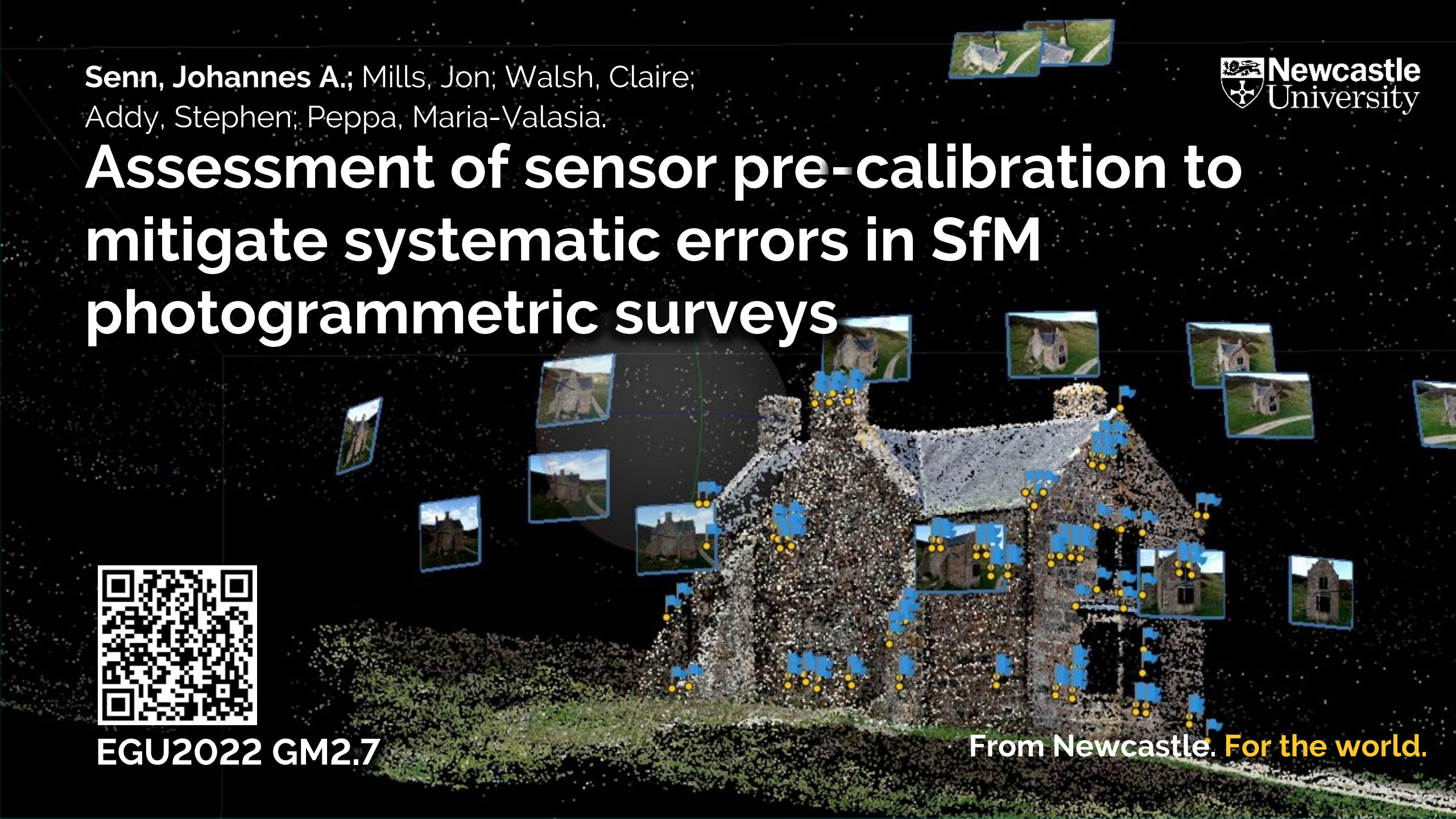
Senn, Johannes A.; Mills, Jon; Walsh, Claire;
Addy, Stephen; Peppa, Maria-Valasia.

Newcastle University

Assessment of sensor pre-calibration to mitigate systematic errors in SfM photogrammetric surveys



