Drohne für ein hoch genaues Korridor-Mapping

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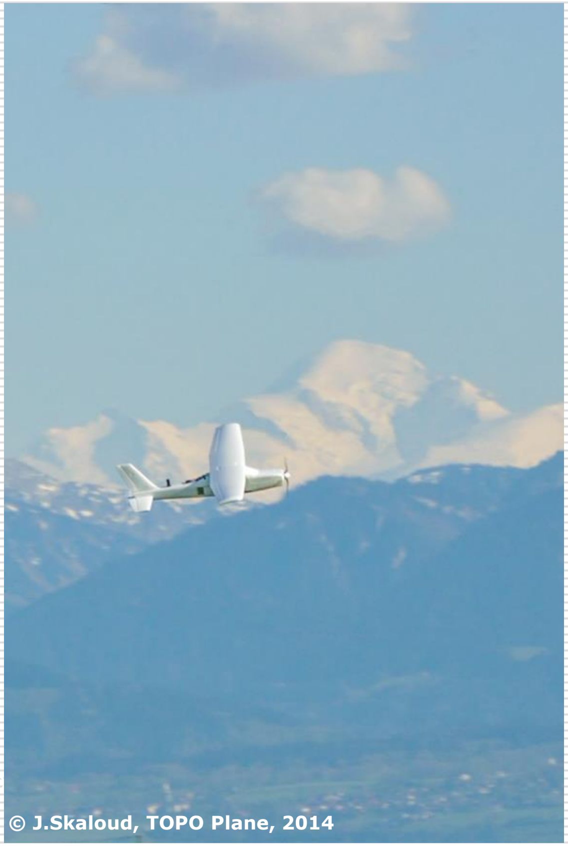

27. November 2015
Ahorn 2015, Wildhaus

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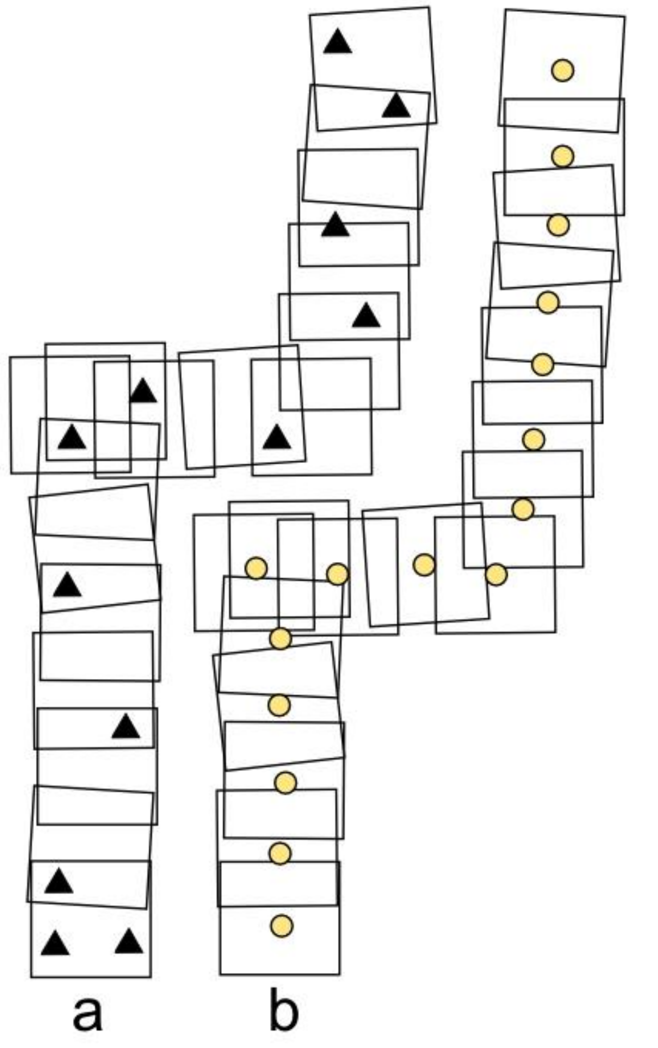
Motivation

- Flussverlauf
- Autobahn
- Pipelines
- …

What's on the menu

- Corridor Mapping
- MAV Platform
- Methodology & testing
  - Calibration fields
  - System calibration
- Mapping & "orientation" performance
- Conclusion

