Creation of UAV-based orthoimages and evaluation for the use in cadastral mapping

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Outline

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- ✓ UAV system
- ✓ Test case – Project area
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  - Flight planning
  - Data acquisition
    - Flight
    - Ground Survey
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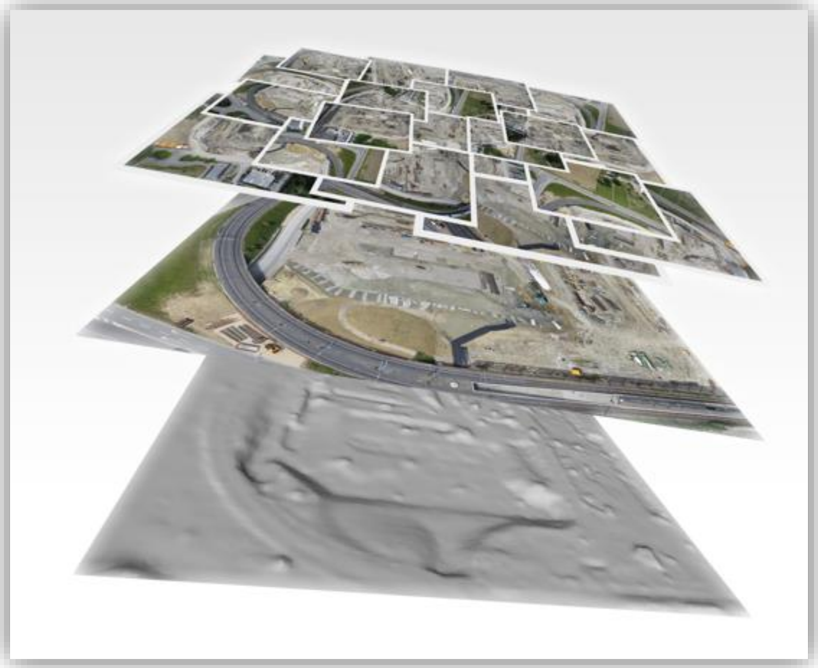
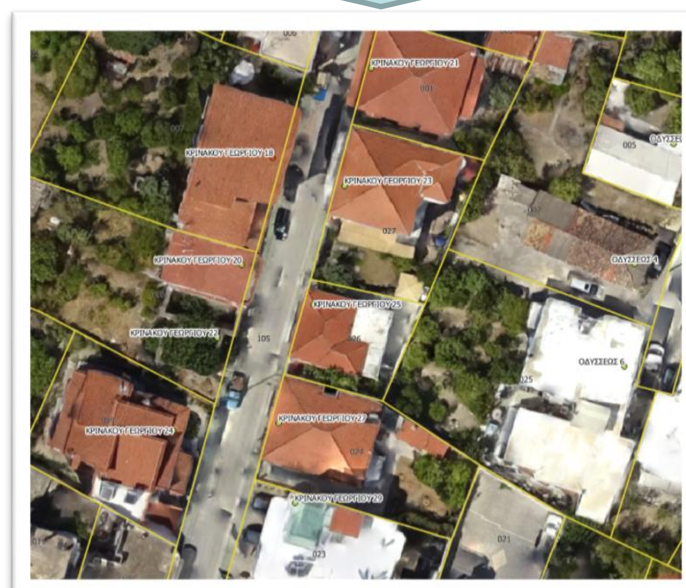
  - Assessing the accuracy of results
- ✓ Summary
- ✓ Models



Scope

Creation of Orthoimages as basemap for

- ✓ Collection of property declarations and Suspension process (statements / objections from the owners)
  - Identifying the location of the parcels
  - Recognition and indication of parcel boundaries
- ✓ Processing of spatial cadastral data
  - Digitizing the obvious materialized parcel boundaries on orthoimages
  - Buildings location
  - Review and process of objections held by owners
  - Drawing up cadastral diagrams
  - visualization of cadastral spatial data
- ✓ Operation of Cadaster
  - Review and process of requests for spatial changes of parcel boundaries
  - Update of cadastral spatial data
  - visualization of cadastral spatial data



UAV to UAS (1)

<u>UAV</u>

An unmanned aerial vehicle (UAV), is an aircraft without a human pilot on board. Its flight is controlled either autonomously by computers in the vehicle, or under the remote control of a pilot on the ground.

