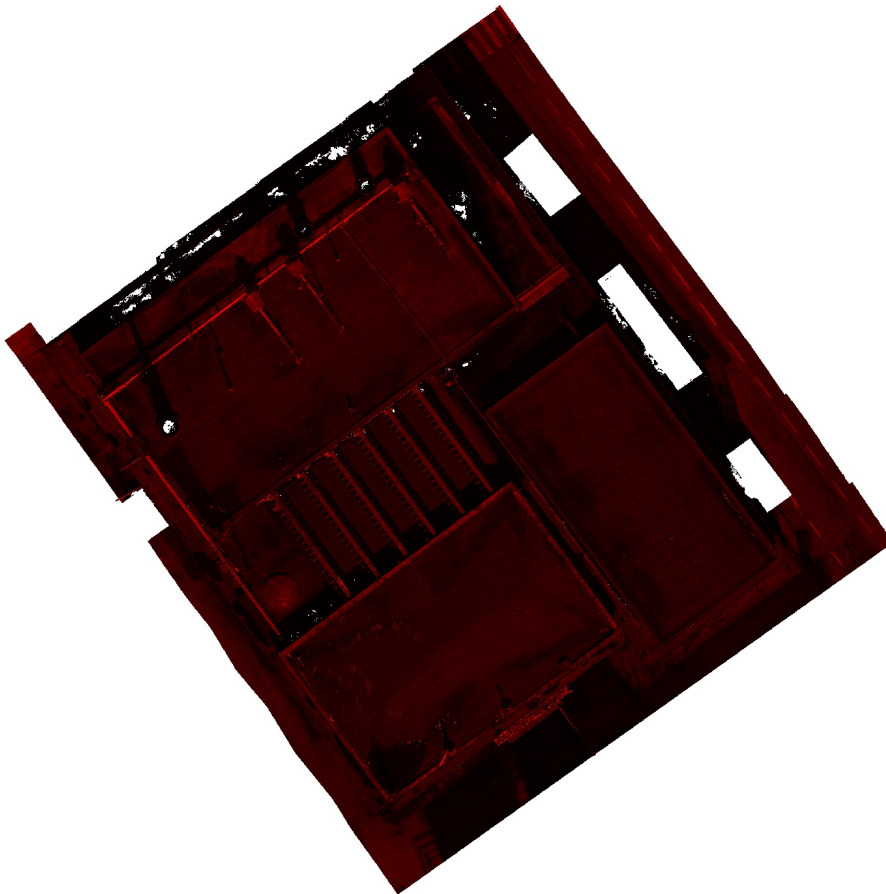


REPORT_UAV_R

report drone r

14 March 2024



Survey Data

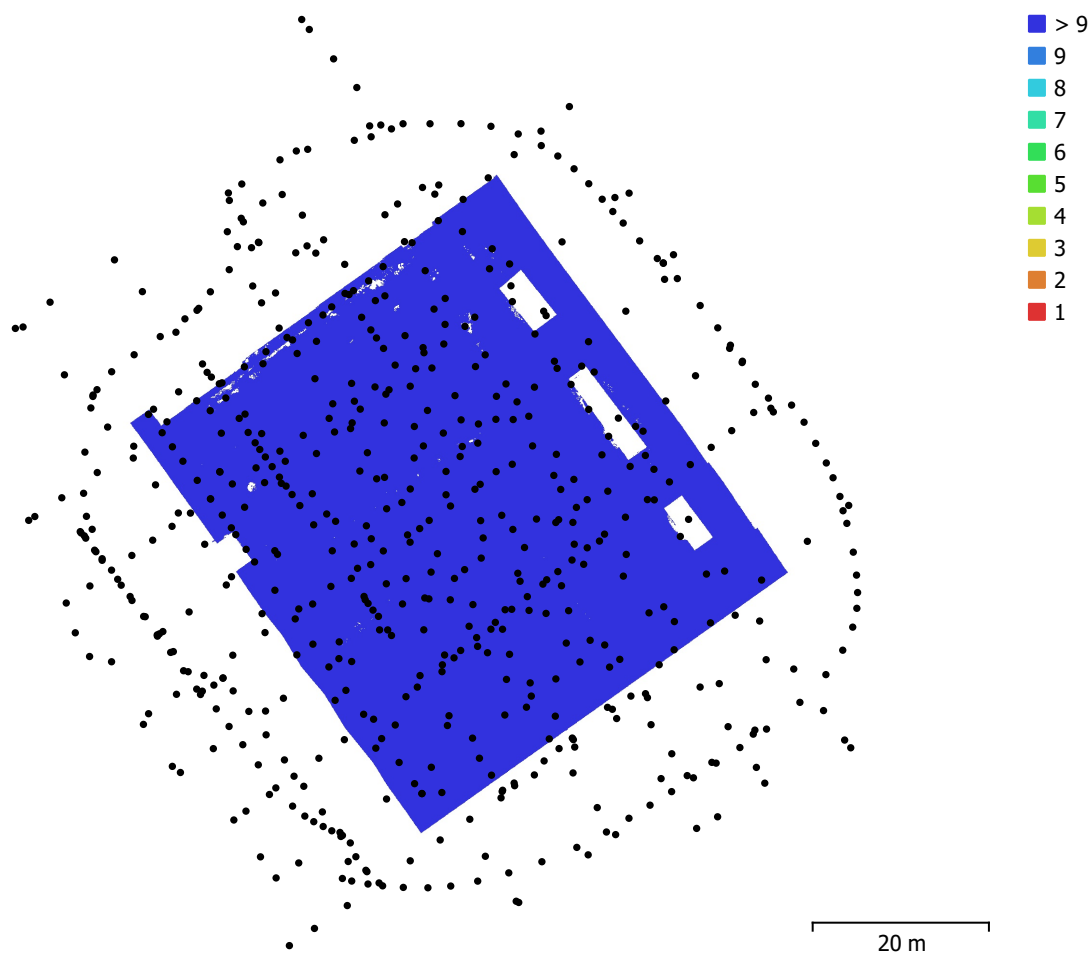


Fig. 1. Camera locations and image overlap.

Number of images:	598	Camera stations:	598
Flying altitude:	25.4 m	Tie points:	221,281
Ground resolution:	1.41 cm/pix	Projections:	802,570
