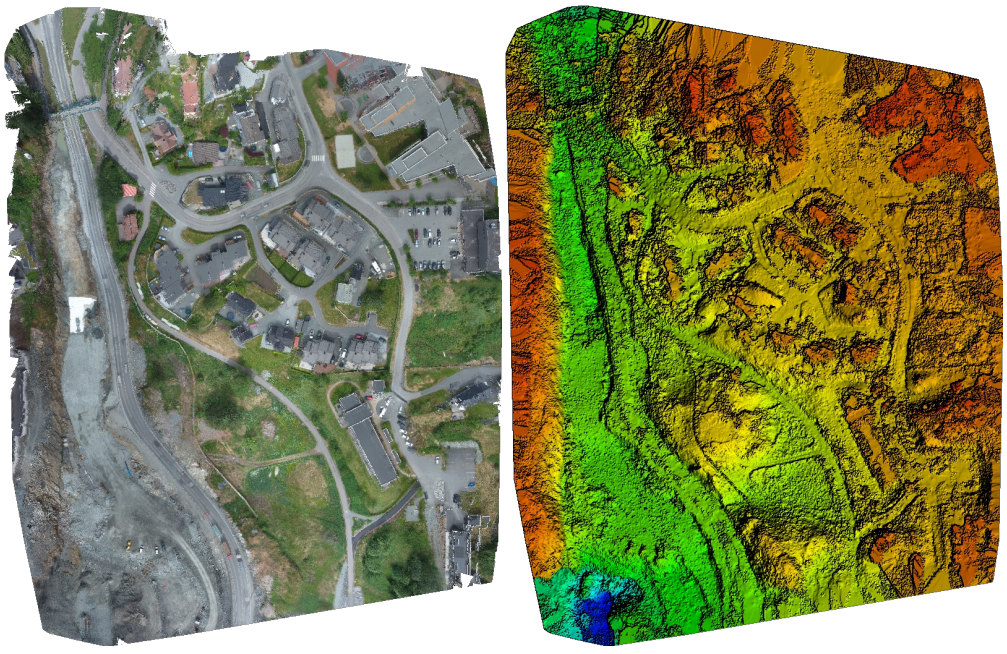


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Calibration Details

Number of Calibrated Images	504 out of 507
Number of Geolocated Images	507 out of 507