<u>UAS</u>

The term unmanned aircraft system (UAS) emphasizes the importance of other elements beyond an aircraft itself.

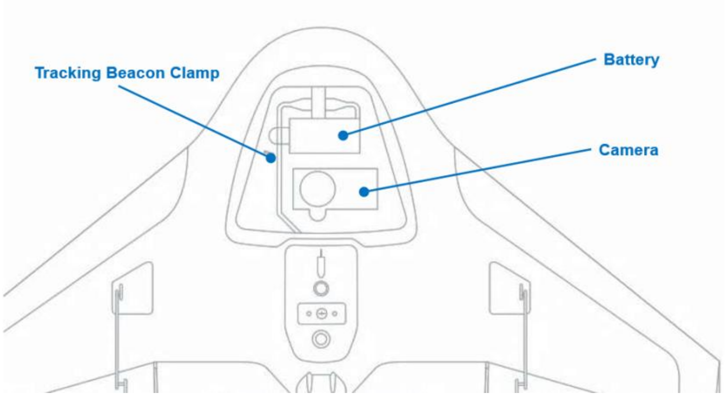
A UAS is an all encompassing description that encapsulates the aircraft or UAV, the ground-based controller, and the system of communications connecting the two.

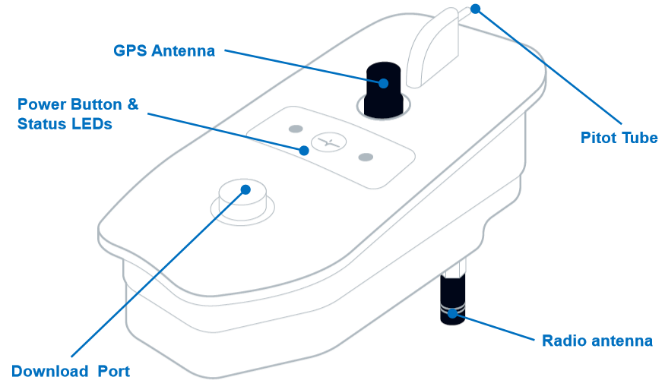
UAV to UAS (2)

UAS

A typical UAS used for geospatial applications consists:

- unmanned aircraft (UAV)
- Camera
- GPS / INS
- control link
- other related support equipment





The UAV GPS/INS system gives rough positions for images, in the range of 3-5 meters

The new systems now have Real Time Kinematic (RTK) measurement capability

Test Case – Project area

Area characteristics: Xılokastro is a seaside town with about 6,000 permanent residents

Unmanned Aerial System (1)

<u>UAV</u>

Sensefly ebee

- **Weight: Apporx. 0,69 Kg**
- Wingspan: 96cm
- Material: EPP foam, carbon stucture and composite parts
- **Maximum flight time: 50min**
- Nominal cruise speed: 40-90km/h
- Radio link range: Up to 3km
- **Maximum coverage (single flight): 12km^2**
- Wind resistance: Up to 45km/h

Unmanned Aerial System (2)

Camera

Sony WX RGB

- Sensor size: 7,76 mm (1/2.3 type)
- 18,2 Megapixels
- Focal length: Approx. 4,3 mm

  It is precisely determined when solving aerotraction by the self-calibration process.
- Image color depth: 24 bit (RGB)
- Image type: JPEG
- Image size: 4896 x 3672 pixels
- **image coverage on the ground at 5cm GSD: 250 x 180 m**
- **image coverage on the ground at 7cm GSD : 340 x 250 m**

