CAA NL/DE Meeting Münster 2010

Behind the scenes: New developments in archaeological remote sensing and geophysics

UAVs and remote sensing – early results of a geodetic approach

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Outline

- Motivation
- Legal matters
- MikroKopter MK-Okto
- Data recording and Data processing
- Examples
- Future works and Outlook

Basis of facts in presentation

- Students projects
- Bachelor thesis
- Master thesis
- Applications in running projects

Background

- i3mainz - Institute for Spatial Information and Surveying Technology at Mainz University of Applied Sciences
- Römisch-Germanisches Zentralmuseum Mainz (RGZM), archaeological Research Institute
- Junior Research Group: Archaeogeophysics at Mainz University, Earth System Research Centre

Background

- Intended applications:
  - Surveying
  - Documentation
  - Archaeological applications
    - mapping of the topographical setting of archaeological sites
    - supporting documentation in excavation trenches
    - architectural survey

Motivation

- High information content of images
- Experiences in photogrammetry
- Shooting positions between a few meters and a few hundred meters are problematic
- Improvements in data processing
- Improvements in flight control – gyroscops and acceleration sensor in cheap systems
- Alternative / supplement for 3D-scanning and other surveying for selected projects

System selction

- Alternatives:
  - kopter, kites, zeppelin, model airplane, ballons ...
- Pros for a (mikro-)kopter:
  - Steering
  - (semi-)autonomic flying to waypoints
  - costs
- Other pojects:
  - http://www.photogrammetry.ethz.ch/research/heli/index.html
  - http://www.ithaca.polito.it/pubs/21.pdf

Legal Matters

- No or different legal regulations in many countries
  - Frequencies for remote control and data telemetry
- Changes in Germany in 2010:
  - System with camera is not just a model, but a UAV
  - Federal Law: Luftverkehrsgesetz plus regulations by the federal states
  - Permission is required

→ **Necessity to inform yourself of regulations**

MikroKopter MK-Okto

- Low-cost system
- Assembly sets available
- Community and forum
- Variety of models (4, 6, 8 rotors)
- Big number of extensions
  - GPS, camera control, ...

i3mainz MikroKopter model

- Frame and landing skit
- 8 brush-less motors, propellers and controller
- Flight Control using gyroscope, acceleration sensors, air pressure sensor, signal transmitter, interfaces
- Navi Control with magnetic compass and GPS modul

i3mainz MikroKopter model

- Camera holder (controllable angle of pitch)
- Digital camera (Canon IXUS 100 IS)
- Spektrum DX7 (remote control)
- Bluetooth module F2M03GXA
- A/V nano transmitter

- Costs: app. 3000,- €

i3mainz MikroKopter model

- Parameters / Data
  - Diameter: 1 m
  - Empty weight: 1.2 kg
  - Weight ready to fly: 2 kg (incl. camera)
  - Max. weight: 3 kg
  - Flight time 8 – 20 min. (dependant on load)
  - Power supply: Lithium-Polymer-Akku (5000 mAh, 14,8 V)

MikroKopter model at i3mainz

MikroKopter model at i3mainz

MikroKopter model at i3mainz

MikroKopter model at i3mainz

2 litres of water are too heavy for controlled flight

Data recording

- Tool for flight planning
  - Area definition
  - Set overlaps
- Camera control via “Canon Hack Development Kit” (CHDK)
  - Taking images in fixed interval, not on request
- UAV flies GPS controlled or remote controlled
- Maximal time of flight: app. 15 min
- Live camera image to PC for interactive control

