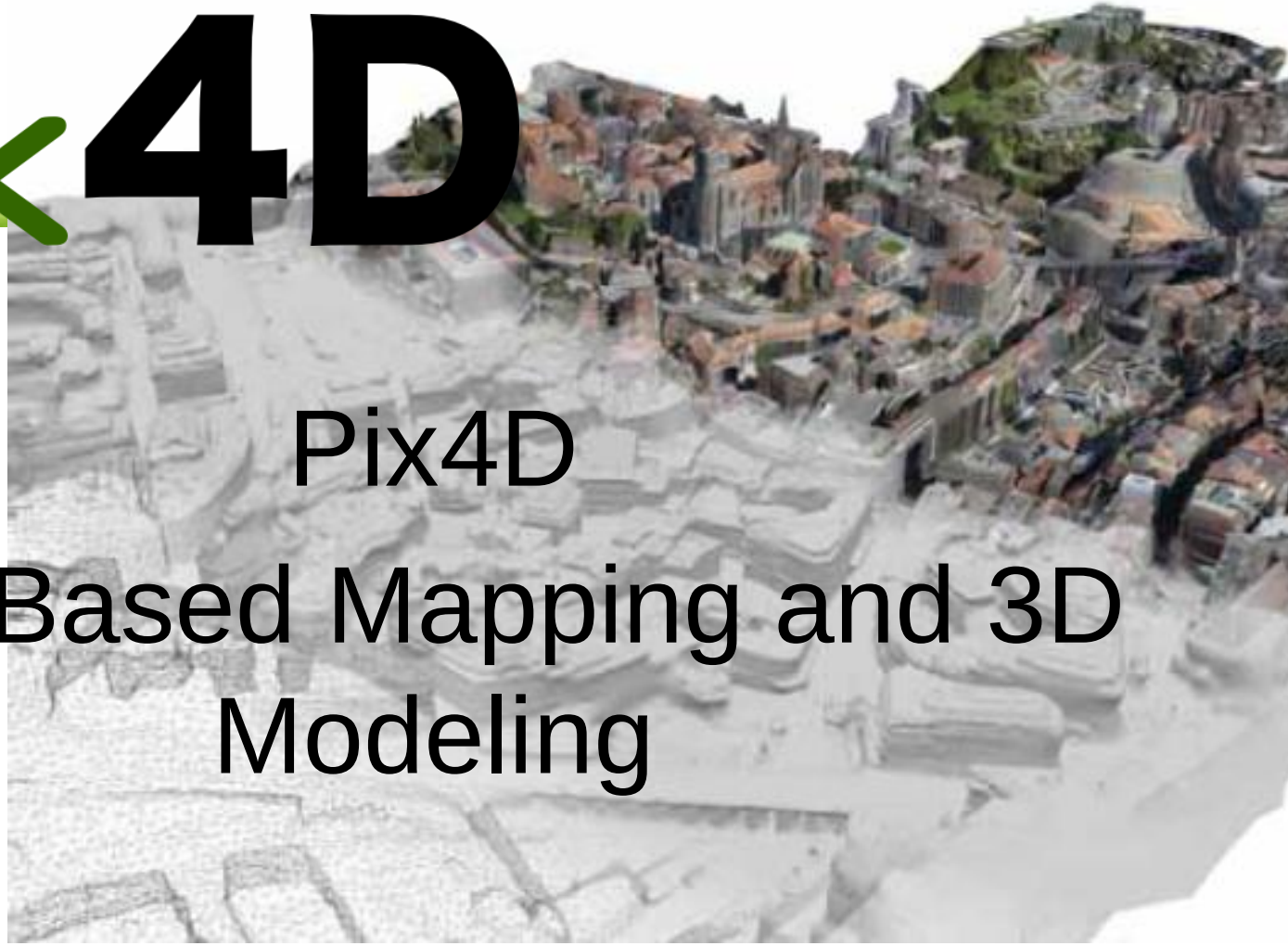


Pix4D
UAV Based Mapping and 3D Modeling

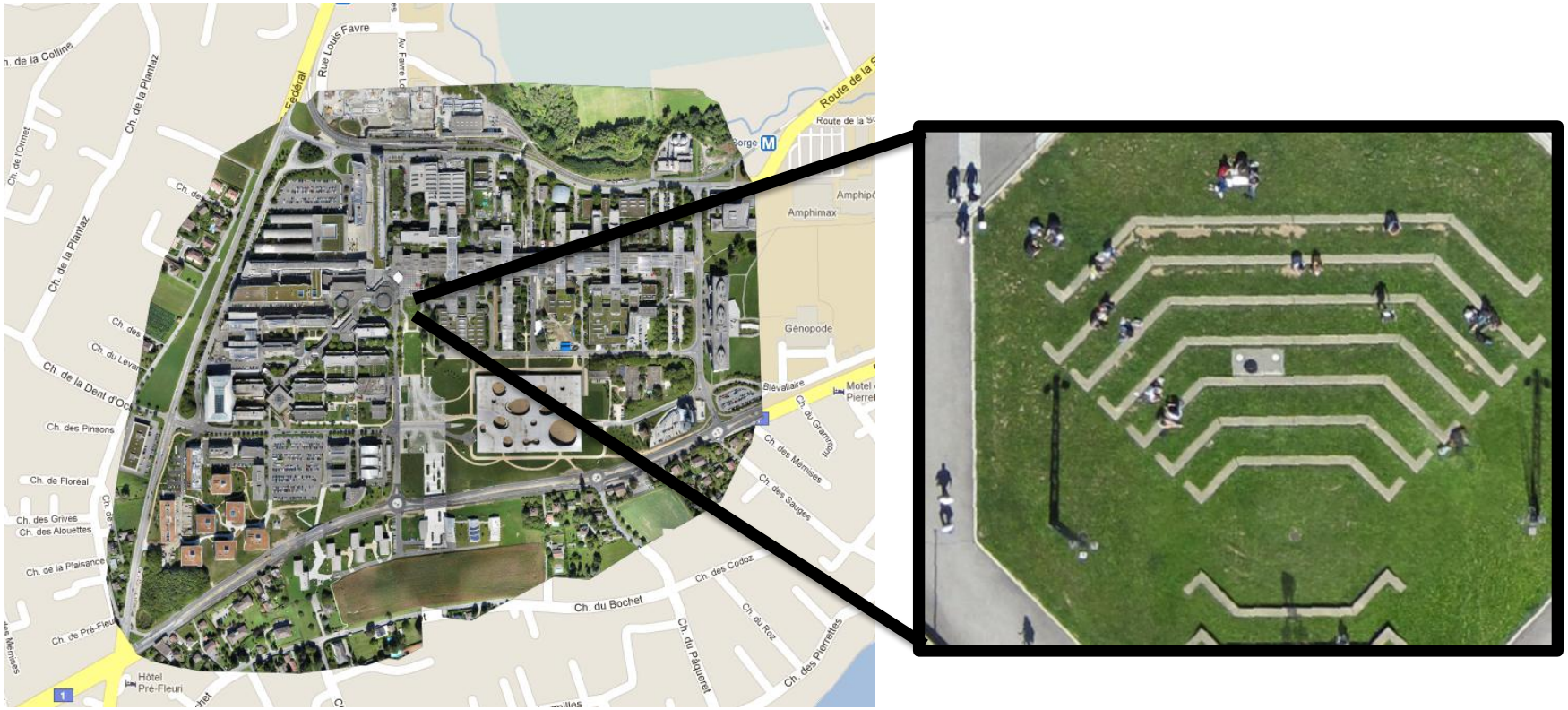
Christoph Strecha EPFL/Pix4D

Olivier Küng EPFL/Pix4D

Pascal Fua EPFL

Automated mapping from UAV

Pix4D



Pix4D

Hands free image processing

Background

Pix4D

Computer vision & Photogrammetry

- **Dense 3D modeling from still images**

  Talk @ ICCV 2003:

  C. Strecha, T. Tuytelaars, L. Van Gool

  Dense Matching of Multiple Wide-baseline Views

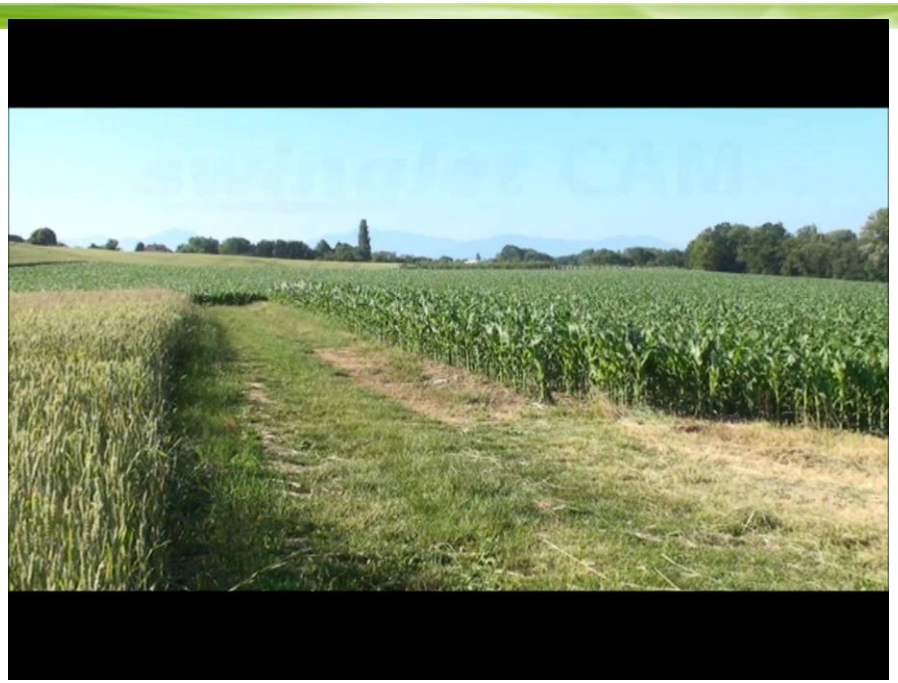
Current Focus

AERIA INSIGH

Lightweight approach:

- Ultra-light UAV platform (< 2kg)
- Low-end camera and GPS (~5m)

- High resolution maps
- **Ease of use**
  - **Repetitive capture (temporal)**
  - **On demand**
  - **Small and medium areas**



Gatewing x100
~2kg
80km/h
www.gatewing.com

senseFly swinglet
~0.5kg
30km/h
www.sensefly.com

many other micro UAV's: e.g. MAVinci, SmartPlanes, TerraPan, Pteryx, Ascending ...

