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A Cost-Efficient Method for Detecting Unexploded 122mm 9M22U Rockets Using Remote Sensing

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INTRODUCTION

- The BM-21 Grad is a Soviet multiple rocket launcher with a high failure rate (over 4%) that may result in up to 1,640 explosive fragments in a 640m x 640m lethal area.[1]

Figure 1: BM-21 Grad[2]

- Magnetometers are sensors that detect magnetic disturbances in the Earth's surface.[3]
- BM-21 Grad 122mm rockets (see figure 6) are composed of magnetic material such as aluminum, so they can be detected by mounting a magnetometer to a drone with a programmed flight path over an area.[4]

Figure 2: Circada drone flying the UMT MFAM Magpike over a test-site in Ukraine

METHODS

1. The UMT MFAM MagPike was mounted on a Cicada drone (see figure 2)
2. Flew the MFAM over multiple sites that had simulated UXOs and live 9M22U rockets
3. Parsed and de-striped Raw magnetics data to remove directional interference
4. Removed the takeoff, landing, and line leveling errors from the data using Arc Map.
5. Removed the total magnetic field from each data set
6. Created Power Spectral Density (PSD) plots to analyze site-wide background noise
7. Visualized each data set using Kriging interpolation, and a low-pass convolution filter was used to remove signal noise for data analysis

Tiny drone-based magnetic sensors can cost-effectively detect unexploded rockets

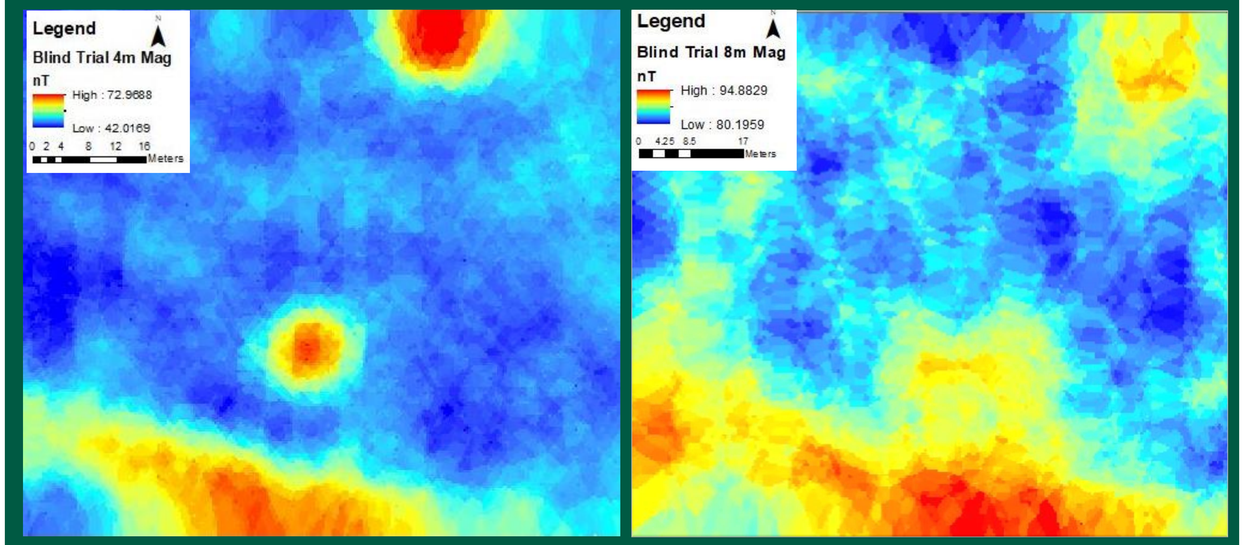

Figure 3: Aerial images of unexploded 122mm 9M22U rockets collected from Ukraine. In the left image, the magnetometer is collecting data from 4 meters above ground level, while the right image depicts data collected at 8 meters above ground level. The two buried rockets are identifiable by the circular red spots, with the elongated red spot on the bottom of the image being a road.

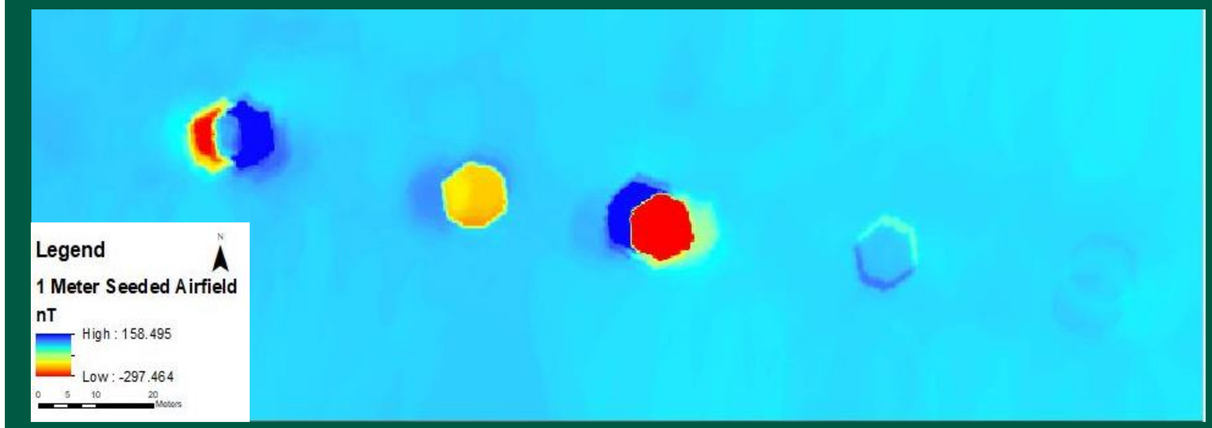

Figure 4: 1-meter magnetometer data collected over an airfield in Chernihiv, Ukraine. The trial was completed at ground level with a handheld magnetometer. Being closest to the surface resulted in the clearest imaging, indicating that there are six anomalies in the survey area.

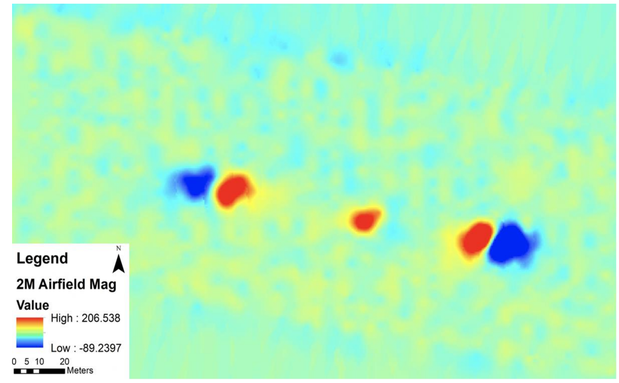

Figure 5: Aerial magnetometer data taken over an airfield in Chernihiv, Ukraine. The magnetometer was oriented 2-meters above the ground. The airfield contained three large unexploded rockets, which are identifiable compared to the background magnetic signature of the site.

RESULTS/CONCLUSIONS

1. Magnetometry is an effective method for visualizing large unexploded ordnances.

2. The methodology is less effective for detecting small munitions.

3. Magnetometry reduces false positive rates by being highly accurate.

4. The effectiveness of MFAM tapers off as the distance of the drone increases from the target (see figure 3).

Figure 6: BM-21 Grad 122-millimeter rocket

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