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The Army Environmental Quality Technology User Requirement A (1.6.a) UXO Screening, Detection, and Discrimination UXO Program FY02 and FY03 Annual Report

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14. ABSTRACT

Under contract to the U.S. Army Environmental Center and Booz Allen Hamilton, this report was developed to highlight and summarize the endeavors of the U.S. Army Environmental Quality Technology (EQT) Unexploded Ordnance (UXO) Program during fiscal year (FY) 2002 and FY 2003. The purpose of this annual report is to assist in helping readers to better understand the EQT Program's efforts and capabilities, and to serve as a key technology transfer tool to be used not only to document program advancements but also to demonstrated the efficient utilization of scarce RDT&E funds.

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INTRODUCTION

This Annual Report describes the endeavors of the U.S. Army Environmental Quality Technology (EQT) Unexploded Ordnance (UXO) Program during fiscal year (FY) 2002 and FY 2003. The research, development, test and evaluation (RDT&E) efforts described within this document 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). These project summaries will help readers to better understand the EQT Program's efforts and capabilities. The annual report also serves as a key technology transfer tool to be used not only to document program advancements but also to demonstrate the efficient utilization of scarce RDT&E funds.

The characterization of UXO contaminated lands and shallow waters continues to be the Army's highest priority environmental restoration requirement 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 requirement, the Army EQT Program is developing improved UXO sensing, positioning, analysis, and visualization technologies that will efficiently and effectively detect and discriminate subsurface, and underwater UXO from natural and man-made clutter.

As posed by the user community in Restoration Requirement A (1.6.a), UXO Screening, Detection, and Discrimination, the RDT&E efforts to be conducted under this Environmental Technology Management Plan (ETMP) include two primary thrust areas: ground based 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 man-made 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.

Technology is a major weapon in the Army's efforts to remediate formerly used ranges, avoid future liabilities, sustain training capabilities, and maintain the environment. Through the programs described in this report, the Army EQT UXO Program is providing the Army with the most effective and affordable UXO detection and discrimination technologies available.

PROGRAMMATICS

Throughout the execution of this program, there have been certain events that have impacted the implementation of these projects. These events will be noted in this Annual Report. Examples of these events include the status of the Environmental Quality Technology Operational Requirements Document (EQT-ORD), modification to the schedule, impacts of budgetary cuts,

the arrival of late funding, and modifications to individual tasks that address Independent Review Panel (IPR) comments.

FULLY FUNDED PROGRAM

The program to support user requirement A (1.6.a) had a variety of trailblazing activities. It was the first EQT program to receive Budget Activity BA4 and BA6 funds. It also developed the first EQT-ORD. Although, the mechanism for development and approval of both of these activities were not completely addressed in the EQT Operating Principles, and since the process was both created and formalized by this program, this process took much longer than initially anticipated.

The release of budget activity for BA4 and BA6 required a signed, approved EQT-ORD. This in combination with the late release of BA4 and BA6 funding caused the program to fall behind schedule, as detailed in the EQT Management Plan by 11 months before the program even started. As a result, this report covers August 2002 through September 2003.

MODIFICATION TO EXECUTION PLAN

There have been numerous modifications for this program, and it has been necessary to reallocate funds during this particular time frame covered within the Annual Report. In most cases, funding levels have not remained consistent. Consequently, it has been necessary to increase some project specific funding levels due to additional tasks being identified during the execution of the project. Unfortunately, some tough decisions were also made to reduce or eliminate the scope of certain projects tasks.

The Army EQT UXO Program took a $500K funding cut to BA2 in FY02 and a $1267K BA4 cut in FY03. Minor cuts were also realized in FY03 for BA6. Although, these cuts caused changes in both the project milestones and number of products planned for the program, significant advances will still be achieved as a result of this funded effort. Major changes to the BA4 effort include reduction of ground truth recovery for task IC, the number of platforms developed in task IID, and the trimming of funds available for demonstrations at the Standardized Sites, and for tasks IIF and IB, there were funding cuts and the tasks were cancelled.

The EQT IPR meeting held on August 12-13, 2003, identified some overall issues within the program including the technology transition/transfer issues of information, hardware, software and other products. Technology transition has been noted as a very important aspect of the work and a huge hurdle to accomplish. Another major issue identified for the whole program is the result of funding increases and/or decreases for milestones and products. Lastly as a result of the IPR, emphasis will be placed on the testing and evaluation of government and COTS systems during FY05 and FY06.

WHAT'S INSIDE

The FY 2002 EQT UXO Annual Report is organized by the following categories:

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

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

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

I. Standardized Sites

II. UXO Technology Demonstrations

III. Hardware/Software Integration

IV. Geophysical QA/QC

V. Technology Transfer

Project descriptions are organized into several sections:

OVERVIEW:	What problem does the project address? How does the project help its users? Why develop such a technology? How does it work? What is the development approach?
ACCOMPLISHMENTS AND RESULTS:	So far, what results have been achieved?
ISSUES:	What might affect the use of this technology?
PLANNED ACTIVITIES:	What additional requirements are anticipated?
POINT OF CONTACT:	Whom do I contact for more information?
PUBLICATIONS:	What publications relate to the project?

FOR MORE INFORMATION

Want to know more about the Army EQT UXO Program?

WRITE to t2hotline@aec.apgea.army.mil

CALL the Army Environmental Hotline at (800) USA-3845.

VISIT the USAEC Website at http://aec.army.mil/usaec/technology/uxo00.html or http://www.uxotestsites.org

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

I. Site Characterization Issues and Approach Strategy

BA2 I.A. Identification and Evaluation of Key Site Parameters Impacting Technology

OVERVIEW: The purpose of this task is to identify the geophysical, geological, and cultural parameters that influence the sensors used for UXO detection. This encompasses (1) identifying current, prototype, 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.

The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and formerly used defense sites (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, electromagnetic induction (EMI), and ground penetrating radar (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, ordnance and explosives (OE) history, 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.

This work unit provides 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.

ACCOMPLISHMENTS AND RESULTS:
This task has compiled a list of UXO detector sensors and the technical specifications. A list of geophysical parameters and expected range in magnitude for a variety of soil types has been created. It has identified and met with complimentary sources, such as U-Hunter, Geosoft, etc. The identification of when background may interfere with sensor performance and the

relationship of geophysical and environmental parameters to sensor specifications was determined. And guidelines for UXO detection survey planning were developed.

PLANNED ACTIVITIES:
As an action, a brief description of each sensor technology and how the natural and cultural surroundings can influence the measurement will be added.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
"Guidelines for UXO Detection Survey Planning" Technical Report is pending for publication.

BA2 I.B. Expert Systems to Support UXO Site Characterization Technology Selection

OVERVIEW: The purpose of this task 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.

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 procedures are employed when developing a UXO detection survey plan. This commonality is the basis for the MAUDE software. 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.

The MAUDE software 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.

ACCOMPLISHMENTS AND RESULTS:
This task was scheduled to commence in FY03 but due to funding being received late and the time frame being adjusted, this task is now expected to be fielded in FY04 and the products will be explained more thoroughly in the 2004 Annual Report.

The MAUDE software platform and structure was outlined. UXO detection guidelines were incorporated and site related information such as OE history and cultural background, were also incorporated into the program. Also, a beta version of the MAUDE software was created.

ISSUES:
In a government provided program, no specific magnetometer sensor should be stated since there are a variety of magnetometers that perform equally well for UXO detection surveys. Since there are a limited number of electromagnetic (EM) sensors that are currently available and utilized for UXO surveys, it is acceptable to specify the EM sensor.

Current penetration depth tables based on muzzle velocity generally overestimate ordnance burial depth, making the penetration depth data inaccurate.

PLANNED ACTIVITIES:
Creation of a C-type code, executable file that can be run from most platforms will be addressed in 1QFY04 and as part of the BA2IC FY04 effort, user input will be obtained.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
User's manual will be produced for MAUDE, FY04.

BA2 I.C. Verification of MAUDE—a Management Aid for UXO Detection Efforts

OVERVIEW: The purpose of this task 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.

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 MAUDE software 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.

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

ACCOMPLISHMENTS AND RESULTS:
This task is not scheduled to commence until 2004.

ISSUES:
MAUDE is not intended to provide statistically optimized survey sampling patterns.

PLANNED ACTIVITIES:
During the 1Q04, the first Standardized UXO Technology Demonstration Site to test the MAUDE software will be visited and selected, and field-testing will be completed. Following in the 2Q04, the second Standardized UXO Technology Demonstration Site to test the MAUDE software will be visited and selected, and field-testing will be completed. During the 3Q04, the MAUDE software will be modified and improved. As a product during the 3Q04, the MAUDE software will be enhanced and verified.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

II. Modeling, Analyses, and Processing

BA2 II.A. Investigation of Time Domain EMI and Magnetic Methods for Enhanced UXO Detection and Discrimination

OVERVIEW:
The purpose of this task 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 90% 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., 98%).

The detection and clearing of UXO in ranges, impact areas, burning and open detonation areas, and formerly used defense sites (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). To reach the goal of reducing the false alarm rates by tenfold, 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 time domain electromagnetic (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.

This work unit will advance the capabilities for UXO detection and discrimination in four (4) 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) and the development of initial approaches to inverse modeling capability for determination of geophysical anomaly source characteristics.