Initial Image Positions

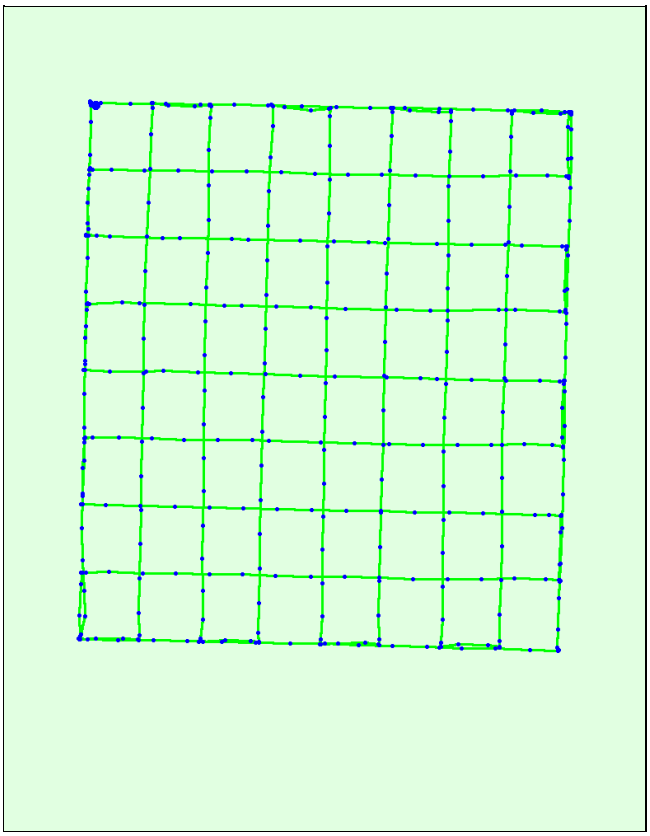
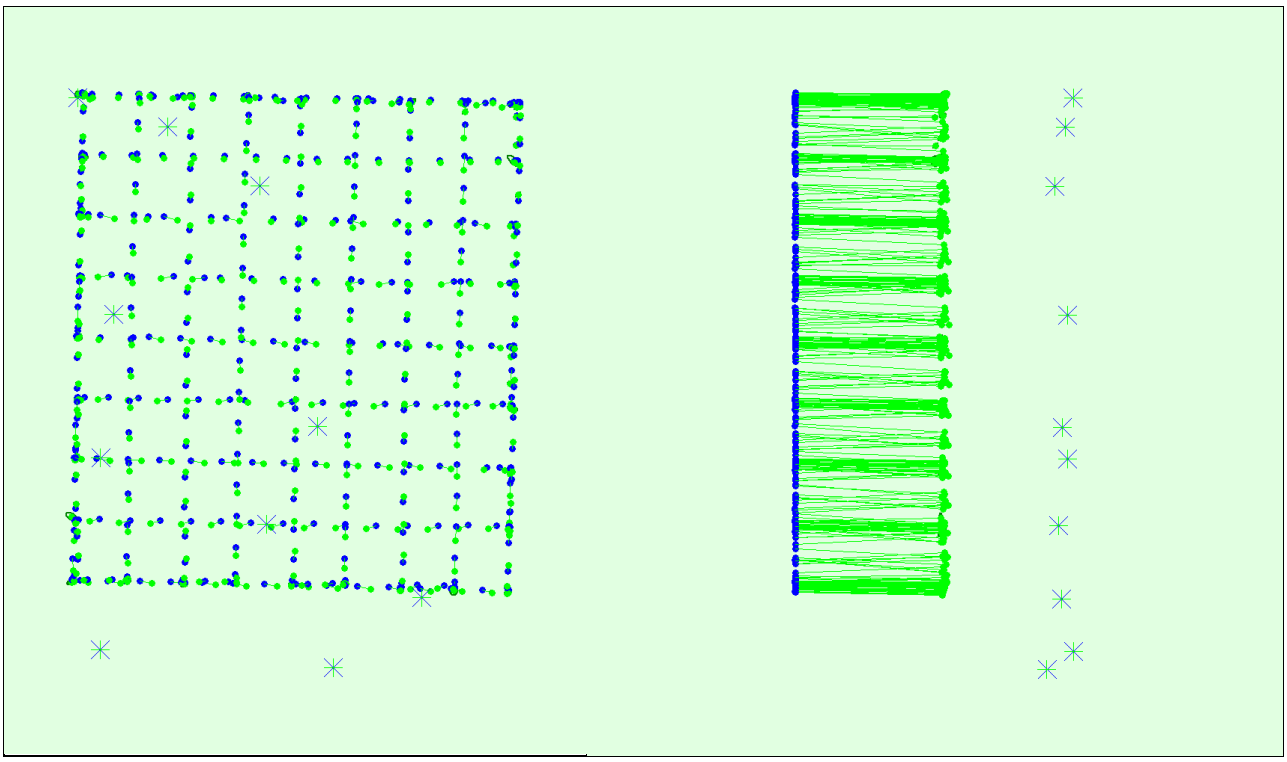
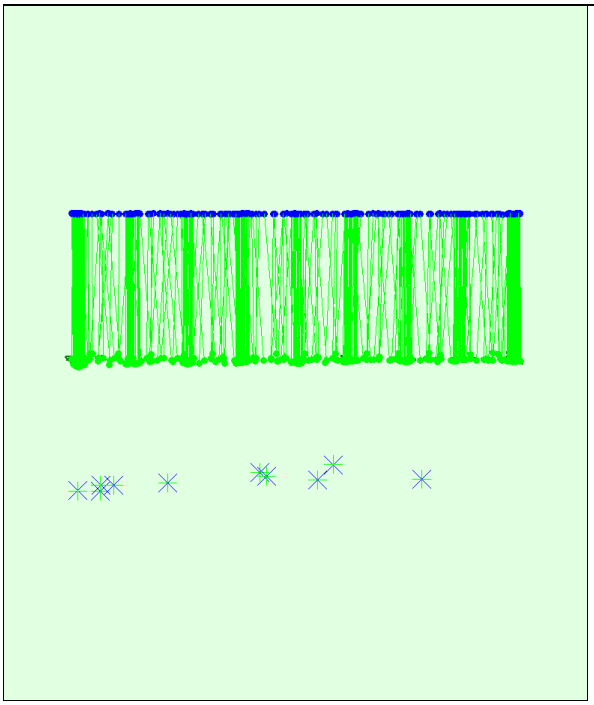


