

Integrated System for Bathymetry with Echo Sounder

System description

Bathymetry measures the depth of water in oceans, rivers, or lakes. The standard measurement tool for bathymetry is an echo sounder, and the survey process involves using a ship, boat, or unmanned surface vehicle (USV) as a platform for the sensor.

Sometimes, the use of a boat can be complicated, especially in the case of small or hard-to-reach rivers and lakes. The use of USV is only feasible in some situations, too. Firstly, it is necessary to have a good point of entry to the water for deployment/recovery. Secondly, using USV in shallow lakes with lots of seaweed may be impossible. Last but not least, in many cases, USV should be big enough to resist the waves, and a big car may be necessary to transport it.

An alternative is to fly a drone (UAV) to carry the echo sounder. A drone is compact and easy to transport and deploy. Drones also have a high precision of following planned survey lines and can be used anywhere where there is at least a small area for take-off and landing near the surveyed water surface.

The integrated drone system for bathymetry includes the following:

- A commercially available drone like DJI M350/M300 RTK or drone based on the Pixhawk autopilot,
- Echo sounder sensor on a rope (cable),
- Radar altimeter to measure the precise altitude of the drone over the water surface,
- On-board computer to control the mission and store geotagged measurements,
- Software to control the mission.

Below is the photo of configured system before take-off.



The sensor

Three options exist for single-beam echo sounders (please see the table below). All sensors are manufactured by Korean company EofE Ultrasonics Ltd. (<https://www.echologger.com/>), which specializes in survey-grade sonar products.

All echo sounders are equipped with integrated tilt sensors, allowing to reject data when the sensor attitude is not close to vertical, and temperature sensor.

The nominal accuracy of all echo sounder models is 0.2% of the depth, and the resolution is <1mm.

Sensor	ECT 400S	ECT D052S	ECT D024S
Type	Single frequency	Dual frequency	Dual frequency
Acoustic frequency	450 kHz	50/200 kHz	200 kHz / 450 KHz
Measurement range*	0.15 ... 100m	1.0 ... 200m (50 kHz) 0.5 ... 200m (200 kHz)	0.5 ~ 200m (200 kHz) 0.15 ~100m (450 kHz))
Beam width Conical (-3dB)	5°	27° / 7° (50 kHz/200 kHz)	10° / 5°
Weight of the echo sounder (in the air)	275g	460g	280g
Weight of all components in the air (echo sounder, SkyHub, altimeter, housing, cables, mountings)	1.6 kg (light housing) 2.6 kg (heavy housing)	2.7 kg	1.6 kg (light housing) 2.6 kg (heavy housing)

(*) Measurement range is from the bottom of transducer. The practical minimum depth is around 15cm deeper because the sensor should be submerged during measurement.

The sensors use the RS232 interface to provide robust data transmission via long cable.

Altimeter

For precise depth measurements (and for the safety of the drone) it is vital to control precise altitude over the water's surface.

We use a high-frequency [radar altimeter](#) and a special terrain (surface) following algorithm to keep the altitude of the drone constant during automatic survey missions.

On-board computer

The heart of the integrated system is 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 water 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. With a radar altimeter, on the other hand, the drift of flight altitude is about 10 cm.

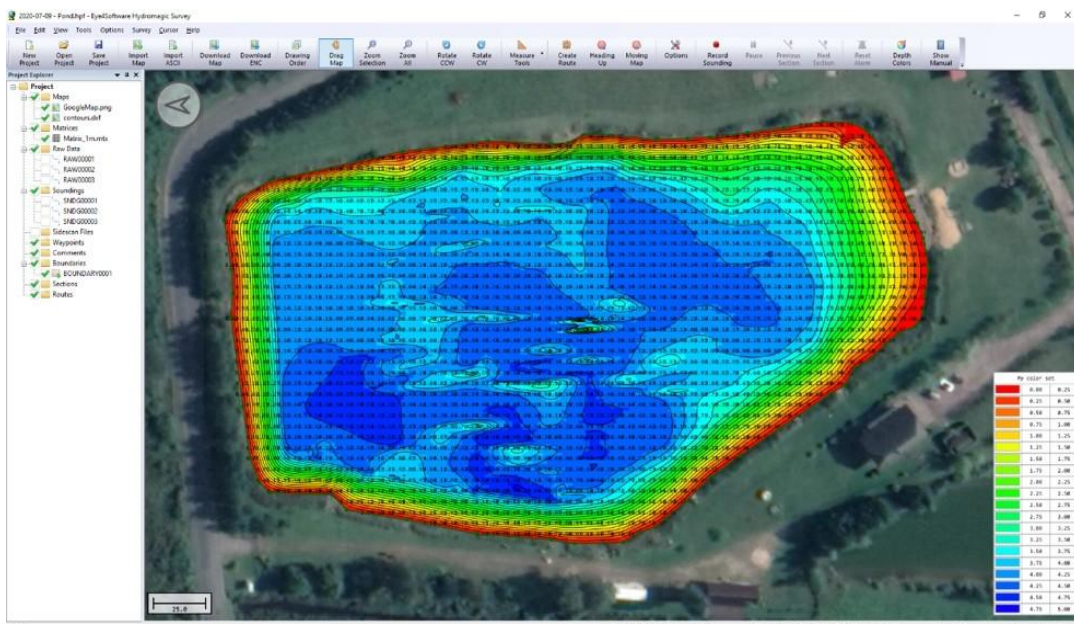
The second function of the onboard computer is to log echo sounder measurements in geotagged form. To geotag data, the UAV's GPS receiver is used. If the drone is equipped with an RTK/PPK receiver, data points will have coordinates with precision down to centimeters.