ACCOMPLISHMENTS AND RESULTS:
The enhanced phenomenological assessment of geologic/geophysical backgrounds at Jefferson Proving Ground (JPG) was performed in 1999, and the Engineering Research and Development Center (ERDC) UXO test site in Vicksburg, MS was established. A prototype UXO gravity modeling program was developed in 1999. In 2000, the field validation and documentation of the gravity model was performed, and the field validation and documentation of the predictive model for vector magnetic signatures of UXO has been performed. TDEM forward modeling

procedures have been validated. The TDEM inverse modeling procedures were documented in 2001. Full-scale field surveys with new technologies were performed at documented test sites. Magnetic inverse modeling procedures were documented in 2002. Also, the results of the full-scale field surveys at documented test sites were recorded.

The phenomenological impacts of background on UXO detection and discrimination were documented. The forward and inverse TDEM modeling capability was established in 2001. And the forward and inverse magnetic modeling capability was established in 2002. Documentation of field performance of advanced geophysical technology and interpretation procedures at documented field test site were recorded.

ISSUES:
No limitations identified to preclude further exploratory development and demonstration /validation of the magnetic and TDEM forward and inverse modeling capability. While gravity models were successfully developed, feasibility field tests indicate that the applicability of the methods to UXO detection/discrimination is too limited to justify further development.

PLANNED ACTIVITIES:
No activities are planned for this task. This task was completed in FY02.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Butler, D. K., Cespedes, E. R., Cox, C. B., and Wolfe, P. J. (1998). “Multisensor methods for buried unexploded ordnance detection, discrimination, and identification,” Technical Report SERDP-98-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Butler, Dwain K. (2000). "Assessment of Microgravimetry for UXO Detection and Discrimination," ERDC/GSL TR-00-5, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Pasion, Leonard R. and Oldenburg, Douglas W. (2001). "Locating and Characterizing Unexploded Ordnance Using Time Domain Electromagnetic Induction," ERDC/GSL TR-01-10, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Butler, D. K. (2001). "Potential Fields Methods for Location of Unexploded Ordnance," *The Leading Edge* 20(8): 890-895.

Butler, D. K., Wolfe, P. J., and Hansen, R. O. (2001). "Analytical Modeling of Magnetic and Gravity Signatures of Unexploded Ordnance," *Journal of Environmental and Engineering Geophysics* 6(1): 33-46.

Billings, S. D., Pasion, L. R., and Oldenburg, D. W. (2002). "Discrimination and Identification of UXO By Geophysical Inversion of Total-Field Magnetic Data," ERDC/GSL TR-02-16, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Butler, D. K. (2003). "Implications of magnetic backgrounds for unexploded ordnance detection," *Journal of Applied Geophysics*, Vol. 54, 111-125.

Proceeding publications from the UXO/Countermine Forum, the Symposium on Application of Geophysics to Environmental and Engineering Problems, and the Annual International Meeting of the Society of Exploration Geophysicists.

BA2 II.B. Evaluation of Advanced Signature Models and Inversion Technologies

OVERVIEW: The purpose of this task 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 Data Acquisition/Data Analysis System (DAQ/DAS).

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). To reach this goal of reducing the false alarm rates by tenfold, advanced technologies that can accurately detect and discriminate buried UXO must be developed and demonstrated.

Under BA2 RDT&E projects that ended in FY02, forward and inverse modeling techniques for total field magnetics (TFM), magnetic vector component, time domain electromagnetics (TDEM), and frequency domain electromagnetics (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 ending in FY03, contributed to the development of constrained, cooperative, and joint inversion capabilities for the 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 (AI) 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.

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 AI guides for algorithm selection and application, and (7) identify approaches to efficiently transition these advanced analysis algorithms and overall capability to the generalized system DAQ/DAS being developed under another project.

ACCOMPLISHMENTS AND RESULTS:
High quality data sets (TFM and TDEM) were acquired at the Yuma UXO Standardized Site for use in evaluating and implementing the modeling and inversion software during the 3Q03. Manual and automated anomaly selection and cross-correlation between multiple datasets was performed during the 4Q03. Implementation of TFM and TDEM inversion technology was coordinated between implementation plans for advanced UXO modeling and inversion in Geosoft developed under the EQT and ESTCP UXO programs during the 3Q03. A software test bed was developed for evaluating and testing the TFM inversion and discrimination algorithms during the 4Q03.

ISSUES:
Limitations on this technology are based on approximate modeling of UXO and the acquired data resolution and quality. These issues will be documented in the final report.

PLANNED ACTIVITIES:
Various advanced data processing and inversion algorithms and integrated framework will be implemented in 4Q04. Guidance for selection of optimum analysis approaches implemented in 4Q04.

As a product in 4Q04, advanced algorithms for geophysical anomaly selection and classification and constrained, cooperative, reduced parameter, and joint inversion of multiple geophysical data types will be developed.

As an action item from the Independent Review Panel Meeting, there is a need for the term "high quality" to be defined and quantified. A criterion for collecting this "high quality" data also needs to be established. It was noted that there is a high potential for application on sites in the future, with remnant magnetization as a discriminator. There is also a need to conduct a workshop to decide on a tool set for magnetic and EMI analysis to include in Geosoft.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:

Billings, S. D. and Herrmann, F. (2003). “Automatic detection of position and depth for potential UXO using continuous wavelet transforms,” SPIE Conference OR48: Detection and Remediation Technologies for Mines and Mine-like Targets, Orlando, Florida.

Billings, S. D., Pasion, L. R., and Oldenburg, D. W. (2002). "Discrimination and Identification of UXO By Geophysical Inversion of Total-Field Magnetic Data," ERDC/GSL TR-02-16, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Pasion, Leonard R. and Oldenburg, Douglas W. (2001). "Locating and Characterizing Unexploded Ordnance Using Time Domain Electromagnetic Induction," ERDC/GSL TR-01-10, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Billings, S. D., Stanley, J. M., and Youmans, C. (2002). "Magnetic Discrimination that will Satisfy Regulators," *UXO/Countermine Forum 2002*, Orlando, FL.

Billings, S. D., Pasion, L. R. & Oldenburg, D. (2002). “Inversion of magnetics for UXO discrimination and identification,” *UXO/Countermine Forum 2002*, Orlando, FL.

BA2 II.C. Joint Inversion Investigations for UXO Discrimination

OVEVIEW: The purpose of this task 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.

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). To reach this goal of reducing false alarm rates by tenfold, advanced technologies that can accurately detect and discriminate buried UXO must be developed and demonstrated.

Under the BA2 RDT&E projects for 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.

This work unit will advance the 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) and identify

approaches to efficiently transition the joint inversion analyses approaches to real-time analysis algorithms.

ACCOMPLISHMENTS AND RESULTS:
TFM and TDEM constrained, cooperative, and joint inversion algorithm development was completed during the 4Q03. Analysis of uncertainties in final UXO discrimination assessments and identifications were completed during the 4Q03.

ISSUES:
Limitations on this technology are based on approximate modeling of UXO and the acquired data resolution and quality. These limitations will be documented in the final report.

PLANNED ACTIVITIES:
As a product during the 4Q04, the algorithms for constrained, cooperative, and joint inversion of multiple geophysical data types and analysis of uncertainties will be implemented.

As an action item from the Independent Review Panel Meeting, it is critical to define data quality requests as soon as possible so that it can be coordinated with sensor design and survey production constraints, and this will be addressed in FY04-05 research effort. As a proposed programmatic issue for resolution as a FY04 activity, a workshop will be conducted to discuss the advanced modeling, inversion, and joint inversion as part of the technology transfer activities. There is a need to leverage with Hunter Ware, and ERDC will provide models and training as leverage if the Hunter Ware proposal is funded.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
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Pasion, L. R., Billings, S. D., and Oldenburg, D. W. (2003). "Joint and Cooperative Inversion of Magnetic and Time Domain Electromagnetic Data for the Characterization of UXO," *Proceedings of the Symposium on Application of Geophysics to Environmental and Engineering Problems 2003 (CD)*, Environmental and Engineering Geophysical Society, San Antonio, TX, 2003.

BA2 II.D. Algorithms For Inferring Shape Of Composite Targets (UXO)

OVERVIEW: The purpose of this task is to develop processing schemes to enable discrimination of UXO-like shapes in composite targets.

Many if not most UXO contain more than one metal type. Electromagnetic induction (EMI) 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. This project will implement material that develops in the PI's basic research program on composite objects. It will also include implementation options for taking advantage of new EMI sensors that receive magnetic signals along more than one axis (direction).

This work unit will significantly advance the ability to distinguish UXO-like objects from clutter, while providing better discrimination of UXO that are made with composite materials.

ACCOMPLISHMENTS AND RESULTS:
The relative benefits of existing and prospective sensor systems were assessed during the 3Q02. The first design of new algorithms and simulations were completed, and data was acquired with available instruments during the 4Q02. Algorithms were revised and evaluated using new ERDC measurements on representative buried UXO and clutter targets during the 3Q03. First generation algorithms and models were transitioned to ERDC and contract developers in 3Q03. Algorithms were revised so that they would apply to new generation instruments including time domain based instruments. The final version will be tested using measurements on representative buried UXO and clutter targets, using new or modified detection technologies. Numerous journal articles and conference papers were produced during this project, as well as detailed reports on algorithms and their use. Final user manuals for the computer codes/software are now in draft.