Data processing

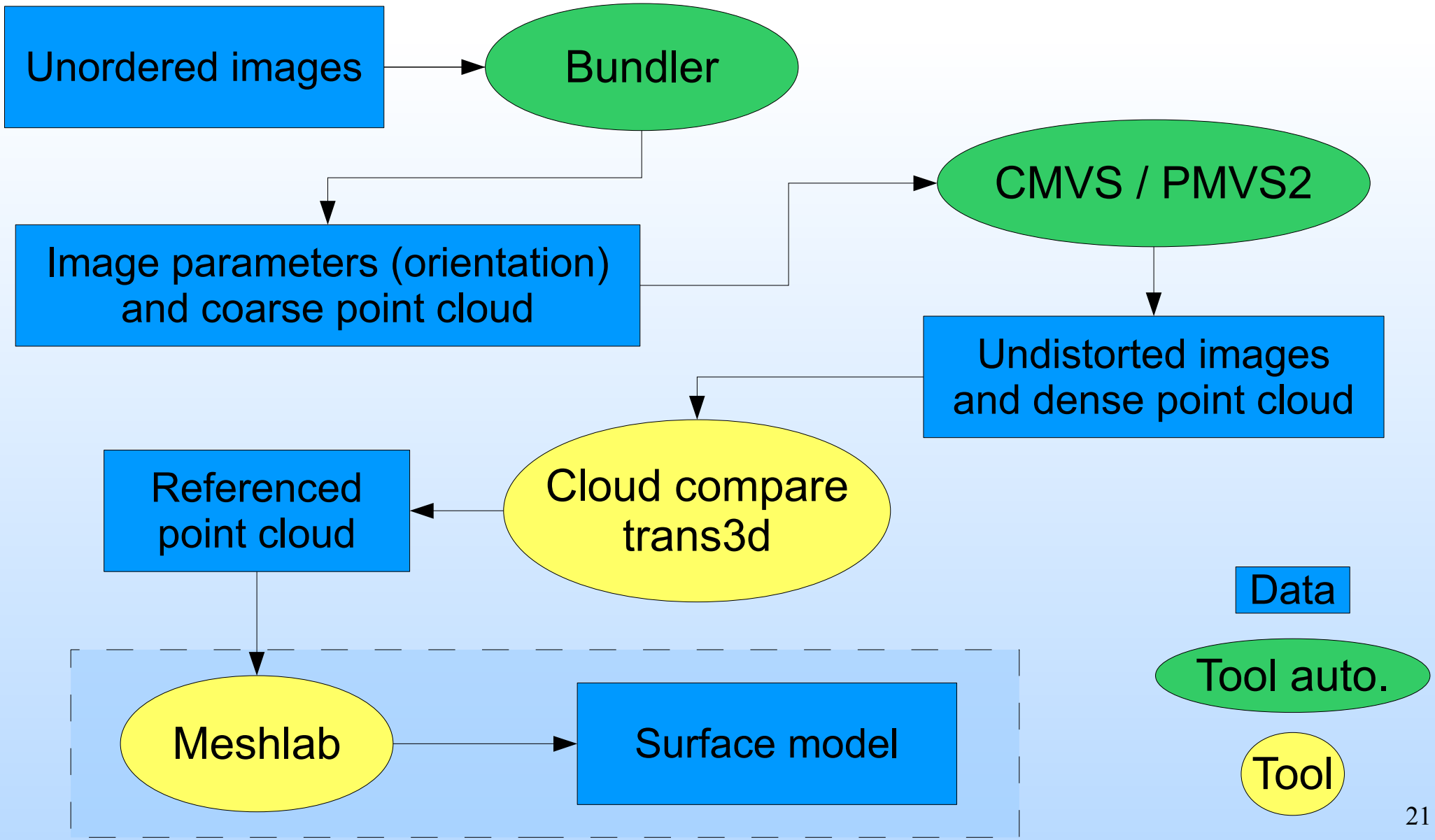
- "Classical" photogrammetric approach
  - Calibrated camera
  - Stereo models
  - Detailed study at: H. Bankel, T. Strellen, Luftphotogrammetrische Vermessung der römischen Stadt Minturnae mit einer GPS-gesteuerten Drohne, in: Von Handaufmaß bis High Tech III, 3D in der historischen Bauforschung, Kolloquium Cottbus 2010

Data processing

- Multi view stereo image processing, reconstructs 3D structure of an object or a scene visible in the images
  - MS Photosynth, ARC 3D webservice , Bundler / PMVS2, AgiSoft PhotoScan
  - Accuracy and reliability from redundancy
  - limited user interaction needed

- Used in the examples presented

Data processing with Bundler / PMVS2



Examples of Applications at i3mainz

- Survey of a dumping ground
- Documentation of an archaeological trench
- Recording of a parking area for accuracy testing