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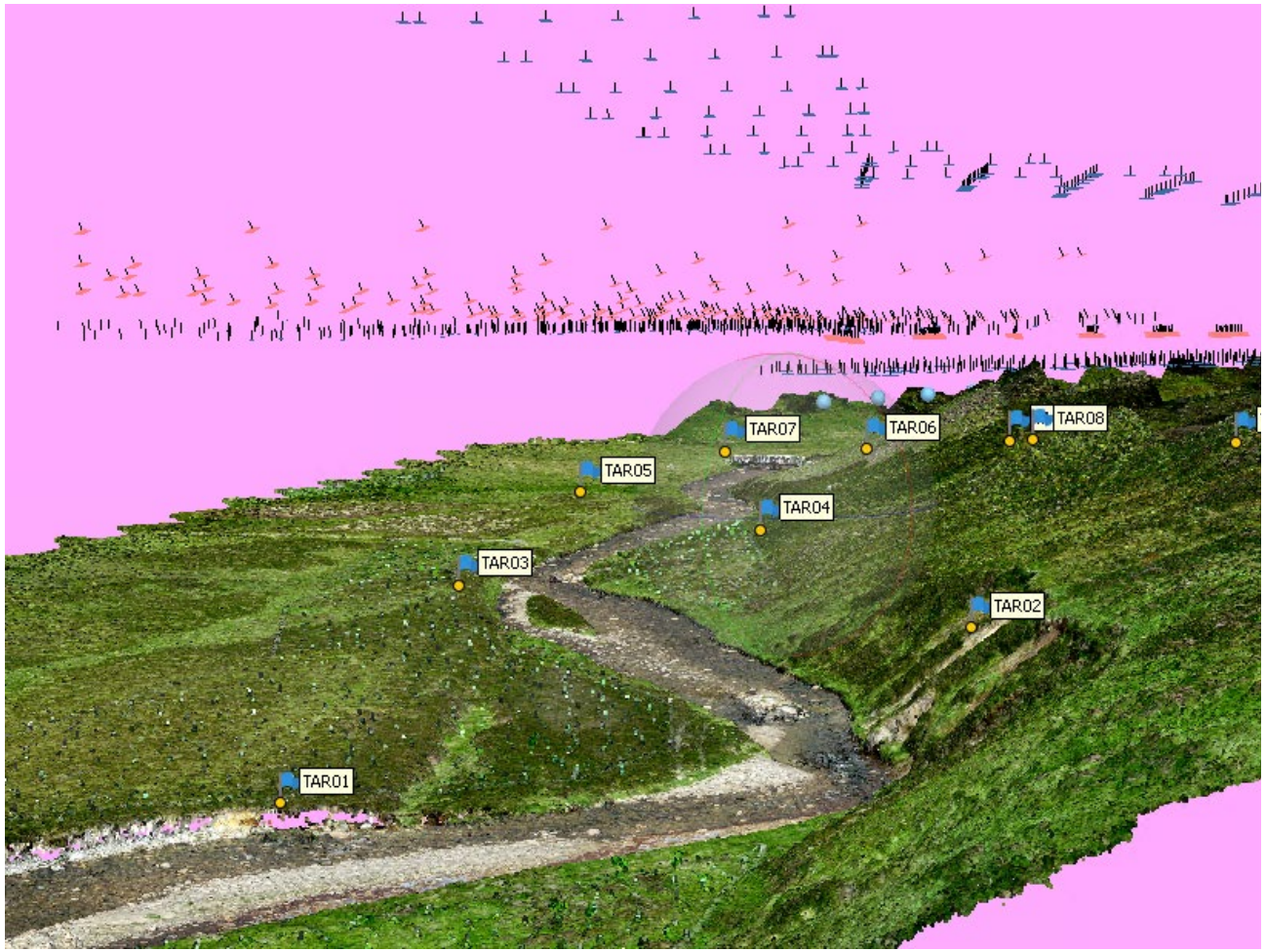
Self-calibration using the survey dataset



YES:

- Straight-forward application
- Prevents changing camera geometry between calibration and survey

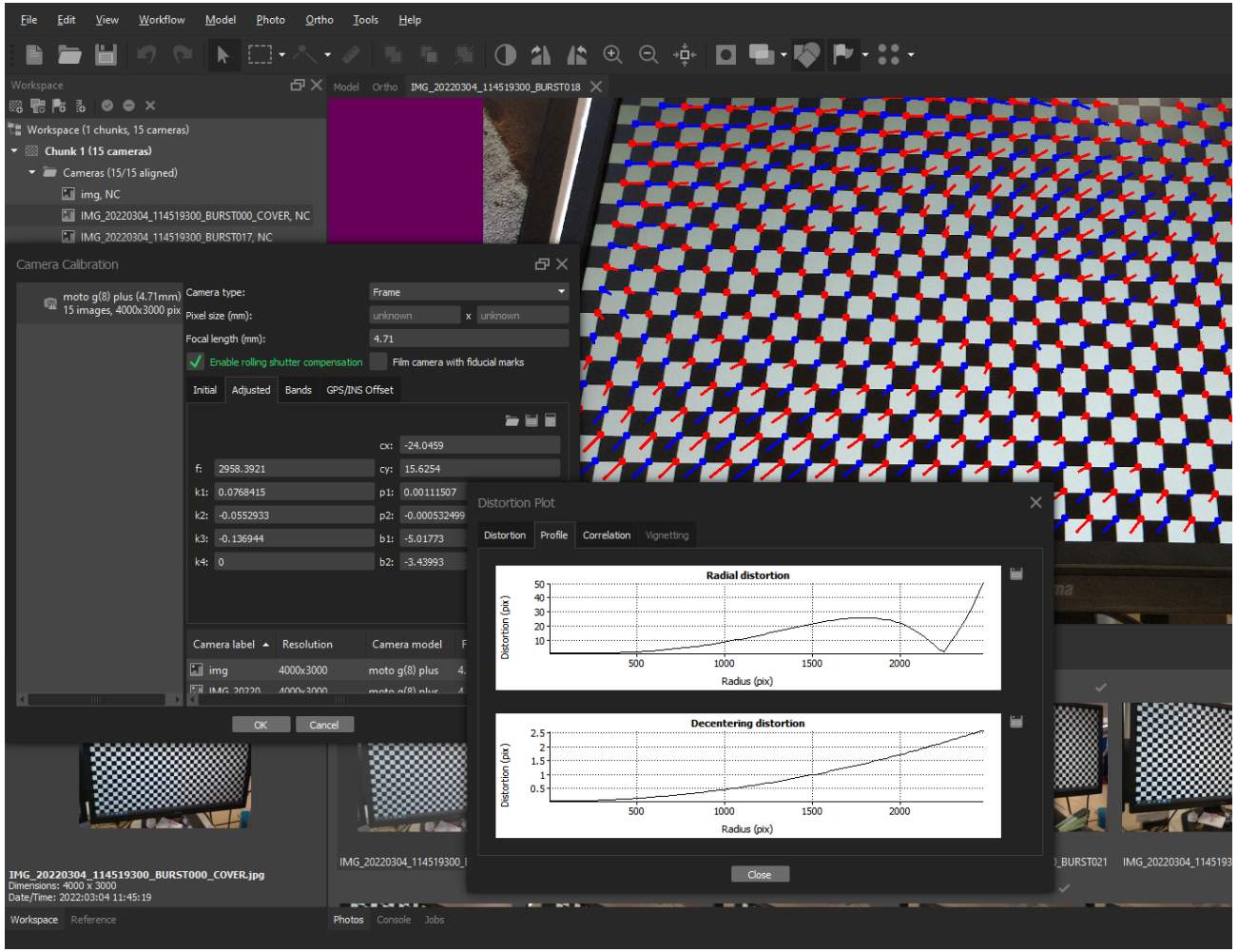
BUT:

