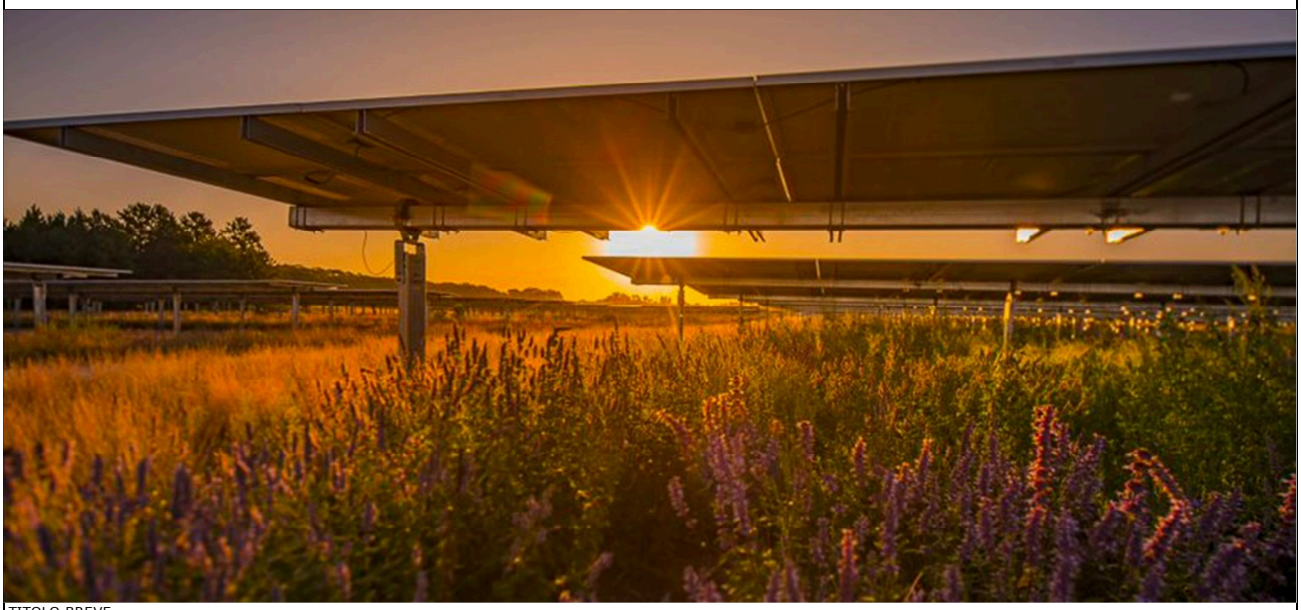
LOCALIZZAZIONE

REGIONE SICILIA
PROVINCIA DI TRAPANI
COMUNI DI TRAPANI E MARSALA



TITOLO BREVE

AGROVOLTAICO "CUDDIA"

SPAZIO PER ENTI (VISTI, PROTOCOLLI, APPROVAZIONI, ALTRO)

REVISIONI						
	00	10/02/2022	PRIMA EMISSIONE ELABORATO	Dario D'Angelo	Vincenzo Scarpinato	Claudio Rizzo
	REV	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO

PROPONENTE

X-ELIO

X-ELIO ITALIA 6 S.r.l.
Corso Vittorio Emanuele II, 349
00186 - ROMA
C.F./P.IVA 15465311007

PROGETTAZIONE E SERVIZI

EnvLab Environment Engineering Lab

ENVLAB s.r.l.s. - C.F./P. IVA 02920050842
Via Smeraldo n. 39 - 92016 RIBERA (AG)
0925 096280 - envlab@pec.it - www.envlab.it

CODICE ELABORATO

XE-CUDDIA-AFV-PD-R-1.1.2.0-r0A-R00

FOGLIO	FORMATO	SCALA	
1/49	A4	--------	

IL DIRETTORE TECNICO DI ENVLAB

Sezione A N.A 1259
Ordine degli Ingegneri della Provincia di Agrigento
Dott. Ing. Rizzo Claudio
Settori civile, ambientale, industriale, dell'informazione

PROGETTO

IMPIANTO AGROVOLTAICO "CUDDIA"
PROGETTO PER LA REALIZZAZIONE DI UN IMPIANTO AGROVOLTAICO DELLA POTENZA DI 46.39 MW E RELATIVE OPERE DI CONNESSIONE ALLA RTN RICADENTE NEI COMUNI DI TRAPANI E MARSALA

OGGETTO ELABORATO

PROGETTO DEFINITIVO

REPORT RILIEVO E RESTITUZIONE ORTOFOTOGRAMMETRICA DELLE AREE DI PROGETTO

1. PREMESSA

Il presente documento costituisce il *Report relativo alle operazioni di rilievo e restituzione ortofotogrammetrica* delle aree entro cui è stato elaborato il progetto dell'impianto agrovoltaico "CUDDIA" della potenza di 46,39 MWp e delle relative opere di connessione alla RTN che la società X-ELIO ITALIA 6 S.r.l. intende realizzare nei Comuni di Trapani e Marsala in provincia di Trapani.

Il soggetto proponente dell'iniziativa è la Società X-ELIO ITALIA 6 S.r.l. avente sede legale ed operativa in ROMA, Corso Vittorio Emanuele II n. 349, iscritta nella Sezione Ordinaria della Camera di Commercio Industria Agricoltura ed Artigianato di Roma, C.F. e P.IVA N. 15465311007.

In particolare il rilievo aero-topografico o fotogrammetrico di prossimità è operato mediante Sistemi Aeromobili a Pilotaggio Remoto (SAPR, comunemente denominati "droni") registrati presso ENAC: la finalità è quella di fornire, attraverso l'attività di tecnici qualificati ed abilitati, un modello fotogrammetrico, ovvero un modello tridimensionale misurabile, in scala, dell'area rilevata, che ne riporta tutte le caratteristiche geometriche, cromatiche e materiche e che rappresenta un database sempre interrogabile.

La ENVLAB è operatore regolarmente abilitato da ENAC con codice "*ITEFZcUeXi*" verificabile nell'elenco operatori raggiungibile al seguente link https://www.d-flight.it/new_portal/elenco-operatori/.

La pianificazione del volo del SAPR consta della definizione dei parametri necessari all'esecuzione del rilievo fotogrammetrico di prossimità da SAPR che sono:

- *Ts tempo di scatto (espresso in secondi);*
- *Fs frequenza di scatto (n° foto al secondo);*
- *Vs velocità di volo del SAPR (metri/secondo);*
- *GSD (Ground Simple Distance).*

Il rilievo dell'area oggetto del progetto è stato eseguito mediante l'ausilio di sistemi aerofotogrammetrici, con apposito aeromobile a pilotaggio remoto o APR , dotato di camera digitale ad alta risoluzione.

L'impianto topografico generale e il rilievo dei relativi Ground Control Point (GCP) posizionati secondo il piano di volo programmato, è stato condotto mediante strumentazione GPS (NRTK-GNSS) e successiva acquisizione, interpretazione, elaborazione e restituzione finale di dati.

I dati risultanti dai rilievi acquisiti con sistemi APR costituiscono il dato di input per le successive analisi di caratterizzazione dell'area indagata.

L'APR è condotto da un pilota in possesso del riconoscimento della competenza (Attestato/Licenza di Pilota di APR), in stato di validità di cui alla Sezione IV del Regolamento ENAC vigente.

Il rilievo si è svolto secondo le seguenti attività:

1. *pianificazione piano di volo in funzione delle condizioni climatiche;*
2. *rilievo aerofotogrammetrico mediante sistema APR;*
3. *elaborazione big data da rilievo;*
4. *restituzione di cartografia di base in scala di dettaglio in proiezione planoaltimetrica;*
5. *realizzazione di un modello tridimensionale in formato mesh;*
6. *produzione di un dettagliato Modello Digitale del Terreno (DTM);*

7. *elaborazione di un ortofotopiano in formato TFF/TFW e sua sovrapposizione alla CTR regionale o alla aerofotogrammetria pubblica esistente;*
8. *estrapolazione di curve di livello del terreno sull'intera area indagata in formato DWG/SHP, UTM dato ERTS 89/WGS84;*
9. *estrapolazione di punti quotati;*
10. *produzione di ortofoto in formato .kml da importare direttamente in Google Earth.*

Le informazioni acquisite con metodo fotogrammetrico sono state integrate da rilievi in campo con strumentazione topografica e/o GNSS per garantire la corretta definizione della geometria del terreno oggetto di studio.

Nel seguito è riportato integralmente il Report generato dal software PIX4D impiegato per l'elaborazione delle immagini georeferenziate acquisite da Drone.

Le migliaia immagini in alta risoluzione, la grande quantità di dati generata e le elaborazioni di modelli 3D, DEM ed ortomosaici sono disponibili presso gli archivi digitali di Envlab per eventuale consultazione su richiesta.

Quality Report

Generated with Pix4Dmapper version 4.6.4

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	CUDDIA_NORD_1
Processed	2021-04-09 11:35:33
Camera Model Name(s)	FC6310_8.8_5472x3648 (RGB)
Average Ground Sampling Distance (GSD)	1.93 cm / 0.76 in
Area Covered	0.039 km^2 / 3.9273 ha / 0.02 sq. mi. / 9.7095 acres
Time for Initial Processing (without report)	03m:04s

Quality Check

Images	median of 65115 keypoints per image	✓
Dataset	46 out of 46 images calibrated (100%), all images enabled	✓
Camera Optimization	7.06% relative difference between initial and optimized internal camera parameters	⚠
Matching	median of 19268 matches per calibrated image	✓
Georeferencing	yes, no 3D GCP	⚠

Preview

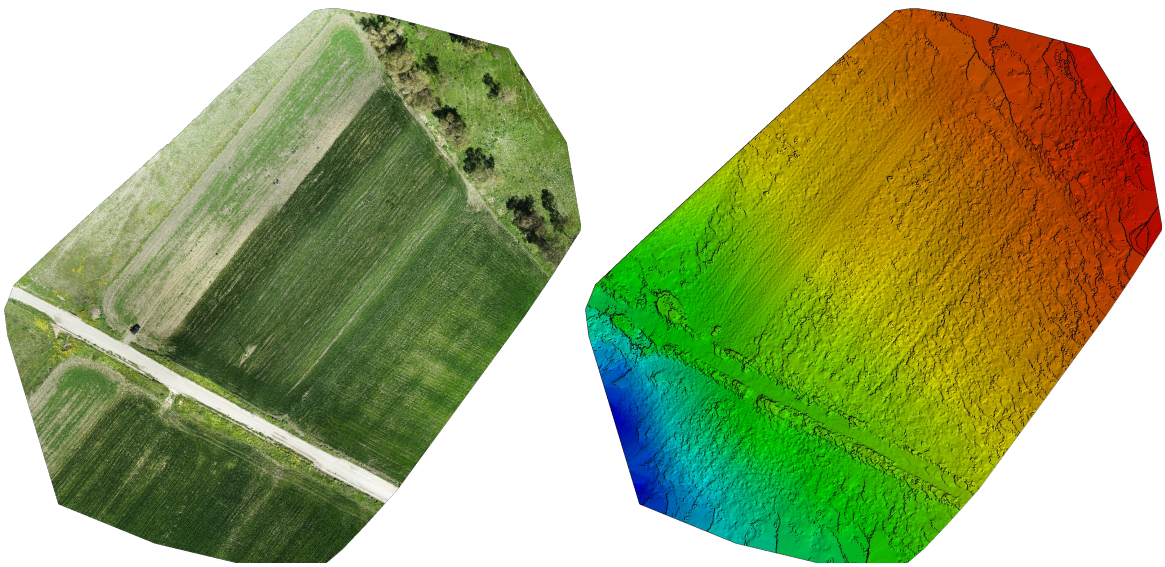


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Calibration Details

Number of Calibrated Images	46 out of 46
Number of Geolocated Images	46 out of 46