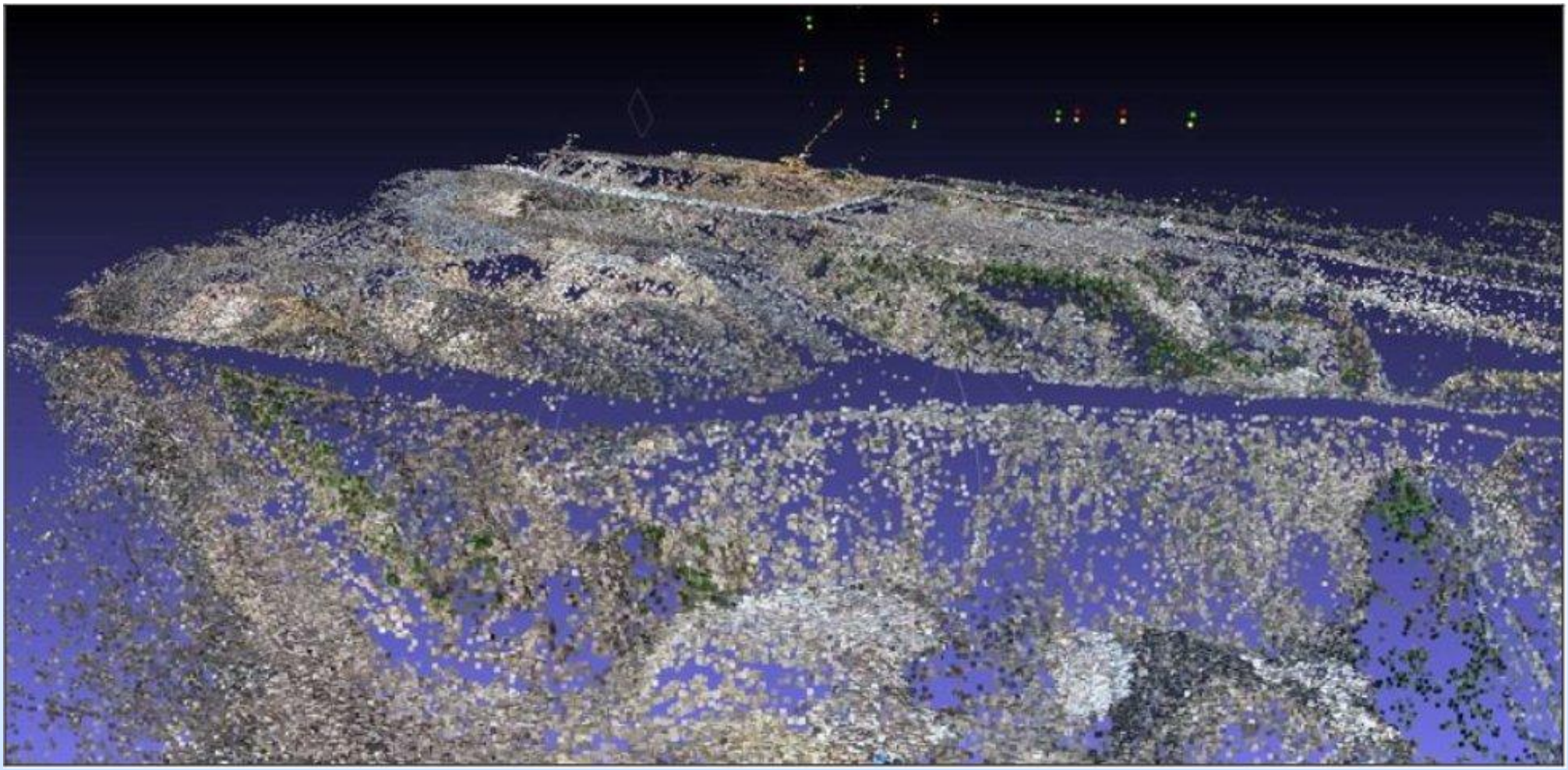
Survey of a dumping ground

- Purpose: DEM generation
- Area: 25.000 m²
- Number of images:
  - 300 processed, 600 recorded
- Data processing:
  - Bundler / PMVS2, georeferencing, DEM generation
- Result: Elevation model

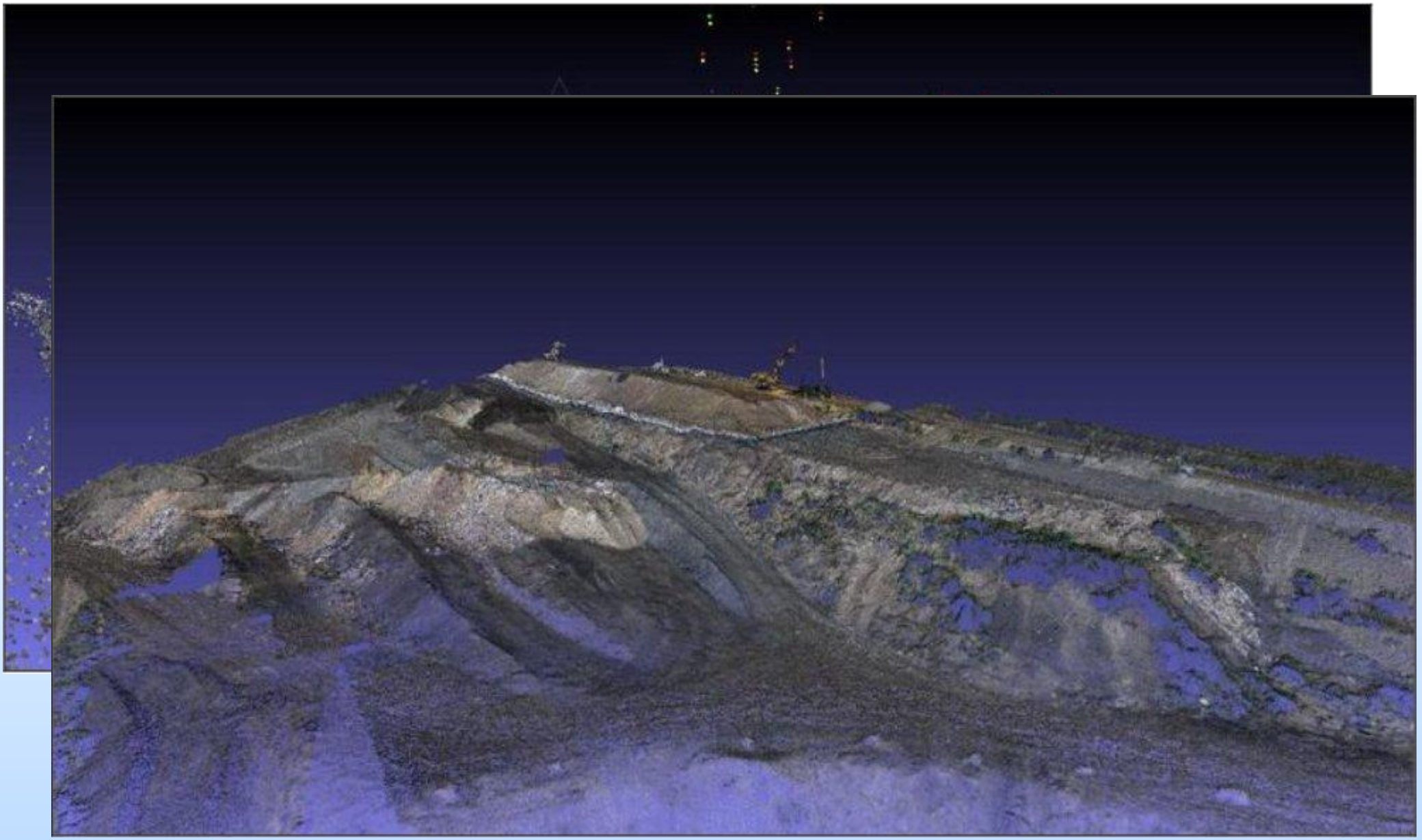
- From: J.-P. Dasbach, Einsatz von low-cost Unmanned Aerial Vehicles (UAV) bei der Vermessung von Tagebau- oder Deponiegebieten. Bachelorarbeit Studiengang Geoinformatik und Vermessung der Fachhochschule Mainz B 0052, 2010 (Betreuer: Klonowoksi, J.; Neitzel, F.)