InterGEO 2011

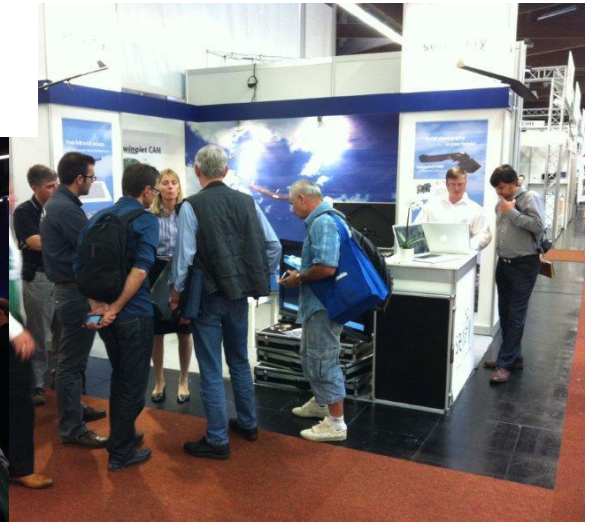
World wide largest trade for GIS

Pix4D

Year	2009	2010	2011
# UAV manufacturers	**0** UAV	**2** UAV	**8** UAV

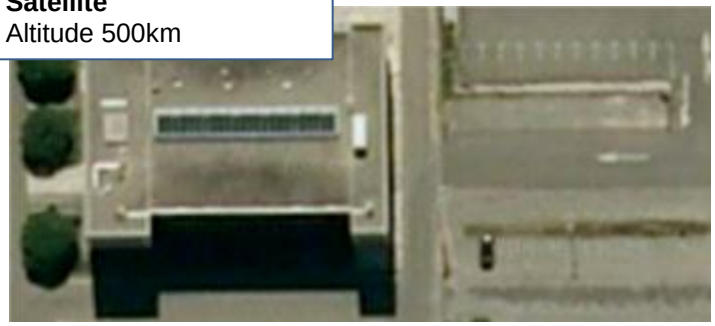
MAVinci / Pix4D

Gatewing / Pix4D

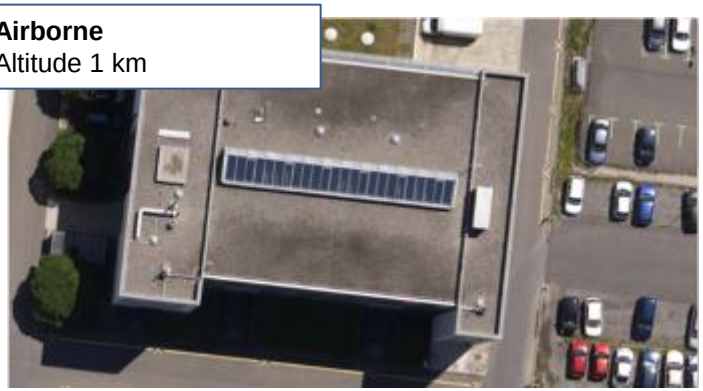


Sensefly / Pix4D

Satellite
Altitude 500km



Airborne
Altitude 1 km



UAV
Altitude 100m

What is different to traditional sensors?

- Low accuracy of GPS / sometimes missing
- Very low accuracy of orientation sensors
- Image blurr in 1-5 % of the images
- Irregular flight plans – disturbed by wind

- High redundancy overcomes above problems
- Challange for fully atomated processing

- Many low resolution images instead of few high resolution images

Historical Developments in Photogrammetry

Data acquisition

Data processing

Pix4D

Data acquisition

Data processing

Manned Airplanes / Helicopters	Manual: «click points»

Done only by experts!

Data acquisition

Data processing

Manned Airplanes / Helicopters	Manual: «click points»
Manned Airplanes / Helicopters Precise GPS and IMU	(Automated) refinement of accurate sensor information

Done only by experts!

Data acquisition

Data processing

Manned Airplanes / Helicopters	Manual: «click points»
Manned Airplanes / Helicopters Precise GPS and IMU	Automated: refinement of accurate sensor information
UAVs operated from ground autonomus flight, easy to use	Fully automated: results possible without GPS/IMU

No expert knowledge required!

Not for data acquisition, not for data processing

Pix4D

Pix4D

Data acquisition

Data processing

Manned Airplanes / Helicopters	Manual: «click points»
Manned Airplanes / Helicopters Precise GPS and IMU	Automated: refinement of accurate sensor information
UAVs operated from ground autonomus flight, easy to use	Fully automated: results possible without or low precision GPS/IMU
UAVs on ground stations autonomus take-off, flight, landing Data transmission and recharching	Fully automated: results possible without GPS/IMU, real-time

Automated fly and processing!

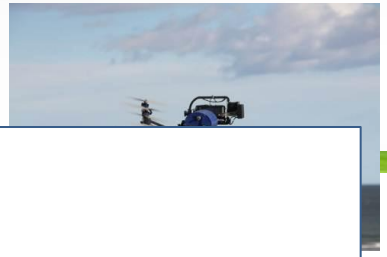
What does this mean?

- More applications – affortable, not expert knowledge
- Much higher update cycles of GIS data
- Temporal modeling

UAVs operated from ground autonomus flight, easy to use	Fully automated: results possible without or low precision GPS/IMU
UAVs on ground stations autonomus take-off, flight, landing Data transmission and recharching	Fully automated: results possible without GPS/IMU, real-time

Automated fly and processing!

Pix4D



Pix4D

Dat

Data processing

Mar	Manual: «click points»
Mar Prec	Automated: refinement of accurate sensor information
UAV autc	Fully automated: results possible without or low precision GPS/IMU
UAV autc Data	Fully automated: results possible without GPS/IMU, real-time

Target:

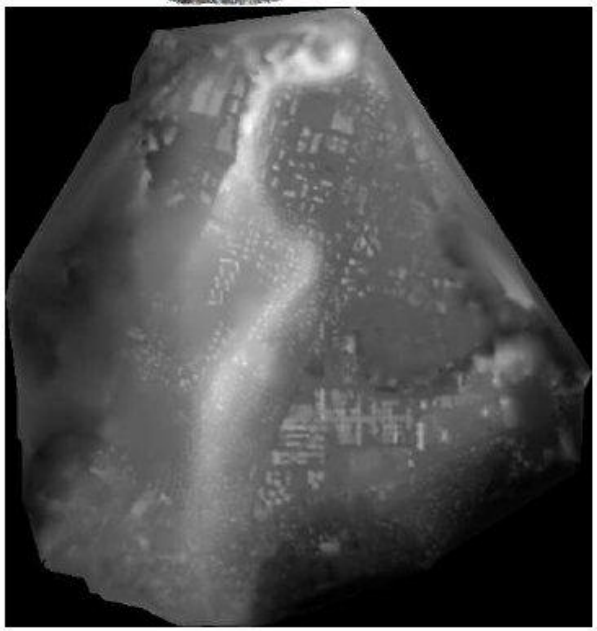
- Show the feasibility of **fully automated** aerial triangulation on UAV data with bad / partially missing GPS and IMU
- Show that these methods can have an **accuracy comparable** to traditional airborn data

number images	ground resolution	flying height	area area	number GCP's
51	33.08cm/pixel	900m	8km^2	13