Coverage area:	2.72e+03 m ²	Reprojection error:	1.68 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
M3M (4.34mm)	2592 x 1944	4.34 mm	2 x 2 μm	Yes

Table 1. Cameras.

Camera Calibration

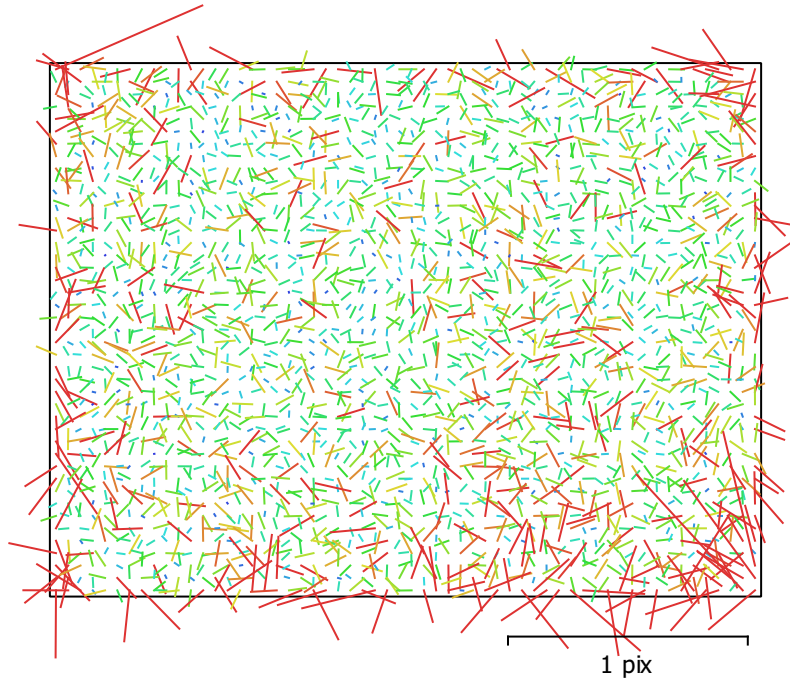


Fig. 2. Image residuals for M3M (4.34mm).

