**Objective:** Determine the level to which data acquired at APG and YPG using commercial EMI and Magnetic sensors support feature-based discrimination decisions

- Evaluate discrimination performance for various models, classifiers, and training data

We selected five data sets based on data quality, type, signal-to-noise, and availability at appropriate intermediate processing stages.

We used five data sets based on data quality, type, signal-to-noise, and availability at appropriate intermediate processing stages.

### Datasets Selected

<table>
<thead>
<tr>
<th>System</th>
<th>Configuration</th>
<th>Positioning System</th>
<th>Lane Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRL EM61 Array</td>
<td>Towed Array</td>
<td>DGPS</td>
<td>0.5g</td>
</tr>
<tr>
<td>NRL EM63 Array</td>
<td>Cart</td>
<td>DGPS</td>
<td>0.5</td>
</tr>
<tr>
<td>Magnetic Array</td>
<td>Towed Array</td>
<td>DGPS</td>
<td>0.25</td>
</tr>
</tbody>
</table>

*Note: surveys collected along perpendicular transects

### Targets of Interest

- **20mm to 155mm Projectile to GP Bomb**
- **Thick walled munitions debris**

### Non-targets of Interest

- **Thick walled munitions debris**

### Criteria

1. Common across data sets
2. Well characterized by models

### Training Data

**Open Field Labels**

- Labelled data not emplaced or selected to provide maximum value for discrimination
- Anomalies in clusters: 112 @ APG, 50 @ YPG

**Reasons for release:**

- 23: least found
- 41: never found
- 17: misclassified
- 7: clear fence
- 3: misclassified

### Results Example

**Classification performance was found to be poor, regardless of model or classifier, if we include all UXO (20mm to GP bombs) in the TOI class.**

Shown here is a typical receiver operating characteristic curve. It is for the NRL EM61 array using the dipole model. Regardless of the data, model, classifier, and/or feature selection methodology used, classification performance is marginal at best.

### Results Summary

- Poor classification is observed if the objective is to separate all UXO from all non-UXO

- Target size is not a useful metric given the diversity of emplaced UXO

- Principal axis polarizations not constrained well enough for shape-based classification

- Classification performance improves significantly if we restrict the TOI-class to specific size ranges

### Results Limit TOI Class

If we restrict the range of UXO included in the TOI class, making it perhaps more reasonable, and classify based primarily on inverted target size, classification performance improves dramatically.

<table>
<thead>
<tr>
<th>Small UXO (&lt;57mm)</th>
<th>Medium UXO (57mm to 2.75”)</th>
<th>Large UXO (&gt;105mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small clutter:</td>
<td>Medium clutter:</td>
<td>Large clutter:</td>
</tr>
<tr>
<td>weight &gt; 1000 g</td>
<td>weight &gt; 8000 g</td>
<td>weight &gt; 8000 g</td>
</tr>
<tr>
<td>57mm</td>
<td>105mm</td>
<td>105mm</td>
</tr>
<tr>
<td>105mm</td>
<td>2.75”</td>
<td></td>
</tr>
</tbody>
</table>

### Classes

- **K-Nearest Neighbor (KNN)**
- **Support Vector Machine (SVM)**
- **Relevance Vector Machine (RVM)**
- **Generalized Likelihood Ratio Test (GLRT)**
- **K-Nearest Neighbor (KNN)**
- **Support Vector Machine (SVM)**
- **Relevance Vector Machine (RVM)**

### Methods

- Dipole Model
- **Magnetic dipole**
- **GEM-3 Array**
- **APG**
- **YPG**
- **Dipole Model (3 polarizations) EM61 MK2 Cart**
- **Simultaneous fit of 5-loop model (weights) Simultaneous FDTD**
- **Dipole Model (3 polarizations)**
- **Magnetic dipole**
- **GEM-3 Array**

### Configuration

- **Calibrated Array**
- **Uncalibrated Array**
- **Dipole Model (3 polarizations) EM61 MK2 Cart**
- **Simultaneous fit of 5-loop model (weights) Simultaneous FDTD**
- **Dipole Model (3 polarizations)**
- **Magnetic dipole**

### Probability of False Alarm

- Small UXO: 0.27
- Medium UXO: 0.30
- Large UXO: 0.30

### Probability of Detection

- Small UXO: 0.57
- Medium UXO: 0.47