# Application of Spheroidal Mode Approach to the Detection and Discrimination of Buried Objects

**X. D. Chen**[1], **K. O'Neill**[2], **T. M. Grzegorczyk**[3], **and J. A. Kong**[3]

[1]National University of Singapore, Singapore
[2]ERDC Cold Regions Research and Engineering Laboratory, USA
[3]Massachusetts Institute of Technology, USA

The detection and removal of buried unexploded ordnance (UXO) is an important environmental problem, made very expensive and challenging by the high false alarm rate. Among the techniques for detecting UXOs, electromagnetic induction (EMI) is promising and has been widely explored. In the magneto-quasistatic (MQS) regime, both the primary and the secondary magnetic fields are irrotational and can be expressed in terms of the gradient of a scalar potential governed by the Laplace equation. In this work, both the primary and the secondary magnetic fields are expressed as linear superpositions of basic modes in the spheroidal coordinate system. Spheroidal modes are chosen because the spheroidal coordinate system can be made to conform to the general shape of an object of interest, whether flattened or elongated, and many of our objects of interest are bodies of revolution. Due to the orthogonality and the completeness of the spheroidal basic modes, the scattering coefficients, in response to unitary magnitude of the primary mode excitation, are uniquely determined. They are characteristics of the object and can then be treated as discriminators in pattern matching and classification. The scattering coefficients are retrieved from the knowledge of the secondary fields, where both the synthetic and measurement data are used. The ill-conditioning issue is dealt with by mode truncation and Tikhonov regularization technique. Stored in a library, the scattering coefficients can produce fast forward models for use in pattern matching. Also they can be used to train a support vector machine (SVM) to sort objects into generic classes, such as elongated or not, permeable or not. The success of the retrieval from both synthetic and measurement data shows the promise of the spheroidal mode approach in the detection and classification of buried objects.