

Virtual Surveying: Mapping and Modeling Cadastral Boundaries Using Unmanned Aerial Systems (UAS)

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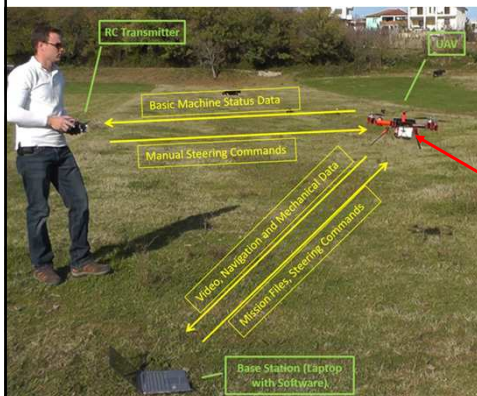
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Contents

- Emergence of UAS – logical progression of geospatial technology trajectory
- UAS components
- UAS Mapping work flow – from project design/prep to cadastral map
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Acknowledgement: Funding for this project was provided through an Innovation Grant from the ECA Region of the World Bank. We would like to thank the ECA land group, especially Kathrine Kelm.

UAS Components



Optional Dual Frequency GPS receiver for precise geo-referencing

Stand alone GPS receiver for platform navigation



Off-the-shelf digital camera

Software:

- Mission Planner (open source)
- Photoscan (AgiSoft)
- Virtual Surveyor (Geo-ID)

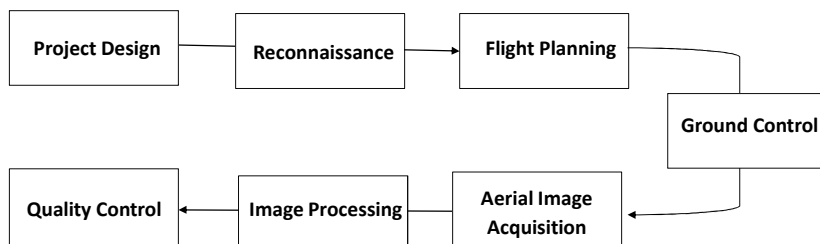
Quadcopter:

Take-off weight 2.4kg, Payload 350g,
Endurance 10-15 mins.
Flight line per battery: 4km

PRICE < GNSS ROVER (US\$12k)!!!

UAV – VTOL vs Fixed Wing

Work Flow

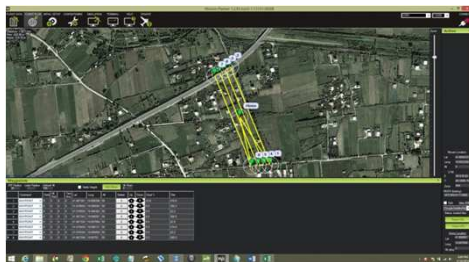


Project Design and Reconnaissance

- **Scale, Resolution and Imagery Needs**
- **Pre-Testing** UAS Configuration
- **Legal** Constraints and Regulation
- **Transporting** UAV and batteries to field site
- **On-site field Reconnaissance**
 - Community Participation
 - Inspection
 - Equipment Checks
- **Ground Control** (if necessary)



Flight Planning and Automated Image Acquisition



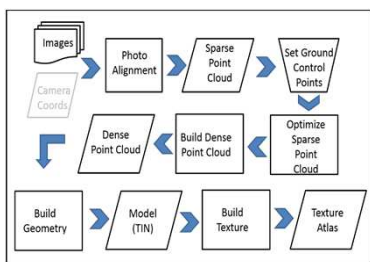
High Resolution UAS Aerial Images



- Flying Height = 75m
- GSD = 2cms
- Camera - Samsung NX1000
- Focal Length = 16mm;
- 80% forward overlap;
- 70% side overlap

Typical Workflow of Image Processing

Structure from Motion

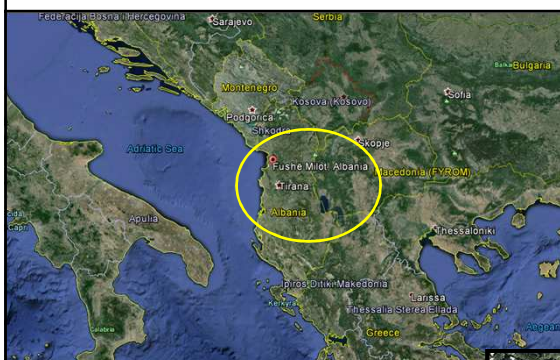


Photos aligned and sparse point cloud



Dense Point Cloud of Fushe Milot (Albania)