ISSUES:
Dense data sets, including (ideally broadband) EMI measurements at a variety of well-defined positions around a perceived anomaly are needed for optimum results. This places a considerable burden on positioning systems for EMI surveying. Data from more than one elevation of the sensor head is recommended and will enhance discrimination.

PLANNED ACTIVITIES:
Discrimination algorithms will be transitioned to government and contract developers for evaluation. Algorithms will be evaluated for distinguishing the shape of buried metallic objects, for classification as UXO-like or clutter.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Work for most of these publications was supported by more than one work item, including this one.

Journals Articles:

K. Sun, K. O'Neill, S.A. Haider, and K.D. Paulsen (2002). Simulation of electromagnetic induction scattering from targets with negligible to moderate penetration by primary fields, IEEE Trans. on Geo-science and Remote Sensing (TGARS), Vol. 40, No 4, 910-927.

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F. Shubitidze, K. O'Neill, K. Sun, and K.D. Paulsen (2003). Investigation of broadband electromagnetic induction scattering by highly conductive, permeable, arbitrarily shaped 3-D objects, accepted for publication, TGARS.

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C. D. Moss, K. O'Neill, T.M. Grzegorczyk, and J.A. Kong (2003). A hybrid time domain method to calculate electromagnetic induction scattering from targets with arbitrary skin depths, Proc. ACES, 2003, Monterey CA, 24-28 Mar 2003, p.390-396.

F. Shubitidze, K. O'Neill, K. Sun, I. Shamatava and K.D. Paulsen (2003). Analysis of EMI scattering to support UXO discrimination: Heterogeneous and multiple objects, SPIE'03, Orlando, 21-25 April 03.

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K. Sun, K. O'Neill, F. Shubitidze, I. Shamatava and K. D. Paulsen (2003). Application of TSA formulation for inversion of a metallic objects electromagnetic properties from EMI data, International Geo-science & Remote Sensing Symposium, 21-25 July 2003, Toulouse, Vol. 6, 3860-62.

I. Shamatava, F. Shubitidze, K. O'Neill, K. Sun, and K.D. Paulsen (2003). An efficient, user-friendly program for computing electromagnetic induction (EMI) responses from heterogeneous objects subject to state-of-the-art sensors, accepted for publication, UXO/Countermine Forum 2004.

BA2 II.E. Improved Ultra-Wideband (UWB) Survey Protocols, Associated Sensor Designs and Processing Algorithms for Enhanced Discrimination of Buried UXO from Clutter

OVERVIEW: The purpose of this task is to develop improved ultra-wideband (UWB) survey protocols, associated sensor designs and processing algorithms for enhanced discrimination of buried UXO from clutter.

The combined bandwidth runs from the electromagnetic induction (EMI) realm up through that for the ground penetrating radar (GPR). The ultimate sensors in those sub-bands are physically separate, as opposed to being on a single platform or in one "dual mode" instrument. Much of the emphasis is on techniques for reducing false alarms due to clutter, as part of the discrimination phase of surveying. Implementation of basic research on discrimination of multiple targets is ongoing. Information obtained from each sub-band is 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 of each technology are combined in the processing, less by joint processing, than by using particular facets of information from each sensor type to constrain the processing done by the other. Ideally multi-axis data are acquired in each sensor type. The principal thrusts of the work are carried out for each sensor type. The principal thrusts of the work are:

a) Evaluate instrument (especially antenna) design and develop new configurations

b) Identify the most promising new instrument configurations

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

d) Implement 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 from smaller clutter.

This work unit will substantially reduce the false alarm rates and rates of missed detections during the discrimination phase of surveying.

ACCOMPLISHMENTS AND RESULTS:
The availability and relative benefits of sensor systems from different sources were assessed during 3Q02. Simulations and design calculations for modifications of these systems or for prototype systems for new survey techniques were completed. Simulations and algorithm development for new discrimination techniques using both EMI and GPR were completed during the 3Q03, and new instrument designs and design algorithms were implemented.

Processing algorithms and models were transitioned to government and contract developers during the 3Q03. Algorithm evaluation is ongoing.

ISSUES:
The positioning system reliability has been an issue, as well as, access to both GPR and EMI equipment (the default being EMI alone). Currently interference issues with the positioning system appear to have been resolved for the particular induction sensors under consideration. Data density: dense data sets are recommended and should include, EMI measurements (ideally broadband) and GPR measurements at a variety of well-defined positions in the vicinity of the anomaly.

PLANNED ACTIVITIES:
Processing algorithms and documentation for field evaluation will be transitioned to government and contract developers. The complete evaluation will be performed on algorithms for discriminating UXO from clutter, combining information from both EMI and GPR.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Work for most of these publications was supported by more than one work item, including this one.

Journal Articles

K. Sun, K. O'Neill, S.A. Haider, and K.D. Paulsen (2002). Simulation of electromagnetic induction scattering from targets with negligible to moderate penetration by primary fields, IEEE Trans. on Geo-science and Remote Sensing (TGARS), Vol. 40, No 4, 910-927.

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F. Shubitidze, K O'Neill, K. Sun, I. Shamatava and K.D. Paulsen (2003). Coupling between highly conducting and permeable metallic objects in the EMI frequency range, accepted for publication, J. ACES.

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K. O'Neill, K. Sun, F. Shubitidze, I. Shamatava, and K.D. Paulsen (2004). Accounting for the effects of widespread discrete clutter in subsurface EMI remote sensing and discrimination, submitted for publication.

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F. Shubitidze, K O'Neill, K. Sun, and I. Shamatava (2003). Interaction between highly conducting and permeable metallic objects in the low frequency EMI range, Proc. Applied Computational Electromagnetics Symposium (ACES), 2003, Monterey CA, 24-28 Mar 2003, p.625-631.

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K. Sun, K. O'Neill, L. Liu, F. Shubitidze, I. Shamatava (2003). Application of Bayesian inversion of electromagnetic induction data for UXO discrimination, Proc. Symposium for the Application of Geophysical Engineering & Environment Problems (SAGEEP), San Antonio TX, 6-10 Apr 2003, p.1469-1478.

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F. Shubitidze, K. O'Neill, and K.D. Paulsen (2003). Investigation of side looking EM field scattering from a buried metallic object to support UXO discrimination, 2003 IEEE AP-S International Symposium & USNC/CNC/URSI National Radio Science Meeting, Columbus, OH, June 22-27, 2003.

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K. O'Neill, K. Sun, C.C. Chen, F. Shubitidze, and K.D. Paulsen (2003). Combining GPR and EMI data for discrimination of multiple subsurface metallic objects, International Geo-science. & Remote Sensing Symposium, 21-25 July 2003, Toulouse, Vol. 7, p. 4157-59.

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B. E. Barrowes, T. M. Grzegorczyk, J. A. Kong, K. O'Neill and C.O. Ao (2003). Broadband analytical solution of electromagnetic induction (EMI) response by spheroidal objects under arbitrary excitation, PIERS'03, Honolulu, 13-16 Oct 2003, p. 127.

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I. Shamatava, F. Shubitidze, K. O'Neill, K. Sun, and K.D. Paulsen (2003). An efficient, user-friendly program for computing electromagnetic induction (EMI) responses from heterogeneous objects subject to state-of-the-art sensors, accepted for publ, UXO/Countermine Forum 2004.

BA2 II.F. Advanced Sensor Data Analysis Technologies for Improved Buried Target Detection and Discrimination

OVERVIEW: The purpose of this task is to develop advanced frequency domain electromagnetic (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 FDEM induction sensor data to achieve 90% 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., 98%) and a maximum false negative rate of 0.5%.

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). To reach this goal of reducing false alarm rates by tenfold, 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 FY02.

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.

ACCOMPLISHMENTS AND RESULTS:
Laboratory evaluation of enhanced FDEM Detection/Discrimination software has been completed. The FDEM software has been transitioned to field demonstrations. And the documentation of quantified FDEM code performance enhancements has been completed. As a product, the FDEM Detection/Discrimination Software for the improved GEM-3 prototype has been created. Also, the documentation of field performance of advanced FDEM Detection/Discrimination software has been completed.

PLANNED ACTIVITIES:
No activities are planned for this task. This task was completed in FY02.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
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Proceeding publications are from presentations at the UXO/Countermine Forum.

III. Sensor Design and Enhancement

BA2 III.A. Frequency Domain EM Enhancements

OVERVIEW: The purpose of this task 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 goal of this effort is to demonstrate the improved FDEM induction prototype's capability to achieve 90% 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., 98%) and a maximum false negative rate of 0.5%.

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). To reach this goal of reducing false alarm rates by tenfold, 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 evaluations 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 Small Business Innovative Research (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 time domain/frequency domain (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.

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.

ACCOMPLISHMENTS AND RESULTS:

The advanced GEM-3 prototype development has been completed. The advanced GEM-3 prototype has been transitioned to BA4 field demonstrations. A technical report documenting the FDEM prototype performance enhancements has been created. Also, the specifications for the improved dual-mode GEM-3 sensor were established. As a product, an improved GEM-3 prototype was created. And the specifications for the improved dual-mode GEM-3 sensor have been established.