Low cost camera
Approx. $535

Defining the flight

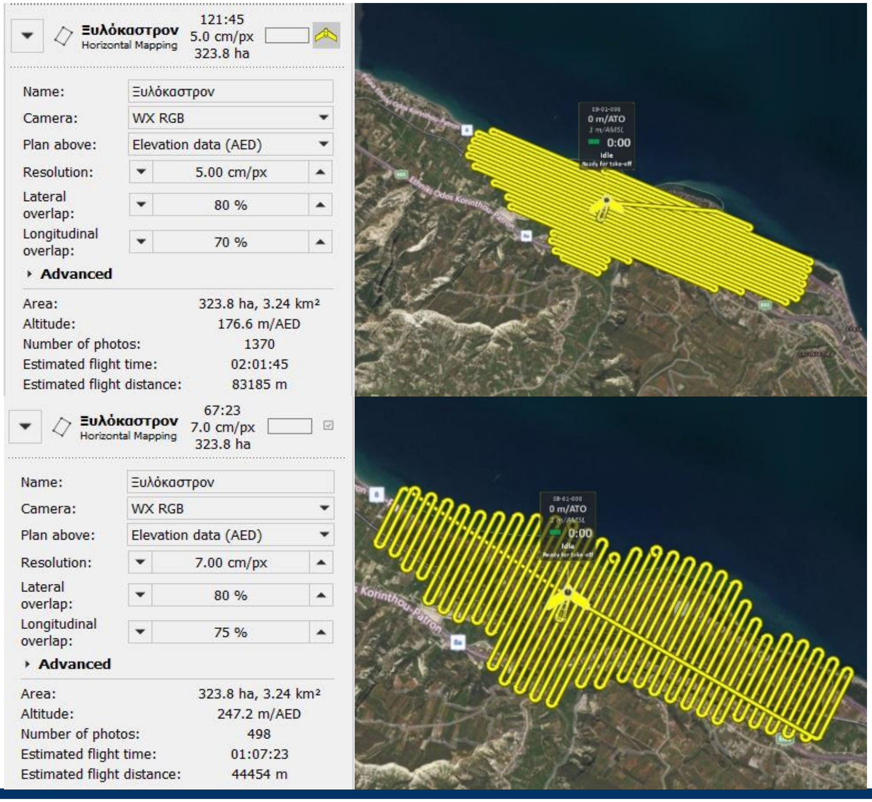
Perform cross-country flights of different size GSD (5 cm and 7 cm).

- Transverse flights ensure the elimination of concealment
- Different flight subsurface sizes ensure the best geometry of images

Drawing a flight diagram

- ✓ Create a polygon of interest area in Google Earth software
- ✓ Import the above polygon into the Emotion software (Sensefly)
- ✓ Define flight line addresses
- ✓ Set image resolution
- ✓ Set image overlaps
    - **Lateral: 80%**
    - **Longitudinal: 75%**