Initial Image Positions

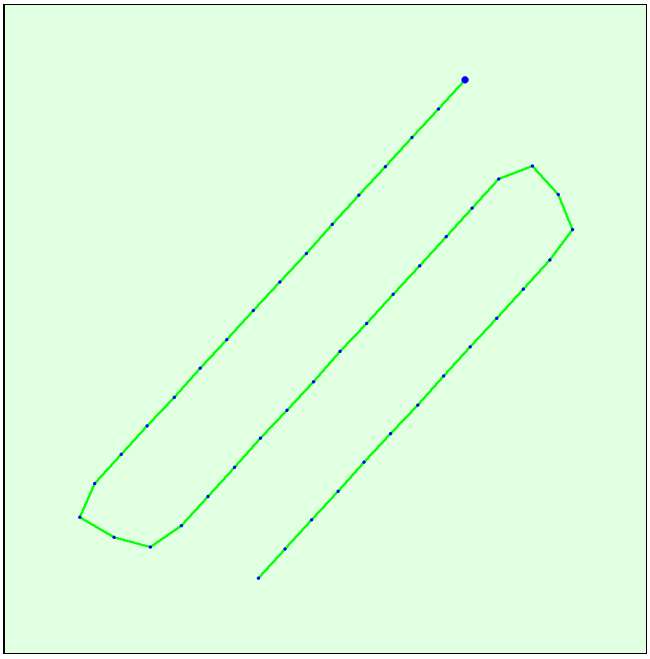
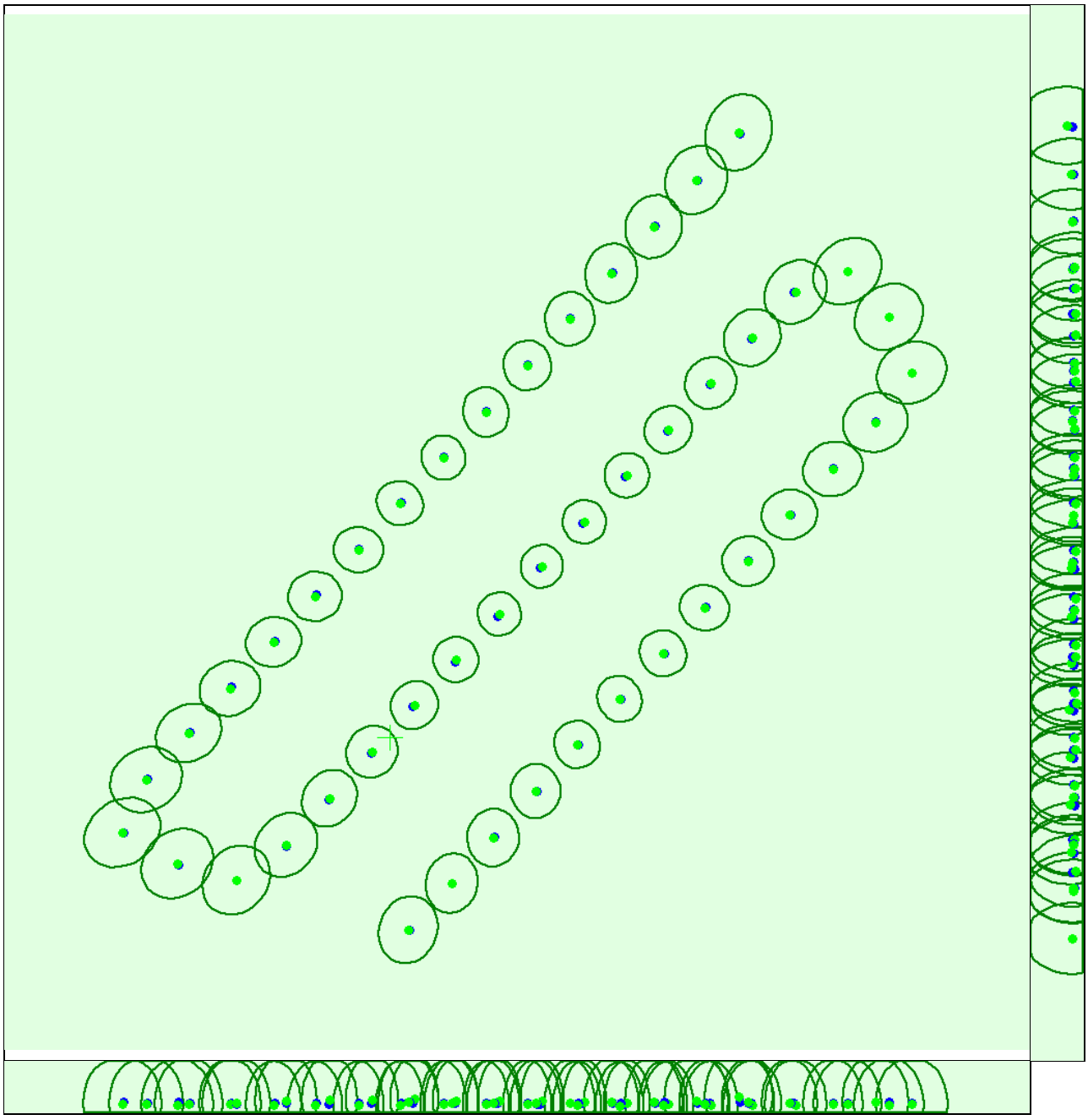


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

Computed Image/GCPs/Manual Tie Points Positions



Uncertainty ellipses 50x 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). 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	0.120	0.119	0.192	0.057	0.058	0.060
Sigma	0.020	0.020	0.007	0.002	0.001	0.000

Overlap

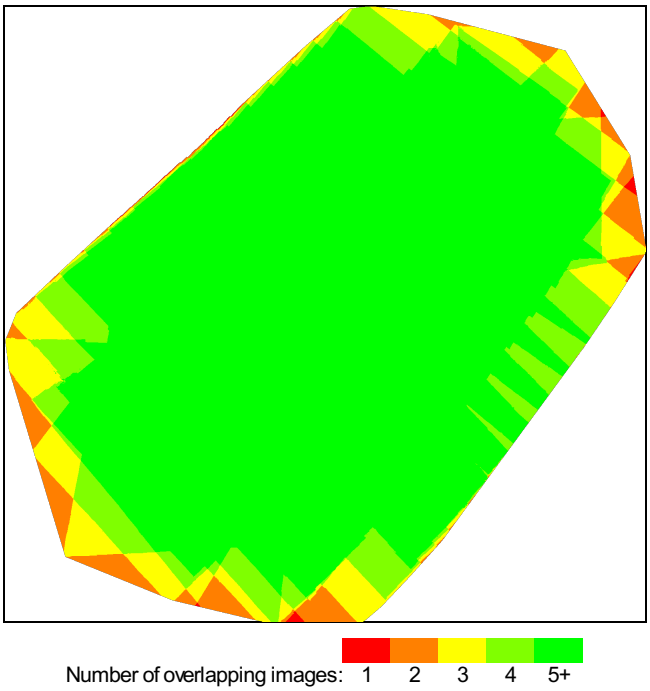


Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.
Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint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

Bundle Block Adjustment Details

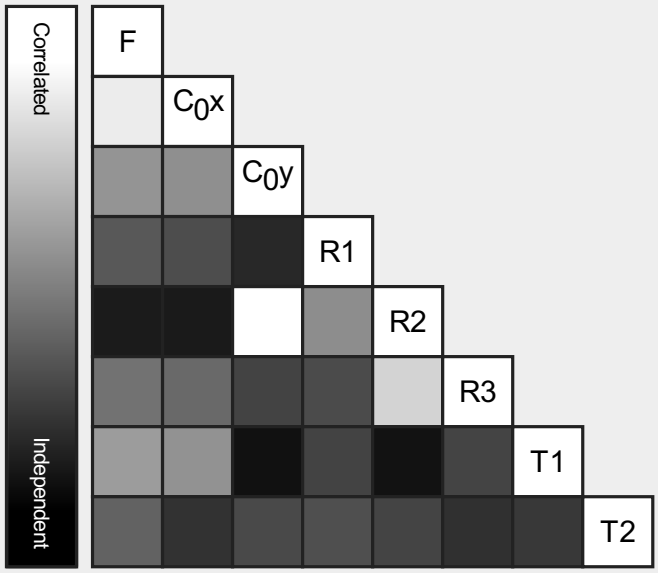
Number of 2D Keypoint Observations for Bundle Block Adjustment	886504
Number of 3D Points for Bundle Block Adjustment	350446
Mean Reprojection Error [pixels]	0.144

Internal Camera Parameters

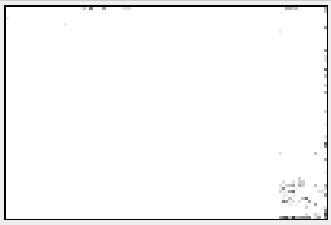
FC6310_8.8_5472x3648 (RGB). Sensor Dimensions: 12.833 [mm] x 8.556 [mm]

EXIF ID: FC6310S_8.8_5472x3648

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	3668.759 [pixel] 8.604 [mm]	2736.001 [pixel] 6.417 [mm]	1823.999 [pixel] 4.278 [mm]	0.003	-0.008	0.008	-0.000	0.000
Optimized Values	3927.944 [pixel] 9.212 [mm]	2720.940 [pixel] 6.381 [mm]	1809.230 [pixel] 4.243 [mm]	-0.016	0.004	0.009	-0.002	-0.002
Uncertainties (Sigma)	12.825 [pixel] 0.030 [mm]	0.442 [pixel] 0.001 [mm]	0.171 [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	65115	19268
Min	58793	7702
Max	69385	29946
Mean	65226	19272

3D Points from 2D Keypoint Matches

	Number of 3D Points Observed
In 2 Images	260011
In 3 Images	50770
In 4 Images	18031
In 5 Images	8973
In 6 Images	4691
In 7 Images	2640
In 8 Images	1802
In 9 Images	1347
In 10 Images	993
In 11 Images	578
In 12 Images	369
In 13 Images	135
In 14 Images	59
In 15 Images	34
In 16 Images	10
In 17 Images	3

2D Keypoint Matches

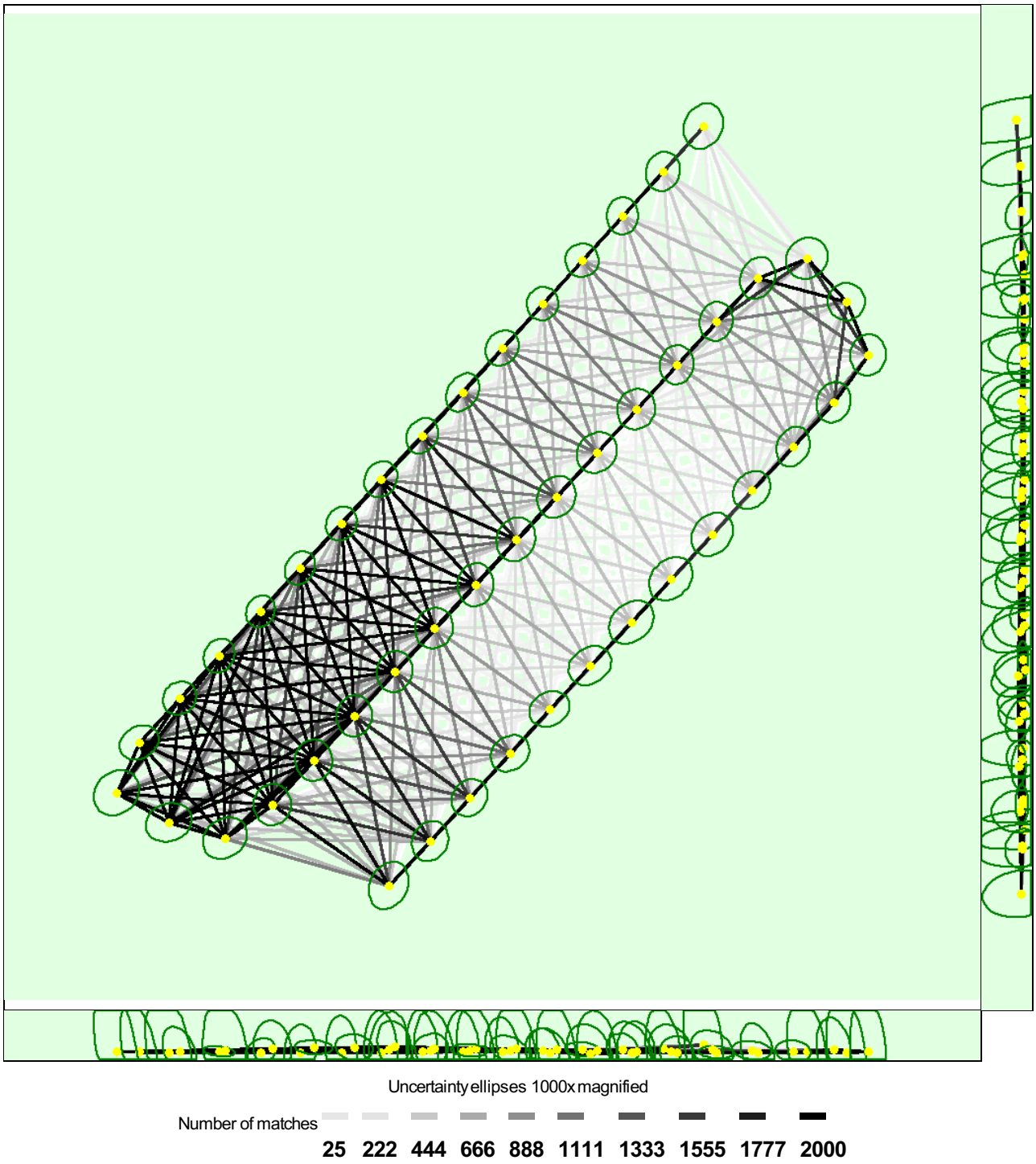


Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images. Dark green ellipses indicate the relative camera position uncertainty 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	0.004	0.004	0.007	0.012	0.012	0.002
Sigma	0.000	0.000	0.004	0.007	0.007	0.000

Manual Tie Points

MTP Name	Projection Error [pixel]	Verified/Marked
mtp1	1.428	3 / 3

Projection errors for manual tie points.The last column counts the number of images where the manual tie point has been automatically verified vs. manually marked.

Geolocation Details

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	0.00	0.00	0.00
-3.00	0.00	34.78	43.48	43.48
0.00	3.00	65.22	56.52	56.52
3.00	6.00	0.00	0.00	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]		0.000110	-0.000023	0.000307
Sigma [m]		0.194368	0.205707	0.393157
RMS Error [m]		0.194368	0.205707	0.393157

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.