Accuracy of automatic processing

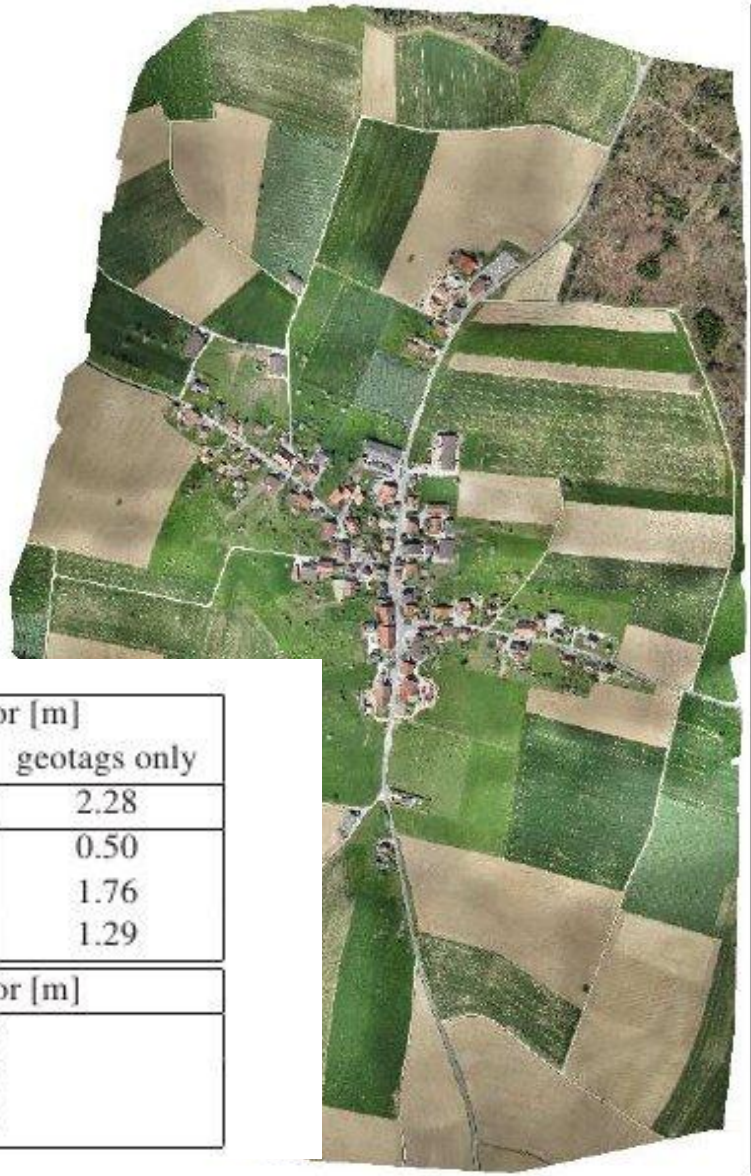
8 square km – 33cm GSD – 1.25m accuracy

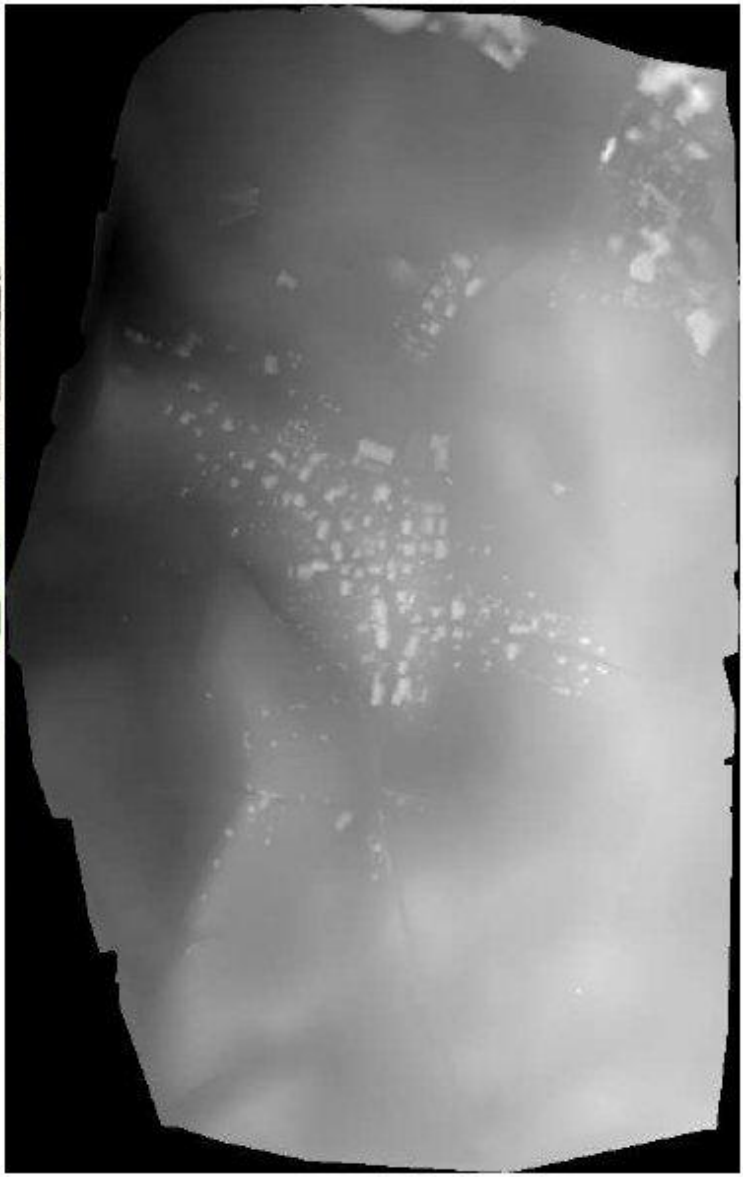
	GCP's error [m]	
	including GCP's	geotags only
σ	1.25	7.84
σ_x	0.37	2.45
σ_y	0.38	4.40
σ_z	1.07	5.42
	geotag error [m]	
σ_x	3.73	
σ_y	7.70	
σ_z	3.80	



number images	ground resolution	flying height	area	number GCP's
526	7.87cm/pixel	262m	2.1km^2	19

2.1 square km
8 cm GSD
0.19 m accuracy



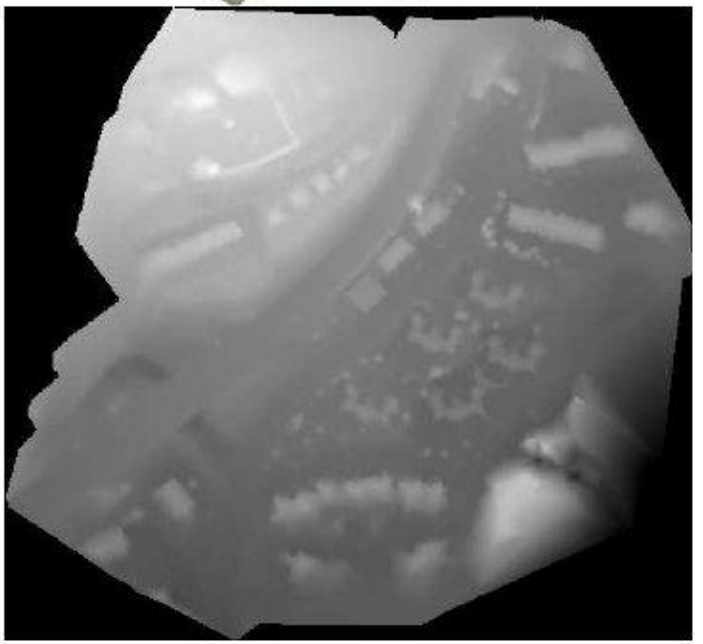


	GCP's error [m]	
	including GCP's	geotags only
σ	0.19	2.28
σ_x	0.130	0.50
σ_y	0.117	1.76
σ_z	0.045	1.29

	geotag error [m]
σ_x	2.73
σ_y	4.75
σ_z	1.99

number images	ground resolution	flying height	area area	number GCP's
73	5.7cm/pixel	130m	0.13km^2	12