- Insufficient relief can cause poor calibration (parameter correlation)

→ Systematic errors in the DEMs (dome/bowl)

- Application may restrict geometry e.g. bathymetry or orthophoto creation (nadir-only to minimize refraction / shadows)
- Time restrictions (battery, sunlight, other tasks)

2D Calibration Plane



YES:

- Portable, light
- Efficient automatic implementations

BUT:

- Parameter correlation
- Non-planarities cause systematic errors
- Not on survey-scale

Lab calibration & Transport

YES:

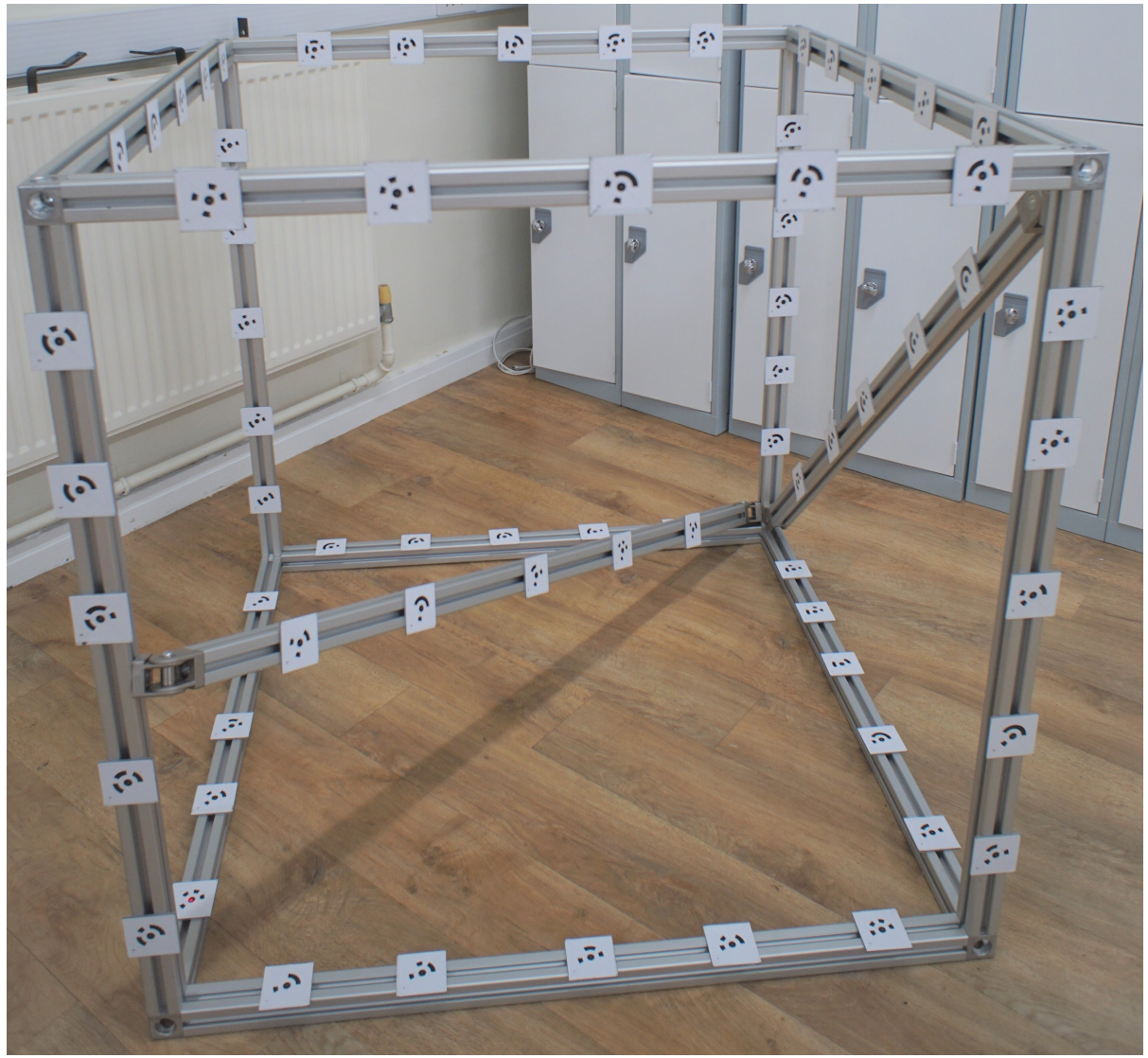
- Allows for permanent calibration field (no re-surveying)
- Coded targets: Efficient for detection in imagery
- 3D: Reduced parameter correlation

BUT:

- Changing environmental conditions: temperature, atm. pressure
- Physical disturbance: vibrations, shocks, handling
- Not on survey-scale

Image: On the Potential of Low-Cost UAV Camera Systems, University of Stuttgart, Institute for photogrammetry (Accessed: 22/05/2022) https://www.ifp.uni-stuttgart.de/en/research/photogrammetric_systems/low-cost-uav-camera-systems/

