Fixed-Wing Micro UAV Open Data

with digiCam & raw INS/GNSS

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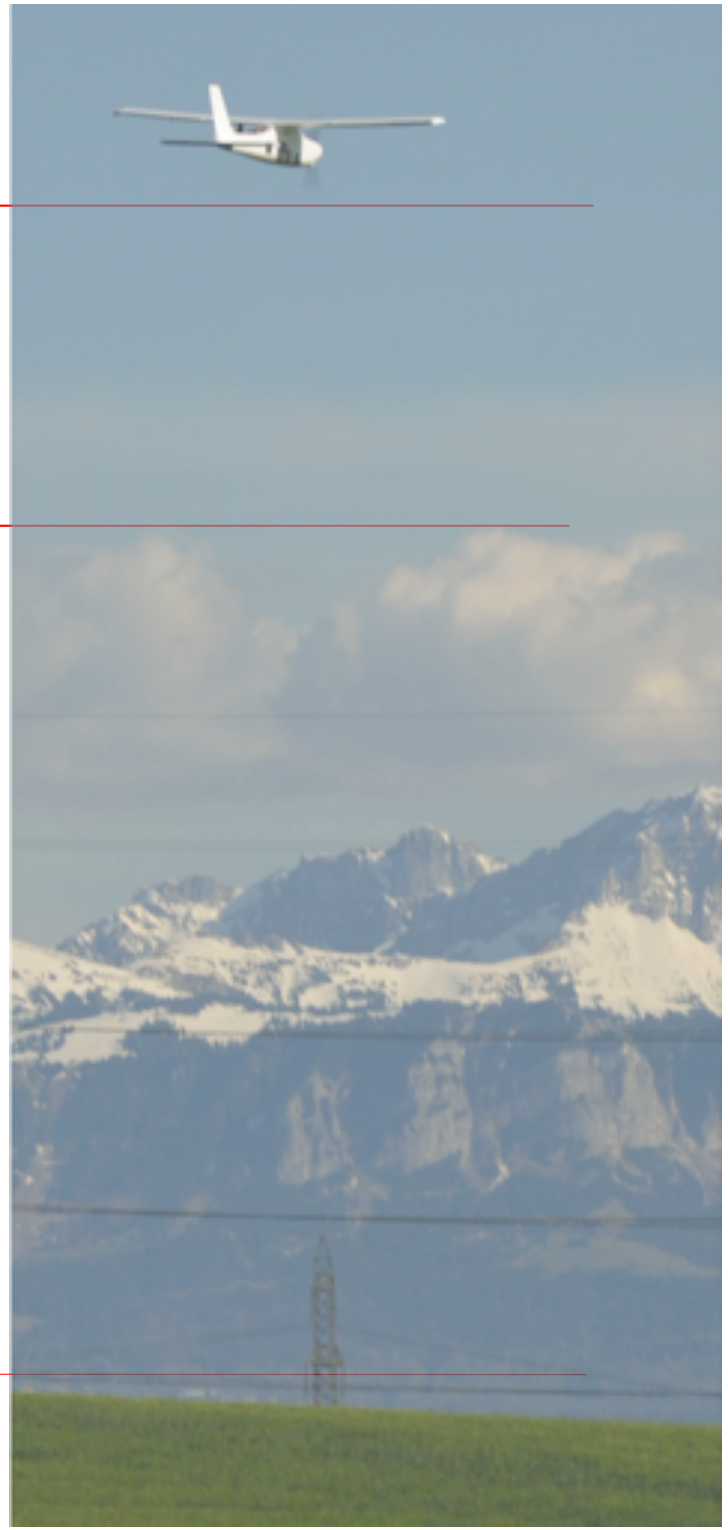
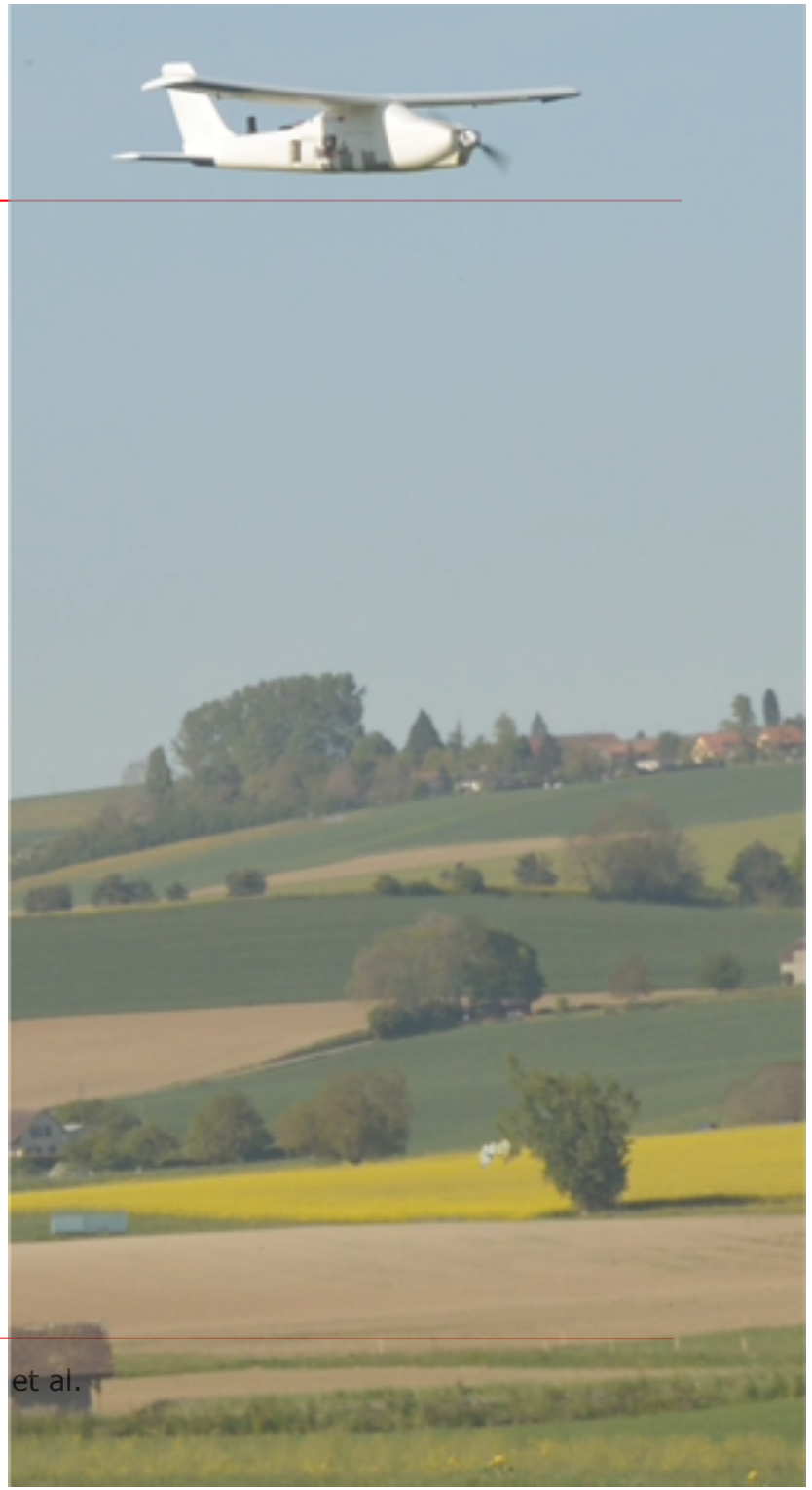