Area to record (in blue) together with waypoints (from flight planning tool)

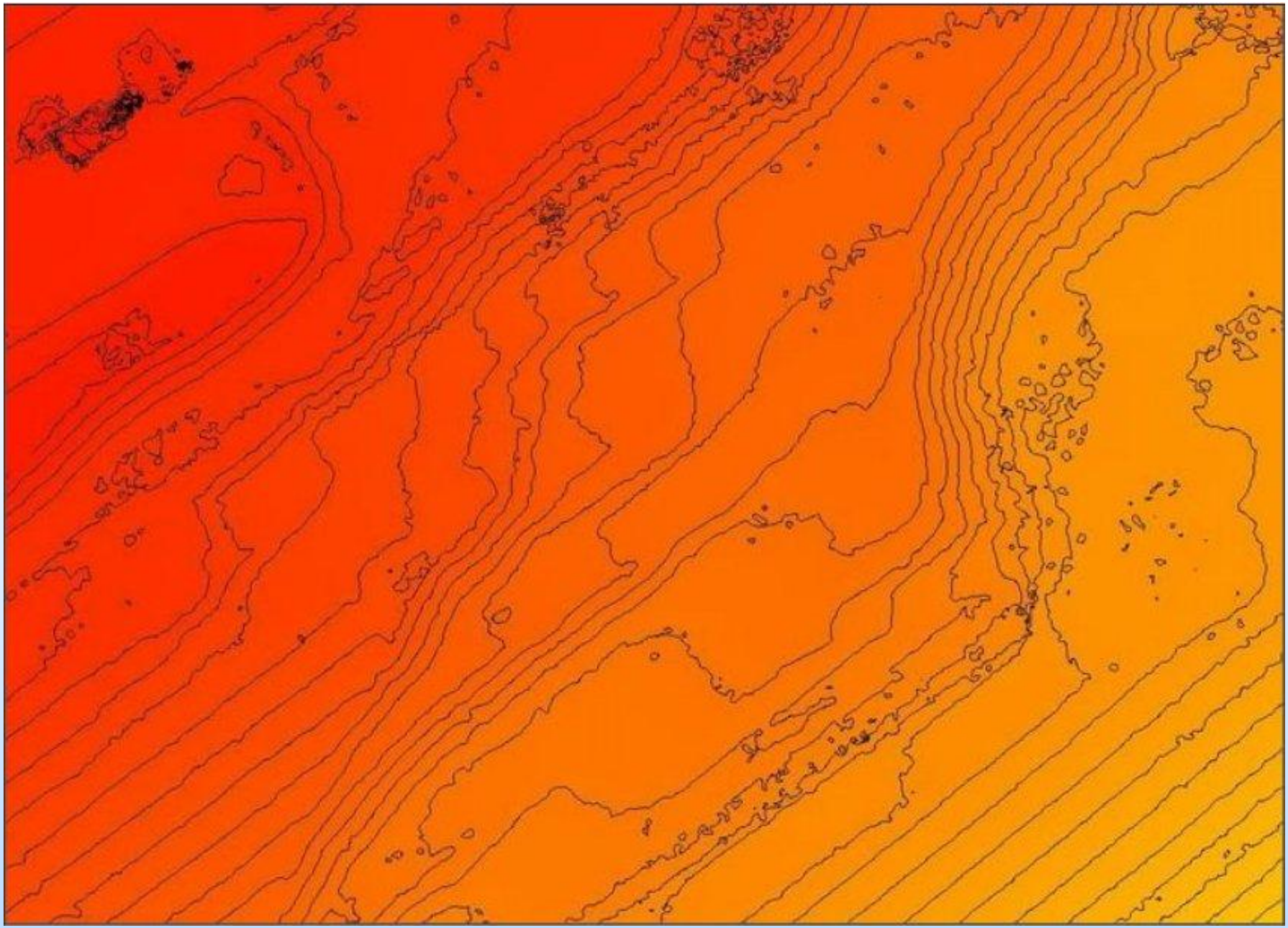
Targets for georeferencing point cloud in aerial images



