The Potential of Unmanned Aerial Vehicles for Mapping

Henri Eisenbeiss September 6, 2011

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ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich
geomETH

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- Introduction
- UAV-Systems
- Case studies
- Conclusions and Future activities

What is a UAV?

UAVs: Unmanned Aerial Vehicles

"UAVs are to be understood as uninhabited and reusable motorized aerial vehicles" (Blyenburg, 1999). These vehicles are remotely controlled, semi-autonomous, autonomous, or have a combination of these capabilities.

Main communities

Military, Artificial Intelligence, Computer Vision, Robotics, Aeronautics, …

Geomatics (Photogrammetry, Remote Sensing and Surveying)

UAV Photogrammetry

UAV photogrammetry opens various new applications in the close range domain, combining aerial and terrestrial photogrammetry, but also introduces low-cost alternatives to the classical manned aerial photogrammtery.

In the context of mapping

- Geospatial data collection with high geometric and temporal resolution (large scale data)
- Generation of elevation models, orthophotos, maps, 3D models etc.

Introduction - *Motivation for the use of UAVs*

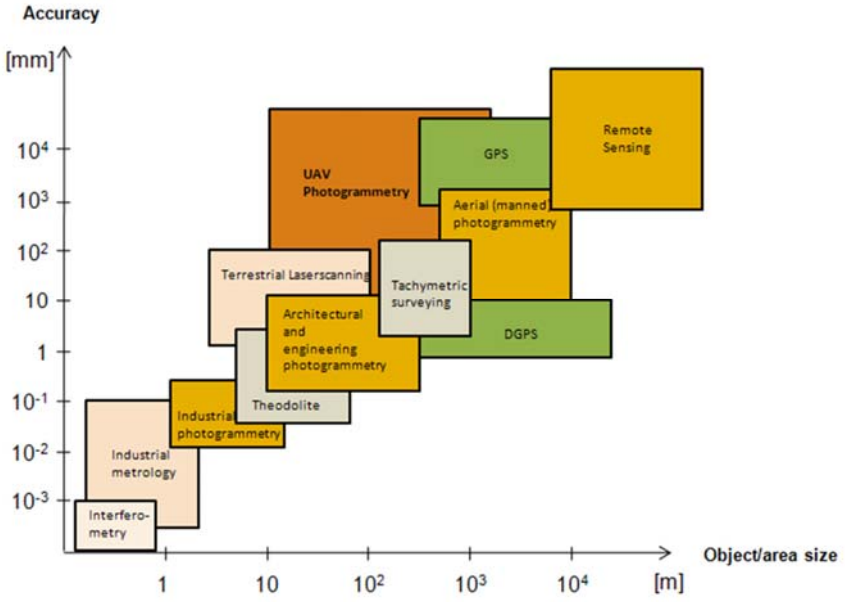
Advantages of UAVs

- Use in high risk situations and inaccessible areas
- Data acquisition with high temporal and spatial resolution
- Autonomous and stabilized
- Low-cost

Limitations in the use of UAVs

- Limitations of the payload
- Regulations and insurance
- Use of Low-cost Sensors

Introduction - *Motivation for the use of mini UAVs*



The accuracy of measurement methods in relation to the object/area size. Modified from Fig. 1.4 in Luhmann, et al., 2006.

UAV Systems – *Applied at IGP, ETH Zurich*

Mikrokopter

(Open Source Projekt)

Falcon 8, Astec

(Student projects)

Scout B1-100, Aeroscout

(Tests with Riegl Laserscanner)

MD4-200, Microdrones

(Bhutan (3000m)
and Jungfraujoch (3500m))

Copter 1B, Surveycopter

(Peru, Honduras,
student projects)