Motivation

- New practices
  - integrated sensor orientation
  - camera/system calibration
  - R-IMU setup / pre-calibration
  - autonomous navigation

- Open reference
  - benchmarking - methods
  - comparing software

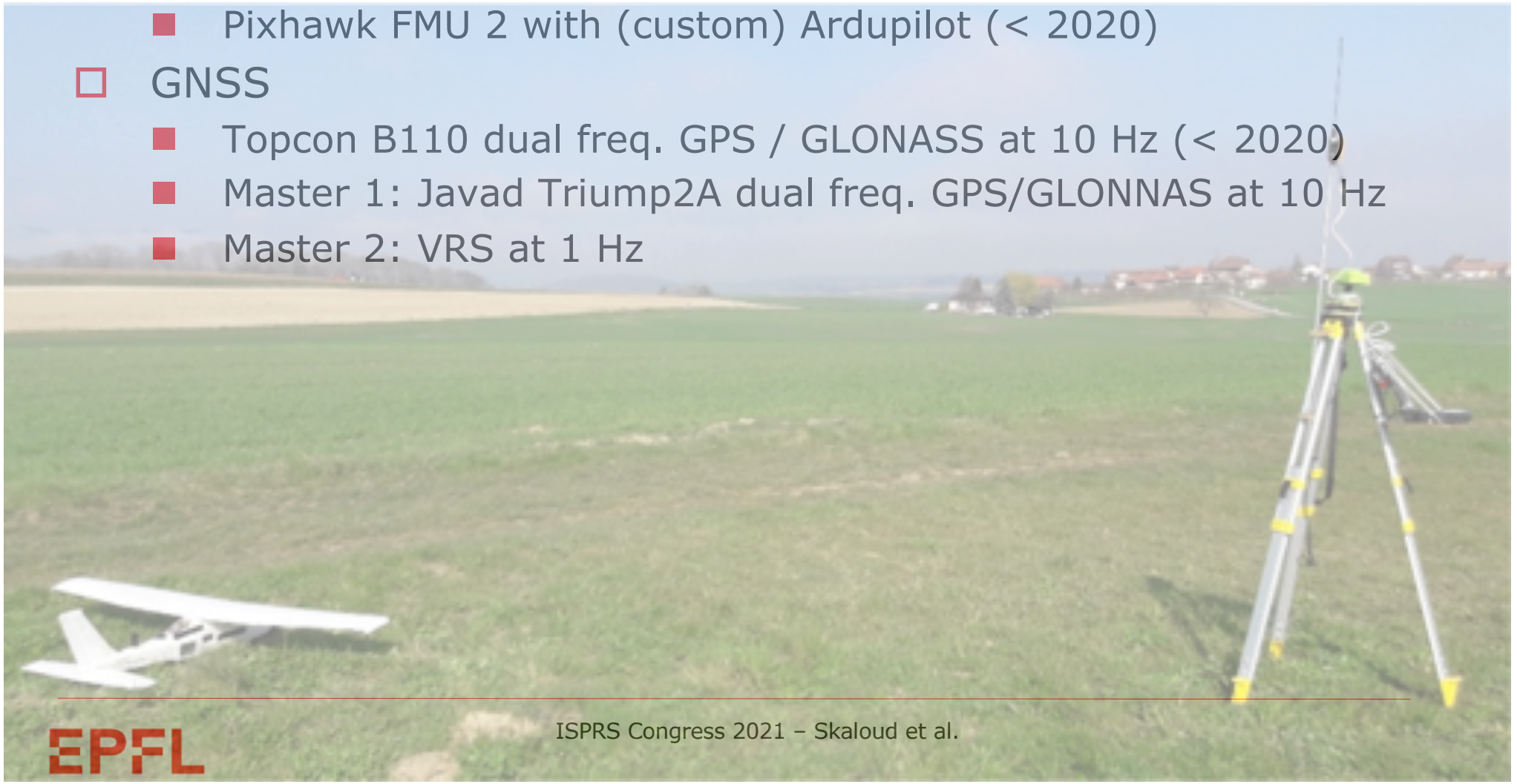


Agenda

1. Platform and payload
2. System calibration
3. Missions
4. Data access, formats & organization

Platform and payload – Aircraft & GNSS

- Plane
  - Mentor Multiplex (Elapor foam), 1.6 m wing-span, 2.7 kg TOW
  - Pixhawk FMU 2 with (custom) Ardupilot (< 2020)
- GNSS
  - Topcon B110 dual freq. GPS / GLONASS at 10 Hz (< 2020)
  - Master 1: Javad Triump2A dual freq. GPS/GLONNAS at 10 Hz
  - Master 2: VRS at 1 Hz