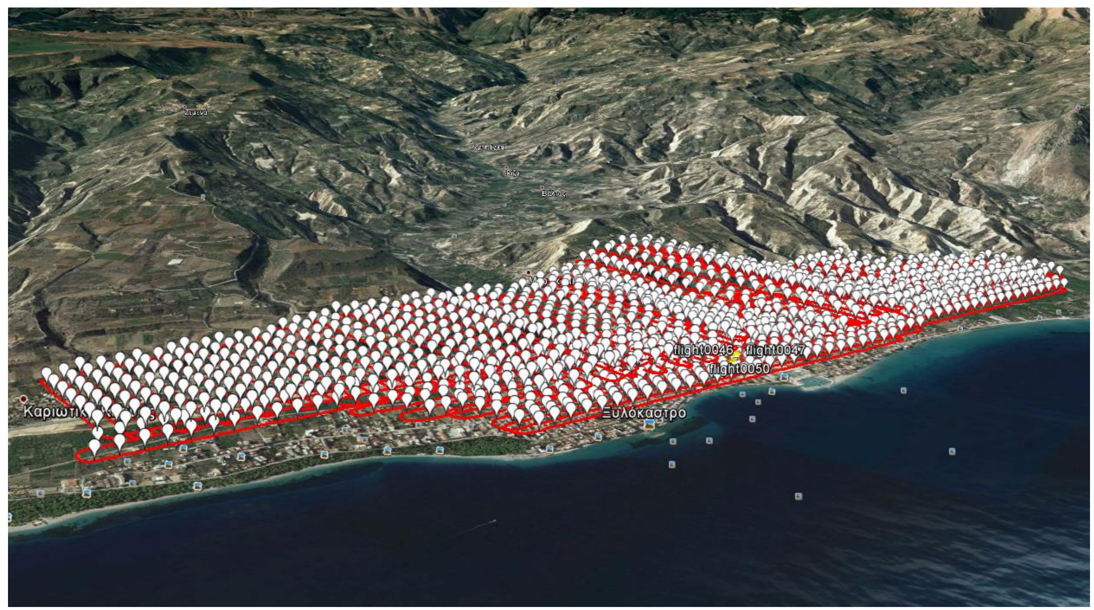
Flight planning work: Approx. 3h



Flight (1)

- ✓ Take-off from the operator's hands with a small push
- ✓ Weather conditions - wind: There are no flights under the rain. The wind should not exceed 6 bf (12m/sec). In the case of Xilokastro the flights were carried out with a air speed ~12km/h (Gentle Breeze - 3 Beaufort – 3m/sec).
- ✓ Landing ın a field

Total flight duration:
6 hours



Flight (2)

<u>5 cm Image GSD</u>

- Flight height: 176 m
- Total images total: 1.420
- Lateral overlap: 80%
- Longitudinal overlap: 70%
- Number of flight lines total: 27

<u>7 cm Image GSD</u>

- Flight height: 247m
- Total images total: 860
- Lateral overlap: 80%
- Longitudinal overlap: 70%
- Number of flight lines total: 57

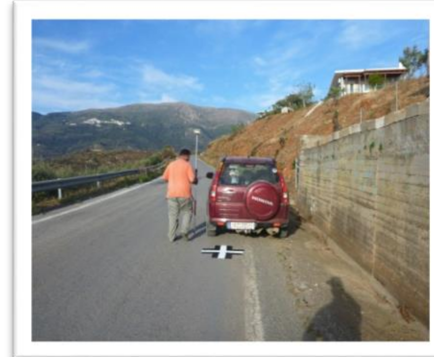
- ✓ **Total images: 2.280**
- ✓ **Aligned Images: 2.080**

Of the total number of images, removed about 200, because the 80% of the image represented sea and they could not be used in aerotriangulation

Ground survey

- ✓ Measurement method:
  - 49 points measured (RTK)
  - 10 points measured (Static)
- ✓ Total number of GCPs: 49
- ✓ Total number of Check points: 8
- ✓ Measurement Accuracy: 1 cm Horizontal
  3 cm Vertical

Measurement time: 2 man-days



Data Processing Flowchart (1)

***Processing time**:*

- *1 man-day for customizing work, performing quality controls and measuring gcps - check points*
- *3-4 days of processing time.*

Software:
emotion, Pix4d, Bentley Contex Capture, Hexagon Image Station & Customised Software

Preparing the Raw Images

↓

Import photos
Import gcps and check points coordinates

↓

Automatically resolving relative orientation

solving orientations to create approximate values (Pix4D Software).
Pix4Dmapper read the geolocation files delivered by the UAS

Data Processing Flowchart (2)