3D Calibration Frame



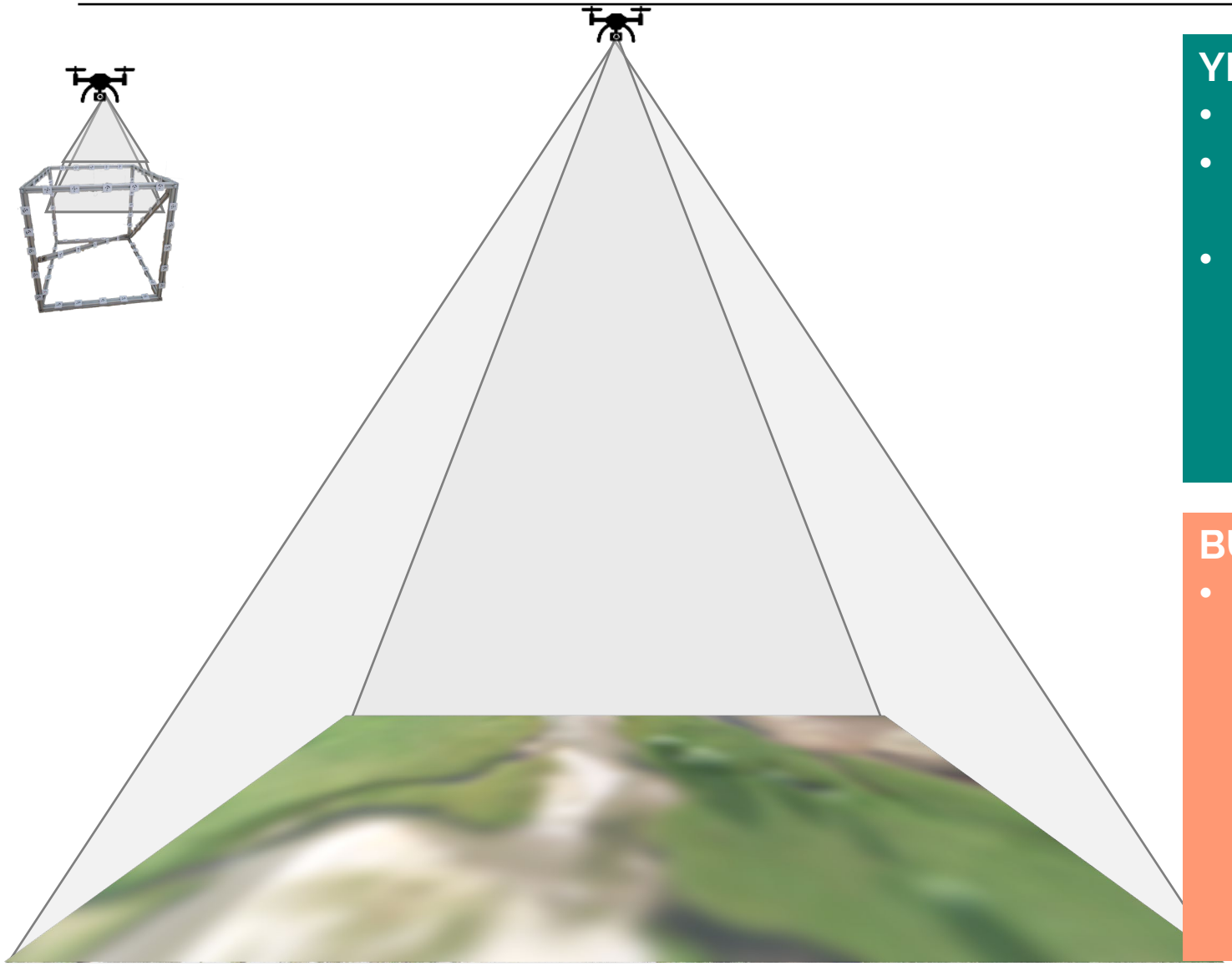
YES:

- Somewhat portable → Avoid transport
- 3D: Reduced parameter correlation
- Coded targets: Efficient for detection in imagery

BUT:

- Potential instability of frame or targets
- Surveying time consuming (total station)