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

Computed Image/GCPs/Manual Tie Points Positions





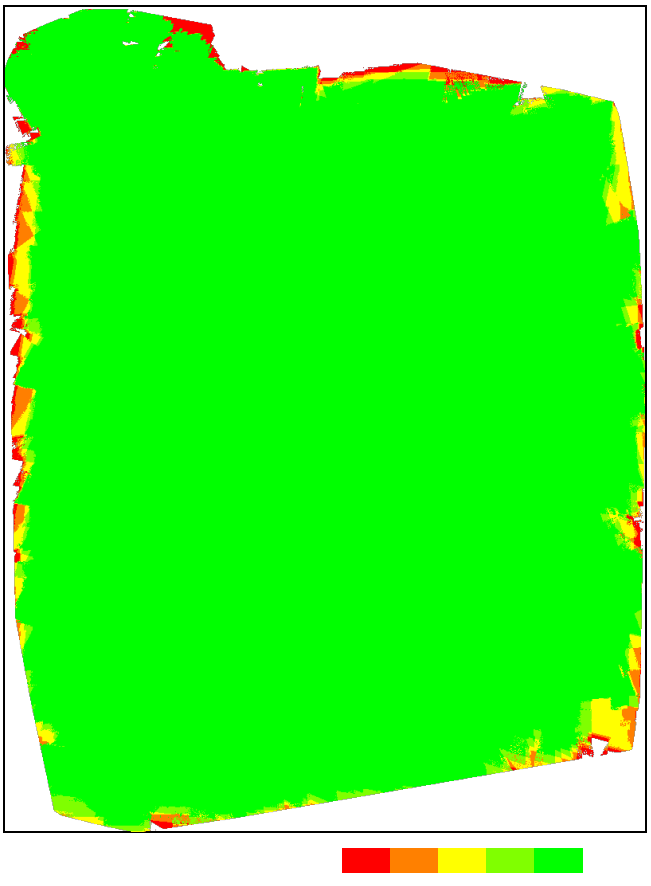
Uncertainty ellipses 100x magnified

Figure 3: Offset between initial (blue dots) and computed (green dots) image positions as well as the offset between the GCPs initial positions (blue crosses) and their computed positions (green crosses) in the top-view (XY plane), front-view (XZ plane), and side-view (YZ plane). Red dots indicate disabled or uncalibrated images. Dark green ellipses indicate the absolute position uncertainty of the bundle block adjustment result.

Absolute camera position and orientation uncertainties

	X [m]	Y [m]	Z [m]	Omega [degree]	Phi [degree]	Kappa [degree]
Mean	0.008	0.007	0.007	0.008	0.008	0.004
Sigma	0.002	0.002	0.001	0.002	0.002	0.001

Overlap



Number of overlapping images: 1 2 3 4 5+

Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.
Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint matches is also sufficient for these areas (see Figure 5 for keypoint matches).

