DRONES AND THE STRUCTURE FROM MOTION (SfM) TECHNIQUE IN LAND RIGHT FORMALIZATION AND MUNICIPAL LAND ADMINISTRATION

– FIRST EXPERIENCES IN ACCRA, GHANA.

. **Samuel Larbi Darko**

Founder and CEO, Losamills Consult Limited, Accra Ghana
www.losamills.com

Walter Volkmann, President, Micro Aerial Projects LLC, Gainesville, Florida, USA
www.microaerialprojects.com

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Why drones and Structure from Motion (SfM) technique?

Affordable and Automatic

Lower entry barrier

Small **LOCAL** enterprises

Fast response to local demand

Faster land title roll-out

Africa beyond Aid?

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Legitimization of Drone/SfM Technology

Good Cadastral System

- Personal Accountability ✓
- Tolerance for Errors ✓
- Physical Evidence ✓

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Types of Drones: Multirotor Platform

- Easy to operate.
- Best for small areas.
- Can hover.
- High Image Resolution.
- High Accuracy

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Types of Drones: fixed Wing Plaftform

- Requires flying skills
- Needs larger landing space

- Best for larger areas

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Types of Drones: Hybrid – VTOL/Fixed Wing

- Easy to operate.
- Vertical Take-Off and Landing

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Dual frequency GNSS equipment for precise positioning

- Geodetic quality for long range connection to geodetic control points
- Survey of Ground Control Points
- Precise aerial camera exposure positioning

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Dual frequency GNSS equipment for precise positioning

Dual frequency GNSS receiver connected to camera

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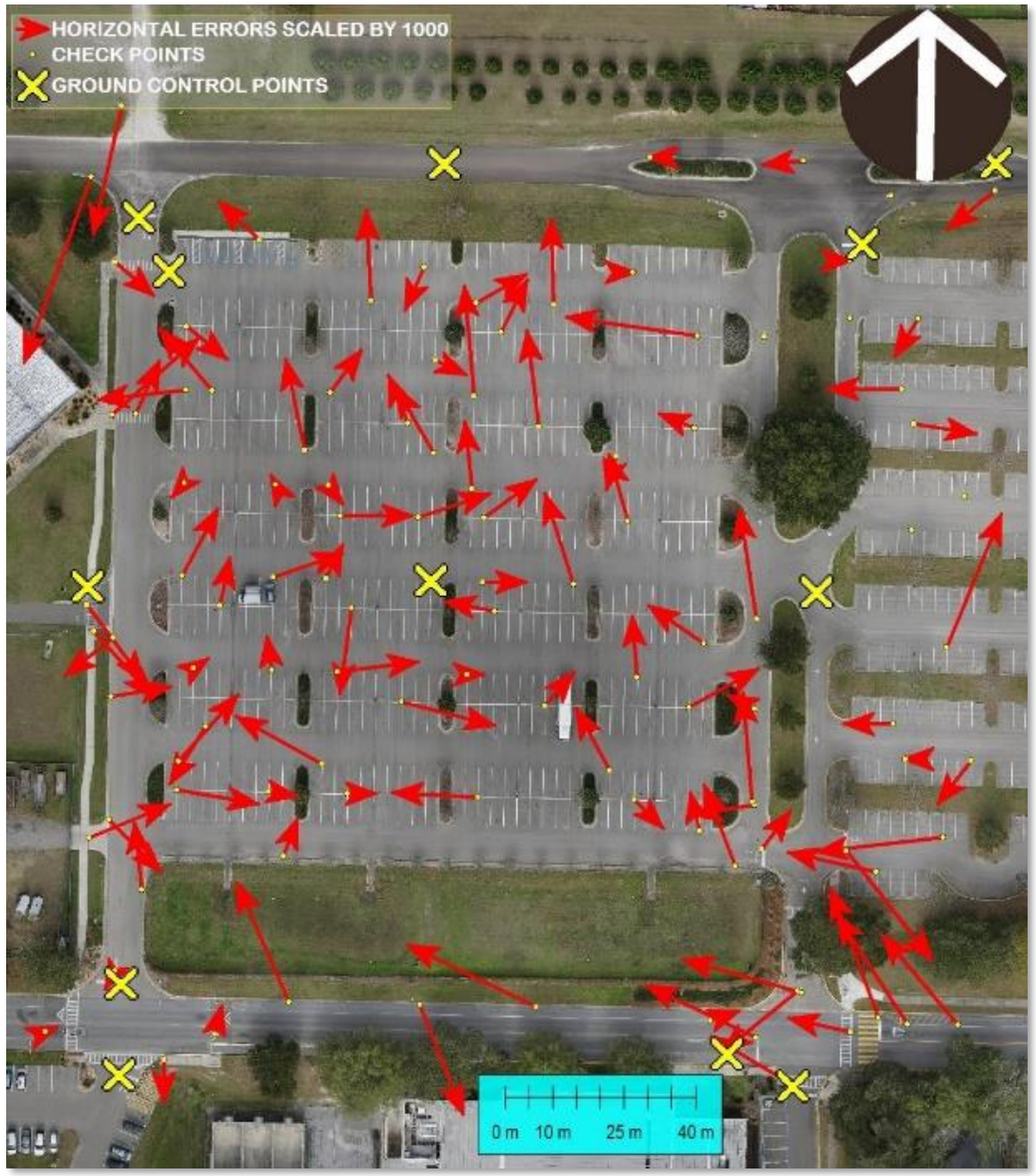
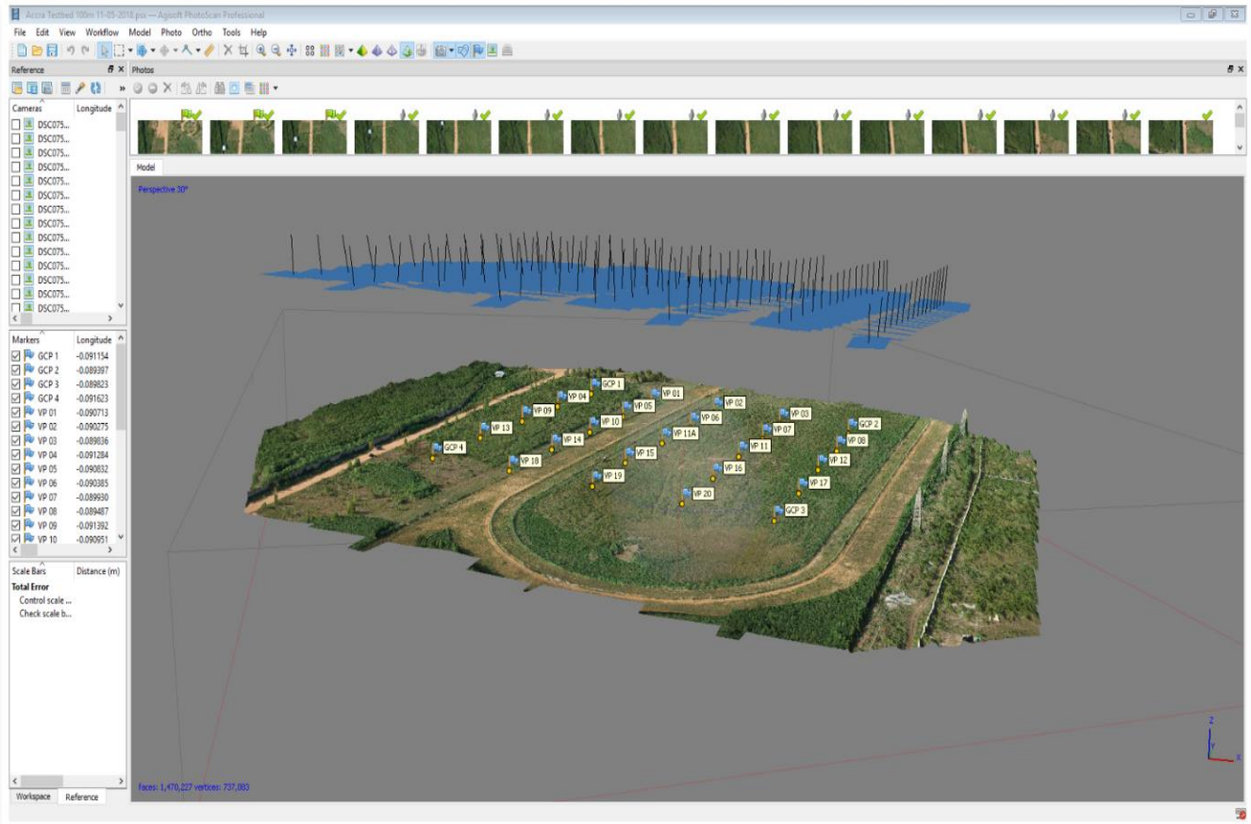
Test Bed for Robust Error Analysis