PLANNED ACTIVITIES:
No activities are planned for this task. This task was completed in FY02.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Proceeding publications from presentations at the UXO/Countermine Forum.

BA2 III.B. Enhanced Data Acquisition/Data Analysis System (DAQ/DAS)

OVERVIEW: The purpose of this task is to develop technologies to support the acquisition and analysis of data collected from advanced multi-sensor prototypes systems. These support technologies are required to demonstrate the capability of handheld and man-portable systems to achieve the EQT program's UXO detection, discrimination, location, and production rate goals.

The enhanced DAQ/DAS will be an integrated software platform that will allow data from multiple UXO sensors and high-accuracy positioning and tracking systems to be acquired, merged, and stored in digital format. Tools will be provided to assess sensor data quality and area coverage, perform corrections to the data, and select anomalies for analysis. Advanced physics-based algorithms and/or model-based single and joint inversion techniques for UXO detection/discrimination will be integrated into the DAQ/DAS.

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.

ACCOMPLISHMENTS AND RESULTS:
Geosoft's Oasis Montaj was selected as the base platform for DAQ/DAS. The Oasis Montaj platform is already used by many in the UXO community and provides a great deal of functionality such as flexible import procedures, mapping, data management, and other utilities needed for DAQ/DAS. It also serves as the base platform for work being conducted under SERDP/ESTCP by CEHNC on QA/QC tools and by AETC on detection/discrimination. ERDC has established a contract with AETC to work on developing UXO data analysis capabilities. Basic data import procedures for sensors under evaluation have been established. Magnetic (MAG) and TDEM (EM-63) models developed by The University of British Columbia (UBC), and an FDEM (Gem-3) model and classification algorithms developed by Duke University have been currently implemented in Matlab. Conversion of these algorithms to C code is ongoing and will facilitate their integration with Oasis Montaj. Development of joint and cooperative inversion procedures by UBC are in progress. The EQT UXO Product Delivery Team (PDT) has met with personnel of the ESTCP office to discuss coordination and integration of UXO detection/discrimination algorithms and models with the Geosoft Oasis Montaj platform.

PLANNED ACTIVITIES:
Implementation of modeling and classification algorithms into C code, and integration into Oasis Montaj will be completed during 2004. The algorithms and procedures developed for DAQ/DAS will be evaluated using data from the Standardized UXO Technology Demonstration Sites at Aberdeen Proving Ground (APG) and Yuma Proving Ground (YPG). The DAQ/DAS will be transitioned for BA4 field evaluations during the 4Q04. Documentation of the optimized DAQ/DAS system specifications and field performance capabilities will be completed during the 4Q04.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Goodson, R. A., et al. (2002). "Analysis of GEM-3 Data from the Advanced UXO Detection/Discrimination Technology Demonstration - U.S. Army Jefferson Proving Ground, Madison, Indiana," ERDC/EL TR-02-25, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

BA2 III.C. UXO Sensor Positioning and Tracking Technologies

OVERVIEW: The purpose of this task 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.

The detection and clearing of UXO in ranges, impact areas, burn, 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 global positioning systems (GPS) and other line-of-sight tracking and positioning systems are unreliable, prohibitively expensive and hazardous for remediation personnel. In order to adequately characterize and remediate these difficult areas, advanced positioning and tracking technologies must be developed and demonstrated.

This work unit will leverage ESTCP and U.S. Army Corps of Engineers, Huntsville Center (CEHNC) investments to develop and test several navigation technologies, focusing on the unique requirements of a hand held sensor. Emphasis will be placed on development of systems for the acquisition of highly accurate three-dimensional data in environmentally challenging areas such as heavily wooded sites. Systems under investigation include: low-cost inertial measurement unit (IMU) with a GPS and electronic compass system; navigation/visualization system with Hexamite ultrasonic positioning, GPS, electronic compass and real time visualization software; multiple laser transmitter stations with rover station system; the robotic total station system using multiple laser measurement units; and Radio Frequency (RF) positioning integrated with inertial navigation system (INS). The IMU system uses GPS for base accuracy and the IMU to maintain the accuracy when the satellites are obstructed. The navigation/visualization system provides high 3D accuracy to a relative position for anomaly interrogation. The two laser based systems are highly accurate line of sight systems that interpolate for obstructed points. Both provide high 3D accuracy for anomaly interrogation. The RF/INS system uses the radio navigation for the base positioning and then used the INS for highly accurate 3D relative positioning of the instrument location. Following field evaluations, a go/no go decision will be made for the continuation of individual system development.

Navigation system application will focus on supporting handheld sensors to accurately record and integrate sensor position in three dimensions in open and obstructed areas. Proof of concept systems will initially be with an EM-61 Hand held (HH) and G-858 magnetometer integrated and demonstrated at the navigation test course, McKinley Range, Redstone Arsenal, Huntsville, Alabama. After additional development, the systems shall area map the Aberdeen Proving Ground Test Site Wooded and Calibration Lanes areas. The mogul area will be used to test slope effects on accuracy for a series of fixed points. Select geophysical anomalies will be interrogated in both a static and dynamic mode to create 3D data sets at several heights above the ground surface. The Government will compare the results with the traditional baseline methodologies such as commercial RTK Digital Global Positioning System (DGPS). Following the evaluation of the data sets, the most promising navigation/mapping system(s) will

be integrated with a geophysical sensor and a prototype system developed. The system(s) will be developed and transitioned to BA4 for field-evaluation and demonstration.

This work unit will provide the capability to map the location of UXO targets in difficult environments and will address the user requirements for reduced risks and costs associated with UXO environmental remediation efforts.

ACCOMPLISHMENTS AND RESULTS:
The proof of concept prototype testing of low-cost GPS/IMU/electronic compass system with low accuracy card based GPS was completed. Development and evaluation of prototype navigation/visualization Ordnance Detection System with Hexamite Ultrasonic, GPS, Electronic Compass and real-time visualization was completed during 3Q03. Field performance of the GPS/IMU prototype system was documented during the 1Q03. The field performance of the navigation/visualization prototype system was documented during the 3Q03.

PLANNED ACTIVITIES:
The navigation/visualization, line of sight laser robotic total station, and line of sight laser with multiple transmitter/receiver and the Hexamite Ultrasonic, GPS, Electronic Compass and real-time visualization systems will be tested at Aberdeen Proving Ground (APG) during the 1Q-2Q FY04. The evaluation of 3D data sets and select system(s) for development will also be completed during the 2Q04. Optimum system(s) specifications will be completed and sensor integrations will begin during the 3Q04. During the 4Q04, the evaluation of 3D data sets for RF/INS will be completed, the optimized prototype integrated system(s) will be completed, and the optimum RF/INS specifications will be completed and the sensor integrations will be initiated. The optimum RF/INS prototype integrated system will be completed during the 2Q05.

Documentation of field performance of navigation/visualization system, robotic total station laser system, and the multiple transmitter/rover system testing at APG using data sets will be completed during the 2Q04. Optimized prototype positioning and tracking system(s) will be developed and field performance documentation of the RF/INS system testing at APG using data sets will be completed during the 3Q04. The RF/INS prototype integrated system will be optimized for better performance during the 2Q05.

Ongoing work will be coordinated with AETC/SERDP sponsored work. In the Phase II final report, a summary table will be included that documents performance metrics, costs of equipment, and a relative evaluation of ease of implementation and use. A paper analysis of the required drift rate to interrogate will be completed for optimal INS.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
The following CEHNC report will be published as a result of this effort:

Innovative Navigation Systems to Support Digital Geophysical Mapping Phase II Demonstrations.

IV. Hand Held UXO Detector Design Thrust Oversight

BA2 IV.A. UXO Multi-sensor Systems Design, Oversight, and Integration

OVERVIEW: The purpose of this task is to coordinate EQT program sensor development activities and 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. The 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 Demonstration/Validation (Dem/Val) and to the UXO remediation user community.

The detection and clearing of UXO on ranges, impact areas, open 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 inability to discriminate UXO targets from non-UXO anomalies. It is currently estimated that over 70% of UXO remediation costs are due to excavating non-UXO items (false alarms). To reach this goal of reducing false alarm rates by tenfold, advanced prototype systems are under development that incorporate multi-sensing data acquisition, signal analysis, and sensor positioning technologies for the improved detection and discrimination of buried and shallow water UXO.

This work unit provides the design and oversight support needed to integrate 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.

ACCOMPLISHMENTS AND RESULTS:
A technology workshop was conducted to identify a candidate dual sensor technology during the 3Q02. The design and fabrication of prototype bench-scale multi-sensor handheld and man-portable systems were completed during the 1Q04.

ISSUES:
Work is still ongoing. No limitations have been identified at this time.

PLANNED ACTIVITIES:
Field evaluations of prototype systems will be completed during the 2Q04. The design of the optimized multi-sensor prototype system will be completed during the 1Q05. System specifications and field performance capabilities of the optimized prototype systems will be documented in a final report during the 2Q05.

Design specifications for multi-sensor prototype systems will be completed during the 3Q04. The handheld and man-portable system prototypes will be optimized during the 4Q04.