Details on corridor mapping



ground control point

time, 3D position/attitude

Image with photo measurements

- No typical block structure
- Small lateral overlap
- Texture (snow, vegetation)
- GCPs take time to set up

a – indirect SO

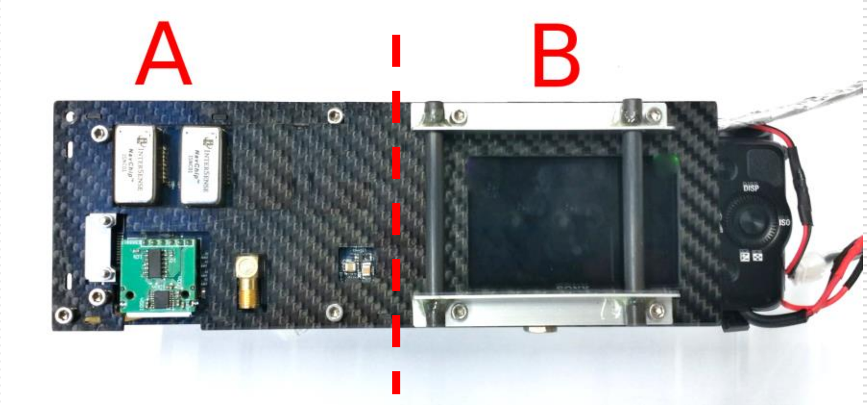
b – direct/integrated SO

TOPO plane - Structure

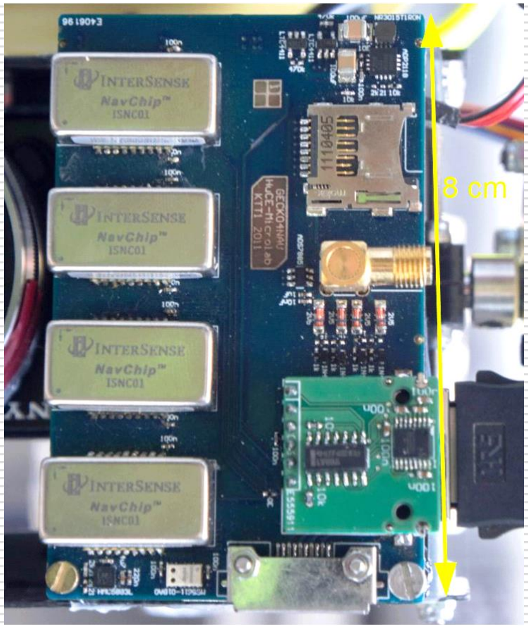
- Characteristics
  - Custom built
    - 150 Euro frame (the same as MAVinci UAV)
    - Off-the-shelf components
  - 1630 x 1170 mm
  - Operational weight 2800g
  - Endurance 40 min with 600 g of payload
  - Flying speed 16-20 m/s
  - Pixhawk (ETHZ) autopilot