Relative Geolocation Variance

Relative Geolocation Error	Images X [%]	Images Y [%]	Images Z [%]
[-1.00, 1.00]	100.00	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	0.975
Phi	0.899
Kappa	4.567

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) Core(TM) i7-10700 CPU @ 2.90GHz RAM: 16GB GPU: NVIDIA Quadro P1000 (Driver: 27.21.14.5148), Intel(R) UHD Graphics 630 (Driver: 27.20.100.8190)
Operating System	Windows 10 Pro, 64-bit

Coordinate Systems

Image Coordinate System	WGS 84 (EGM96 Geoid)
Output Coordinate System	WGS 84 / UTM zone 33N (EGM96 Geoid)

Processing Options

Detected Template	CUDDIA CURVE OK*
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, yes

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	yes
3D Textured Mesh Settings:	Resolution: Medium Resolution (default) Color Balancing: no
LOD	Generated: no
Advanced: 3D Textured Mesh Settings	Sample Density Divider: 1
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Time for Point Cloud Densification	03m:13s
Time for Point Cloud Classification	38s
Time for 3D Textured Mesh Generation	02m:23s

Results

Number of Generated Tiles	1
Number of 3D Densified Points	7243883
Average Density (per m^3)	402.96

DSM, Orthomosaic and Index Details

Processing Options

DSM and Orthomosaic Resolution	1 x GSD (1.93 [cm/pixel])
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp
Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes
Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: yes
Grid DSM	Generated: yes, Spacing [cm]: 100
Raster DTM	Generated: yes Merge Tiles: yes

DTM Resolution	5 x GSD (1.93 [cm/pixel])
Contour Lines Generation	Generated: yes Contour Base [m]: 0 Elevation Interval [m]: 0.5 Resolution [cm]: 300 Minimum Line Size [vertices]: 10
Time for DSM Generation	03m:35s
Time for Orthomosaic Generation	07m:17s
Time for DTM Generation	03m:24s
Time for Contour Lines Generation	01s
Time for Reflectance Map Generation	00s
Time for Index Map Generation	00s

Quality Report

Generated with Pix4Dmapper version 4.6.4

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	NORD_2
Processed	2021-04-09 17:07:36
Camera Model Name(s)	FC6310_8.8_5472x3648 (RGB)
Average Ground Sampling Distance (GSD)	3.08 cm / 1.21 in
Area Covered	0.273 km^2 / 27.3448 ha / 0.11 sq. mi. / 67.6055 acres
Time for Initial Processing (without report)	59m:15s

Quality Check

Images	median of 73341 keypoints per image	✓
Dataset	562 out of 562 images calibrated (100%), all images enabled	✓
Camera Optimization	1.43% relative difference between initial and optimized internal camera parameters	✓
Matching	median of 33894.1 matches per calibrated image	✓
Georeferencing	yes, no 3D GCP	⚠

Preview

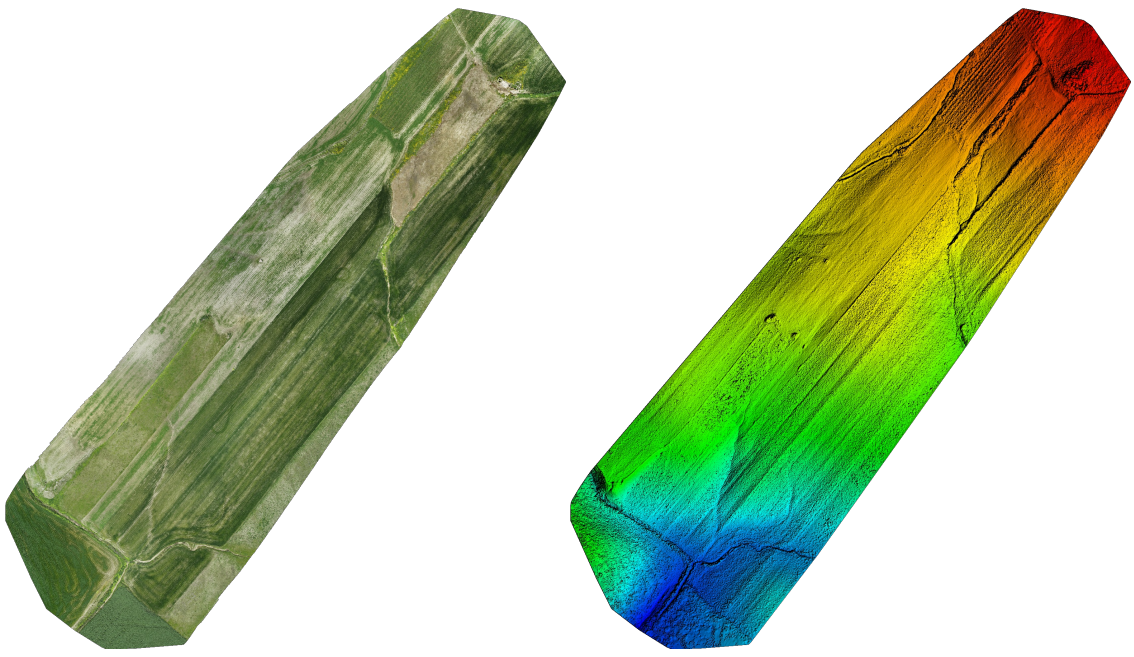


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Calibration Details

Number of Calibrated Images	562 out of 562
Number of Geolocated Images	562 out of 562

Initial Image Positions

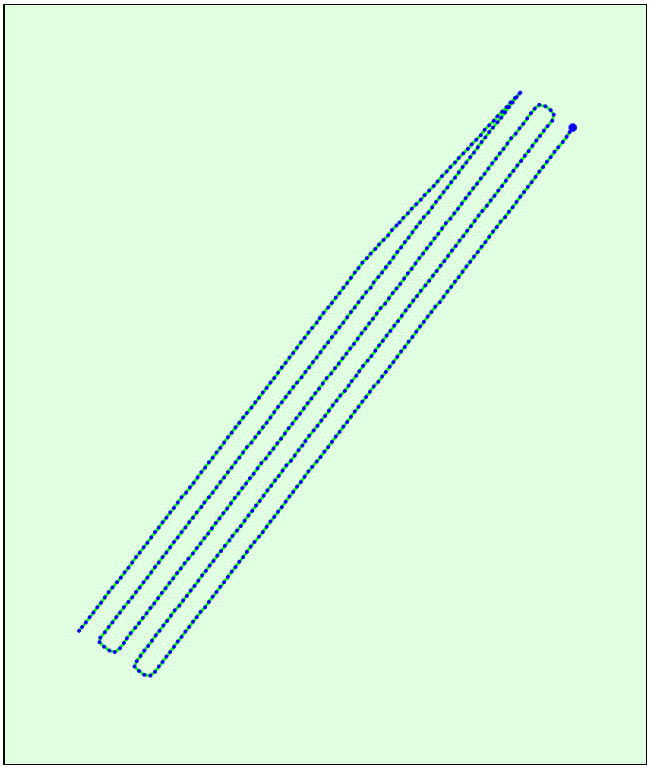
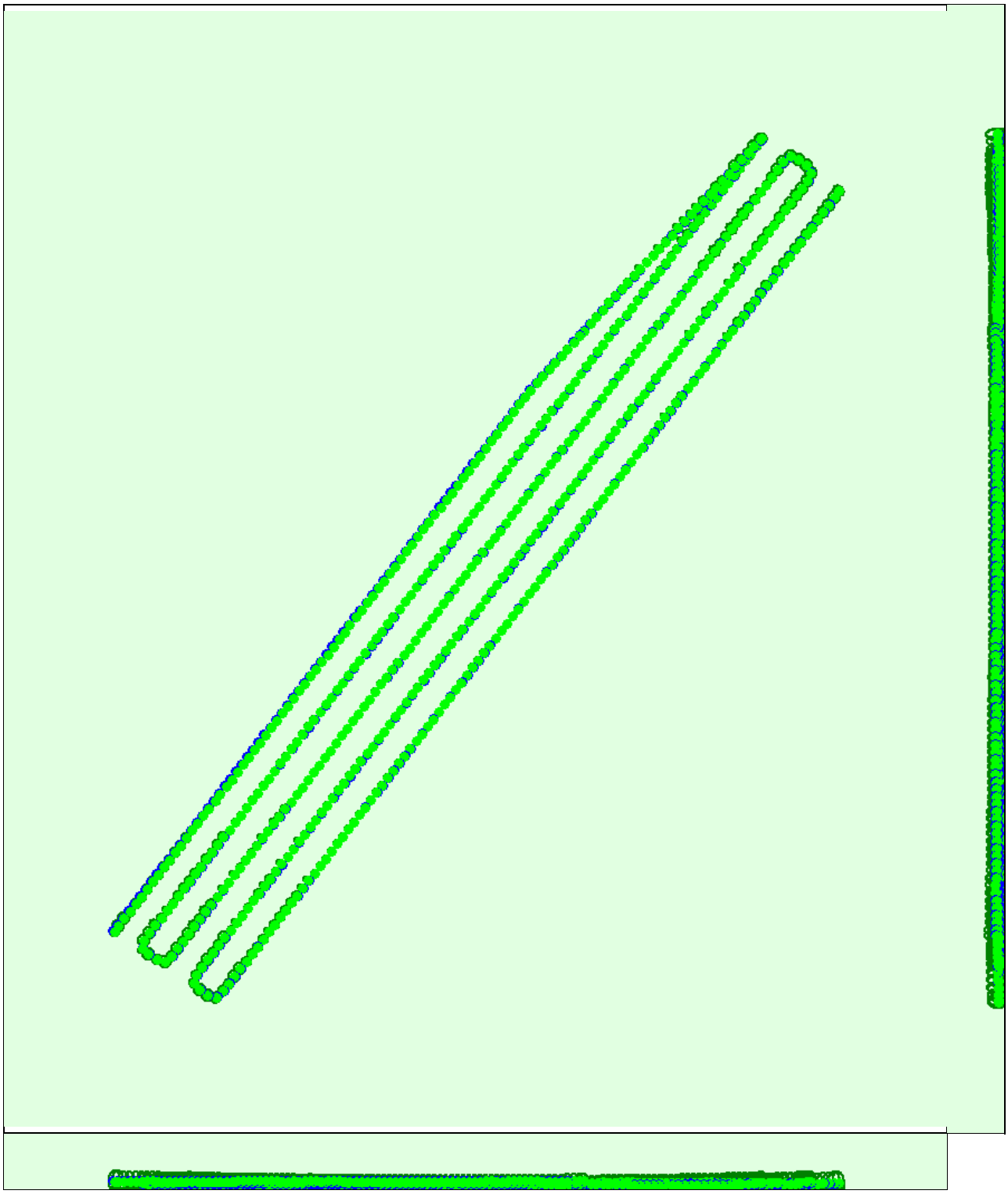


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

Computed Image/GCPs/Manual Tie Points Positions



Uncertainty ellipses 50x 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). 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	0.066	0.066	0.129	0.027	0.029	0.010
Sigma	0.014	0.014	0.023	0.005	0.002	0.000

Overlap

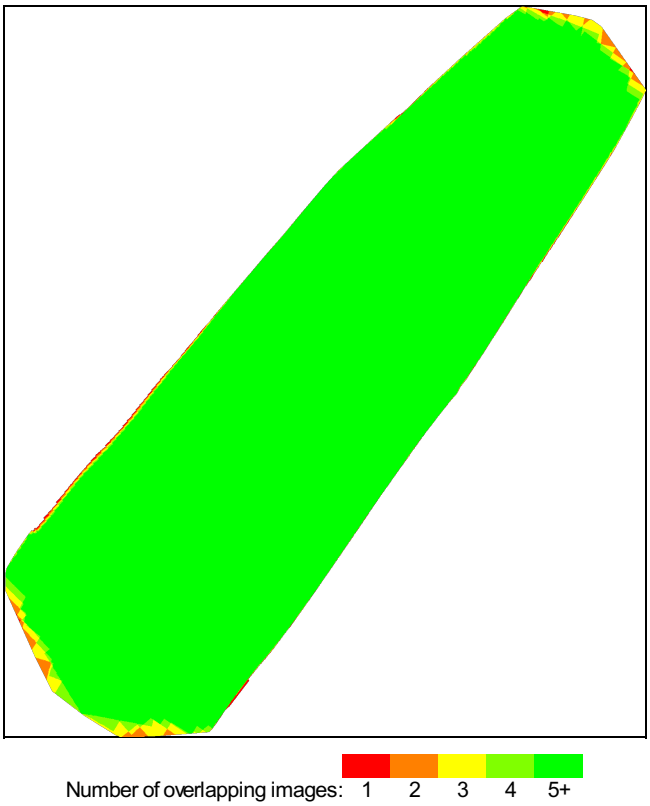


Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.
Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint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

Bundle Block Adjustment Details

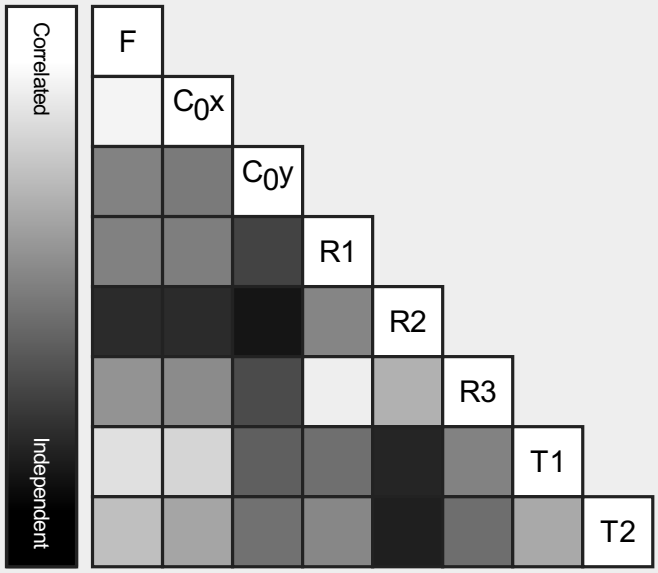
Number of 2D Keypoint Observations for Bundle Block Adjustment	18908054
Number of 3D Points for Bundle Block Adjustment	4748191
Mean Reprojection Error [pixels]	0.122

Internal Camera Parameters

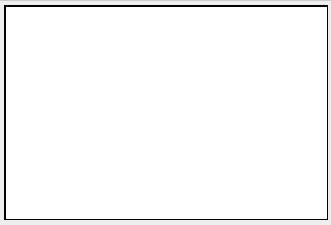
FC6310_8.8_5472x3648 (RGB). Sensor Dimensions: 12.833 [mm] x 8.556 [mm]