Accuracy at 95% Confidence Level:

Horizontal (“approx. circular Error”): 0.028m

Vertical: 0.038m

Compatible with RTK GNSS

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Pilot Project: Dansoman

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Double Altitude Aerial Image Acquisition

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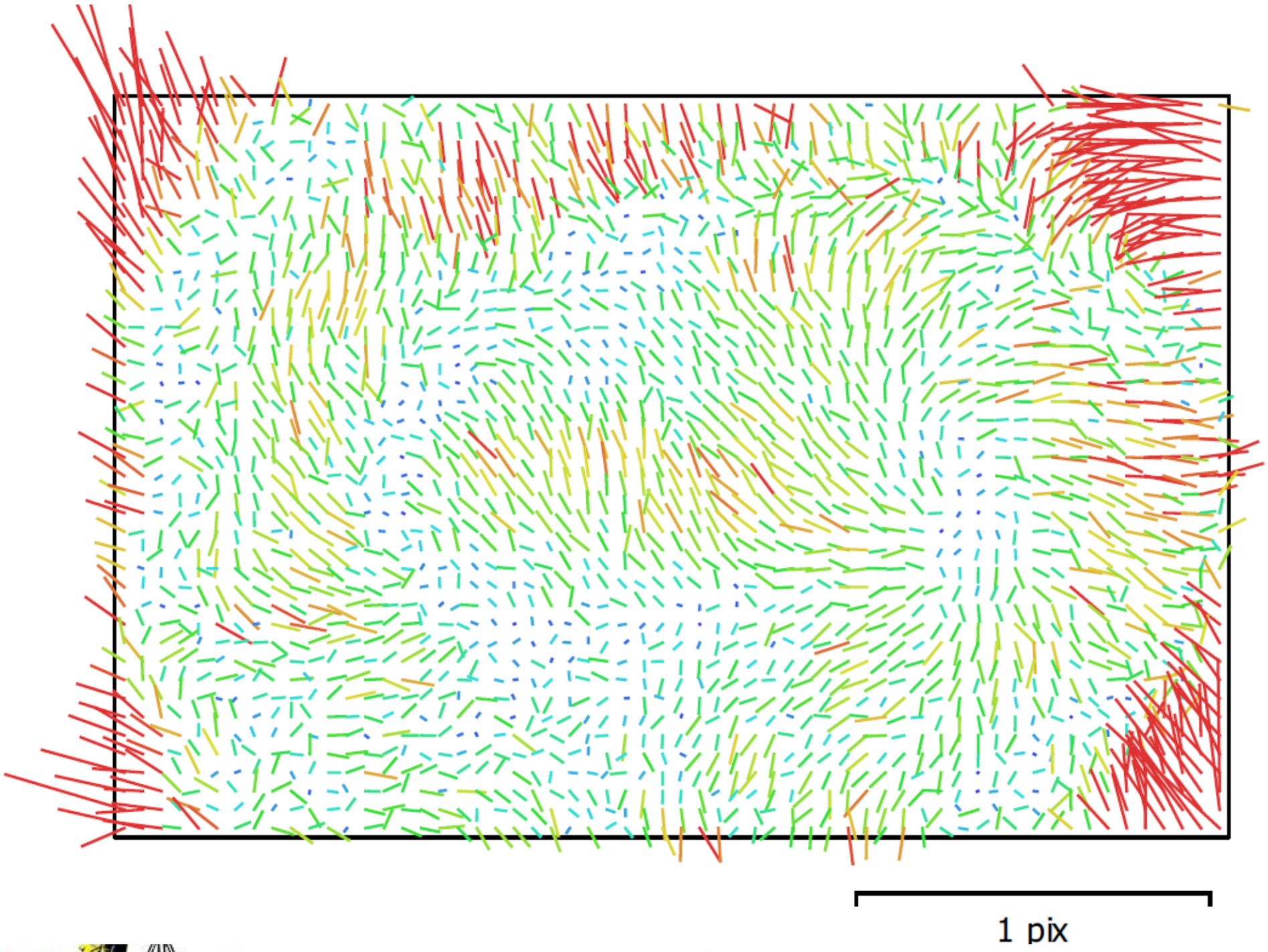
Processing the images with the Structure from Motion (SfM) technique.



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Processing the images with the Structure from Motion (SfM) technique.

X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total error (cm)
2.50324	3.77646	2.45109	4.53077	5.15128

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ORTHO PHOTO GSD 16mm

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Comparison with conventional methods

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Comparison with conventional methods

Parcel	Conventional	SfM	Differences		Remarks
	Area (m²)	Area (m²)	m²	%	
42	621.0	660.0	39.0	6%	Identification
43	1094.8	1065.8	-29.0	3%	
44	1064.4	1072.4	8.0	1%	
44	1034.8	1046.3	11.5	1%	
45	632.4	642.1	9.6	2%	
46	684.9	686.7	1.8	0%	
47	665.3	668.5	3.2	0%	
48	677.4	665.2	-12.2	2%	
49	695.7	702.6	6.9	1%	
50	693.6	705.7	12.1	2%	
51	659.4	652.4	-6.9	1%	
52	694.5	691.9	-2.7	0%	
53	688.8	686.9	-1.9	0%	
54	853.6	892.9	39.3	5%	Definition
54	1040.0	1039.8	-0.2	0%	
55	915.3	924.0	8.7	1%	
56	862.7	855.1	-7.6	1%	
57	844.8	855.7	10.9	1%	
58	519.4	510.7	-8.8	2%	
59	337.8	359.3	21.6	6%	Definition
60	895.6	904.6	9.0	1%	
61	906.6	901.3	-5.3	1%	
62	900.9	908.4	7.5	1%	
63	997.8	982.6	-15.2	2%	
64	983.5	991.7	8.2	1%	
65	1078.5	1094.3	15.8	1%	
66	474.7	526.9	52.2	11%	Identification
Totals	**21518.1**	**21693.6**	**175.5**		
	Average Differences		**13.2**	**2%**	
After removal of outliers:					
Totals	**20084.6**	**20147.3**	**62.7**		
	Average Differences		**8.8**	**1%**	