Maintaining focus settings



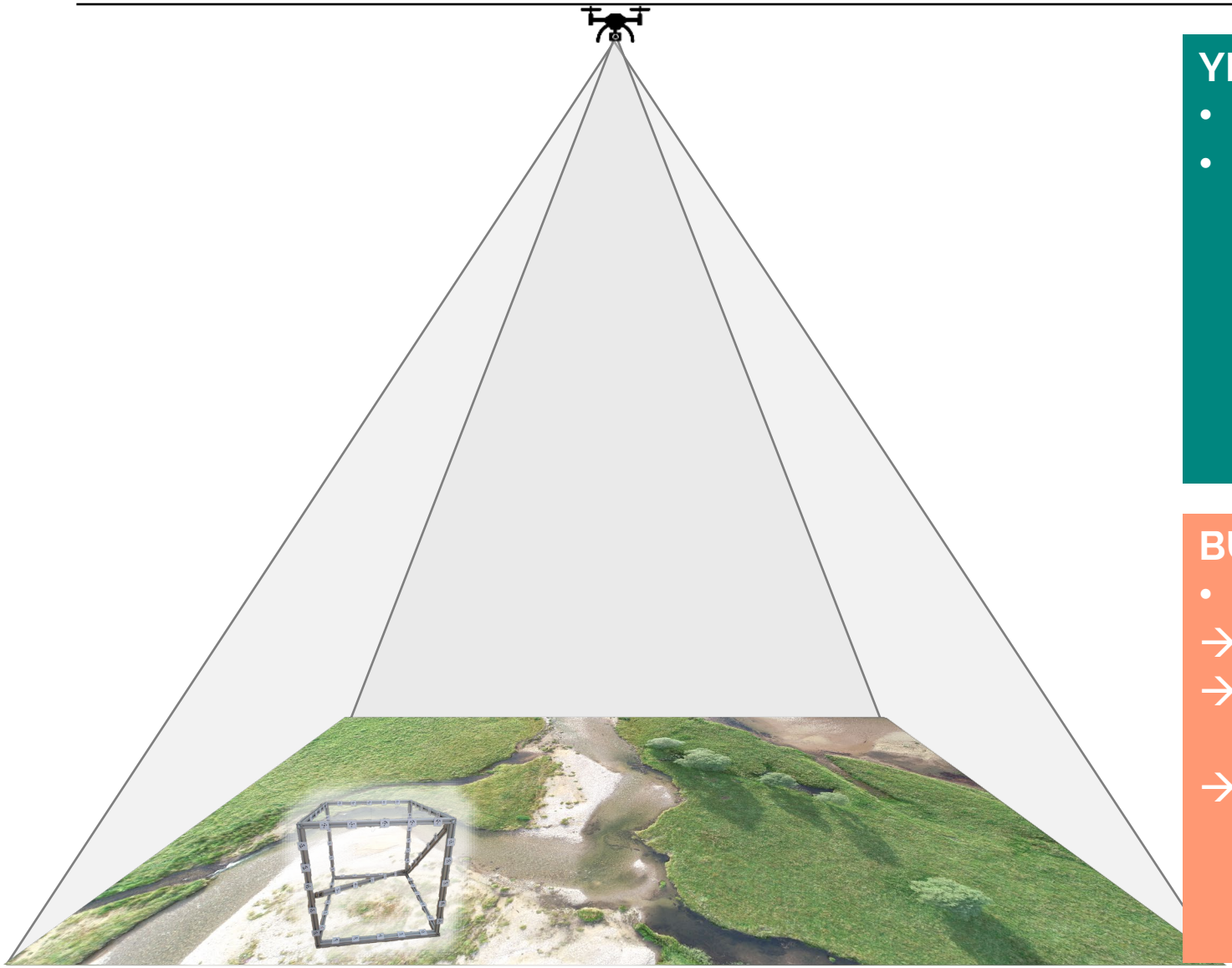
YES:

- Unchanged internal sensor geometry
- Reasonably sized calibration objects and targets → portability
- Full sensor coverage

BUT:

- Out of focus

Calibration on survey-scale



YES:
- In focus
- Maintained sensor geometry

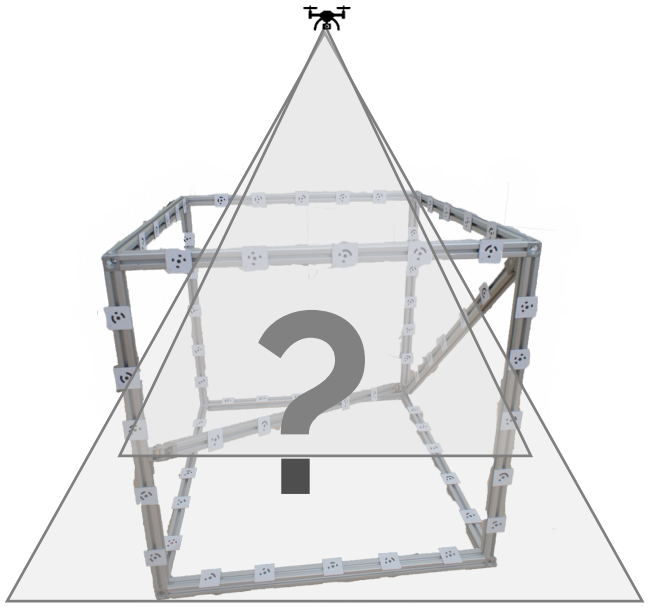
BUT:
- Does not cover entire sensor area

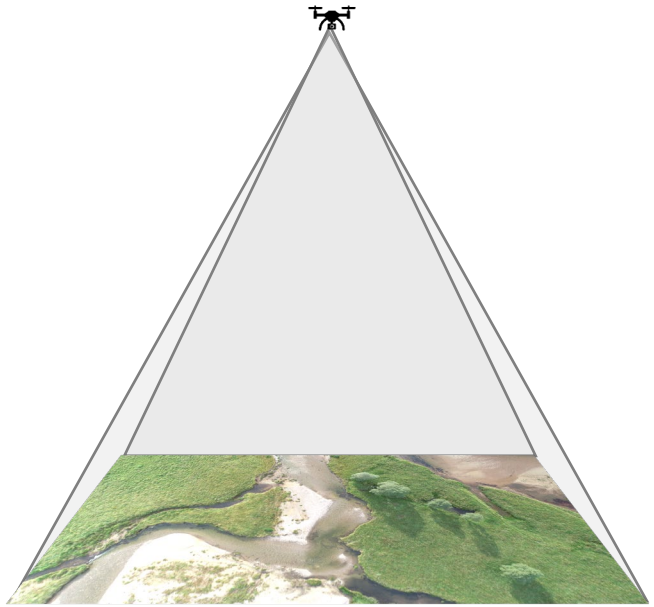
→ Calibration only valid for subset of sensor

→ Requires large calibration objects and targets

→ Rules out portable calibration objects

Dilemma: survey-scale || sensor coverage || maintaining sensor geometry





YES:

