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Ultra-lightweight integrated unmanned aerial systems for a wide range of geophysical magnetic exploration: a single system for high-precision archaeological surveys to rugged topography geological acquisitions

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Magnetic mapping is commonly used in the academic and industrial sectors for a wide variety of objectives. To comply with a broad range of survey designs, the use of unmanned aerial vehicles (UAVs) has become frequent over the recent years. The majority of existing systems involves a magnetic acquisition equipment and its carrier (an UAV in this context) with no -or very few- connections between the two systems. Terremys is conceiving and optimizing UAVs specifically adapted for geophysical magnetic acquisitions together with the appropriate processing tools, and performs magnetic surveying in challenging environments. Terremys' "Q6" system weights 2.5 kg in air, including UAV & instrumentation, and allows 30 min swarm or individual flights.

Rotary-wing UAVs are found to be the most adaptive systems for a wide range of contexts and constraints (extensive range of flights heights even with steep slopes). They offer more flight flexibility than fixed-wing aircrafts. One of the major problems in the use of rotary-wings UAVs for magnetic mapping is the magnetic field generated by the aircraft itself on the measurements. Towing the magnetic sensor 2 to 5 m under the aircraft reduces data positioning accuracy and decreases the performances of the UAV, which can be critical for high-resolution surveys. To overcome these problems, a deployable 1 m long boom is rigidly attached to the UAV. The UAV magnetic signal can be divided between 1-the magnetic field of the whole equipment and 2-a low to high frequency magnetic field mostly originating from the motors. The magnetization of the system is the principal source of magnetic noise. It is modelled and corrected by calibration-compensation processes permitted by the use of three-component fluxgate magnetometers. The time-varying noise depends on the motors rotational speed and is minimized by optimizing the UAV components and characteristics along with the boom's length.

The final set-up is able to acquire magnetic data with a precision of 1 to 5 nT at any height from 1 to 150 m above ground level. The high-precision magnetic measurements are coupled with a centimetric RTK navigation system to allow for high-resolution surveying. The quality of the obtained data is similar to that obtained with ground or aerial surveys with conventional carriers and matches industrial standards. Moreover, Terremys' systems merge in real-time data from all

the aircraft instruments in order to integrate magnetic measurements, positioning information and all the UAV's flight data (full telemetry) into a unique synchronized data file. This opens up many possibilities in terms of QA/QC, data processing and facilitates on-field workflows.

Case studies with diverse designs, flight altitudes and targets are presented to investigate the acquisition performances for different applications, as distinct as network positioning, archaeological prospecting or geological mapping.

The full integration of the magnetic sensor to the drone opens the possibility for implementation additional sensors to the system. The adjoining of other magnetic sensors would allow multi-sensors surveying and increases daily productivity. Diverse geophysical sensors can also be added, such as thermal/infrared cameras, spectrometers, radar/SAR.