

Army Environmental Quality Technology (EQT) Program

Overall Description

Objective: The February 1998 Defense Science Board (DSB) Task Force report titled “Landmine Detection and De-mining and Unexploded Ordnance (UXO) Clearance” (Ref. 2) recommends a short term (3–5 year) tenfold false alarm reduction as the goal of the UXO Environmental Remediation R&D program. The Army UXO program objective defined by the ETMP is to achieve the DSB goals and to develop and demonstrate technologies that meet the exit criteria for detection/discrimination performance, production rates, and costs listed in the A (1.6.a) Environmental Quality Technology Operational Requirements Document (EQT-ORD). Successful completion of the RDT&E efforts described here will substantially reduce UXO site remediation costs while improving detection capabilities to over 95% for all ordnance types at their maximum site-dependent penetration depths. This will be accomplished by thoroughly defining the impact of site conditions on sensing and discrimination of UXO and developing and demonstrating robust multi-sensing approaches and physics-based analysis and joint inversion techniques to mitigate these site-dependent effects. Specific technology development and demonstration efforts associated with this program are detailed in the appendix of the execution plans of the PMP. The objectives of these efforts are summarized as follows:

- [**FY02 Objectives**](#)
- [**FY03 Objectives**](#)
- [**FY04 Objectives**](#)
- [**FY05 Objectives**](#)

Specific technical goals of this program include:

- Improving the capability to detect subsurface and shallow water UXO thereby reducing residual risks and facilitating acceptance by regulators and stakeholders.
- Improving discrimination capability in order to significantly reduce UXO remediation costs without increasing residual risks.
- Improving buried UXO identification capability in order to reduce safety risks associated with UXO removal and disposal activities.

To successfully meet these goals, significant breakthroughs are required in the following technology efforts:

- Develop and validate models of Magnetic (MAG), Electromagnetic induction (EMI), and Ground Penetrating Radar (GPR) signatures of UXOs in representative environmental/ geophysical conditions. Incorporate these models into physics-based data analysis systems for improved UXO detection and discrimination.
- Develop, evaluate, and demonstrate enhanced sensors and associated platforms for subsurface and shallow water UXO detection/discrimination.
- Develop, integrate, evaluate, demonstrate, and transition advanced multi-sensor technologies.

Major Program Thrusts, BA2/3 and BA4/6 Thrusts:

- **BA2/3 Thrusts:**
 - I. Site Characterization Issues and Approach Strategy**
 - II. Modeling, Analyses, and Processing**
 - III. Sensor Design and Enhancement**
 - IV. Hand Held UXO Detector Design Thrust Oversight**
- **BA4/6 Thrusts:**
 - I. Standardized Sites**
 - II. UXO Technology Demonstrations**
 - III. Hardware/Software Integration**
 - IV. Geophysical QA/QC**
 - V. Technology Transfer**

[Link to the Army EQT UXO Management Plan \(PMP\)](#)

[Link to the EQT Operational Requirements Document \(ORD\)](#)

[Link to reports/activities](#)

- **[Standardized Guidance for Geophysical Prove-Outs](#)**

For further information, please contact the AEC Hotline:

Technology Transfer Hotline

T2hotline@aec.apgea.army.mil

(800) USA-3845, DSN 584-1699

Overall Description

Description: The Environmental Technology Management Plan (ETMP) summarizes the major thrust areas, work units, performers, and funding required to execute the Army's unexploded ordnance (UXO) research, development, test, and evaluation (RDT&E) program for the EQT Program. The RDT&E efforts described herein address a high priority Army Environmental Requirement and Technology Assessment (AERTA) user requirement (Restoration 1.6.a, UXO Screening, Detection, and Discrimination) and are fully coordinated with other UXO Environmental Remediation (UXO-ER) RDT&E programs within the Department of Defense (DoD), such as those executed by the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP).

The characterization of UXO contaminated lands and shallow waters continues to be the Army's highest priority environmental restoration problem and is a highly visible issue that involves a variety of stakeholders, including: the U.S. Environmental Protection Agency (EPA), state and local regulators, land owners, land managers, and numerous local citizens' groups. In order to successfully address this problem, the Army needs significantly improved sensing, positioning, analysis, and visualization technologies that efficiently and effectively characterize and remediate sites that may contain surface, subsurface, and underwater UXO.

As posed by the user community in Restoration Requirement A (1.6.a), UXO Screening, Detection, and Discrimination, the taxonomy of the RDT&E efforts to be conducted under the ETMP include three primary thrust areas: wide area screening, ground based detection and discrimination, and shallow water detection and discrimination. The limited capabilities of current technologies to screen for, detect, and discriminate UXO are well documented. Of particular concern is the inadequate capability to discriminate subsurface UXO from the manmade or natural clutter found on a site. This inability to distinguish hazardous UXO from non-hazardous site anomalies results in unacceptably high remediation costs and intolerable residual risks. The ETMP presents a strategy and execution plan that addresses the development and demonstration of technologies, procedures, and methodologies to meet each of these user-identified needs.

Objectives

FY02 Objectives:

- Initiate field demonstrations at Standardized UXO Technology Demonstration Sites to baseline capabilities of current handheld and man portable UXO detection and discrimination systems.
- Provide comprehensive sensor performance specifications (probability of detection, probabilities of false alarm, false alarm rates, discrimination performance, and receiver operating characteristics curves) for UXO target, environmental, geophysical, and clutter combinations using advanced electromagnetic, magnetic, and ground penetrating radar.
- Validate advanced UXO signature models of emerging sensors to support multi-sensor systems development and integration and improved analysis techniques.
- Establish baseline for meeting exit criteria.

FY03 Objectives:

- Provide validated UXO signature models of emerging sensors to support multi-sensor systems development and improved analysis techniques.
- Develop advanced multi-sensor prototype systems for field demonstrations and validation
- Demonstrate advanced man portable and vehicular towed UXO detection and discrimination systems.

FY04 Objectives:

- Complete field demonstrations of dual mode sensors systems.
- Transition handheld sensor technologies to user.
- Transition advanced algorithms to commercial users.
- Open Active Response UXO Demonstration Site
- Open wide area survey Standardized UXO Technology Demonstration Site
- Baseline shallow water UXO detection and discrimination technologies
- Demonstrate standardized guidance for geophysical prove outs.

FY05 Objectives:

- Complete development and field demonstrate UXO sensing and analysis that will reliably reduce false alarm rates by 90% over a wide variety of conditions while also improving the current Probability of Detection (Pd) levels to 98% for all UXO types to their maximum site dependent penetration depths.
- Conduct advanced technology demonstrations to validate improvements in UXO detection and discrimination capabilities.
- Transition validated technologies to field use.
- Conduct Standardized UXO Technology Demonstration Program 2005.
- Demonstrate and validate discrimination and detection software packages.
- Complete demonstration of fill identification technologies.

BA2/3 Thrusts

Four Major Thrust Areas:

I. Site Characterization Issues and Approach Strategy

- A. [Identification and Evaluation of Key Site Parameters Impacting Technology](#)
- B. [Expert System to Support UXO Site Characterization Technology Selection](#)
- C. [Verification of MAUDE Model](#)

Rationale: Develop expedient site characterization procedures for UXO detection survey planning. What are the magnitudes and the spatial variability scales (horizontal and vertical) of the key geophysical parameters—permittivity, permeability/susceptibility, and conductivity? Does this geologic background pose problems for system performance of specific UXO detection sensors? What are the sources and magnitude of background cultural clutter, including ordnance-related debris? Considering the geologic and cultural backgrounds, which sensing method or combination of methods is required? Considering the site OE history, what is the likely distribution of ordnance sizes, types, and depths? What specific sensor characteristics, line spacing and measurement spacing along line are required for the site specific OE history? Develop an “expert system-like” planning and training tool for UXO detection efforts.

II. Modeling, Analyses, and Processing

- A. [Investigation of Time Domain EMI and Magnetic Methods for Enhanced UXO Detection and Discrimination](#)
- B. [Evaluation of Advanced Signature Models and Inversion Technologies](#)
- C. [Joint Inversion Investigations for UXO Discrimination](#)
- D. [Develop Processing Schemes to Enable Discrimination of UXO-Like Shapes in Composite Targets](#)
- E. [Develop Improved Ultra-Wideband \(UWB\) Survey Protocols, Associated Sensor Designs and Processing Algorithms for Enhanced Discrimination of Buried UXO from Clutter](#)
- F. [Advanced Sensor Data Analysis Technologies for Improved Buried Target Detection and Discrimination](#)

Rationale: Survey and assimilate all available UXO models and modeling efforts. Assess strengths, weaknesses, and gaps. Develop comprehensive suite of forward and inverse (single, constrained, and joint) modeling tools for total field magnetic (TFM), time-domain electromagnetic induction (TDEM), and frequency-domain electromagnetic induction (FDEM) datasets. Examine signature definition and resolution issues for detection and discrimination with various sensor types and configurations. Develop executable modules and protocols for handoff to an enhanced data acquisition/data analysis system. The EQT-funded chemical sensor development effort has advanced the fundamental knowledge of the compounds and concentrations associated with the chemical signatures of buried UXO, and has established processes and metrics that support advanced sensor development. This program will fund the S&T portion of this effort to completion, and will transition this technology to agencies conducting advanced chemical sensor development and demonstration research to address the UXO discrimination problem. This effort will also support follow-on development of sensors to

address the requirement for identifying and remediating the environmental problems associated with the releases of other UXO constituents.

III. Sensor Design and Enhancement

- A. [Frequency Domain EM Enhancements](#)
- B. [Enhanced Data Acquisition/Data Analysis System \(DAQ/DAS\)](#)
- C. [UXO Sensor Positioning and Tracking Technologies](#)

Rationale: Optimal sensor and survey geometry for buried object “illumination” will be investigated for enhanced detection and discrimination. Requirement or desirability of total field versus gradient information will be assessed. Enhanced sensors will be developed to improve Signal to Noise Ratio (SNR), data throughput, data fidelity, and integrated navigation/positioning. New sensor designs investigated previously, as part of BA1 efforts will be matured as appropriate. Feasibility of dual mode sensors will be assessed, e.g., dual TDEM/FDEM, dual TFM/EM. Develop comprehensive DAQ/DAS protocols. Assess available software, e.g., MTADS DAS, U-Hunter, Geosoft, etc., for overall functionality: versatile geo-referencing capability; anomaly picking and display; capability for versatile analysis tools, e.g., thresholding, simple analytical/empirical anomaly assessment, and model-based inversion modules; GIS-type display and query, etc. Select and enhance or develop modular and adaptable DAQ/DAS software for fielded capability. Key system issues such as versatile navigation/positioning options, from RTK differential GPS to acoustic to radio wave to laser reflectometer, platform stability, sensor standoff (interference) issues, etc., will be investigated. Platform stability issues include variable height above surface and variable tilt and associated requirements for corrections for positions and sensor readings.