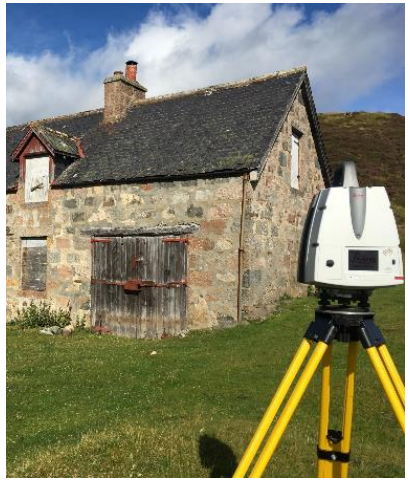
- Well suitable method

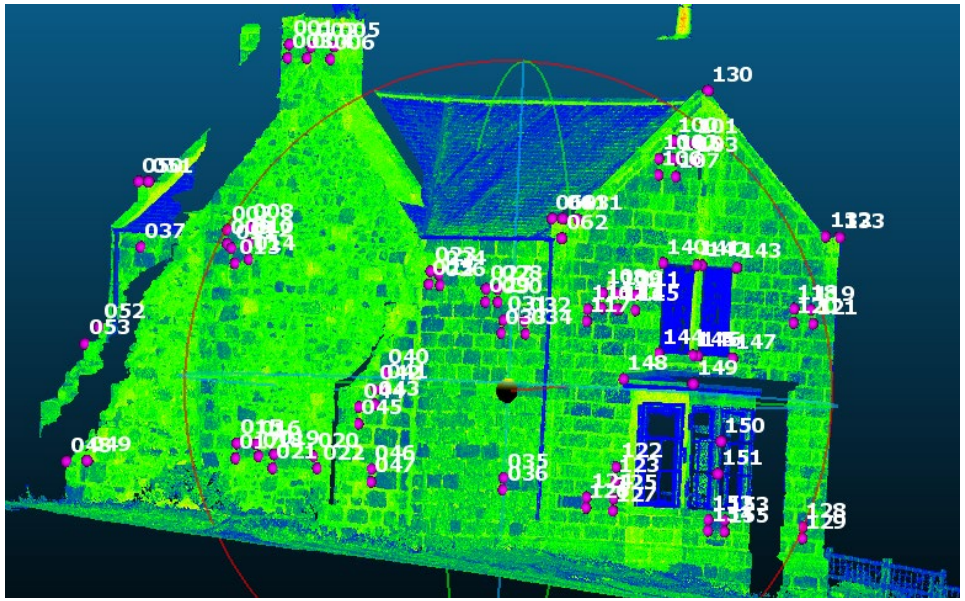
BUT:

