ARMY

Environmental Quality Technology

OASA (ALT) OASA (I&E)

The Army Environmental Quality Technology User Requirement A (1.6.a) UXO Screening, Detection, and Discrimination UXO Program FY04 Annual Report

Office of the Assistant Secretary of the Army
(Acquisition, Logistics and Technology)

and the

Office of the Assistant Secretary of the Army
(Installations and Environment)

April 2005

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
April 2005	Annual Report - Final	01 OCT 2003 – 30 SEPT 2004

4. TITLE AND SUBTITLE

The Army Environmental Quality Technology User Requirement A (1.6.a) UXO Screening, Detection, and Discrimination UXO Program FY04 Annual Report.

5a. CONTRACT NUMBER
GS-23F-9755H

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Voigt, Kathleen, M.

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Booz Allen Hamilton, Inc.
1309-R Continental Drive
Abingdon, MD 21009

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

US Army Environmental Center
ATTN: SFIM-AEC-AT (Mr. George Robitaille)
Bldg. E4430
Aberdeen Proving Ground, MD 21010-5401

10. SPONSOR/MONITOR'S ACRONYM(S)
USAEC

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Unclassified. Unlimited distribution.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This 93-page report describes the endeavors of the EQT UXO Program from October 01, 2003 through September 30, 2004. Each BA2/3 and BA4/6 work unit is discussed in this report with focus given to FY04 objectives and accomplishments, issues that resulted in objectives not being met if applicable, planned activities for FY05, and documents published during the fiscal year related to each task.

This report has been prepared in conjunction with the Aberdeen Test Center (ATC) at Aberdeen Proving Ground, Maryland and the US Army Corps of Engineers – Engineer Research and Development Center in Vicksburg, Mississippi.

15. SUBJECT TERMS

UXO, environmental quality, detection & discrimination technology, remediation, range clearance

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			George Robitaille
U	U	U	SAR	93	19b. TELEPHONE NUMBER *(Include area code)* 410-436-6865

Reset

TABLE OF CONTENTS

APPENDICES

ACRONYMS & ABBREVIATIONS

1Q04……First Quarter of Fiscal Year 2004
2Q04……Second Quarter of Fiscal Year 2004
3Q04……Third Quarter of Fiscal Year 2004
4Q04……Fourth Quarter of Fiscal Year 2004
AERTA…… Army Environmental Requirement and Technology Assessment
AI……Artificial Intelligence
APG……Aberdeen Proving Ground (Maryland)
ASTM……American Society for Testing and Materials
ATC……US Army Aberdeen Test Center
BAA……Broad Agency Announcement
CEBES……Cognitive Engineering Based Upon Expert Skill
CEHNC……US Army Corps of Engineers, Huntsville Center
CMU……Carnegie Mellon University
COTS……Contractor Off the Shelf
CTC……Concurrent Technologies Corporation
DAQ/DAS……Data Acquisition/Data Analysis System
Dem/Val……Demonstration/Validation
DGPS……Digital Global Positioning System
DoD…… Department of Defense
DTRA……Defense Threat Reduction Agency
EM……Electromagnetic
EMI……Electromagnetic Induction
EOD……Explosives Ordnance Disposal
EPA……US Environmental Protection Agency
EQT……Environmental Quality Technology
EQT-ORD……Environmental Quality Technology Operational Requirements Document
ERDC……US Army Engineer Research and Development Center
ESTCP…… Environmental Security Technology Certification Program
ETMP……Environmental Technology Management Plan
FDEM……Frequency Domain Electromagnetic
FUDS……Formerly Used Defense Sites
FY……Fiscal Year
GMR……Giant Magnetoresistive
GOTS……Government Off the Shelf
GPO……Geophysical Prove-Out
GPS……Global Positioning System
GPR……Ground Penetrating Radar
HFA……Human Factors Applications, Inc.
HH……Handheld
IDA……Institute for Defense Analysis
IMU……Inertial Measurement Unit
INS…… Inertial Navigation System
IPR……Independent Program Review
ITRC……Interstate Technology Regulatory Council
JPG……Jefferson Proving Ground (Indiana)
JUXOCO……Joint UXO Coordination Office
kHz……kilohertz
Mag……Magnetic
MAUDE…… Management Aide for UXO Detection Efforts

MR……Magnetoresistive
MTADS……..…..Multi-sensor Towed Array Detection System
NAEVA……..…North American Exploration of Virginia, Inc.
NAVEODTECHDIV……..Naval Explosive Ordnance Disposal Technology Division
NAVFAC……Naval Facility
NDCEE…..……National Defense Center for Environmental Excellence
NRL……..Naval Research Laboratory
OASA (ALT)……..Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology)
OASA (I&E)……Office of the Assistant Secretary of the Army (Installations and Environment)
OE…… ….Ordnance and Explosives
PDT……Product Delivery Team
POC……...……Point of Contact
psi……..pounds per square inch
QA……..…Quality Assurance
QC……..……Quality Control
R&D……..Research and Development
RDT&E…..……..……Research, Development, Test, and Evaluation
RF……Radio Frequency
RTK……real-time kinematic
SAM……..……Sub-Audio Magnetics
S&T…….……Science and Technology
SBIR……..……Small Business Innovative Research
SERDP…… Strategic Environmental Research and Development Program
SMS……..……Sweep Monitoring System
STO……..Science and Technology Objective
STOLS……..……Surface Towed Ordnance Locator System
T2 or T^2……Technology Transfer
T&E……..……..……..Test and Evaluation
TD/FD…… …..Time Domain/Frequency Domain
TDEM……Time Domain Electromagnetic
TFM……..…Total Field Magnetics
TMS…….……Total Monitoring System
USACE……...……..……US Army Corps of Engineers
USAEC……..……...……..US Army Environmental Center
UBC……..……..University of British Columbia (Canada)
UWB…….……Ultra-wideband
UXO……..……Unexploded Ordnance
UXO-ER…….…….... UXO Environmental Remediation
YPG……..……..Yuma Proving Ground (Arizona)

INTRODUCTION

This Annual Report describes the endeavors of the US Army Environmental Quality Technology (EQT) Unexploded Ordnance (UXO) Program during fiscal year 2004 (FY04). 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. This 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 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 US 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 UXO Program is developing improved UXO sensing, positioning, data processing and 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 AERTA Requirement, "UXO Screening, Detection, and Discrimination" (Restoration, 1.6.a)", the RDT&E efforts conducted under the Environmental Technology Management Plan (ETMP) include two primary thrust areas: (1) ground based UXO detection and discrimination and (2) shallow water UXO 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 naturally occurring clutter found on UXO contaminated sites. This inability to distinguish hazardous UXO from non-hazardous site anomalies results in unacceptably high remediation costs and substantial 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 EQT 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 Program Review (IPR) comments.

FULLY FUNDED PROGRAM[1]

The program to support user AERTA Requirement, Restoration 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 table below shows funding (broken down by BA) for the EQT UXO Program from its inception in FY02 through funding that has been allocated for FY05 activities. (Funding is shown in $K.)

BA/PE/Project	FY02	FY02 Actual	FY03	FY03 Actual	FY04	FY04 Actual	FY05	FY05 Actual	Total	Total Actual
BA2/622720A/AF25	1902	1696	2044	2044	0	0	0	0	3946	3740
BA3/633728A/D03E	0	150	2129	2051	908	908	0	0	3037	3109
BA3/63779/EN6	1000	566	0	0	0	0	0	0	1000	566
BA4/63779A/D04E	2631	2631	4274	2975	5457	5457	3344	3088	15706	14151
BA6/65857A/M06E	0	0	106	106	110	110	112	107	328	323
Total	5533	5043	8553	7176	6475	6475	3456	3195	24017	21889

The release of budget activity for BA4 and BA6 required a signed and 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 eleven months before the program started. As a result the first Annual Report for this program was inclusive of August 2002 through September 2003. The release of funding for FY04 was also delayed – funds were not available to the program until the beginning of the third quarter of FY04.

This Annual Report will cover FY04 activities (i.e. from October 01, 2003 through September 30, 2004).

MODIFICATION TO EXECUTION PLAN

During FY02 and FY03 there were numerous modifications to this program, and it was necessary to reallocate funds during that particular time frame covered by the FY02/03 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 project tasks.

As reported in the FY02/03 Annual Report the Army EQT UXO Program received a $490K funding cut to BA2/3 in FY02 and a $1.299M 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 these funded efforts. Major changes to the BA4 effort

[1] Originally a fully funded program, the EQT UXO Program has taken numerous budget cuts and seen multiple funding redistributions since FY02 resulting in a reduction of approximately $2M.

include reduction of ground truth recovery for Task I.C., a 35 percent cut in Task II.D. for vehicular-towed and handheld system demonstrations, the trimming of funds available for demonstrations at the Standardized Sites, and Tasks I.B. and II.F. were cancelled.

The amount of funding was not the only issue. Originally the program was developed to start during the first quarter of FY02 and to end at the completion of the fourth quarter of FY05 (with FY02-05 being funded with RDT&E funds). However, funding has not been delivered on time during the three fiscal years that the program has already spanned. FY02 funding was not received until the final days of the fourth quarter of that fiscal year. FY03 funding was delayed until mid-third quarter. FY04 funding was also delayed until the third quarter. These delays in funding have resulted in the entire program being a full year behind schedule.

WHAT'S INSIDE

The FY04 EQT UXO Annual Report is organized by the following categories:

PROGRAM FOCUS: Science and Technologies (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. Handheld UXO Detector Design Thrust Oversight

PROGRAM FOCUS: Demonstration/Validation (BA4 and BA6) Major Thrust Areas

I. Standardized Sites
II. UXO Technology Demonstrations
III. Hardware/Software Integration
IV. Geophysical Quality Assurance/Quality Control (QA/QC)
V. Technology Transfer (T^2)

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?
FY04 OBJECTIVES:	What objectives were set for the project for the 2004 fiscal year?
ACCOMPLISHMENTS AND RESULTS:	What results were achieved during FY04?
ISSUES:	What might affect the use of this technology? If any FY04 Objectives were not met, why?
PLANNED ACTIVITIES:	What additional activities are planned?
POINT OF CONTACT:	Whom do I contact for more information?
PUBLICATIONS:	List of publications relating to the project.

FOR MORE INFORMATION:

SEND INQUIRES to t2hotline@aec.apgea.army.mil
CALL the Army Environmental Hotline at 1-800-USA-3845.
VISIT USAEC websites at http://aec.army.mil/usaec/technology/uxo00.html or http://www.uxotestsites.org or the ERDC UXO website at http://el.erdc.usace.army.mil/uxo/index.html

Science and Technology (S&T) (BA 2/3) 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 was 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, and ordnance-related and other man-made debris all influence the value measured by the UXO detection sensor. A compilation of geophysical and environmental parameters and how they influence the geophysical sensors employed during UXO surveys will aid in the planning of time and cost effective UXO detection surveys.

This work unit provided a reference identifying the geophysical and environmental parameters and how they influence sensors deployed to detect UXO. Results were used in developing the computer software MAUDE, a Management Aid for UXO Detection Efforts, which was developed during FY03 under BA3 I.B.

ACCOMPLISHMENTS AND RESULTS:
This task was completed in FY02 and transitioned in FY03 to BA3 I.B. Therefore, no work was conducted on BA2 I.A. during FY04.

PLANNED ACTIVITIES:
This task has been completed and no additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:
See BA3 I.C. for applicable publications.

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

OVERVIEW: The purpose of this task was to develop expedient site characterization procedures for UXO detection survey planning. The guidelines developed during FY02 for BA2 I.A. and other site-related information (cultural background, OE history, etc.) will be incorporated into the MAUDE software. The software provides 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 provides a mechanism for 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 developed describe the UXO detection sensor specifications, geophysical and environmental parameters, and the parametric influence on the sensors. MAUDE provides the flexibility 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 is 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 completed in FY03 and transitioned to FY04 to BA3 I.C. and III.B.

PLANNED ACTIVITIES:
This task has been completed and no additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:

See BA3 I.C. for applicable publications.

BA3 I.C. Verification of MAUDE—a Management Aid for UXO Detection Efforts

OVERVIEW: The purpose of this task was to evaluate and expand the capabilities of computer software that was developed under a FY03 AF25-301E work unit. The MAUDE software was evaluated using real UXO cleanup site scenarios to identify weaknesses and to incorporate changes to improve capabilities.

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 was tested and evaluated using historical, geophysical, geological, and cultural data available from established Standardized UXO Technology Demonstration Sites. Results of these tests were used to refine the software.

This work unit produced 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 enables UXO site managers to reduce the time and cost of planning a UXO detection survey.

FY04 OBJECTIVES:
The objectives of this work were: (1) to expand the capabilities and evaluate computer software that was developed under BA3 I.B., (2) evaluate MAUDE using real UXO cleanup site scenarios to identify weaknesses and to incorporate changes for improvement, (3) complete and distribute MAUDE software CD, Version 1.4, and (4) publish Guidelines Report for planning UXO detection surveys that includes a phenomenological evaluation of topography, vegetation, soil, and moisture; identifies unique site areas, geophysical parameters, ordnance types; and selection of sensor systems and platforms.

This task is complete and has been transitioned to BA4 II.C., Tasks 1 and 2.

ACCOMPLISHMENTS AND RESULTS:
MAUDE was submitted for evaluation at the Aberdeen Proving Ground Standardized UXO Technology Demonstration Site. MAUDE software CD, Version 1.4. was distributed to the UXO user community during the August 2004 EQT Hardware and Software Workshop in Huntsville, Alabama and MAUDE Version 1.4.1 was placed on the ERDC UXO website located at: http://el.erdc.usace.army.mil/uxo/

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

PLANNED ACTIVITIES:
This task has been completed and no additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:

Technical Report:
Simms, J.E., Larson, R.J., Murphy, W.L., and Butler, D.K. (2004). "Guidelines for Planning Unexploded Ordnance (UXO) Detection Surveys," ERDC/GSL TR-04-8, US Army Engineer Research and Development Center, Vicksburg, MS. The report is available on the ERDC UXO website at http://el.erdc.usace.army.mil/elpubs/pdf/trgsl04-8.pdf

Journal Article:
Butler, Dwain K. (2003). "Implications of Magnetic Backgrounds for Unexploded Ordnance Detection," *Journal of Applied Geophysics*, vol 54, 111-125.