Measurement of gcps
only a part - Scattered each corner of project's boundary

↓

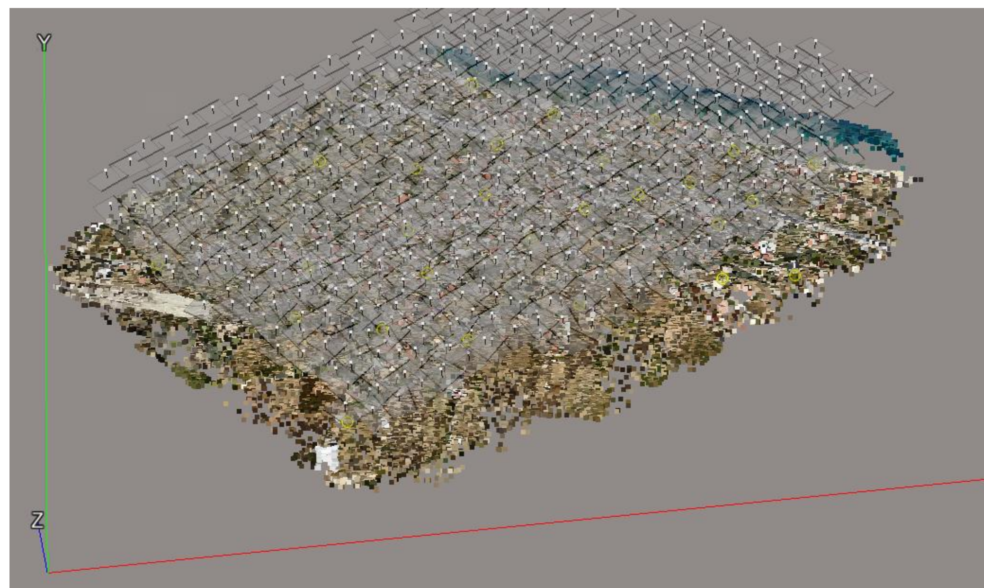
Bundle block adjustment with auto calibration of the camera

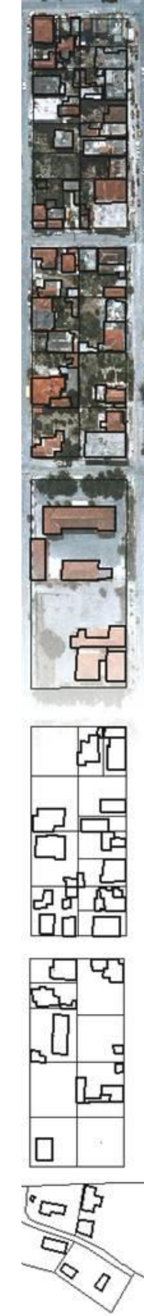
↓

Measurement of all gcps and check points

↓

Final bundle block adjustment with auto calibration of the camera





Data Processing Flowchart (3)