0.13 square km – 5.7cm GSD – 0.05m accuracy

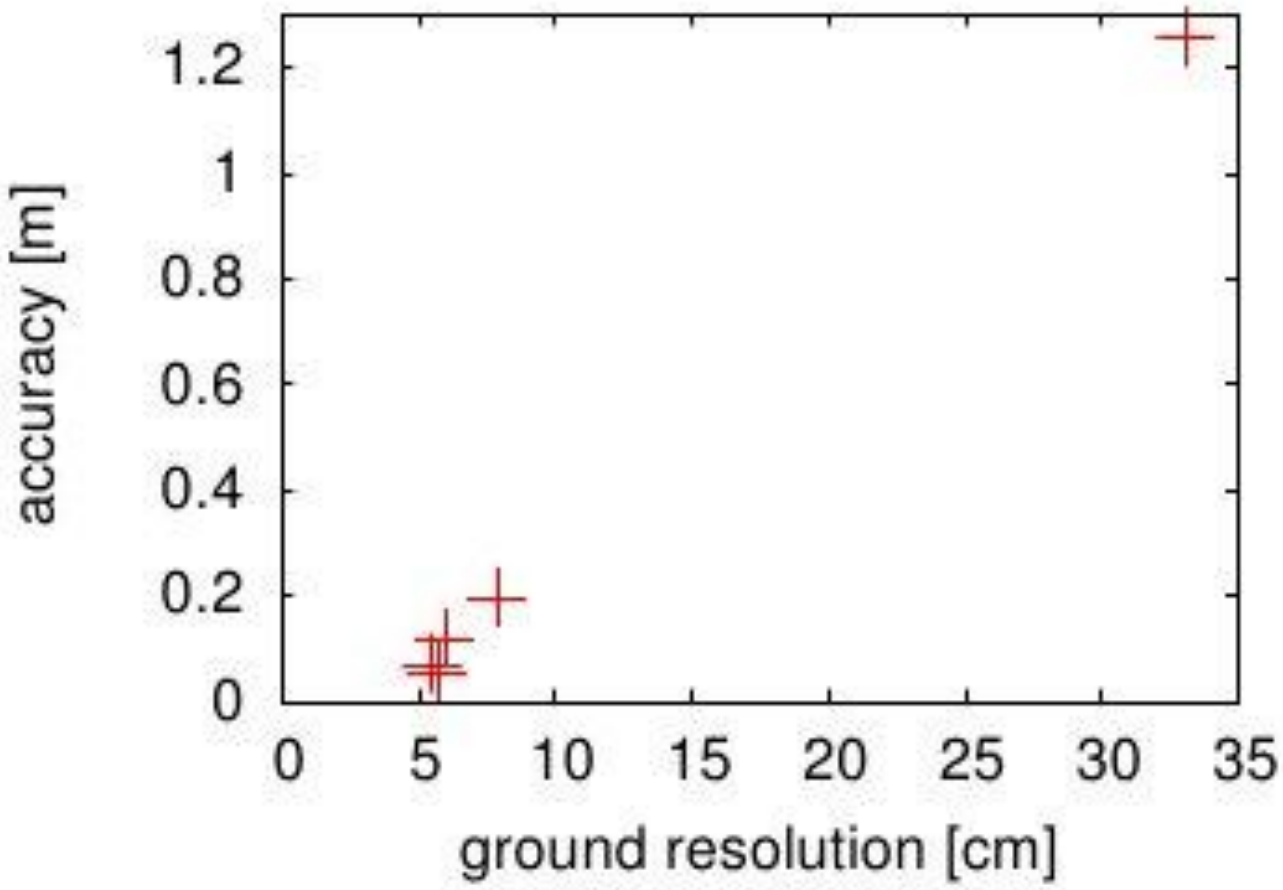


	GCP's error [m]	
	including GCP's	geotags only
σ	0.056	1.97
σ_x	0.028	0.58
σ_y	0.038	0.65
σ_z	0.017	1.76

	geotag error [m]
σ_x	1.84
σ_y	2.00
σ_z	1.65

Accuracy of automatic processing

Fully automatic (one click)
Accuracy 1-3 times the GSD



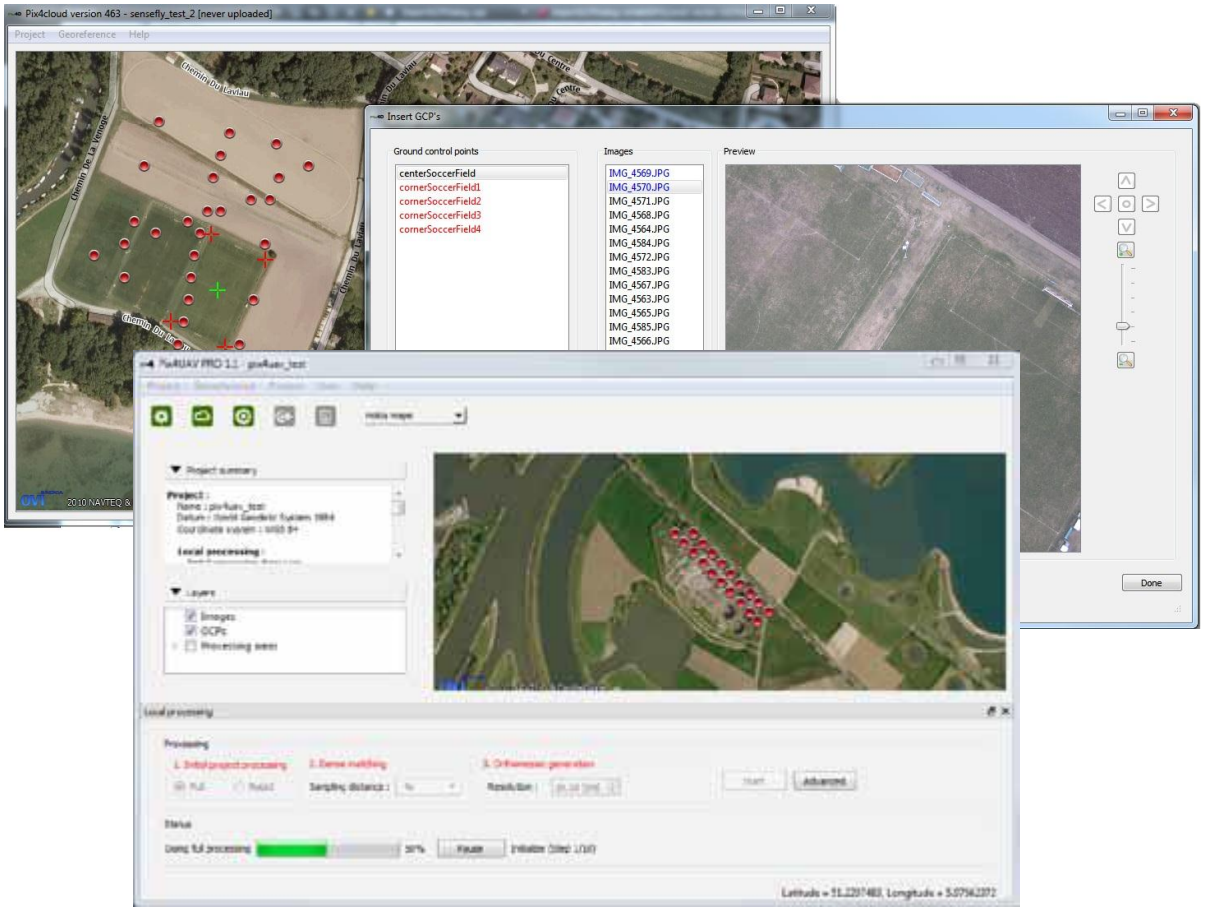
Products

Pix4D

- **Cloud “Pay as you go”**
  - Software as a service

- **Desktop License**
  - Local processing
  - Window / Linux server

Pix4D: Practice



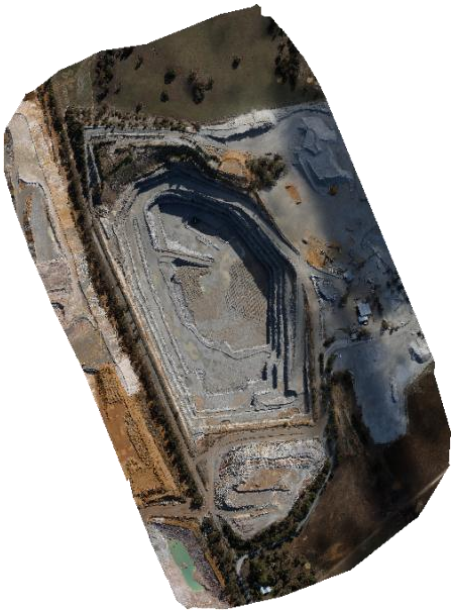
Pix4UAV GUI
With GCP interface

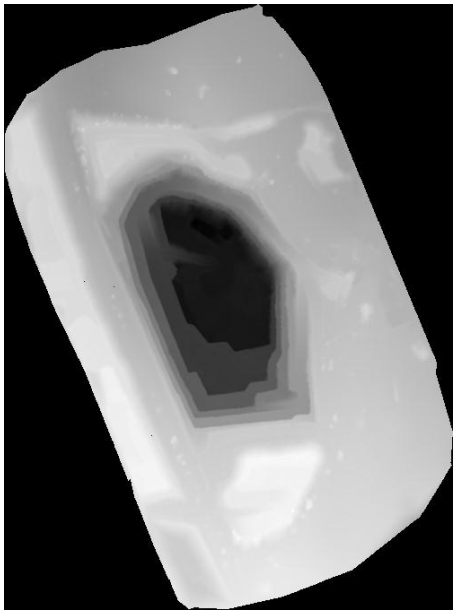
Software allows one click:

local processing
cloud processing

Mining site near Perth Australia

UAV: Gatewing (Belgium)





Gatewing x100 dataset
416 images
11 GCPs

GCP statistics

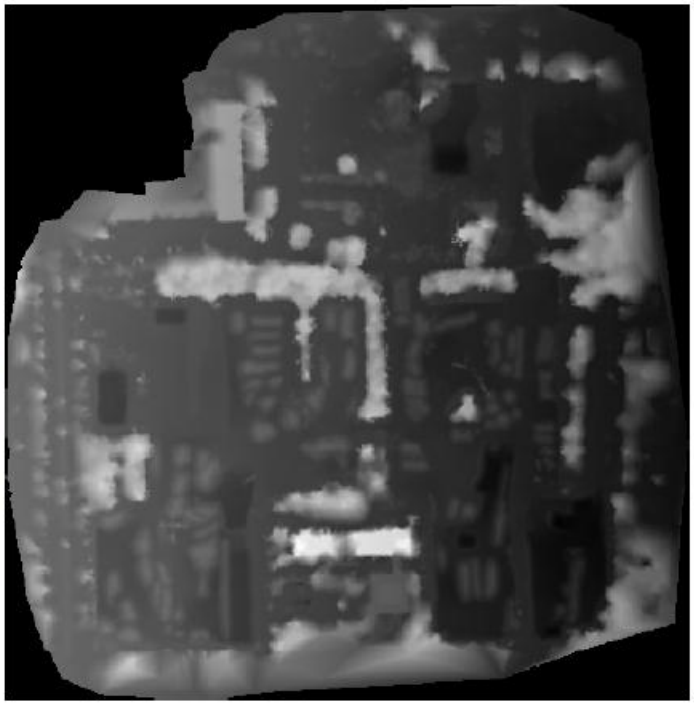
	X[m]	Y[m]	Z[m]
RMS	0.086	0.074	0.053
б	0.040	0.061	0.053

