



TECHNICAL PAPER

STANDARDIZED UXO DEMONSTRATION SITES

ARM GROUP INC. – MINELAB EXPLORER II METAL DETECTORS/HANDHELD

BLIND GRID SCORING RECORD NO. 695



The Minelab Explorer II Metal Detector in the handheld platform is shown as demonstrated by Arm Group Inc.

The Minelab Explorer II Metal Detector in the handheld platform was demonstrated by Arm Group Inc. at the Aberdeen Proving Ground Standardized Demonstration Site's Blind Grid Area.

This technical paper contains the results of that demonstration.

This is a reference document only and does not serve as an endorsement of the demonstrator's product by the US Army or the Standardized UXO Technology Sites Program.

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Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland and Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the U.S. Army Environmental Center (USAEC), The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP) and the Army Environmental Quality Technology Program (EQT).

DEMONSTRATOR'S SYSTEM AND DATA PROCESSING DESCRIPTION

The Minelab Explorer II metal detector is designed as a metal detector for amateur prospectors. It is currently being used on a number of projects as an unexploded ordnance (UXO) detector because it incorporates features that are considered advantageous to detect and discriminate between UXO-related material targets and non-UXO-related material targets. The system can be considered a hybrid of better known PEMI and FD systems in that it transmits a CW waveform based on 28 frequencies ranging between 1.5 and 100 kHz but uses time domain gating techniques to demodulate the signal and derive the target response.

The main feature that has attracted the interest of the UXO community is the real-time target discrimination capability: a two-dimensional map that plots a target response according to its electrical conductivity (on the horizontal axis of the screen) and a purely ferrous response (vertical axis). Operators quickly learn to recognize well-known objects such as bottle tops, coins, nails, etc., based on their on-screen location. Another feature of the Explorer II is its use of sophisticated filtering algorithms to process the target responses, specifically to enhance the signal-to-noise ratio of a detected target against the background response due to the soil or rock. Finally, the Explorer II must be used with a continuous sweeping action across the ground, and the sweeping speed can aid in target discrimination.

The Minelab F3 metal detector is the latest product to be developed by Minelab for landmine detection; eventually, the F3 will supersede the F1A4. The F3 incorporates all of the features of Minelab's patented and well-known Multi Period Sensing technology that has been very successful at eliminating magnetic soil responses. The main difference is that the transmitted waveform in the F3 is bipolar. This type of waveform was developed to produce an instrument that would not set off certain classes of landmines that respond to conventional unipolar electromagnetic induction.

Similar to the F1B2 and F1A4, the F3 provides a two-channel output, available through a serial RS232 interface at the rate of 100 Hz, or alternatively can be used for detection using the audio tone. The most significant difference between these instruments is that the F3 incorporates more digital logic circuitry and microprocessing power. The F3 also has a waveform consisting of a positive long pulse and a negative shorter pulse period with significantly higher amplitude that ensures both pulses have an equal area, resulting in a net zero effect on magnetic mines. The two different pulse lengths are the specific innovations that provide the ability to null out the geologic noise in real time.

A significant improvement in the F3 over previous versions is that it operates in a direct current (DC) mode all the time, and it does not suffer from drift in the same way as the F1 series. Operators find this feature particularly useful if they are accustomed to the F1 series, which required them to repeatedly sweep the coil across the ground at a fast speed in order to detect targets. The coil can be moved as fast or as slow as the operator requires since it does not have an alternating current (AC) filter that can attenuate a response with a slow-moving coil as is the case of the F1 series of detectors.

PERFORMANCE SUMMARY

Results for the Blind Grid test, broken out by size, depth and nonstandard ordnance, are presented below. Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range. The results are relative to the number of ordnances emplaced. Depth is measured from the geometric center of anomalies.

The Response Stage results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the Discrimination Stage are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90-percent confidence limit

on probability of detection and probability of false positive was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

The overall ground truth is composed of ferrous and non-ferrous anomalies. Due to limitations of the magnetometer, the non-ferrous items cannot be detected. Therefore, the summary presented in the Ferrous Only table exhibits results based on the subset of the ground truth that is solely the ferrous anomalies. The second table exhibits results based on the full ground truth. The response stage noise level and recommended discrimination stage threshold values are provided by the demonstrator.

SUMMARY OF BLIND GRID RESULTS FOR THE EXPLORER II/HAND HELD

| Metric | Overall | Standard | Nonstandard | By Size | | | By Depth, m | | |
|-----------------------------|---------|----------|-------------|---------|--------|-------|-------------|-----------|------|
| | | | | Small | Medium | Large | < 0.3 | 0.3 to <1 | >= 1 |
| RESPONSE STAGE | | | | | | | | | |
| P_d | 0.65 | 0.65 | 0.70 | 0.75 | 0.60 | 0.40 | 0.95 | 0.50 | 0.40 |
| P_d Low 90% Conf | 0.59 | 0.55 | 0.56 | 0.66 | 0.48 | 0.19 | 0.89 | 0.37 | 0.21 |
| P_d Upper 90% Conf | 0.73 | 0.74 | 0.79 | 0.95 | 0.72 | 0.85 | 1.00 | 0.81 | 0.57 |
| P_f | 0.75 | - | - | - | - | - | 0.95 | 0.60 | 0.35 |
| P_f Low 90% Conf | 0.68 | - | - | - | - | - | 0.88 | 0.52 | 0.09 |
| P_f Upper 90% Conf | 0.80 | - | - | - | - | - | 0.99 | 0.71 | 0.67 |
| P_{fa} | 0.25 | - | - | - | - | - | - | - | - |
| DISCRIMINATION STAGE | | | | | | | | | |
| P_d | 0.60 | 0.65 | 0.55 | 0.75 | 0.50 | 0.40 | 0.90 | 0.45 | 0.30 |
| P_d Low 90% Conf | 0.53 | 0.53 | 0.45 | 0.64 | 0.36 | 0.19 | 0.78 | 0.34 | 0.16 |
| P_d Upper 90% Conf | 0.68 | 0.72 | 0.69 | 0.83 | 0.61 | 0.65 | 0.95 | 0.58 | 0.50 |
| P_f | 0.60 | - | - | - | - | - | 0.65 | 0.55 | 0.35 |
| P_f Low 90% Conf | 0.52 | - | - | - | - | - | 0.56 | 0.46 | 0.09 |
| P_f Upper 90% Conf | 0.66 | - | - | - | - | - | 0.76 | 0.66 | 0.67 |
| P_{fa} | 0.25 | - | - | - | - | - | - | - | - |

Response Stage Noise Level: 0.50

Recommended Discrimination Stage Threshold: 20.50

Note: The recommended discrimination stage threshold values are provided by the demonstrator.

To view the full Scoring Record for this demonstration and for all other demonstrations conducted at the Aberdeen and Yuma Proving Grounds in support of the Standardized UXO Technology Demonstration Sites Program please visit our Web site at: www.uxotestsites.org.