3D Model Creation

DSM
Creation & Editing

Three-dimensional triangulation for creating 3D Mesh

Texture Mapping 3D Mesh

Quality control - Accuracy assessment

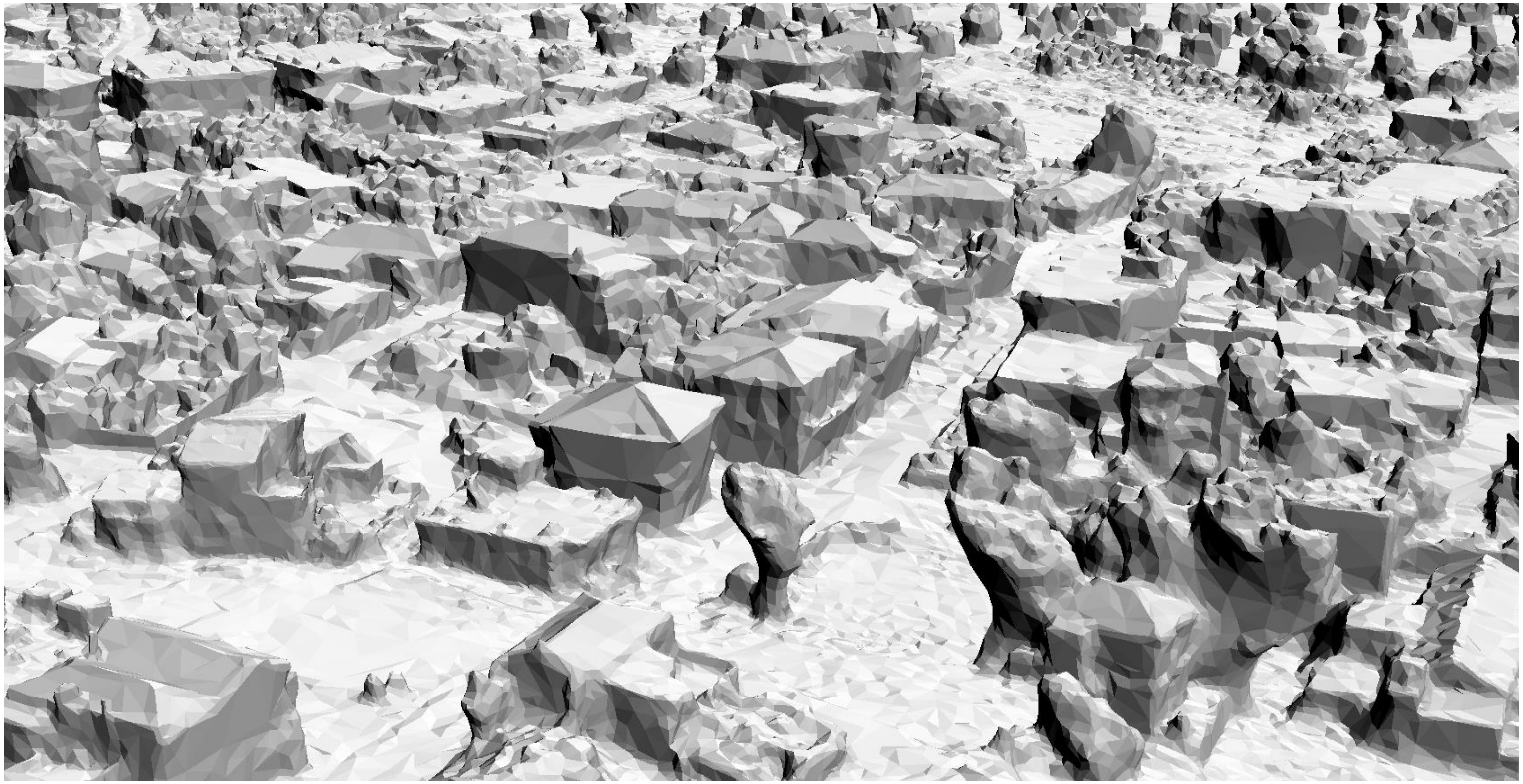
Exterior orientation of images – Stereomodels

Data Processing Flowchart (4)

Products → **3D Point Cloud (las)**

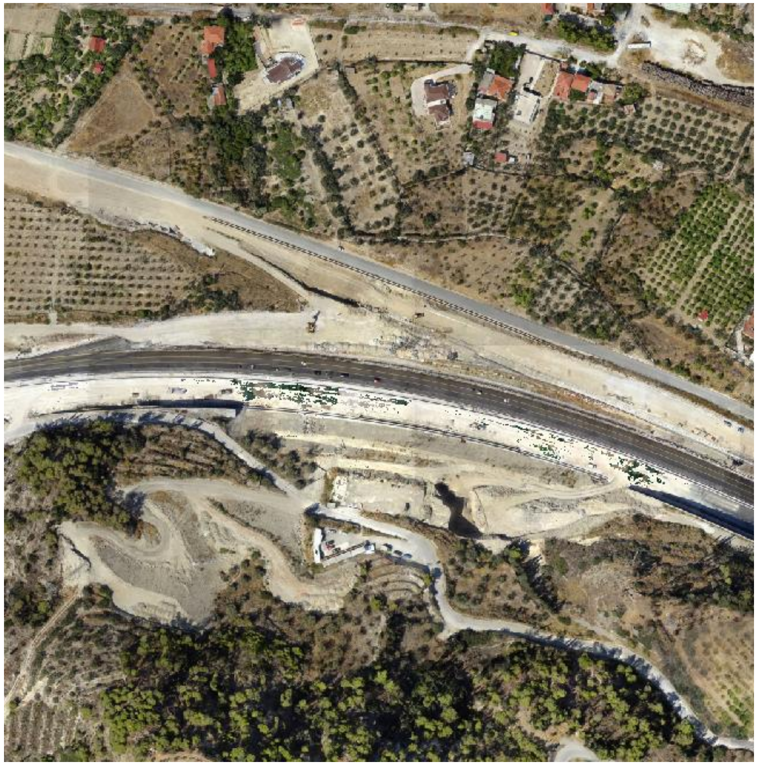
Data Processing Flowchart (5)

