DRONE-INTEGRATED METAL DETECTION SYSTEM WITH GEONICS EM61LITE METAL DETECTOR

SYSTEM DESCRIPTION

COMPONENTS OF THE SYSTEM

1. Geonics EM61Lite time domain metal detector.

2. UgCS SkyHub onboard computer – acts as data logger for metal detector and manages flight on low altitude in True Terrain-Following mode.

3. Radar altimeter – used to measure the distance to the ground surface.

4. Onboard software of UgCS SkyHub to manage the flight, log data, and deliver real-time sensor data down to the ground.

5. UgCS – Universal ground Control Software to plan and execute drone missions.

6. UgCS Custom Payload Monitor application – special add-on application for UgCS to control low-altitude flight in True Terrain-Following mode and receive metal detector data in real-time.

7. Suitable drone. Standard drones like DJI M600 Pro recommended for small to medium scale surveys. For large-scale surveys, drones with a hybrid propulsion system will deliver better productivity.

8. Power converter with a remotely controlled relay to feed EM61Lite from the drone's battery.

9. Processing software. The recommended software is Seequent Oasis montaj or Golden Software Surfer.

10. Optional component: RTK/PPK GNSS receiver on the drone to geotag the data with cm-level precision.


APPLICATION SCENARIOS

- UXO (unexploded ordnance) search
- Locating underground infrastructure (metal pipes and cables)
- Archaeology
- Surveying for any metal objects lying underground

CAPABILITIES OF THE SYSTEM

The system is capable to detect metallic (ferrous and non-ferrous) items on the surface and in the first few meters under surface. Detection capability depends on the distance between object and sensor coil, and characteristics of the target, *i.e.* size, shape, orientation, material composition,

material thickness, material integrity, etc. System operation over salt water may have a small effect on response amplitude.

Below are results of EM61Lite tests over SPH Engineering's test range with pipes and barrels placed underground. Flight with elevation of the sensor's coil 110 cm over ground, flight speed 1m/s. Pipes were put underground in diagonal orientation (one end shallow, another end deeper).
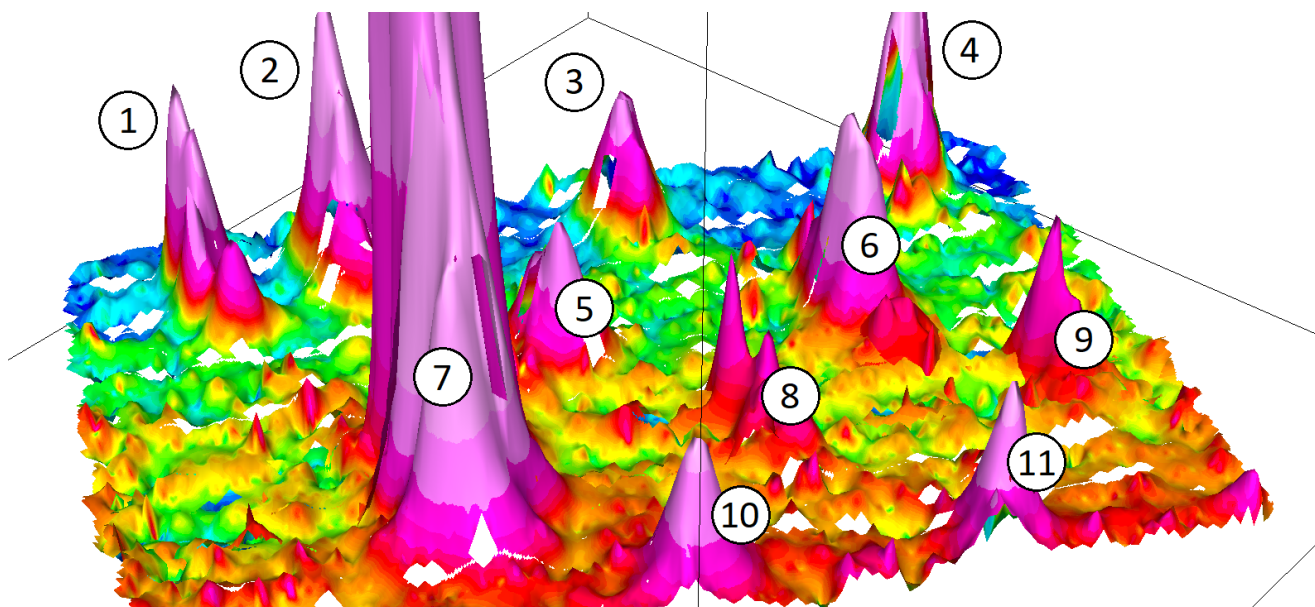
#	Type of target	Diameter, mm	Length, m	Distance from the coil, m (shallow-deep ends)	Depth under surface, m (shallow-deep ends)
1	Stainless steel pipe	110	6.0	1.5 – 2.1	0.4 – 1.0
2	Steel pipe 4.0mm wall	500	6.0	2.1 – 3.1	1.0 – 2.0
3	Steel pipe 3.0mm wall	314	6.0	2.1 – 3.1	1.0 – 2.0
4	Steel pipe 2.5mm wall	200	6.0	1.6 – 2.6	0.5 – 1.5
5	Steel barrel 200 L, vertical	610	0.88	2.1	1.0
6	Steel barrel 200 L, horizontal	610	0.88	2.1	1.0
7	Reinforced concrete pipe	1000	8.0	2.1 – 3.1	1.0 – 2.0
8	Steel pipe 3.0mm wall	50	6.0	1.6 – 2.6	0.5 – 1.5
9	Steel pipe 1.5mm wall	110	6.0	1.6 – 2.6	0.5 – 1.5
10	Steel barrel 200 L, diagonal	610	0.88	2.1	1.0
11	Steel barrel 200 L, flattened (crashed)	610	0.88	2.1	1.0