IV. Hand Held UXO Detector Design Thrust Oversight

- A. [UXO Multi-sensor Systems Design, Oversight and Integration](#)

Rationale: In addition to a general-purpose large area surveying capability and compatible man-portable adjunct, a hand-held survey capability is needed. The hand-held system must record data digitally and include navigation/positioning that can be geo-referenced to all other survey data. The hand-held instrument should be adaptable for different OE items of interest and different desired depths of detection and be deployable in rugged and/or heavily vegetated areas. The ideal hand-held system might be dual-mode sensor, e.g., a combination of magnetic and electromagnetic sensors.

A workshop will be held to: (1) define the “ideal” or near-ideal system capability and operational constraints; and (2) brainstorm and define key design and implementation issues.

This thrust to design a hand-held UXO detector system will be managed as an umbrella oversight function of the above three thrusts to insure arrival at a prototype design to hand off to BA4 by the end of FY03, for prototype completion by the end of FY04, with subsequent field demonstration in FY05.

Key Products:

Thrust I: Guidelines, Expert System

Thrust II: Forward and Inverse Modeling Capability; DAQ/DAS for systems

Thrust III: New/enhanced sensor designs and configurations; Dual-mode sensors; Integrated, adaptable navigation capability; Sensor/platform adaptations to rugged terrain, vegetated terrain

Thrust IV: New hand-held UXO detector prototype design

BA4/6 Thrusts

During the construction of the BA4 and BA6 Program, the PDT recognized that the T&E program did not fully fit into the Thrust Areas as identified in Appendix D. Therefore the PDT modified the thrusts to coincide with the developed program.

Required BA4 activities fall into the following Thrust areas:

Thrust I. Standardized Sites

- A. [Standardized UXO Technology Demonstration Site Support](#)
- B. [Wide Area Survey Standardized Technology Demonstration Site](#)
- C. [Establishment of Active Response Demonstration Areas](#)

This thrust area focuses on the need to both establish and maintain Standardized UXO Technology Demonstration Sites to demonstrate UXO detection and discrimination technologies. The creation of Wide Area Survey Sites will support future demonstrations utilizing aerial platforms. The Active Response Demonstration Areas will demonstrate a correlation between technology performance at standardized sites and UXO remediation sites. Efforts under this thrust will support the other thrust areas in this ETMP as well as other COTS and GOTS technology demonstration and validation efforts.

Thrust II. UXO Technology Demonstrations

- A. [Hand Held UXO Detector Design Demonstration and Validation](#)
- B. [Baseline Handheld/Man Portable System Performance](#)
- C. [Standardized UXO Technology Demonstration 2005](#)
- D. [Sensor/Platform Integration and Demonstration](#)
- E. [Demonstrate UXO Detection Systems in Shallow Water](#)
- F. [Demonstration of Fill Identification Technologies](#)

This thrust area focuses on demonstrating and evaluating a wide variety of UXO detection and discrimination technologies. Efforts in this thrust directly support the demonstration of BA2/BA3 developed prototypes from this program as well as other COTS and GOTS technologies. Not only will this thrust area baseline hand held, man portable, vehicular towed, and shallow water systems, but also provide the data to document the advancements made by this EQT programs. The performance of technologies demonstrated in this thrust area will be used to meet the exit criteria stated in the EQT-ORD.

Thrust III. Hardware/Software Integration

- A. [Software Demonstration/Validation Assessment](#)
- B. [Modeling Analyses and Processing Demonstration/Validation](#)
- C. [MAUDE Demonstration Validation](#)

This thrust area focuses on demonstrating and evaluating the advancements of hardware and software development efforts. Models and systems demonstrated/validated will be transferred to the user community to support site characterization procedures and detection/discrimination technology performance. Software will be demonstrated and integrated into discrimination platforms to support

the improvement of UXO detection and discrimination systems in a variety of geophysical and environmental conditions.

Thrust IV. Geophysical QA/QC

- A. [Standardized Guidance for Geophysical Prove-Outs](#)
- B. [QC for UXO Sensor Technology Operators](#)

This thrust area focuses on establishing guidance for geophysical prove outs and quality control procedures for sensor technology operators. The ultimate goal will be to have this guidance ratified as an ASTM document method. The influence of UXO sensor technology operators on results has not been thoroughly documented. This thrust area will determine the level of influence and provide feedback to the community on mechanisms to mitigate the impact of the operator.

Thrust V. Technology Transfer

- A. [Technology Transfer Support](#)
- B. [Technology Review and Knowledge Exchange Seminar](#)

This focus area will support the transfer of information, technologies, results, lessons learned, products, and experience to the user community. This thrust area will provide the mechanism and support necessary to accomplish technology transfer for the other thrust areas.

Required BA6 activities involve documentation and coordination required to implement, transfer, and support developed and demonstrated technologies in the BA4 program.

S&T (BA2/3) Major Thrust Areas:

I. Site Characterization Issues and Approach Strategy

A. S&T EQT Military RDT&E Project Execution Plan

TITLE: Identification and Evaluation of Key Site Parameters Impacting Technology

OBJECTIVE: The objective of this work unit is to identify the geophysical, geological, and cultural parameters that influence the sensors used for UXO detection. This encompasses (1) identifying current, proto-type, and potential technologies for detecting UXO, (2) identifying the magnitudes and spatial variability of geophysical parameters, (3) identifying the sources and magnitude of environmental parameters (geological and cultural), and (4) relating the geophysical and environmental parameters and how they impact the UXO detection sensors.

DESCRIPTION: The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and FUDS is the Army's highest priority Environmental Restoration problem. Geophysical techniques are routinely used to detect UXO during the investigative phase of a cleanup operation. The geophysical methods commonly employed are magnetometry, EMI, and GPR. In the early technology demonstrations, little attention was given to how the geologic environment and cultural background impact the geophysical sensor measurement. Those demonstrations and more recent ones clearly indicate that the geologic and cultural background can significantly interfere with the ability to detect and discriminate UXO. It is no longer reasonable to perform a UXO survey without prior assessment of the key geophysical and environmental (geologic and cultural) parameters of a site. The geophysical parameters, e.g. magnetic permeability/susceptibility, electrical conductivity, and dielectric permittivity, can vary in magnitude and spatially (horizontally and vertically) within a site. The data sampling density used during a geophysical survey is dependent on the variability of these parameters. Environmental factors such as geology, topography, hydrogeologic setting, soil conditions, OE history, and ordnance-related and other man-made debris all influence the value measured by the UXO detection sensor. A compilation of geophysical and environmental parameters and how they influence the geophysical sensors employed during UXO surveys will aid in the planning of time and cost effective UXO detection surveys.

BENEFITS: This work unit will provide a reference identifying the geophysical and environmental parameters and how they can influence sensors employed to detect UXO. The results will be used in developing the computer software MAUDE – a Management Aid for UXO Detection Efforts – that will be completed under an AF25-301E work unit in FY03.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Compile list and technical specifications of UXO detection sensors	2Q02
Compile list of geophysical parameters and expected range in magnitude for a variety of soil types	3Q02
Identify and meet with complementary sources (U-Hunter, Geosoft, etc.)	3Q02
Compile list of common UXO, dimensions, and expected magnitude response at varying depths and orientations in different soil types for UXO detection sensors	4Q02
Compile list of common cultural clutter, dimensions, and expected magnitude response at varying depths and orientations in different soil types for UXO detection sensors	4Q02
Relate geophysical and environmental parameters to sensor specifications and identify when background may interfere with sensor performance	1Q03

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Guidelines for UXO detection survey planning	3Q03

EXECUTION:

1. ERDC, Geotechnical and Structures Laboratory, Environmental Laboratory, Vicksburg, MS

B. S&T EQT Military RDT&E Project Execution Plan

TITLE: Expert System to Support UXO Site Characterization Technology Selection

OBJECTIVE: The objective of this work unit is to develop expedient site characterization procedures for UXO detection survey planning. The guidelines developed in a FY02 AF25-301E work unit and other site-related information (cultural background, OE history, etc.) will be incorporated into the software MAUDE – a Management Aid for UXO Detection Efforts. The software will

provide a user-friendly, time and cost effective means for determining the sensor technology and survey procedure to employ for UXO detection surveys.

DESCRIPTION: The Army spends millions of dollars annually on the cleanup of UXO contaminated areas. A significant portion of this cost is incurred during the UXO detection survey-planning phase. An expedient means of incorporating site information and detection sensor specifications to generate a survey plan would aid in reducing UXO cleanup costs.

Considerations in common with all UXO detection survey planning are what sensors to employ and what should be the data sampling density. These questions are inherently associated with the influence of the geophysical and environmental characteristics of the site on the detection sensors. Although the physical attributes of UXO contaminated areas vary from site to site, the same considerations and general procedure are employed when developing a UXO detection survey plan. This commonality is the basis for the software MAUDE. The software is a user-friendly UXO detection survey-planning tool that incorporates a variety of historical and technical information to outline a time and cost effective survey plan. Topics addressed by the software include (1) OE history—likely distribution of ordnance sizes, types, and depths, (2) sources and magnitude of background cultural clutter, including ordnance-related debris, (3) influence of geologic background on detection sensors, (3) magnitude and spatial variability of geophysical parameters, (4) considering the geophysical and environmental backgrounds, which sensing method or combination of methods is required, and (5) given the chosen sensors, what is an acceptable data density—line spacing and measurement along line. The guidelines put forth in a FY02 AF25-301E work unit describing the UXO detection sensor specifications, geophysical and environmental parameters, and the parametric influence on the sensors will be incorporated into MAUDE. The program will be flexible to allow the inclusion of developmental sensor technologies. The program can be used as a general planning tool or local site information can be input to obtain a more detailed plan. The program will be suitable for both novice and more experienced UXO detection survey planners and complement other UXO-related software such as U-Hunter and Geosoft.

