# *Ground-coupled Remote Sensing Robotic Snake for Humanitarian Demining in Cambodia*

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## INTRODUCTION

- "In 2010, nearly 300 people were killed or injured by landmines and unexploded ammunition in [Cambodia]" (Cambodian Mine Action Center)
- Currently there are no efficient automated methods of detecting subsurface mines in heavily vegetated areas of Cambodia without destroying vegetation

Figure 1: TM-62 Anti-Tank Mines in Cambodia

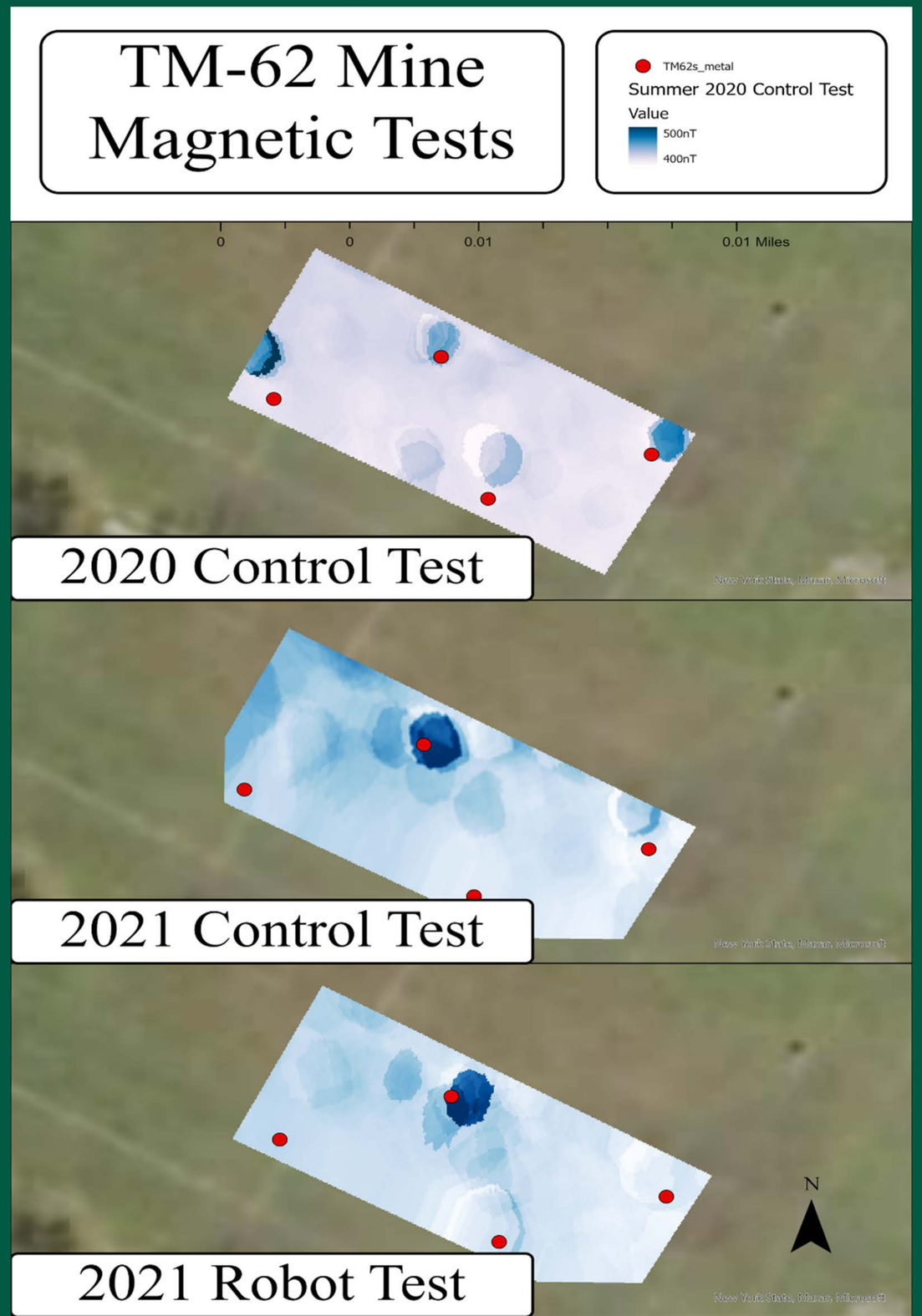
- Magnetometers are sensors that detect magnetic disturbances in the Earth's surface.[1]
- TM-62 are large mines designed to detonate under and destroy military tanks. Those, along with smaller anti-personnel mines, are left uncleared in Cambodia
- Mines have magnetic components

Figure 2: TM-62 field test site at Binghamton; Figure 3: "Fruit Loop" the robot designed to carry an MFAM under vegetation

## METHODS

1. Geometrics MFAM Developer Kit was tested at ground level over a 15m x 25m field of TM-62 shells in Binghamton, NY
2. Binghamton students collaborated with engineers at Villanova University to design a robot which could carry the MFAM
3. Field tests with and without robot at ground level at Binghamton University TM-62 simulated site
4. Parsed and de-striped Raw magnetics data to remove directional interference
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

# Ground-level magnetic surveys show potential for robotic demining in Cambodia



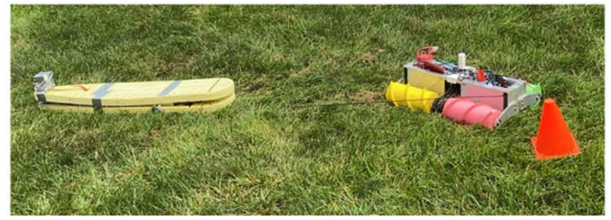



Figure 4: The "snake bot" system: robot designed by Villanova and Binghamton University student carries behind it an MFAM magnetic sensor over a field of TM-62 mine shells. If this method works to produce images that detect mines, it can be used to prevent land razing by traveling under vegetation to detect mines.

## RESULTS/CONCLUSIONS

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

2. MFAMs, while designed to be small enough to be transported aerially, can produce useful surveys at ground level.

3. Introducing a remote-controlled robot reduces the signal accuracy of the MFAM slightly, but with magnetic shielding and further post-processing it creates images accurate enough for landmine detection.

## FUTURE WORK

- The Binghamton University and Villanova University teams hope to travel to Phnom Penh, Cambodia to conduct on-site field tests and work with the local community to assist their demining work
- Shift to programming to automate raster image production ordnance location. We currently have written programs to process data and produce images, but not mine detection

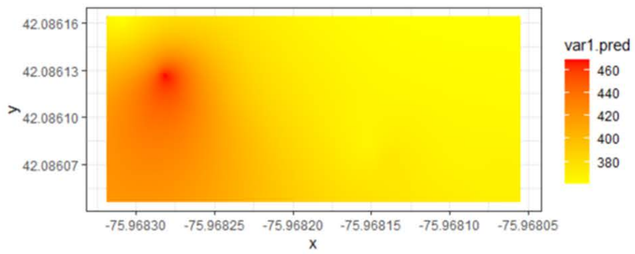



Figure 5: Magnetic survey raster created using R program and ggplot2 package

## REFERENCES

1. Walsh, N.E., and W.S.Walsh (2003) Rehabilitation of landmine victims — the ultimate challenge. Bulletin of the World Health Organization, 81, 665-670.

2. Clayton, G. M. (September 1, 2018). "Mechatronics for Humanitarian Explosive Ordnance Disposal in Cambodia." ASME. Mechanical Engineering. September 2018; 140(09): S4–S10. https://doi.org/10.1115/1.2018-SEP6

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