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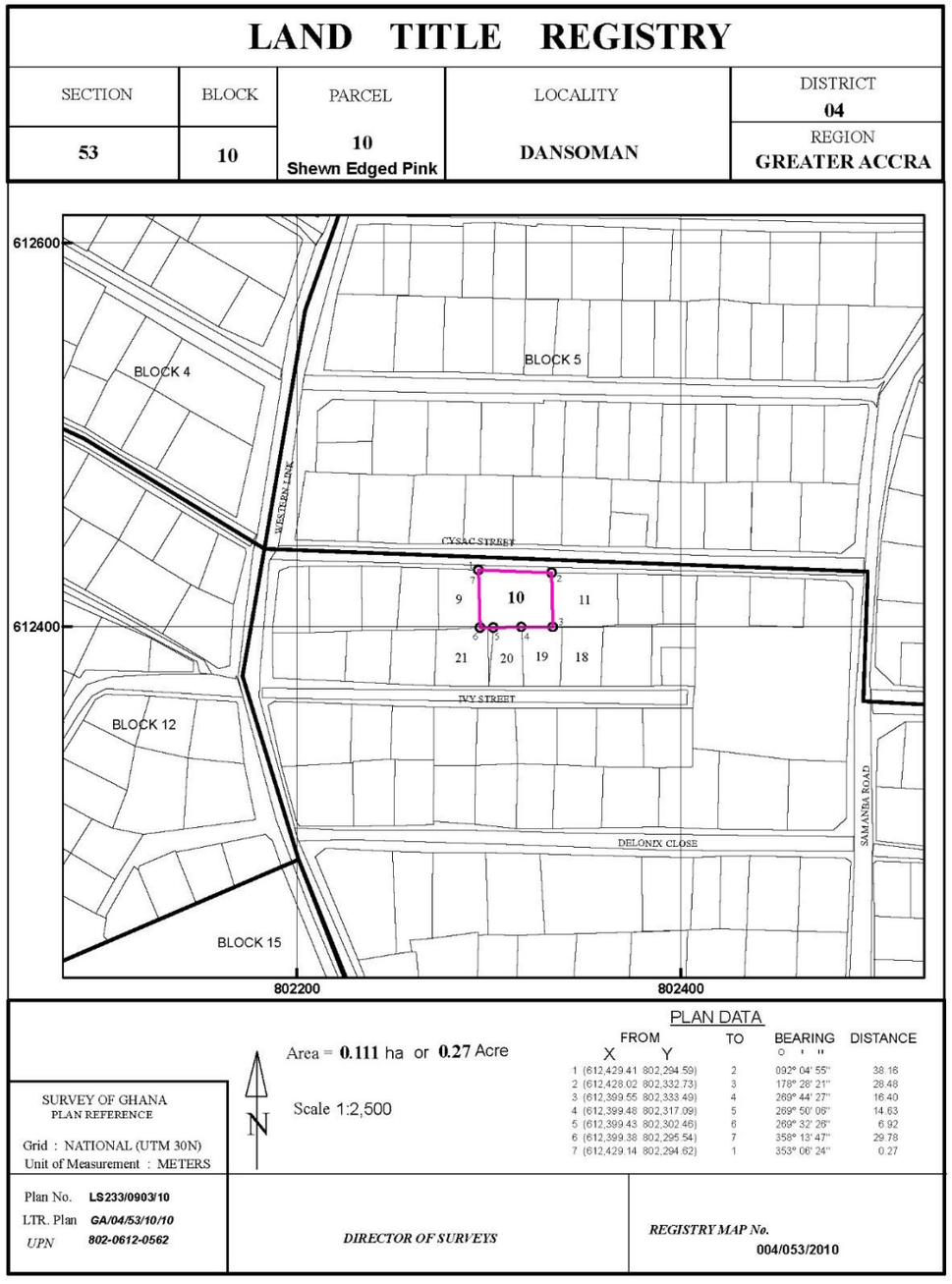
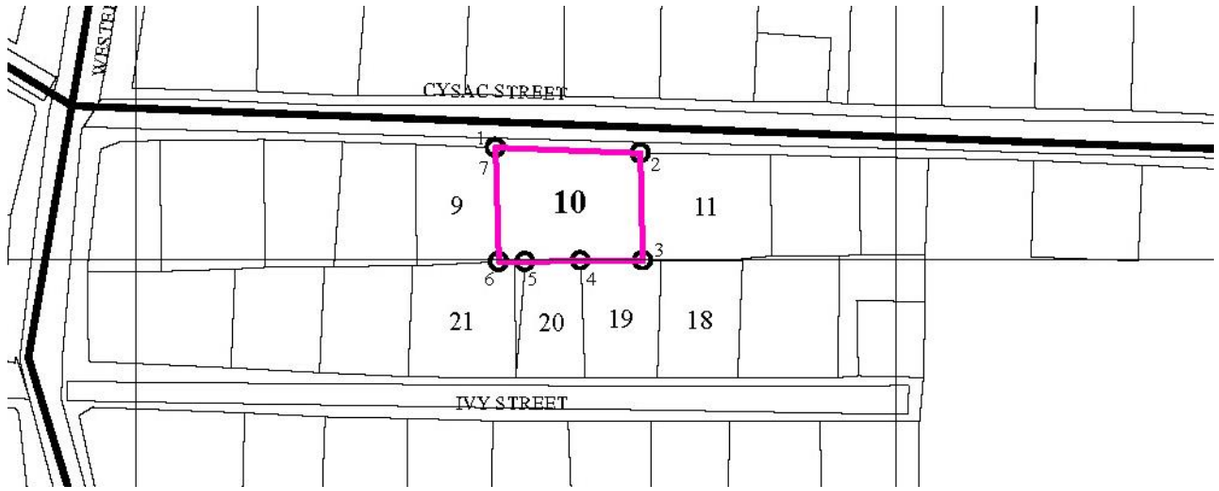
Conventional versus SfM derived Parcel Map