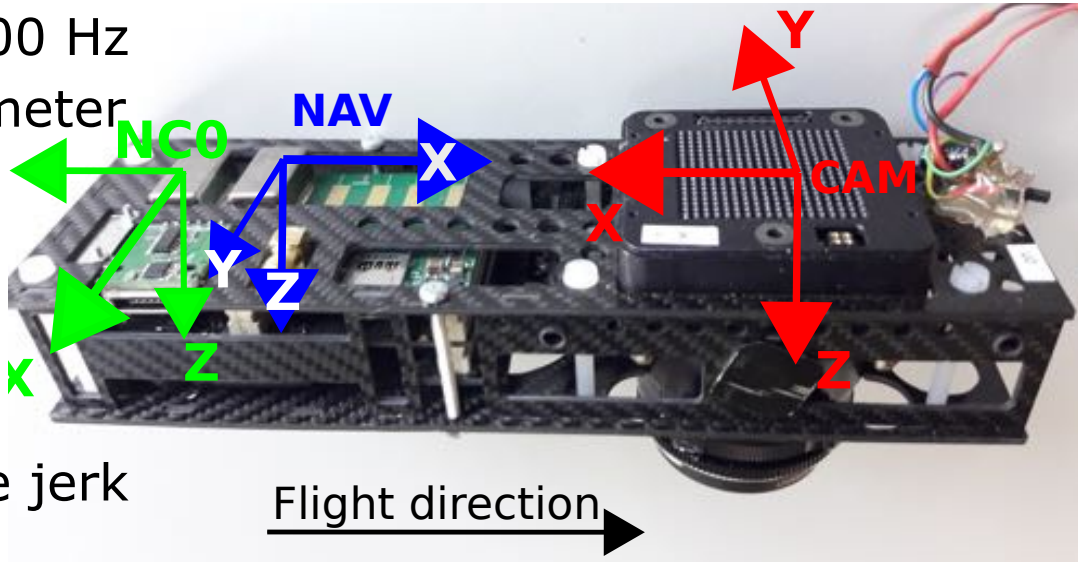


Platform and payload – CAM & INS

- Camera
  - camLight from IGN (French mapping agency)
  - Full frame CMOS, 6 um/pix, 12 bits panchro, *.tiff
  - Zeiss Biogon 35 mm, f 2.8 prime lens
  - Shutter 1/5000 s: blur < 3 mm for 12 mm GSD

- R-IMU
  - 2x Navchip V1 IMUs @ 500 Hz
  - With 2x 3 axes magnetometer
  - High res. Barometer
  - PPS sync sampling rate

- Time tagging
  - All in GPS time, negligible jerk

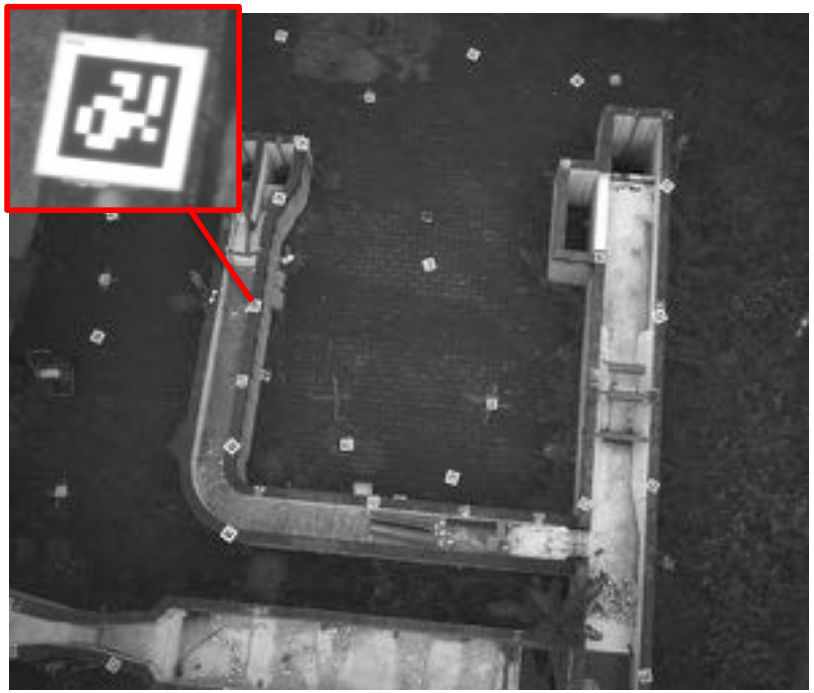


System calibration

- Lever-arm
  - Method: Rehak & Skaloud, 2015
  - Camera -> antenna, std ~ mm, level in camera frame
  - Camera -> IMU, in camera fram from CAD design, std ~ mm
- IMU
  - Method: Clausen & Skaloud, 2020: non-orthogonalities, const. scale factors and const. in-field random biases