BENEFITS: The software MAUDE developed under this work unit will provide UXO detection survey planners a time and cost efficient design tool. Use of this program will help in reducing UXO cleanup costs.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Outline MAUDE software platform and structure	1Q03
Incorporate UXO detection guidelines	2Q03
Incorporate site-related information (OE history, cultural background, etc.)	3Q03

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Management Aid for UXO Detection Efforts (Beta version)	4Q03

EXECUTION:

1. ERDC, Geotechnical and Structures Laboratory, Information Technology Laboratory, Vicksburg, MS

C. S&T EQT Military RDT&E Project Execution Plan

TITLE: Verification of MAUDE—a Management Aid for UXO Detection Efforts

OBJECTIVE: The objective of this work unit is to evaluate computer software that was developed under a FY03 AF25-301E work unit. The software MAUDE – a Management Aid for UXO Detection Efforts – will be evaluated using real UXO cleanup site scenarios to identify its weaknesses and incorporate changes and recommendations for improvement.

DESCRIPTION: The Army spends millions of dollars annually on the cleanup of UXO contaminated areas. A significant portion of this cost is incurred during the UXO detection survey-planning phase. The software MAUDE – a Management Aid for UXO Detection Efforts – was developed to aid detection survey planners in reducing the time and cost of producing an effective plan. The software will be tested and evaluated using historical, geophysical, geological, and cultural data available from established UXO Standardized Test Sites. Results of these tests will be used to refine the software.

BENEFITS: This work unit will produce an in-house tested version of the software MAUDE ready for demonstration and evaluation under a FY04 BA4 work unit in preparation for transition to users. MAUDE will enable UXO site managers to reduce the time and cost of planning a UXO detection survey.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Select first Standardized UXO Technology Demonstration Site and test MAUDE	1Q04
Select second Standardized UXO Technology Demonstration Site and test MAUDE	2Q04

Modify and improve MAUDE 3Q04

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Enhanced and verified MAUDE software	3Q04

EXECUTION:

1. ERDC, Geotechnical and Structures Laboratory, Information Technology Laboratory, Vicksburg, MS
2. Standardized UXO Technology Demonstration Sites (possible candidates are APG, YPG, MMR)

II. Modeling, Analyses, and Processing

A. S&T EQT Military RDT&E Project Execution Plan

TITLE: Investigation of Time Domain EMI and Magnetic Methods for Enhanced UXO Detection and Discrimination

OBJECTIVE: The objective of this Work Unit is to develop advanced geophysical technologies to enhance the ability to discriminate buried UXO in a wide range of environmental and geophysical conditions. The goal of this effort is to demonstrate the role of innovative geophysical technologies in achieving the goal of a 75% reduction of false alarm rates at well characterized UXO test under a variety of natural and man-made clutter conditions, while maintaining a high probability of detection (e.g., >90%).

DESCRIPTION: The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and FUDS is the Army's highest priority Environmental Restoration problem. There are currently over 11 million acres in the U.S. that may contain UXO. The characterization and remediation of these sites using currently available technology is prohibitively expensive and hazardous mainly due to the extraordinarily high level of false detections as well as the inability to achieve 100% probability of detection. It is currently estimated that over 70% of UXO remediation costs are due to excavating non-UXO items (false alarms). The 1997 Defense Science Board Task Force report on "Landmine Detection and De-mining and UXO Clearance" calls for a short term (3-5 year) tenfold false alarm reduction. To reach this goal, advanced technologies that can accurately detect and discriminate buried UXO must be developed and demonstrated.

The effects of environmental/geophysical conditions and man-made clutter on buried UXO detection and discrimination capabilities will be defined by modeling and controlled laboratory and field experiments. Particular emphasis will be placed on defining and quantifying the factors that control magnetic, gravimetric, and TDEM signatures of buried UXO. Advanced sensing and analysis technologies will be developed to mitigate these effects and field tests will be conducted to quantify the performance enhancements.

BENEFITS: This work unit advances capabilities for UXO detection and discrimination in four areas: (1) assessment and field application of emerging geophysical technologies; (2) knowledge of the role of environmental, geologic and geophysical backgrounds in detection capability; (3) development of forward modeling (prediction or simulation) capability for gravity, magnetic (total field and vector components), and TDEM of UXO geophysical anomaly signatures; (4) development of initial approaches to inverse modeling capability for determination of geophysical anomaly source characteristics.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Enhanced phenomenological assessment of geologic/geophysical backgrounds at JPG	09/99
Establish UXO test site at ERDC, Vicksburg site	09/99
Prototype UXO gravity modeling program	09/99
Field validation and documentation of gravity model	09/00
Field validation and documentation of predictive model for vector magnetic signatures of UXO	09/00
Validated TDEM forward modeling procedures	09/00
Documented TDEM inverse modeling procedures	09/01
Full scale field surveys with new technology at documented test sites	09/01
Documented magnetic inverse modeling procedures	09/02
Documentation of results of full-scale field surveys at documented test sites	09/02

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Documentation of phenomenological impacts of background on UXO detection and discrimination	09/30/99
Forward and inverse TDEM modeling capability	09/30/01
Forward and inverse magnetic modeling capability	09/30/02
Documentation of field performance of advanced geophysical technology and interpretation procedures at documented field test site	09/30/02

EXECUTION:

1. ERDC, Geotechnical and Structures Laboratory, Vicksburg, MS
2. University of British Columbia (UBC), Vancouver, British Columbia, Canada
3. Other Contractor through BAA

B. S&T EQT Military RDT&E Project Execution Plan**TITLE:** Evaluation of Advanced Signature Models and Inversion Technologies

OBJECTIVE: The objective of this Work Unit is to develop advanced geophysical data processing and analysis approaches to enhance the ability to discriminate buried UXO in a wide range of environmental and geophysical conditions. The goal of this effort is to exploit forward and inverse modeling and joint inversion capabilities developed under multi-year BA2 research projects that end in FY02 and FY03 to develop a real-time analysis capability for integration and interpretation of multiple-sensor type datasets, leading to enhanced capability for UXO discrimination and identification as part of a specialized UXO DAQ/DAS.

DESCRIPTION: The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and FUDS is the Army's highest priority Environmental Restoration problem. There are currently over 11 million acres in the U.S. that may contain UXO. The characterization and remediation of these sites using currently available technology is prohibitively expensive and hazardous mainly due to the extraordinarily high level of false detections as well as the inability to achieve 100% probability of detection. It is estimated that over 70% of UXO remediation costs are due to excavating non-UXO items (false alarms). The 1997 Defense Science Board Task Force report on "Landmine Detection and De-mining and UXO Clearance" calls for a short term (3-5 year) tenfold false alarm reduction. To reach this goal, advanced technologies that can accurately detect and discriminate buried UXO must be developed and demonstrated.

Under BA2 RDT&E projects that end in FY02, forward and inverse modeling techniques for TFM, magnetic vector component, TDEM, and FDEM have been developed. These models and approaches have been validated by application to geophysical signature databases for selected ordnance types and also to the analysis of datasets acquired at test sites (e.g., Fort Ord, CA). Another RDT&E project that ends in FY03 seeks to develop constrained, cooperative, and joint inversion capabilities for rational integration or "fusion" of multi-sensor type datasets.

The present work unit will exploit products from the preceding BA2 projects to produce near real-time and support development of real-time analysis algorithms for interpretation of geophysical survey data acquired at UXO environmental restoration and active range clearance sites. More specifically, the real-time algorithms goal will be to enable advanced data processing as part of the field processing. Provision will be incorporated for manual and automated anomaly selection from multiple datasets, with location cross-correlation. Anomalies can be selected using a range of criteria, e.g., simple thresholds, spatial characteristics, polarity, etc. Selected anomalies can be interpreted using a variety of analysis and inversion approaches. Simple location coincidence across multiple datasets is the simplest analysis approach. More sophisticated approaches will involve individual dataset inversion, cooperative and constrained inversion of multiple datasets, joint inversion of multiple datasets, reduced parameter model representations, and neural net and/or expert system functionality to guide the processes. The artificial intelligence guides will assess key factors such as data types, data quality, site coverage, and known site conditions to utilize the most sophisticated approach that the overall situation will support.

BENEFITS: This work unit will exploit advanced capabilities for UXO detection, discrimination and identification developed under previous projects to (1) identify circumstances when multiple data types are advantageous or essential, (2) ensure full consideration of multiple geophysical data types when available, (3) develop procedures to rigorously invert multiple datasets, (4) develop intermediate approaches using constrained and cooperative inversion, (5) develop reduced parameter model representations, (6) develop artificial intelligence guides for algorithm selection and application, and (7) identify approaches to efficiently transition the "real-time" analysis algorithms and overall capability to the generalized system DAQ/DAS being developed under another project.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Manual and automated anomaly selection and Cross-correlation between multiple datasets	09/03
Implementation of various data processing and inversion algorithms in a real-time analysis algorithmic framework	09/04

Artificial intelligence guides to selection of optimum analysis approaches 09/04

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Real-time analysis algorithms for geophysical anomaly selection and classification and constrained, cooperative, reduced parameter, and joint inversion of multiple geophysical data types, with AI guides	09/04

EXECUTION:

1. ERDC, Geotechnical and Structures Laboratory, Vicksburg, MS
2. Contract Developer(s)

C. S&T EQT Military RDT&E Project Execution Plan

TITLE: Joint Inversion Investigations for UXO Discrimination

OBJECTIVE: The objective of this Work Unit is to develop advanced geophysical data integration and interpretation approaches to enhance the ability to discriminate buried UXO in a wide range of environmental and geophysical conditions. The goal of this effort is to exploit forward and inverse modeling capability developed under multi-year BA2 research projects that end in FY02 to develop constrained, cooperative and joint inversion approaches for rational interpretation of multiple-sensor type datasets, leading to enhanced capability for UXO discrimination and identification.