Presentations:
Simms, Janet E., Murphy, Williams l., McGill, Thomas E., and Butler, Dwain K. (2003)."The Physical Setting of UXO Detection: Guidelines for Planning UXO Surveys." Military and Geology-Geography Conference, US Military Academy, West Point, NY.

Simms, Janet E. (2004). "Demonstration of MAUDE: A Management Aid for UXO Detection Efforts,." US Army EQT UXO Workshop, Huntsville, AL.

Software:
MAUDE, a Management Aid for UXO Detection Efforts, software package available online at the ERDC UXO website: http://el.erdc.usace.army.mil/uxo/

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 was 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 was to demonstrate the role of innovative geophysical technologies in achieving the EQT UXO Program goal of a 90 percent reduction of false alarm rates at well characterized UXO test sites under a variety of natural and man-made clutter conditions, while maintaining a high probability of detection (e.g., 95 to 98 percent).

The effects of environmental/geophysical conditions and man-made clutter on buried UXO detection and discrimination capabilities were defined by modeling and controlled laboratory and field experiments. Particular emphasis was 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 were developed to mitigate these effects and field tests were conducted to quantify the performance enhancements.

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

ACCOMPLISHMENTS AND RESULTS:
This task was completed in FY02 and transitioned in FY03 to BA3 II.B., II.C., and III.B.

PLANNED ACTIVITIES:
This task was completed during the 2002 fiscal year.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

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

Butler, Dwain K. (2000). "Assessment of Microgravimetry for UXO Detection and Discrimination," ERDC/GSL TR-00-5, US 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, US 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, US 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 was 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 was to exploit forward and inverse modeling and joint inversion capabilities developed under multi-year BA2/BA3 research projects that ended in FY02 and FY03, respectively, to develop an analysis capability for integration and interpretation of multiple-sensor datasets, leading to enhanced capability for UXO discrimination and identification as part of a specialized UXO Data Acquisition/Data Analysis System (DAQ/DAS).

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) were developed. These models and approaches were 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 exploited products from the preceding BA2 projects to produce near real-time algorithms and support development of analysis algorithms for interpretation of geophysical survey data acquired at UXO environmental restoration and active range clearance sites. More specifically, the near real-time algorithms will enable advanced data processing as part of onsite processing. Provisions were 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. Analysis of co-registered multi-sensor datasets is the preferred analysis approach. More sophisticated approaches 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.

This work unit exploited advanced capabilities for UXO detection, discrimination and identification developed under previous BA2 and BA3 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 BA3 project.

FY04 OBJECTIVES:
The objective of this work unit was 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 and BA3 research projects that ended in FY02 and FY03, respectively, to develop

analysis capabilities for integration and interpretation of multi-sensor datasets, leading to enhanced capability for UXO discrimination and identification as part of a specialized UXO DAQ/DAS.

ACCOMPLISHMENTS AND RESULTS:
The MatLab/GeoSoft TDEM and TFM data handling algorithms were successfully redesigned and reprogrammed to provide a common interface.

The TDEM GeoSoft executable code was completed, and TDEM discrimination capabilities were implemented in the inversion software evaluation test bed.

Software evaluation tests of UXOLab V1.0 magnetic and inversion data processing and modeling were completed. Tutorial example data sets were successfully executed.

GX's that support the GeoSoft platform were successfully installed. Magnetic and EM63 inversion and general utility functions that required codes (GX, platforms) and inputs were documented.

Software evaluation tests were conducted using EM63 data collected at the APG Standardized UXO Technology Demonstration Site. Minor software errors were corrected that involved passing data between the magnetics and EMI inversion algorithms and extracting windows of target data.

The UXOLab software was successfully compiled as a standalone executable and allows the program to run without co-installed MatLab software.

Advanced signature models and inversion technology were successfully demonstrated to the user community at the August EQT UXO Hardware/Software Workshop held in Huntsville, Alabama. The technology was demonstrated with the UXOLab software.

Completed draft report titled, "Progress in Inversion Methodologies for Magnetic and Electromagnetic Discrimination of Unexploded Ordnance."

PLANNED ACTIVITIES:
This task has been completed and projects have been transitioned to BA3 III.B. and BA4 II.D. and III.B. No additional activities are planned other than completion of the final report for this work unit.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:
Butler, Dwain K., Yule, Don E., and Bennett, Hollis H. (2004). "Employing Multiple Geophysical Systems to Enhance Buried UXO "Target Recognition" Capability," *Proceedings of the 24th US Army Science Conference*, Orlando, FL, November 28 - December 2, 2004.

Conference Papers:

D. Butler (2004). Commercially Available Electromagnetic Induction and Total Field Magnetometer Systems: Capabilities and Enhancements. Presented at EQT UXO Program Hardware/Software Products in Huntsville, AL 31 August – 01 September 2004.

BA2 II.C. Joint Inversion Investigations for UXO Discrimination

OVERVIEW: The purpose of this task was 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 was to exploit forward and inverse modeling capability developed under multi-year BA2 research projects that ended 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.

Under the BA2 RDT&E projects for FY02, forward and inverse modeling techniques for TFM, magnetic vector component, TDEM, and FDEM were developed. These models and approaches were 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) was analyzed separately. Generally, even when two or more types of geophysical data were 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 multi-sensor datasets was the most rigorous approach to integrating or fusing the information content from multiple sensors or platforms to reveal details or features of subsurface anomalies. 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.

This work unit was designed to 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:
This task was completed in FY03 and transitioned in FY04 to BA3 II.B. and III.B.

PLANNED ACTIVITIES:
This task was completed during the 2003 fiscal year and no additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:

Technical Papers:

Billings, S. D., Pasion, L. R., and Oldenburg, D. W. (2003). "Discrimination and Classification of UXO Using Magnetometry: Inversion and Error Analysis Using Robust Statistics," *Proceedings of the Symposium on Application of Geophysics to Environmental and Engineering Problems 2003 (CD)*, Environmental and Engineering Geophysical Society, San Antonio, TX, 2003.

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.

Butler, Dwain K., Pasion, Leonard R., Billings, Stephen, Oldenburg, Douglas, and Yule, Don. (2003). "Model-based Inversion for Enhanced UXO Detection and Discrimination." *Detection and Remediation Technologies for Mines and Mine-line Targets VIII.* Russell S. Harmon, John H. Holloway, Jr., Broach, Editors, Proceedings of SPIE Vol. 5089, 958-969.

Presentation:

D. Butler (2004). Commercially Available Electromagnetic Induction and Total Field Magnetometer Systems: Capabilities and Enhancements. Presented at EQT UXO Program Hardware/Software Products in Huntsville, AL 31 August – 01 September 2004.

BA2 II.D. Develop Processing Schemes to Enable Discrimination of UXO-Like Shapes in Composite Targets (UXO)

OVERVIEW: The purpose of this task was 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 unique 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 developed data processing schemes that allow inference of basic object geometry whether or not composite metallic targets are involved. This project implemented material that develops the primary investigator's basic research program on composite objects. It also included implementation options for taking advantage of new EMI sensors that receive magnetic signals along more than one axis (direction).

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

FY04 OBJECTIVES:
This work unit was completed in FY03 and transitioned to BA3 III.B.

ACCOMPLISHMENTS AND RESULTS:
Incorporated UXO targets in the standard model set as well as clutter items surveyed with the new GEM-3D instrument.

Resolved timing issues between the different data channels of the new GEM-3D instrument via post-processing software maneuvers.

Completed a draft report documenting the new modeling system and developed a user's manual.

PLANNED ACTIVITIES:
This task has been completed and no additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:

Journal Publications:
Shubitidze, F., O'Neill, K., Sun, K., Shamatava, I., and Paulsen, K.D. (2004). "Coupling Between Highly Conducting and Permeable Metallic Objects in the EMI Frequency Range," *Applied Computational Electromagnetics Journal*, vol 19, No 1b, 139-148.

Conference Papers:

Sun, K., O'Neill, K., Shubitidze, F., Shamatava, I., and Paulsen, K. D. (2004). "Fundamental Mode Approach to Forward Problem Solutions in EMI Scattering - Inferring Fundamental Solutions from Training Data," *Proceedings of the Applied Computational Electromagnetics Symposium*, 19-23 Apr 2004.

Shubitidze, F., O'Neill, K., Shamatava, I., Sun, K., and Paulsen, K.D. (2004). "A New Numerical Procedure for Efficient and Accurate Representation of Low Frequency EM Responses for a Heterogeneous Object," *Proceedings of the Applied Computational Electromagnetics Symposium*, 19-23 Apr 2004.

O'Neill, K., Won, I.J., Oren, A., Chen, Chi-Chih, Youn, Hyoun-Sun, Chen, X., and Sun, K. (2004). "Data Diversity for UXO Discrimination in Realistic Settings with a Handheld EMI Sensor," *Proceedings of the SPIE Defense & Security Symposium*, Orlando, FL, 12-16 April 2004.

Sun, K., O'Neill, K., Shubitidze, F., Shamatava, I., and Paulsen, K. D. (2004). "Fast Data-Derived Fundamental Spheroidal Excitation Models with Application to UXO Identification," *Proceedings of the SPIE Defense & Security Symposium*, Orlando, FL, 12-16 April 2004.

Conference Presentations:

K. O'Neill (2004). BA2 II-D: EMI Sensor Responses to UXO with Geometrical Complexity and Heterogeneous Composition. Presented at November 2004 IPR, Fairfax, VA.

BA2 II.E. Develop 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 was 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 this work unit were carried out for each sensor type. The principal thrusts were to:

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, and
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 was designed to substantially reduce the false alarm rates and rates of missed detections during the discrimination phase of surveying.

FY04 OBJECTIVES:
This work unit was completed in FY03 and transitioned to BA3 III.B.. Therefore, no activities were planned for FY04.

ACCOMPLISHMENTS AND RESULTS:
Follow-on work through BA3 III.B. accomplished the following: The “GEM-3DL” measurement system, which integrates laser positioning with the GEM-3D and operational procedures, was demonstrated. The GEM-3DL has the capability to record the three vector field components in a handheld UWB induction sensor. The laser positioning provides precise records of sensor head position during arbitrary survey motions.

The functionality of GEM-3DL measurement system was demonstrated with 3-D laser positioning of sensor head and for various orientations and heights above targets and a report documenting the GEM-3DL measurement system with laser positioning and operational procedures was completed.

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:
This task has been completed and no additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:

Journal Publication:
Shubitidze, F., O'Neill, K., Sun, K., Shamatava, I., and Paulsen, K.D. (2004). "A Hybrid Full MAS and Combined MAS/TSA Algorithm for Electromagnetic Induction Sensing," *Applied Computational Electromagnetics Journal*, vol 19, no 1b, 112-126.

Conference Papers:
O'Neill, K., Won, I. J., Oren, A., Shubitidze, F., Sun, K., and Shamatava, I. (2004). "A New Handheld Vector EMI Sensor with Precise 3-D Positioning," *Proceedings of the UXO/Countermine Forum 2004*, St. Louis, Missouri, 8-12 Mar 2004.

Shamatava, I., Shubitidze, F., O'Neill, K., Sun, K., and Paulsen, K.D. (2004). "An Efficient, User-Friendly Program for Computing Electromagnetic Induction (EMI) Responses from Heterogeneous Objects Subject to State-Of-The-Art Sensors," *Proceedings of the UXO/Countermine Forum 2004*, St. Louis, Missouri, 8-12 Mar 2004.

Sun, K., O'Neill, K., Shubitidze, F., and Chen, Chi-Chih (2004). "Highly Contaminated UXO Sites: Dual Sensor Discrimination of Clustered Targets," *Proceedings of the UXO/Countermine Forum 2004*, St. Louis, Missouri, 8-12 Mar 2004.

Shubitidze, F., O'Neill, K., Shamatava, I., Sun, K., and Paulsen, K.D. (2004). "Use of Standardized Source Sets for Enhanced EMI Classification of Buried Heterogeneous Objects," *Proceedings of the SPIE Defense & Security Symposium*, Orlando, FL, 12-16 April 2004.

Shamatava, I., Shubitidze, F., Chen, C.C., Youn, H. S., O'Neill, and Sun, K. (2004). "Potential Benefits of Combining EMI and GPR for Enhanced UXO Discrimination at

Highly Contaminated Sites," *Proceedings of the SPIE Defense & Security Symposium*, Orlando, FL, 12-16 April 2004.

Conference Presentations:

O'Neill, Kevin. (2004). "GEM-3DL Handheld Sensor System: Overview, Capabilities and Data Processing." EQT UXO Program Workshop, Huntsville, AL.

K. O'Neill (2004). "BA2 II-E: Improved UWB Survey Protocols, Processing Algorithms, and Sensor Designs – The GEM-3DL Handheld Sensor, Data Processing and Measurement Techniques." Presented at November 2004 IPR, Fairfax, VA.

Technical Report:

O'Neill, Kevin and Won, I.J. (2004). "Project UXX-1353: GEM-3D," Final Report, US Army Engineer Cold Regions Research and Engineering Laboratory, Hanover, NH.

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

OVERVIEW: The purpose of this task was 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.

This work unit represented the last year of AF-25 (BA2) funding under the original Army Science and Technology Objective (STO) for UXO Environmental Remediation. During the past three years, the primary effects of environmental/geophysical conditions and man-made clutter on buried UXO detection and discrimination capabilities of FDEM sensors were defined by modeling, algorithm development, and by controlled laboratory and field experiments. Advanced detection and discrimination techniques using FDEM sensor data were developed during this BA2 effort. At the time, the most effective approaches currently relied on the use of multi-frequency EM data to compute the eigenvalues of the polarizability matrix. These eigenvalues were 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 were further refined during FY02 and transitioned to BA4 demonstrations at the Standardized UXO Technology Demonstration Sites (gridded areas) during FY02.

This work unit was designed to advance 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:
This task was completed in FY02 and the results transitioned in FY03 to BA3 III.B. Therefore, no work was conducted on BA2 II.F. during FY04.

PLANNED ACTIVITIES:
This task has been completed and no additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:
Simms, J.E., Smithhart, L. B., and Butler, D.K. (2000). "Evaluation of three-component magnetic sensors for delineation and identification of UXO," Technical Report ERDC TR-00- 06, US Army Engineer Research and Development Center, Vicksburg, MS.