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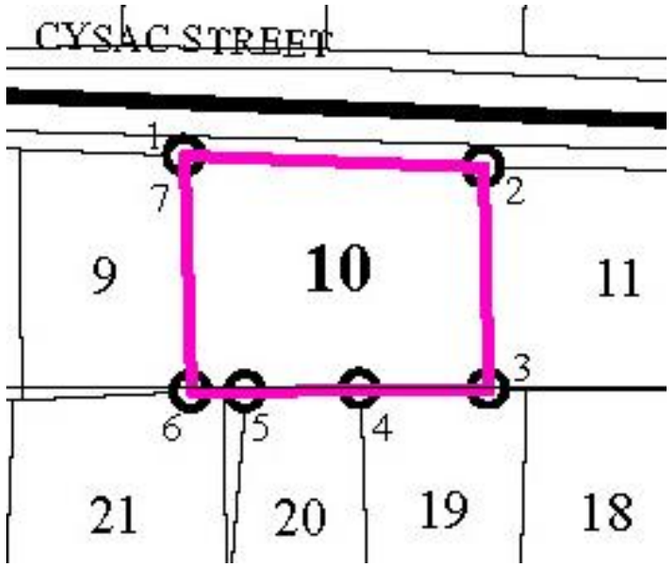
Conventional versus SfM derived Parcel Map



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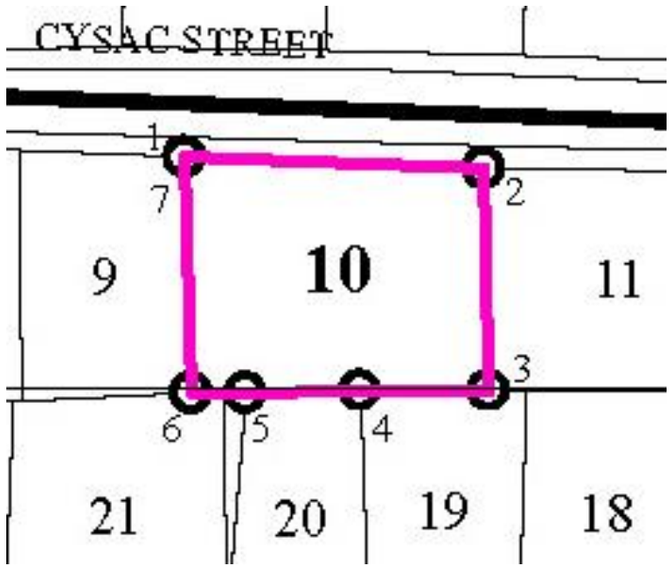
Conventional versus SfM derived Parcel Map



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Conventional versus SfM derived Parcel Map

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Cost/benefit analysis between SfM and Conventional Methods

Drones and Structure from Motion (96 Parcels)

Field Work	Time (min)	Time (hrs)	Unit Cost	Total Cost
Pre-flight assembly and checklist	30	0.5	$20	$10
From Altitude of 50m	20	0.3	$20	$7
From Altitude of 75m	15	0.3	$20	$5
Insurance				$40
Totals	**65**	**1.1**		**$62**
Office Work	**Time (min)**	**Time (hrs)**	**Unit Cost**	**Total Cost**
Flight Planning	30	0.5	$20	$10.0
Computations of Camera exposure positions	60	1.0	$20	$20.0
Setting up of processing batch	30	0.5	$20	$10.0
Structure from Motion Processing				
Camera Alignment (High Accuracy)	34	0.6	$0.80	$0.5
Optimization	1	0.0	$0.80	$0.0
Dense Point Cloud Generation (Aggressive Filtering, High Qaulity)	1260	21.0	$0.80	$16.8
Building of Texture Atlas	143	2.4	$0.80	$1.9
Building of Tiled Surface Model	586	9.8	$0.80	$7.8
Generation of Digital Elevation Model	7	0.1	$0.80	$0.1
Generation of Orthomosaic	95	1.6	$0.80	$1.3
Digitizing Parcel Boundaries from Orthomosaic	960	16.0	$20	$320.0
Totals	**3176**	**52.9**		**$388.3**

Total Cost of Field and Office Work: $450.01

Cost per parcel: $4.69

Conventional (GNSS) Survey (100 Parcels)

Field Work	Time (min)	Time (hrs)	Unit Cost	Total Cost
Field Work Party Chief	2400	40.0	$20	$800
Field Work Instrument Man	2400	40.0	$15	$600
Totals	**4800**	**80.0**		**$1,400**
Office Work	**Time (min)**	**Time (hrs)**	**Unit Cost**	**Total Cost**
Draughting and Computations	480	8.0	$20	$160.0
Totals	**480**	**8**		**$ 160.0**