DESCRIPTION: The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and FUDS is the Army's highest priority Environmental Restoration problem. There are currently over 11 million acres in the U.S. that may contain UXO. The characterization and remediation of these sites using currently available technology is prohibitively expensive and hazardous mainly due to the extraordinarily high level of false detections as well as the inability to achieve 100% probability of detection. It is estimated that over 70% of UXO remediation costs are due to excavating non-UXO items (false alarms). The 1997 Defense Science Board Task Force report on "Landmine Detection and De-mining and UXO Clearance" calls for a short term (3-5 year) tenfold false alarm reduction. To reach this goal, advanced technologies that can accurately detect and discriminate buried UXO must be developed and demonstrated.

Under BA2 RDT&E projects that end in FY02, forward and inverse modeling techniques for TFM, magnetic vector component, TDEM, and FDEM have been developed. These models and approaches have been validated by application to geophysical signature databases for selected ordnance types and also to the analysis of datasets acquired at test sites (e.g., Fort Ord, CA). Each dataset acquired at a site, e.g., TFM or TDEM, is analyzed separately. Generally, even when two or more types of geophysical data are acquired at the same site, the analysis of one dataset does not make use of the results of the analysis of the other datasets or make use of the information content in all the datasets simultaneously. Model- or physics-based joint inversion of multiple sensor type datasets is the most rigorous approach to integrating or fusing the information content from multiple sensors or platforms to reveal details or features of subsurface objects. Joint inversion rationally accounts for the interrelation of object intrinsic and extrinsic parameters across sensor types, frequency ranges, and measurement scenarios, and quantifies the confidence of UXO discrimination and identification. Achieving true joint inversion of two or more sensor type datasets is a significant technical undertaking and challenge. Intermediate approaches, which can be identified as cooperative and constrained inversion, make use of attributes or constraints derived from one type of sensor data during the inversion of another type of sensor data. In addition to enhanced capability for UXO discrimination, the potential for actual identification of individual UXO type or UXO class will be assessed.

BENEFITS: This work unit advances capabilities for UXO detection, discrimination and identification in five areas: (1) identify circumstances when multiple data types are advantageous or essential; (2) ensure full consideration of multiple geophysical data types when available; (3) develop procedures to rigorously invert multiple datasets; (4) develop intermediate approaches using constrained and cooperative inversion; (5) identify approaches to efficiently transition the joint inversion analyses approaches to real-time analysis algorithms.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Identify requirements and approaches to joint inversion for TFM and TDEM, TFM and FDEM, TDEM and FDEM, etc.	09/02
Complete constrained and cooperative inversion assessments and development	09/02
Complete joint inversion development	09/03
Complete analysis of uncertainties in final UXO discrimination assessments and identifications	09/03

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Algorithms for constrained, cooperative, and joint inversion of multiple geophysical data types and analysis of uncertainties	09/03

EXECUTION:

1. ERDC, Geotechnical and Structures Laboratory, Vicksburg, MS
2. Contract Developer(s)

D. S&T EQT Military RDT&E Project Execution Plan**TITLE:** Algorithms For Inferring Shape Of Composite Targets (UXO)**OBJECTIVE:** Develop processing schemes to enable discrimination of UXO-like shapes in composite targets.**DESCRIPTION:** Many if not most UXO contain more than one metal type. Electromagnetic induction sensors respond differently to different metal types. This creates uniqueness problems for inversion schemes designed to tell whether something is a UXO or UXO-like object. The same general shape can produce very different signatures depending on the particular metals involved, and on how completely they are in contact. This project will produce data processing schemes to allow inference of basic object geometry whether or not composite metallic targets are involved. To do this will require the use of relatively high frequency or "early time" sensors. These emit signals that bounce off the surface of metallic objects and thereby produce signatures depending only on external shape, not internal content. The two sensor types that do this are EMI and GPR. Multi-axial receivers will probably also be required. This project will implement material that develops in the PI's basic research program on composite objects.**BENEFIT:** Because so many UXO consist of composite materials and because this can muddle discrimination and inversion schemes, this project will significantly advance our ability to distinguish UXO-like objects from clutter.**MILESTONES:** Note, the "new or modified instruments" are those developed under other projects within the program, including Improved UWB Survey Protocols, Processing Algorithms, and Sensor Designs (below)

3Q02. Assess relative benefits of existing and prospective sensor systems.

4Q02. Complete first design of new algorithms; complete simulations and analysis needed to test new algorithms; assemble available data and acquire new data with available instruments; perform first test of new algorithms on this data.

3Q03. Revise algorithms and test them using new backyard measurements on representative buried UXO and clutter targets, to the extent possible with new or modified instruments.

3Q03. Handoff algorithms and models to ERDC and contract developers for use in processing.

4Q03. Revise algorithms so that they apply to new generation instruments including time domain; test final versions using backyard measurements on representative buried UXO and clutter targets, using new or modified instruments.

1Q04. Report on algorithms with documentation for their use and evaluation; handoff processing algorithms to other ERDC and contract developers.

PRODUCTS:

One journal article and one conference paper per year; detailed reports on algorithms and their development 2Q03, and on algorithm evaluation 1Q04.

Tested algorithms for distinguishing shape of buried metallic objects, with classification as UXO-like or clutter, whether the objects are homogeneous or composite.

Input to design of new survey systems for implementing these algorithms.

EXECUTORS: ERDC-CRREL and contract developers**E. S&T EQT Military RDT&E Project Execution Plan****TITLE:** Improved UWB Survey Protocols, Processing Algorithms, And Sensor Designs**OBJECTIVE:** Develop improved ultra-wideband (UWB) survey protocols, associated sensor designs and processing algorithms for enhanced discrimination of buried UXO from clutter.**DESCRIPTION:** The combined bandwidth will run from the EMI realm up through GPR. The ultimate sensors in those sub-bands will be physically separate as opposed to being on a single platform or in one "dual mode" instrument. Much of the emphasis will be

on techniques for reducing false alarms due to clutter, as part of the discrimination phase of surveying. Progress in basic research on discrimination of multiple targets, from other projects, will be implemented here. Information obtained from each sub-band will be combined during processing to achieve optimal target classification. Each of the survey modes has its strong points: GPR is superior for estimating target elongation and length (longest dimension), depth, and orientation, for penetrating to greater depths in dry soil, for dealing with composite targets, and for filtering out the signal from widespread small clutter. EMI is superior for penetrating moist soil and for estimating main target aspect ratio. The virtues will be combined in the processing, less by joint processing than by using particular facets of information from each sensor type to constrain the processing done with the other. Multi-axis data will probably be required in each sensor type. The principal thrusts of the work will be:

Calculations to evaluate instrument (especially antenna) design and to design new configurations.

Realization of the most promising new instrument configurations.

Design of new methods for applying the improved instrumentation, e.g. prescribed patterns of antenna movement to develop spatial patterns of frequency or time domain response.

Implementation of innovative processing from this and associated projects to achieve successful discrimination, in terms of overall object shape or isolation of a single UXO-like shape amidst smaller clutter.

BENEFIT: Substantially reduced false alarm rates and rates of missed detections during discrimination phase of surveying.

MILESTONES: NOTE! In terms of fiscal as opposed to calendar years, FY02 is the first year of this project. Because we have only received trickles of funds to date and are already halfway through the year, most of the first year goals that would ordinarily be distributed through the year are lumped into the last quarter.

3Q02. Assess availability and relative benefits of sensor systems from different sources.

3Q02. Complete simulations and design calculations for modifications of these systems or for alternative new ones to fill the needs, and for new survey techniques using them.

3Q03. Complete simulations and algorithm development for new discrimination techniques using both EMI and GPR.

3Q03. Realization of new instrument designs and application algorithms.

3Q03. Handoff of processing algorithms and models to ERDC and contract developers.

4Q03. Test algorithms using backyard measurements on representative buried UXO and clutter arrangements, using new or modified instruments.

1Q04. Handoff of processing algorithms and documentation to ERDC and contract developers for field evaluation.

PRODUCTS: Note, at the end of the B2 part of this project the government would not own the technology. Purchase of the instrumentation would be done under B4.

One journal article and one conference paper per year, intermediate reports and detailed final report.

Tested algorithms for discriminating UXO from clutter using information from both EMI and GPR.

New survey system designs and implementations for these algorithms and the two sensing modes. "Survey systems" here means the instrumentation, in both EMI and GPR, plus a defined protocol for using them (layout and sequence of measurements around each "hotspot," which scattered components to measure, etc).

EXECUTORS: ERDC-CRREL and contract developers.

F. S&T EQT Military RDT&E Project Execution Plan

TITLE: Advanced Sensor Data Analysis Technologies for Improved Buried Target Detection and Discrimination

OBJECTIVE: The objective of this Work Unit is to develop advanced FDEM-based signal processing technologies to enhance the ability to detect and discriminate buried UXO in a wide range of environmental and geophysical conditions. The goal of this effort is to demonstrate the capability to process FEDM induction sensor data to achieve the interim goal of a 75% clutter rejection rates at well characterized UXO test under a variety of natural and man-made clutter conditions, while maintaining a high probability of detection (e.g., >90%) and a false negative rate of less than 5%.

DESCRIPTION: The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and FUDS is the Army's highest priority Environmental Restoration problem. There are currently over 11 million acres in the U.S. that may contain UXO. The characterization and remediation of these sites using currently available technology is prohibitively expensive and hazardous mainly due to the extraordinarily high level of false detections as well as the inability to achieve 100% probability of detection. It is currently estimated that over 70% of UXO remediation costs are due to excavating non-UXO items (false alarms). The 1997 Defense Science Board Task Force report on "Landmine Detection and De-mining and UXO Clearance" calls for a short term (3-5 year) tenfold false alarm reduction. To reach this goal, advanced technologies that can accurately detect and discriminate buried UXO must be developed and demonstrated.

This work unit represents the last year of AF-25 (BA2) funding under the original Army Science and Technology Objective (STO) for UXO Environmental Remediation. During the past 3 years, the primary effects of environmental/geophysical conditions and man-made clutter on buried UXO detection and discrimination capabilities of FDEM sensors have been defined by modeling, algorithm development, and by controlled laboratory and field experiments. Advanced detection and discrimination techniques using FDEM sensor data have been developed during the past 2 years of this BA2 effort. The most effective approaches currently rely on the use of multi-frequency EM data to compute the eigenvalues of the polarizability matrix. These eigenvalues are then evaluated to make the UXO/clutter decision and matched with a UXO signature library to classify the UXO by class/type. These eigenvalue-based techniques will be further refined during FY02 and transitioned to BA4 demonstrations at Standardized UXO Technology Demonstration Sites (gridded areas) during 4A FY02.