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

III. Sensor Design and Enhancement

BA2 III.A. Frequency Domain EM Enhancements

OVERVIEW: The purpose of this task was to develop improved frequency domain electromagnetic (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 was to demonstrate the role of improved FDEM induction prototypes in achieving the EQT UXO Program goals of 90 percent clutter rejection rates at well characterized UXO test sites, under a variety of natural and man-made clutter conditions while maintaining a high probability of detection (e.g., 95 to 98 percent) and a maximum false negative rate of 0.5 percent.

This work unit represented the last years of the AF-25 project funded under the original STO for UXO Environmental Remediation. This project 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 were performed and significant progress was made in the development of UXO signature databases to support phenomenology studies, modeling, and algorithm development. This project 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 was to implement 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 provides increased frequency range, improved data acquisition electronics, enhanced near real-time analysis capabilities, and improved display. Also under FY02 funding, laboratory investigations were 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, were evaluated to determine the feasibility of operating the GEM-3 as a dual-mode (passive magnetometer/FDEM) sensor. This work extended the GEM-3 frequency range for direct current to over 100 kHz.

This work unit advanced capabilities for buried UXO detection and discrimination using FDEM sensors and addressed user requirements to reduce risks and costs associated with UXO environmental remediation efforts.

ACCOMPLISHMENTS AND RESULTS:
This task was completed in FY02 and the results were transitioned in FY03 to BA3 III.B.

PLANNED ACTIVITIES:
This task has been completed and no additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:
Simms, J.E., Smithhart, L. B., and Butler, D.K. (2000). "Evaluation of three-component magnetic sensors for delineation and identification of UXO," Technical Report ERDC TR-00- 06, US Army Engineer Research and Development Center, Vicksburg, MS.

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

BA3 III.B. Enhanced Data Acquisition/Data Analysis System (DAQ/DAS)

OVERVIEW: The purpose of this task was to develop technologies to support the acquisition and analysis of data collected from advanced multi-sensor prototype 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 is an integrated software platform that allows data from multiple UXO sensors and high-accuracy positioning and tracking systems to be acquired, merged, and stored in digital format. Tools are 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 are integrated into the DAQ/DAS.

The DAQ/DAS provides advanced processing techniques 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.

FY04 OBJECTIVES:
The objectives of this work unit were to: (1) develop advanced technologies to support the acquisition and analysis of data collected from advanced multi-sensor prototypes developed under other work units in this program; (2) obtain data from multiple UXO sensors and high-accuracy navigation and positioning systems; and (3) integrate advanced physics-based algorithms and/or model-based joint and cooperative inversion techniques into the DAQ/DAS to provide near real-time feedback to the operator regarding sensor data quality, target/clutter information, position accuracy, area coverage, and system status warnings.

The goal of this effort was to develop the support technologies required to demonstrate the capabilities of handheld, man-portable, and vehicular-towed systems to achieve the EQT program's UXO detection, discrimination, location, and production rate goals.

ACCOMPLISHMENTS AND RESULTS:
Procedures to automate the histogram-based anomaly-picking scheme were developed and applied to GEM-3 data collected at the Aberdeen Proving Ground Standardized UXO Technology Demonstration Site. Data collected in an onsite pit was used as training data. Preliminary detection/discrimination results were used to test the US Army Aberdeen Test Center (ATC) scoring submittal validation program.

University of British Columbia (UBC) MatLab-based UXOLab software, which includes Mag and EM-63 inversion, was successfully demonstrated. GX and C code to interface UXOLab with GeoSoft Oasis Montaj is ongoing but will continue under a separate work unit.

Duke University C code for GEM-3 inversion was completed. Development of GX code to integrate the Duke C code into GeoSoft is ongoing but will continue under a separate work unit.

ERDC and AETC, Inc. (ERDC contractor), made presentations pertaining to UXO analysis software in GeoSoft Oasis Montaj at the 31 August-01 September 2004 UXO Hardware/Software Workshop in Huntsville, Alabama.

PLANNED ACTIVITIES:
This task has been completed. The only activities planned for FY05 is the publication of a technical report entitled “Unexploded Ordnance (UXO) Data Analysis System” and the transition of products to BA4 tasks.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

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

BA3 III.C. UXO Sensor Positioning and Tracking Technologies

OVERVIEW: The purpose of this task was 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.

This work unit leveraged ESTCP and US Army Corps of Engineers, Huntsville Center (CEHNC) investments to develop and test several positioning technologies, focusing on the unique requirements of a handheld sensor. Emphasis was placed on development of systems for the acquisition of highly accurate three-dimensional data in environmentally challenging areas such as heavily wooded sites. Systems investigated include: (1) low-cost inertial measurement unit (IMU) with a GPS and electronic compass system; (2) navigation/visualization system with Hexamite ultrasonic positioning, GPS, electronic compass and real time visualization software; (3) multiple laser transmitter stations with rover station system; (4) the robotic total station system using multiple laser measurement units; and (5) 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 radio positioning for the base positioning and then uses the INS for highly accurate 3D relative positioning of the instrument location. Following field evaluations, a go/no go decision was made for the continuation of individual system development.

Positioning system application focused on supporting handheld sensors to accurately record and integrate sensor position in three dimensions in open and obstructed areas. Proof of concept systems were initially assessed with an EM-61 handheld (HH) and G-858 magnetometer integrated and demonstrated at the navigation test course, McKinley Range, Redstone Arsenal, Huntsville, Alabama.

The systems will be transitioned to BA4 for technology demonstration and used to map the Aberdeen Proving Ground Standardized Test Site's Wooded Area and Calibration Lanes. 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 prototype system will be compared to results of traditional baseline methodologies such as commercial real-time kinematics (RTK) Digital Global Positioning System (DGPS).

Following the evaluation of the data sets, the most promising positioning and tracking system(s) will be integrated with a geophysical sensor and a prototype system developed. The system(s) developed have been transitioned to BA4 II.D. for field-evaluation and demonstration.

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

ACCOMPLISHMENTS AND RESULTS:
Follow-on efforts accomplished the following –

1. During 1Q04 test kit data from the Standardized Site at Aberdeen Proving Ground was evaluated for the enhanced GEM-3. Evaluation of the test kit determined that GPS interference was not present in the enhanced system.

2. Positioning systems demonstrated during 2Q04 included Shaw IT and Gifford Integrated Sciences systems. A third system attempted a demonstration, but the ArcSecond system experienced equipment malfunctions and was unable to complete the demonstration. Data from the Shaw and Gifford demonstrations were evaluated by ERDC and USACE-Huntsville during the third quarter.

3. A successful demonstration of the ArcSecond system was completed during 4Q04. Upon completion of the demo, the system was given to USACE-Huntsville Engineering and Support Center for use during an UXO remediation project.

PLANNED ACTIVITIES:
This task has been completed and no additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

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.

Conference Papers:
S. Millhouse (2004). Innovative Navigation Systems to Support Digital Geophysical Mapping Phase II. Presented at UXO/Countermine Forum 2004.

R. Young (2004). Digital Geophysical Versus Mag & Flag – Choosing the Approach for Your Project. Presented at UXO/Countermine Forum 2004.

IV. Handheld UXO Detector Design Thrust Oversight

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

OVERVIEW: The purpose of this task was 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 developed system-level designs to integrate multi-sensing technologies into selected handheld and man-portable platforms. The primary thrust of this effort was 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.

This work unit provided 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.

FY04 OBJECTIVES:
The objectives of this work unit were to: (1) coordinate sensor development activities of the EQT program, as well as to integrate applicable products from other DoD programs such as SERDP, ESTCP, and SBIR; (2) develop system-level designs to integrate the multi-sensing technologies into selected handheld, man-portable, vehicular, and/or waterborne platforms; and (3) ensure the compatibility, performance, and timely availability of technologies required to transition complete prototype systems to BA4 Dem/Val and ultimately to meet the EQT UXO Program's detection/discrimination performance goals.

ACCOMPLISHMENTS AND RESULTS:
Developed design methodologies with AETC, Inc. to address latency and timing issues and the integration of an ArcSecond positioning system into a multi-sensor UXO detection system.

A prototype man-portable EQT multi-sensor UXO detection system was developed and preliminary evaluations of the system were conducted. Development of a handheld version of the man-portable multi-sensor system is ongoing and will continue under a separate work unit.

Enhancements to the GeoCenters Surface Towed Ordnance Locator System (STOLS) multi-sensor platform were incorporated and consisted of new generation TDEM (Geonics EM61 MKII) technology and EQT-developed data processing algorithms.

Development of a 3-mode multi-sensor system that incorporated GEM-3, EM63, and G858 Magnetometer technologies was discontinued due to the impracticality of sensor integration on a single platform (sensor cross-talk interference).

Work was conducted to reduce the handheld/sensor assembly weight of 20 lbs and a magnetic compensation methodology was implemented.

ISSUES:

The development of waterborne UXO sensor configurations and platforms was not initiated under this task since waterborne UXO technologies are being developed under the sponsorship of the ESTCP.

PLANNED ACTIVITIES:
Work planned for this task has been completed. No additional activities are planned.

POINT OF CONTACT:
US Army Corps of Engineers – Engineer Research and Development Center Subsurface Unexploded Ordnance (UXO) Detection/Discrimination R&D Program. Contact the UXO Focus Area Manager at 601-634-2446.

PUBLICATIONS:
Journal Publication:
Butler Dwain K. (2004). "Report on a Workshop on Electromagnetic Induction Methods for UXO Detection and Discrimination," *The Leading Edge*, vol 23, No 8, 766-770.

Conference Presentations:
Wright, David. (2004). "Handheld Dual Magnetic/EMI Sensor Development." SERDP/ESTCP/EQT EMI Workshop, Annapolis, Maryland.

Wright, David, Kindon, Jim, and Bennett, Hollis H. (2004). "Development of a Combined EMI/Magnetometer Sensor for UXO." UXO/Countermine Forum 2004.

Wright, David, and Bennett, Hollis H. (2004). "Enhancements to the Combined EMI/Magnetometer Sensor for UXO." EQT UXO Program Workshop, Huntsville, Alabama.

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 maintenance and management of the Standardized UXO Technology Demonstration Site Program.

ESTCP and EQT developed the Standardized UXO Technology Demonstration Sites for man-portable and vehicle based platforms at the Aberdeen and Yuma Proving Grounds. The demonstration sites require short-term maintenance and programmatic oversight. This oversight includes scheduling, document distribution, scoring, protocol modification, and technology transfer. Other efforts developed Standardized UXO Technology Demonstration Sites for wide area, shallow water, and active response sites.

The maintenance portion of this task provides 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 provides necessary oversight to insure proper use, promote the site, and overcoming developing issues. The EQT Product Delivery Team (PDT), aided by the site managers, is responsible for identifying necessary maintenance activities during the course of the program.

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

The full potential of the standardized sites will be met with proper maintenance, upgrading, and flexible management of the program. Demonstration scoring records document the advancements in technologies, demonstrate positive utilization of S&T funds, and provide an avenue for repeatable, scientifically defensible technology demonstrations.

FY04 OBJECTIVES:
The overall objectives for this work unit were to: (1) provide maintenance and management of the Standardized UXO Technology Demonstration Site Program; (2) maintain calibration lanes, blind grid, open field, moguls, wooded and desert extremes and challenge areas at APG and YPG throughout the year; (3) finalize the format for the standardized report format; and (4) maintain the standardized target repository.

Specific FY04 objectives included the demonstration of handheld, man-portable, and vehicular systems at both standardized test sites.

ACCOMPLISHMENTS AND RESULTS:
Maintenance on both sites was performed throughout the course of the fiscal year.

During FY04 the following demonstrators completed demonstrations at APG with their respective systems:

1. G-Tek – TM-5EMU and TM4
2. Shaw Environmental – EM61 Pushcart
3. Tetra Tech/Foster Wheeler – EM61 Sling and Pushcart
4. Gifford Integrated Sciences – GeoVisor Ultrasonic Relative Positioning Navigational System
5. ERDC – EM63 Pushcart
6. GeoCenters – Dual-mode EM61 MKII/Mag
7. Human Factors Applications, Inc (HFA) – Schonstedt
8. NAEVA Geophysics, Inc. – EM61 MKII Man-portable and Towed Array
9. Blackhawk Geoservices – Dual-mode EM/Mag Pushcart and
10. Parsons – EM61 Pushcart and Schonstedt

The following demonstrators completed demonstrations at YPG with their respective systems:

1. G-Tek – TM-5EMU and TM4 Handheld
2. Shaw Environmental – EM61 Pushcart and Mag 858 Pushcart
3. Tetra Tech/Foster Wheeler – EM61 Sling and Pushcart
4. HFA – Schonstedt
5. Blackhawk Geoservices – Dual-mode G822 Mag/EM61 MKII Man-portable and Towed Array
6. Parsons – EM61 Pushcart and Schonstedt
7. GeoCenters – Dual-mode EM61 MKII/Mag Towed Array

The majority of these demonstrations were conducted in support of SERDP/ESTCP and Army EQT programs. Raw data collected during site surveys was reformatted and clarified allowing for easy reuse in other work efforts if desired. A total of twenty-one (21) scoring records for the Blind Grid and Open Field scenarios have been published since demonstrations began.

The entire Blind Grid and portions of the Open Field Areas at the APG site were reconfigured. Ground Truth will be released to all demonstrators and will be posted online at www.uxotestsites.org. A test stand utilized during a previous UXO detection testing effort at Fort Ord was acquired and reconstructed at the APG site. Other site enhancements were added to the site throughout the year including enhanced grid layouts (red, yellow, and blue survey plates were used to delineate the corners of the blind, calibration, and mine grids, respectively) allowing the site to be traversed more easily and a temperature controlled maintenance area with a roll-up door to accommodate large towed array systems. Additionally, the maintenance area was furnished with a small office area that includes a wireless network connection and multiple phone lines.

The Target Repository provided items to nine (9) agencies totaling 179 targets. Additionally, the repository added standardized test spheres to its list of available targets. A tracking system was also developed to ease the tracing of repository items after items have been provided to requesting agencies.

The Standardized UXO Technology Demonstration Sites also provided support for advanced navigational systems testing by ERDC and the US Army Corps of Engineers-Huntsville, Engineering and Support Center.

Additionally, an automated scoring submission tool was added to the Standardized Sites Program's website (www.uxotestsites.org) to ensure that user data submissions comply with the required format. The application uses data that is entered/imported to create a validated, properly-formatted Excel spreadsheet that can be sent via e-mail to the appropriate destination.

ISSUES:
To date, attempts to acquire 37mm rounds for the Standardized Target Repository have been unsuccessful due to issues associated with mercury contamination of the ordnance. Efforts to resolve this issue are ongoing.