Bundle Block Adjustment Details

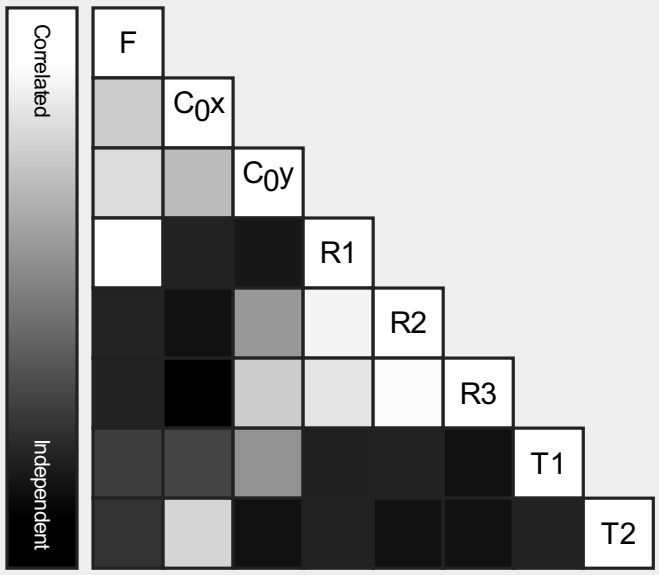
Number of 2D Keypoint Observations for Bundle Block Adjustment	4195802
Number of 3D Points for Bundle Block Adjustment	1104059
Mean Reprojection Error [pixels]	0.177

Internal Camera Parameters

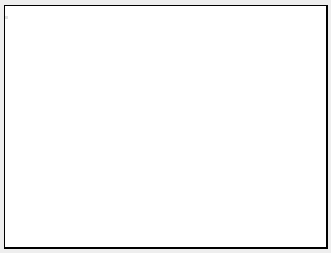
FC330_3.6_4000x3000 (RGB). Sensor Dimensions: 6.317 [mm] x 4.738 [mm]

EXIF ID: FC330_3.6_4000x3000

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	2285.722 [pixel] 3.610 [mm]	2000.006 [pixel] 3.159 [mm]	1500.003 [pixel] 2.369 [mm]	-0.001	-0.002	0.000	-0.001	-0.001
Optimized Values	2379.094 [pixel] 3.757 [mm]	2002.703 [pixel] 3.163 [mm]	1482.548 [pixel] 2.341 [mm]	-0.006	0.005	-0.003	0.000	-0.001
Uncertainties (Sigma)	0.210 [pixel] 0.000 [mm]	0.061 [pixel] 0.000 [mm]	0.114 [pixel] 0.000 [mm]	0.000	0.000	0.000	0.000	0.000



The correlation between camera internal parameters determined by the bundle adjustment. White indicates a full correlation between the parameters, ie. any change in one can be fully compensated by the other. Black indicates that the parameter is completely independent, and is not affected by other parameters.



The number of Automatic Tie Points (ATPs) per pixel, averaged over all images of the camera model, is color coded between black and white. White indicates that, on average, more than 16 ATPs have been extracted at the pixel location. Black indicates that, on average, 0 ATPs have been extracted at the pixel location. Click on the image to the see the average direction and magnitude of the re-projection error for each pixel. Note that the vectors are scaled for better visualization. The scale bar indicates the magnitude of 1 pixel error.

2D Keypoints Table

	Number of 2D Keypoints per Image	Number of Matched 2D Keypoints per Image
Median	34768	7299
Min	18556	471
Max	55765	24054

Mean	35147	8325

3D Points from 2D Keypoint Matches

	Number of 3D Points Observed
In 2 Images	669675
In 3 Images	188490
In 4 Images	83826
In 5 Images	42601
In 6 Images	25446
In 7 Images	18030
In 8 Images	11917
In 9 Images	9381
In 10 Images	7031
In 11 Images	5264
In 12 Images	4255
In 13 Images	3918
In 14 Images	4511
In 15 Images	3167
In 16 Images	2208
In 17 Images	1835
In 18 Images	1447
In 19 Images	1238
In 20 Images	1010
In 21 Images	896
In 22 Images	779
In 23 Images	651
In 24 Images	651
In 25 Images	615
In 26 Images	528
In 27 Images	526
In 28 Images	467
In 29 Images	437
In 30 Images	456
In 31 Images	427
In 32 Images	426
In 33 Images	414
In 34 Images	370
In 35 Images	371
In 36 Images	362
In 37 Images	330
In 38 Images	326
In 39 Images	297
In 40 Images	319
In 41 Images	310
In 42 Images	309
In 43 Images	293
In 44 Images	306
In 45 Images	250
In 46 Images	282
In 47 Images	262
In 48 Images	247
In 49 Images	241
In 50 Images	275
In 51 Images	242
In 52 Images	252
In 53 Images	231
In 54 Images	227