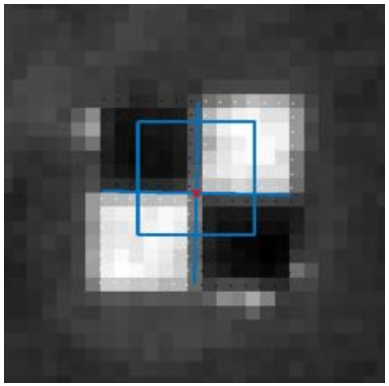
System calibration

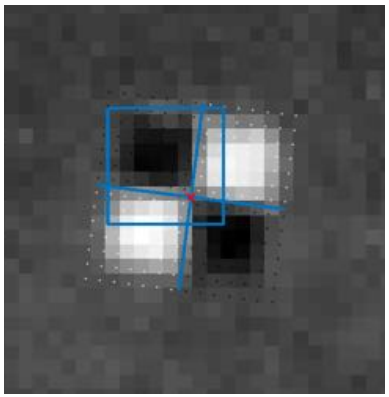
- Lens
  - Close range ~50 signalized “aruko-targets”, photos with converging geometry
  - In-flight (large block)
  - Comparison of models Cledat et al. 2020 (young author award)
  - Indepenent study conducted by IFP, U. Stuttgart (M. Cramer)
- Boresight
  - In-flight (large block)