TOPO Plane – Photogrammetry Payload

- Redundant-IMU (A)
  - FPGA board
  - 1-4 x MEMS IMU
  - 250 – 500 Hz



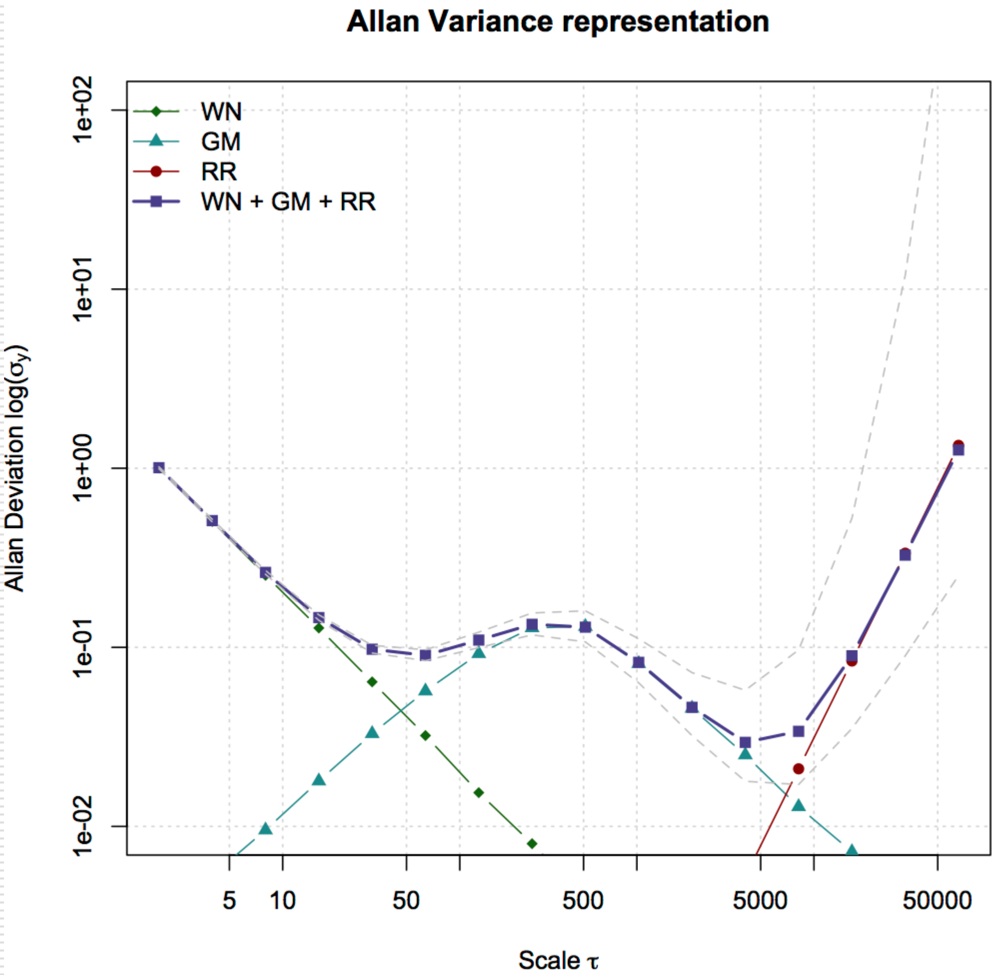
- Camera (B)
  - Sony NEX 5T camera (16 Mpx)
  - 16 mm lens (used in test)
  - synchronization module (flash)



- GNSS
  - multi freq., PPS, Event
  - GPS/Glonass L1/L2 antenna

System & Sensor Calibration

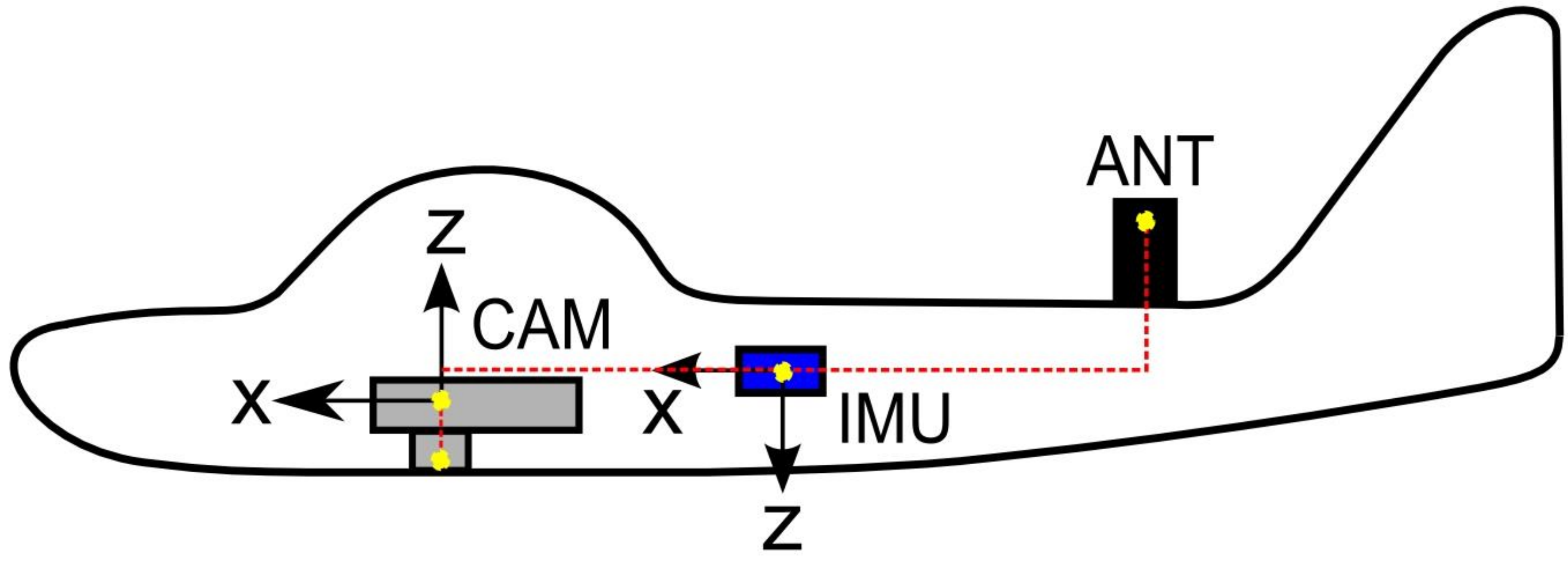
- Camera calibration
  - Self calibration during a separate flight
- IMU calibration
  - LSQ method for estimating "constant" elements (e.g. biases)
  - GMWM for estimating sensor noise characteristics
- Bore-sight
  - Camera – Body frame (IMU)