In 55 Images	254
In 56 Images	279
In 57 Images	247
In 58 Images	229
In 59 Images	235
In 60 Images	197
In 61 Images	232
In 62 Images	223
In 63 Images	242
In 64 Images	281
In 65 Images	271
In 66 Images	247
In 67 Images	268
In 68 Images	290
In 69 Images	316
In 70 Images	504
In 71 Images	538
In 72 Images	289
In 73 Images	111
In 74 Images	57
In 75 Images	40
In 76 Images	15
In 77 Images	7
In 78 Images	7
In 79 Images	5
In 80 Images	5
In 81 Images	3
In 82 Images	4
In 83 Images	5
In 84 Images	2
In 85 Images	2
In 86 Images	4
In 87 Images	4
In 88 Images	2
In 89 Images	1
In 90 Images	1
In 91 Images	2
In 92 Images	2
In 93 Images	2
In 94 Images	4
In 95 Images	1
In 96 Images	1
In 98 Images	1
In 99 Images	1
In 100 Images	1
In 101 Images	2

2D Keypoint Matches

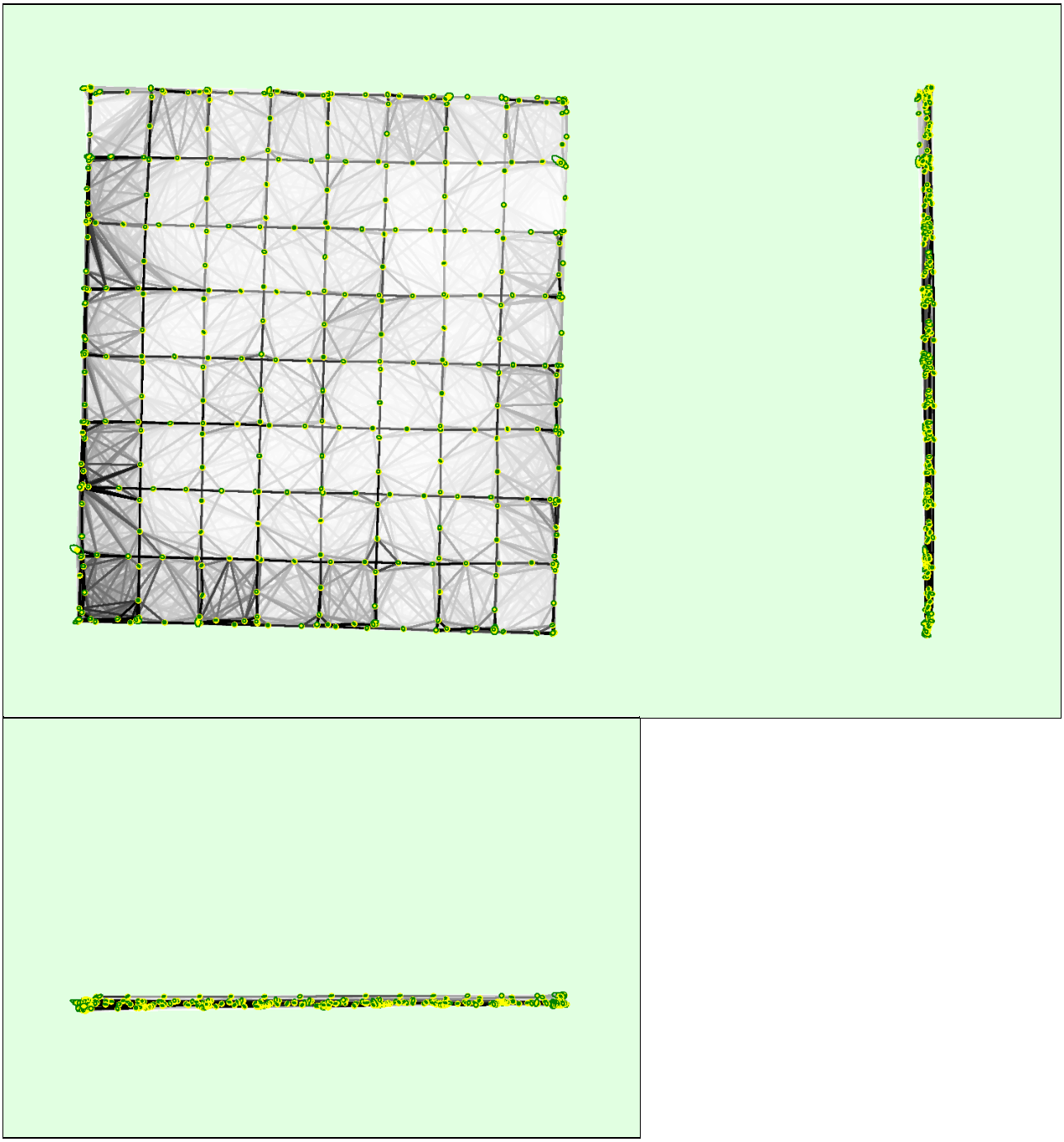


Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images. Dark green ellipses indicate the relative camera position uncertainty of the bundle block adjustment result.

Relative camera position and orientation uncertainties

	X [m]	Y [m]	Z [m]	Omega [degree]	Phi [degree]	Kappa [degree]