EXIF ID: FC6310S_8.8_5472x3648

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	3668.759 [pixel] 8.604 [mm]	2736.001 [pixel] 6.417 [mm]	1823.999 [pixel] 4.278 [mm]	0.003	-0.008	0.008	-0.000	0.000
Optimized Values	3721.481 [pixel] 8.728 [mm]	2713.963 [pixel] 6.365 [mm]	1805.779 [pixel] 4.235 [mm]	-0.014	0.004	0.006	-0.002	-0.001
Uncertainties (Sigma)	7.220 [pixel] 0.017 [mm]	0.228 [pixel] 0.001 [mm]	0.068 [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	73341	33894
Min	65068	16145
Max	79991	43185
Mean	73718	33644

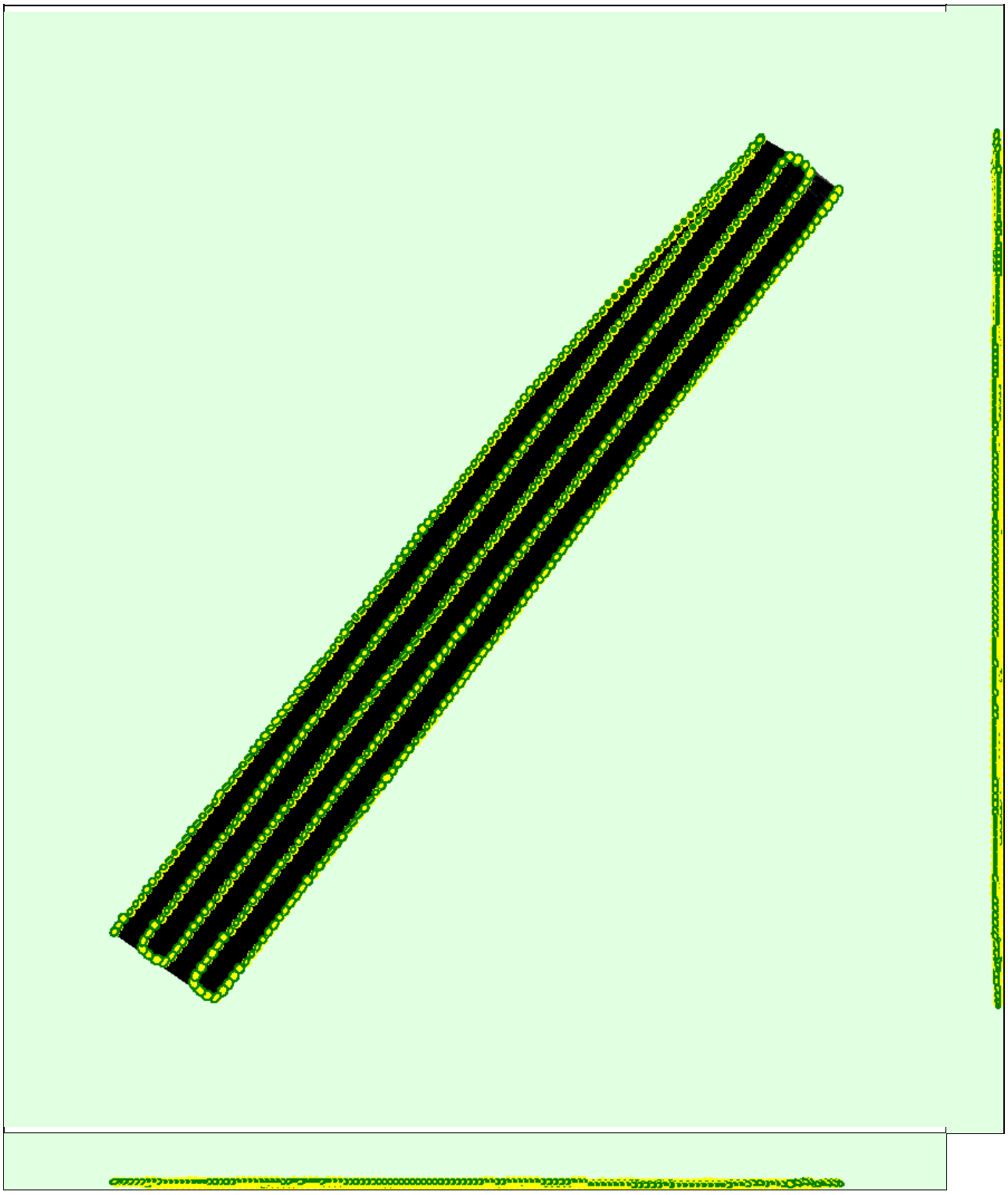
3D Points from 2D Keypoint Matches

	Number of 3D Points Observed
In 2 Images	2422722
In 3 Images	905226
In 4 Images	446589
In 5 Images	257020
In 6 Images	164462
In 7 Images	111861
In 8 Images	80366
In 9 Images	60077
In 10 Images	46190
In 11 Images	36728
In 12 Images	29923
In 13 Images	24434
In 14 Images	20061
In 15 Images	16728
In 16 Images	13680
In 17 Images	11294
In 18 Images	9782
In 19 Images	8565
In 20 Images	7949
In 21 Images	6920
In 22 Images	6087
In 23 Images	5497

In 24 Images	5073
In 25 Images	4479
In 26 Images	4063
In 27 Images	3575
In 28 Images	3149
In 29 Images	2793
In 30 Images	2675
In 31 Images	2401
In 32 Images	2213
In 33 Images	2106
In 34 Images	1850
In 35 Images	1748
In 36 Images	1652
In 37 Images	1555
In 38 Images	1484
In 39 Images	1423
In 40 Images	1261
In 41 Images	1146
In 42 Images	1033
In 43 Images	892
In 44 Images	821
In 45 Images	778
In 46 Images	769
In 47 Images	719
In 48 Images	617
In 49 Images	589
In 50 Images	477
In 51 Images	477
In 52 Images	400
In 53 Images	348
In 54 Images	318
In 55 Images	308
In 56 Images	281
In 57 Images	236
In 58 Images	219
In 59 Images	194
In 60 Images	196
In 61 Images	210
In 62 Images	191
In 63 Images	159
In 64 Images	184
In 65 Images	116
In 66 Images	108
In 67 Images	102
In 68 Images	92
In 69 Images	68
In 70 Images	52
In 71 Images	40
In 72 Images	42
In 73 Images	32
In 74 Images	38
In 75 Images	31
In 76 Images	26
In 77 Images	36
In 78 Images	30
In 79 Images	29
In 80 Images	27
In 81 Images	21
In 82 Images	18

In 83 Images	17
In 84 Images	15
In 85 Images	6
In 86 Images	2
In 87 Images	6
In 88 Images	6
In 89 Images	2
In 90 Images	2
In 91 Images	2
In 92 Images	1
In 94 Images	1

2D Keypoint Matches



Uncertainty ellipses 500x magnified

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	0.006	0.007	0.003	0.003	0.003	0.001
Sigma	0.001	0.001	0.001	0.001	0.001	0.000

Geolocation Details

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	0.00	0.00	0.00
-3.00	0.00	26.69	49.47	41.28
0.00	3.00	73.31	50.53	58.72
3.00	6.00	0.00	0.00	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]		0.000016	-0.000006	-0.002426
Sigma [m]		0.551330	0.339344	0.687234
RMS Error [m]		0.551330	0.339344	0.687238

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.

Relative Geolocation Variance

Relative Geolocation Error	Images X [%]	Images Y [%]	Images Z [%]
[-1.00, 1.00]	100.00	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	0.976
Phi	1.021
Kappa	7.535

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) Core(TM) i7-10700 CPU @ 2.90GHz RAM: 16GB GPU: NVIDIA Quadro P1000 (Driver: 27.21.14.5148), Intel(R) UHD Graphics 630 (Driver: 27.20.100.8190)
Operating System	Windows 10 Pro, 64-bit

Coordinate Systems

Image Coordinate System	WGS 84 (EGM96 Geoid)
Output Coordinate System	WGS 84 / UTM zone 33N (EGM96 Geoid)

Processing Options

Detected Template	CUDDIA CURVE OK*
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	yes
3D Textured Mesh Settings:	Resolution: Medium Resolution (default) Color Balancing: no
LOD	Generated: no
Advanced: 3D Textured Mesh Settings	Sample Density Divider: 1
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Time for Point Cloud Densification	25m:48s
Time for Point Cloud Classification	02m:08s
Time for 3D Textured Mesh Generation	06m:35s

Results

Number of Processed Clusters	15
Number of Generated Tiles	1
Number of 3D Densified Points	23487550
Average Density (per m^3)	228.78

DSM, Orthomosaic and Index Details

Processing Options

DSM and Orthomosaic Resolution	1 x GSD (3.08 [cm/pixel])
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp
Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes
Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: yes
Grid DSM	Generated: yes, Spacing [cm]: 100
Raster DTM	Generated: yes Merge Tiles: yes
DTM Resolution	5 x GSD (3.08 [cm/pixel])
Contour Lines Generation	Generated: yes Contour Base [m]: 0 Elevation Interval [m]: 0.5 Resolution [cm]: 300 Minimum Line Size [vertices]: 10
Time for DSM Generation	07m:23s
Time for Orthomosaic Generation	43m:03s
Time for DTM Generation	08m:09s
Time for Contour Lines Generation	02s
Time for Reflectance Map Generation	00s
Time for Index Map Generation	00s

Quality Report

Generated with Pix4Dmapper version 4.6.4

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	CUDDIA NORD 4
Processed	2021-04-13 00:38:28
Camera Model Name(s)	FC6310_8.8_5472x3648 (RGB)
Average Ground Sampling Distance (GSD)	3.05 cm / 1.20 in
Area Covered	0.872 km^2 / 87.2026 ha / 0.34 sq. mi. / 215.5939 acres
Time for Initial Processing (without report)	04h:13m:10s

Quality Check

Images	median of 72732 keypoints per image	✓
Dataset	2124 out of 2124 images calibrated (100%), 6 images disabled, 2 blocks	⚠
Camera Optimization	1.43% relative difference between initial and optimized internal camera parameters	✓
Matching	median of 30751.3 matches per calibrated image	✓
Georeferencing	yes, no 3D GCP	⚠