Documentation of field performance of advanced prototype systems will be completed during the 2Q05.

Work will also be conducted to reduce the pole/sensor assembly weight of 20 lbs and to implement a magnetic compensation methodology.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
The following ERDC reports will be published as a result of this effort:

AETC Handheld Dual-Sensor System Development Phase I

Geophysical Solutions Multi-Sensor System Development Phase I

G-Tek Sub-Audio Magnetic Receiver Development

DEM/VAL (BA4 & BA6) Major Thrust Areas

I. Standardized Sites

BA4 I.A. Standardized UXO Technology Demonstration Site Support

OVERVIEW: The purpose of this task is to provide for maintenance and management of the Standardized UXO Technology Demonstration Site Program.

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 active 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 (PDT) aided by the site managers will identify necessary maintenance activities during the coarse of the program.

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 PDT 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.

ACCOMPLISHMENTS AND RESULTS:
The APG and YPG Standardized sites have been operational since August 2002 and January 2003, respectively. Maintenance on both sites was performed throughout the course of the fiscal year. Supported twelve (12) demonstrations at the APG Site. The majority of these demonstrations were conducted in support of SERDP/ESTCP and the Army EQT programs. Also, one of the demonstrators funded their own demonstration while on APG. Six (6) demonstrations were supported at the YPG Site. All demonstrations were conducted in support of SERDP/ESTCP and Army EQT programs. Automated software to score demonstrations was verified and version control was implemented. Six (6) scoring records for the Blind Grid scenario have been published. Refined guidance on gaining site access and process to providing

demonstration data (raw data and scoring submittals) has been implemented via the Army Environmental Center (AEC) UXO website, http://www.uxotestsites.org. Site improvements have been implemented for both APG and YPG. These site improvements included the installation of grid markers in the calibration lanes and blind grid (and mine grid at APG), to improve location awareness on the site areas. Also, boundary markers were installed which clearly delineate each scenario area. Exit Surveys/Feedback Forms (site layout/usage and scoring records) were created in an attempt to improve the overall program. The repository was expanded to include clutter items.

ISSUES:
Partial release of the ground truth to demonstrators has been an issue for this program because it's release must be limited to prevent uncovering the complete ground truth to the demonstrators.

PLANNED ACTIVITIES:
The programmatic coordination and oversight of the Standardized and Active Response Sites is scheduled for completion during the 4Q05. Further Standardized Site maintenance is scheduled for completion during the 3Q04, 4Q04, 3Q05, and 4Q05. The addition of challenges to the Sites is scheduled to commence during the 3Q05, as well as, the reconfiguration of the Sites in the 3Q04 and 3Q05. In addition, during the 3Q06 the recovery of targets is scheduled for completion.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Standardized UXO Technology Demonstration Blind Grid Scoring Record # 37, Zonge Engineering, Dated October 2003.

Standardized UXO Technology Demonstration Blind Grid Scoring Record # 39, AETC Incorporated, Dated October 2003.

Standardized UXO Technology Demonstration Blind Grid Scoring Record # 45, Witten Technologies, Dated October 2003.

Standardized UXO Technology Demonstration Blind Grid Scoring Record # 49, GEOPHEX LTD, Dated October 2003.

Standardized UXO Technology Demonstration Blind Grid Scoring Record # 50, GEOPHEX LTD, Dated October 2003.

Standardized UXO Technology Demonstration Blind Grid Scoring Record # 40, GEO-CENTERS INC., Dated November 2003.

BA4 I.B. Wide Area Survey Standardized Technology Demonstration Site

OVERVIEW: The purpose of this task is to leverage work being done in the Wide Area Survey Standardized UXO Technology Demonstration Site Program.

The Standardized UXO Technology Demonstration Sites 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. ESTCP funded a program to begin the preliminary work on the development of the Wide Area Survey Sites Program. There were funds from 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 Joint UXO Coordination Office (JUXOCO) and Defense Threat Reduction Agency (DTRA) to establish necessary protocols to develop and operate wide area sites.

Information obtained from the Wide Area Survey will focus the site manager's resources 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.

ACCOMPLISHMENTS AND RESULTS:
The performance of the sensor platforms tested under ESTCP's Wide Area Demonstration and Survey program as described in the reports published by the Naval Research Laboratory (NRL) and Oak Ridge National Laboratory (ORNL) was reviewed during Task 1. The information in these reports was compared and contrasted looking for strengths and weaknesses in detection capabilities to gauge the current "state-of-the-art".

The field logistics required for conducting the wide area test were also reviewed to gain insight on the support facilities needed to accommodate the demonstrators. Specific items were airfield support (work space, power requirements, fueling, and air-traffic control) range safety, security, administrative work areas, and data processing.

During Task 2, two reports were provided and reviewed:

- Standoff Minefield Detection System Advanced Technology Transition Demonstration (STAIMDS ATTD) published by Waterways Experimental Station.

- Sensors for the Detection of Land-Based Munitions, published by the Naval Postgraduate School, September 1995.

Based on the lessons learned during the AEC, ESTCP and the Directorate of Safety, Health, and Environment (DSHE) funded Wide Area Demonstration and Survey conducted by Aberdeen Test Center (ATC) and the literature searches, a list of questions were developed to be used in the test site selection process.

ATC considered several possible test site locations. Contact was made with two Department of Defense bases (Yuma Proving Ground and Eglin Air Force Base) and one Department of Energy site (Lawrence Livermore Laboratory). Discussions revolved around the willingness to participate in this type of program, areas that could be used, existing facilities and the requirements needed to operate at those facilities.

The purpose of this exercise was to get a feel for what types of areas were available for use, and how accessible those areas would be. This information was to help in the further development of the wide area test plan. It should be noted that all three of these sites have expressed a willingness to participate in a program such as this, and each has something to offer.

Key features in the test site design, test plan elements and site operation were developed during Task 3.

Very little time or effort was spent on Task 4 of this program. Thought was given to the caliber, quantity and distribution of items that might be required. The site concept and design was not developed to the point of determining exact number and type of standardized targets. Therefore, no targets were procured.

ISSUES:
Selection of an area to develop into a test site is the most significant factor to consider in this program in that it determines what can and cannot be included in a test and evaluation plan. Construction, development and operation costs are also driven by the site selection.

PLANNED ACTIVITIES:
During the Army EQT Independent Review Panel Meeting held on August 13, 2003 the decision was made by the Product Delivery Team (PDT) to cancel this task.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

BA4 I.C. Establishment of Active Response Demonstration Areas

OVERVIEW: The purpose of this task is to establish an Active Response Demonstration Area to correlate technology performance between Standardized UXO Technology Demonstration Sites and Active Response Areas. Although the Standardized sites provide an excellent means of base lining and provide statistically valid data for UXO detection and discrimination data, it is essential to correlate the technology performance between the Standardized sites and realistic range areas in order to validate the Standardized Sites and demonstrate the technologies "real" performance. The objectives are to establish protocols and mechanisms to determine the technologies ability to perform on an Active Response Site.

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 (S&T) 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 2006.

Demonstrations on Active Response Site areas are necessary because of stakeholder concerns that seeded sites are different from Active Response Sites. This program will allow for the demonstration of the technologies true capabilities and provide a means of correlating technology performance with the Standardized Sites, ultimately demonstrating the validity of the Standardized Sites Technologies that perform well in both the Standardized Site, and the Active Response Demonstration area. Overall, this will provide overwhelming evidence that the technology is technically mature and ready for full implementation by the user community.

ACCOMPLISHMENTS AND RESULTS:
During the 4Q03, the protocols for the Active Response Demonstration Area were established and applicable areas were identified.

ISSUES:
There is unknown ground truth at the Active Response Test Site.

PLANNED ACTIVITIES:
During the 1Q04, the preparation of the Active Response Demonstration Site will be completed and in 2Q05, the demonstrators will be able to perform on the Active Response Site. This task will also leverage with the Standardized UXO Technology Demonstration Program 2006 during the 1Q05. Following in 2Q05, the Active Response Area will be evaluated against the Standardized Sites. Suggested modifications to the Standardized UXO Technology Demonstration Sites will be conducted during the 3Q05.

As an action item, a site usage application process will be created so that other technologies (non-EQT) can be brought in, and the criteria for evaluating certain technologies capabilities will be established. Also, a list of existing cleanup sites for interfacing with the research and development (R&D) community will be developed and this project will need to coordinate with ESTCP Project 02EB-UX1-003.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Detailed Test Plan for the Active Response Test Site, in progress.

II. UXO Technology Demonstrations

BA4 II.A. Dual Mode UXO Detector Design Demonstration and Validation

OVERVIEW: The purpose of this task is to demonstrate dual-mode sensor systems.

The purpose of this effort is to demonstrate the state of the art for currently available dual-mode sensor systems. There will be three (3) focus areas for the BA4 program: supporting the demonstration of Army EQT BA2/BA3 hand held 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.

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 the demonstration of the products will occur.

ACCOMPLISHMENTS AND RESULTS:
A Dual Mode Sensor workshop was facilitated during the 3Q02. A Broad Agency Announcement (BAA) was implemented by the U.S. Army Aberdeen Test Center (ATC) to facilitate demonstrations of Dual Mode systems.