Mean	0.007	0.006	0.006	0.011	0.010	0.005
Sigma	0.002	0.002	0.002	0.003	0.003	0.001

Geolocation Details

Ground Control Points

GCP Name	Accuracy XY/Z [m]	Error X [m]	Error Y [m]	Error Z [m]	Projection Error [pixel]	Verified/Marked
P2 (3D)	0.020/ 0.020	-0.015	0.025	0.011	0.466	31 / 31
P1 (3D)	0.020/ 0.020	-0.030	-0.044	-0.032	0.649	45 / 46
P3 (3D)	0.020/ 0.020	-0.021	0.025	0.340	0.050	71 / 71
P4 (3D)	0.020/ 0.020	0.030	-0.005	0.018	0.741	46 / 46
P8 (3D)	0.020/ 0.020	0.044	-0.003	0.018	0.579	44 / 44
P7 (3D)	0.020/ 0.020	-0.005	-0.032	0.042	0.715	30 / 31
P9 (3D)	0.020/ 0.020	-0.000	-0.008	0.002	0.472	34 / 34
P6 (3D)	0.020/ 0.020	-0.002	-0.004	-0.063	0.756	16 / 17
P5 (3D)	0.020/ 0.020	-0.000	0.040	0.030	0.645	24 / 26
P10 (3D)	0.020/ 0.020	0.013	0.017	-0.021	0.586	52 / 53
Mean [m]		0.001458	0.001028	0.034449		
Sigma [m]		0.021548	0.024884	0.106118		
RMS Error [m]		0.021598	0.024905	0.111569		

Localisation accuracy per GCP and mean errors in the three coordinate directions. The last column counts the number of calibrated images where the GCP has been automatically verified vs. manually marked.