M3M (4.34mm)

598 images, precalibrated

Type	Resolution	Focal Length	Pixel Size
Frame	2592 x 1944	4.34 mm	2 x 2 μm

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	2170.35	0.076	1.00	-0.04	-0.43	-0.29	-0.04	-0.51	0.47	-0.43	0.39	-0.00	-0.31
Cx	5.70706	0.084		1.00	0.03	0.00	0.13	-0.01	0.01	-0.01	0.01	0.85	0.01
Cy	10.7819	0.089			1.00	-0.08	0.09	-0.01	-0.01	0.01	-0.01	-0.01	0.68
B1	-0.919965	0.029				1.00	-0.02	0.01	-0.02	0.02	-0.02	-0.00	0.21
B2	-0.731104	0.025					1.00	-0.00	0.00	-0.00	0.00	-0.10	0.02
K1	0.00996545	0.00041						1.00	-0.97	0.93	-0.88	-0.00	-0.03
K2	-0.0557505	0.0029							1.00	-0.99	0.96	0.00	0.00
K3	0.0180105	0.0082								1.00	-0.99	-0.01	0.00
K4	-0.0343792	0.0078									1.00	0.01	-0.00
P1	0.000344189	1.2e-05										1.00	0.00
P2	0.000303012	1.1e-05											1.00

Table 2. Calibration coefficients and correlation matrix.