BENEFITS: This work unit advances capabilities for buried UXO detection and discrimination using FDEM sensors and addresses the user requirements to reduce risks and costs associated with UXO environmental remediation efforts.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Complete laboratory evaluation of enhanced FDEM Detection/Discrimination software	05/02
Transition FDEM software to field demonstrations	06/02
Documentation of quantified FDEM code performance enhancements	09/02

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
FDEM Detection/Discrimination Software for improved GEM-3 prototype	06/30/02
Documentation of field performance of advanced FDEM Detection/Discrimination Software	09/30/02

EXECUTION:

1. ERDC, Environmental Laboratory, Vicksburg, MS

III. Sensor Design and Enhancement

A. S&T EQT Military RDT&E Project Execution Plan

TITLE: Frequency Domain EM Enhancements

OBJECTIVE: The objective of this Work Unit is to develop improved FDEM induction sensor prototypes to enhance the ability to discriminate buried UXO in a wide range of environmental and geophysical conditions. The interim goal of this effort is to demonstrate the improved FEDM induction prototype's capability to achieve the goal of a 75% clutter rejection rates at well characterized UXO test under a variety of natural and man-made clutter conditions, while maintaining a high probability of detection (e.g., >90%) and a false negative rate of less than 5%.

DESCRIPTION: The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and FUDS is the Army's highest priority Environmental Restoration problem. There are currently over 11 million acres in the U.S. that may contain UXO. The characterization and remediation of these sites using currently available technology is prohibitively expensive and hazardous mainly due to the extraordinarily high level of false detections as well as the inability to achieve 100% probability of detection. It is currently estimated that over 70% of UXO remediation costs are due to excavating non-UXO items (false alarms). The 1997 Defense Science Board Task Force report on "Landmine Detection and De-mining and UXO Clearance" calls for a short term (3-5 year) tenfold false alarm reduction. To reach this goal, advanced technologies that can accurately detect and discriminate buried UXO must be developed and demonstrated.

This work unit represents the last year of the AF-25 project funded under the original STO for UXO Environmental Remediation. This project has produced significant improvements to the GEM-3 system, and the development of the first GEM-5 prototype. In addition, extensive laboratory and field-testing of these sensors have been performed and significant progress has been made in the development of UXO signature databases to support phenomenology studies, modeling, and algorithm development. This project has leveraged funding and results from related SERDP, ESTCP, and SBIR projects. The primary goal of the FY02 portion of this effort is to implement all of the hardware/firmware/software improvements in an improved GEM-3 prototype to hand off to BA4 field demonstrations to be performed during 4Q FY02. The improved GEM-3 will have increased frequency range, improved data acquisition electronics, enhanced real-time analysis capabilities, and improved display. Also under FY02 funding, laboratory investigations will be conducted to evaluate the capability of operating the GEM-3 in a dual TD/FD mode. In addition, different receiver configurations such as magnetoresistive (MR)/giant magnetoresistive (GMR) vs. coils, will be evaluated to determine the

feasibility of operating the GEM-3 as a dual-mode (passive magnetometer/FDEM) sensor. If successful, this work would extend the GEM-3 frequency range to D.C. to over 100 kHz.

BENEFITS: This work unit advances capabilities for buried UXO detection and discrimination using FDEM sensors and addresses the user requirements to reduce risks and costs associated with UXO environmental remediation efforts.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Complete advanced GEM-3 prototype development	05/02
Transition advanced GEM-3 prototype to BA4 field demonstrations	06/02
Technical Report documenting FDEM prototype performance enhancements	09/02
Specifications for improved dual-mode GEM-3 sensor	09/02

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Improved GEM-3 prototype	06/30/02
Specifications for improved dual-mode GEM-3 sensor	09/30/02

EXECUTION:

1. ERDC, Environmental Laboratory, Vicksburg, MS
2. Contract Developer(s)

B. S&T EQT Military RDT&E Project Execution Plan

TITLE: Enhanced Data Acquisition/Data Analysis System (DAQ/DAS)

OBJECTIVE: The objective of this Work Unit is to develop advanced technologies to support the acquisition and analysis of data collected from advanced multi-sensor prototypes developed under other Work Units in this program. Data from multiple UXO sensors and high-accuracy navigation and positioning systems will be acquired, merged, and stored in digital format. Advanced physics-based algorithms and/or model-based joint inversion techniques will be integrated into the DAQ/DAS to provide real-time feedback to the operator regarding sensor data quality, target/clutter information, position accuracy, area coverage, and system status warnings. The goal of this effort is to develop the support technologies required to demonstrate the capability of handheld, man-portable, and shallow water systems to achieve the EQT program's UXO detection, discrimination, location, and production rate goals.

DESCRIPTION: The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and FUDS is the Army's highest priority Environmental Restoration problem. There are currently over 11 million acres in the U.S. that may contain UXO. The characterization and remediation of these sites using currently available technology is prohibitively expensive and hazardous mainly due to the extraordinarily high level of false detections as well as the inability to achieve 100% probability of detection. It is currently estimated that over 70% of UXO remediation costs are due to excavating non-UXO items (false alarms). The 1997 Defense Science Board Task Force report on "Landmine Detection and De-mining and UXO Clearance" calls for a short term (3-5 year) tenfold false alarm reduction. To reach this goal, advanced sensing, positioning, and analysis technologies must be integrated into field-capable platforms to demonstrate the improved capabilities to accurately detect and discriminate buried and shallow water UXO.

BENEFITS: This work unit provides advanced technologies needed to integrate data and algorithms into prototype systems capable of demonstrating improved UXO detection/discrimination performance and addresses the user requirements to reduce risks and costs associated with UXO environmental remediation efforts.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Select initial DAQ/DAS software platform	09/02
Complete multi-sensor DAQ/DAS Prototype	09/03
Complete field evaluations of DAQ/DAS prototypes	12/03
Complete handheld, man-portable, and shallow water DAQ/DAS systems	03/04

Transition optimized DAQ/DAS systems to BA4 field evaluations	09/04
Report documenting system specifications and field performance capabilities of the optimized DAQ/DAS prototypes	09/04

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Design specifications for multi-sensor DAQ/DAS prototypes	09/04
Documentation of field performance of advanced DAQ/DAS Prototypes	09/04

EXECUTION:

1. ERDC, Environmental Laboratory, Vicksburg, MS
2. AEC
3. ATC
4. BAA

C. S&T EQT Military RDT&E Project Execution Plan

TITLE: UXO Sensor Positioning and Tracking Technologies

OBJECTIVE: The objective of this Work Unit is to develop improved positioning and tracking technologies that will allow UXO sensors to operate in difficult environments where GPS and other line-of-sight systems have proven to be unreliable.

DESCRIPTION: The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and FUDS is the Army's highest priority Environmental Restoration problem. There are currently over 11 million acres in the U.S. that may contain UXO. A considerable portion of these areas are located in highly vegetated or mountainous/hilly/steep terrains where GPS and other systems that depend on maintaining line-of-sight access to the UXO sensor platform for accurate tracking and positioning are impractical. The characterization and remediation of these sites using currently available technology is unreliable, prohibitively expensive and hazardous. In order to adequately characterize and remediate these difficult areas, advanced positioning and tracking technologies must be developed and demonstrated.

As part of this effort, we will evaluate the tracking improvements achievable by integrating a low-cost inertial measurement unit (IMU) with a high-accuracy Global Positioning System (GPS). The goal is to develop techniques to efficiently incorporate IMU information so as to increase overall system performance when operating in areas where GPS operation is intermittent. Following field evaluations, we will make a go/no go decision on the IMU integration. During FY03, we will investigate integrating advanced inertial, acoustic, optical, and GPS systems to provide accurate and cost-effective wide-area operation in difficult environments. Following initial laboratory and controlled field evaluations, an optimized prototype system will be developed and transitioned to BA4 field-testing and demonstrations.

BENEFITS: This work unit advances capabilities of UXO sensors to operate in difficult environments, and addresses the user requirements to reduce risks and costs associated with UXO environmental remediation efforts.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Complete GPS/IMU system	11/02
Go/No Go decision on Inertial Navigation-based methods	12/02
Complete evaluation of acoustic/optical/and GPS based methods	03/03
Complete optimum system specifications	06/03
Complete optimized prototype system	09/03

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Prototype GPS/IMU system for tracking handheld systems in highly vegetated environments (transition to BA4)	09/30/02
Documentation of field performance of GPS/IMU prototype system	12/31/02
Optimized prototype positioning and tracking system	09/30/03

EXECUTION:

- 1. ERDC, Environmental Laboratory, Vicksburg, MS
- 2. CEHNC
- 3. Contract Developer(s)

IV. Hand Held UXO Detector Design Thrust Oversight

- A. S&T EQT Military RDT&E Project Execution Plan

TITLE: UXO Multi-sensor Systems Design, Oversight, and Integration

OBJECTIVE: The objective of this Work Unit is to coordinate all of the sensor development activities of the EQT program, as well as to integrate applicable products from other DoD programs such as SERDP, ESTCP, and SBIR. This work unit will develop system-level designs to integrate the multi-sensing technologies into selected handheld and man-portable platforms. Primary thrust of this effort will be to ensure the compatibility, performance, and timely availability of technologies required to transition complete prototype systems to BA4 Dem/Val and ultimately to meet the EQT UXO program’s detection/discrimination performance goals.

DESCRIPTION: The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and FUDS is the Army’s highest priority Environmental Restoration problem. There are currently over 11 million acres in the U.S. that may contain UXO. The characterization and remediation of these sites using currently available technology is prohibitively expensive and hazardous mainly due to the extraordinarily high level of false detections as well as the inability to achieve 100% probability of detection. It is currently estimated that over 70% of UXO remediation costs are due to excavating non-UXO items (false alarms). The 1997 Defense Science Board Task Force report on "Landmine Detection and De-mining and UXO Clearance" calls for a short term (3-5 year) tenfold false alarm reduction. To reach this goal, advanced prototype systems that incorporate multi-sensing, data acquisition, signal analysis, and positioning technologies must be integrated into field-capable platforms to demonstrate the improved capabilities to accurately detect and discriminate buried and shallow water UXO.