Important note – these results are related to this particular test only. They mean that similar targets should be detected in similar conditions, and most targets can be detected at greater distances from the EM61Lite coil.

METAL DETECTOR VS. MAGNETOMETERS

Currently, there are many airborne magnetometers on the market, applicable for use on medium UAV and proposed exactly for the same application scenarios.

Each type of sensor has its own benefits and drawbacks, and they can complement each other depending on the type of job/survey.

Metal detector benefits:

- Can detect both ferrous and non-ferrous metallic items (made of copper, aluminum, stainless steel, cast iron, etc.)
- Can detect smaller items
- Relatively limited response to magnetic soil and rock materials
- Reduced sensitivity to sources of cultural noise
- Greater target resolution
- Simplified interpretation

Magnetometer benefits:

- Can detect larger metallic items to depths greater than 10 meters; EMI (electromagnetic induction) metal detectors have limited range
- Some makes of magnetometers like SENSYS MagDrone R3 are compact and applicable for use with medium drone in windy weather

GEONICS EM61LITE TIME DOMAIN METAL DETECTOR

Geonics EM61Lite is airborne version of proven EM61-MK2 time domain metal detector (http://geonics.com/html/em61-mk2.html).

EM61Lite parts:
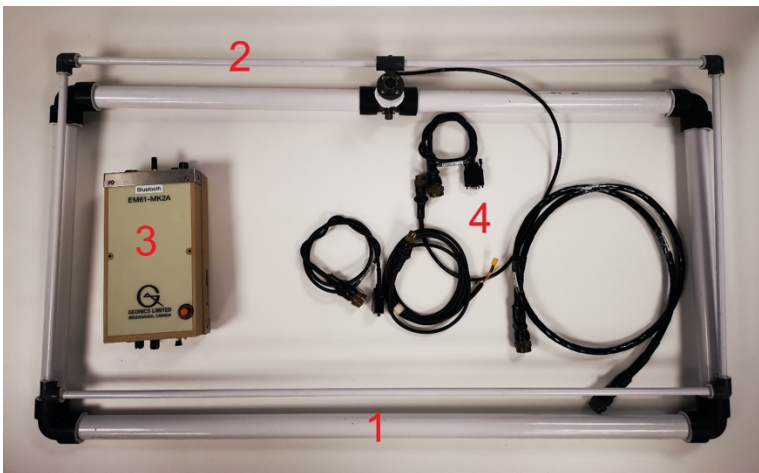
1 – Sensor coil: size: 1 x 0.5 m, weight: 3.4 kg

2 – Noise compensation coil: size: 1 x 0.5 m, weight: 0.35 kg

3 – Console: size: 28 x 14 x 8 cm, weight: 1.4 kg

4 – Cables, weight: 0.35 kg

Total weight of EM61Lite set is 5.5 kg.