PLANNED ACTIVITIES:
Anticipate performing initial demonstrations in 2Q FY04. During the 2Q04, the commercial off the shelf (COTS) demonstrations at the Standardized Sites will be completed. The Army prototype dual mode hand held field evaluation testing is scheduled for completion during the 4Q04. Following with an Army dual mode hand held demonstration during the 1Q05. During the 1Q06, the COTS and government off the shelf (GOTS) will be completed at Active Response Areas and Standardized Sites. Finally in 3Q06, the transition and final report on dual

mode sensor systems will be completed. Also, a reliable matrix for comparing Army and COTS systems will be established.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

BA4 II.B. Baseline Hand held/Man Portable System Performance

OVERVIEW: The purpose of this task is to baseline system performance for hand held and man portable sensor systems at Standardized UXO Technology Demonstration Sites.

This work unit will initially document the capabilities and limitations of the hand held and man portable UXO sensor systems at Standardized UXO Technology Demonstration Sites. Baseline information will be used to direct RDT&E activities and will 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.

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 improvement in technology from EQT investment will be documented at the end of the program.

ACCOMPLISHMENTS AND RESULTS:
The Yuma Proving Ground (YPG) Standardized UXO Demonstration Site was completed during the 2Q03. Fabrication of a prototype Sub-Audio Magnetic (SAM) receiver system was completed during the 3Q03. The transition performance matrix milestone for MAG, TDEM, and FDEM, set for completion in 4Q04 was removed and will not be performed.

PLANNED ACTIVITIES:
Three contractor outfits utilizing a total of five (5) different technologies were awarded contracts to perform demonstrations at the APG and YPG Standardized UXO Technology Demonstration Sites. The demonstrations were conducted at both sites by all of the contractors and the results of their performance are being documented through Standardized UXO Technology Demonstration Site Scoring Records. Results of all demonstrations will be completed during the 2Q04 and will be posted on the AEC UXO website, http://www.uxotestsites.org. Additional funding was received through SERDP/ESTCP to fund "Mag and Flag" and "EM and Flag" demonstrations at both Standardized Sites. Contracting mechanisms are being established to fund these demonstrations. Completion of these additional demonstrations is anticipated to be complete by the 4Q04. The fabrication of prototype Sub-Audio Magnetic (SAM) receiver system was completed in the 3Q03.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
The following ATC reports will be published as a result of this effort:

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek with TM-4 Mag Sling

Standardized UXO Technology Demonstration site Open Field Scoring Record for

Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek with TM-4 Mag Sling

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek with TM-4 Mag Sling

Standardized UXO Technology Demonstration site Woods Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek with TM-4 Mag Sling

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: G-Tek with TM-4 Mag Sling

Standardized UXO Technology Demonstration site Open Field Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: G-Tek with TM-4 Mag Sling

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: G-Tek with TM-4 Mag Sling

Standardized UXO Technology Demonstration site Desert Extreme Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: G-Tek with TM-4 Mag Sling

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek with TM-5 EMU Handheld

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek with TM-5 EMU Sling

Standardized UXO Technology Demonstration site Open Field Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek with TM-5 EMU Sling

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek with TM-5 EMU Sling

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Yuma Proving Ground

Demonstrator: G-Tek with TM-5 EMU Sling

Standardized UXO Technology Demonstration site Open Field Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: G-Tek with TM-5 EMU Sling

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: G-Tek with TM-5 EMU Sling

Standardized UXO Technology Demonstration site Desert Extreme Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: G-Tek with TM-5 EMU Sling

Standardized UXO Technology Demonstration site Woods Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek with TM-5 EMU

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: TT/FW with EM61 Cart

Standardized UXO Technology Demonstration site Open Field Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: TT/FW with EM61 Cart

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: TT/FW with EM61 Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: TT/FW with EM61 Cart

Standardized UXO Technology Demonstration site Open Field Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: TT/FW with EM61 Cart

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: TT/FW with EM61 Cart

Standardized UXO Technology Demonstration site Desert Extreme Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: TT/FW with EM61 Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: TT/FW with EM61 Sling

Standardized UXO Technology Demonstration site Woods Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: TT/FW with EM61 Sling

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with EM61 Cart

Standardized UXO Technology Demonstration site Open Field Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with EM61 Cart

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with EM61 Cart

Standardized UXO Technology Demonstration site Woods Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with EM61 Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: Shaw with EM61 Cart

Standardized UXO Technology Demonstration site Open Field Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: Shaw with EM61 Cart

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: Shaw with EM61 Cart

Standardized UXO Technology Demonstration site Desert Extreme Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: Shaw with EM61 Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with 858 Cart

Standardized UXO Technology Demonstration site Open Field Scoring Record for

Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with 858 Cart

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with 858 Cart

Standardized UXO Technology Demonstration site Woods Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with 858 Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: Shaw with 858 Cart

Standardized UXO Technology Demonstration site Open Field Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: Shaw with 858 Cart

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: Shaw with 858 Cart

Standardized UXO Technology Demonstration site Desert Extreme Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: Shaw with 858 Cart

BA4 II.C. Standardized UXO Technology Demonstration 2006

OVERVIEW: The purpose of this task 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.

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 (JPG). 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.

The demonstration of available UXO detection and discrimination is the ultimate measure of the program's success. Demonstrations of COTS and GOTS technologies will aid the product delivery team (PDT) in determining 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.

ACCOMPLISHMENTS AND RESULTS:
A Broad Agency Announcement (BAA) was implemented by the U.S. Army Aberdeen Test Center (ATC) to facilitate demonstrations of advanced UXO detection and discrimination technologies. Anticipate performing initial demonstrations during the 2Q04.

PLANNED ACTIVITIES:
During the 2Q06, the demonstration of technologies at the Standardized Sites and Active Response Sites are scheduled for completion. Following in 3Q06, the data from the Standardized Site will be correlated to the Active Response Sites. And finally in 4Q06, a final report on the State of the Art will be produced.

As action items from the Independent Review Panel meeting, there is a need to look at the overlap of sensors and to start discussing what metrics are appropriate for determining state of art, as well as, a need to raise the level of funding for this effort to ensure it is done properly. Also, a government work group will be held to look at augmenting the baseline/processing approach. Coordination will be conducted between SERDP/ESTCP, ERDC, ATC, and AEC to distribute matrix/processes.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

BA4 II.D. Sensor/Platform Integration and Demonstration

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

This work unit will focus on five (5) focus areas in the Army's EQT BA2/BA3 projects in UXO Sensor/Platform Design and Enhancement: (1) Frequency Domain EM Enhancements, (2) Enhanced Data Acquisition/Data Analysis System, (3) UXO Sensor Position and Tracking Technologies, (4) Spatial pattern Survey Strategies and Sensor Configuration Optimization, and (5) Performance Protocols.

BA4 technology demonstrations for Frequency Domain EM Enhancements will baseline capabilities and limitations of the improved GEM-3 prototype. The demonstrations will provide information pertaining to the integration of future dual-mode/multi-sensor systems. The demonstration will be conducted at the Aberdeen Proving Ground (APG) and the Yuma Proving Ground (YPG) Standardized UXO Demonstration 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 be conducted in three phases: (1) the integration of the dual-mode/multi-sensor system onto the platforms, (2) a field test and demonstration to hone the final product, and (3) an independent evaluation of both systems at all standardized and two (2) 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 positioning systems, designed for use 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 documented. The optimized system will not only be independently evaluated at a standardized site but also evaluated at active response sites.

BA4 technology demonstrations for Spatial pattern Survey Strategies and Sensor Configuration Optimization will focus on new sensor configurations and will evaluate processing algorithms for Ultra wideband (UWB) surveys. The project will demonstrate advances provided by the advanced instrument sensor design and will validate the developed algorithm. The algorithm will be evaluated by both the development and the user communities using independently gathered datasets and will be documented and transitioned to the user community.

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.

The demonstration and validation of the Sensor/Platform Design and Enhancement focus area will provide a marked advancement in UXO sensor/platform design and performance.

Demonstrations will document capabilities of the improved GEM-3 Prototype, dual-mode/multi-sensor man portable and vehicular platforms, optimized position/tracking system, validated ultra wide band processing algorithms and sensor designs, and will evaluate the performance of platforms for housing sensors.

ACCOMPLISHMENTS AND RESULTS:
During the forth quarter of 2003 the improved GEM-3 prototype was demonstrated and the position/tracking system baseline was documented.

PLANNED ACTIVITIES:
The dual-mode/multi-sensor system and DAS will be integrated onto both man portable and vehicular platforms during the 1Q05. The integrated prototype man portable and vehicular platforms field evaluations will be completed during the 2Q05. The final integrated man portable and vehicular platforms (cost integrated into Standardized UXO Technology Demonstrations 2006) will be demonstrated during the 3Q05. A final report documenting the Enhanced Data Acquisition/Data Analysis System will be completed during the 4Q05.

The Prototype position/tracking system field evaluations will be completed during the 3Q04. The independent demonstration of the optimized position/tracking system will be conducted during the 4Q04. And during the first quarter of 2005, the system will be transitioned to the user community.

The optimized UWB Sensor Configuration will be demonstrated during the 3Q04. The UWB algorithm will be demonstrated using data sets during the 3Q04, and platform performance protocols will be developed during the 2Q04.