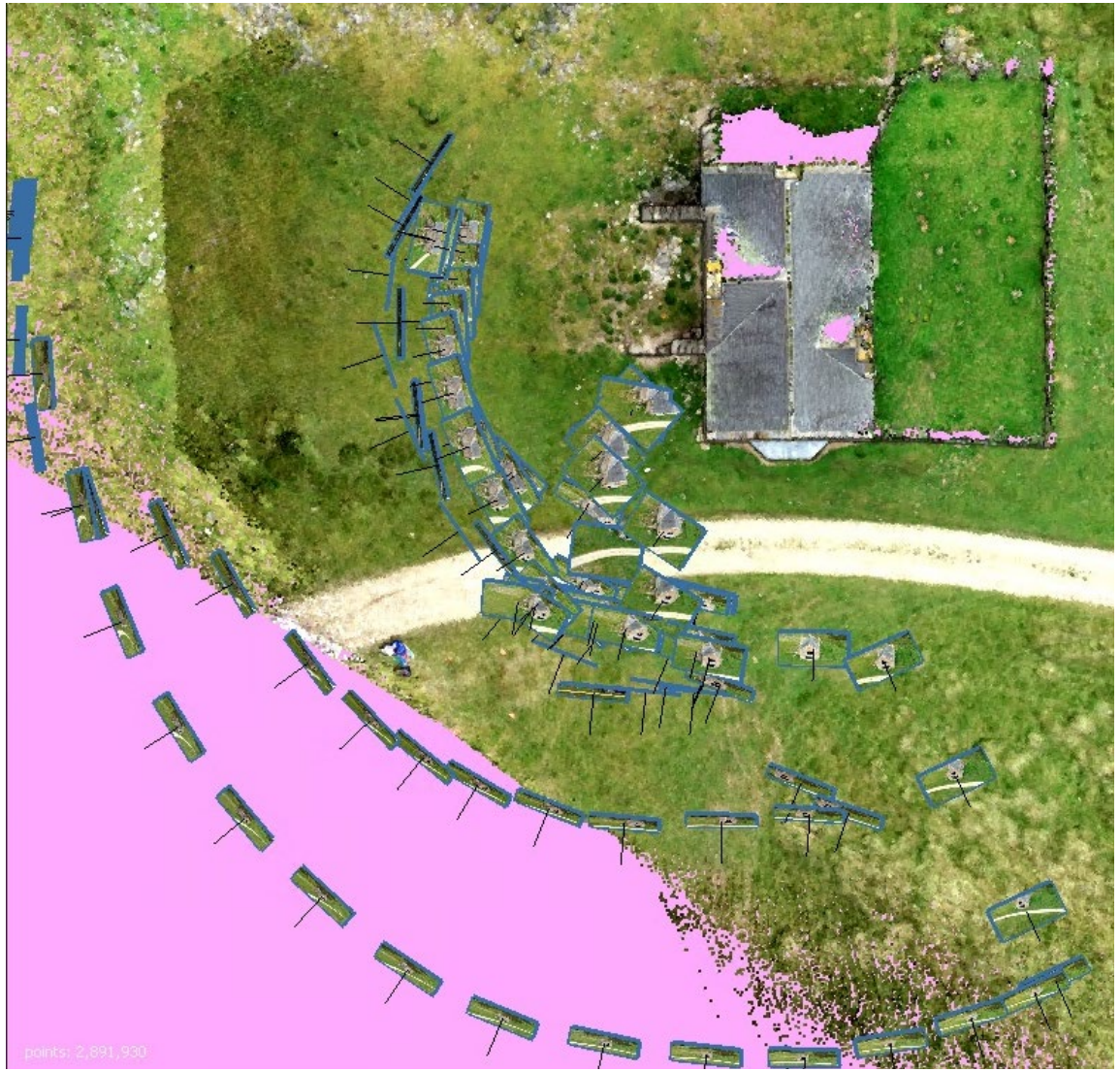
- We had to invent it

Our approach for camera pre-calibration

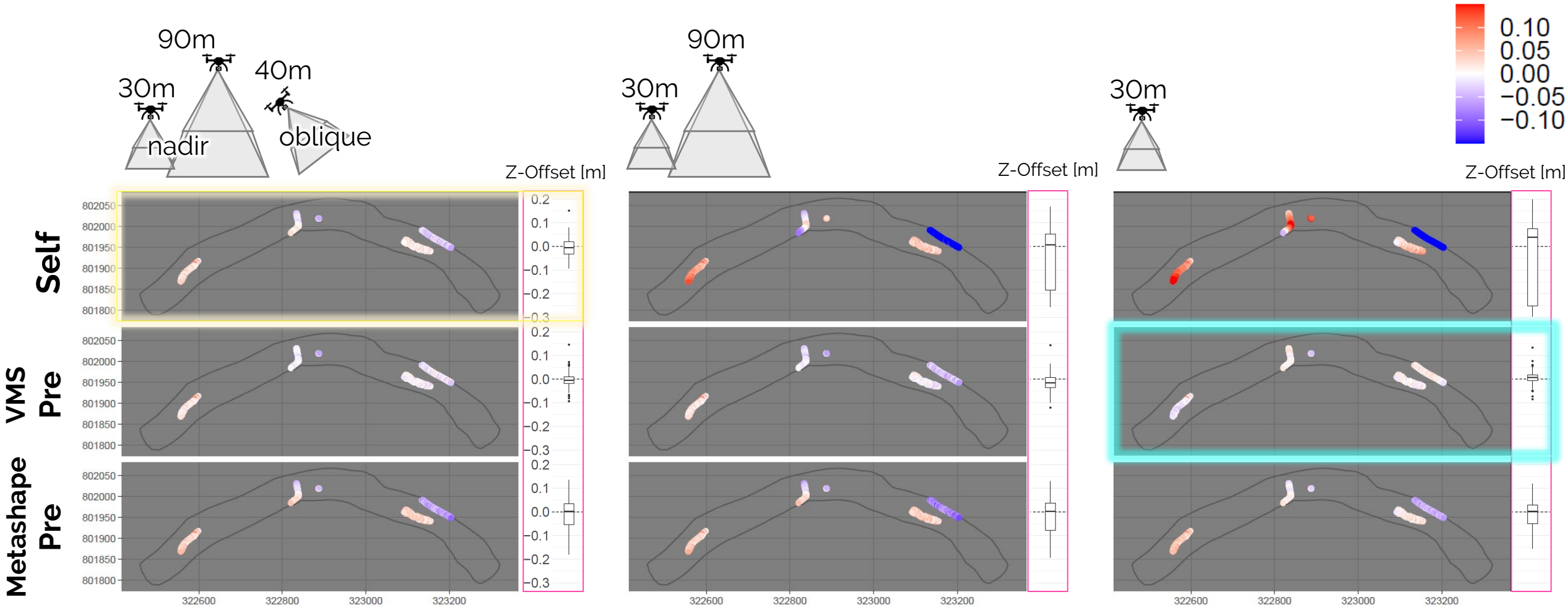
Permanent & on-site
TLS scans for reference
Natural features
Strong geometric image network
On survey scale