NEO S-300, Swiss-UAV

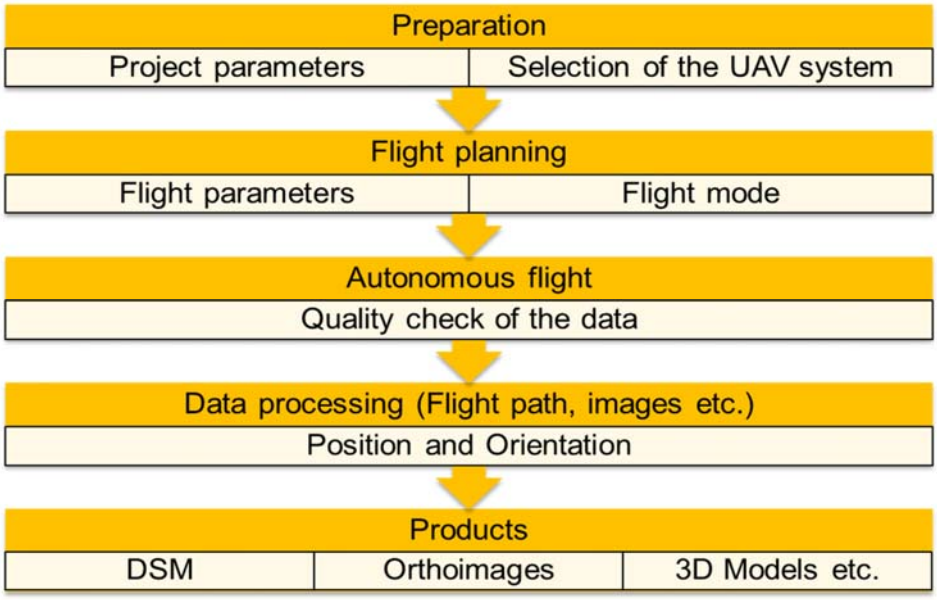
(First tests 2010)

UAV Systems

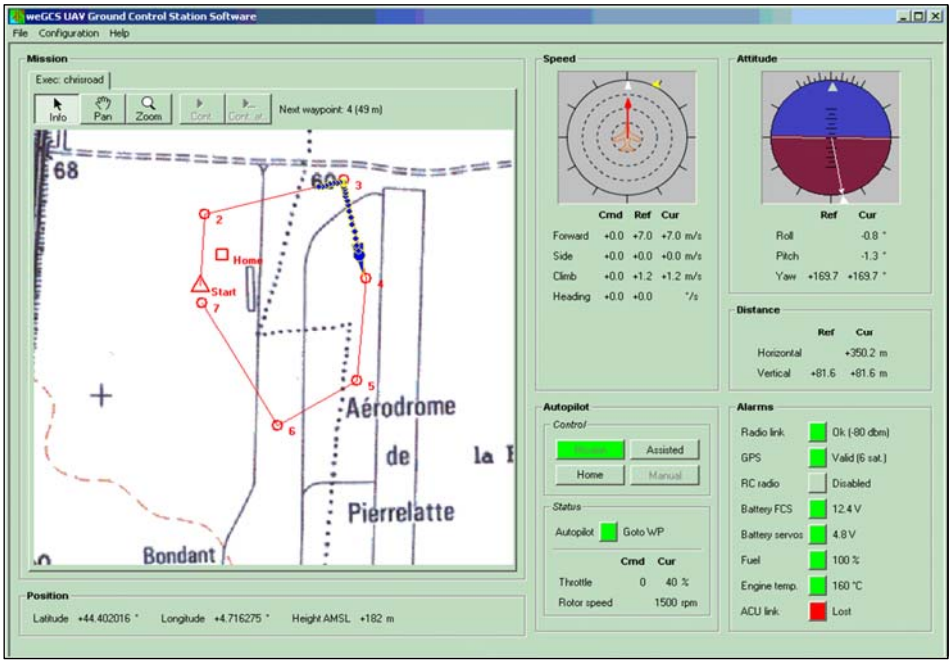
Type of aircraft	Range	Endurance	Weather and wind dependency	Maneuverability	Payload capacity
Balloon	0	++	0	0	+
Airship	++	++	0	+	++
Gliders/Kites	+	0	0	0	0
Fixed wing gliders	++	+	+	+	+
Propeller & Jet engines	++	++	+	+	++
Rotor-kite	++	+	0	+	+
Single rotor (helicopter)	+	+	+	++	+
Coaxial	+	++	+	++	++
Quadrotors	0	0	0	++	0
Multi-copters	+	+	+	++	+

Pro and cons of the different types of UAVs (0: Lowest value; +: Middle value; ++: Best).

