Demonstration of a fully integrated handheld Ultra Lightweight ElectroMagnetic Array (ULEMA-H)

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# Abstract

Current and former battlefields as well as military practice ranges are littered with potentially hazardous remnants of war, such as unexploded ordnances (UXO) and landmine. Remediating UXOs is time-consuming and costly process that poses significant safety risks to both civilians and military personnel. While advanced geophysical sensors capable of single-pass detection and classification are commercially available, they are often large and bulky. These systems typically weigh hundreds of pounds and require carts or vehicles for deployment, restricting their effectiveness in UXO remediation across diverse landscapes. As a result, their use is limited in challenging environments such as uneven terrain, forested areas, mountain cliffs, and other difficult-to-access locations.

Over the past five years, our group has designed, developed, built, and tested a prototype handheld advanced geophysical classification sensor designed for deployment in challenging terrains. The system features four coplanar transmitter coils—three 40 cm diameter coils arranged in a triangular configuration and a larger coil wrapped around them. Additionally, it incorporates four triaxial receiver cubes, providing a total of 48 data channels. The transmitter sequentially energizes the coils, achieving an EMI data output rate of 7.5 full data cycles per second. The sensor integrates a compact Real-Time Kinematic (RTK) GPS with a compact antenna and an Inertial Measurement Unit (IMU), delivering centimeter-level positioning and attitude data at 10 Hz. The measured EMI signals are co-registered with GPS and IMU data to enhance data inversion accuracy and generate DAGCAP-compatible classification and detection results from single-pass ULEMA-H datasets. The sensor weighs approximately 14 lbs and is designed to be carried by a single operator, while an additional team member collects data remotely via a MATLAB-based user interface, untethered from the sensor head.

This paper presents the detection and classification capabilities of the fully integrated single-pass ULEMA-H and RTK-GPS system. Data was collected over a set of buried targets at a test site, including three sizes (small, medium and large) of Industry Standard Object (ISO) of varying material (aluminum, brass and iron) buried at depths ranging from 0.08 m to 0.5 m. In addition to the thirteen ISO pipes, the test site contained six metallic clutter items. The results of target detection, localization, and classification are presented and highlighted.