Point cloud from bundler software



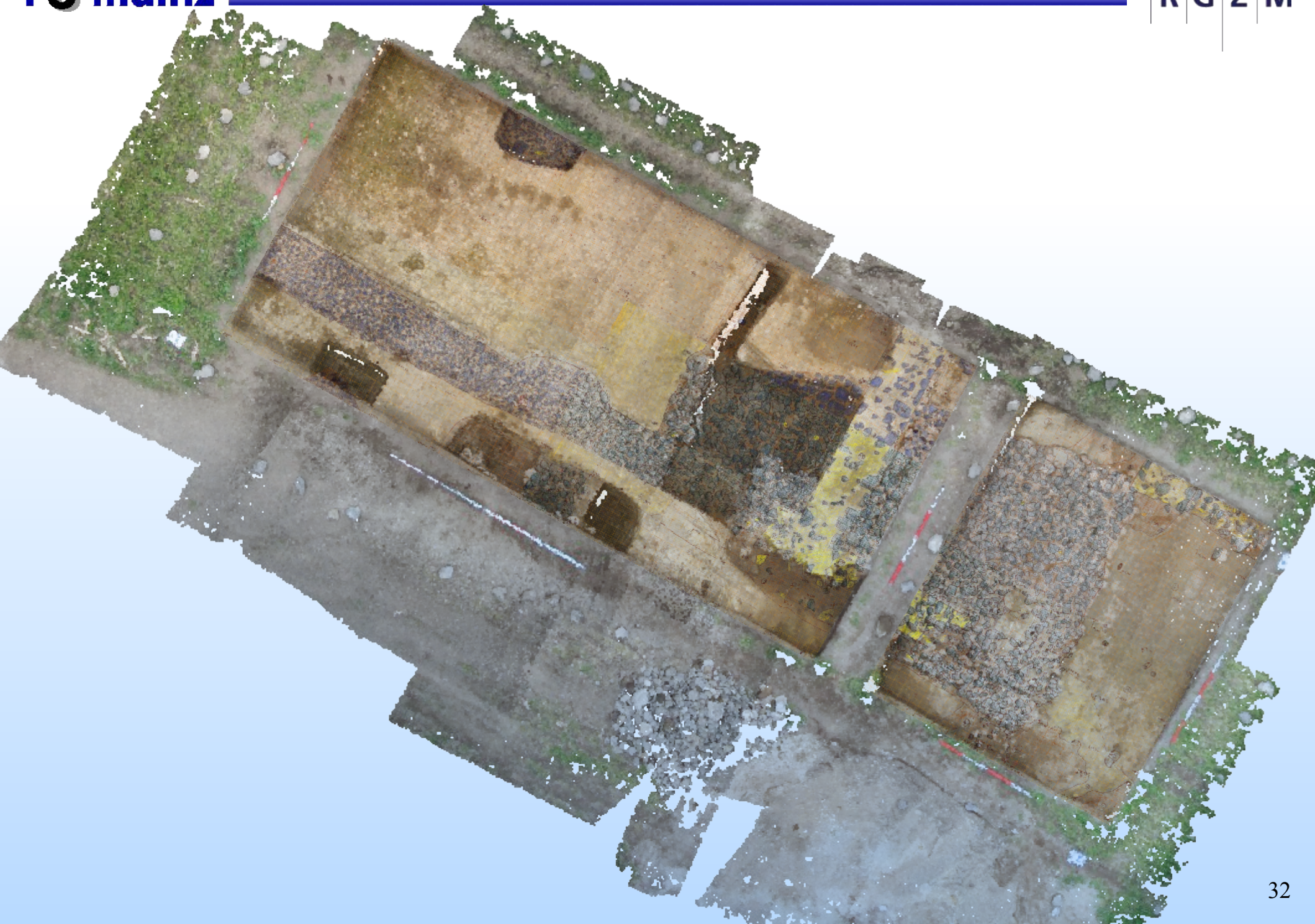
Point cloud from PMVS2 software

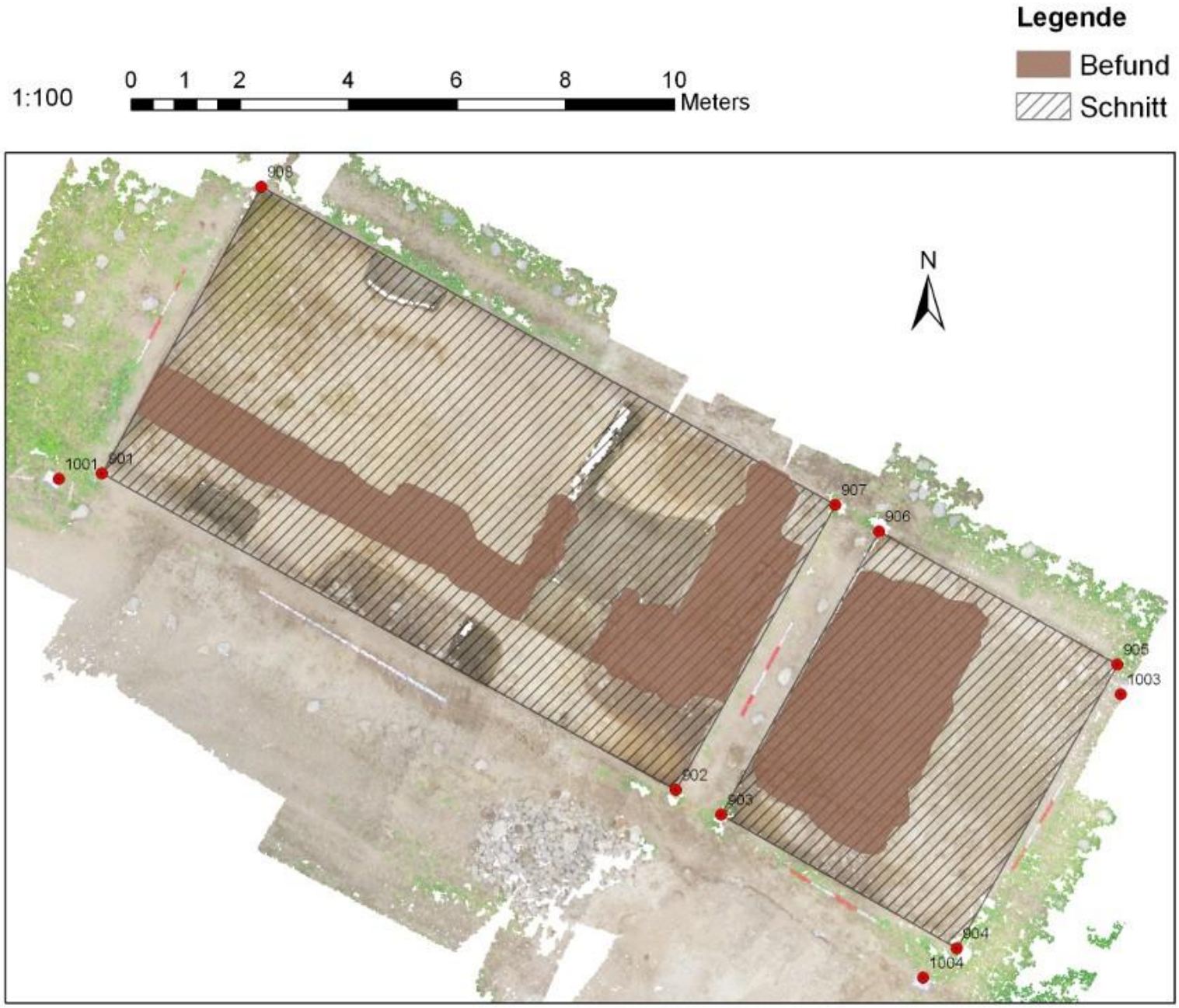


DEM of dumping ground (contour lines and colour coding)

Documentation of an archaeological trench

- Area:
  - Trench: 6m x 18m