Workflow – *Overview*



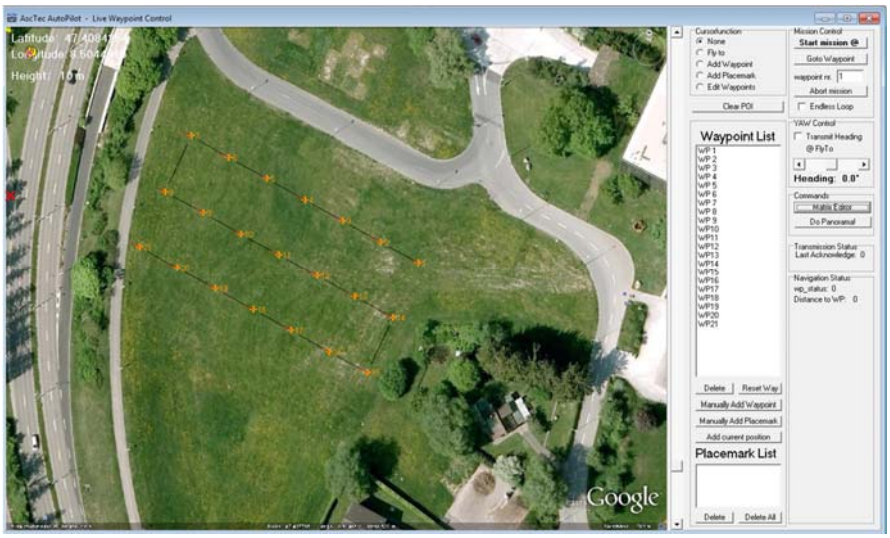
UAV Systems – *Flight control*



UAV Systems – *Falcon 8 (Astec)*

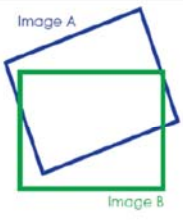
Remote Control Futaba FX-30

Falcon 8



Astec Autopilot

Bhutan – *Processing*

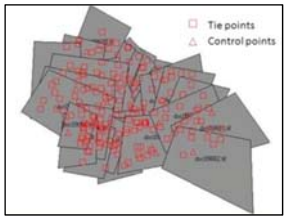
Criterion	*Appropriate picture(s)*	*Inappropriate picture(s)*
Image sharpness		
Orientation		
Overlapping area		

Left: Appropriate image acquisition in the cruising mode.

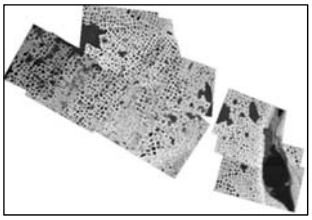
Right: Problems resulting from stop mode.

Workflow – *UAV flight: autonomous vs. manual*

- Typical block configuration for manually controlled flights:

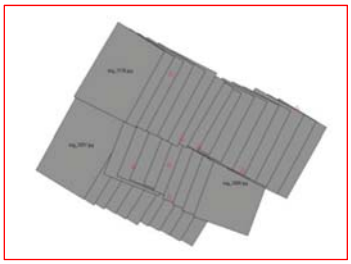


Motorized kite Susi over a forestry area.

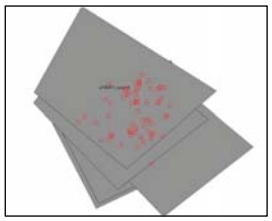


Zeppelin over Samoilov Island (Russia).

- and for autonomous flights:



IGP model helicopter over Campus Hoenggerberg.

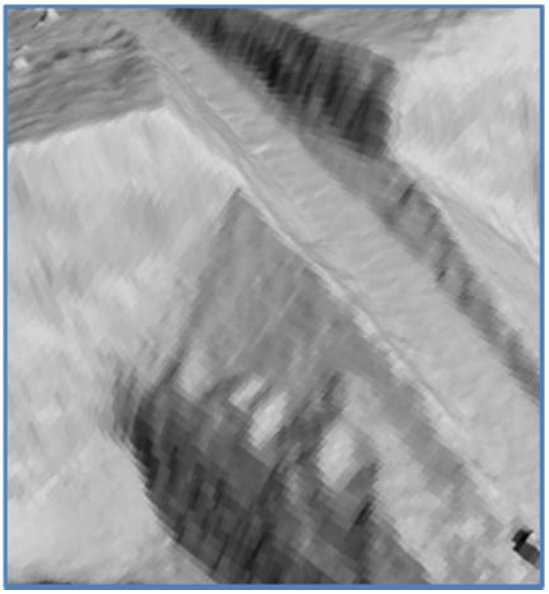


Quadrocopter, gravel pit.