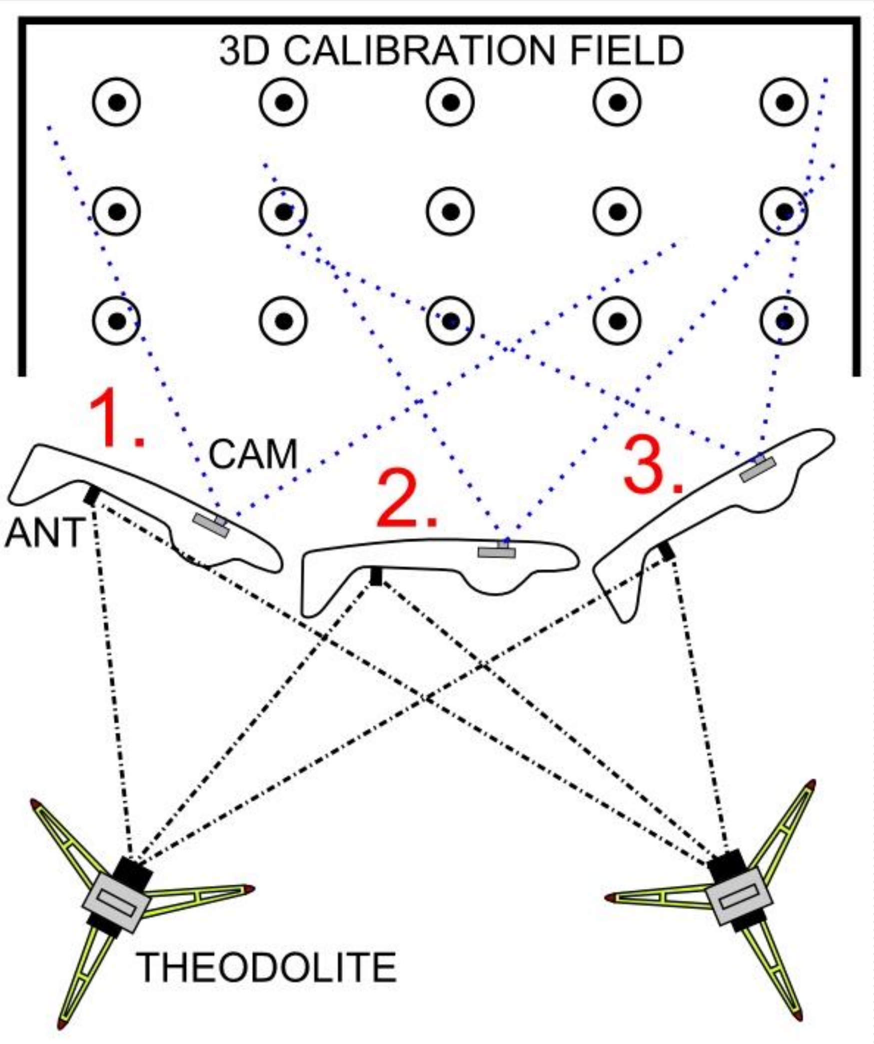
Guerrier, S., Skaloud, J., Stebler, Y. Victoria-Feser, M.-P. Wavelet-variance-based estimation for composite stochastic processes, **Journal of the American Statistical Association**, 108(503): 1021-1030.