POINTS OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
The following ATC reports were published as part of this effort:

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: ERDC with Standard GEM-3 Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Aberdeen Proving Ground
Demonstrator: ERDC with Enhanced GEM-3 Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: ERDC with Enhanced GEM-3 Cart

Standardized UXO Technology Demonstration site Open Field Scoring Record for

Site Location: Yuma Proving Ground
Demonstrator: ERDC with Enhanced GEM-3 Cart

Standardized UXO Technology Demonstration site Moguls Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: ERDC with Enhanced GEM-3 Cart

Standardized UXO Technology Demonstration site Desert Extreme Scoring Record for
Site Location: Yuma Proving Ground
Demonstrator: ERDC with Enhanced GEM-3 Cart

The following ERDC reports will be published as a result of this effort:

GEM-3 Data Collection at Standardized UXO Technology Demonstration Site, Aberdeen Proving Ground, Maryland

GEM-3 Data Collection at Standardized UXO Technology Demonstration Site, Yuma Proving Ground, Arizona

BA4 II.E. Demonstrate UXO Detection Systems in Shallow Water

OVERVIEW: The purposes of this task are to baseline current shallow water UXO detection technologies and to establish a Shallow Water Standardized UXO Technology Demonstration Site in which to test and evaluate existed and emerging concepts and methods in this field of detection.

The next area of concern for the Army is UXO detection and discrimination in shallow water and littoral areas. There have been limited demonstrations done in these areas but there is no standardized evaluation site or plan to assess the current state of the art. This program will leverage a limited shallow water demonstration program, initiate the team development of standardized protocols, which will outline 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 and tested through a competitive BAA and proposal process to demonstrate the current state of the art.

This effort is proactive in the face of increasing pressure and 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 (PDT) 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.

ACCOMPLISHMENTS AND RESULTS:
In 3Q03, the shallow water portion of the Wide Area Survey efforts was leveraged. This effort involved a demonstrator, using a boat-mounted detection system, surveying a large pond that had been seeded with a variety of ordnance items and scanned using helicopter-mounted equipment during the wide area survey. Results from the boat survey are not yet available.

Between the second and fourth quarter of FY04, an installations survey was conducted looking for bodies of water that could be developed into a test site. Historical records for three possible sites were reviewed. Bathymetry plots were obtained for all three of the ponds and magnetic surveys were obtained for two of the ponds.

ISSUES:
There are several open issues in defining the “shallow-water” environment. Some of these issues include for example, the water depth, presence of currents or tides, salinity and bottom types. There is also the unknown technical aspect as to the detection capabilities/limitations of existing systems within a given environment.

This is a proactive, “living” program, seeking to anticipate and address environmental and technical requirements associated with locating and identifying UXO hazards in shallow water.

The test site constructed under this program will represent a starting point, with limited growth potential, to baseline existing and emerging shallow water detections systems.

PLANNED ACTIVITIES:
During the 1Q04, Standardized Protocols will be established. Following in the 4Q04, a Standardized Site will be constructed and the targets will be procured. Baseline demonstrations are scheduled for completion during the 3Q05, and in the 1Q06, technology gaps will be evaluated and reported. The site is scheduled for a clean up during the 4Q06.

As an action item, a working group has convened to assess the joint needs and the possible consolidation of R&D efforts, and this will continue to be an on-going process.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Final Shallow Water Report drafted, FY04.

BA4 II.F. Demonstration of Fill Identification Technologies

OVERVIEW: The purpose of this task is to demonstrate the ability of selected technologies to determine the fill material of ordnance without penetrating the skin.

During UXO remediation, the contents of discovered rounds are not always obvious. Current fielded technologies have only a limited ability to identify fill material of munitions. Munitions could contain inert fill, conventional explosives, improved conventional munitions, chemical warfare material, 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 program will leverage other similar 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.

The ability to identify materials contained within an UXO during a removal action is critical to safety 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 items.

ACCOMPLISHMENTS AND RESULTS:
This program was never started. The scope of the project did not have the necessary allocation of resources. It was also discovered during project planning that the Navy has an extensive program to address this issue. It was decided by the Program Development Team (PDT) that the assigned resources for this program would be better used elsewhere.

ISSUES:
Funding has been reallocated from this program. The program is currently on hold.

PLANNED ACTIVITIES:
Monitor Navy efforts in this area to determine if products meet the requirements identified in the Army UXO Operational Requirements Document (ORD).

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

III. Hardware/Software Integration

BA4 III.A. Software Demonstration/Validation Assessment

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

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.

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 an inventory of the software packages, a demonstration and evaluation of the software packages, and the incorporation of the software packages into the Geosoft platform.

ACCOMPLISHMENTS AND RESULTS:
Over 40 questionnaires were sent out to individuals involved in Ordnance and Explosives (OE) geophysical surveys and analysis, requesting information regarding the types of software being used and requesting observed strengths and weaknesses of each. Eleven (11) respondents involved in OE geophysical projects returned completed questionnaires; five (5) from government organizations, five (5) from consulting firms and one (1) from a University. The findings from the questionnaires show that twenty-seven (27) software products are currently in use throughout the OE community. The identification and reporting on the available software was completed during the 2Q03.

ISSUES:
Due to funding issues, the software has not been implemented into Geosoft fully. Some inaccuracies have been reported on the survey sheets, but inconsistencies were expected and were useful to emphasize how human factors and experience with the individual software packages affect patterns of usage of the available tools.

PLANNED ACTIVITIES:
The demonstration and assessment of the software is scheduled for completion during the 3Q04. Following in 1Q05, software systems will be inserted into the Geosoft Systems.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

BA4 III.B. Modeling Analyses and Processing Demonstration/Validation

OVERVIEW: The purpose of this task 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.

Forward and inverse modeling techniques for total magnetic field, magnetic vector component, time domain electromagnetic induction and frequency domain electromagnetic induction will be developed under Army EQT BA2/BA3 RDT&E projects. In addition, constrained, cooperative, and joint inversion capabilities for rational integration or "fusion" of multi-sensor type data sets will be provided under the Army EQT BA2 Program. The Modeling Analyses and Processing area has been broken down into five focus areas: (1) Advanced Sensor Data Analysis Technologies for Improved Buried Target Detection and Discrimination, (2) Investigation of Time Domain EM and Magnetic, (3) Evaluation of Advanced Signature Models and Inversion Technologies, (4) Algorithm for Inferring Shape of Composite Targets, and (5) Joint Inversion Investigation for UXO Discrimination.

BA4 technology demonstrations for Advanced Sensor Data Analysis Technologies for Improved Buried Target Detection and Discrimination will be conducted at the two standardized UXO technology demonstration sites and will demonstrate frequency domain electromagnetic (FDEM) software using the enhanced GEM-3 Sensor man-portable platform. A report of results will be generated and the enhanced software will be applied to traditional GEM-3 Sensor to document improvements in the sensor system and in the discrimination software.

BA4 technology demonstrations for investigation of time domain Electromagnetics (TDEM) and Magnetic (MAG) will produce guidelines for optimum application of TDEM and MAG. The guidelines will be coordinated and be transitioned to the user community.

UXO technology demonstrations will be conducted under BA4 to evaluate: (1) Advanced Signature Models and Inversion Technologies for advanced UXO detection and discrimination, (2) Algorithms for Inferring Shape of Composite Targets and the ability to distinguish UXO-like objects from clutter, and (3) Joint Inversion Investigation for UXO Discrimination and the ability to use 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. Independent operators will be used to evaluate technology systems on the two (2) standardized sites and will evaluate the capabilities of detection/discrimination algorithms and their ease of use during field investigations.

The validation and demonstration of UXO detection and discrimination algorithms will enhance the capabilities of government and private UXO remediation site evaluations. The evaluation plan also ensures that the technologies developed in the BA2/BA3 portion of the EQT program are commercially mature and user friendly.

ACCOMPLISHMENTS AND RESULTS:

The FDEM software for the enhanced GEM-3 was demonstrated, and real time results were documented in a report. Enhanced software was also applied to the traditional GEM-3 models during the 4Q03. High quality data sets (TF Magnetics and TDEM) were acquired at the Yuma UXO Standardized Site for use in demonstrating the modeling and inversion software. This data set contains 1 of 2 required data sets from the Blind Grids and will be used in demonstrating and validating this technology.

ISSUES:
Issues on this technology are based on approximate modeling of UXO and the acquired data resolution and quality. Certain particular issues will be documented in the final report.

PLANNED ACTIVITIES:
Guidelines for the application of TDEM and MAG/TDEM will be completed during the 4Q04. The transition to CEHNC and the commercial user community will be completed during the 4Q04. The demonstration of "real time" algorithms for MAG, TDEM, and FDEM are scheduled for completion during the 2Q05. And the final report on Advance Signature Models and Inversion Technologies Implementation is scheduled for completion during the 3Q05.

For the section that focuses on the algorithm for inferring the shape of composite targets, data sets will be collected from the Blind Grids during the 3Q04, followed by the application of the algorithm to data sets (developer, user) in 3Q04, and the transition to Geosoft in 4Q04.