Absolute Geolocation Variance

Min Error [m]	Max Error [m]	Geolocation Error X [%]	Geolocation Error Y [%]	Geolocation Error Z [%]
-	-15.00	0.00	0.00	0.00
-15.00	-12.00	0.00	0.00	0.00
-12.00	-9.00	0.00	0.00	0.00
-9.00	-6.00	0.00	0.00	0.00
-6.00	-3.00	8.13	8.13	0.99
-3.00	0.00	50.99	35.71	46.63
0.00	3.00	33.33	48.21	52.38
3.00	6.00	7.54	7.94	0.00
6.00	9.00	0.00	0.00	0.00
9.00	12.00	0.00	0.00	0.00
12.00	15.00	0.00	0.00	0.00
15.00	-	0.00	0.00	0.00
Mean [m]		-0.131680	0.715688	58.823752
Sigma [m]		1.877731	1.790843	1.086570
RMS Error [m]		1.882343	1.928556	58.833787

Min Error and Max Error represent geolocation error intervals between -1.5 and 1.5 times the maximum accuracy of all the images. Columns X, Y, Z show the percentage of images with geolocation errors within the predefined error intervals. The geolocation error is the difference between the initial and computed image positions. Note that the image geolocation errors do not correspond to the accuracy of the observed 3D points.

Geolocation Bias	X	Y	Z
Translation [m]	-0.131680	0.715688	58.823752

Bias between image initial and computed geolocation given in output coordinate system.

Relative Geolocation Variance

Relative Geolocation Error	Images X [%]	Images Y [%]	Images Z [%]
[-1.00, 1.00]	96.03	100.00	100.00
[-2.00, 2.00]	100.00	100.00	100.00
[-3.00, 3.00]	100.00	100.00	100.00
Mean of Geolocation Accuracy [m]	5.000000	5.000000	10.000000
Sigma of Geolocation Accuracy [m]	0.000000	0.000000	0.000000

Images X, Y, Z represent the percentage of images with a relative geolocation error in X, Y, Z.

Geolocation Orientational Variance	RMS [degree]
Omega	1.574
Phi	2.343
Kappa	5.487

Geolocation RMS error of the orientation angles given by the difference between the initial and computed image orientation angles.

Initial Processing Details

System Information

Hardware	CPU: Intel(R) Xeon(R) CPU E5-2643 v4 @ 3.40GHz RAM: 64GB GPU: NVIDIA NVS 315 (Driver: 10.18.13.6191)
Operating System	Windows 10 Enterprise, 64-bit

Coordinate Systems

Image Coordinate System	WGS84 (egm96)
Ground Control Point (GCP) Coordinate System	ETRS89 / UTM zone 32N (2D)
Output Coordinate System	ETRS89 / UTM zone 32N (2D)

Processing Options

Detected Template	No Template Available
Keypoints Image Scale	Full, Image Scale: 1
Advanced: Matching Image Pairs	Aerial Grid or Corridor
Advanced: Matching Strategy	Use Geometrically Verified Matching: no
Advanced: Keypoint Extraction	Targeted Number of Keypoints: Automatic
Advanced: Calibration	Calibration Method: Standard Internal Parameters Optimization: All External Parameters Optimization: All Rematch: Auto, no

Point Cloud Densification details

Processing Options

Image Scale	multiscale, 1/2 (Half image size, Default)
Point Density	Optimal
Minimum Number of Matches	3
3D Textured Mesh Generation	no
LOD	Generated: no
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Time for Point Cloud Densification	35m:16s
Time for Point Cloud Classification	02m:16s
Time for 3D Textured Mesh Generation	NA

Results

Number of Generated Tiles	1

Number of 3D Densified Points	26961402
Average Density (per m^3)	454.26

DSM, Orthomosaic and Index Details

Processing Options

DSM and Orthomosaic Resolution	1 x GSD (2.13 [cm/pixel])
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp
Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: no
Time for DSM Generation	00s
Time for Orthomosaic Generation	35m:04s
Time for DTM Generation	00s
Time for Contour Lines Generation	00s
Time for Reflectance Map Generation	00s
Time for Index Map Generation	00s

Triangle Volume Report

Report Created: 6/29/2018
Time: 9:53am

Mode: Entire Surface
Input Grid Factor: 1.000000

Original Surface: **terreng**
Description:
Preference: Default
Type: Existing
Design Surface: **avgr**
Description:
Preference: Default
Type: Existing
Cut Factor: 1.0000
Fill Factor: 1.0000

Cut: 16342.97 cu m
Fill: 1558.12 cu m
Net: 14784.85 cu m