Preview

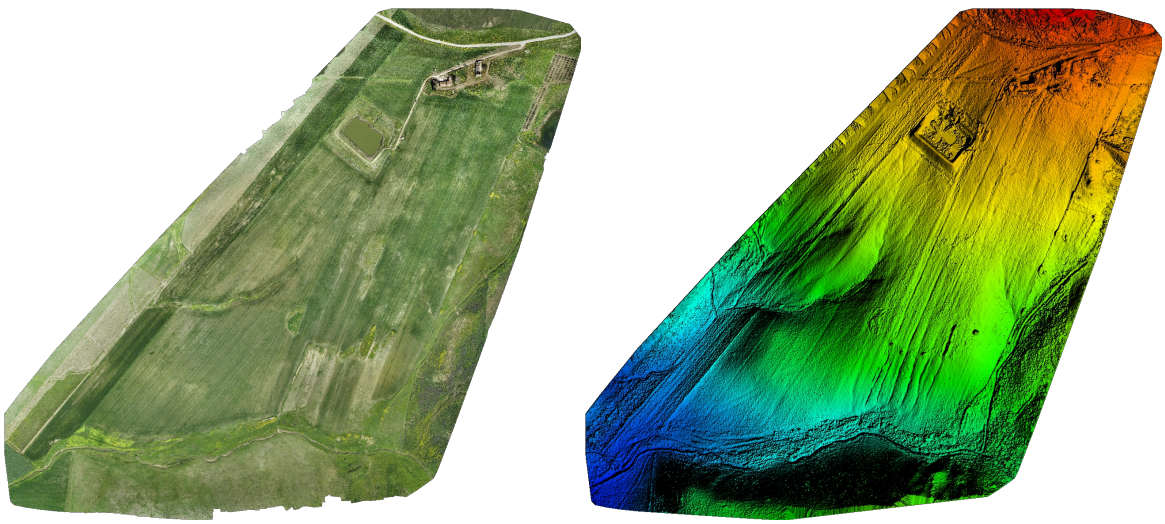


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Calibration Details

Number of Calibrated Images	2124 out of 2130

Number of Geolocated Images	2130 out of 2130

Initial Image Positions

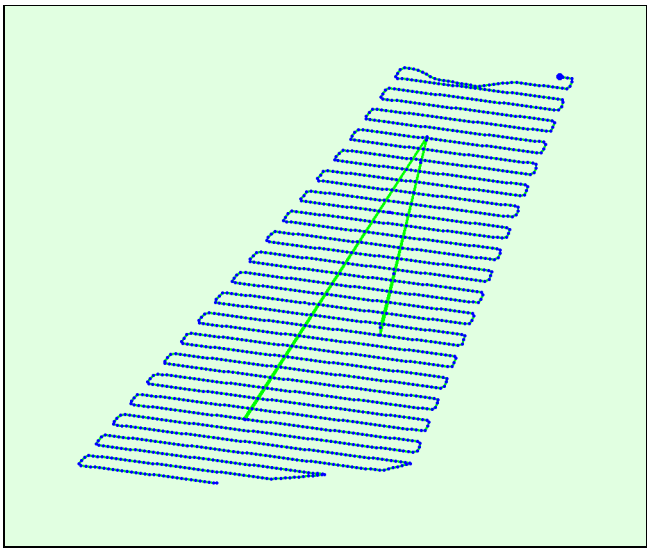
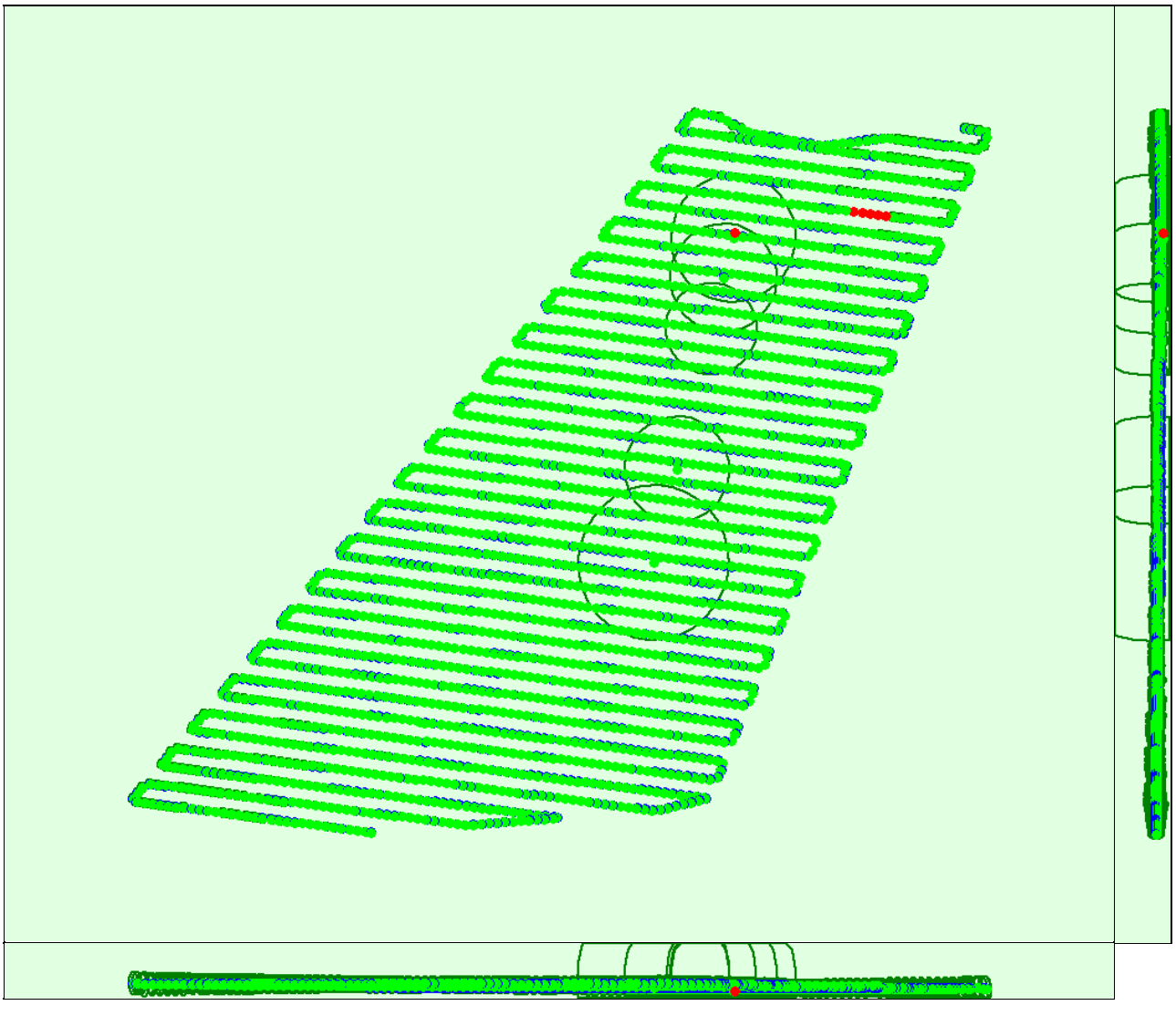


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

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	0.043	0.043	0.091	0.014	0.016	0.005
Sigma	0.039	0.039	0.067	0.013	0.009	0.006

Overlap

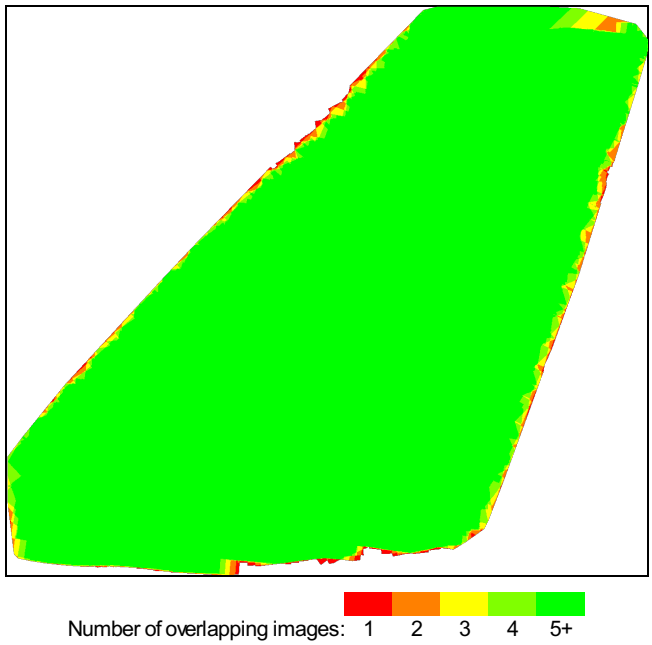


Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.
Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint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

Bundle Block Adjustment Details

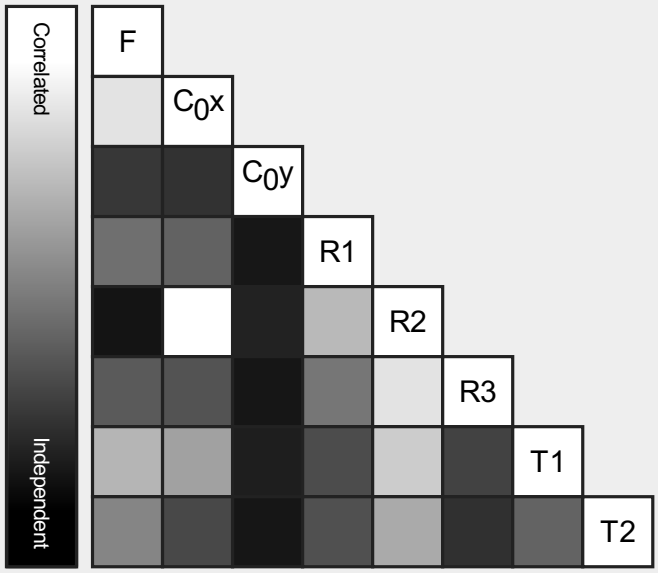
Number of 2D Keypoint Observations for Bundle Block Adjustment	54263343
Number of 3D Points for Bundle Block Adjustment	15385598
Mean Reprojection Error [pixels]	0.122

Internal Camera Parameters

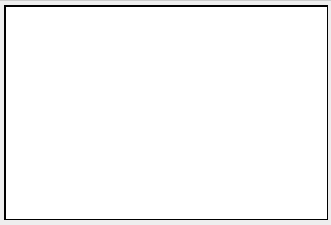
FC6310_8.8_5472x3648 (RGB). Sensor Dimensions: 12.833 [mm] x 8.556 [mm]

EXIF ID: FC6310S_8.8_5472x3648

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	3668.759 [pixel] 8.604 [mm]	2736.001 [pixel] 6.417 [mm]	1823.999 [pixel] 4.278 [mm]	0.003	-0.008	0.008	-0.000	0.000
Optimized Values	3721.428 [pixel] 8.728 [mm]	2714.114 [pixel] 6.365 [mm]	1806.217 [pixel] 4.236 [mm]	-0.014	0.003	0.006	-0.002	-0.001
Uncertainties (Sigma)	2.612 [pixel] 0.006 [mm]	0.089 [pixel] 0.000 [mm]	0.038 [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	72732	30751
Min	19590	534
Max	80000	42912
Mean	72825	25548

3D Points from 2D Keypoint Matches

	Number of 3D Points Observed
In 2 Images	8725116
In 3 Images	2890945
In 4 Images	1316168
In 5 Images	717624
In 6 Images	437951
In 7 Images	288552
In 8 Images	201384
In 9 Images	146331
In 10 Images	109300
In 11 Images	84358
In 12 Images	66658
In 13 Images	52993
In 14 Images	43350
In 15 Images	35557
In 16 Images	30279
In 17 Images	25594
In 18 Images	21885
In 19 Images	19083
In 20 Images	16852
In 21 Images	14532
In 22 Images	12878
In 23 Images	11290

In 24 Images	10185
In 25 Images	8881
In 26 Images	8151
In 27 Images	7454
In 28 Images	6585
In 29 Images	5697
In 30 Images	5301
In 31 Images	4877
In 32 Images	4432
In 33 Images	4048
In 34 Images	3809
In 35 Images	3567
In 36 Images	3145
In 37 Images	2933
In 38 Images	2700
In 39 Images	2493
In 40 Images	2265
In 41 Images	2044
In 42 Images	1921
In 43 Images	1836
In 44 Images	1648
In 45 Images	1591
In 46 Images	1499
In 47 Images	1338
In 48 Images	1319
In 49 Images	1193
In 50 Images	1098
In 51 Images	1062
In 52 Images	1043
In 53 Images	952
In 54 Images	884
In 55 Images	877
In 56 Images	750
In 57 Images	742
In 58 Images	718
In 59 Images	609
In 60 Images	583
In 61 Images	514
In 62 Images	532
In 63 Images	452
In 64 Images	445
In 65 Images	358
In 66 Images	416
In 67 Images	309
In 68 Images	306
In 69 Images	288
In 70 Images	285
In 71 Images	270
In 72 Images	257
In 73 Images	235
In 74 Images	233
In 75 Images	196
In 76 Images	198
In 77 Images	158
In 78 Images	152
In 79 Images	127
In 80 Images	103
In 81 Images	105
In 82 Images	115

In 83 Images	95
In 84 Images	66
In 85 Images	48
In 86 Images	63
In 87 Images	54
In 88 Images	47
In 89 Images	36
In 90 Images	32
In 91 Images	32
In 92 Images	39
In 93 Images	26
In 94 Images	17
In 95 Images	21
In 96 Images	5
In 97 Images	15
In 98 Images	9
In 99 Images	10
In 100 Images	9
In 101 Images	4
In 102 Images	2
In 103 Images	2
In 104 Images	1
In 105 Images	1

2D Keypoint Matches

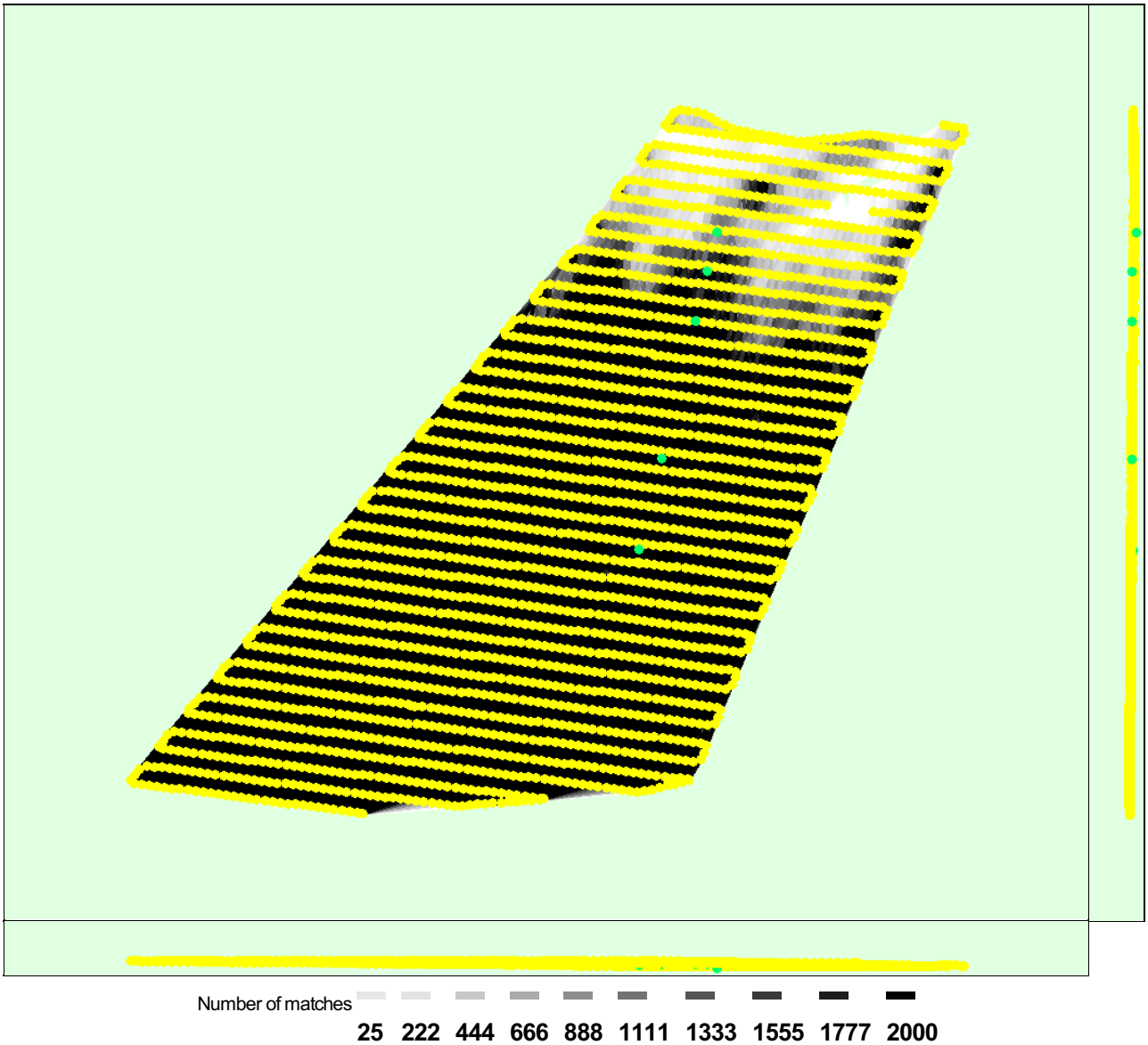


Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images.