PLANNED ACTIVITIES:
Objectives for FY05/06 include reconfiguration of the Blind Grid and a portion of the Open Field Areas at APG and YPG including a release of the Ground Truth to all demonstrators.

Sites will also continue to receive routine maintenance and occasional modifications. Attempts to acquire uncontaminated 37mm rounds for the Target Repository will continue.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
Scoring Reports
Standardized UXO Technology Demonstration Open Field Scoring Record #38, Zonge Engineering and Research, dated 07 May 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #142, US Army Corps of Engineers, dated 21 April 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #125, Geophex, Ltd, dated 20 April 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #159, Tetra Tech-Foster Wheeler, Inc., dated 23 June 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #141, US Army Corps of Engineers, dated 11May 2004.

Standardized UXO Technology Demonstration Open Field Scoring Record #187, GeoCenters, Inc., dated 16 July 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #157, Tetra Tech-Foster Wheeler, Inc., dated 13 July 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #183, G-Tek Australia PTY Limited, dated 11 August 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #197, Shaw Inc., dated 09 September 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #198, Shaw Inc., dated 27 August 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #184, G-Tek Australia PTY Limited, dated 22 September 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #216, US Army Corps of Engineers, dated 09 September 2004.

Standardized UXO Technology Demonstration Blind Grid Scoring Record #134 US Army Corps of Engineers, dated 22 September 2004.

Conference Presentations

L. Overbay. (2004). "Standardized UXO Technology Demonstration Sites." Presented at UXO/Countermine Forum 2004.

D. Butler (2004). Commercially Available Electromagnetic Induction and Total Field Magnetometer Systems: Capabilities and Enhancements. Presented during 2004 Workshop on EQT UXO Hardware/Software Products and at November 2004 IPR, Fairfax, VA.

H. Jay Bennett, Jr. (2004). SAM System Development. Simultaneous Magnetic and EM Detection: Overview, Capabilities, Status. Presented during 2004 Workshop on EQT UXO Hardware/Software Products.

D. Wright (2004). Development of a Combined EMI/Magnetometer Sensor for UXO. Presented during 2004 Workshop on EQT UXO Hardware/Software Workshop, Huntsville, AL.

R. Siegel (2004). Simultaneous Magnetometer and EM61 Vehicular Towed Array ("Multi-sensor STOLS"). Presented during 2004 Workshop on EQT UXO Hardware/Software Workshop, Huntsville, AL.

K. O'Neill (2004). GEM-3DL Handheld Sensor System Overview, Capabilities, and Processing Potential. Presented during 2004 Workshop on EQT UXO Hardware/Software Workshop, Huntsville, AL.

H. Jay Bennett, Jr. (2004). UXO Sensor Positioning and Tracking Technologies. Presented during 2004 Workshop on EQT UXO Hardware/Software Workshop, Huntsville, AL.

S. Millhouse (2004). Innovative Navigation Systems to Support Digital Geophysical Mapping Phase III. Presented during 2004 Workshop on EQT UXO Hardware/Software Products and November 2004 IPR, Fairfax, VA.

R. Goodson (2004). Enhanced Data Acquisition/Data Analysis System (DAQ/DAS). Presented during 2004 Workshop on EQT UXO Hardware/Software Products and November 2004, Fairfax, VA.

D. Keiswetter (2004). Feature-Based UXO Detection and Discrimination UX-200210. Presented during 2004 Workshop on EQT UXO Hardware/Software Workshop, Huntsville, AL.

K. O'Neill (2004). Discrimination of UXO with Geometrical Complexity and Heterogeneous Composition. Presented during 2004 Workshop on EQT UXO Hardware/Software Workshop, Huntsville, AL.

H. Jay Bennett, Jr. (2004). G-Tek SAM and GeoCenters STOLS Sensor System Development. Presented at November 2004 IPR, Fairfax, VA.

D. Wright (2004). Enhancements to the Combined EMI/Magnetometer Sensor for UXO. Presented at November 2004 IPR, Fairfax, VA.

G. Rowe (2004). Sensor/Platform Integration and Demonstration (BA4 II.D.). Presented at November 2004 IPR, Fairfax, VA.

R. Young (2004). Digital Geophysical Versus Mag & Flag – Choosing the Approach for Your Project. Presented at UXO/Countermine Forum 2004.

H. Jay Bennett, Jr. (2004). Baseline Evaluation at Standardized UXO Technology Demonstration Sites. Presented at UXO/Countermine Forum 2004

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 man-portable 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 US 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.

ISSUES:
This program was canceled due to funding cuts in FY03. SERDP/ESTCP has taken over the lead for this program area.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
Analysis of Airborne Magnetometer Data from Tests at Aberdeen Proving Grounds, Maryland, Institute for Defense Analysis (IDA) Document D-3015, July 2002.

Wide Area UXO Technology Demonstration and Survey, DTC Project No. 8-CO-160-UXO-012. Report Number ATC-8716, November 2003.

Conference Papers:
G. Rowe (2004). Procedures and results of the Demonstration of UXO Wide Area Survey at APG. Presented at UXO/Countermine Forum 2004.

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. 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 performance and 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.

FY04 OBJECTIVES:
The overall objective of the BA4 I.C. Active Response Site work unit is to establish active response demonstration areas to correlate technology performance between Standardized Sites and areas containing actual UXO. Specific fiscal year objectives included the completion of the active response demonstration area as well as the establishment of protocols for the site.

ACCOMPLISHMENTS AND RESULTS:
Protocols for the Active Response Demonstration Area were established and applicable areas were identified early in the first quarter of FY04. Boundaries for the APG site were delineated and a detailed test plan was developed.

The site was "rolled" to ensure the safety of demonstrators while on site. Rolling of the site was completed using a large landscape roller filled with water. The roller, towed with an armored vehicle, was used to exert the maximum amount of ground pressure (80 psi) to ensure that no live ordnance rounds would detonate during demonstrations. Since 80 psi exceeds the pressure exerted by any of the systems evaluated on site, the ATC was able to safely approve the area used without having to conduct exhaustive clearance activities.

The test plan describing proposed use of the site was developed by ATC and approved by all participants. To date four demonstrators have collected data at the APG Active Response Demonstration Area. Areas on the site will be broken into four one acre grids with initial digs tentatively scheduled for the fourth quarter of FY05.

PLANNED ACTIVITIES:
FY05 plans include the recovery and distribution of Ground Truth data for the Blind Grid and Open Field Areas.

Additionally, this task will 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 will be developed and this project will also be coordinated with ESTCP Project 02EB-UX1-003.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
Detailed Test Plan for the Active Response Test Site, has been developed and approved, awaiting publication.

II. UXO Technology Demonstrations

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

OVERVIEW: 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 BA3 handheld dual mode products, baseline of the current state of the art of dual mode systems, and demonstration of GOTS and COTS at the end of the program.

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

In addition, this effort will support the demonstration of prototype sensor systems that are produced by the preceding BA3 projects and collect the information necessary at both Standardized and Active Response 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.

FY04 OBJECTIVES:
FY04 objectives for the demonstration of dual mode sensors included determination of baseline capabilities of COTS dual mode sensors and the conduct of field-testing of Army prototype systems.

ACCOMPLISHMENTS AND RESULTS:
Based on discussions during the Dual Mode Sensor Workshop held during the 3Q02 in Denver, Colorado, the program established technology limitations and areas for further research.

To date, three (3) COTS demonstrations have been completed at APG and YPG. EQT is sponsoring the RDT&E of handheld, man-portable, and vehicular platforms. GeoCenters and G-Tek demonstrated the STOLS and Sub-Audio Magnetic (SAM) GOTS systems, respectively. The Blackhawk GeoServices' system has been the only COTS system demonstrated to date.

GeoCenters and G-Tek are funded through FY05 to make enhancements to their systems based on knowledge gained during demonstrations. Both systems are scheduled for re-demonstration in FY05.

ISSUES:
The Army prototype systems developed and originally scheduled for demonstration during FY04 have been rescheduled for demonstration during the third and fourth quarters of FY05.

PLANNED ACTIVITIES:
Demonstrate COTS and GOTS systems at Active Response and Standardized Sites. Complete dual mode sensor field-testing with Army prototypes.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

BA4 II.B. Baseline Handheld/Man-Portable System Performance

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

This work unit will initially document the capabilities and limitations of the handheld 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 handheld and man-portable technologies. The improvement in technology from EQT investment will be documented at the end of the program.

FY04 OBJECTIVES:
The overall objective of this work unit was to determine the baseline of handheld and man-portable UXO detection and discrimination systems' performance. FY04 objectives were to utilize the BAA contract mechanism to baseline current capabilities of handheld and man-portable systems at the Standardized UXO Technology Demonstration sites and to transition the performance matrix.

ACCOMPLISHMENTS AND RESULTS:
Fabrication of the SAM Receiver Systems prototype was completed. Leveraged with ESTCP to bring in multiple "Mag and Flag" operations (two vendors and two systems to cover all areas). Parsons conducted full demonstrations of their "Mag and Flag" and "EM and Flag" systems at both Standardized Sites with ESTCP leveraged funds. Additionally, HFA conducted a "Mag and Flag" demonstration at both APG and YPG. Completed scoring reports and their associated fact sheets are posted on the website www.uxotestsites.org once finalized.

ISSUES:
The transition performance matrix milestone for Mag, TDEM, and FDEM, set for completion during 4Q04 was removed and will not be performed due to funding cuts.

PLANNED ACTIVITIES:
This task has been completed. No other activities will be performed under this work unit. Future demonstrations will be leveraged under Task BA4 II.C.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
Scoring Records:
Standardized UXO Technology Demonstration site Blind Grid Scoring Record #37
Site Location: Aberdeen Proving Ground
Demonstrator: Zonge with 4D TEM

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #39
Site Location: Aberdeen Proving Ground

Demonstrator: AETC, Inc. with EM61 Handheld

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #45
Site Location: Aberdeen Proving Ground
Demonstrator: Witten with 200 Hz Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #139
Site Location: Yuma Proving Ground
Demonstrator: USACE – ERDC with GEM-3 Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #198
Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with UXO Mapper Pushcart/G858 Mag Configuration

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #197
Site Location: Yuma Proving Ground
Demonstrator: G-Tek with TM-5 EMU Sling

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #186
Site Location: Yuma Proving Ground
Demonstrator: G-Tek Australia, PTY Ltd with TM-5 EMU Dual Sensor/Man-Portable

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #184
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek Australia, PTY Ltd with TM-5 EMU Handheld

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #183
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek Australia, PTY Ltd with TM-5 EMU Man-Portable

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #157
Site Location: Yuma Proving Ground
Demonstrator: Tetra Tech/Foster Wheeler with EM61 MKII Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #216
Site Location: Yuma Proving Ground
Demonstrator: USACE – ERDC with EM63 Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #125
Site Location: Aberdeen Proving Ground
Demonstrator: Geophex, LTD with GEM-3 Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #127
Site Location: Aberdeen Proving Ground
Demonstrator: Naval Research Laboratory with MTADS GEM Towed

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #141
Site Location: Aberdeen Proving Ground
Demonstrator: USACE – ERDC with GEM-3 Pushcart Standard

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #142

Site Location: Yuma Proving Ground
Demonstrator: USACE – ERDC with GEM-3 Pushcart Enhanced

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #159
Site Location: Aberdeen Proving Ground
Demonstrator: Tetra Tech/Foster Wheeler with EM61 MKII Man-Portable

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #40
Site Location: Aberdeen Proving Ground
Demonstrator: GeoCenters with STOLS

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #49
Site Location: Aberdeen Proving Ground
Demonstrator: GeoCenters with GEM-3 Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #50
Site Location: Aberdeen Proving Ground
Demonstrator: GeoCenters with GEM-3 Man-Portable

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #168
Site Location: Yuma Proving Ground
Demonstrator: Tetra Tech/Foster Wheeler with EM61 MKII Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #199
Site Location: Yuma Proving Ground
Demonstrator: Shaw with EM61 Pushcart

Standardized UXO Technology Demonstration site Moguls Scoring Record #126
Site Location: Aberdeen Proving Ground
Demonstrator: Witten with Cart Imaging System

Standardized UXO Technology Demonstration site Open Field Scoring Record #38
Site Location: Aberdeen Proving Ground
Demonstrator: Zonge with 4D TEM Pushcart

Standardized UXO Technology Demonstration site Open Field Scoring Record #129
Site Location: Aberdeen Proving Ground
Demonstrator: Geophex, LTD with GEM-3 Pushcart

Standardized UXO Technology Demonstration site Open Field Scoring Record #187
Site Location: Aberdeen Proving Ground
Demonstrator: GeoCenters with Dual Mode/Towed Mag EM61

Conference Presentation:
H. Jay Bennett, Jr. (2004). SAM System Development – Simultaneous Magnetic and EM Detection: Overview, Capabilities, Status. Presented at EQT UXO Program Hardware/Software Products in Huntsville, AL 31 August – 01 September 2004.

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 technologies 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.

FY04 OBJECTIVES:
The objective of this work unit is to open the Standardized UXO Technology Demonstration Sites and Active Response Sites to the UXO community in an effort to generate a snapshot of current technologies' capabilities and limitations. The FY04 objective for BA4 II.C was to set up a BAA to facilitate the funding process.

ACCOMPLISHMENTS AND RESULTS:
The Broad Agency Announcement (BAA) was released by the US Army Aberdeen Test Center (ATC) to facilitate demonstrations of advanced UXO detection and discrimination technologies.

PLANNED ACTIVITIES:
Upcoming demonstrations have been awarded under the BAA. Geophex will demonstrate a GEM-3 system for real time discrimination in a project carried over from FY04. Additionally, the ARM Group will look at applying mine detector capabilities into the UXO arena. ARM will demonstrate two systems (both handheld) at the APG Standardized Site.

During 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. Finally, in 4Q06 a final report on the state-of-the-art will be produced.

During FY05/06 this program will evaluate technology advancement from the R&D, COTS, and GOTS communities to determine the technologies' ability to meet PDT and EQT-ORD metrics. Final reports will be generated.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
Conference Papers:
L. Overbay (2004). Standardized UXO Technology Demonstration Sites. Presented at UXO/Countermine Forum 2004.

H. Jay Bennett, Jr. (2004). Baseline Evaluation at Standardized UXO Technology Demonstration Sites. Presented at UXO/Countermine Forum 2004.