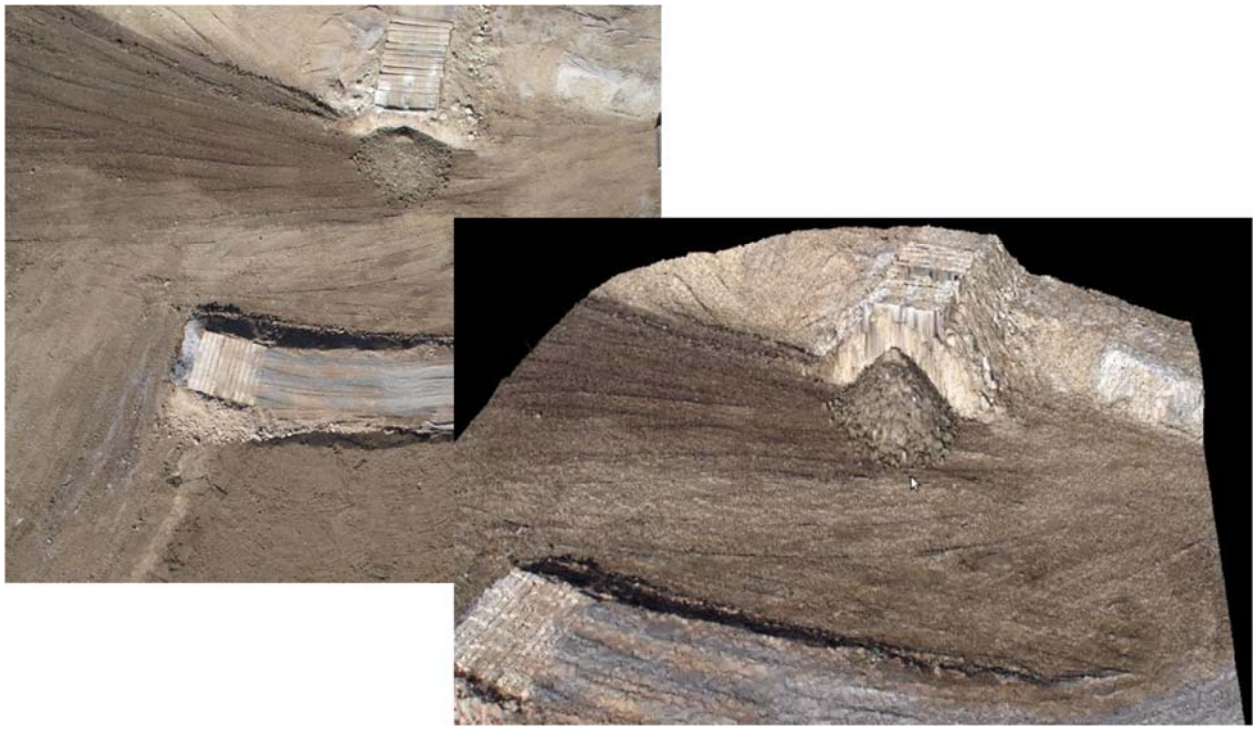
Gravel pit

Gravel pit Loetscher@Ballwil

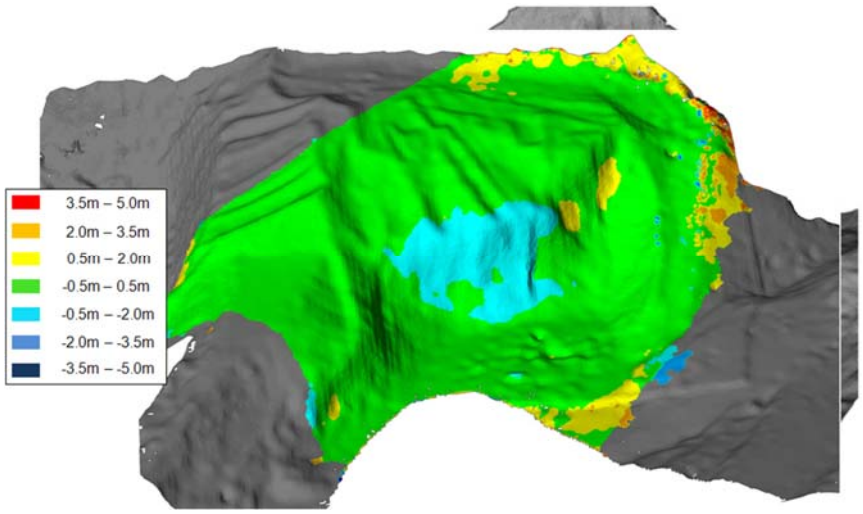
Gravel pit – *Results*



Gravel pit – *Results*



Gravel pit – *DSM results*



Cadastre application

Cadastre application – *Topics of investigation*

- Evaluation of UAV-systems for the use in cadastral surveying
- Comparison between tachymeter and UAV
  - Accuracy
  - Feasibility
  - Time for data acquisition and processing (Costs)
- Can we use the UAV technology as a standard method for cadastral surveying?