Total Cost of Field and Office Work: $1,560.00

Cost per parcel: $15.60

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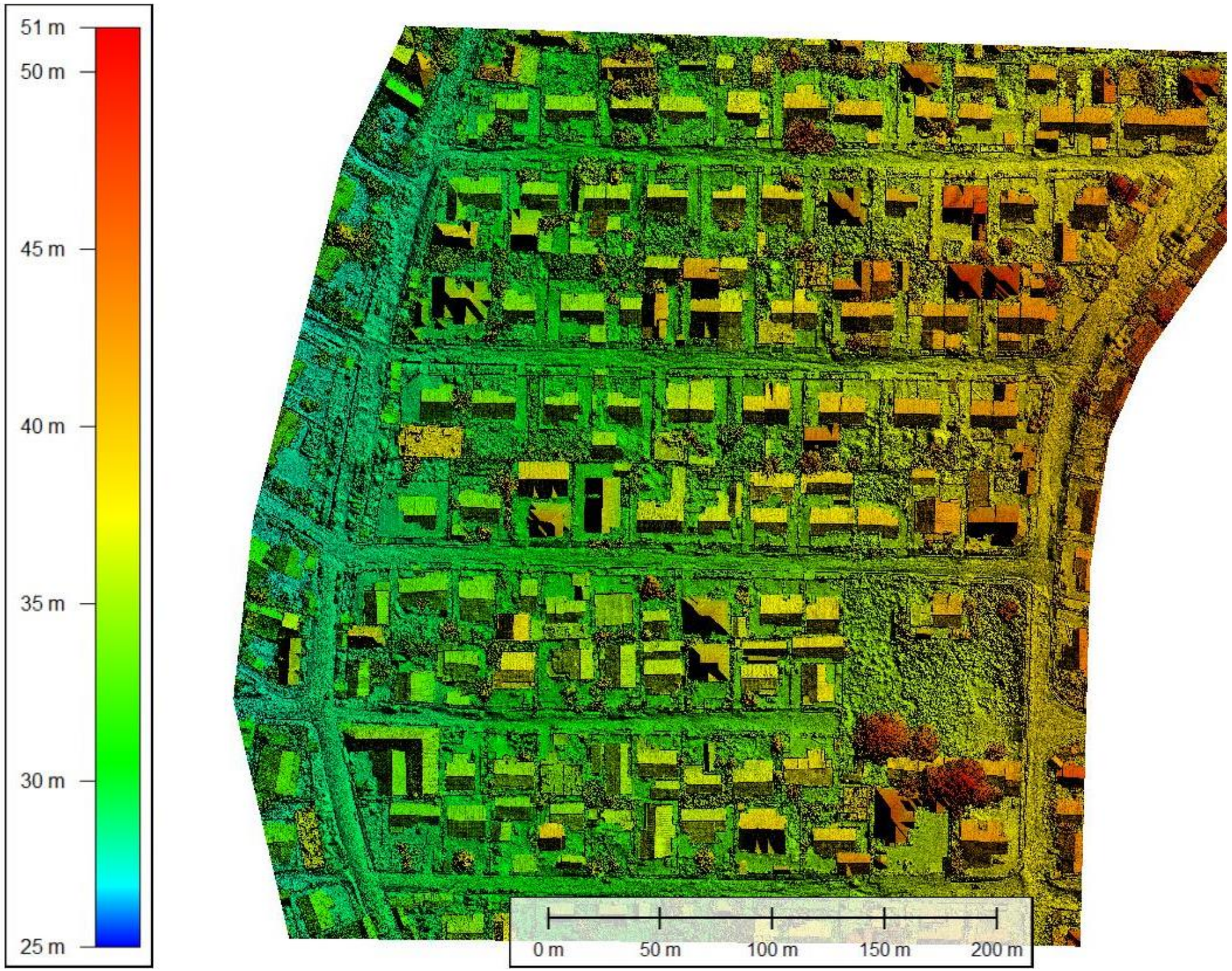
Digital Elevation Model GSD 31mm



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POINT CLOUD 1000 points/m²

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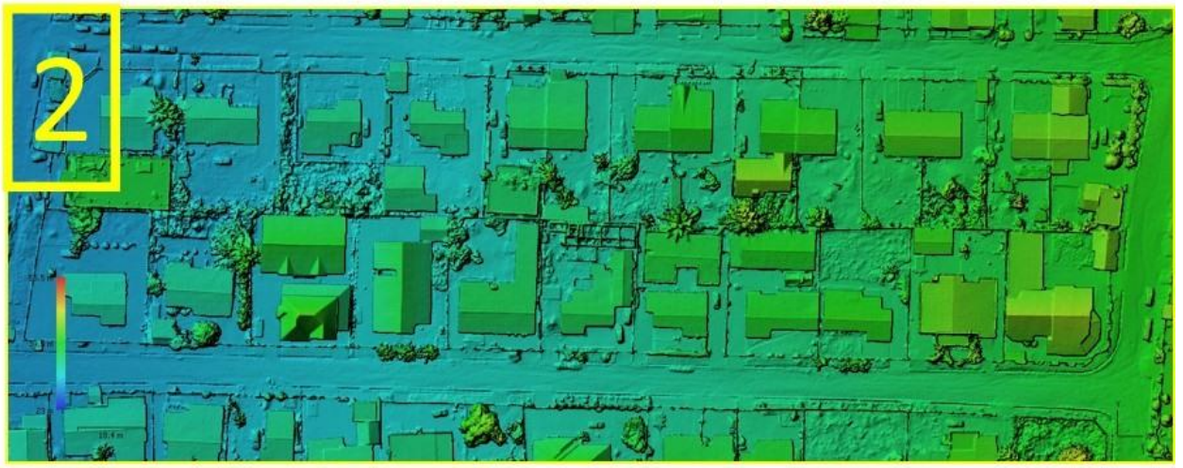
From manual digitizing to automatic feature detection