Geolocation Details

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	0.00	0.00	0.00
-3.00	0.00	47.32	51.84	40.16
0.00	3.00	52.68	48.16	59.84
3.00	6.00	0.00	0.00	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]		-0.000000	0.000000	0.000000
Sigma [m]		0.568348	0.493175	1.045233
RMS Error [m]		0.568348	0.493175	1.045233

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.

Relative Geolocation Variance

Relative Geolocation Error	Images X [%]	Images Y [%]	Images Z [%]
[-1.00, 1.00]	100.00	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	0.980
Phi	0.440
Kappa	2.600

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) Core(TM) i7-10700 CPU @ 2.90GHz RAM: 16GB GPU: NVIDIA Quadro P1000 (Driver: 27.21.14.5148), Intel(R) UHD Graphics 630 (Driver: 27.20.100.8190)

Operating System	Windows 10 Pro, 64-bit

Coordinate Systems

Image Coordinate System	WGS 84 (EGM96 Geoid)
Output Coordinate System	WGS 84 / UTM zone 33N (EGM96 Geoid)

Processing Options

Detected Template	CUDDIA CURVE OK*
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	yes
3D Textured Mesh Settings:	Resolution: Medium Resolution (default) Color Balancing: no
LOD	Generated: no
Advanced: 3D Textured Mesh Settings	Sample Density Divider: 1
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Time for Point Cloud Densification	02h:05m:31s
Time for Point Cloud Classification	14m:28s
Time for 3D Textured Mesh Generation	20m:19s

Results

Number of Processed Clusters	66
Number of Generated Tiles	6
Number of 3D Densified Points	164047696
Average Density (per m^3)	301.01

DSM, Orthomosaic and Index Details

Processing Options

DSM and Orthomosaic Resolution	1 x GSD (3.05 [cm/pixel])
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp
Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes

Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: yes
Grid DSM	Generated: yes, Spacing [cm]: 100
Raster DTM	Generated: yes Merge Tiles: yes
DTM Resolution	5 x GSD (3.05 [cm/pixel])
Contour Lines Generation	Generated: yes Contour Base [m]: 0 Elevation Interval [m]: 0.5 Resolution [cm]: 300 Minimum Line Size [vertices]: 10
Time for DSM Generation	01h:15m:19s
Time for Orthomosaic Generation	04h:48m:50s
Time for DTM Generation	52m:38s
Time for Contour Lines Generation	08s
Time for Reflectance Map Generation	00s
Time for Index Map Generation	00s

Quality Report

Generated with Pix4Dmapper version 4.6.4

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	SUD1
Processed	2021-04-10 18:05:51
Camera Model Name(s)	FC6310_8.8_5472x3648 (RGB)
Average Ground Sampling Distance (GSD)	2.17 cm / 0.86 in
Area Covered	0.900 km^2 / 89.9753 ha / 0.35 sq. mi. / 222.4490 acres
Time for Initial Processing (without report)	07h:12m:40s

Quality Check

Images	median of 69878 keypoints per image	✓
Dataset	2737 out of 2742 images calibrated (99%), all images enabled	✓
Camera Optimization	1.3% relative difference between initial and optimized internal camera parameters	✓
Matching	median of 24889.1 matches per calibrated image	✓
Georeferencing	yes, no 3D GCP	⚠

Preview

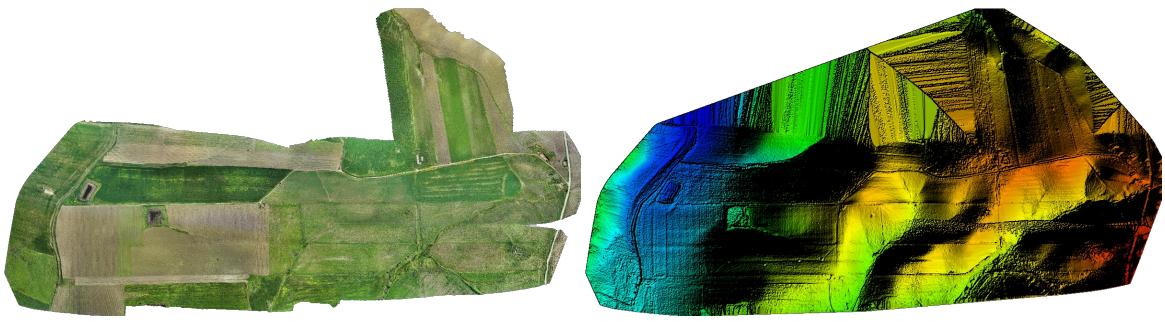


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Calibration Details

Number of Calibrated Images	2737 out of 2742
Number of Geolocated Images	2742 out of 2742

Initial Image Positions

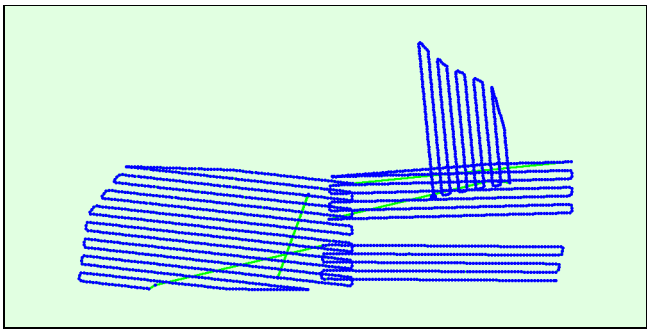
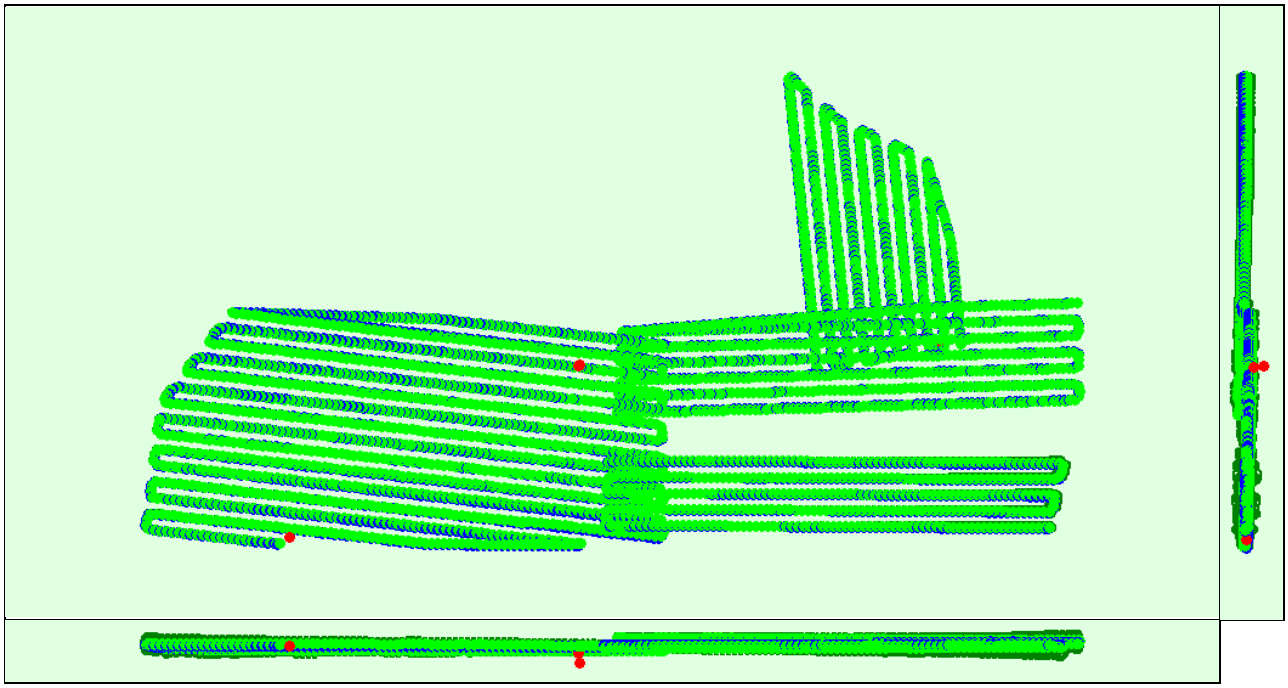


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

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	0.047	0.044	0.098	0.016	0.015	0.005
Sigma	0.014	0.010	0.025	0.002	0.004	0.001

Overlap

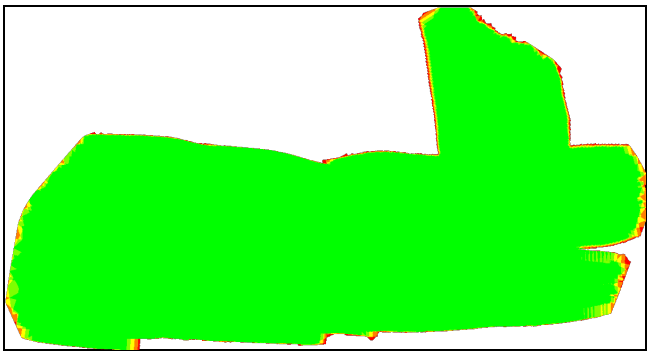


Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.
Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint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

Bundle Block Adjustment Details

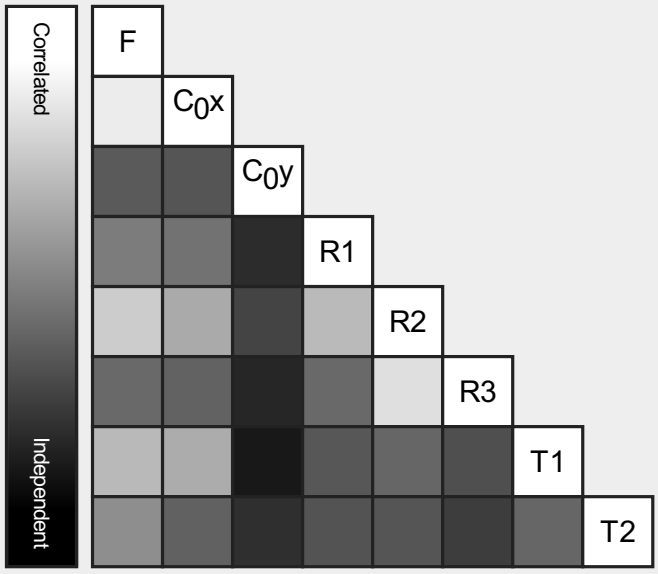
Number of 2D Keypoint Observations for Bundle Block Adjustment	65542846
Number of 3D Points for Bundle Block Adjustment	20857997
Mean Reprojection Error [pixels]	0.117

Internal Camera Parameters

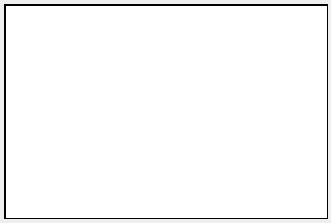
FC6310_8.8_5472x3648 (RGB). Sensor Dimensions: 12.833 [mm] x 8.556 [mm]

EXIF ID: FC6310S_8.8_5472x3648

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	3668.759 [pixel] 8.604 [mm]	2736.001 [pixel] 6.417 [mm]	1823.999 [pixel] 4.278 [mm]	0.003	-0.008	0.008	-0.000	0.000
Optimized Values	3716.599 [pixel] 8.716 [mm]	2713.972 [pixel] 6.365 [mm]	1806.098 [pixel] 4.236 [mm]	-0.013	0.002	0.007	-0.002	-0.001
Uncertainties (Sigma)	2.666 [pixel] 0.006 [mm]	0.093 [pixel] 0.000 [mm]	0.033 [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	69878	24889
Min	47400	3081
Max	85283	41081

Mean	68650	23947

3D Points from 2D Keypoint Matches

	Number of 3D Points Observed
In 2 Images	12436170
In 3 Images	3966187
In 4 Images	1737521
In 5 Images	908755
In 6 Images	533106
In 7 Images	337846
In 8 Images	224842
In 9 Images	154731
In 10 Images	110315
In 11 Images	82648
In 12 Images	63721
In 13 Images	49637
In 14 Images	40059
In 15 Images	32562
In 16 Images	26583
In 17 Images	21969
In 18 Images	18322
In 19 Images	14958
In 20 Images	13039
In 21 Images	11034
In 22 Images	9453
In 23 Images	8046
In 24 Images	7133
In 25 Images	6222
In 26 Images	5238
In 27 Images	4735
In 28 Images	4096
In 29 Images	3579
In 30 Images	3284
In 31 Images	2811
In 32 Images	2503
In 33 Images	2225
In 34 Images	1801
In 35 Images	1607
In 36 Images	1289
In 37 Images	1124
In 38 Images	1001
In 39 Images	927
In 40 Images	819
In 41 Images	738
In 42 Images	651
In 43 Images	524
In 44 Images	487
In 45 Images	465
In 46 Images	406
In 47 Images	318
In 48 Images	307
In 49 Images	264
In 50 Images	254
In 51 Images	197
In 52 Images	193
In 53 Images	153
In 54 Images	151