For the section that focuses on the joint inversion investigation for UXO discrimination, the second data set will be collected from the Blind Grid at Aberdeen Proving Ground, Maryland, during the 3Q04, followed by the application of the algorithm to data sets (developer, user) during the 3Q04, and the transition to Geosoft during the 4Q04.

POINTS OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Associated technical reports:

Billings, S. D., Pasion, L. R., and Oldenburg, D. W. (2002). "Discrimination and Identification of UXO By Geophysical Inversion of Total-Field Magnetic Data," ERDC/GSL TR-02-16, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Pasion, Leonard R. and Oldenburg, Douglas W. (2001). "Locating and Characterizing Unexploded Ordnance Using Time Domain Electromagnetic Induction," ERDC/GSL TR-01-10, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

BA4 III.C. MAUDE Demonstration Validation

OVERVIEW: The purpose of this task 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.

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.

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

ACCOMPLISHMENTS AND RESULTS:
Selected an appropriate site/location to demonstrate software and provided baseline data on the selected location (GIS files including the soil type, natural and cultural resources, geology and hydrogeology conditions, vegetative cover, etc.)

PLANNED ACTIVITIES:
During the 2Q04, ERDC will demonstrate the MAUDE software at the two (2) Standardized Sites, Aberdeen Proving Ground (APG) and Yuma Proving Ground (YPG). Following in 4Q04, ATC will demonstrate the MAUDE software at two (2) Active Response Demonstration Sites. Finally in 2Q05, the software will be transitioned (ex. CEHNC, ITRC, and Geosoft).

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

IV. Geophysical QA/QC

BA4 IV.A. Standardized Guidance for Geophysical Prove-Outs

OVERVIEW: The purpose of this task is to generate standardized guidance for Geophysical Prove-Outs (GPO).

Due to the site-specific nature of UXO technology capabilities and limitations, it is necessary to conduct a GPO survey 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 American Society for Testing and Materials (ASTM) guidance document.

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

ACCOMPLISHMENTS AND RESULTS:
During the 2Q03, mechanisms for stakeholder acceptance were identified. A chapter on the major steps involved in understanding the Geophysical Process, within the ITRC Geophysical Prove-Out (GPO) Guidance document was drafted. Interstate Technology Regulatory Council (ITRC) UXO team meetings and monthly conference calls were conducted to define the path forward. Completion of the GPO document with full concurrence is expected in October during the 1Q04.

ISSUES:
The Department of Defense (DoD) concurrence process within ITRC for documents has not been standardized.

PLANNED ACTIVITIES:
A final guidance document is scheduled for completion during the 3Q04. As an action item from the Independent Review Panel meeting, there is a need for DoD interaction and coordination efforts through ITRC within the UXO community.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
Draft Geophysical Prove-Out (GPO) Guidance Document, December 2003.

BA4 IV.B. QC for UXO Sensor Technology Operators

OVERVIEW: The purpose of this task is to determine the level of influence of the operator on UXO technology results.

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 Explosive Ordnance Disposal (EOD) technicians and comparing their detection and discrimination results. Operator impact has not been evaluated in the UXO community. The community points to antidotal 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.

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.

ACCOMPLISHMENTS AND RESULTS:
The identification of the number of operators (22) to participate in the demonstration was determined during the 3Q03. Carnegie Mellon University (CMU) POC, Dr. Jim Staczewski, will support this effort by providing data analysis and monitoring and software equipment. They will provide modeling of expert processes using a Cognitive Engineering theory called Cognitive Engineering Based Upon Expert Skill (CEBES). Dr. Herman (CMU) will support this effort by modifying and providing usage for the Sweep Monitoring System (SMS), which he developed and prototyped for the countermine community. The detailed test plan has been drafted for the peer review cycle. Texas A&M University will be instrumental for providing the novice operators for participation. A test bed and quantities have been generated to include five (5) types of ordnance and various sizes of clutter items.

ISSUES:
The challenge of quantifying and representing each variable exhibited numerically. The review panel team should be expanded above the PDT to include others on the review panel. Recommend referring to Adak (NAVFAC), Alaska for QC procedures.

PLANNED ACTIVITIES:
During the 2Q04, the technician training will be executed. And during the 3Q04, demonstrations will commence. The operator influence on the system will be evaluated following these demonstrations. Following in 4Q04, feedback, guidance, workshops, and mechanisms to remove bias will be provided. During the 2Q05, the demonstration will be repeated and the operator influence on the system will be re-evaluated. Finally in 3Q05, a training course will be developed.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

V. Technology Transfer

BA4 V.A. Technology Transition Support

OVERVIEW: The purpose of this task is to provide programmatic support and stakeholders buy in for UXO technology test and evaluation.

A barrier in implementing state of the art technologies is convincing stakeholders of the validity of data and instilling confidence in the technology. The Interstate Technology Review Council (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 (PDT) cannot accomplish the coordination of this programmatic oversight alone. This programmatic support will also support technology transfer issues.

The PDT 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.

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 PDT is essential to the success of the program. Without their technical oversight and involvement, the test and evaluation (T&E) 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.

ACCOMPLISHMENTS AND RESULTS:
The Technology Transfer Plan has been drafted. Also, a target stakeholder list is being compiled and the opportunities/mechanisms for disseminating information are being identified. The Strategic Communication Plan has been drafted. A briefing on the UXO Standardized Technology Site was conducted at the EMI Workshop in February 2004. The SERDP/ESTCP

Project of the Year Award was received in FY03. The UXO Countermine Forum will be conducted in FY04.

PLANNED ACTIVITIES:
Regulatory participation in the program is scheduled for completion during the 3Q06. Also in 3Q06, programmatic support will be provided to the test and evaluation (T&E) and science and technology (S&T) communities.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

BA4 V.B. Technology Review and Knowledge Exchange Seminar

OVERVIEW: The purpose of this task is to bring together technical executors of the EQT program to exchange issues and progress of the program.

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.

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.

ACCOMPLISHMENTS AND RESULTS:
The 2002 Technology Review Meeting has been conducted and 2002/2003 EQT Annual Report is in progress and scheduled for completion in FY04. An EQT IPR Meeting was held in February 2003. The 2003 Technology Review Meeting is scheduled for August 2004.

ISSUES:
Due to late funding, the scheduled completion date for the 2002 Annual Report was pushed back and the 2002/2003 Annual Reports were combined.

PLANNED ACTIVITIES:
The 2003 Technology Review meeting and Annual Report will be scheduled for completion in 2Q04. The 2004 Technology Review meeting and Annual Report will be scheduled for completion in 2Q05. The 2005 Technology Review meeting and Annual Report will be scheduled for completion in 2Q06. And in 4Q06, the program final report is scheduled for completion.

POINT OF CONTACT:
U.S. Army Environmental Center (AEC) Hotline at (800) 634-2655

PUBLICATIONS:
2002/2003 Environmental Quality Technology (EQT) UXO Annual Report, FY04.

Appendix A

EQT UXO Independent Review Panel Meeting
August 12-13, 2003

PURPOSE

The following Meeting Minutes summarize a meeting held in accordance with BA4 V.B. Task 1 of the Environmental Quality Technology (EQT) UXO Program, focusing on the Technology Review and Knowledge Exchange Seminar task. The EQT UXO Independent Review Panel meeting was conducted on August 12-13, 2003 in the BRTRC Conference Facility in Fairfax, VA. Both the Army EQT Program and the Joint UXO Coordination Office (JUXOCO) participated in the sponsoring of this meeting. The purpose of this meeting was to bring together technical executors of the EQT program to exchange issues and to aid in the progression of the program. Representatives from the Army Corps of Engineers (ERDC, Huntsville Engineering Center), the Army Environmental Center (AEC), Aberdeen Test Center (ATC), Joint UXO Coordination Office (JUXOCO), Navy, SERDP/ESTCP, state regulators, academia, and other stakeholders participated in the meeting. A list of attendees is included in the following Meeting Minutes.

BACKGROUND

The Army depends on the private sector to conduct the vast majority of UXO remediation projects. The principal emphasis of technology transition is early fielding of technological advances at actual UXO sites by the private sector.

Presenting interim results at briefings, conferences, and symposiums will accelerate the technology transfer process; publication of peer reviewed engineering and scientific papers; and preparation of technical reports, technical notes, and trade publications. Particular attention will be given to developing a close working relationship with the regulatory community, including the Interstate Technology Regulatory Council (ITRC) and the Environmental Protection Agency (EPA). Updates to the EPA Handbook on UXO Remediation will be proposed as a means of expediting acceptance of new technologies developed under this program.

This program will bring 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 and will also bring in members of the other services, academia, ESTCP, and technical leads as needed.

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.

SUMMARY

Overall general comments from the EQT IPR meeting held on August 12-13, 2003, identified some issues within the program including the technology transition/transfer issues of information, hardware, software and other products. Technology transition has been noted as a very important aspect of the work and a huge hurdle to accomplish. Another major issue identified for the whole program is the result of funding increases and/or decreases for milestones and products. Lastly as a result of the IPR, emphasis will be placed on the testing and evaluation of government and COTS systems during FY05 and FY06, as well as a need for further baselining assessments.

Draft Meeting Minutes
EQT UXO Independent Review Panel Meeting
August 12-13, 2003
BRTRC Conference Facility, Fairfax Virginia
Sponsored by the Army EQT Program and JUXOCO

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