Products → **3D Mesh**



Data Processing Flowchart (6)

Products → **Orthoimages**



Geometric Accuracy

		RMSxy (m)	RMSz (m)
Aerotriangulation	49 ground control points	0,041	0,025
Aerotriangulation	10 check points	0,062	0,059
Orthoimage 5cm	25 individual points	0,113	

“Standard Mapping and GIS work specify a 2-pixel RMSEx and RMSEy accuracy class.

This accuracy is appropriate for a standard level of high quality and high accuracy geospatial mapping applications”.

“ASPRS “Positional Accuracy Standards for Digital Geospatial Data (edition 1, version 1.0. – November, 2014)”

VLSO vs UAV orthoimagery (1)

Detail of VLSO true orthoimage in Xilokastro
Flight Date: June 2008, pixel size 20cm

Detail of UAV orthoimage in Xilokastro
Flight Date: September 2016, pixel size 5cm

VLSO vs UAV orthoimagery (2)

Compare UAS orthoimage with existing VLSO orthoimage

POINT

1031

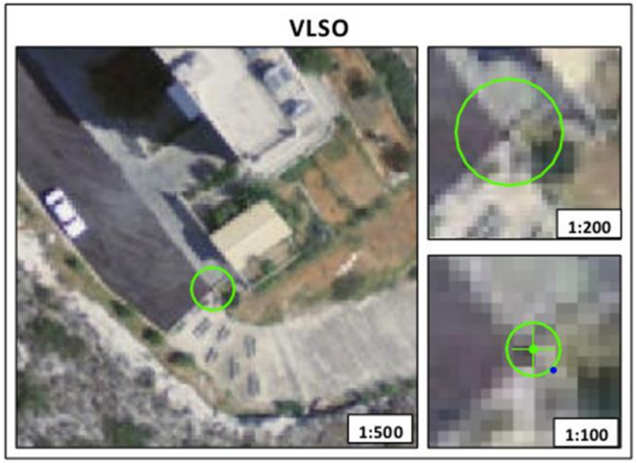
ΥΠΟΜΝΗΜΑ

ΘΕΣΗ ΣΗΜΕΙΟΥ

RTK HEPOS

VLSO

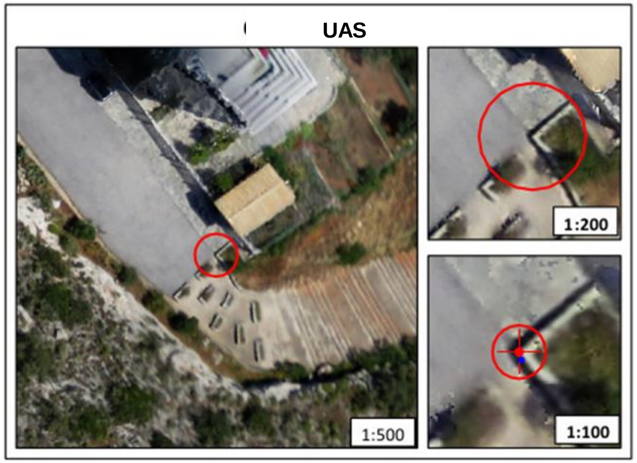
UAV



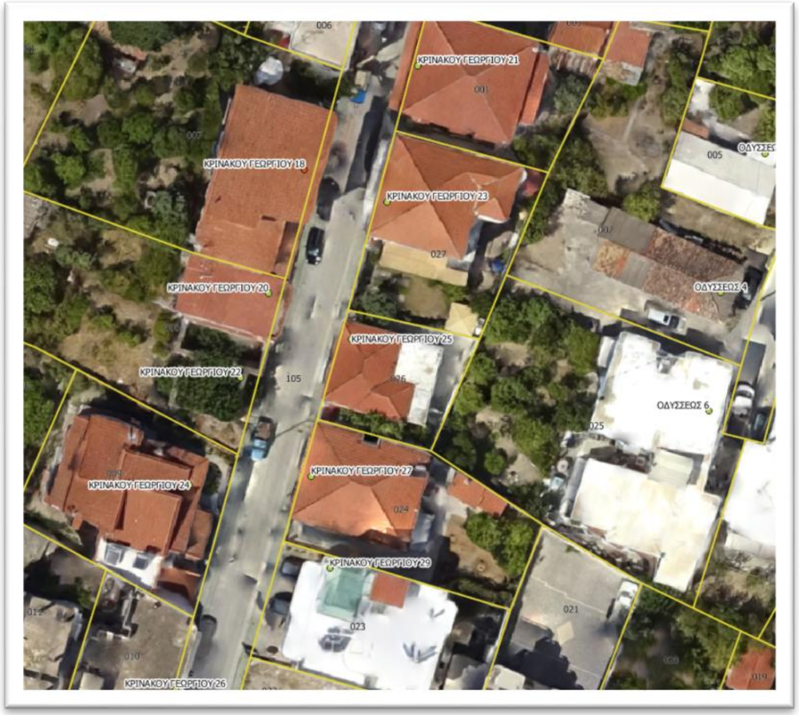
GPS Measurement (RTK – HEPOS)			
Point No	X	Y	H
1011	482215,555	4184416,140	34,735

Compare GPS Measurement with VLSO (20cm GSD)					
Point No	X	Y	Dx	Dy	RMSxy
1011	482215,181	4184416,530	0,374	-0,390	0,385

Compare GPS Measurement with UAS (5cm GSD)					
Point No	X	Y	Dx	Dy	RMSxy
1011	482215,512	4184416,232	0,043	-0,092	0,121



Use of Orthoimages



Identifying the location of the parcels from owners

Georeferencing of old administrative acts

Summary (1)