  - Recorded: 13m x 25m
- Remote controlled flight
- Number of Images: 61 processed
- Data processing: Bundler / PMVS2, referencing
- Results: georeferenced 3D-point cloud





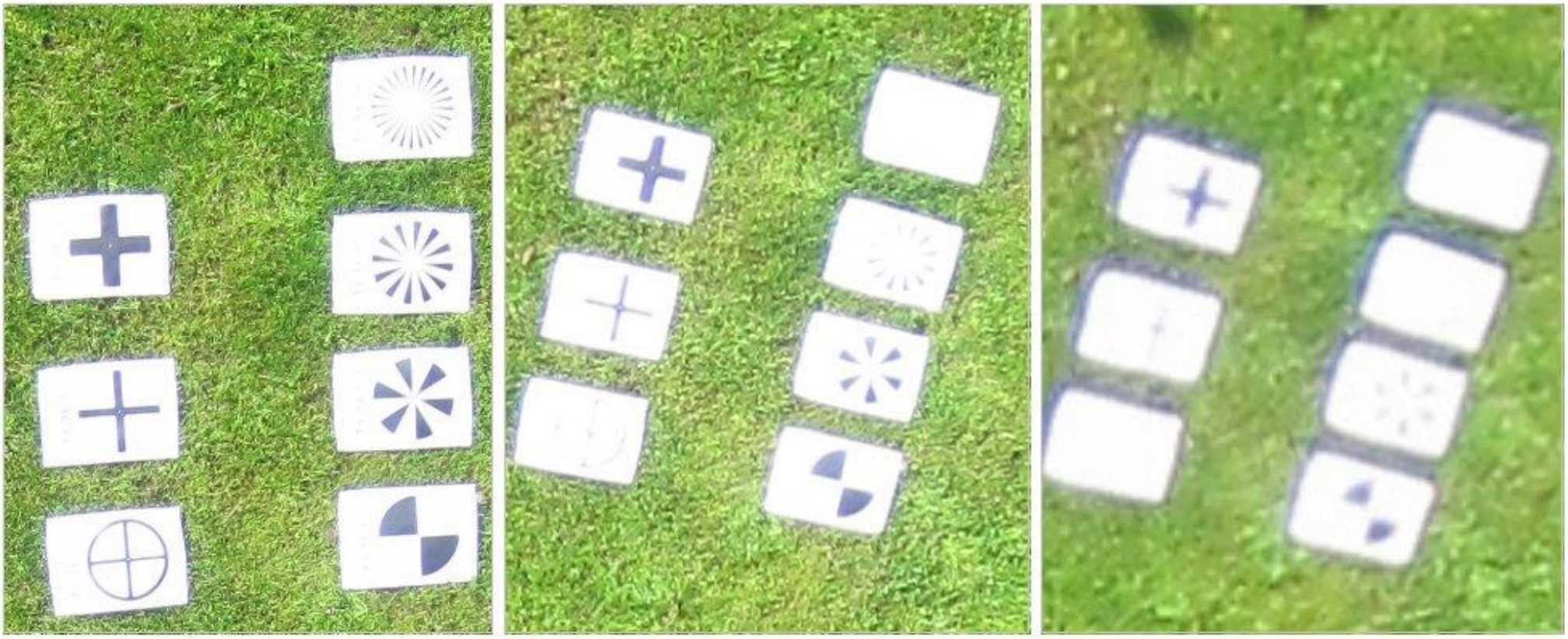
Map of trench based on reference points and georeferenced point cloud rendering