ALTIMETER

To achieve good results (and for the safety of the drone) it is vital to control precise low altitude over the ground surface. For the metal detector recommended flight altitude is 0.5...1.0 m between sensor coil and the ground,

We use a high-frequency radar altimeter with precision 2cm and a special terrain-following algorithm to keep the altitude of the drone constant during automatic survey missions.

ON-BOARD COMPUTER

The heart of the integrated system is UgCS SkyHub – a small and powerful onboard computer with special software.

The first function of this onboard computer is to maintain a constant altitude of the drone over the surface using data from the radar altimeter. Standard DJI drones do not have such function and rely on a barometric altimeter for altitude control. Unfortunately, it is not a precise sensor and altitude drift per single flight can be up to several meters.

The second function of the onboard computer is to store metal detector measurements in geotagged form. To geotag data, the UAV's GPS receiver is used. If the drone is equipped with an RTK/PPK receiver, data points will have coordinates with precision down to centimeters.

Measurements are stored in simple textual CSV format with coordinates allowing the import to a variety of software capable to process XYZ data (Surfer, Oasis montaj).
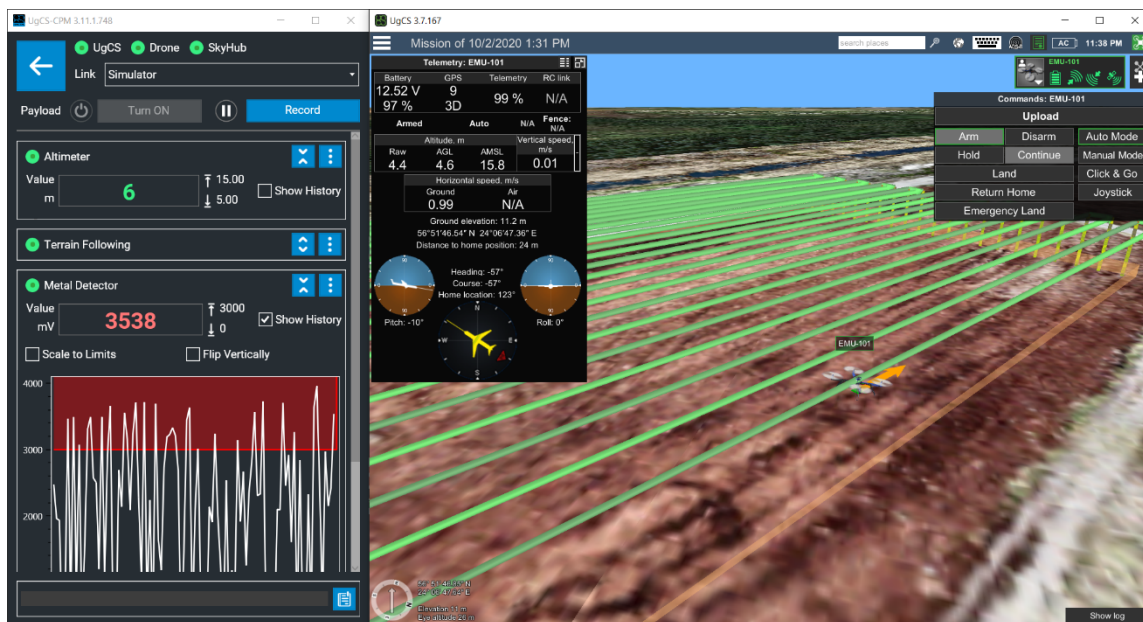
Data logging begins automatically after take-off and stops after landing.

The onboard software also sends current metal detector data to the ground station allowing the operator to make sure that everything is functioning and to see detections in real-time.

User manual for UgCS SkyHub: https://integrated.ugcs.com/dl/docs/skyhub-user-manual-r4.pdf

GROUND CONTROL SOFTWARE AND CUSTOM PAYLOAD MONITOR

The ground control software is UgCS with the additional companion application (UgCS Custom Payload Monitor) that controls the metal detector. During the flight operator on the ground can see current data from metal detector.

Video – https://youtu.be/NdNis68X-7E

Sample data set with pipes and drums detection – https://files.ugcs.com/s/e5rygGibeYFQbix