Ground Control Points

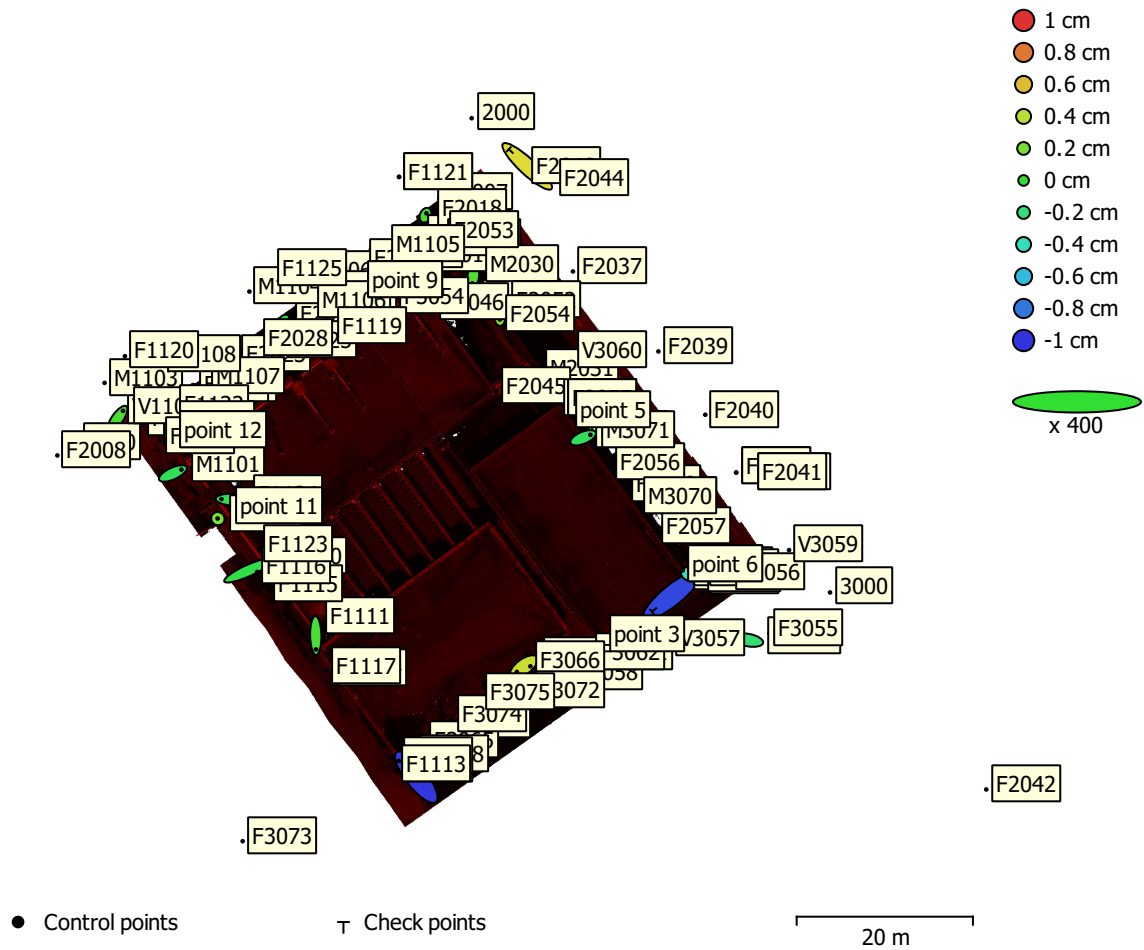


Fig. 3. GCP locations and error estimates.

Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.

Estimated GCP locations are marked with a dot or crossing.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
24	0.334105	0.304753	0.246475	0.452217	0.515025

Table 3. Control points RMSE.

X - Easting, Y - Northing, Z - Altitude.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
5	0.930191	0.939622	0.664567	1.32217	1.47979

Table 4. Check points RMSE.

X - Easting, Y - Northing, Z - Altitude.

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
1000					
3000					
2000					
M2001					
M2002	0.332692	-0.0134425	-0.204501	0.390749	0.269 (7)
M2003					
M2004					
V2005					
V2006					
F2007					
F2008					
F2015					
F2016					
F2017	0.013095	0.184896	0.0440352	0.190518	0.281 (10)
F2018	0.0485595	0.109327	0.045543	0.128002	0.309 (10)
F2019	-0.626139	0.0232406	-0.412119	0.749954	0.661 (10)
F2020	-0.498979	-0.268605	0.31818	0.649898	0.452 (10)
F2021					
F2022	-0.141238	-0.219237	-0.0359842	0.263264	0.589 (10)
F2023					
F2025					
F2026					
F2027					
F2028					
M2029					
M2030	-0.0521505	-0.386886	0.0855185	0.399642	0.200 (10)
M2031					
M2032					
M2033					
C2034					
C2035					

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
F2035					
F2036					
F2037					
M2038					
F2039					
F2040					
F2041					
F2042					
F2043					
F2045					
F2046					
F2047					
F2048					
F2049	-0.241842	0.207337	0.385049	0.499739	0.300 (10)
F2050					
F2051					
F2052	0.0228604	-0.370136	0.231611	0.437226	0.670 (10)
F2053	0.13436	-0.0696971	0.403827	0.431262	0.662 (8)
F2054					
F2055					
F2056					
F2057					
F2058					
M3050	-0.48513	0.0895216	-0.17234	0.522558	0.264 (7)
M3051	-0.399669	-0.292117	0.435472	0.659321	0.387 (8)
F3053	0.219527	-0.0264572	-0.434335	0.48738	0.560 (10)
F3054	-0.0445547	0.580948	-0.314588	0.662156	0.370 (10)
F3055					
V3056	0.488859	-0.0275832	0.0411854	0.491366	0.224 (10)
V3057					
V3058					
V3059					