Cadastre application – *Test sides*

Left: Krattigen (Bern); Right: HXE Campus Science City, Hoenggerberg (Zurich).

Cadastre application – *Flight planning & UAV flight*

Krattigen

Data acquisition Krattigen

HXE Campus Science City

Cadastre application – *Orientation results*

Flight	Height	σ_0	RMSE of GCP			RMSE of image observation	
		[Pixel]	X [m]	Y [m]	Z [m]	x [Pixel]	y [Pixel]
Krattigen	40 m	0.85	0.01	0.01	0.01	0.51	0.76
HXE	60 m	0.69	0.01	0.02	0.01	0.24	0.25

Orientation values of the images taken from the Falcon 8 system.

Image orientation Krattigen

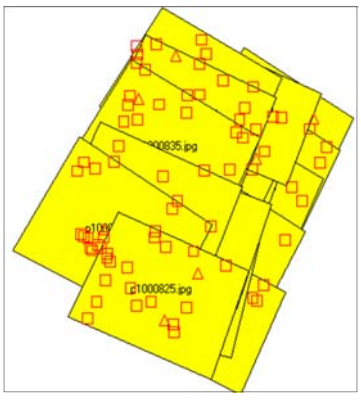
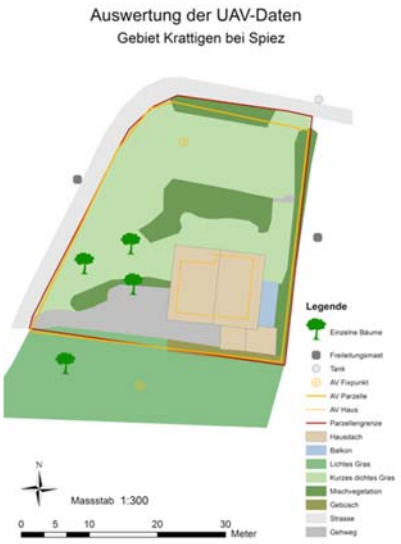


Image orientation HXE

Cadastre application *–Results*



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Cadastre application *–Results*

Conclusion and Future work

- Low-cost UAV systems
  - Easily controllable
  - Fast overview of the area of interest
  - Practicable for projects with less accuracy requirements
  - Usable for teaching
- UAVs for accurate 3D measurements
  - Stabilized systems
  - 3D trajectory can be generated with high accuracy using D-GNSS and IMUs (high precision), GCPS or combination of both
  - Integration of various sensors for data acquisition, such as metric cameras, thermal cameras, laser scanner, range cameras …

Future work – *hot topics*

- UAV and new sensors (e.g. range imaging)
- Orientation of UAVs with d-GNSS
- Automated and real time data processing (images, point clouds etc.)
- Sensor fusion (combination laser scanning and images)
- Thermal images
  - Detection of animals, fire spots
  - Analysis of springs after a rain event
  - Thermography of buildings
- UAV swarms
- …

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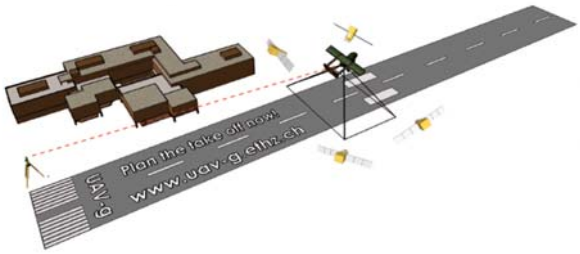
UAV-g 2011
unmanned aerial vehicle in geomatics

International Conference on Unmanned Aerial Vehicle in Geomatics

September 14 - 16, 2011
www.uav-g.ethz.ch

Registration open till September 7 (Tomorrow)



Campus Science City ETH Zurich, Switzerland

Thank you for your attention !