UAV photogrammetry provides higher quality and reliability of spatial products.
High overlapped vertical aerial images of UAV photogrammetry are capable to make higher dense and more reliable spatial products speeding up the mapping process.

UAV photogrammetry is capable to produce many outputs including ortho-image-mosaic, image-map, 3D textured realistic model, high density coloured point cloud, and 3D flight simulation video.

UAV photogrammetry can fill in the gaps of existing technology

Summary (2)

- UAV photogrammetry does not require a professional onboard pilot, high-cost cameras and IT equipment (very large image files must be processed and saved)
- Low-altitude systems have advantages in conducting photogrammetric surveys under the cloud, providing different views and tilted images of the surveyed objects
- UAV photogrammetry is extremely time and cost efficient. Cost effective in smaller project area
- Fast data acquisition, while transmitting the image, video and orientation data in real time to the ground control station
- Fast processing of data
- Lower Altitude $\rightarrow$ Higher Resolution
- Low end UAV photogrammetry can provide reliable horizontal accuracy
- Vertical accuracy require denser ground control network to be reliable
- Provides high resolution texture mapping
- UAV successfully used for capturing the digital aerial images for mapping urban and suburban areas for large scale mapping (cadastral diagrams)
- This technology is very beneficial for monitoring purpose (operation of cadaster)

Models