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 focus 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 innovative 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-towed platforms for 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.

FY04 OBJECTIVES:
The objective of this effort is to support the demonstration and validation of the Army's EQT BA2/3 projects for UXO Sensor/Platform Design and Enhancement. Specific objectives addressed the demonstration of the Enhanced GEM-3 prototype and the integration of dual mode and data acquisition systems onto man-portable and vehicular platforms. Development of baselines for COTS navigation and position systems as well as a field test for the BA3 prototype navigation and positioning system were also set as objectives to be completed during FY04. Demonstrations of an optimized ultra-wide bands (UWB) sensor and a BA3 prototype system platform were also scheduled.

ACCOMPLISHMENTS AND RESULTS:
During the forth quarter of 2003 the improved GEM-3 prototype was demonstrated and the position/tracking system baseline was documented. The program also evaluated advancements made for positioning systems at the Aberdeen standardized site.

ISSUES:
ERDC received a 35 percent funding cut over two years and therefore deleted two of the five systems that were initially planned. ERDC also did not receive funding until 3QFY03 and 3QFY04, thus delaying products initially scheduled for FY04 demonstrations. Due to these funding issues, ERDC will conduct originally scheduled FY04 technology demonstrations during FY05.

To date, demonstration of advanced navigation systems has progressed towards completion.

PLANNED ACTIVITIES:
The dual-mode/multi-sensor system and DAS will be integrated onto both handheld and vehicular-towed platforms during 1QFY05 and 2QFY05. The integrated prototype handheld and vehicular-towed platforms will be field evaluated during the 2QFY05 and 3QFY05. The final integrated handheld and vehicular-towed platforms (cost integrated into Standardized UXO Technology Demonstrations 2006) will be demonstrated during the 3Q05.

Support the demonstration of BA2/BA3 UXO Sensor/Platform Design and Enhancement Projects to include frequency domain EM enhancements, enhanced data acquisition/data analysis system, UXO sensor positioning and tracking technologies, spatial pattern survey strategies, and sensor configuration optimization.

A final report documenting the Enhanced Data Acquisition/Data Analysis System will be completed during the 4Q05. Products will be transitioned to the user community during the 1QFY06.

POINTS OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
Scoring Records:
Standardized UXO Technology Demonstration site Blind Grid Scoring Record #37
Site Location: Aberdeen Proving Ground
Demonstrator: Zonge with 4D TEM

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #39
Site Location: Aberdeen Proving Ground
Demonstrator: AETC, Inc. with EM61 Handheld

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #45
Site Location: Aberdeen Proving Ground
Demonstrator: Witten with 200 Hz Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #139
Site Location: Yuma Proving Ground
Demonstrator: USACE – ERDC with GEM-3 Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #198
Site Location: Aberdeen Proving Ground
Demonstrator: Shaw with UXO Mapper Pushcart/G858 Mag Configuration

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #197
Site Location: Yuma Proving Ground
Demonstrator: G-Tek with TM-5 EMU Sling

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #186
Site Location: Yuma Proving Ground
Demonstrator: G-Tek Australia, PTY Ltd with TM-5 EMU Dual Sensor/Man-Portable

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #184
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek Australia, PTY Ltd with TM-5 EMU Handheld

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #183
Site Location: Aberdeen Proving Ground
Demonstrator: G-Tek Australia, PTY Ltd with TM-5 EMU Man-Portable

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #157
Site Location: Yuma Proving Ground
Demonstrator: Tetra Tech/Foster Wheeler with EM61 MKII Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #216
Site Location: Yuma Proving Ground
Demonstrator: USACE – ERDC with EM63 Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #125
Site Location: Aberdeen Proving Ground
Demonstrator: Geophex, LTD with GEM-3 Cart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #127
Site Location: Aberdeen Proving Ground
Demonstrator: Naval Research Laboratory with MTADS GEM Towed

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #141
Site Location: Aberdeen Proving Ground

Demonstrator: USACE – ERDC with GEM-3 Pushcart Standard

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #142
Site Location: Yuma Proving Ground
Demonstrator: USACE – ERDC with GEM-3 Pushcart Enhanced

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #159
Site Location: Aberdeen Proving Ground
Demonstrator: Tetra Tech/Foster Wheeler with EM61 MKII Man-Portable

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #40
Site Location: Aberdeen Proving Ground
Demonstrator: GeoCenters with STOLS

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #49
Site Location: Aberdeen Proving Ground
Demonstrator: GeoCenters with GEM-3 Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #50
Site Location: Aberdeen Proving Ground
Demonstrator: GeoCenters with GEM-3 Man-Portable

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #168
Site Location: Yuma Proving Ground
Demonstrator: Tetra Tech/Foster Wheeler with EM61 MKII Pushcart

Standardized UXO Technology Demonstration site Blind Grid Scoring Record #199
Site Location: Yuma Proving Ground
Demonstrator: Shaw with EM61 Pushcart

Standardized UXO Technology Demonstration site Moguls Scoring Record #126
Site Location: Aberdeen Proving Ground
Demonstrator: Witten with Cart Imaging System

Standardized UXO Technology Demonstration site Open Field Scoring Record #38
Site Location: Aberdeen Proving Ground
Demonstrator: Zonge with 4D TEM Pushcart

Standardized UXO Technology Demonstration site Open Field Scoring Record #129
Site Location: Aberdeen Proving Ground
Demonstrator: Geophex, LTD with GEM-3 Pushcart

Standardized UXO Technology Demonstration site Open Field Scoring Record #187
Site Location: Aberdeen Proving Ground
Demonstrator: GeoCenters with Dual Mode/Towed Mag EM61

Conference Presentations:

G. Rowe (2004). Sensor/Platform Integration and Demonstration (BA4 II.D.). Presented at November 2004 IPR, Fairfax, VA.

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 existing 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 identify and demonstrate the current state-of-the-art as well as identify to stakeholders capabilities and limitations of current technologies. 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. Since shallow water applications not only occur along coastlines but also on ranges that contain swamps, ponds, lakes, rivers, or streams there is also a need to determine the impact of navigation and positioning on shallow water systems in a variety of conditions. These additional studies will be evaluated using the soon to be completed Littoral Warfare Facility at APG.

FY04 OBJECTIVES:
The objective of this work unit is to establish a Shallow Water Standardized UXO Technology Demonstration Site at APG and evaluate the current state-of-the-art technologies available for shallow water UXO detection and discrimination. FY04 specific objectives included the establishment of standardized protocols, procurement of target items and construction of the site.

ACCOMPLISHMENTS AND RESULTS:
Between the second and fourth quarter of FY04, an installations survey was conducted looking for bodies of water that could be developed into the proposed shallow water test site. Historical records for three of the candidate ponds were reviewed. Bathymetry plots were obtained for all three candidates and magnetic surveys were obtained for two of those ponds. A site located at APG's Aberdeen Test Center in Maryland was selected and initial construction of the facility was begun. Currently, a ribbon-cutting ceremony for the facility is scheduled for mid May 2005 to officially open the site to demonstrators.

A baseline demonstration was conducted with the Huntsville Engineering and Support Center, standardized site protocols were established in early FY04 and wide area effects data was leverage on site. The site was approximately 90 percent complete by the end of FY04 and is scheduled to be opened for demonstrations in mid May of 2005. Extra standard targets have been procured for use on the site.

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 program is 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:
Baseline demonstrations are scheduled for completion during the 3Q05, and in the 1Q06, technology gaps will be evaluated and reported. Navigation and positioning demonstrations will be conducted on the site with reports being generated and made available on the Standardized Site's website www.uxotestsites.org. 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.

A Broad Agency Announcement will be used to fund demonstration efforts.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
Reports:
Airborne MTADS Demonstration at The Aberdeen Proving Ground, Naval Research Laboratory (NRL), July 2002.

Analysis of Airborne Magnetometer Data from Tests at Aberdeen Proving Grounds, Maryland, Institute for Defense Analysis (IDA) Document D-3015, July 2002.

Munition Item Detection Systems Used by the US Army Corps of Engineers in Shallow Water Environments, US Army Engineering and Support Center Huntsville, February 2003.

Wide Area UXO Technology Demonstration and Survey, DTC Project No. 8-CO-160-UXO-012. Report Number ATC-8716, November 2003.

Assess Extent of Shallow Water on Ranges, Identify and Assess Technological Impediments to Remediation Site Investigation and Characterization, and Identify and Assess Associated Regulatory Issues, Draft Final Report, for UXO Task 318, Subtask 2 prepared for the National Defense Center for Environmental Excellence (NDCEE), Concurrent Technologies Corporation (CTC), September 2004.

Conference Papers:
J. Hood (2004). Demonstration of Shallow Water UXO Detection Technology at APG. Presented at UXO/Countermine Forum 2004.

M. Tuley (2004). UXO Detection and Discrimination Evaluation of Airborne Magnetometer Systems. Presented at UXO/Countermine Forum 2004.

G. Rowe (2004). "Demonstrate UXO Detection Systems in Shallow Water (BA4 II E)." Presented at November 2004 IPR, Fairfax, VA

J. Hood (2004). Demonstration of Shallow Water UXO Detection Technology at APG. Presented at UXO/Countermine Forum 2004.

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 because 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 Product Delivery Team (PDT) that the assigned resources for this program would be better used elsewhere.

ISSUES:
Funding has been reallocated from this program. SERDP/ESTCP and NAVEODTECHDIV have taken over the lead for this area.

POINT OF CONTACT:
US Army Environmental Center (USAEC) 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.

FY04 OBJECTIVES:
The objective of this work unit is to identify and assess available GOTS and COTS UXO detection and discrimination software then insert (where applicable) into the GeoSoft Oasis Montaj platform. The only FY04 specific objective for this work unit was to demonstrate and assess currently available software.

ACCOMPLISHMENTS AND RESULTS:
GOTS and COTS UXO software was identified and assessed for potential use during detection and discrimination activities. The demonstration and assessment of the software was completed during the latter portions of FY04.

In August 2004, as part of EQT's technology transfer efforts, members from various UXO fields took part in a hardware/software workshop organized by the US Army Corps of Engineers (USACE) Huntsville Engineering and Support Center. Sponsored by EQT, the workshop consisted of thirteen technical presentations on geophysical hardware/software products currently under development by EQT. The workshop took place over the course of two days in Huntsville, Alabama and in addition to the presentations included hands-on demonstrations of UXO screening detection and navigation technologies at Redstone Arsenal's McKinley Range. Seventy members of government, industry, academia fields, and State and Federal regulators attended the workshop. Feedback from participants was very positive. Huntsville plans to host a similar workshop in two years to facilitate UXO detection and discrimination technology transfer.

This program has been leveraged into a SERDP/ESTCP cooperative agreement with GeoSoft.

PLANNED ACTIVITIES:
Software systems will be inserted into the GeoSoft platform during FY05.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:

Conference Presentation:
R. Young (2004). "BA4 III.A. Task 3: Insert Software into Geosoft Systems. Software Demonstration/Validation Assessment." Presented at November 2004 IPR, Fairfax, VA.

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 were 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 were 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 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) AdvancedSignature 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.

FY04 OBJECTIVES:
The objectives of this work unit are to demonstrate/validate advanced geophysical data processing and analysis and to enhance the ability to discriminate buried UXO in a wide range or environmental and geophysical conditions. Objectives set specifically for the 2004 fiscal year included investigation and reporting of guidelines for optimum

application of TDEM and Mag platforms, collection of data sheets at blind grids for the both the application of algorithms for inferring shapes of composite targets and joint inversion investigations for UXO discrimination.

ACCOMPLISHMENTS AND RESULTS:
For the section that focuses on the algorithm for inferring the shape of composite targets, data sets were collected from the Blind Grids during the third quarter of the FY, followed by the application of the algorithm to data sets (developer, user) also during the third quarter, and the transition to GeoSoft in the fourth quarter.

For the section that focuses on the joint inversion investigation for UXO discrimination, the second data set was collected from the Blind Grid at Aberdeen Proving Ground, Maryland, during the third quarter of the FY, followed by the application of the algorithm to data sets (developer, user) also during the third quarter, and finally the transition to GeoSoft during the fourth quarter.

Guidelines for the application of TDEM and Mag/TDEM were completed during the fourth quarter of FY04. The transition to CEHNC and the commercial user community was also completed during the fourth quarter.

ISSUES:
Issues regarding this technology are based on approximate modeling of UXO, positioning accuracy of multi-sensor systems, and the acquired data resolution and quality. Particular issues will be documented in the final report.

PLANNED ACTIVITIES:
The demonstration of near real-time algorithms for Mag, TDEM, and FDEM are scheduled for completion during the 2Q05. The final report on Advance Signature Models and Inversion Technologies Implementation is scheduled for completion during the 3Q05.

Additional activities planned for FY05/06 include completing the transition of the algorithm for inferring shape of composite targets to GeoSoft and as well as the transition of the Joint Inversion algorithm for UXO discrimination.

POINTS OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:

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, US 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, US 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 BA3 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 systematize the planning process and reduce UXO cleanup cost.

FY04 OBJECTIVES:
The objective of this work unit was to demonstrate/validate expedient site characterization procedures for UXO detection survey planning through the application of BA3 generated MAUDE software. Objectives for FY04 included an ERDC demonstration of MAUDE at both standardized UXO sites and an ATC demonstration of MAUDE at an active response site and at least one actual UXO cleanup site.

ACCOMPLISHMENTS AND RESULTS:
During the second quarter of the fiscal year, ERDC demonstrated the MAUDE software during field tests at both the APG and YPG Standardized Sites. Additionally during the fourth quarter, ATC demonstrated the MAUDE software at APG's Active Response Demonstration Site and began planning a demonstration at Tobyhanna Army Depot in Pennsylvania.

PLANNED ACTIVITIES:
In 2Q05, the software will be transitioned (ex. CEHNC, ITRC, and GeoSoft) with software being tentatively scheduled for demonstration in April 2005 and MAUDE upgrades will be provided periodically. A second demonstration at an active response site will be completed at Tobyhanna Army Depot.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
Simms, J.E., Larson, R.L., Murphy, W.L, and Butler, D.K. 2004. "Guidelines for planning unexploded ordnance (UXO) detection surveys," Technical Report ERDC/GSL TR-04-8, US Army Engineer Research and Development Center, Vicksburg, MS. Available at http://el.erdc.usace.army.mil/elpubs/pdf/trgsl04-8.pdf

MAUDE, a Management Aid for UXO Detection Efforts, software package is available on the ERDC UXO website at: http://el.erdc.usace.army.mil/uxo/

Conference Papers:

J. Simms (2004). Variability of Magnetic Susceptibility and Its Importance in UXO Detection Surveys. Presented at UXO/Countermine Forum 2004.