BENEFITS: This work unit provides the design and oversight support needed to integrate all of the technologies developed under the Army EQT UXO program into prototype systems capable of demonstrating improved UXO detection/discrimination performance and addresses the user requirements to reduce risks and costs associated with UXO environmental remediation efforts.

MILESTONES:

<u>Milestone</u>	<u>Scheduled Completion</u>
Conduct technology workshop to identify “ideal” dual sensor	05/02
Complete design and fabrication of multi-sensor handheld and man-portable system prototypes	08/03
Complete field evaluations of prototype systems	12/03
Complete design of optimized multi-sensor prototype system	09/04
Final report documenting system specifications and field performance capabilities of the optimized prototype systems	12/04

PRODUCTS:

<u>Product</u>	<u>Delivery Date</u>
Design specifications for multi-sensor prototype systems	02/04
Optimized handheld and man-portable system prototypes	09/04
Documentation of field performance of advanced prototype systems	12/04

EXECUTION:

- 1. ERDC, Environmental Laboratory, Vicksburg, MS
- 2. AEC
- 3. ATC
- 4. Contract Developer(s)

DEM/VAL (BA4 &BA6) Major Thrust Areas:

I. Standardized Sites

A. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Standardized UXO Technology Demonstration Site Support

OBJECTIVE: The objective of this Work Unit is to provide for maintenance and management of the Standardized UXO Technology Demonstration Site Program.

DESCRIPTION: ESTCP and EQT are investing in the construction of Standardized UXO Technology Demonstration Sites for hand held and vehicle based platforms. The demonstration sites require short-term maintenance and programmatic oversight. This oversight includes scheduling, document distribution, scoring, protocol modification, and technology transfer. Other efforts will develop Standardized UXO Technology Demonstration Sites for wide area, shallow water, and live sites.

The maintenance portion will allow for the modification, reconfiguration, expansion, and addition of challenges to the sites. The release of a selected amount of ground truth on a periodic basis requires the site to be reconfigured. The programmatic issue will provide necessary oversight to insure proper use, promote the site, and overcoming developing issues. The EQT Product Delivery Team aided by the site managers will identify necessary maintenance activities during the course of the program.

BENEFITS: The Standardized UXO Technology Demonstration sites provide fair, consistent, and scientifically defensible UXO technology demonstrations. The demonstrations at the sites will provide data to determine if programmatic metrics are being met. The data will also provide measures of improvement caused by the investment in the RDT&E program. Use of the Standardized Sites will establish baseline abilities of technologies that can be done in a statistically valid and repeatable manner.

The standardized sites full potential will be met with proper maintenance, upgrading, and flexible management of the program. This program will allow the Product Delivery Team to show the advancements in technologies, demonstrate positive utilization of S&T funds, and provide an avenue for repeatable, scientifically defensible technology demonstrations into the future.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Programmatic Coordination and Oversight of the Standardized and Active Response Sites	4Q FY05
2	Standardized Site Maintenance	2,3Q FY03, 04, 05
3	Addition of Challenges to Sites	3Q FY05
4	Reconfiguration of Sites	3Q FY03, 04, 05

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC
5. YPG, MMR

B. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Wide Area Survey Standardized Technology Demonstration Site

OBJECTIVE: The objective of this Work Unit is to leverage work being done in the Wide Area Survey Standardized UXO Technology Demonstration Site Program.

DESCRIPTION: The Standardized UXO Technology Demonstration Sites under construction are geared primarily toward hand held and vehicle based systems. Wide Area Survey UXO detection is used to focus the site project manager on areas where further investigation should occur. There are proposed programs through the NDCEE and ESTCP program to begin the preliminary work on the development of the Wide Area Survey Sites. There are funds from NDCEE, ESTCP, and the U.S. Army Aberdeen Garrison to establish an initial site. EQT dollars are needed to leverage the efforts of others to fully develop Wide Area Survey Standardized Technology Demonstration Sites. The Standardized Sites will provide technology baselines and statistically valid data. This program will leverage other programs such as JUXOCO and DTRA to establish necessary protocols to develop and operate wide area sites.

BENEFITS: Wide Area Survey focuses the site managers on areas that contain the highest risk of containing UXO. This allows for the most efficient use of limited resources for UXO restoration. This effort will allow the Army to benefit from the leveraged efforts of other organizations. The Army will also have input on the establishment of the sites and continue to be a leader in the program. Wide Area Survey Standardized UXO Technology Demonstration Sites are needed to produce uniform, statistically valid data for the evaluation of airborne UXO detection platforms.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Leverage ESTCP Efforts	4Q FY02

2	Leverage JUXOCO Efforts	1Q FY03
3	Leverage Protocol Development From NDCEE	2Q FY03
4	Procure Standardized Targets	3Q FY03
5	Construct Standardized Sites	1Q FY04
6	Open Sites	2Q FY04

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC

C. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Establishment of Active Response Demonstration Areas

OBJECTIVE: The objective of this Work Unit is to establish Active Response Demonstration Areas to correlate technology performance between Standardized UXO Technology Demonstration Sites and active Response Areas.

DESCRIPTION: Although the Standardized UXO Technology Demonstration Sites provide an excellent means of base lining and providing statistically valid data for UXO detection and discrimination data, there is concern in the community that a technology performing well on a constructed site may not do as well on an active response site. This program will establish protocols and mechanism to determine the technologies ability to perform on an active response site. This follow up check is important to not only the user community but to the Science and Technology community. The vendor would characterize an area known to contain UXO and provide the dig sheet to the program team. The team would first check anomalies identified by the vendor, correlate their results, and then carefully characterized the entire site. This project will lead into the Standardized UXO Technology Demonstration Program 2005.

BENEFITS: Demonstrations on active response demonstration areas are necessary because of stakeholder concerns that seeded sites are different then active response sites. Technologies that perform well in both the standardized site and the active response demonstration area will provide overwhelming evidence that the technology is technically mature and ready for full implementation by the user community.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Establish Protocols for Active Response Demonstration Area	4Q FY03
2	Identify Applicable Areas	4Q FY03
3	Complete Preparation of Active Response Demonstration Areas	1Q FY04
4	Leverage with Standardized UXO Technology Demonstration Program 2005	1Q FY05
5	Evaluate Active Response Area against Standardized Sites	2Q FY05
6	Suggest Modifications to Standardized UXO Technology Demonstration Sites	3Q FY05

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC

II. UXO Technology Demonstrations

A. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Hand Held UXO Detector Design Demonstration and Validation

OBJECTIVE: The objective of this work unit is to demonstrate dual-mode sensor systems.

DESCRIPTION: The purpose of this effort is to demonstrate the state of the art for currently available dual-mode sensor systems. There will be three focus areas for the BA4 program: Supporting the demonstration of Army EQT BA2/BA3 handheld dual mode products, baseline of the current state of the art of dual mode systems, and demonstration of GOTS and COTS at the end of the program.

There will be an initial workshop held to refine and focus the Army's RDT&E UXO program and to discuss potential dual-mode sensor approaches. There will be demonstrations conducted at the Standardized UXO Technology Demonstration Sites of currently available sensors systems to document a baseline of technology capabilities and limitations to direct future efforts.

In addition, this effort will support the demonstration of prototype sensor systems that are produced by the preceding BA2 projects and collect the information necessary at both Standardized and Live sites to promote the transition of the products produced by this work unit.

Finally the program will demonstrate commercially available and government developed dual mode sensors regardless of their platform. This will show the advances made in the dual mode arena since the beginning of the program and highlight the effectiveness of a coordinated UXO community approach to a problem.

BENEFITS: This effort advances capabilities for UXO detection and discrimination using dual-mode sensor systems and addresses the user requirements to reduce risks and costs associated with UXO environmental remediation efforts. By partnering and soliciting developer, vendor, and user input, scarce dollars will be leveraged and demonstration of the products will occur.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Facilitate Dual Mode Sensor Workshop	3Q FY02
2	Complete COTS Demonstrations at Standardized Sites	2QFY04
3	Complete Army Prototype Dual Mode Hand Held Field Testing	FY04
4	Complete Army Dual Mode Hand Held Demonstration	1QFY05
5	Complete COTS & GOTS at Active Response and Standardized Sites	2Q FY05
6	Transition and Final Report of Dual Mode Sensor Systems	4Q FY05

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC
5. BAA

B. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Baseline Handheld/Man Portable System Performance

OBJECTIVE: The objective of this effort is to baseline system performance for handheld and man portable sensor systems at Standardized UXO Technology Demonstration Sites

DESCRIPTION: This work unit will initially document the capabilities and limitations of handheld and man portable UXO sensor systems at Standardized UXO Technology Demonstration Sites. The information generated will be used to direct RDT&E activities and document the baseline by which system improvements will be measured. The information generated will also be transitioned to the user community for application at UXO remediation sites.

BENEFITS: This effort will provide an initial baseline for hand held and man portable technologies. The S&T portion of the program will fix the inadequacies of the systems. The evaluation will be redone and the improvement in technology from EQT investment can then be quantified at the end of the program.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Complete YPG standardized UXO test site	2QFY03
1	Complete fabrication of prototype sub-audio magnetic (SAM) receiver system	3QFY03
1	Contract field performance of UXO sensor systems at Standardized UXO Technology Demonstration Sites	3Q FY03
2	Transition performance matrix (MAG, TDEM, FDEM)	4Q FY04
3	Reevaluation of UXO Sensor Performance Leverage Standardized UXO Technology Demonstration 2005	2Q FY05
4	Final Report of Sensor Performance Leverage Standardized UXO Technology Demonstration 2005	4Q FY05

EXECUTION:

1. AEC
2. ATC
3. ERDC
4. BAA

C. BA4 &BA6 EQT Military RDT&E Project Execution Plan

TITLE: Standardized UXO Technology Demonstration 2005

OBJECTIVE: The objective of this Work Unit is to open the Standardized UXO Technology Demonstration and the Active Response Demonstration Sites to the UXO community. This will provide the Community a snapshot of current technologies capabilities and limitations.