Pilot Test Area in Albania



- 23 hectares agricultural area (Fushe Milot)
- 40 kilometers from the capital city of Tirana
- Proposed site of new urban water supply scheme
- Recent expropriation for new highway



Comparison with Existing Image Data



Orthophoto Imagery (2007) draped over Google Earth



Imagery from Google Earth (2012)



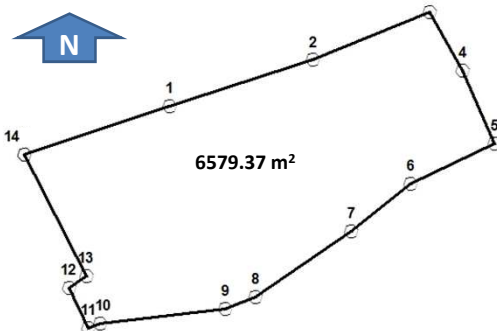
UAV-based Orthophoto (Dec 2013) draped over Google Earth

UAS Cadastral Map



Virtual Surveying - Results

Cadastral Plan
Parcel 22



FUSHE MILOT, ALBANIA

| Pt. ID | X (m) | Y (m) | | DIST (m) | AZIMUTH (dms) |
|--------|------------|--------------|-------|----------|---------------|
| 1 | 391,348.74 | 4,613,704.29 | 1-2 | 43.71 | 72.0529 |
| 2 | 391,390.33 | 4,613,717.73 | 2-3 | 36.69 | 67.5049 |
| 3 | 391,424.31 | 4,613,731.56 | 3-4 | 19.27 | 151.0546 |
| 4 | 391,433.63 | 4,613,714.69 | 4-5 | 23.10 | 156.1518 |
| 5 | 391,442.93 | 4,613,693.54 | 5-6 | 26.89 | 244.2624 |
| 6 | 391,418.68 | 4,613,681.94 | 6-7 | 22.21 | 231.2506 |
| 7 | 391,401.31 | 4,613,668.09 | 7-8 | 33.54 | 235.1947 |
| 8 | 391,373.73 | 4,613,649.01 | 8-9 | 9.42 | 248.3835 |
| 9 | 391,364.96 | 4,613,645.59 | 9-10 | 36.46 | 263.2459 |
| 10 | 391,328.74 | 4,613,641.41 | 10-11 | 3.76 | 248.5448 |
| 11 | 391,325.23 | 4,613,640.05 | 11-12 | 12.94 | 334.5612 |
| 12 | 391,319.74 | 4,613,651.78 | 12-13 | 6.11 | 56.3343 |
| 13 | 391,324.84 | 4,613,655.14 | 13-14 | 39.60 | 332.5150 |
| 14 | 391,306.78 | 4,613,690.38 | 14-1 | 44.20 | 71.4004 |

UTM 34N – Albanian Geoid

Surveyed by: WV, OV and GB

Method: UAS Orthophoto

Ground Control: GPS

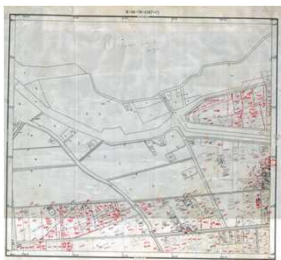
Date of Survey: 5 December, 2013

SCALE: 1/1000

Cadastral Plan with UAS Ortho Backdrop



Comparison with Existing Cadastral Map



Official Cadastral Map



De jure vs de facto (UAS-orthophoto) boundaries



De jure boundaries compared with land use (2007 Orthophoto)



De jure boundaries vs land use (UAS Orthophoto)

Fit for Purpose

- ✓ **Flexible** – image, boundary defined graphically, coords, etc
- ✓ **Inclusive** – includes various sets of rights
- ✓ **Participatory** - community buy-in from start (transparency)
- ✓ **Affordable** – outcompetes conventional approaches (time/cost)
- ✓ **Reliable** – provides current data as needed
- ✓ **Attainable** – Transferable with order of magnitude time savings (days vs months or years)
- ✓ **Upgradeable** - Incremental approach - 'just-in-time' spatial data provision
- ✓ **Appropriate** – technology and approach

F for P implies that the land admin system "should be flexible and focused on citizens' needs..... (see FIG/WB 2014, p.6)