Workshop Presentation:

J. Simms (2004). Guidelines for Planning Unexploded Ordnance (UXO) Detection Surveys. Presented during August 2004 EQT UXO Hardware/Software Workshop in Huntsville, Alabama.

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.

FY04 OBJECTIVES:
The objective of this work unit is to generate standardized guidance for geophysical prove outs. FY04 objectives included providing support to ITRC efforts to publish guidance related to geophysical prove outs and to identify the information necessary for decision makers to make informed choices when choosing UXO detection and discrimination technologies.

ACCOMPLISHMENTS AND RESULTS:
The ITRC GPO guidance document was developed and went through the formal DoD review process during the fourth quarter of FY04. The final GPO document with full DoD concurrence will be published during early first quarter FY05. The guidance document provides information on GPOs and the broader topics of geophysical surveys, equipment, and methodologies currently used in munitions response actions. This effort contributed to an ongoing positive relationship between ITRC, DoD, and regulatory personnel.

ISSUES:
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.

PLANNED ACTIVITIES:
Support ITRC development of a web based GPO training course. This training will introduce the purpose and scope of GPOs; provide examples of goals and objectives associated with GPOs; and present detailed information needed to evaluate the design, construction, implementation and reporting of GPOs. The course will be based on ITRC's *Geophysical Prove-Outs for Munitions Response*.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
ITRC. Technical/Regulatory Guidance. *Geophysical Prove-Outs for Munitions Response Projects.* Prepared by the ITRC Unexploded Ordnance Team. December 2004.

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 will determine the level of influence and what steps are necessary to remove this bias.

Technologies that can only be operated by 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.

FY04 OBJECTIVES:
The objective of this work unit was to demonstrate the level of influence contributed by the operator to the UXO sensor system performance. FY04 objectives included the execution of technician training, demonstration completion, and evaluation of operator influence on system performance during field-testing of the EM-61 and Shonstedt handheld systems.

ACCOMPLISHMENTS AND RESULTS:
Completed development of a site at APG for conducting the evaluation of operator influence on UXO detection and discrimination technologies. Completed data collection for all data categories (cognitive, physiological, operating parameters, and system performance). The thirteen (13) operators evaluated included ten (10) novices and three (3) experts. Field tests were completed and the data is currently being evaluated to identify potential trends. The new countermine Total Monitoring System (TMS) was leverage for this project.

ISSUES:
The review panel team should be expanded to include additional members, such as personnel from Naval Facility (NAVFAC) Adak, Alaska, due to their familiarity with QC procedures.

During review of the collected data it was discovered that, due to inaccurate telemetry data during field testing, there were numerous data gaps for the Shonstedt system. In order to address data gaps and make data viable for comparison to EM-61 data re-testing of demonstrators on the system is highly desired. However, due to lack of funding, additional QC testing of operators will not occur.

Originally scheduled for development during FY05, a workshop designed to address potential remedies for removing bias has been indefinitely postponed due to lack of funding.

PLANNED ACTIVITIES:
Evaluation of the data collected during initial field tests of operators utilizing EM-61 and Shonstedt systems will be completed.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
Conference Presentations:
Hood, Jacquelyn. Operator Influence on UXO Detection Technologies. Presented at UXO/Countermine Forum 2004.

Hood, Jacquelyn. Operator Influence on UXO Detection Technologies. Presented at EQT UXO IPR in Fairfax, VA at BRTRC Facilities. 11 November 2004.

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 task provides funding for labor and travel 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 reciprocity with some 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 PDT 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.

FY04 OBJECTIVES:
The objective of this work unit was to provide programmatic support and stakeholder support for EQT UXO technology test and evaluation products. Fiscal year objectives included generation of an annual report and development of a Technology Transfer Products Toolbox. Additionally, products were made available through the USAEC website (www.uxotestsites.org) and other media venues. Also events would be leveraged to create opportunities for technology demonstrations and transfer and to develop regulatory buy-in and support.

ACCOMPLISHMENTS AND RESULTS:
A briefing on the UXO Standardized Technology Site was conducted at the EMI Workshop in February 2004. The UXO Countermine Forum was conducted during

FY04. The Standardized Sites' website (www.uxotestsites.org) was developed to provide the public and UXO community with access to scoring reports, fact sheets, site descriptions, the FY 02/03 Annual Report and information on the target repository.

In August 2004, as part of EQT's technology transfer efforts, members from various UXO fields took part in a hardware/software workshop organized by the US Army Corps of Engineers' (USACE) Huntsville Engineering and Support Center. Sponsored by EQT, the workshop consisted of thirteen technical presentations on geophysical hardware/software products currently under development by EQT. The workshop took place over the course of two days in Huntsville, Alabama and in addition to the presentation included hands-on demonstrations of UXO screening detection and navigation technologies at the Redstone Arsenal's McKinley Range. Seventy members of government, industry, and academia fields attended the workshop. The workshop is being used by ESTCP/SERDP as a future model for similar activities.

The Technology Transfer (T^2) Strategy was created, updated and published during FY04. In addition to the Strategy a T^2 Management Plan was drafted. A T^2 Toolbox containing fact sheets, CD-ROM products, posters, copies of displays, presentations, scoring reports, a newsletter, and news & journal articles was developed.

Events associated with the Standardized Sites, such as ribbon cutting ceremonies, tours, and visits, are being leveraged for product demonstrations.

ISSUES:
It should be noted that technology transfer is currently an unfunded component of each work unit and that the majority of T^2 activities are not scheduled to occur until FY06. Despite this lack of funding, T^2 activities are ongoing and information is transitioned as it becomes available

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. Technology transfer of all products generated will be continued throughout FY05/06.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
The Army Environmental Quality Technology User Requirement A (1.6.a) UXO Screening, Detection, and Discrimination UXO Program FY02/FY03 Annual Report. July 2004.

Technology Transfer Plan for US Army Environmental Center's Environmental Quality Technology Program A (1.6.a) UXO Screening, Detection, and Discrimination Operational Requirements Document Program (EQT-ORD Program). October 2004.

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 (T^2) 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. Programs will be modified to reflect user requirements.

FY04 OBJECTIVES:
The objective of this work unit was to bring together technical executors of the EQT program to exchange issues and progress of the program. Specific fiscal year objectives included the establishment of an Independent Program Review (IPR) and facilitation of an annual meeting to provide an update on the current and future efforts of the EQT UXO Program.

ACCOMPLISHMENTS AND RESULTS:
An EQT UXO IPR was held on 10 November 2004 built on progress made during the August 2003 IPR meeting which identified some overall issues within the program such as the technology transfer of final research and development information, hardware, software and other products. Technology transfer was noted as a very important aspect of the program and as a difficult task to accomplish. Suggestions collected during the meeting resulted in changes to projects and the program's management plan. Draft meeting minutes can be reviewed in Appendix B.

ISSUES:
It should be noted that T^2 is currently an unfunded component of each work unit and that the majority of T^2 activities are not scheduled to occur until FY06. Despite this lack of funding, technology transfer activities are ongoing and information is transitioned as it becomes available

Due to late funding, the scheduled completion date for the 2002 Annual Report was pushed back and the 2002/2003 Annual Reports were combined into a single deliverable.

PLANNED ACTIVITIES:
The 2003 Technology Review meeting and FY03 Annual Report were completed during the second quarter of FY04. The 2004 Technology Review meeting and FY04 Annual Report will be scheduled for completion in 2Q05. The 2005 Technology Review meeting and FY05 Annual Report will be scheduled for completion in 2Q06. And in 4Q06, the program final report is scheduled for completion.

POINT OF CONTACT:

US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:

The Army Environmental Quality Technology User Requirement A (1.6.a) UXO Screening, Detection, and Discrimination UXO Program FY02/FY03 Annual Report. July 2004.

Technology Transfer Plan for US Army Environmental Center's Environmental Quality Technology Program A (1.6.a) UXO Screening, Detection, and Discrimination Operational Requirements Document Program (EQT-ORD Program). October 2004.

BA6 IV.A Standardized Guidance for Geophysical Prove Outs

OVERVIEW: Geophysical systems are used to detect surface and subsurface anomalies (i.e. unexploded ordnance and/or discarded military munitions) during geophysical surveys of munitions response sites. These systems are tested, evaluated, and demonstrated by a site-specific geophysical prove-out (GPO). Information collected during the implementation of the prove-out is analyzed and used to select or confirm the selection of a geophysical system that can meet the performance requirements established for the geophysical survey.

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

FY04 OBJECTIVES:
The objective of this work unit is to generate standardized guidance for geophysical prove outs. FY04 objectives included providing support to ITRC efforts to publish guidance related to geophysical prove outs and to identify the information necessary for decision makers to make informed choices when choosing UXO detection and discrimination technologies.

ACCOMPLISHMENTS AND RESULTS:
The ITRC GPO guidance document was developed and went through the formal DoD review process during the fourth quarter of FY04. The final GPO document with full DoD concurrence will be published during the early first quarter of FY05. The guidance document provides information on GPOs and the broader topics of geophysical surveys, equipment, and methodologies currently used in munitions response actions. This effort contributed to an ongoing positive relationship between ITRC, DoD, and regulatory personnel.

ISSUES:
During FY04 $30K in funding was redirected from the ASTM to the US Army Aberdeen Test Center to support ITRC with the writing of the guidance document for geophysical prove-outs.

PLANNED ACTIVITIES:
Support ITRC development of a web-based GPO training course. This training will introduce the purpose and scope of GPOs, provide examples of goals and objectives associated with GPOs, and present detailed information needed to evaluate the design, construction, implementation and reporting of GPOs. The course will be based on ITRC's *Geophysical Prove-Outs for Munitions Response*.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
ITRC. Technical/Regulatory Guidance. *Geophysical Prove-Outs for Munitions response Projects.* Prepared by the ITRC Unexploded Ordnance Team. December 2004.

BA6 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 task provides funding for labor and travel 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 reciprocity with some 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 support of 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 PDT 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.

FY04 OBJECTIVES:
The objective of this work unit was to provide programmatic support and stakeholder support for EQT UXO technology test and evaluation products. Fiscal year objectives included generation of an annual report and development of a Technology Transfer Products Toolbox. Additionally, products were made available through the USAEC website (www.uxotestsites.org) and other media venues. Also events would be leveraged to create opportunities for technology demonstrations and transfer and to develop regulatory buy-in and support. The majority of T^2 activities are not scheduled to occur until FY06

ACCOMPLISHMENTS AND RESULTS:
A briefing on the UXO Standardized Technology Site was conducted at the EMI Workshop in February 2004. The UXO Countermine Forum was conducted during FY04. The Standardized Sites' website (www.uxotestsites.org) was developed to

provide the public and UXO community with access to scoring reports, fact sheets, site descriptions, the FY 02/03 Annual Report and information on the target repository.

In August 2004, as part of EQT's technology transfer efforts, members from various UXO fields took part in a hardware/software workshop organized by the US Army Corps of Engineers' (USACE) Huntsville Engineering and Support Center. Sponsored by EQT, the workshop consisted of thirteen technical presentations on geophysical hardware/software products currently under development by EQT. The workshop took place over the course of two days in Huntsville, Alabama and in addition to the presentation included hands-on demonstrations of UXO screening detection and navigation technologies at the Redstone Arsenal's McKinley Range. Seventy members of government, industry, and academia fields attended the workshop. The workshop is being used by ESTCP/SERDP as a future model for similar activities.

The Technology Transfer (T^2) Strategy was created, updated and published during FY04. In addition to the Strategy a T^2 Management Plan was drafted. A T^2 Toolbox containing fact sheets, CD-ROM products, posters, copies of displays, presentations, scoring reports, a newsletter, and news & journal articles was developed.

Events associated with the Standardized Sites, such as ribbon cutting ceremonies, tours, and visits, are being leveraged for product demonstrations.

ISSUES:
It should be noted that technology transfer is currently an unfunded component of each work unit. However, despite this lack of funding T^2 activities are ongoing and information and products are transitioned as they becomes available

PLANNED ACTIVITIES:
The draft FY04 Annual Report will be completed and provided for review and comment early 1QFY05 with a final report being made available during 2QFY04. The FY05 Annual Report will be drafted in late 4QFY05.

The Shallow Water Standardized UXO Technology Demonstration Site's ribbon cutting ceremony scheduled for early Spring 2005 will be leverage for product demonstrations of shallow water detection and discrimination technologies.

A meeting of the PDT will take place in May 2005. Additionally, an IPR meeting will be held during the 3rd or 4th quarter of FY05.

POINT OF CONTACT:
US Army Environmental Center (USAEC) Hotline at (800) 634-2655

PUBLICATIONS:
The Army Environmental Quality Technology User Requirement A (1.6.a) UXO Screening, Detection, and Discrimination UXO Program FY02/FY03 Annual Report. July 2004.

Technology Transfer Plan for US Army Environmental Center's Environmental Quality Technology Program A (1.6.a) UXO Screening, Detection, and Discrimination Operational Requirements Document Program (EQT-ORD Program). October 2004.

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 (USAEC), 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 base-lining assessments.

Appendix B

Draft Meeting Minutes
EQT UXO Independent Review Panel Meeting
10 November 2004
BRTRC Conference Facility, Fairfax Virginia
Sponsored by the Army EQT Program and JUXOCO

Welcome (Dr. M. John Cullinane)
2nd time – outside look at Army EQT program.
Most important thing is feedback.

0805-0815
Objectives of Today's IPR & Instructions (George Robitaille)

- Input from last IPR did have effect on program & tasks. Helped direct program towards projects.
- Comments that had effect:
  - Availability of clutter added to standardized site repository
  - Work plan for complete reconfiguration program of sites (in progress)
- BA4 IB: canceled due to lack of funding. Funding reprogrammed for demonstration in other tasks. ESTCP has lead & is working.
- BA4 IC: site is set up. 4 demonstrations to date. Budget for archeological report cut – only site is now four acres at APG. Methodology to be used developed by ATC. No mag/flag at site. Preliminary survey near 2500 hits.
- BA4 IIA: Capture data from all demonstrators. Can be used by anyone, only need to request. Matrix for Army/COTS ultimate product is scoring report on each system and a final report.
- BA4 IIB: Major issue raised – increase funding for baseline. Funding reprogrammed from other areas. 2 mag/flag conducted at APG/YPG (Parsons & HFA). Leveraged money from ESTCP.
- BA4 IIE: increased test site from one acre to approx. 12. Located at APG
- BA4 IIF: cancelled due to lack of funding. Money was reprogrammed to other tasks.