Building site in Munich

UAV: AscTec (Germany)

Falcon 8 dataset
212 images

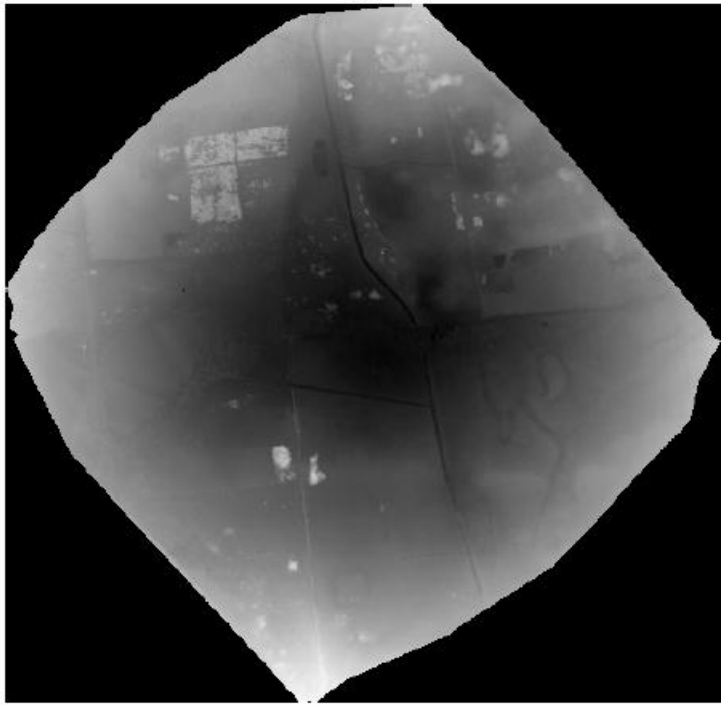
2.5 cm GSD



Building site

UAV: Pteryx (Poland)

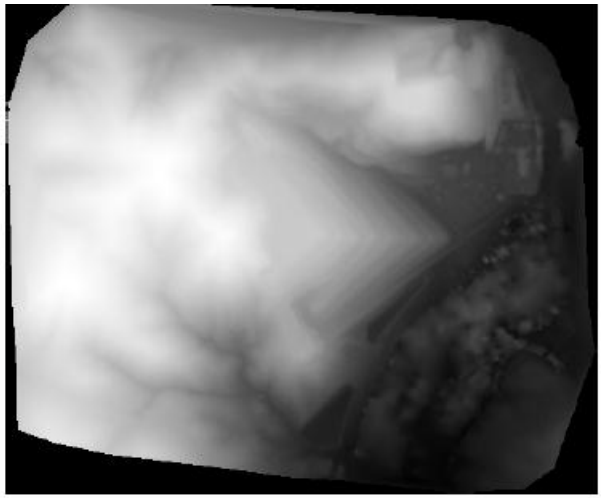
Pteryx dataset
766 images



Building site

UAV: TerraPanLabs (USA)

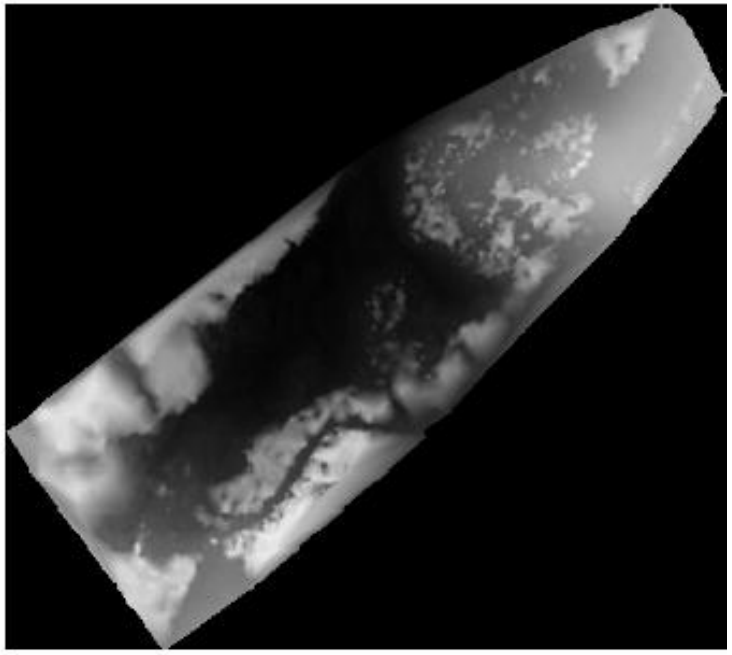
LOUIS dataset
252 images



Forestry

UAV: KAHU HAWK (NewZeeland)

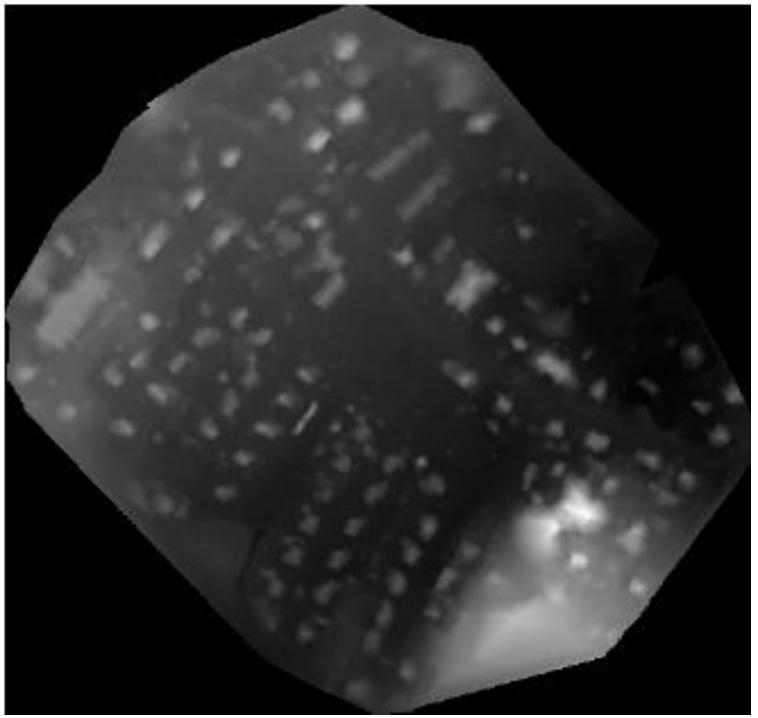
KAHUdataset
131 images



Development

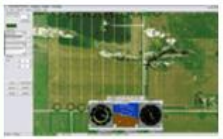
UAV: Smartplanes (Zweden)

SmartOne dataset
100 images



Development

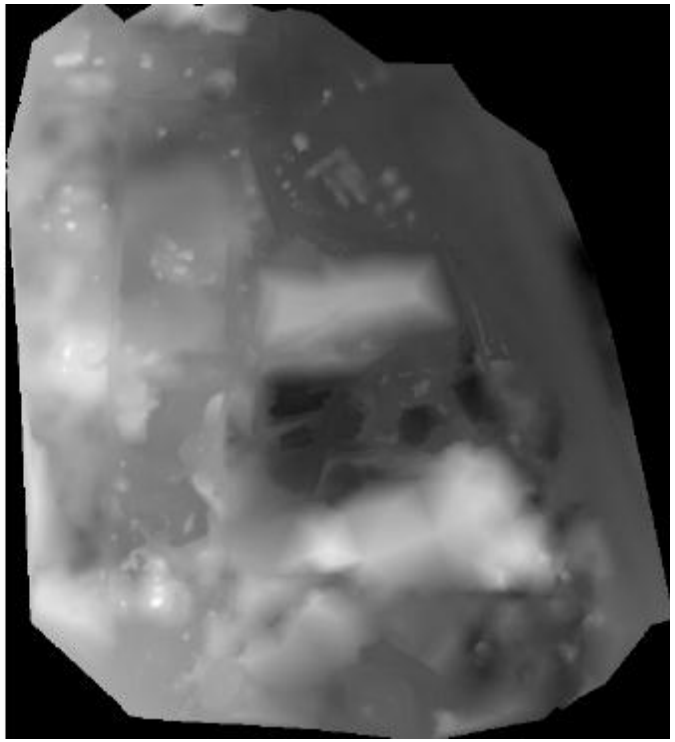
Launch the 6 pound plane and the **powerful autopilot** does the rest



Zoom in on images or use in a **World file**

UAV: CropCam (USA)