System & Sensor Calibration

- Lever-arms
  - GNSS antenna – body frame (IMU)
  - Camera – body frame
  - “Pseudo-measurement” technique

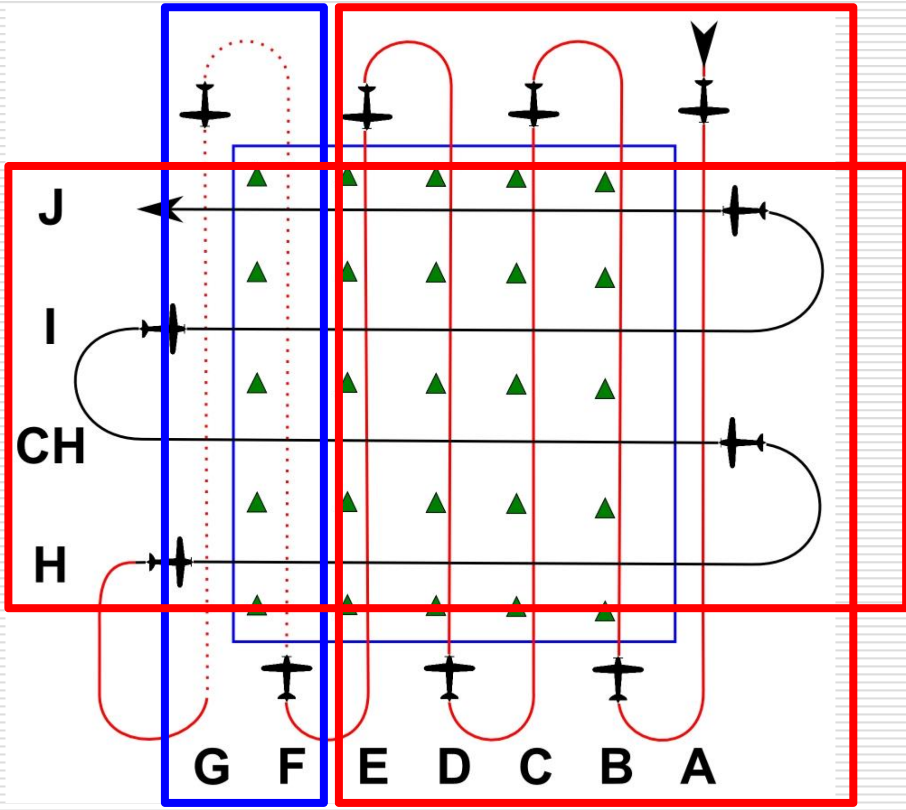


System & Sensor Calibration



Flights

- Total Calibration field
  - 100 ha
  - **26 control/check points**
  - ~30 m height differences
- Calibration block
  - Strips: A-E + H-J
  - Two heights: **120** and **150 m**
  - **17 control points**
- Corridor
  - Strips F+G
  - 1200 x 180 m long
  - **9 check points**
- Statistics
  - 520 images
    - 459 used for calibration
    - 61 for corridor evaluation
  - Average GSD 3.8 cm



Processing Steps

- Image measurements – auto & manual (GCP) via Pix4D
- GNSS antenna positions – GrafNav (10 Hz)
- IMU position & attitude – custom filter/smoother
- Camera position & attitude transfer/adapt. – CAMEO

1. Calibration block
   - Camera self calibration + bore-sight estimation

2. Corridor
   - Bundle adjustment with POS and POS/ATT, no GCPs
   - Pix4D, several processing approaches

Mapping Accuracy – Corridor

- No GCPs in the adjustment
- Fixed IO parameters, bores-sight and lever-arm
- Evaluated at 9 check points
- Angular observation plays a role

EO parameters	Residual	Position [m]	Height [m]
Position **only**	MAX	0.147	0.114
	MEAN	**0.037**	-0.008
	RMS	**0.070**	**0.070**
Position + **Attitude**	MAX	0.062	0.136
	MEAN	0.009	-0.003
	RMS	**0.029**	**0.070**