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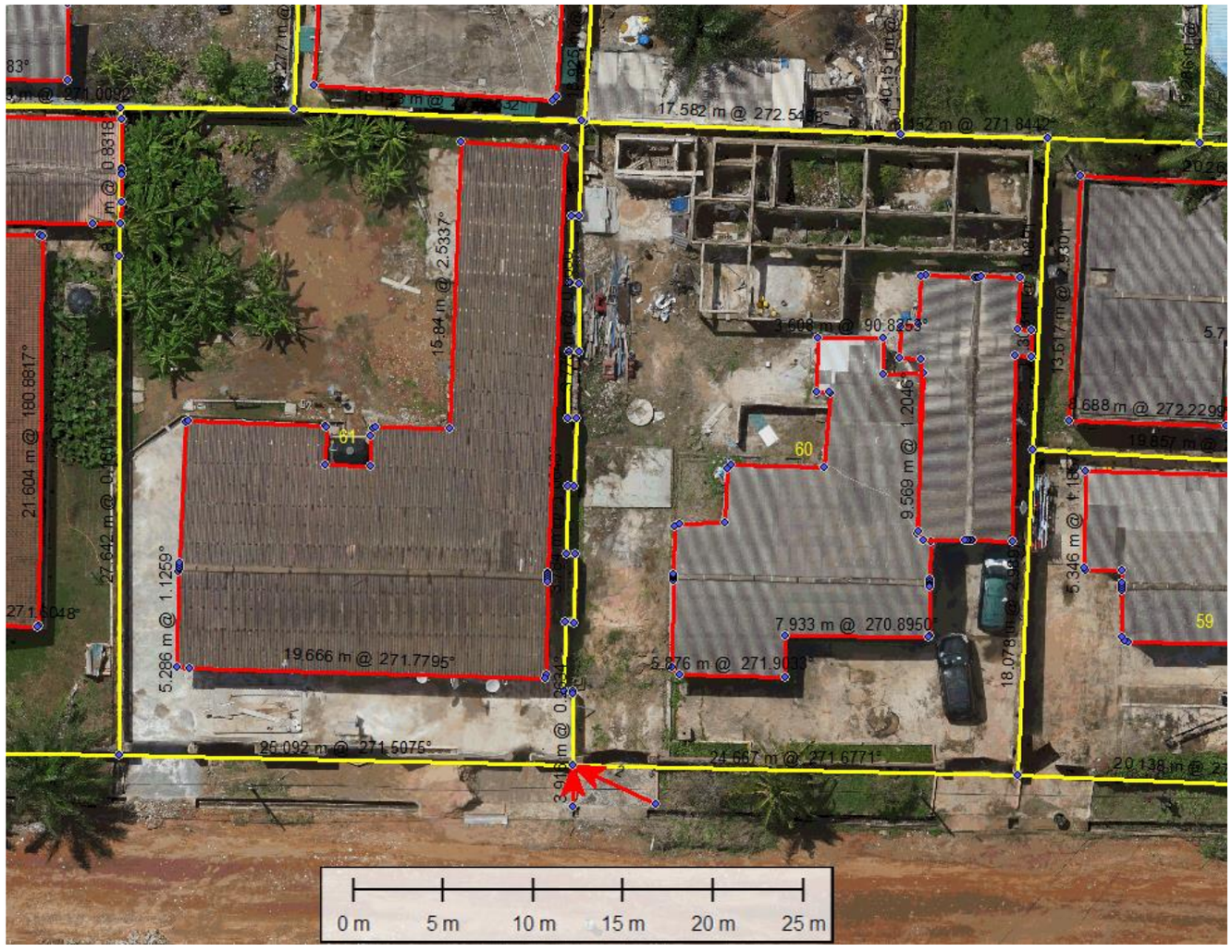
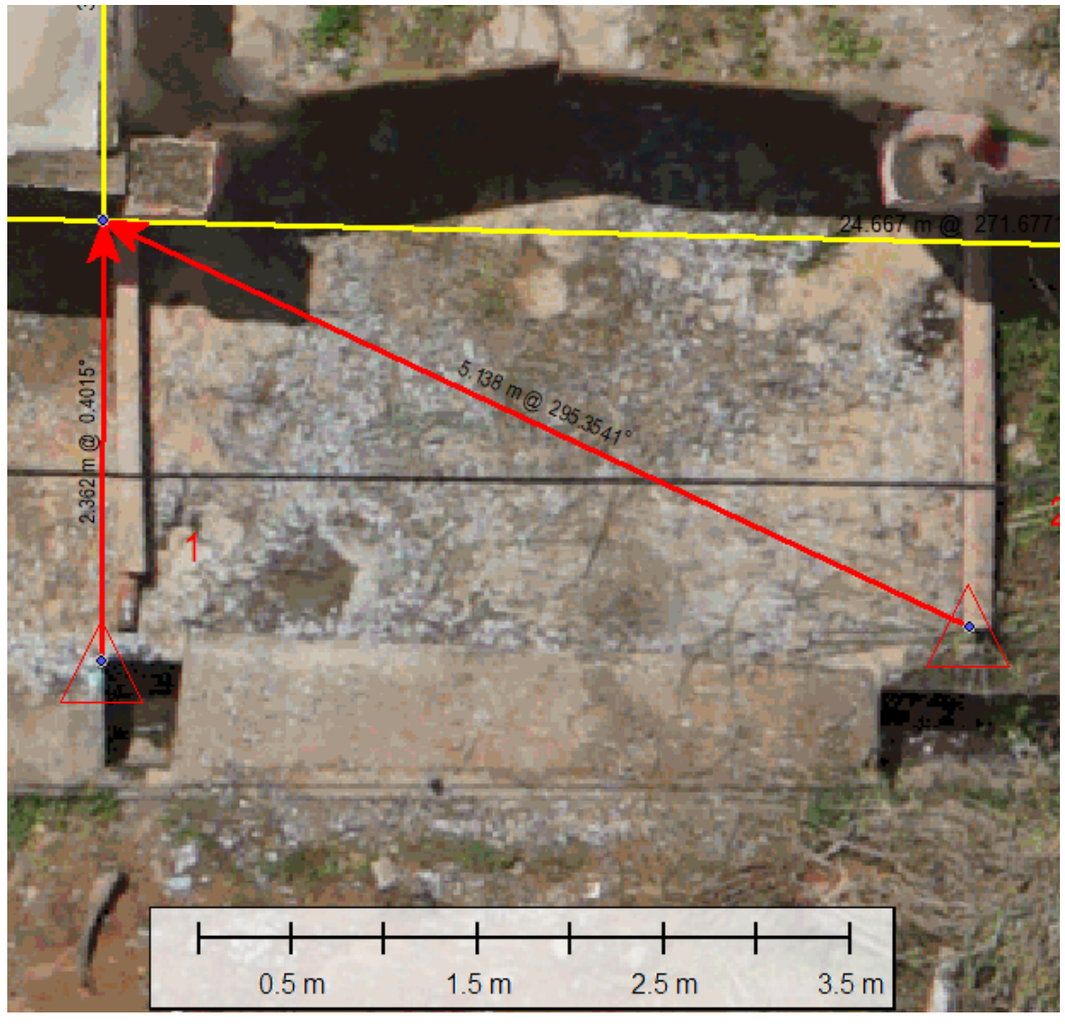
GEO-REFERENCED, HI-RES MAP = GEODETIC INFRASTRUCTURE