DESCRIPTION: It is recognized that the state of the art in UXO technologies for detection and discrimination is constantly changing. Periodically there needs to be an evaluation of the advancements made by the community to transfer the technology to the user community. This program will open up the Standardized UXO Technology Demonstration Sites and Active Response Demonstration Sites through a competitive BAA and proposal process to demonstrate the current state of the art. This process will be similar to the process that was executed at the demonstrations done at Jefferson Proving Grounds. The sites and demonstrations will be open to the public and government to view the operations in action, to ask questions of the vendors, and to eventually evaluate the results.

BENEFITS: The demonstration of available UXO detection and discrimination is the ultimate measure of the program's success. Demonstrations of COTS and GOTS technologies will determination by the product delivery team if the program was able to meet the threshold exit criteria in the EQT ORD. These demonstrations will show where there continues to be technical difficulties, where there may need to be further S&T work, and the next steps necessary to fully realize the potential of the new technologies.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Complete Demonstration of Technologies at Standardized Sites	3Q FY05
2	Complete Demonstration of Technologies at Active Response Sites	3Q FY05
3	Correlate Data from Standardized Site to Active Response Sites	4Q FY05
4	Final Report on State of the Art	4Q FY05

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC

D. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Sensor/Platform Integration and Demonstration

OBJECTIVE: The objective of this effort is to support the demonstration and validation of the Army's EQT BA2/BA3 projects in UXO Sensor/Platform Design and Enhancement.

DESCRIPTION: This work unit will focus on five focus areas in the Army's EQT BA2/BA3 projects in UXO Sensor/Platform Design and Enhancement: Frequency Domain EM Enhancements, Enhanced Data Acquisition/Data Analysis System, UXO Sensor Position and Tracking Technologies, Spatial pattern Survey Strategies and Sensor Configuration Optimization, and Performance Protocols.

BA4 technology demonstrations for Frequency Domain EM Enhancements will baseline the improved GEM-3 prototype. This will identify its capabilities and limitations while providing insight onto incorporation into future dual mode sensors. The demonstration will be done at two of the Standardized Sites.

BA4 technology demonstrations for Enhanced Data Acquisition/Data Analysis System focuses on the incorporation of dual mode systems into both man portable and vehicular based platforms. The project will take place in three phases, first is the integration of the dual mode onto the platforms, second is a field test and demonstration to hone the final product, and finally is an independent evaluation of both systems at all standardized and two active response sites. This will be incorporated directly into the Standardized UXO Technology Demonstration 2005 program.

BA4 technology demonstrations for UXO Sensor Position and Tracking Technologies will focus on the advancements made for navigation systems designed to be uses in difficult environments. The project will look at both BA2/BA3 prototype system and the next generation-optimized system. The prototype system will be evaluated at the standardized site and its capabilities and limitations captured. The optimized system will not only be independently evaluated at the standardized site but also challenged at active response sites.

BA4 technology demonstrations for Spatial pattern Survey Strategies and Sensor Configuration Optimization will focus on new sensor configurations and test processing algorithms for Ultra wideband surveys. The project will demonstrate advances realized by the advanced instrument sensor designed and to independently validate the developed algorithm. The algorithm will be tested by both the development and the user communities using independently gathered datasets. The results will be evaluated, transitioned, and reported.

Finally, BA4 technology demonstrations for Platform Performance Protocols will provide the S&T community with a set of protocols for evaluating the performance of man portable and vehicular platform for the dual mode sensor integration.

BENEFITS: The demonstration and validation of the Sensor/Platform Design and Enhancement focus area will provide a marked advancement in the state of the art. At the completion of this effort there will be a demonstration of the improved GEM-3 Prototype,

Fully transitioned dual mode man portable and vehicular platforms, transitioned optimized navigation/position system to be used in difficult environments, validated ultra wide band processing algorithms and sensor designs, and a means to evaluate the performance of platforms for housing sensors.

MILESTONES:

Frequency Domain EM Enhancements

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Demonstrate Improved GEM-3 Prototype	4QFY03

Enhanced Data Acquisition/Data Analysis System

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
2	Integrate Dual Mode and DAS onto Man Portable and Vehicular Platforms	4Q FY04
3	Field Test BA3 Integrated Prototype Man Portable and Vehicular Platforms	1QFY05
4	Demonstrate Final Integrated Man Portable and Vehicular Platforms – Cost Integrated into Standardized UXO Technology Demonstrations 2005	3Q FY05
5	Final Report on Enhanced Data Acquisition/Data Analysis System	4Q FY05

UXO Sensor Position and Tracking Technologies

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
6	Baseline navigation/positioning system	4Q FY02
7	Field Test BA3 Prototype navigation/positioning system	3Q FY04
8	Independent Demonstration of Optimized navigation/positioning system	4Q FY04
9	Transition to User Community	1Q FY05

Spatial Pattern Survey Strategies and Sensor Configuration

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
10	Demonstrate optimized UWB Sensor Configuration	2Q FY04
11	Demonstrate UWB algorithm against Datasets	4Q FY04

Platform Evaluation

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
12	Develop Platform Performance Protocols	1QFY04

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC

E. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Demonstrate UXO Detection Systems in Shallow Water

OBJECTIVE: The objective of this work unit is to establish a Shallow Water Standardized UXO Technology Demonstration Site and to establish a technology of capabilities and limitations.

DESCRIPTION: The next area of concern for the Army in UXO detection and discrimination is shallow water and littoral areas. There has been limited demonstrations done in this area and there is no evaluation of the current state of the art. This program will leverage a limited shallow water demonstration site using existing programs, initiate the team to develop standardized protocols outlining all aspects of the site construction, technology demonstration, and performance scoring and reporting. A site will be then selected and constructed. After construction, the site will be opened and technologies will be selected through a competitive BAA and proposal process to demonstrate the current state of the art.

BENEFITS: This effort is to be proactive in the face of increasing pressure and possible focus on the shallow water UXO contamination. The demonstration of available shallow water technologies will demonstrate a good faith effort in identifying the current state of the art as well as identifying to stakeholders the current capabilities and limitations. The results of the demonstrations will be analyzed by the product delivery team and the members of the technology review workshop to identify areas which need further S&T, highlight systems that have the greatest probability of success, and to focus the shallow water program. Shallow water applications not only occur in coastlines but also on ranges that contain swamps, ponds, lakes, rivers, or streams.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Leverage Water Portion of Wide Area Survey Efforts	1Q FY03
2	Identify Applicable Installations/Record Search	2Q FY03
3	Establish Standardized Protocols	4Q FY03
4	Construct Standardized Site/Procure Targets	2Q FY04
5	Conduct Baseline Demonstrations	4Q FY04
6	Evaluate and Report Technology Gaps	2Q FY05
7	Site Clean Up	4Q FY05

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC
5. BAA

F. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Demonstration of Fill Identification Technologies

OBJECTIVE: The objective of this Work Unit is to demonstrate the variety of technologies available to determine in-situ the fill of ordnance.

DESCRIPTION: During the detection and discrimination phase of UXO remediation, the ability to know the contents of the round is not always obvious. Current technology has only limited ability to identify fill material of munitions. Munitions could contain inert fill, conventional explosives, Improved conventional munitions, chemical warfare materiel, smoke, and other military unique material. As a result all munitions detected by geophysical methods must be considered to be "live" until proven otherwise, even though many are eventually determined to be inert. The UXO Screening, Detection and Discrimination ORD will leverage other ORD efforts in order to improve fill detection capability. This program will publish a baseline of the current state of the fill detection capability and execute RDT&E demonstrations as deemed necessary to fill obvious data gaps.

BENEFITS: The identification of UXO fill during the detection and discrimination phase is an important aspect of removal and risk reduction. Understanding the type of UXO and its potential fill supports the decision making process of the site manager to focus their limited resources on high-risk areas.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Identify Current Fill Detection Technologies	1Q FY04
2	Complete Demonstration of Fill Detection Technologies	1Q FY05
3	Identify Shortfalls in Fill Detection Technologies	2Q FY05

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. SBCCOM
5. BAA

III. Hardware/Software Integration

A. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Software Demonstration/Validation Assessment

OBJECTIVE: The objective of this effort is to identify and assess available GOTS and COTS UXO detection and discrimination software and insert where appropriate into the Geosoft platform.

DESCRIPTION: The purpose of this work unit is to inventory all available software that may be used to support UXO technology detection and discrimination activities. These software programs are important to the advancement of discrimination capabilities of UXO sensor systems. Typically these software programs are used for detection, discrimination, or data visualization. This effort will collect a complete of the inventory of all DA, GOTS, and COTS UXO software. The entire inventory will be evaluated for capabilities and limitations and the findings released. After evaluation, the applicable software packages will be interfaced with the Geosoft platform.

BENEFITS: This effort will evaluate current software packages to identify strengths and weaknesses and increase the capabilities of UXO detection, demonstration and data visualization. The products of this work will be a inventory of the software packages, a demonstration and evaluation of the software packages, and the incorporation of the software packages into the Geosoft platform.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Identify and Report on Available Software	2Q FY03
2	Demonstrate and Assess Software	4Q FY03
3	Insert Software Systems into Geosoft Systems	3Q FY04

EXECUTION:

1. AEC
2. CEHNC
3. ERDC

B. BA4 & BA6 EQT Military RDT&E Project Execution Plan

TITLE: Modeling Analyses and Processing Demonstration/Validation

OBJECTIVE: The objective of this work unit is to demonstrate/validate advanced geophysical data processing and analysis approaches to enhance the ability to discriminate buried UXO in a wide range of environmental and geophysical conditions.

DESCRIPTION: Under BA2 RDT&E projects, forward and inverse modeling techniques for total magnetic field, magnetic vector component, time domain electromagnetic induction and frequency domain electromagnetic induction will be developed. In addition, another BA2 product will be constrained, cooperative, and joint inversion capabilities for rational integration or “fusion” of multi-sensor type data sets. The Modeling Analyses and Processing area has been broken down into five focus areas: Advanced Sensor Data Analysis Technologies for Improved Buried Target Detection and Discrimination, Investigation of Time Domain EM and Magnetic, Evaluation of Advanced Signature Models and Inversion Technologies, Algorithm for Inferring Shape of Composite Targets, and Joint Inversion Investigation for UXO Discrimination.