Results: Vertical offsets to GNSS reference measurements



Read more:
doi.org/10.1002/esp.5338

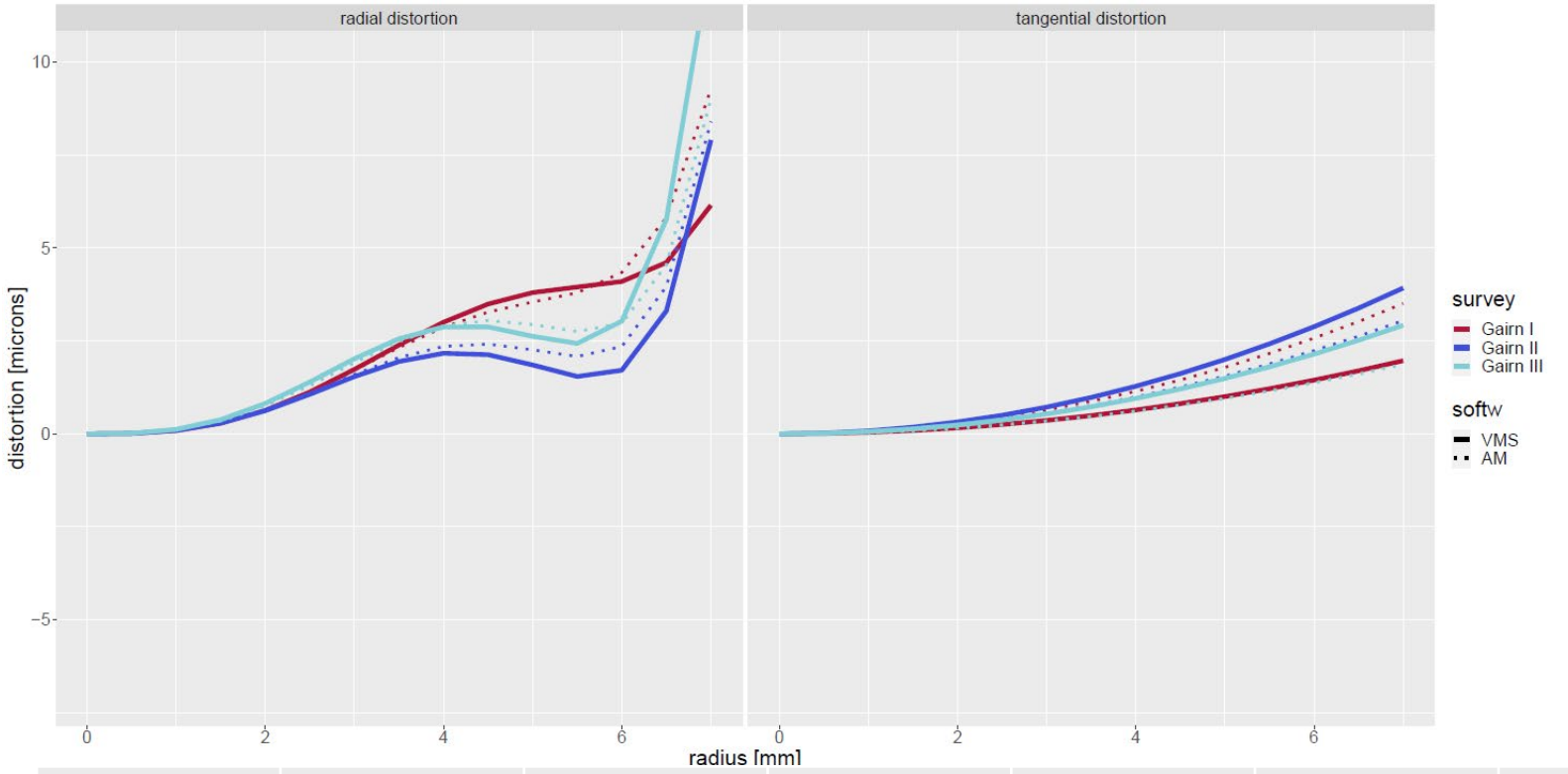
RESEARCH ARTICLE

ESPL WILEY

On-site geometric calibration of RPAS mounted sensors for SfM photogrammetric geomorphological surveys

Johannes Antenor Senn[1,2] | Jon Mills[1] | Claire L. Walsh[1] | Stephen Addy[2] | Maria-Valasia Peppa[1]

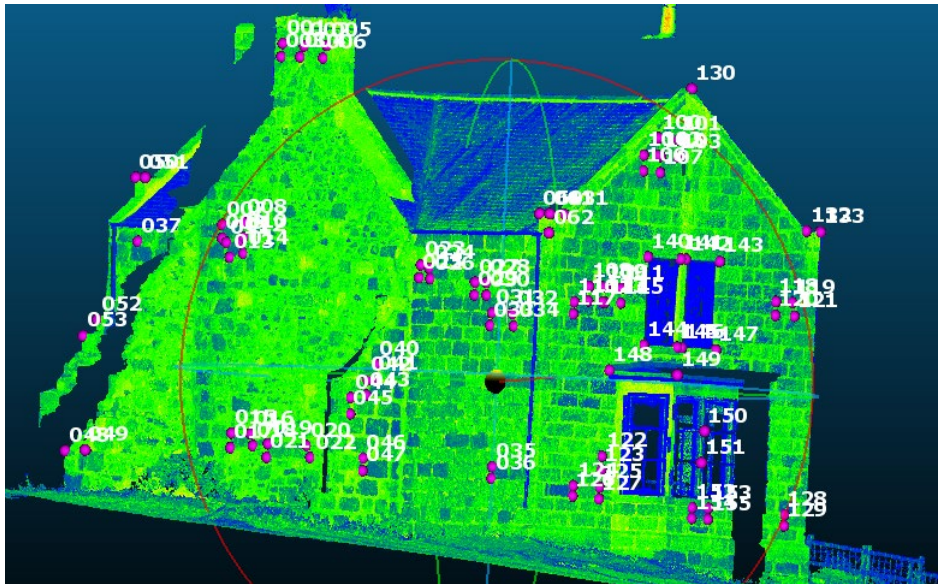
Calibration Stability



September 2019
October 2019
August 2021

dataset	software	images	observations	RMSE (pix)	f	x_p	y_p
Gairn I	VMS	16	1046	0.32	8.831	8.90×10^{-3}	$-2.33E^{-2}$
	AM	16		0.54/0.54	8.844	8.80×10^{-3}	-2.32×10^{-2}
Gairn II	VMS	16	957	0.24	8.829	-2.70×10^{-3}	-1.43×10^{-2}
	AM	16		0.41/0.37	8.840	4.40×10^{-3}	-1.33×10^{-2}
Gairn III	VMS	17	1112	0.2	8.828	2.81×10^{-2}	-1.64×10^{-2}
	AM	17		0.34/0.28	8.837	2.39×10^{-2}	2.00×10^{-4}

Summary



YES:

- Alternative to self-calibration in photogrammetrically challenging survey conditions
- Can be efficiently integrated into geomorphological surveys. Repeatable and time-saving
- Best case: VMS pre-calibration with single-scale nadir-only design

Made possible by

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- James Hutton Institute
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- Fieldwork Helpers
- Colleagues
- Estates, Fisheries

Thank You!