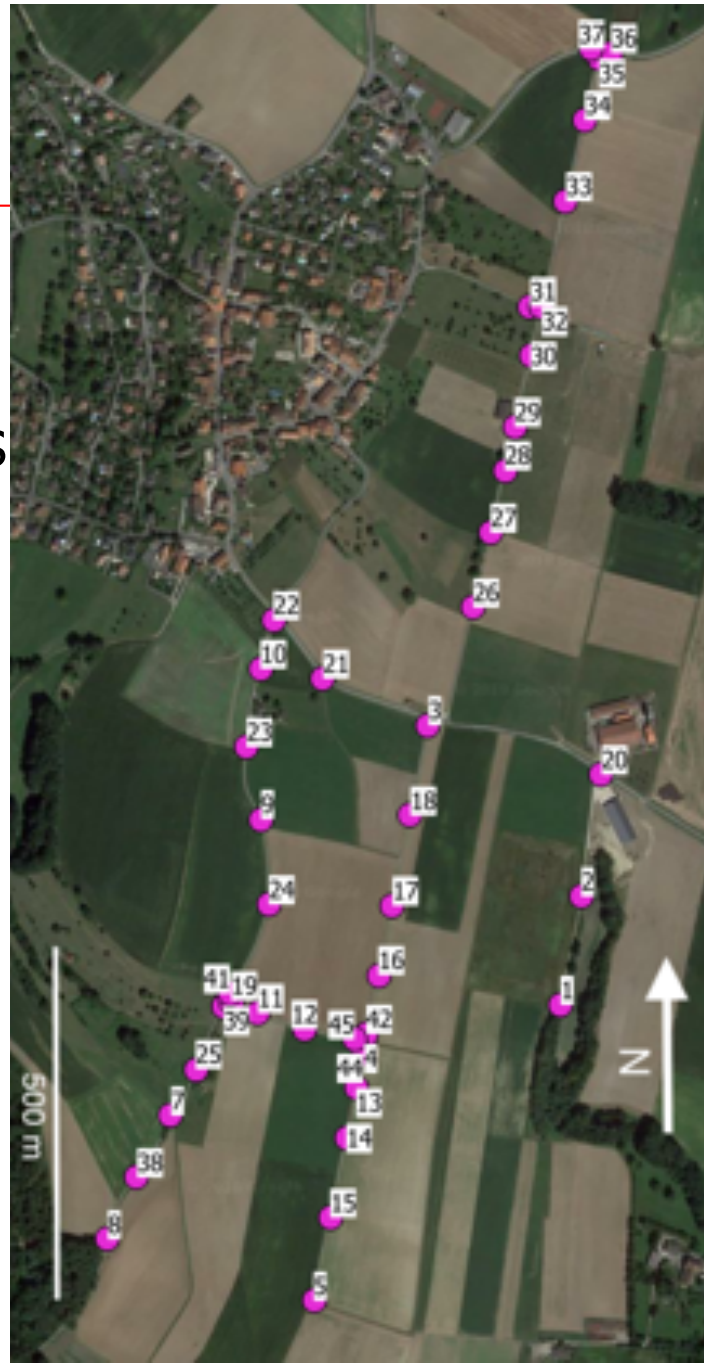


Missions – test zone

- Ground control
  - 40 signalized points 30 x 30 cm
  - ~1-2 cm accuracy, ~40 min static GNSS
  - For auto centering (~ 0.1 - 0.05 pix)