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
V3060	-0.051016	0.00327604	-0.0143778	0.0531045	0.573 (10)
F3061	0.536248	-0.212272	-0.409264	0.70719	2.370 (14)
F3062					
F3063					
F3064	0.131043	0.597304	-0.0363852	0.612591	0.354 (10)
F3065					
F3066					
F3067					
F3069					
M3070					
M3071	0.404386	0.167657	-0.119863	0.453877	0.195 (10)
F3072					
F3073					
F3074					
F3075					
M1100					
M1101	0.479568	0.22017	-0.0992398	0.536943	0.311 (12)
M1102	-0.0162695	0.0128311	0.222139	0.223103	0.488 (13)
M1103					
M1104					
M1105					
M1106					
M1107					
M1108					
V1109	0.315061	0.447304	0.0714904	0.551775	0.385 (10)
F1111	0.0140255	-0.784641	0.0575076	0.786871	0.320 (10)
F1112					
F1113					
F1114					
F1115					
F1116					
F1117					

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
F1118					
F1119					
F1120					
F1121					
F1122					
F1123					
F1124	-0.583292	0.0272611	-0.0885605	0.590606	0.361 (10)
F1125					
point 3					
point 4					
point 5					
point 6					
point 7					
point 8					
point 9					
point 10					
point 11					
point 12					
Total	0.334105	0.304753	0.246475	0.515025	0.708

Table 5. Control points.
X - Easting, Y - Northing, Z - Altitude.

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
F2024	-0.423011	1.20996	0.305078	1.31757	0.124 (9)
F2044	-1.04254	0.970456	0.507673	1.51208	0.726 (5)
M3052	-1.15981	-0.937328	-0.93868	1.76206	0.315 (10)
F3068	-0.740471	0.943576	-0.986157	1.55278	0.536 (10)
F1110	1.08028	0.489641	-0.0617505	1.18767	0.477 (10)
Total	0.930191	0.939622	0.664567	1.47979	0.450

Table 6. Check points.
X - Easting, Y - Northing, Z - Altitude.