Instructions

- Open forum for questions. Time is constrained (written comment forms available). Specific questions to be answered in technical sessions.
- Objectives-
  1. Provide constructive input.
  2. Leverage coordination with similar activities.
  3. Tech transfer opportunity

0815-0835
Discuss/Distribute UXO Detection Survey Planning Report / Overview Demonstration of Management Aide for UXO Detection MAUDE - (Dr. Janet Simms)

- Two topics – guidelines for planning surveys & software MAUDE
- Published ERDC report Aug. 04 – gives framework behind MAUDE. Discusses UXO characteristics to start. Penetration vs. burial depth. Geophysical sensors used. Target sensor (size, shape, orientation). Site variability (geologic noise).
- Phenomenological evaluation (geologic descriptions) – four aspects of site (topography, vegetation, soil, moisture) – then separate each four into unique

areas, those 4 sets combined and geophysical parameters identified, then identify ordnance of interest, then select sensors & platforms that may be applicable for each area.

- Demonstrated at hardware/software workshop. Received good feedback.
- Basis for MAUDE is Phenomenology: Topography (6 categories), Vegetation (7 categories), Soil (USDA classification – 12categories), and Moisture (3 categories – dry, moderate, wet). Usually very little information on moisture type so category was kept simple.
- First action is to import GIS files and then identify polygon.
    - Next step is identify geophysical parameters of each polygon – 2 choices (done for you w/ nominal values or input w/ options to edit parameter values w/ actual data if available).
    - Next step define ordnance looking for (currently NDCEE database, would like to add statistical data on penetration/burial as database matures) – set up option of 2 files (1) favorites – installation wide type ordnance used or (2) Site specific ordnance. Currently there are approximately 100 ordnance types included, each w/ a help file – facts & photo included.
    - Next step: sensor and platform selection (2 options – general or area specific which uses geophysical parameters) – creates table for all polygons w/ senor & platform listings.
    - Summary function provides summary of data for all polygons.
    - Spatial sampling – Line or Along Line sampling available.
        - Line sampling: chart generated provides five offsets for each ordnance item and provides idea of maximum response curve as sensor/platform moves away from item.
        - Along Line sampling – chart generated provides offset along line connecting 2 known points.

      Q: Detection or discrimination?
      A: Detection.

      Q: Why 2 points?
      A: For anomaly response

      Q: Can we assume the line goes over top of item?
      A: You can choose an offset

    - Model Ordnance Response – plot in profile or in grid.

      Q: Can you show what the anomaly would look like based on the profile plot?
      A: No. But might be a good idea. You can specify what your spacing is in terms of your grid development spacing, so in that sense you could, but not in the profile plot.

- Summary – designed for individuals with little or no geophysical experience. Provides a feeling for the complexity of a site. Identifies features that may be influential. Provides values that have a defensible basis when interacting with contractors & regulators.

Q: Is there any capacity in the program for selection of different positioning or navigational systems, i.e. GPS?
A: No. Wouldn't be too difficult to include if necessary, but currently no plans to add.

Q: Have you completed MAUDE and is it being used by contractors (field deployed)?
A: Beta version provided at workshop, errors identified and a couple have been corrected. Still one thing that may be changed (time domain modeling still not included).

Q: How do you envision the PM using this tool? It seems like a lot of data to be inputted for very little output. Not sure of value to new PM.
A: Doesn't believe there is a lot data. Main data will come from installation GIS group – that information is inputted and then parameter information can be used as pre-installed nominal data.

Comment: Soil types not broken up by grid.
Q: How much data is needed to break up grid?
A: Depends on complexity of site.

Q: Is this design interactive with GIS set up for management of site?
A: It takes strict GIS files (polygon data) & inputs it in.

Q: Any interest from contractors?
A: Some have shown interest. CDs were handed out after (hardware/software) workshop. It will be posted on UXO ERDC website.

0835-0845
MAUDE Test and Evaluation / Technology Transfer- (Larry Overbay)

- ATC just beginning to use MAUDE in April 2004. Abbey Point import selected as primary demonstration site because it is a true clean up area.
- We want to have program managers at the installation level that can help us (ATC) out.
- Point is to develop and implement T&E strategy. Solicit input into how to make program more accessible/easily useable.
- Test plan being developed (ready for distribution in a month or two). Deliverable due 2nd quarter of this FY. Soliciting involvement of installation personnel. Test MAUDE at standardized site because we know all of the background information (topography, etc.) associated with the site. Verify ability of MAUDE to expedite site characterization procedures.
- Test plan is currently being developed.
- Full scale testing to begin 12/04.

Q: What are thoughts on how it expedites site characterization?
A: We first try to validate the information that is there (ordnance, other details). "We are T & Eers, we aren't technical people."

Q: Have you thought about going to a project that has been completed, past the characterization stage?
A: Yes – Abbey Point.

Q: Suggestion to run several duplications.
A: Data from Huntsville being evaluated from non-active sites.

Q: Have you considered attending the Navy meeting in Huntsville?
A: As of now we don't have current plans, but we will consider attending.
Comment: may be good idea since numerous PMs will be in attendance

UXO Sensor Systems and Enhancements

0845-0905

Commercially Available Electromagnetic Induction (EMI) and Total Field Magnetic (TFM) Systems/Capabilities and EQT System Enhancements / Capabilities (Dr. Dwain Butler)

- Conceptualization of UXO environmental remediation process. Early to mid 1990s thought they had the sensors necessary. Some were adequate for problem, but didn't know how to apply them to large areas.
- Methods of choice – magnetometry & EMI. Cost drivers indicate that most sites will need to reply on only one sensor even though the use of both types would be ideal. Cost has been driver for development of dual sensors.
- EMI methods are mature & well documented. Versatile implementation possibilities & considerable potential for mass development.
- Time-domain EM System – most widely used system for digital geophysical surveys. Not completely easy to develop into arrays, but they can be. Deployment problems in rugged terrain/thick vegetation.
    i. Hand-held/Man-portable versions
    ii. New generation – Geonics EM63 (c 2000) measures vertical component only, but measures complete time decay. Zonge NanoTEM (c 2001)
    iii. EM 61-Mk2 current system of choice
- Frequency Domain EM systems – Geophex GEM3 most applicable to UXO surveys. Multi-frequency system. In survey mode 2-7 frequencies at walking speed, covers 2-3 acres/day. System enhancements – great bandwidth, larger diameter Tx Loops, improved transmitter signal, evaluation sites: Fort Ord, YPG, & APG. Observations: good resolution for small items, lightweight and maneuverable, consistent, limited depth of detection (pressing to go much below a meter for any item), not ruggedized, significant noise issues at lower frequencies.
- TFM – optically pumped mags have completely adequate sensitive and accuracy for UXO applications. Original system Geometrics G-858 (c1996) Cesium Vapor TMI. 2-4 acres a day – relatively straightforward integration into arrays and dual sensor systems. Arrays – high resolution, accurately fixed relative sensor locations, efficient area coverage, access limited by topography & vegetation.
- Handheld (1 acre/hour) /towed arrays (2-5 acres/hour)
- Dual sensor system development – current thrust of development. Data is much more precisely collocated than w/ separate systems.
- Sub-audio Magnetics – simultaneously measures TFM & TDEM using a mag. Combines best attributes of TFM & EMI.

Q: Where are you headed next?
A: No specific plans. Briefing is just a placeholder to summarize past four years. You will see where we are going in the following presentations.

0905-0935
Standardized UXO Technology Demo Sites/COTS, GOTS, & Government Developed UXO Technology Demonstration Results / Baseline Tasks, Active Sites, Demo 06, and Demos to Date (Larry Overbay)

- Demo sites are backbone of EQT UXO program. Center of UXO technology demonstrations. Measuring stick for the demonstrations.
- Total of 122 to date (74 at APG; 48 at YPG). All forms of sensors tested. Provides for evaluation of navigational tools & UXO avoidance training.
- Site upgrades – new site building under construction at APG – provide secured storage for test equipment, wireless network, workbench & power outlets for maintenance and repair. New addition – test stand (idea from Fort Ord) similar to observation tower at test sites.
- Raw data management: Standardization of demonstrator data, revised instructions and coordination prior to demos, user friendly data sets
- Scoring Submittals – demonstrators "dig list" – constant errors w/ submissions so developed scoring submission software. Feed excel sheet into & provides proper format. Currently on website for demonstrators to look at.
- Site reconfiguration (APG) – 100% of blind grid reconfiguration, partial in open field. Requested input from targeting community – reconfigurations based on those inputs. Leveraging efforts – migration studies, remnant magnetization study. Issues during recovery – difficulty finding small ordnance & clutter. Unintentional disturbance causing loss of recovery data.
- Ground Truth (GT) release – Blind Grid GT available, Open Field available end of 11/04. Will be posted on website. Notification will be provided to all demonstrators. Waiting on final data submittals prior to release. Working on format that is more than an Excel spreadsheet – interactive type tool.
- Repository status – provided to 20 agencies totaling 750 targets. Tracking systems being enhanced, added calibration spheres (1/2 inch – 4in balls). Collecting program wide information. 37mm projectiles hard to find, those that have been found are contaminated with mercury.

Q: Has Dean gotten through the backlog?
A: Yes.

Q: What about 40mm ferrous (since 37mm are being found, even though difficult)?
A: Let's talk about it offline, it's difficult because of the learning process.

- BA4/BA6 Tasks Supported:
  - Active Response Site (IC): adjacent to APG standardized site. Area known to have clutter & UXO. Conduct arch dig GT
  - Demonstration of dual mode systems (IIA): demonstrations of COTS (Blackhawk) and GOTS. Not a lot out there.
  - Baseline Handheld/Man Portable (IIB): baseline of ERDC develop tech completed at APG & YPG. Private industry demons completed at APG & YPG. Leveraged w/ ESTCP to fund & conduct multiple mag/EM & flag demos.
  - Standardized UXO Tech Demo 2006 (IIC): FY05 start, BAA currently available, product development team to select techs to demo

Q: Where are you dealing with the backlog?

A: We are really ripping them out right now. The problem we have is that we go through the signature process (3 layers of OPSEC must be addressed). We can go from cradle to grave in about a month. Ideally we would like to be done by Christmas or the first of the year. 25/28 are done & posted. We are now waiting for data from some demonstrators.

Q: During the recovery stage, what is the ratio of those that are degaussed vs. pulled out?
A: I'll provide results offline. Parsons just finished at YPG have 2 more weeks before they have to provide data.

Q: What is the time schedule after reconfiguration for use?
A: It's based on usage currently. March/April at Yuma?

Q: During the reconfiguration process, were you able to adjust to the size of the range, based on the results of what has happened before?
A: No. Went back to same process we went with before, with reality, we didn't do it out of sensor performance. We went through NDCEE firing & recovery database to look at reality of where items are typically found. Reconfiguration not based on demonstrator results.

Q: Influenced by ordnance distribution? Testing with more stringent requirements?
A: Depending on distribution – modification of ground truth. Basic premise is to stress systems.

Q: Is there concern of different issues with discrimination vs. texture?
A: You can modify the parameters.

0935-1000
G-Tek SAM & GeoCenters Multi-Sensor System Development
Overview/Capabilities/Status (Jay Bennett / David Wright)

- Overview of sensor system development. (G-Tek SAM, GeoCenters STOLS, AETC Dual Sensor)
- ESTCP, USACE, EQT support.
- SAM System – simultaneous collection of TMI & TFEM w/ a single sensor head (cesium vapor). Survey area is typically 30mX30m up to 100mX100m. Quad sensor array. Highly conductive ground conditions limit detectibility. 6 case studies have been completed (Australia, 2 sites in MT, AL, APG, HI). Limestone Hills, MT – rough terrain case study. Achievable detection depth below 100mm not well detected. Pre-processing program MagPI. Current status – new transmitter being built, new user interface that incorporates navigation, integrated GPS and radio modem into single box. Field demonstrations w/ new transmitters at APG & YPG May '05

Q: Have you seen design specification for the transmitter?
A: No.

Q: With the added complexity with the coil in the field, are their types of sites you are focusing this technology on? What type of site are you looking at using this technology?

A: Extra depth detection. It's a two-man system; you can do both EM and Mag at the same time. There are areas where you will have to use other EM systems (i.e. Hawaii with Magnetite naturally occurring).

Q: Planning on changing the loop w/ new reconfiguration?
A: There will be fewer turns, cut down by 20%. When new transmitter is released, they will have a better idea.

- STOLS System – Have applied for patent for system. Combination Mag/EM61 – increased probability of detection due to complementing sensors. First demo at APG 11/02 13acres in 1.5 days. Improvements under CRADA w/ CEHNC added suspension and increased bracing to make more survivable, ruggedized notebook, widened platform. Future – funded by ESTCP man-portable version of interleaving tech for FY04-05; ongoing surveys; design & build improved platform w/ micro-positioning of sensors; incorporate discrimination techniques.

Q: Do you have any specific plans on hooking up with other researches from other organizations on discrimination work?
A: Yes - UXOLAB.

--Break—

1015-1040
AETC Handheld Sensor System Development Overview / Capabilities / Status (David Wright)

- AETC Dual Sensor System – Enhancement to the combined EMI/Mag. Objective is to improve this instrument's mode of deployment. Effect of the EM field on the TMF is zero. Shakedown tests demonstrated at NRL Blossom Point and at ERDC UXO Test facility. GEM-3/Mag (final version backpack 16lbs, hand carry 15lb, total 31lbs). GEM-3MC (magnetometer-compatible). Remaining tasks – static measurements of selected ordnance, field shakedown tests

Q: Since you are operating at a high frequency, how much information are you getting out of this, what kind of discrimination can be gotten out of the system?
A: We haven't exactly modeled it.

Q: With the modification to GEM3 – are you seeing any improvements or stability at lower frequencies?
A: No. The lowest I can go is 3Hz.