Measurements are stored in three formats:

- simple textual CSV format with coordinates, depth and additional information allowing the import to a variety of software capable to process XYZ data (Surfer, Oasis Montaj, Excel),
- NMEA 0183 compatible with popular hydrographic software ([HydroMagic](#), [Reefmaster](#)),
- SEG-Y with full echo sounder data.

In addition to depth measurements, water temperature and tilt angles of the sensor are logged.

Example of a colored depth map, data processed in the HydroMagic software:

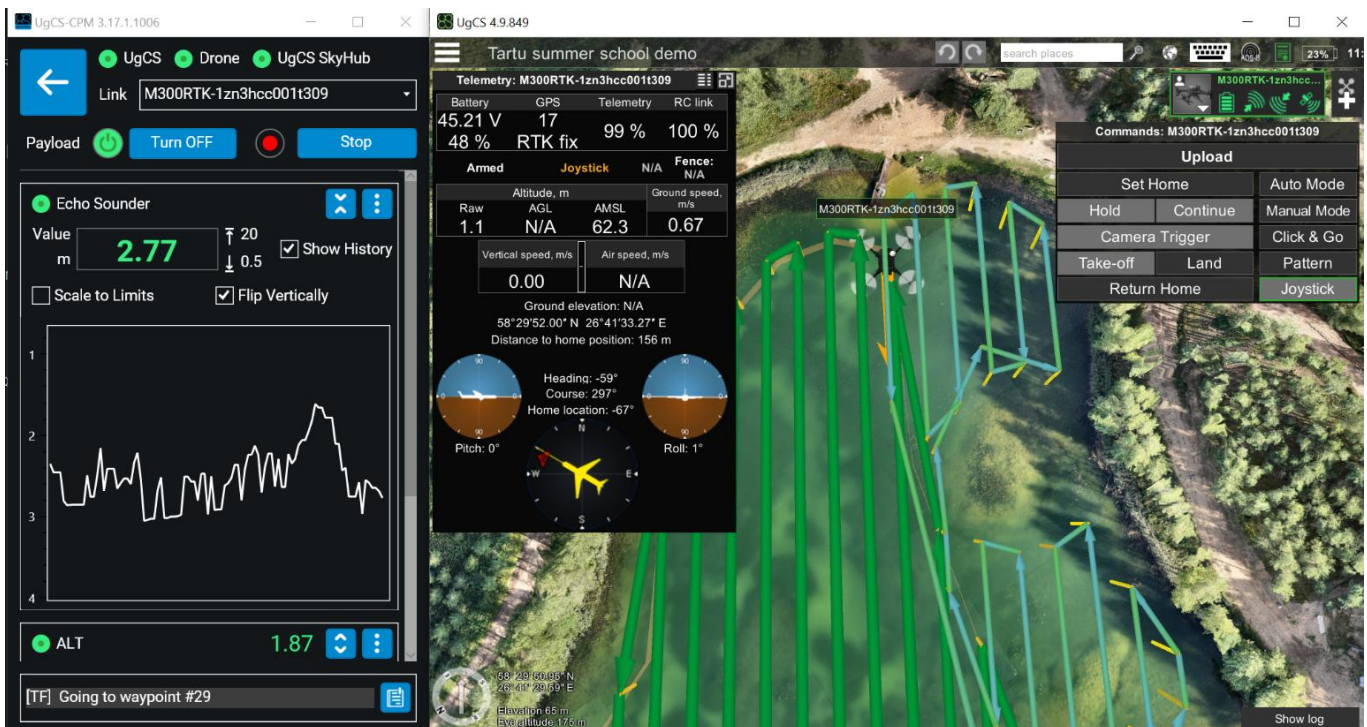


Data logging begins automatically when the echo sounder is submerged and stops when the sensor is in the air again.

The onboard software also sends current depth measurements to the ground station allowing the operator to make sure that everything is functioning as it should and to make manual measurements (when the drone is not on an automatic mission).

Ground Control Software

The ground control software is [UgCS](#) with the additional companion application that controls the echo sounder. During the flight operator on the ground can see current depth measured by echo sounder.



Usage scenarios

The integrated system supports 3 modes of operations:

- continuous measurements along survey lines;
- measurements in specified waypoints;
- manual measurement.

In the first case, the drone operator should plan missions with a survey grid (or separate lines) over water. When sensors are submerged underwater, data logging will start automatically. The drone will tow the submerged sensor on low speed (0.5 – 0.7 m/s) and perform constant depth measurements. In some cases, continuous measurements cannot be done, for example, if there is a lot of seaweed in the water. In such a case, the operator should plan a grid over water and set waypoints where it is necessary to make a “shot”. The drone will fly between waypoints, descend to required altitude to submerge the sensor, make measurements, ascend to a safe altitude and move to the next waypoint.

Video of the lake survey near Riga - <https://youtu.be/rsxTDhion70>

Video of surveys in Israel - <https://youtu.be/LN1ybqPMJ3A>

Data sets - <https://files.ugcs.com/s/t67bWmaEjG6nDD6>