In 55 Images	131
In 56 Images	134
In 57 Images	99
In 58 Images	87
In 59 Images	83
In 60 Images	66
In 61 Images	54
In 62 Images	59
In 63 Images	51
In 64 Images	37
In 65 Images	50
In 66 Images	24
In 67 Images	30
In 68 Images	15
In 69 Images	11
In 70 Images	17
In 71 Images	11
In 72 Images	12
In 73 Images	6
In 74 Images	6
In 75 Images	1
In 76 Images	1
In 77 Images	3
In 78 Images	1
In 79 Images	2

2D Keypoint Matches

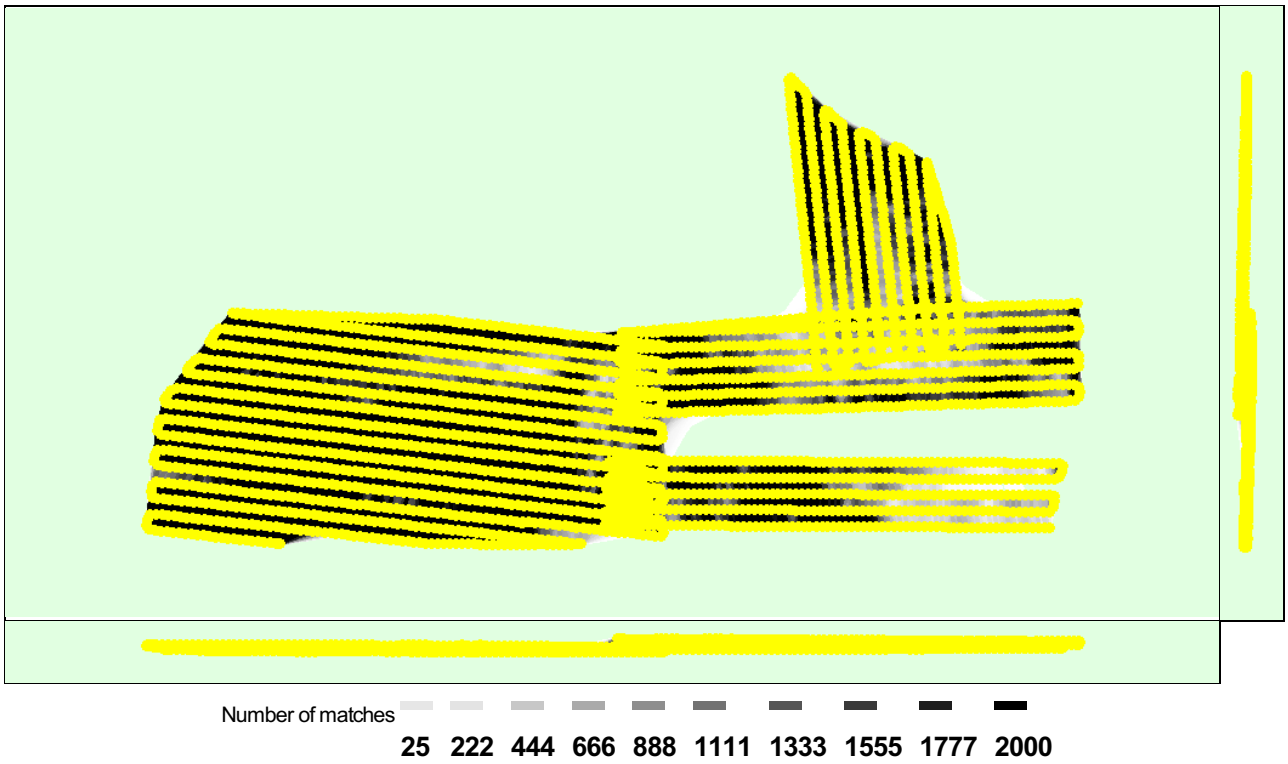


Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images.

Geolocation Details

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	1.46
-6.00	-3.00	2.41	1.53	11.80
-3.00	0.00	54.22	40.85	34.60
0.00	3.00	40.92	57.62	37.92
3.00	6.00	2.45	0.00	14.21
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]		-0.000000	0.000000	-0.000000
Sigma [m]		1.515776	1.374401	2.588179
RMS Error [m]		1.515776	1.374401	2.588179

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.

Relative Geolocation Variance

Relative Geolocation Error	Images X [%]	Images Y [%]	Images Z [%]
[-1.00, 1.00]	100.00	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	1.716
Phi	0.535
Kappa	6.968

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) Core(TM) i7-10700 CPU @ 2.90GHz RAM: 16GB GPU: NVIDIA Quadro P1000 (Driver: 27.21.14.5148), Intel(R) UHD Graphics 630 (Driver: 27.20.100.8190)
Operating System	Windows 10 Pro, 64-bit

Coordinate Systems

Image Coordinate System	WGS 84 (EGM96 Geoid)
Output Coordinate System	WGS 84 / UTM zone 33N (EGM96 Geoid)

Processing Options

Detected Template	CUDDIA CURVE OK*
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	yes
3D Textured Mesh Settings:	Resolution: Medium Resolution (default) Color Balancing: no
LOD	Generated: no
Advanced: 3D Textured Mesh Settings	Sample Density Divider: 1
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Time for Point Cloud Densification	02h:56m:45s
Time for Point Cloud Classification	20m:30s
Time for 3D Textured Mesh Generation	33m:43s

Results

Number of Processed Clusters	74
Number of Generated Tiles	9
Number of 3D Densified Points	251756194
Average Density (per m^3)	458.6

DSM, Orthomosaic and Index Details

Processing Options

DSM and Orthomosaic Resolution	1 x GSD (2.17 [cm/pixel])
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp
Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes
Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: yes
Grid DSM	Generated: yes, Spacing [cm]: 100
Raster DTM	Generated: yes Merge Tiles: yes
DTM Resolution	5 x GSD (2.17 [cm/pixel])

Contour Lines Generation	Generated: yes Contour Base [m]: 0 Elevation Interval [m]: 0.5 Resolution [cm]: 300 Minimum Line Size [vertices]: 10
Time for DSM Generation	01h:45m:30s
Time for Orthomosaic Generation	04h:01m:11s
Time for DTM Generation	02h:56m:47s
Time for Contour Lines Generation	12s
Time for Reflectance Map Generation	00s
Time for Index Map Generation	00s

Quality Report

Generated with Pix4Dmapper version 4.6.4

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	CUDDIA_SSEU
Processed	2021-04-12 09:32:49
Camera Model Name(s)	FC6310_8.8_5472x3648 (RGB)
Average Ground Sampling Distance (GSD)	1.77 cm / 0.70 in
Area Covered	0.079 km^2 / 7.9411 ha / 0.03 sq. mi. / 19.6331 acres
Time for Initial Processing (without report)	26m:37s

Quality Check

Images	median of 82934 keypoints per image	✓
Dataset	187 out of 187 images calibrated (100%), all images enabled	✓
Camera Optimization	1.45% relative difference between initial and optimized internal camera parameters	✓
Matching	median of 48135.8 matches per calibrated image	✓
Georeferencing	yes, no 3D GCP	⚠

Preview

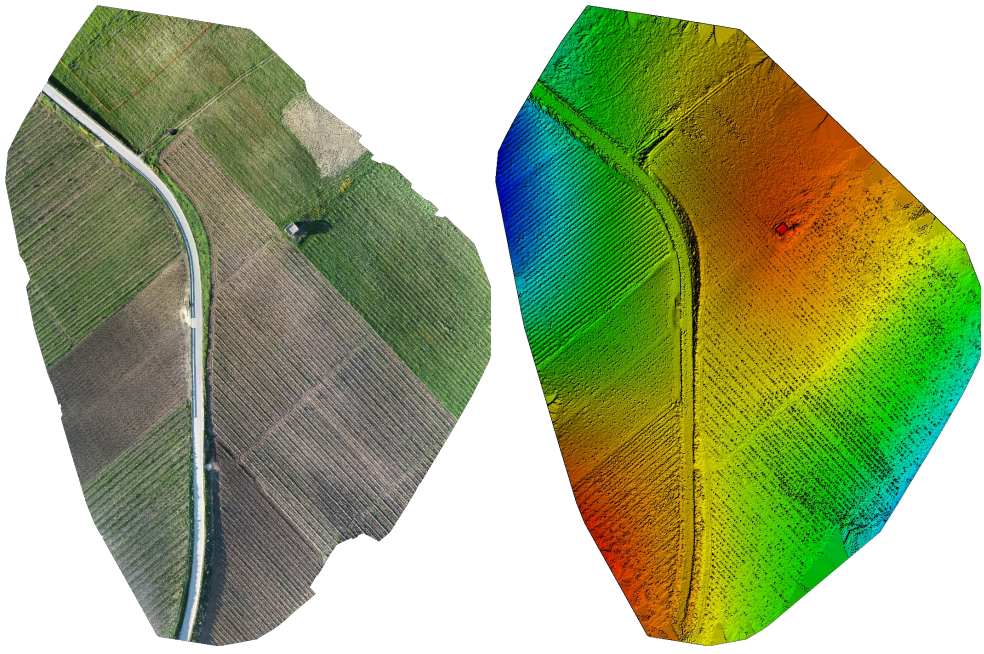


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Calibration Details

Number of Calibrated Images	187 out of 187
Number of Geolocated Images	187 out of 187

Initial Image Positions

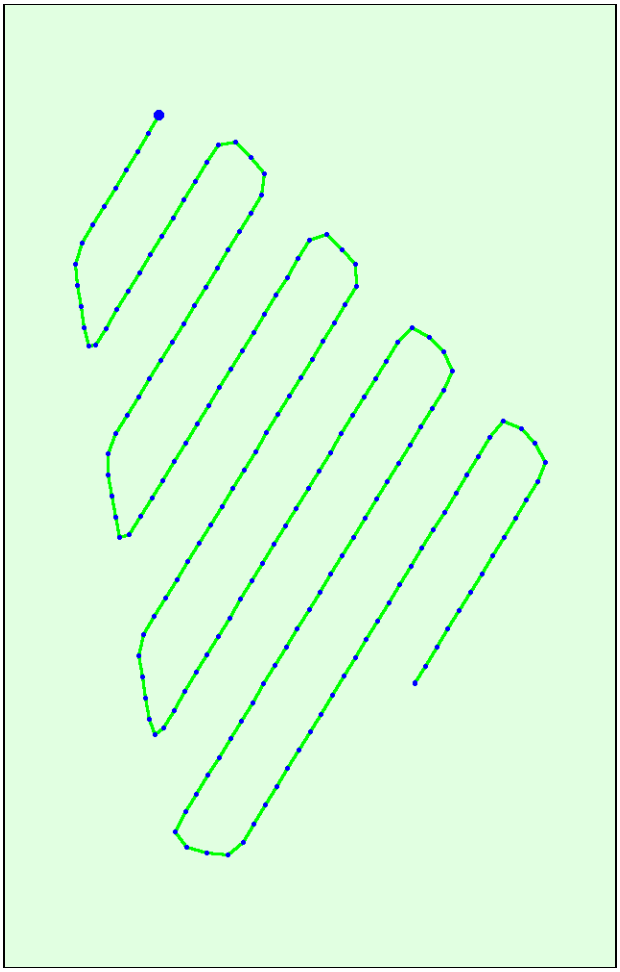
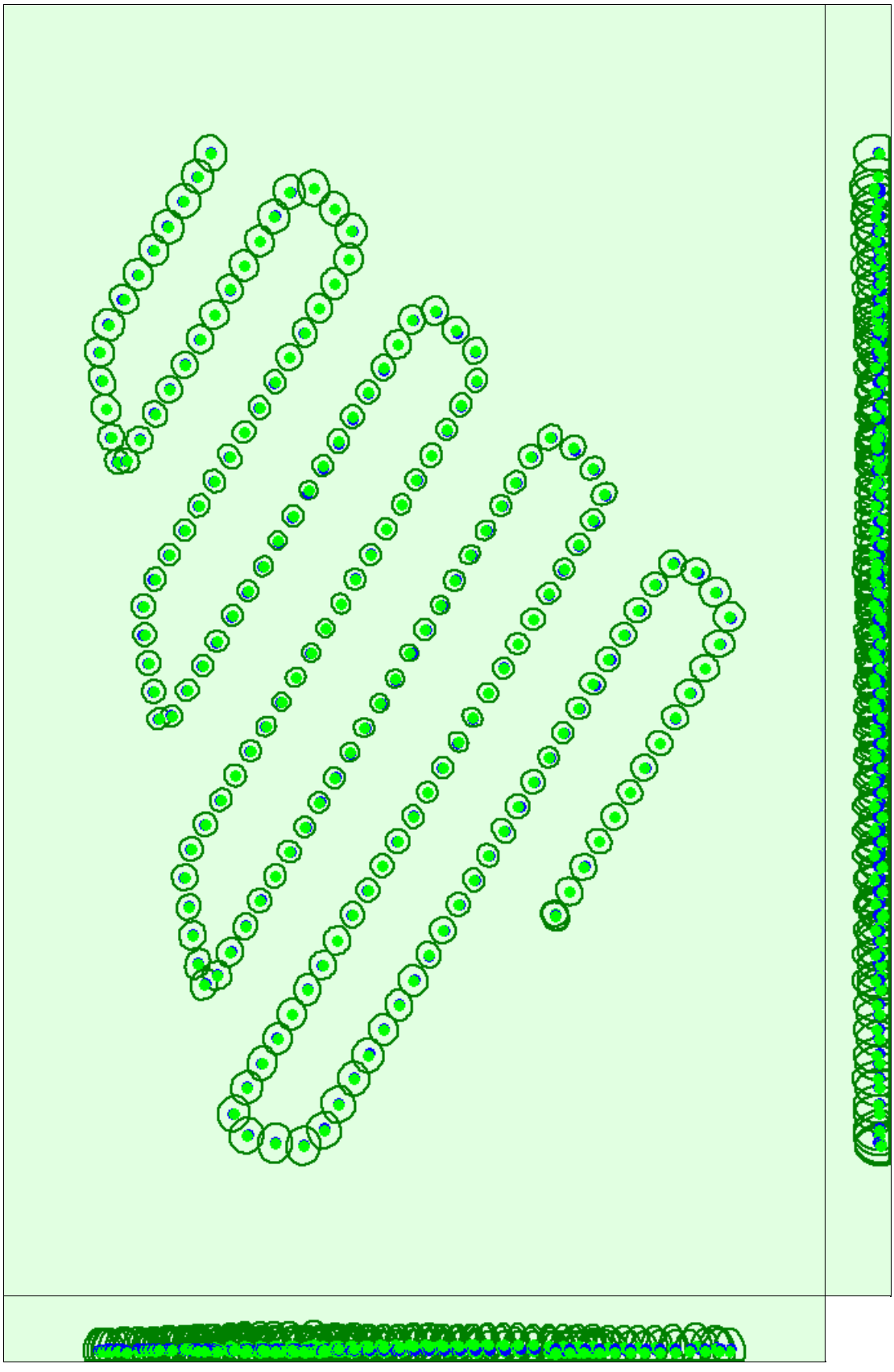