Presentation of 3D-Pointcloud

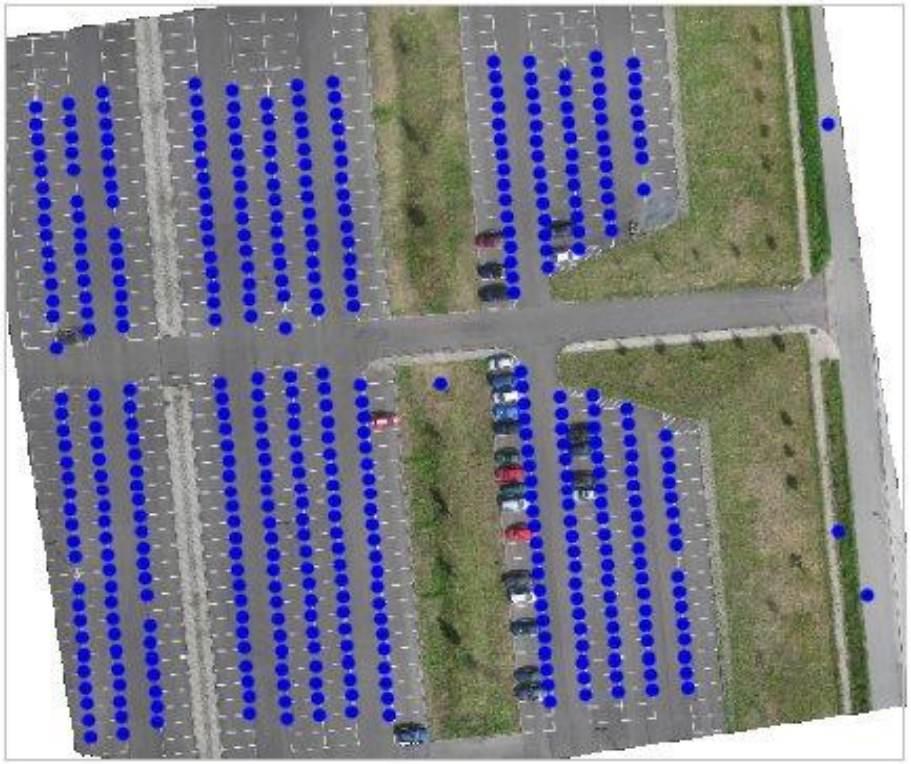
Recording of a parking area for accuracy testing

- Purpose: testing of tools and processes
- Area: app. 130 x 80 m²
- Number of Images:
  - 120 recorded / 99 processed
- Flight height: 50 m

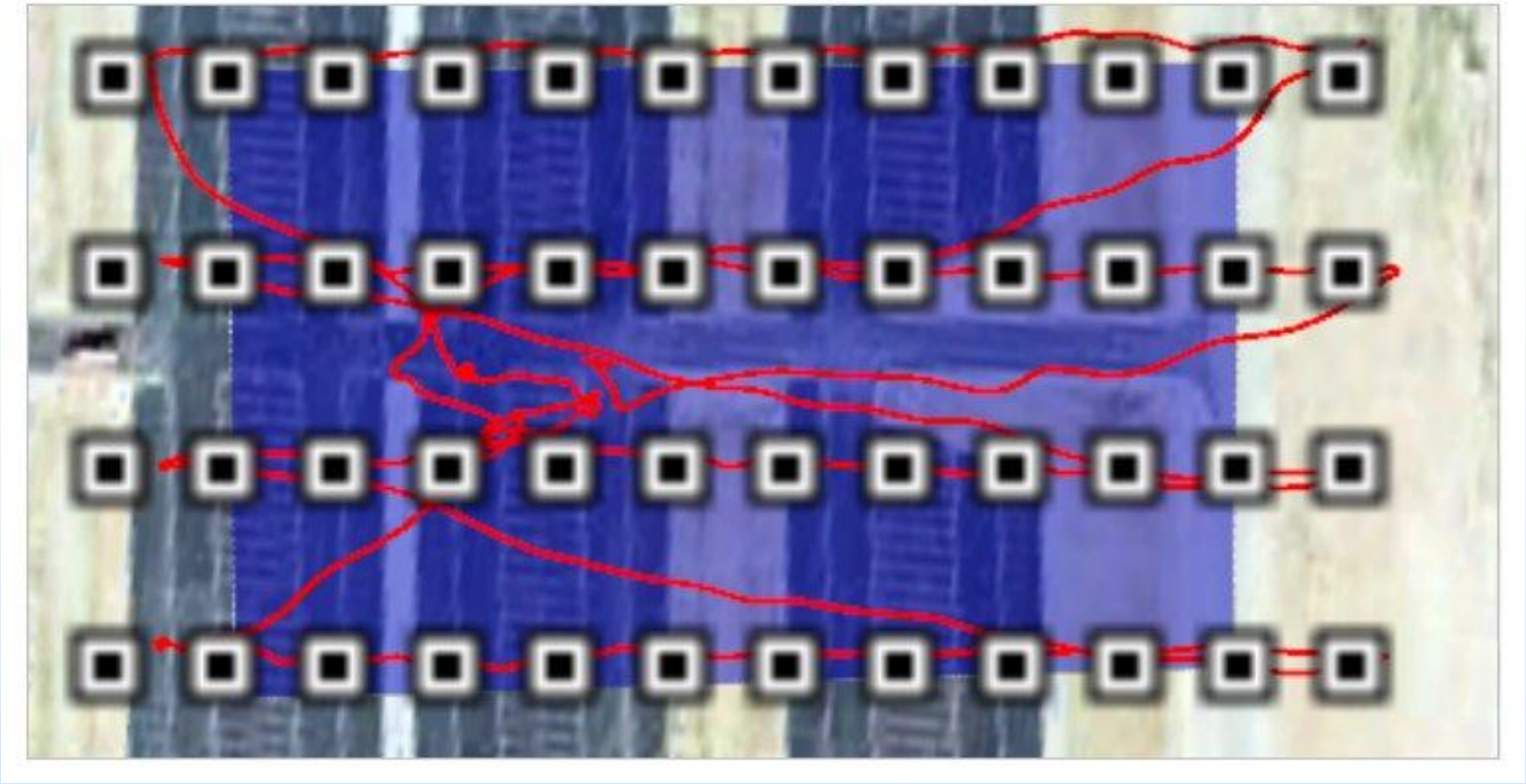
- From: Siebert, S.: Untersuchungen zur Geodatenerfassung mit einem Low-Cost Unmanned Aerial Vehicle (UAV), Fachhochschule Mainz, Lehreinheit Geoinformatik und Vermessung, Masterarbeit KM019, 2010 (Betreuer: Klonowoksi, J.; Neitzel, F.)