BA4 technology demonstrations for Advanced Sensor Data Analysis Technologies for Improved Buried Target Detection and Discrimination will demonstrate FDEM software on the enhanced GEM-3 Sensor. This will be done at two standardized sites. A report of results will be generated and the enhanced software will be applied to traditional GEM-3 Sensor and TDEM to see the improvement made by both improvements in the sensor and the software.

BA4 technology demonstrations for Investigation of Time Domain EM and Magnetic will produce guidelines for optimum application of TDEM and Mag. The guidelines will be coordinated and be transitioned to the user community.

BA4 technology demonstrations for Evaluation of Advanced Signature Models and Inversion Technologies will evaluate “real time” algorithms for UXO detection and discrimination. Since the algorithms should be ready for the user community, independent operators of the technology systems on two standardized sites will conduct the demonstrations. Not only will the capabilities of the algorithms be tested but also their ease of use and field friendliness evaluated.

BA4 technology demonstrations for Algorithm for Inferring Shape of Composite Targets will evaluate the ability to distinguish UXO-like objects from clutter in mixed metal. The algorithms will be used against datasets collected at the standardized sites. Since the algorithms should be ready for the user community, independent operators of the technology systems on two standardized sites will conduct the demonstrations. Not only will the capabilities of the algorithms be tested but also their ease of use and field friendliness evaluated.

BA4 technology demonstrations for Joint Inversion Investigation for UXO Discrimination will evaluate the ability to used advanced geophysical data integration and interpretation approaches to enhance the ability to discriminate UXO. The algorithms will be used against datasets collected at the standardized sites. Since the algorithms should be ready for the user community, independent operators of the technology systems on two standardized sites will conduct the demonstrations. Not only will the capabilities of the algorithms be tested but also their ease of use and field friendliness evaluated.

BENEFITS: Demonstrating advancements in algorithms are a key component to the success of the EQT program. By validating and demonstrating the algorithms, the user community can be confident in the detection and discrimination abilities of the sensors. The evaluation plan also ensures that the technologies developed in the BA2/BA3 portion of the EQT program are commercially mature and user friendly.

MILESTONES:

Advanced Sensor Data Analysis Technologies for Improved Buried Target Detection and Discrimination

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Demonstrate FDEM Software for Enhanced GEM-3	4Q FY02
2	Generate Report of Real Time Results	4Q FY02
3	Apply Enhanced Software to traditional GEM-3 and TDEM	4Q FY02

Investigation of Time Domain EM and Magnetic

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
4	Produce Final Report on Guidelines for Application of TDEM & Mag/TDEM	3Q FY03
5	Transition To User Community (CEHNC, ITRC)	4Q FY03

Evaluation of Advanced Signature Models and Inversion Technologies

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
6	Demonstrate "Real Time" Algorithms for Mag, TDEM, and FDEM	2Q FY05
7	Final Report on Advanced Signature Models and Inversion Technologies Implementation	3Q FY05

Algorithm for Inferring Shape of Composite Targets

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
8	Collect Datasets at Blind Grids	1Q FY04
9	Apply Algorithm to Data Sets (Developer, User)	2Q FY04
10	Transition to Geosoft	3Q FY04

Joint Inversion Investigation for UXO Discrimination

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
11	Collect Datasets at Blind Grids	1Q FY04
12	Apply Algorithm to Data Sets (Developer, User)	2Q FY04
13	Transition to Geosoft	3Q FY04

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC
5. ITRC

C. BA4 & BA6 EQT Military RDT&E Project Execution Plan

TITLE: MAUDE Demonstration Validation

OBJECTIVE: The objective of this work unit is to demonstrate/validate expedient site characterization procedures for UXO detection survey planning through the application of BA2 generated software-MAUDE. The software will provide a user-friendly, procedure to employ for UXO detection survey.

DESCRIPTION: An expedient means of incorporating site information and detection sensor specifications to generate a survey plan would aid in reducing UXO cleanup costs. Although the physical attributes of UXO contaminated areas vary from site to site, the same considerations and general procedure are employed when developing a UXO detection survey plan. This commonality is the basis for the software MAUDE. This software will incorporate a variety of historical and technical information to outline a time and cost effective survey plan. The program will interface with other UXO related software such as GeoSoft.

BENEFITS: The program The MAUDE program will provide UXO detection survey planners a design tool that will help reduce UXO cleanup cost.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	ERDC Demonstrate Maude Software at 2 Standardized Sites	2Q FY04
2	ATC Demonstrate Maude Software at 2 Active Response Demonstration Sites	4Q FY04
3	Transition Software (CEHNC, ITRC, Geosoft)	2Q FY05

EXECUTION:

1. AEC
2. ATC
3. ERDC
4. ITRC

IV. Geophysical QA/QC

A. BA4 & BA6 EQT Military RDT&E Project Execution Plan

TITLE: Standardized Guidance for Geophysical Prove Outs

OBJECTIVE: The objective of this Work Unit is to generate standardized guidance for geophysical prove outs.

DESCRIPTION: Due to the site-specific nature of UXO technology capabilities and limitations, it is necessary to conduct a geophysical prove out at a location which is representative of the area to be remediated. The standardized protocols for carrying out this test effort would need to be acceptable to both state and federal representatives. All viable approaches will be investigated for producing this product before proceeding. One approach would be to interface with the ITRC and write an ASTM guidance document.

BENEFITS: Standardizing the approach for the setup and methods for conducting the test would provide valuable data for application at other sites being remediated.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Identify Mechanisms for Stakeholder Acceptance	2Q FY03
2	Draft Guidance	4Q FY 03
3	Final Guidance	3Q FY 04

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC
5. ITRC

B. BA4 & BA6 EQT Military RDT&E Project Execution Plan

TITLE: QC for UXO Sensor Technology Operators

OBJECTIVE: The objective of this Work Unit is to determine the level of influence of the operator on UXO technology results.

DESCRIPTION: The countermine community has found that a large impact on the ability of systems to detect and discriminate mines is operator influence. They have demonstrated this utilizing identically trained EOD technicians and comparing their detection and discrimination results. Operator impact has not been evaluated in the UXO community. The community points to anecdotal evidence but validated data is not currently available. This program will take operators trained in identical manners and compare their ability to operate a system as instructed. The results of this demonstration will then be evaluated and the level of influence quantified. The knowledge gained is will determine the level of influence and what steps are necessary to remove this bias.

BENEFITS: Technologies that can only be operated at a high level by the experts and manufactures are not of much use to the user community. The proper training and transfer of detection and discrimination technologies is as important as the capability of the technology. This project will quantify the bias and produce improvements to the baseline transition and training programs of the technologies.

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Identify Operators to Participate in Demonstration	1Q FY03
2	Determine Current Training Mechanisms	1Q FY03
3	Execute Technician Training	3Q FY03
4	Complete Demonstrations	1Q FY04
5	Evaluate Operator Influence on System	2Q FY04
6	Provide Feedback, Guidance, Workshop, and Mechanisms to Remove Bias	3Q FY04
7	Repeat Demonstration and Reevaluate Operator Influence on System	2Q FY05
8	Training Course Development	3Q FY05

EXECUTION:

1. AEC
2. ATC
3. CEHNC
4. ERDC
5. Contract

V. Technology Transfer

A. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Technology Transition Support

OBJECTIVE: The objective of this Work Unit is to provide programmatic support and stakeholders buy in for UXO technology test and evaluation.

DESCRIPTION: A barrier in implementing state of the art technologies is convincing stakeholders of the validity of data and instilling confidence in the technology. The ITRC is partnering with DoD to provide regulatory input and guidance to technology. The ITRC involvement in the review of all documents and reports resulting from technology demonstrations is necessary.

There is a need to coordinate programmatic issues dealing with the large volume of demonstrations and validations occurring. The product delivery team cannot accomplish the coordination of this programmatic oversight alone. This programmatic support will also support technology transfer issues.

The Product Delivery Team also needs to support their programmatic involvement in technology demonstration and transfer. This will provide for a certain amount of labor hour and travel dollars to participate in Technology Demonstrations, Programmatic Oversight, and document Review.

BENEFITS: ITRC involvement makes the transition of technologies into active response sites is necessary. The ITRC provides a certain amount of reciprocity within the states. The ITRC review of the technologies not only provides valuable state input but also improves the visibility of successful demonstrations.

The large scale of the efforts being undertaken by the demonstration program requires constant coordination and executive oversight. This requires an individual to support the technology demonstration program team in following up with actions and programmatic needs. By having a focal point for technology transfer issues, the Army will prevent duplication of effort and efficiently disseminate information about the program.

Full and active participation by the Product Delivery Team is essential to the success of the program. Without their technical oversight and involvement, the test and evaluation community will be missing the input from their essential science and technology counterparts. This collaborative effort will guarantee that demonstrations are done in a cost effective and scientifically defensible manner.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	Regulatory Participation In Program	4Q FY05
2	Programmatic Support to T&E Community	4Q FY05
3	Programmatic Participation by S&T Community	4Q FY05

EXECUTION:

1. AEC
2. ITRC
3. ERDC

B. BA4 & BA6 EQT Military RDT&E Project Execution Plan

TITLE: Technology Review and Knowledge Exchange Seminar

OBJECTIVE: The objective of this Work Unit is to bring together technical executors of the EQT program to exchange issues and progress of the program.

DESCRIPTION: This program brings together the technical executors of the UXO program to review the current status of the program, identify shortfalls, and evaluate future programs. These meetings will be held in accordance with the technology transfer and demonstration program plan. These meetings will also bring in members of the other services, academia, ESTCP, and technical leads as needed.

BENEFITS: By having a workshop to discuss programs and for technology transfer issues, the Army will prevent duplication of effort between other programs executing UXO work. Partnerships will be solidified and opportunities to leverage work and funds will be identified. At this workshop decisions will be made to stop programs that are not meeting designated goals or have shown inability to meet the user requirements. Programs will be modified to reflect user requirements.

MILESTONES:

<u>Task</u>	<u>Milestone</u>	<u>Scheduled Completion</u>
1	2002 Technology Review Meeting/Annual Report	4Q FY02
2	2003 Technology Review Meeting/Annual Report	4Q FY03
3	2004 Technology Review Meeting/Annual Report	4Q FY04
4	2005 Technology Review Meeting/Annual Report	3Q FY05
5	Program Final Report	4Q FY05

EXECUTION:

1. U.S. Army Environmental Center