CropCam dataset
143 images



Application: Mining

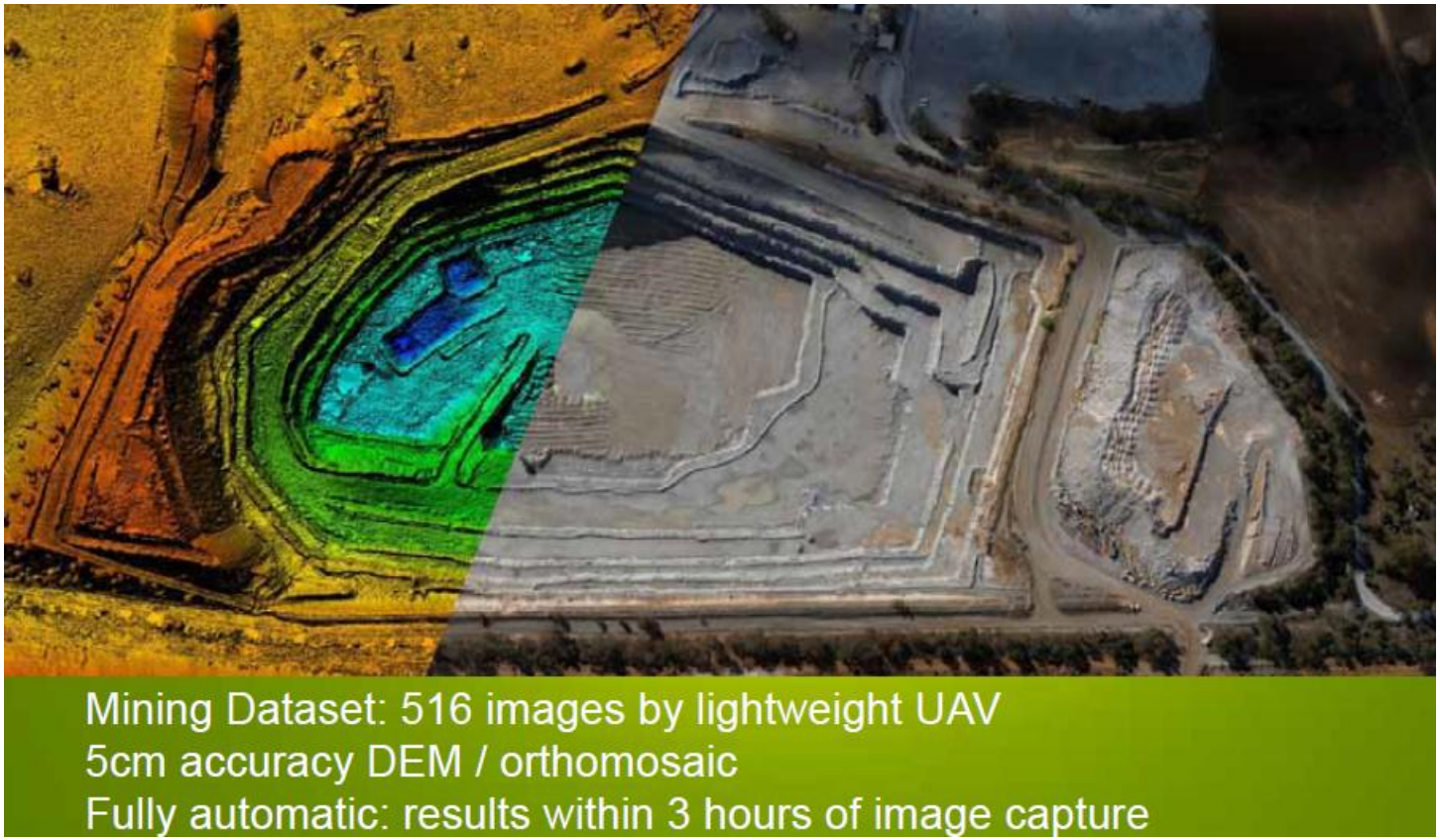
More aerial data is needed

1) Remote operations
2) Safety
3) Environment monitoring

- Local updates are required to “remotely operate” the mine

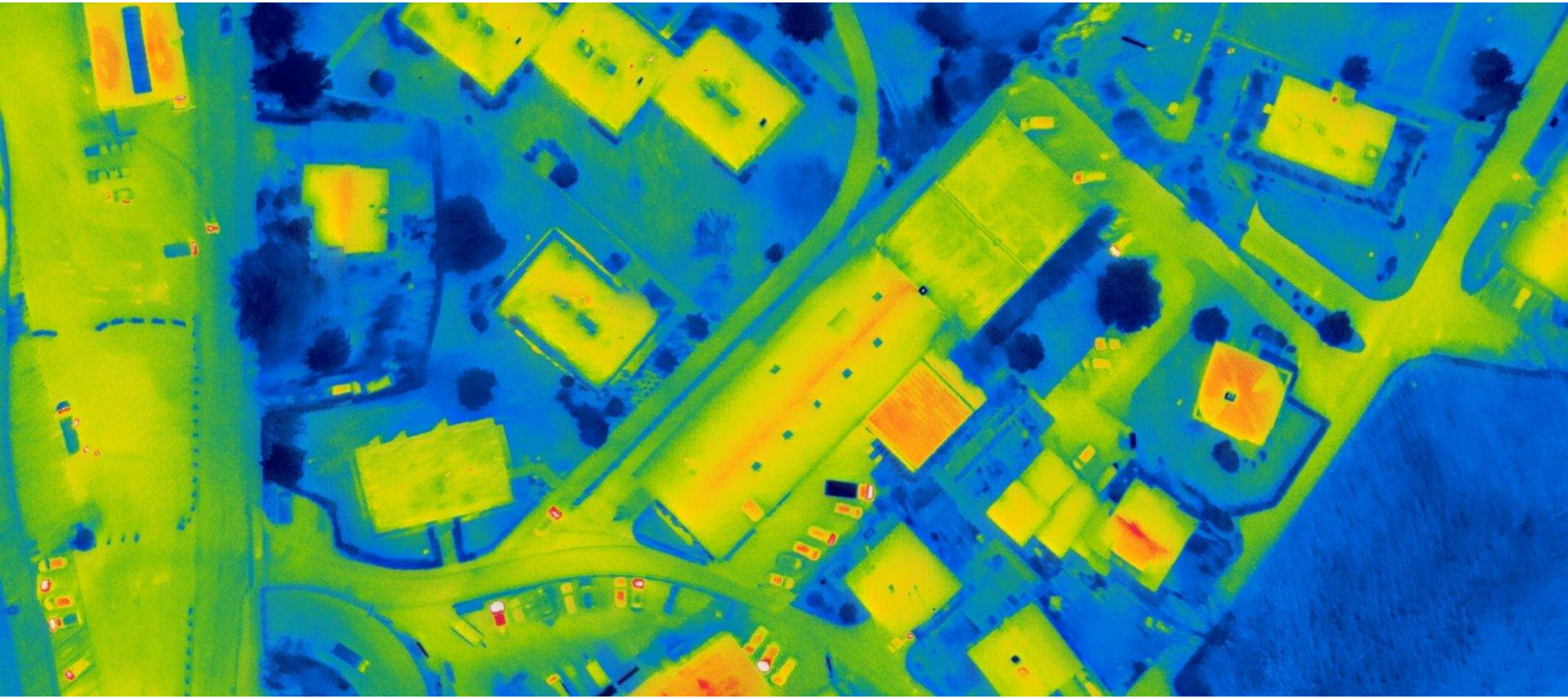
Application: Mining

Pix4D



Example: creek flooding

Application : Thermal imagery

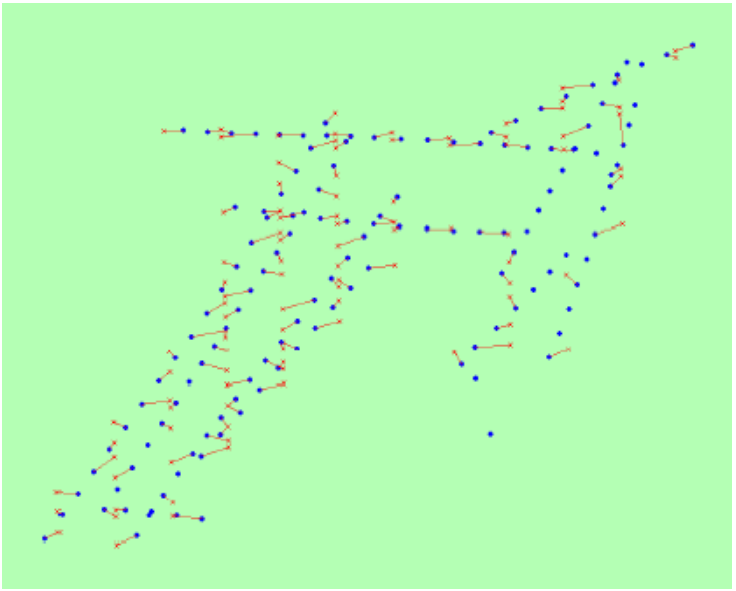


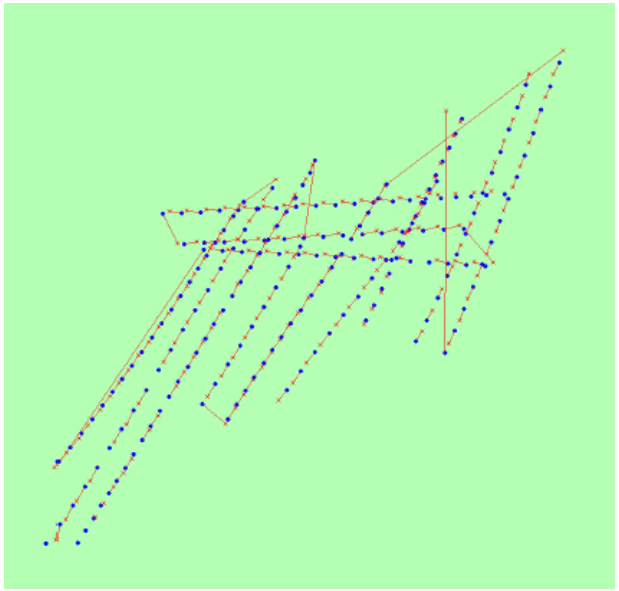
Part of the ortho image
200 images at 640x480 pixel