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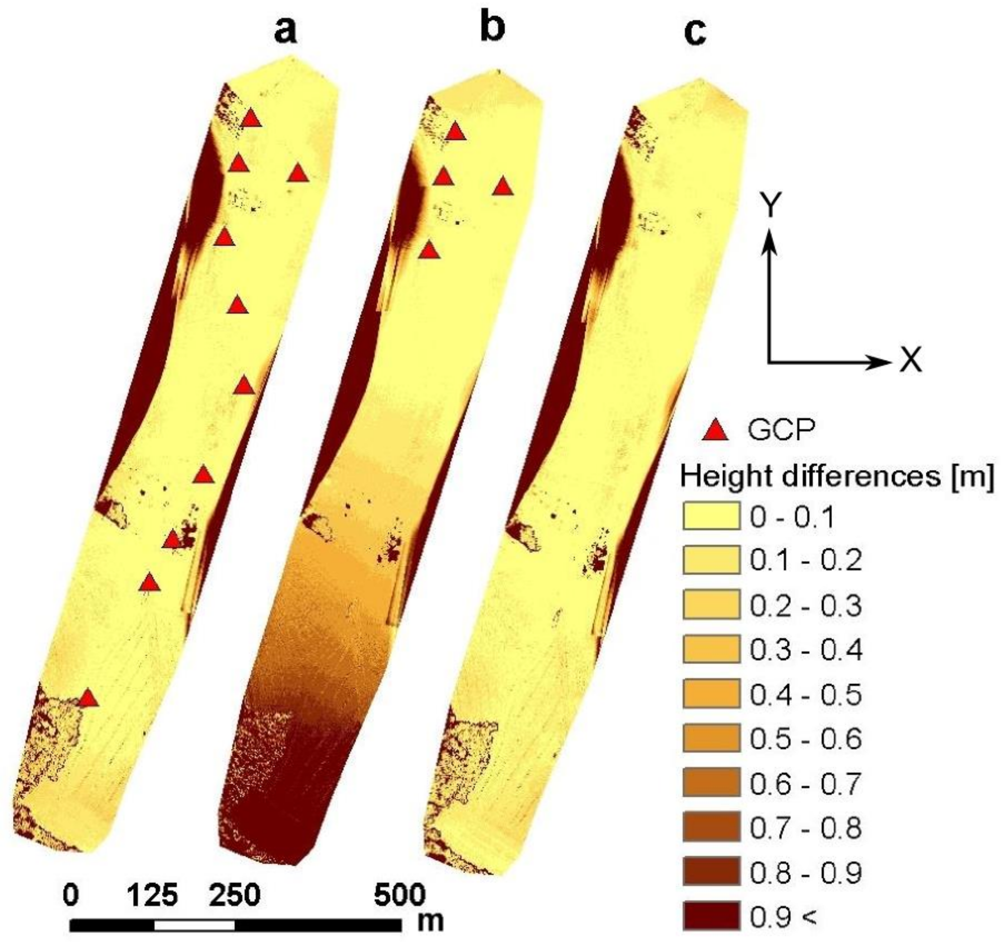
DTM Mapping Accuracy – Corridor

- Processed in Pix4D
  - Recalibrated IO
- **Block:** Complete set of images + all GCPs = **reference**
- **Corridor:** 3 different processing scenarios
  - a) 9 GCPs – indirect
  - b) 4 close GCPs - indirect
  - c) NO GCPs - **integrated**



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Conclusion

- MAV: hobby-grade plane + open source autopilot + correct instruments = **an affordable MAV mapping tool**

- **Sensor calibration**
  - One-time workflow for constant parameters
  - Good system calibration is needed.
  - Time varying parameters (IO) can be recalibrated in-flight.

- Achieved accuracy in corridor with POS/ATT: **1.5 GSD** in position and **2 GSD** in height *without GCPs.*

Conclusion

- One step closer to accurate direct sensor orientation with MAVs

- Requirements
  - Redundant-IMU with higher accuracy is needed.
  - Fault Detection and Identification (FDI) algorithm should be applied.
  - ...

- Déjà vu in aerial photography with manned aircraft?

Questions

Thank you for your attention!

To find more about the specific topic of
sensor orientation on MAVs
(and other platforms)

http://www.eurocow2016.org/
Feb. 10-12, 2016
EPFL campus

Reference

- *Rehak, M. and Skaloud, J.: FIXED-WING MICRO AERIAL VEHICLE FOR ACCURATE CORRIDOR MAPPING, ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., II-1/W1, 23-31, doi:10.5194/isprsannals-II-1-W1-23-2015, 2015.*