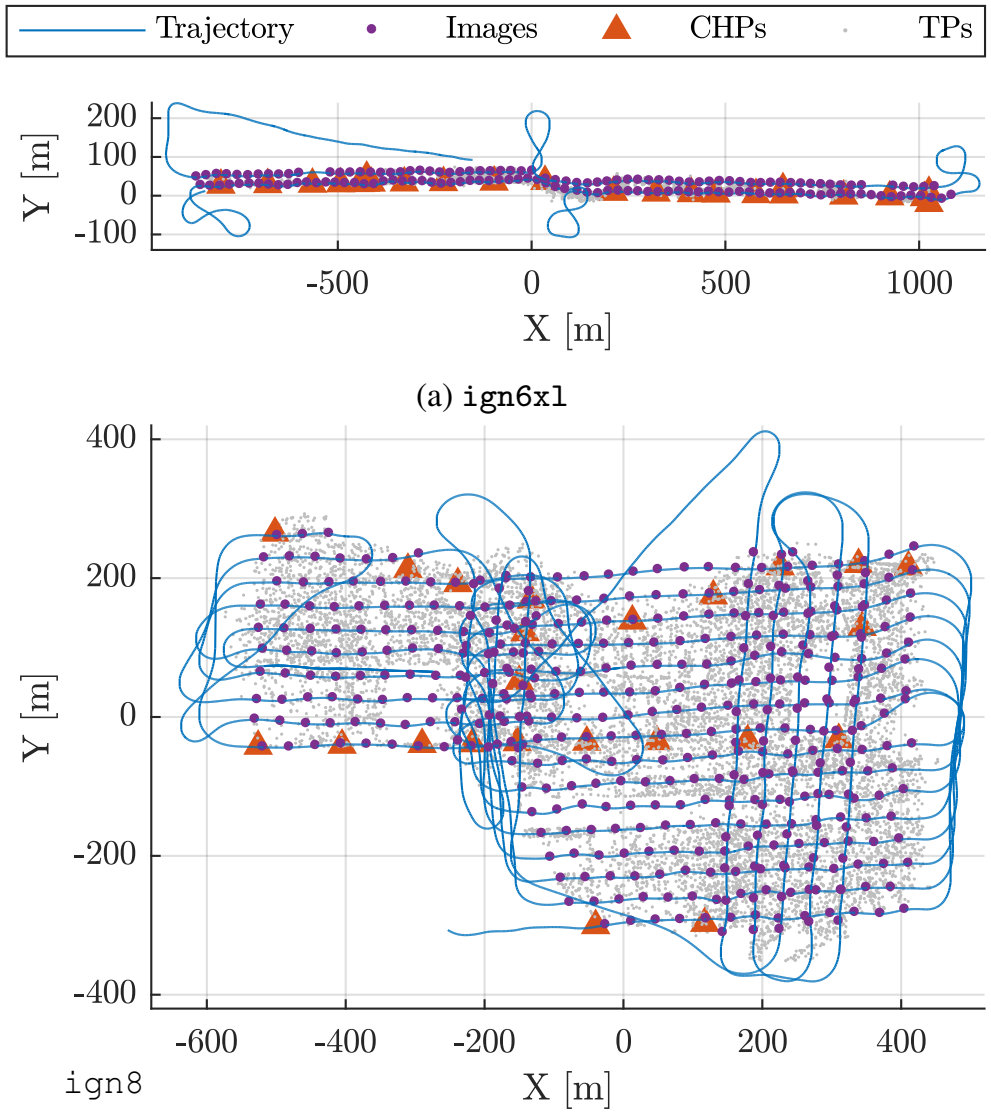




Missions

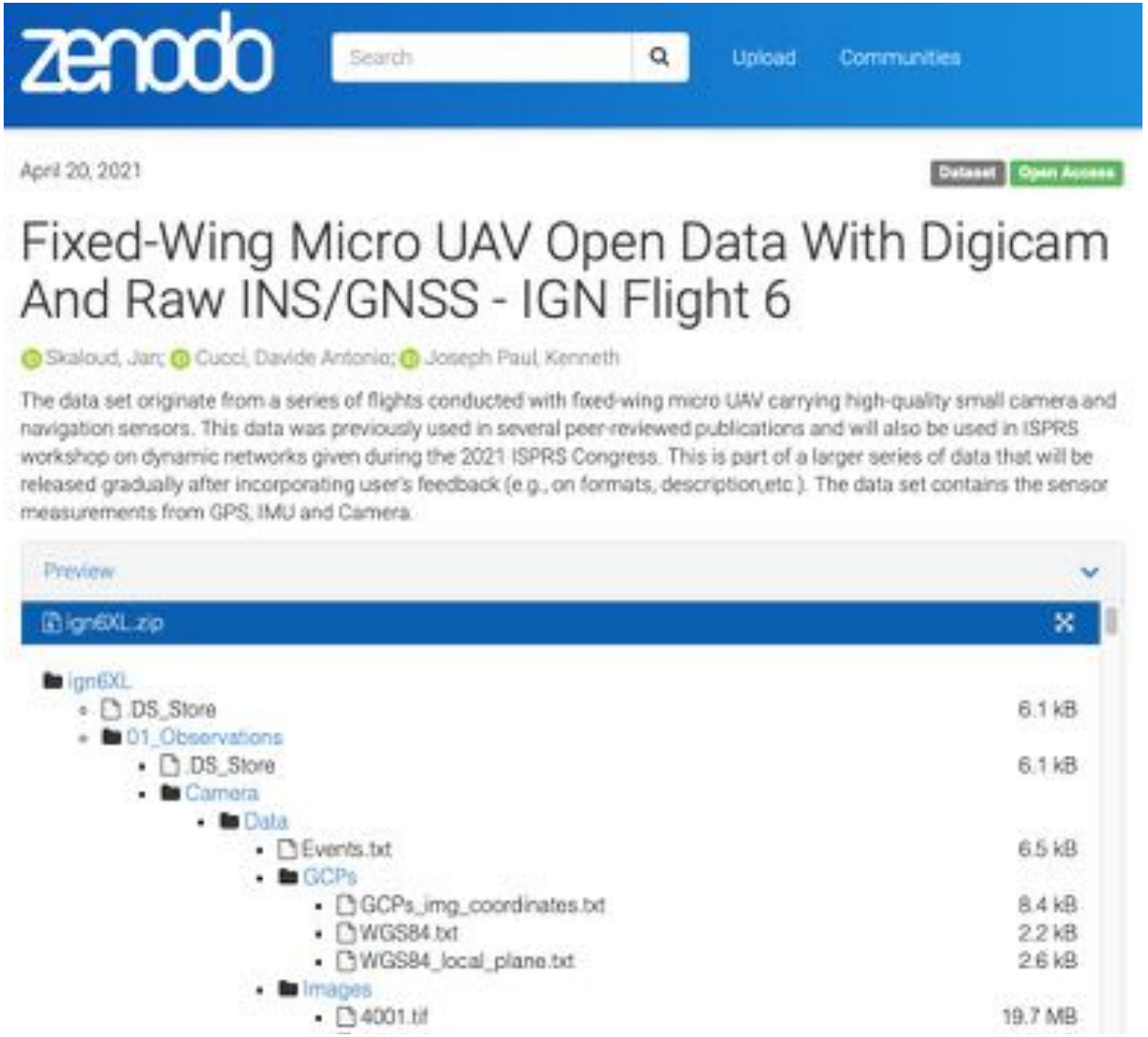
- Close range (no EO)
- Large block (40 min)
- Long corridor (2 km)