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

Computed Image/GCPs/Manual Tie Points Positions



Uncertainty ellipses 50x 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). 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	0.078	0.080	0.130	0.037	0.037	0.031
Sigma	0.012	0.015	0.009	0.001	0.002	0.000

Overlap

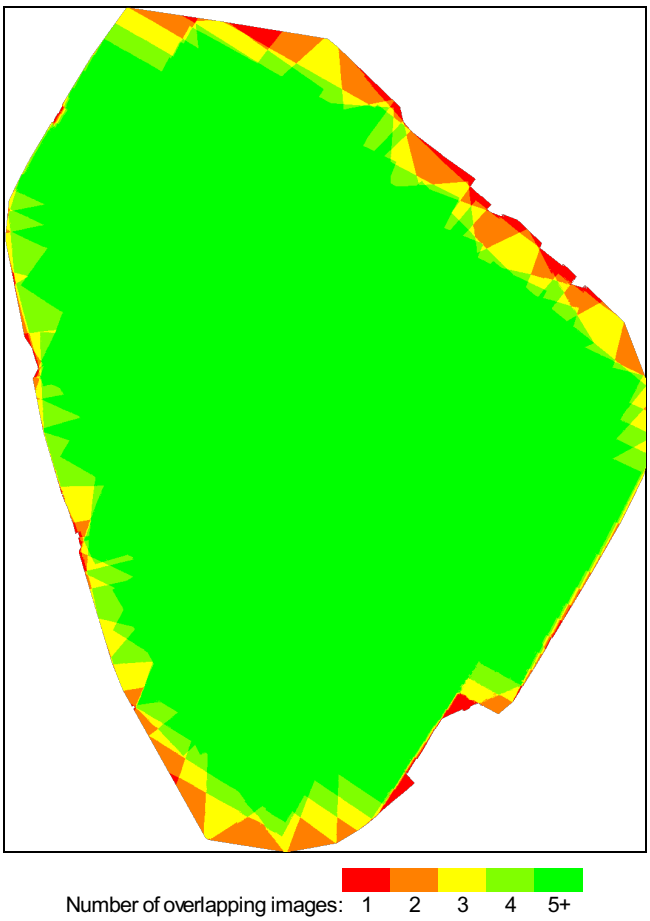


Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.
Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint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

Bundle Block Adjustment Details

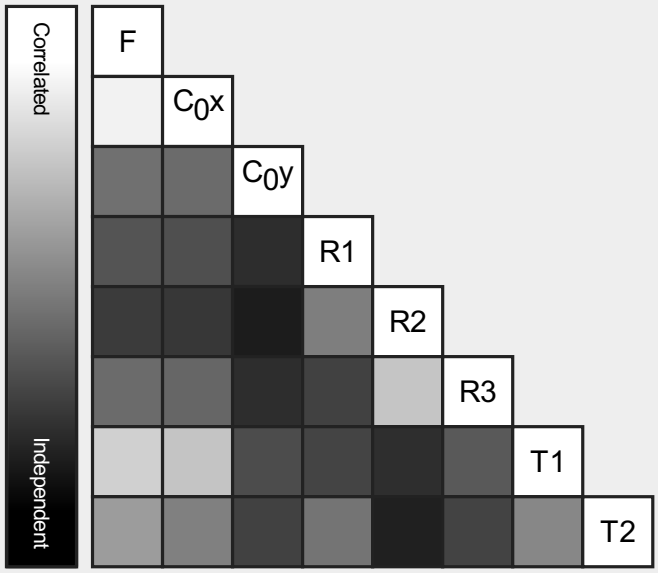
Number of 2D Keypoint Observations for Bundle Block Adjustment	8955094
Number of 3D Points for Bundle Block Adjustment	2761241
Mean Reprojection Error [pixels]	0.148

Internal Camera Parameters

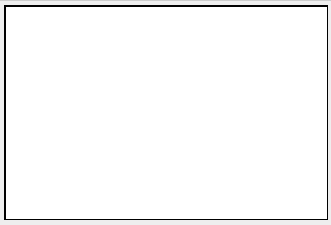
FC6310_8.8_5472x3648 (RGB). Sensor Dimensions: 12.833 [mm] x 8.556 [mm]

EXIF ID: FC6310S_8.8_5472x3648

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	3668.759 [pixel] 8.604 [mm]	2736.001 [pixel] 6.417 [mm]	1823.999 [pixel] 4.278 [mm]	0.003	-0.008	0.008	-0.000	0.000
Optimized Values	3722.199 [pixel] 8.730 [mm]	2713.941 [pixel] 6.365 [mm]	1806.502 [pixel] 4.237 [mm]	-0.014	0.005	0.005	-0.002	-0.001
Uncertainties (Sigma)	6.708 [pixel] 0.016 [mm]	0.214 [pixel] 0.001 [mm]	0.066 [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	82934	48136
Min	74398	34791
Max	88062	65974
Mean	82349	47888

3D Points from 2D Keypoint Matches

	Number of 3D Points Observed
In 2 Images	1589142
In 3 Images	514430
In 4 Images	235116
In 5 Images	130466
In 6 Images	80917
In 7 Images	54384
In 8 Images	36961
In 9 Images	26935
In 10 Images	20689
In 11 Images	16114
In 12 Images	12839
In 13 Images	10007
In 14 Images	7891
In 15 Images	5899
In 16 Images	4576
In 17 Images	3375
In 18 Images	2659
In 19 Images	2224
In 20 Images	1709
In 21 Images	1325
In 22 Images	988
In 23 Images	770

In 24 Images	595
In 25 Images	408
In 26 Images	311
In 27 Images	213
In 28 Images	112
In 29 Images	78
In 30 Images	72
In 31 Images	22
In 32 Images	11
In 33 Images	2
In 36 Images	1

2D Keypoint Matches

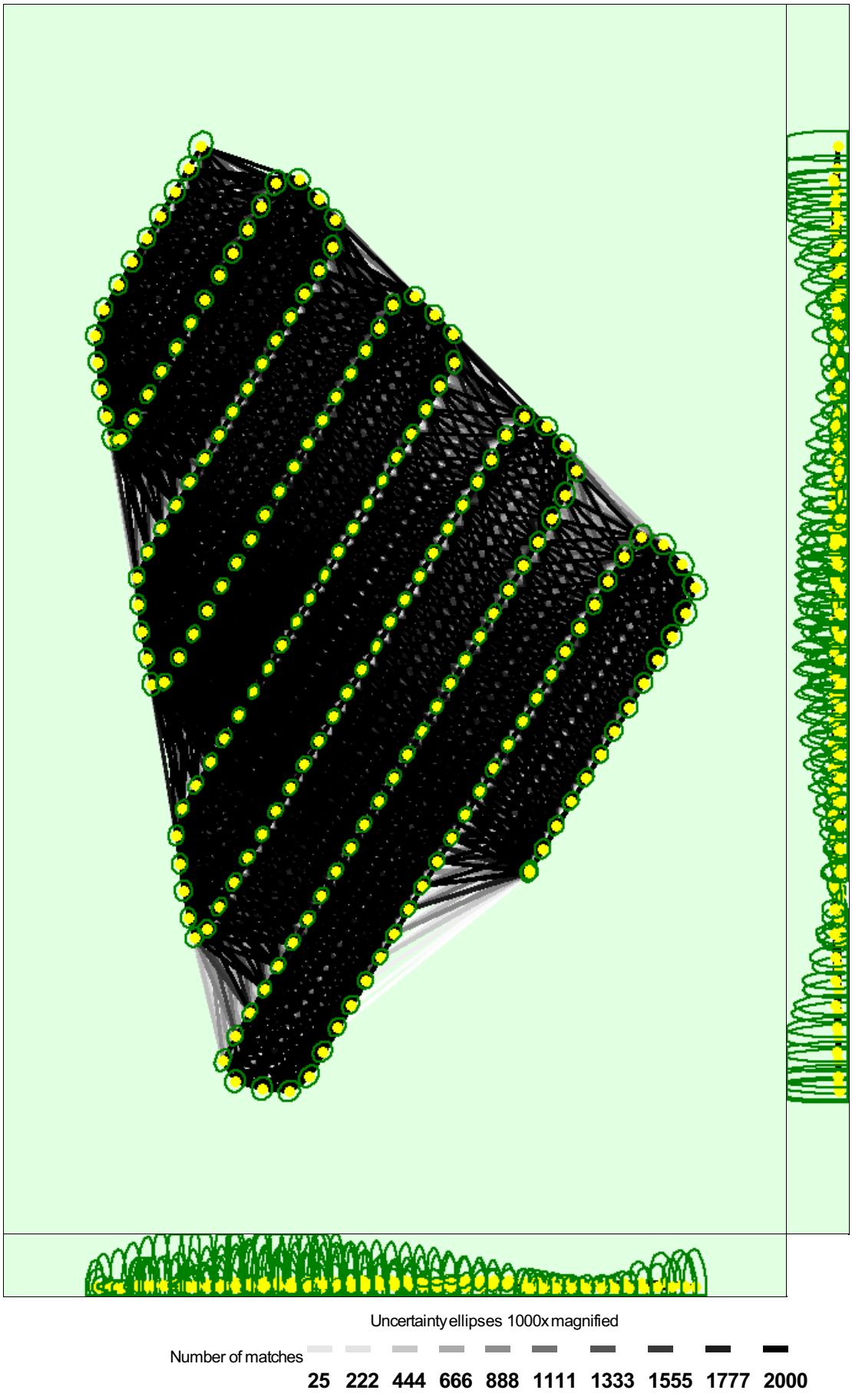


Figure 5: Computed image positions with links between matched images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images. Dark green ellipses indicate the relative camera position uncertainty 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	0.003	0.003	0.008	0.009	0.012	0.001
Sigma	0.000	0.000	0.006	0.006	0.007	0.000

Geolocation Details

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	0.00	0.00	0.00
-3.00	0.00	50.80	48.13	41.18
0.00	3.00	49.20	51.87	58.82
3.00	6.00	0.00	0.00	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]		0.000000	0.000000	0.000000
Sigma [m]		0.293527	0.251882	0.823910
RMS Error [m]		0.293527	0.251882	0.823910

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.

Relative Geolocation Variance

Relative Geolocation Error	Images X [%]	Images Y [%]	Images Z [%]
[-1.00, 1.00]	100.00	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	0.868
Phi	0.756
Kappa	3.491

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) Core(TM) i7-10700 CPU @ 2.90GHz RAM: 16GB GPU: NVIDIA Quadro P1000 (Driver: 27.21.14.5148), Intel(R) UHD Graphics 630 (Driver: 27.20.100.8190)
Operating System	Windows 10 Pro, 64-bit

Coordinate Systems

Image Coordinate System	WGS 84 (EGM96 Geoid)
Output Coordinate System	WGS 84 / UTM zone 33N (EGM96 Geoid)

Processing Options

Detected Template	CUDDIA CURVE OK*
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, yes

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	yes
3D Textured Mesh Settings:	Resolution: Medium Resolution (default) Color Balancing: no
LOD	Generated: no
Advanced: 3D Textured Mesh Settings	Sample Density Divider: 1
Advanced: Image Groups	group1
Advanced: Use Processing Area	yes
Advanced: Use Annotations	yes
Time for Point Cloud Densification	13m:18s
Time for Point Cloud Classification	01m:46s
Time for 3D Textured Mesh Generation	05m:54s

Results

Number of Generated Tiles	1
Number of 3D Densified Points	20061324
Average Density (per m^3)	629.28

DSM, Orthomosaic and Index Details

Processing Options

DSM and Orthomosaic Resolution	1 x GSD (1.77 [cm/pixel])
DSM Filters	Noise Filtering: yes Surface Smoothing: yes, Type: Sharp

Raster DSM	Generated: yes Method: Inverse Distance Weighting Merge Tiles: yes
Orthomosaic	Generated: yes Merge Tiles: yes GeoTIFF Without Transparency: no Google Maps Tiles and KML: yes
Grid DSM	Generated: yes, Spacing [cm]: 100
Raster DTM	Generated: yes Merge Tiles: yes
DTM Resolution	5 x GSD (1.77 [cm/pixel])
Contour Lines Generation	Generated: yes Contour Base [m]: 0 Elevation Interval [m]: 0.5 Resolution [cm]: 300 Minimum Line Size [vertices]: 10
Time for DSM Generation	08m:11s
Time for Orthomosaic Generation	23m:46s
Time for DTM Generation	08m:09s
Time for Contour Lines Generation	01s
Time for Reflectance Map Generation	00s
Time for Index Map Generation	00s