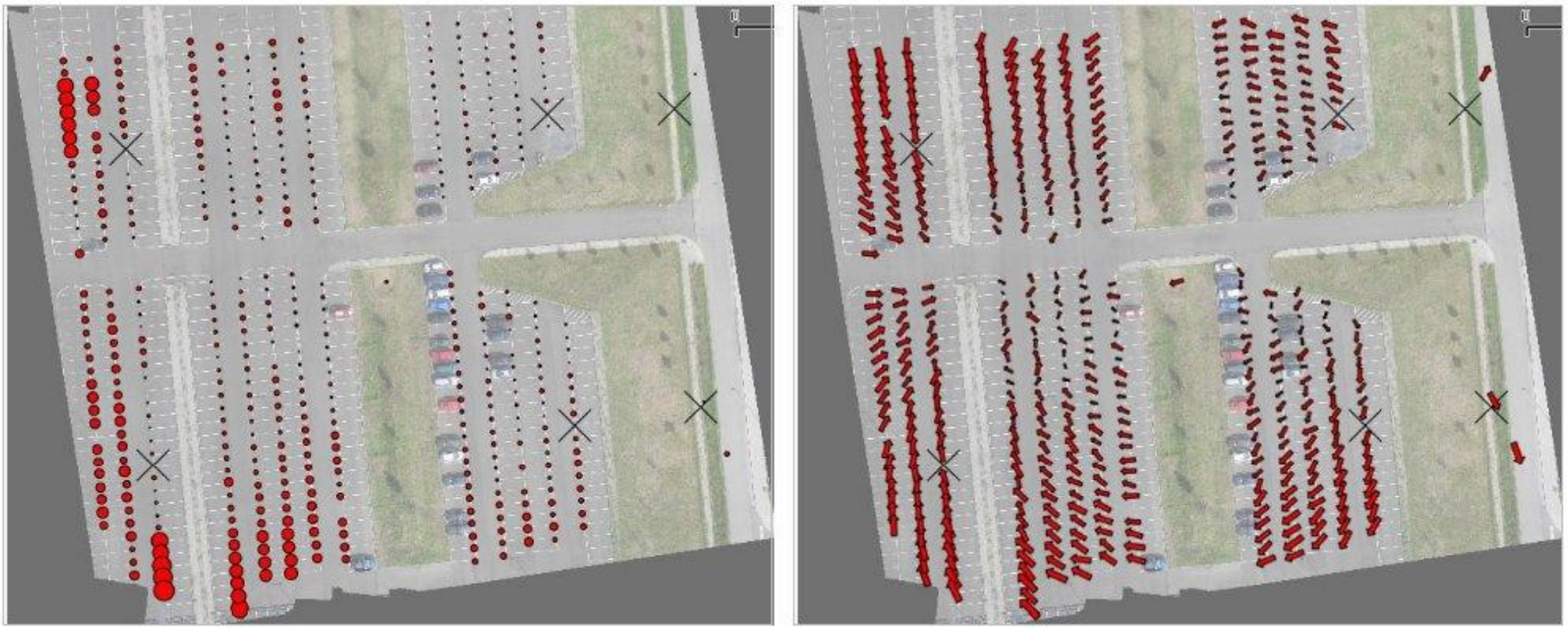
Variation of targets in photos from 20, 40 and 70m flying altitude



Testing area with reference point (left) and control points (right)



Test area (blue), waypoints (boxes) and real flight path (red) as view in GoogleEarth



Differences in height (left) and position (right) of points from Bundler / PMVS2 point cloud after georeferencing using six points

[mm]	Position (all)	Height (all)	Position (inside RP area)	Height (inside RP area)
PMVS2 (4RP)	Ø 206 ±117	Ø -3 ± 55	Ø 122 ± 63	**Ø -7 ± 16**
PhotoScan (4RP)	**Ø 197 ± 106**	**Ø -9 ± 27**	**Ø 115 ± 55**	Ø -30 ±17
PMVS2 (6RP)	**Ø 235 ±127**	Ø 5 ± 60	Ø 136 ± 67	**Ø 2 ± 16**
PhotoScan (6RP)	Ø 256 ± 127	**Ø -5 ± 28**	**Ø 56 ± 63**	Ø -25 ± 18

Average deviations in position and Height with standard deviation (1σ) for PMVS2 and PhotoScan

Software	Processing time [min]	Number of 3D-Points
Microsoft Photosynth	**5** (Windows7 64)	35.246
ARC 3D	**40** (Web Processing)	>20.000.000 (Image resolution 1000 x 750 pixel)
Bundler	**60** (Ubuntu)	36.719
CMVS + PMVS2	**30** (Ubuntu 64)	418.258
AgiSoft PhotoScan	**60** (Windows 7 64)	100.089

Processing times of software tools

Results and conclusions of tests

- Point quality dependant on processing chain
- Further investigations needed:
  - Analysis of algorithms
  - How to define point quality

Future works

- Improvement of (semi-)automatic positioning
  - Using motorized total stations proved to be promising
  - Tools for flight planning
  - …
- Tools for orientation and scaling (georeferencing) of resulting point clouds
- (semi-automatic) generation of 2.5 D elevation model and rectified image

Summary / Outlook

- UAVs are very promising tools for supporting documentation and measurement tasks in certain scale ranges
- Data processing needs to be improved simplified and partly automated
- Geometric quality and reliability needs further investigation
- Instructions / tutorials on configurations

Thank you for your attention

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