- 2 flight levels, 100-180 AGL
- Sharp images



Open data

- Repository
  - Zenondo
  - CC-BY 4.0 license
- Access
  - 3x ref. Skaloud et al. 2021a, b, c
  - https://doi.org/10.5281/zenodo.4705380



Data organization

- Readme.md
  - In each subdirectory
- Formats

	Data	Format
Sensors	GPS	RIINEX 2.11
	IMU	.csv
	Camera	.tif,.txt
Auxiliary	GCPs	.txt
	Trajectory, EO	.txt

- Structure
  - 01_
  - 02_

```
.
|-- 01_Observations
|   |-- Camera
|   |   |-- Data
|   |   |   |-- Events.txt
|   |   |   |-- GCPs
|   |   |   |   |-- GCPs_img_coordinates.txt
|   |   |   |   |-- WGS84.txt
|   |   |   |   |__ WGS84_tangentplane.txt
|   |   |   |__ Images
|   |   |       |-- 8001.tif
|   |   |       |-- 8002.tif
|   |   |       |-- ...
|   |   |__ README.md
|   |-- GPS
|   |   |-- Data
|   |   |   |-- Master
|   |   |   |   |-- tr2b0703a.18G
|   |   |   |   |-- tr2b0703a.18H
|   |   |   |   |-- tr2b0703a.18N
|   |   |   |   |__ tr2b0703a.18o
|   |   |   |-- Rover
|   |   |   |   |-- rov01840.18g
|   |   |   |   |-- rov01840.18n
|   |   |   |   |__ rov01840.18o
|   |   |   |__ Vrs
|   |   |       |-- V339184H.18g
|   |   |       |-- V339184H.18n
|   |   |       |-- V339184H.18o
|   |   |       |__ V339184H.txt
|   |   |__ README.md
|   |__ IMU
|       |-- Data
|       |   |-- Pre_calibrated
|       |   |   |-- f8_0_sob.csv
|       |   |   |__ f8_1_sob.csv
|       |   |__ Raw
|       |       |-- f8_0.csv
|       |       |__ f8_1.csv
|       |__ README.md
|-- 02_Processed
|   |-- GPS-INS
|   |   |__ EO_local-plane.txt
|   |__ GPS-PPK
|       |-- AntennaPos_Img_WGS84.txt
|       |-- AntennaPos_Img_WGS84_tangentplane.txt
|       |__ AntennaPos_WGS84.txt
|-- FLIGHT.md
|__ README.md
```

Conclusions

- Access to high quality data with reference is not obvious to test "new methodologies" (tie-integration of all raw data, error modeling, long corridors, challenging geometry, etc.)
- First 3 data sets from more …
- Goal: bench-marking traditional approaches & faster testing of newer and improved concepts.

Zeiss Biogon: L1006467_f16.tif

Data use examples

- R-IMU calibration
  - Clausen, P., Skaloud, J., 2020. On the calibration aspects of MEMS-IMUs used in micro-UAVs for sensor orientation. Proceedings of IEEE-ION Position Location and Navigation Symposium (PLANS), Portland, OR, USA
- Camera models
  - Cledat, E.; Cucci, D. A., Skaloud, J. Camera calibration models and methods in corridor mapping with UAVs
    ISPRS Annals of ISPRS, 2020, V-1-2020, 231-238
- Integration methodology
  - Cucci, D. A., Skaloud, J. Joint adjustement of raw inertial data and image observations: methods and benefits
    Photogrammetric Week 8, Stuttgart, 2019

Acknowledgements

- Camera: IGN, ENSG, Paris
  - J.-P. Souchon, C. Thom, O. Martin
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  - P. Clausen, E. Cledat
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  - M. Crammer
- Additonal assistants
  - Unnamed