Replacing destroyed corner pillars by means of trilateration





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3D vectors of roof lines

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Surveying of electricity distribution lines

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Aerial Image

3D Model

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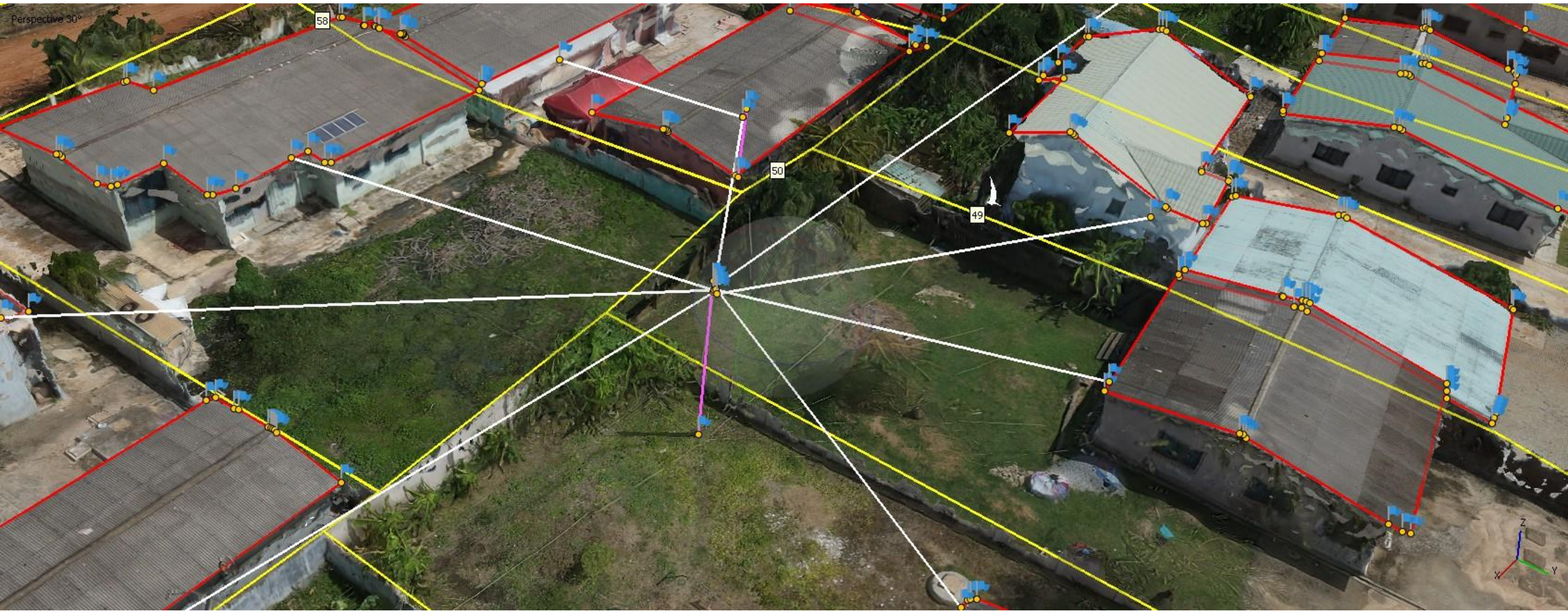

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