Integrating RGB-NIR

Two UAV flights of the same area:

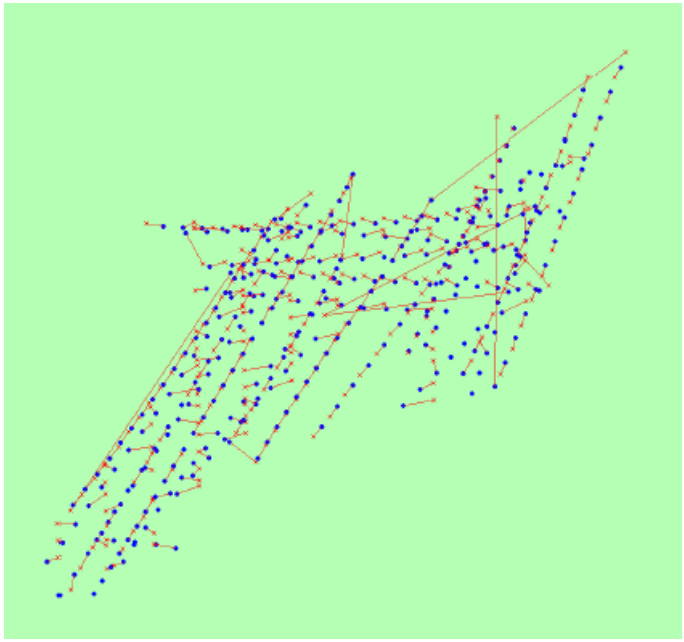
RGB sensor **NIR sensor**

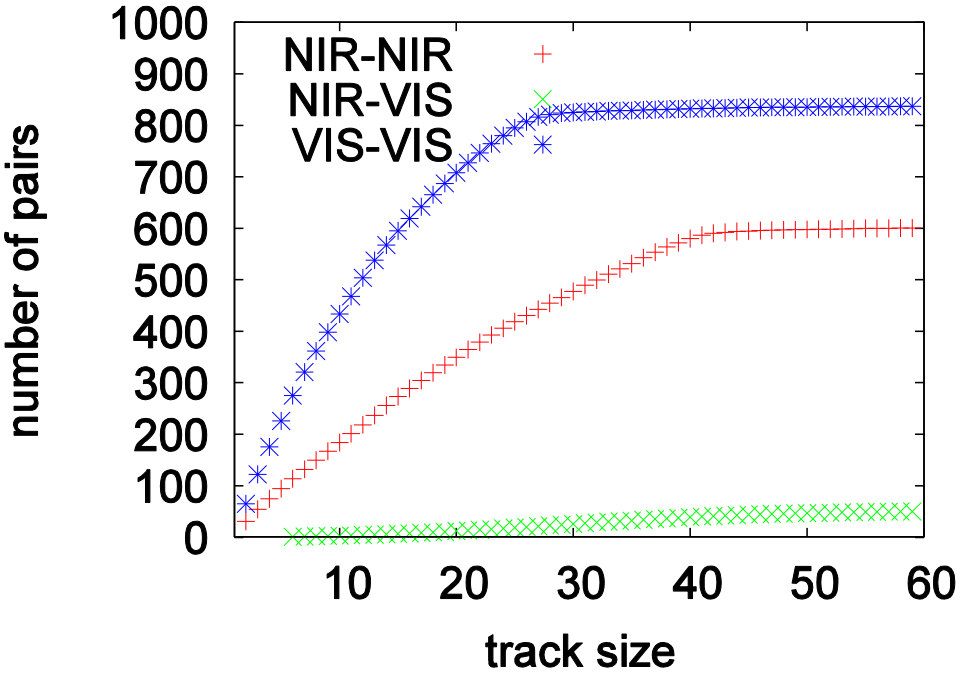




Integrating RGB-NIR

Pix4D

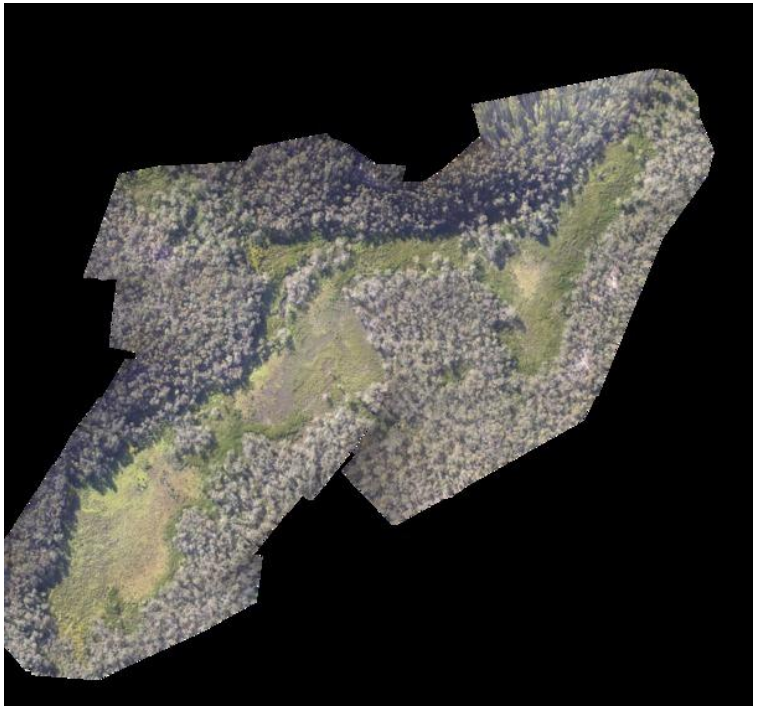


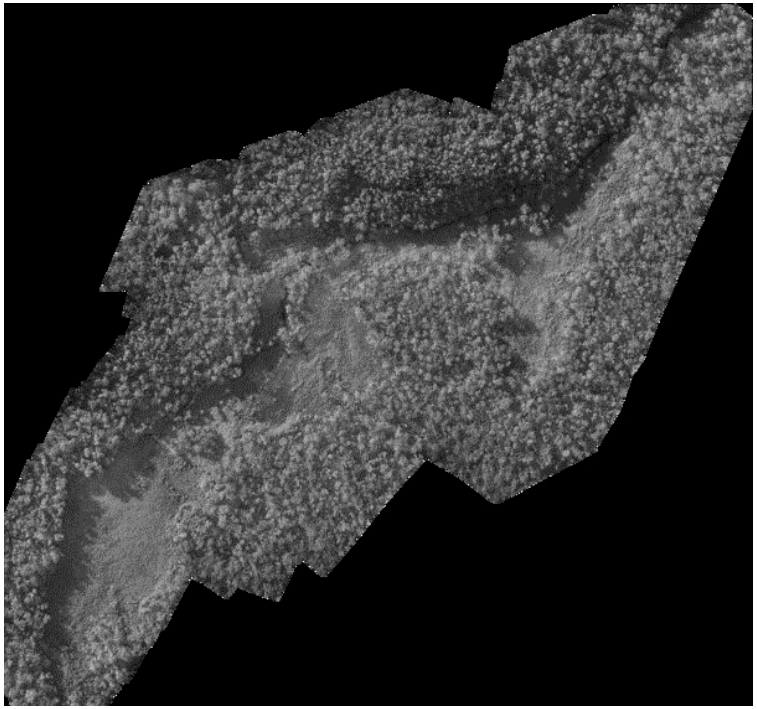


All images:
RGB and NIR

Matches between / within modalities

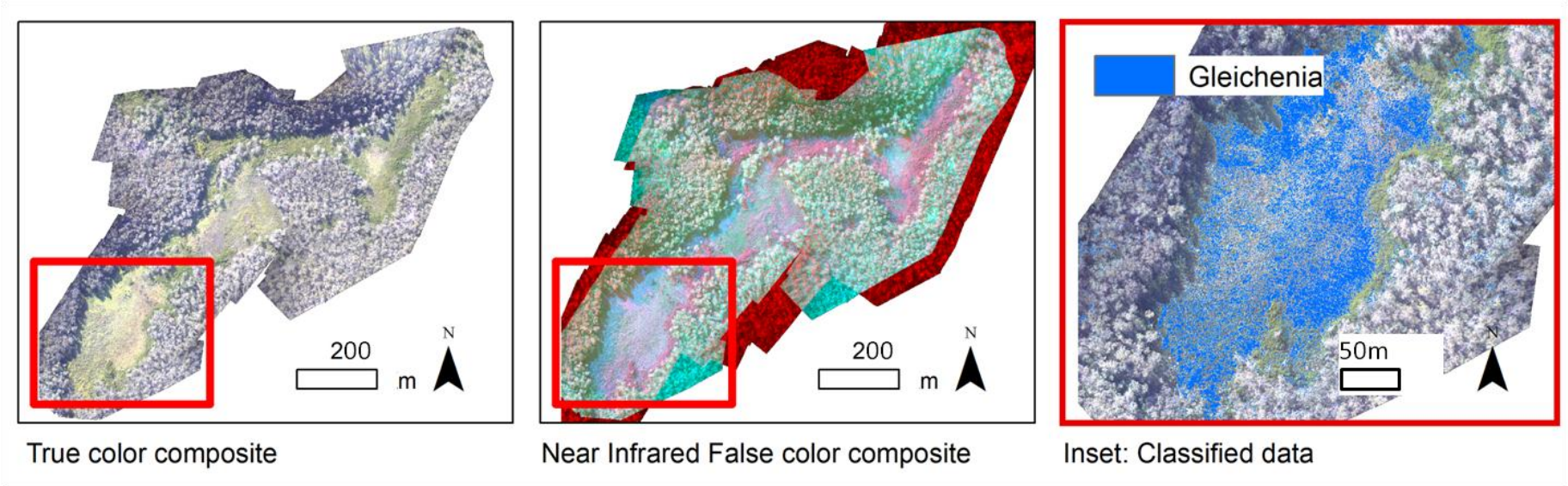
Integrating RGB-NIR





RGB and NIR in the same coordinate system
Possible to create a 4-band image from two flights without GCP's and precise GPS!

Integrating RGB-NIR



True color composite

Near Infrared False color composite

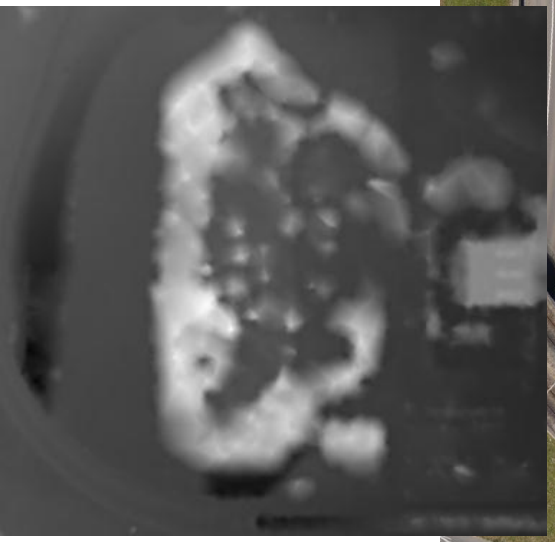
Inset: Classified data

Detection of Gleichenia in the combined RGB-NIR image

