Development and tests of a UXO survey drone system.

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UXO survey and clearance since 2000

- Land Division – Offshore Division
- 20 persons onshore, 40 persons offshore
- About 150 land survey and clearance projects/ year
- 14300 ha of surveyed wind parks, cable routes, pipelines
- 5612 investigated targets
- 183 big UXO’s found
- 42 Detonations
- **NO ACCIDENTS**

Nordsrteam 2 – Dolwin 3 – Merkur – Hohe See – Veja Mate
Nordergründe – Rentel – Trianel
Which drone shall we buy?

There have been quite some questions we had to answer upfront!

Drone or Copter?
Price?
Weight/ Payload?
Data?
Stability?
Sensors?
Positioning?
Battery pack?
Why did we have to answer these questions?

Price?

Backup system, Quality, Spare parts, additional Features, time of delivery,…

Weight/ Payload?

How heavy is the drone and how much payload is left until you reach 5 kg?
Which kind of sensors can be added until you reach the limits payload wise.
Can you get full access to the data, like RTK for positioning electrical power for compensation?.

Data?

The stability of the drone during the flight has a huge impact on data quality.

Stability?

What sensors are coming along with the drone? Collision control, distance above ground?

Sensors?

Which quality has he RTK signal? Single GPS or Dual GPS?

Positioning?

Does the battery's provide enough power for an reasonable flight time without adding to much weight?
The biggest hurdles: **Weight/ Power/ Duration**

A drone heavier than 5kg requires, in Germany, a license for every launch. A light drone may not have enough battery power / payload. The flight time is defined by the battery capacity as a function of the total weight (including load) and the flight maneuvers. Starts, stops, turns, changes in altitude and speed cost battery capacity. Each additional gram on the drone also costs power and thus flight time.

Weight + payload + additional losses = duration of flight

<table>
<thead>
<tr>
<th>Lipo</th>
<th>max. Flight time</th>
<th>200g payload</th>
<th>500g payload</th>
<th>750g payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>3300/4S</td>
<td>21min</td>
<td>18min</td>
<td>14min</td>
<td>11min</td>
</tr>
<tr>
<td>5000/4S</td>
<td>28min</td>
<td>25min</td>
<td>19min</td>
<td>16min</td>
</tr>
</tbody>
</table>

The flight time is defined by the battery capacity as a function of the total weight (including load) and the flight maneuvers. Starts, stops, turns, changes in altitude and speed cost battery capacity. Each additional gram on the drone also costs power and thus flight time.
Beside the geodata, altitude data, acceleration values, the information about the current flow to the rotors, is used for compensation.
To plan the flight of a drone for UXO survey reasons, a flight software is required which is not commercially available. What should this software provide:

- import of dfx overlay/ google earth maps
- correct distance above ground flying 0,5m
- flying smart turns at the end of the lines
- defined line spacing
- autonomous flight mode, without pilot
- flying around obstacle's
- flying up and down steep hills
The biggest hurdles: Flight software
Data: P-P 20.09nT
Model: P-P 19.72nT

Modelled Parameters:
- Modelled depth: 1.838m
- Estimated mass: 8.9kg
- Dipole inclination: 43.3deg
- RMS error: 0.35
- Confidence: 95.4%

Position: _______________________
Mass Factor (Default = 3): 8
Test 2

UXO found – 20 lbs
Test 1 targets/ survey/ results
Höhenlinienplot – Luttmersen

Test 3

Koordinatensystem
- LT 310
- Deutschland (Allgemein)
- UTM Koordinaten (nord. Hemisphäre)
- Zone 32 N
- ETRS89 (Europa, geozentrisch, GRS80)

Aufzeichnungsparameter
- Instrument: MAG Drohne
- Aufzeichnungsort: RTK
- Saumfragen-Interval: 10 s/sec.
- Spurabstand: 2 m

Farbdarstellung
- Farbcode: 0.65 m, 1.95 m
- Histogramm: Weiss, Gelb, Weiß, Blau, Lila
- Interpolation: Linear

Flughöhe [m]
- Standardabweichung: 7 cm

Prozessierer: Dr. André Polster
Messort: 1.250
Messdatum: 05. Februar 2019
Sondierte Fläche: 0.32 ha

Flughöhe: 0.7 m ü. GOK
Test 3

Testfield – Benkovac/ Kroatia
Test 3  Data
Thank you for your attention!