Digital Elevation Model

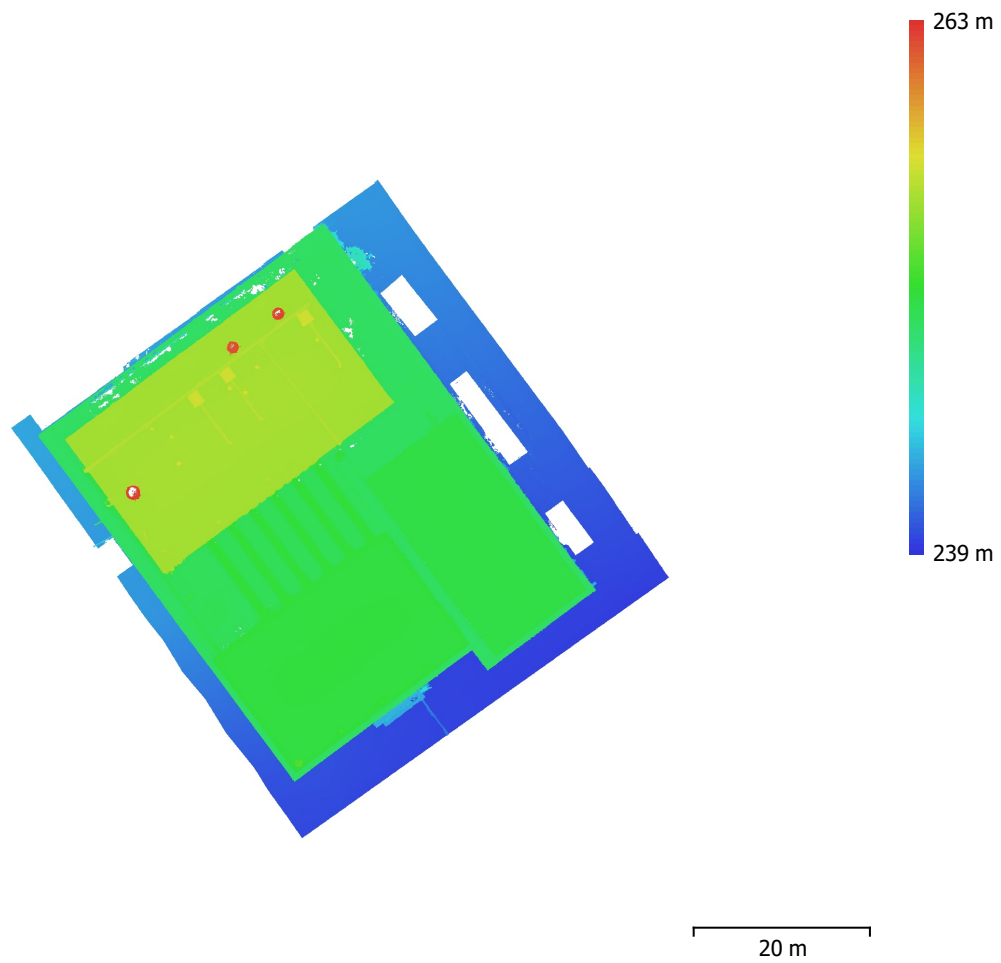


Fig. 4. Reconstructed digital elevation model.

Resolution: 2.83 cm/pix
Point density: 0.125 points/cm²

Processing Parameters

General

Cameras	598
Aligned cameras	598
Markers	120
Coordinate system	WGS 84 / UTM zone 32N (EPSG::32632)
Rotation angles	Yaw, Pitch, Roll

Tie Points

Points	221,281 of 311,815
RMS reprojection error	0.19973 (1.67979 pix)
Max reprojection error	1.17519 (59.8555 pix)
Mean key point size	7.36823 pix
Point colors	1 bands, uint16
Key points	335.06 MB
Average tie point multiplicity	4.48069

Alignment parameters

Accuracy	Medium
Generic preselection	No
Reference preselection	Source
Key point limit	40,000
Key point limit per Mpx	4,000
Tie point limit	4,000
Exclude stationary tie points	No
Guided image matching	No
Adaptive camera model fitting	No
Matching time	3 minutes 5 seconds
Matching memory usage	131.74 MB
Alignment time	3 minutes 49 seconds
Alignment memory usage	425.61 MB

Optimization parameters

Parameters	f, b1, b2, cx, cy, k1-k4, p1, p2
Adaptive camera model fitting	No
Optimization time	6 seconds
Date created	2023:11:21 17:04:02
Software version	1.8.5.15709
File size	32.40 MB

Point Cloud

Points	7,429,104
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Point attributes

Color	1 bands, uint16
Normal	

Point classes

Created (never classified)	7,429,104
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Depth maps generation parameters

Quality	High
Filtering mode	Mild
Max neighbors	16
Processing time	42 minutes 25 seconds
Memory usage	2.59 GB

Point cloud generation parameters

Processing time	56 minutes 11 seconds
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Memory usage	10.79 GB
Date created	2024:01:16 19:14:34
Software version	2.0.3.16960
File size	398.30 MB
DEM	
Size	2,047 x 824
Coordinate system	WGS 84 (EPSG::4978)
Reconstruction parameters	
Source data	Point cloud
Interpolation	Disabled
Processing time	1 seconds
Memory usage	205.52 MB
Date created	2024:01:19 16:05:45
Software version	2.0.3.16960
File size	3.52 MB
Orthomosaic	
Size	1,930 x 777
Coordinate system	WGS 84 (EPSG::4978)
Colors	1 bands, uint16
Reconstruction parameters	
Blending mode	Mosaic
Surface	DEM
Enable hole filling	No
Enable ghosting filter	No
Processing time	2 minutes 16 seconds
Memory usage	170.72 MB
Date created	2024:01:19 16:12:30
Software version	2.0.3.16960
File size	270.01 MB
System	
Software name	Agisoft Metashape Professional
Software version	2.0.3 build 16960
OS	Windows 64 bit
RAM	127.91 GB
CPU	Intel(R) Core(TM) i7-6850K CPU @ 3.60GHz
GPU(s)	Quadro M2000