together with Andrew Fletcher and Alex Lechner (University of Queensland)

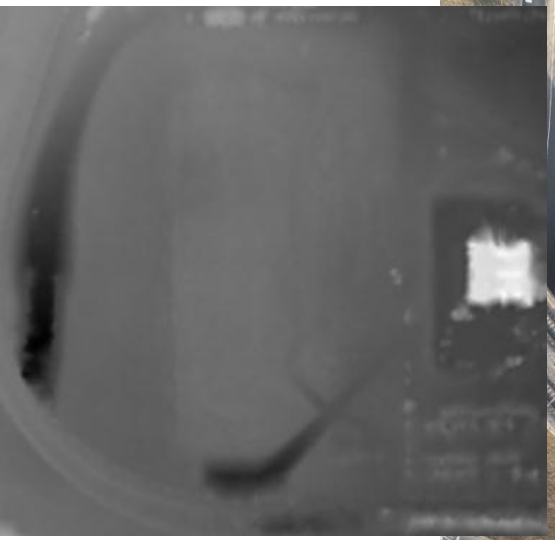
EPFL
Congress
center

Summer 2010



EPFL
Congress
center

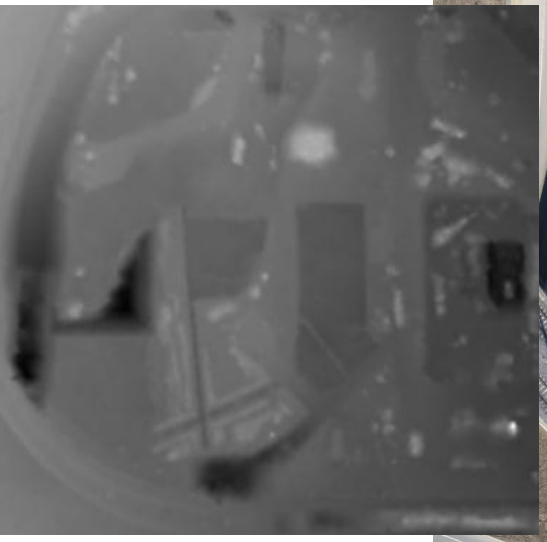
Jan. 2011



EPFL
Congress
center

EPFL
Congress
Center

Orthoimage
DSM



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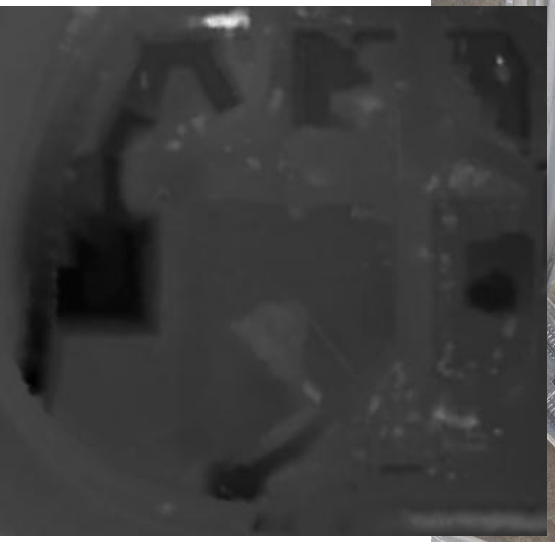

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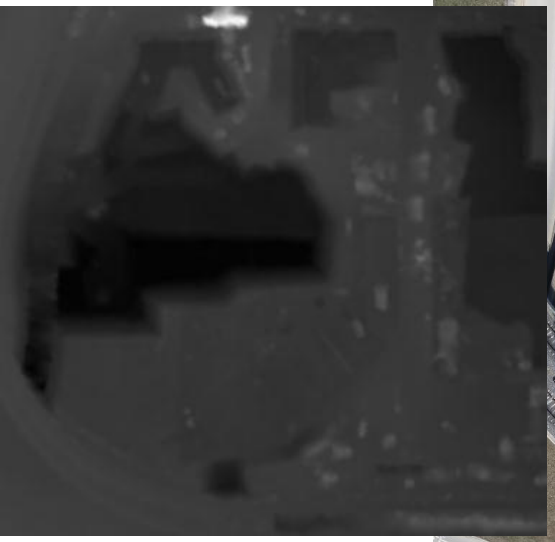

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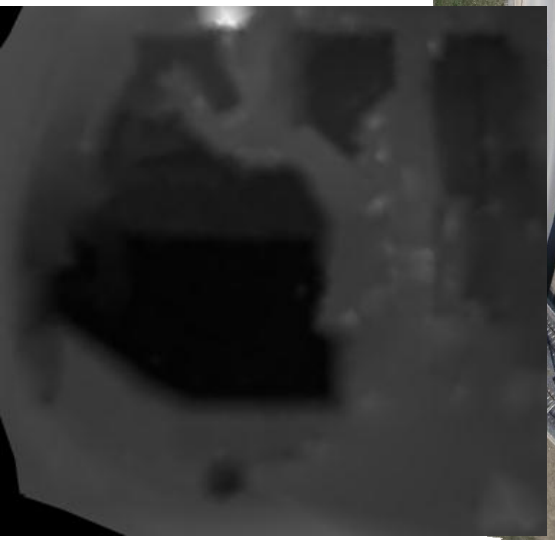

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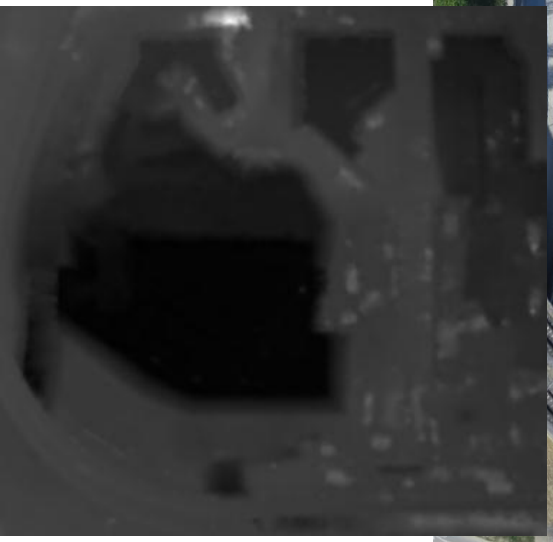
Congress
center

Apr. 2011



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