Position / Tracking Technologies

1040-1100
Positioning Technology Development, Evaluation, and Demonstration (Scott Millhouse)

- Phase I – completed 100% funding from ESTCP
- Phase II – completed principal funding by ESTCP & CEHNC
- Phase III – objective of discussion. 50% funded by each ESTCP & EQT
    - Navigation integrated w/ G858. Demo at APG calibration lanes, wooded & mogul scenarios. 4 vendors (Shaw UXO Mapper – provides local high 3D accuracy for anomaly interrogation; GIS GeoVizor – used ultrasonic

for close position w/ 2m for interrogation; ArcSecond UXO Constellation – laser based, originally commercial system, but funding provided for improvements; ENSCO Ranger – radio nav system / inertial nav system).

- Accuracy: Shaw .07-.27cm; GIS Geovizor .25-1.01m in woods, .1-.15m moguls; ArcSecond .01-.18m demonstrated; ENSCO Ranger .03-.05m w/ INS enhancement w/ G858 .17-.57m

Q: When you first started out, you said how much interference (error) was related to the instrument vs. not holding level (for SHAW GIS)?
A: It's not really an issue at the site on the calibration lanes (straight lanes), took pains to maintain straightness of instrument.

- APG demonstration summary – ArcSecond is most accurate followed by Shaw, ENSCO, and GIS. ArcSecond average local area navigation was 0.01m (1cm). ArcSecond is being developed and integrated for Phase IV for interrogations w/ handheld sensors.

✍ Phase IV – in process looking for tech most effectively on complete position information

Q: Still operating at a 20 second scan?
A: Yes.

Q: How much does the new system weigh (instrument itself) after enhancements?
A: The plan is to get it down to 2-3lbs. Current weight is unknown.

Q: What is the update rate for position?
A: Currently 20htz, end product will be selectable.

Q: Is the interference problem with GEM-3 resolved?
A: Yes it has been resolved. Geophex originally created noise by the poor packing of the coil. The sensors were moved on the coil to reduce the amount of noise.

Q: How much does IMU weigh/cost?
A: 15K unit, weighs 3-5 lbs. Trying to minimize weight as much as possible for stabilization purposes. Would like to get it down to a pound, but it may not be possible with the first generation system. It's about the size of a baseball. The cost is about $15,000 a unit.

Q: How much could you put on it?

A: Prefer to have something small to increase stability.

1100-1120
Integrated UXO Technology Demonstration Approach and Plan (Gary Rowe)

- ✍ Program objective was to support demo and validation of BA2/BA3 projects in UXO sensor platform design & enhancements.
- ✍ Tasks: identify system components, develop an approach to integrate components, implement the approach (field test & demonstrate, transfer)
- ✍ Status – project management plan developed w/ 114 individual tasks being tracked. Selected ArcSecond as navigation component.
- ✍ Next steps – develop test plans for integrated systems, field test systems using UXO standardized sites, debug, conduct final demons, tech transfer.
- ✍ Deliverable – suite of state-of-the-art UXO detection/discrimination technologies & software package, technology transfer

- Key point to take away from briefing – have identified key players, components, and are keeping track of tasks to ensure that the right components come together at the right time. ATC is supporting field-testing of components.

Q: Where does the integration come in and where does the tech transfer come in? Mentioned different pieces and heard about MAUDE but if you need integrated system how are the two integrated?
A: There is no interrelationship between these systems and MAUDE. MAUDE can take any system and work with it. This task takes BA2/BA3. We want to integrate T&E work of BA3/BA4. This is a testing and evaluation tool, not an end user product.

Comment: Not easy to evaluate system performance separate from process linked to. Community needs to force direct tradeoff to evaluate. Be realistic, complete system development not as easy as thought. Not an easy end game.
A: Learning experience, working out bugs.

Q: Is there much effort going on to resolve ergonomic issues with respective to integration?
A: No specific task has been assigned to address it, but we are in the process of putting them together. We are in the process of putting them together; we haven't been able to run them yet. It can be integrated into minor systems. We have not had a chance to run field demos to determine what enhancements can be made to make more user friendly.

Discrimination of UXO w/ Geometric Complexity & Composite Material Targets; GEM-3D Handheld Sensor System Overview/Capabilities/Data Processing (Dr. Kevin O'Neill)

Handout only. No presentation.

1125-1145
Data Acquisition/Data Analysis System (DAQ/DAS) Overview (Ricky Goodson)

- Objective – software processing techniques to support sensor development underway at EQT. Idea is to have integrated system w/ singular software system for processing.
- Selected Geosoft Oasis Montaj as the core platform. Conducted prelim field eval at YPG.
- Contract w/ AETC to leverage their ESTCP work. Developed procedures and code to import, process, & display multi-channel EM data, completed C/Fortran versions of EM-63 and Gem-3 model inversions. Completed prelim integration of EM-63 and Gem-3 model inversion into GeoSoft.
- Latency Corrections, Array Channel Plot, Anomaly Selection, EM-63 Anomaly Plot, GEM-3 Anomaly Plot, GEM-3 Model fit, EM-63 Model Fit
- Ongoing work – incorporate support for new sensors, incorporate inversion algorithms, evaluate performance of detection/discrimination algorithms on data collected at standardized test sites, documentation.

C: Concerned about overlaps between different agencies in this effort. A lot of this sounds like slight variations of the same thing. Would probably be useful to lay out on one chart what's being done. Better is the enemy of the good – scared about confusing the community because there isn't enough demonstrator data to say that there are real differences between efforts.

--LUNCH—

1215-1300
UXOLAB Overview/Demonstration (Don Yule, Dr. Stephen Billings, and Dr. Leonard Pasion)

- Demonstrate UXOLAB – cooperatively inverting TFM and TDEMI
- 2 development platforms – Geosoft and MatLab – existing capabilities for data processing
- Objectives – develop & evaluation advanced data processing & analysis procedures for improved discriminations
- Current state of practice – dig all items above a certain threshold. To improve state of the practices – 2 platform implementations to get programs to users.
- Accomplishments – collected high resolution data sets; forward modeling & inversion tech, cooperative & joint inversion, tech transfer (conferences, workshops, user training)
- FY05 activities – completing test & evaluation, report on results. Advanced data leveling techniques & investigate next-generation forward models.
- FY03 Review comments – were supportive of general thrust, recognized that advanced techniques of modeling and discrimination are critical hurtle – acceptance by stakeholders key. Guidelines on data needs, application guidelines & performance is critical to address stakeholder hurdle.
- Demonstration by of UXOLAB performed by Steve Billings.
    - Upon launch MatLab opens because codes for UXOLAB were written in MatLab. There is a version available that does not require MatLab.
    - EQT funding – mainly used for inversions and discrimination of targets.
    - Mask data works best when anomalies are located too close together.

Q: When it's all said and done, what do results look like? How does it match up to calibration data? Can you identify specific ordnance?
A: We didn't see that there was a lot of class separation with the STOLS data at APG. We did the same process with the EM63 and we got a good separation data set at YPG.

Q: When you did the fit here with the EM data, you picked the EM61data and not the STOLS data, is there a big difference?
A: Yes there is a big difference because the coils are on the edges. That's where you get the biggest difference. We didn't have STOLS info to on the version of UXOLAB utilized.

1300-1315
Standardized UXO Demo Site for QC Evaluation of UXO Sensor Technology Operators (Jacquelyn Hood)

- Looked at CX52 and EM61 Handheld. Identify influences that affect operator performance. And once identified how to incorporate into operator training.
- No documented studies of operator influence in UXO community to date.
- Strives to bridge gap between R&D and end user.
- Cognitive Engineering Based upon Expertise and Skill (CEBES)
- Program objective – implement technician training (6 week course at TX A&M)
- Telemetry/data acquisition, post processing, human factors reviewed. Input of all three categories fed into results

- Current status – completed test on 10 novices and 3 experts using both mag and EM instruments.
- Next steps – continue data analysis, quantify operator influences vs. variables, conduct training/workshop, transition findings to new EQT technologies

Q: Any preliminary results?
A: Experts did extremely well (almost 100%).

1315-1335
Shallow Water Standardized UXO Technology Demonstration Site Approach and Plan (Gary Rowe)

- Official def of shallow water is still in flux.
- Objective – shallow water standardized site to determine capabilities and limitations of current and emerging technologies.
- Criteria – 5 areas of focus. Detection, Discrimination, Reacquisition, cost, production
- Mare Island testing and CEHNC testing at ATC provided limited data, but no baseline has been established.
- Test site – 6 acres seeded w/ targets, water level is controllable between 0-10 feet. Total size is 6-15 acres dependant on water level. Contains elements of the standardized ground test site. Designed to exceed threshold requirements of 10ft.
- 49 magnetic anomalies were identified during site clearance; all but 13 were removed. Those left were detected at depths too deep to remove. Areas with anomalies remaining are designated as no score areas.

Q: Is depth defined as water level depth or burial depth?
A: We are looking at burial depth; it does not take into account water level.

C: People who drag their sensors on the water may not pick up anomalies due to distance between the ground surface and the sensor (i.e. on a boat over deep water).

Q: How large is the site?
A: 43mX96m approx. Developed 2mX2m grid, flagged center of each grid. We feel this will give boats ample maneuvering room.

- Open water area – varying water depths. Varying projectile and clutter depths; includes 8in projectiles. Includes navigation, detection, & discrimination challenges.
- Current – blind grid targets in place. Approximately 96% of open water targets are in place.
- Next steps – complete target placement. Install calibration area. Address sediment and erosion controls. Fill site w/ water, install floating pier. Test scoring – based on ground site scoring methodology.
- Schedule – GT in place 30 Nov; filled w/ water 15 Dec; available for testing Jan05; stock w/ fish early spring 05

Q: Are you going to capture the properties of the water?
A: We are going to fill it with fresh water

Q: Will water be refreshed/replenished periodically?

A: It's not a very porous area. Water will drain periodically, but the bottom is composed of clay so the area should hold water for a significant amount of time.

Q: How long until the water gets really nasty?
A: I don't know, we really haven't thought about that. One option may be to install an aerator. We have provisions for pumping water in or out to maintain water at the level for test systems.

Q: Are you taking soil samples so that you know what the properties of the soil sediments are?
A: We would like to do that before the site is filled, but we haven't yet. What is at the bottom of the Bush River is now at the bottom of my site.

Q: Since you are using fresh water are you concerned with testing during winter months with the possibility of the pond freezing?
A: I don't anticipate people will be testing when it's freezing.

Q: Are there going to be submerged boulders or reefs?
A: Yes, there are going to be bottom lying obstacles that would be typically found in a water area.

Q: Will they be isolated in single area if demonstrators want to just test detection capabilities and not maneuverability?
A: They can be identified if that is a concern. There are three areas where that will be a challenge.

Q: What's the status of the facility with the wave pool?
A: Littoral Warfare Area still under construction. It won't be operational until the end of FY05.

Q: Have you looked into Naval Ordnance?
A: No. We are using what is in our repository. Plus the Navy's definition of shallow water is different than the Army's.

C: Phase I of this kind of work, if after testing has been done for awhile it can be drained and reconfigured w/o having to deal w/ divers or difficult environmental issues. A good test bed, will get type of work off and running.

--Break--

1355-1415
COTS & GOTS UXO Software Evaluation for Geosoft Compatibility (Roger Young)

- Objective of the effort is to identify and assess available COTS & GOTS UXO detection and discrimination software and insert where appropriate into the GeoSoft platform.
- 3 algorithms being added to GeoSoft to be completed by Dec04. Database logic classifier – looks for similar signatures to classify against pre-known anomalies. Track-plot smoothing. ½ height, ½ width calculation.

1415-1420
EQT UXO Hardware/Software Workshop (Roger Young)
Huntsville, Alabama
30 August – 01 September

- Task under EQT to complete tech transfer.
- 13 separate presentations on geophysical hardware/software under development by EQT
- Half-day hands on demonstrations at McKinley range at Redstone showing detection and navigation technologies.
- 70 from government, industry, and academia attended. Feedback generally positive. Would like to hold additional workshops every couple of years. Believe continuing tech transfer is an important issue.

C: Suggestion for forum – look for ways to increase communication with geophysical community (environmental engineering geophysical society) – highly technical group, would be an interesting forum to continue tech transfer.
A: We will be in touch.

1420-1425
Interstate Technology Regulatory Committee (ITRC) (George Robitaille)

- Product from UXO team that is geophysical prove out guidance document w/ DoD review & concurrence.
- GPO training – internet training in December.
- Guidance on historical records searches available through ITRC website.

1425-1445
Technology Transfer & Implementation Plan / Draft Technology and Implementation Plan (Michael Dillaplain)

- FY02/03 Report published July 04.
- Green folder. Expanding – easing into multi-level product useful across several media.
- Barriers to Tech Transfer
  - Unfunded activity
  - Not a standard acquisition program
  - Identifying and reaching appropriate stakeholders – may be barking up some of the wrong trees. Who are the real drivers behind moving technology from RDT&E group to the user group? Stakeholders resistant to using new technologies because they're not a requirement. May want to relook at drivers.
  - Comfort level w/ baseline technologies – a lot of people stick w/ technologies they're use to. Stick w/ a favorite. Opposition to change.
- Path forward – continue status quo activities. Workshops and focus groups – identify key working groups – continue to leverage events. Attempt to field demo products at working sites (some success w/ use on tribal lands). Follow-on packages or key stakeholder demonstrations.
- Draft plan included in folders.

Q: When you talk tech transfer, who is your target audience?
A: We have been talking with in the community. What we heard yesterday (JUXOCO) was that we should focus more on the PMs. There are limitations as to what I can do; I have to look at groupings. With in our current work plan right now, our target audience

would be Huntsville, but it also goes to PMs, regulators, people in that decision tree. There are 38 states with UXO sites.

Q: Who does current plan target?
A: Equivalent of Huntsville who does the majority of implementation for the army.

C: When you say PM, the first thing I think of is government PM. If the contractor goes through the trouble of putting the package together, we (Huntsville) are going to approve it. We need to have the PMs fully understand what the contractor is going to say. Contractors are going to perform it to the standard. Everyone needs to be on the same page.

C: You must present technologies in a way that will make contractors want to use it ("pull" it into use).

C: Not enough for this group to know story, PMs need to know what's emerging and that's not the market for tech transfer that's currently being looked at.

Q: When are we going to get to the point where these technologies have been tested and evaluated and someone would be willing to use them on a site?

A: Farther down schedule, being squeezed into last portion of 06. Need to build in front work/marketing ahead of time, can't wait until last portion of the program with what is being worked on now. Keep bringing people in as progress is made.

1445-1450
Continuing Funding Cuts for a Fully Funded Program (Dr. M. John Cullinane)

- Just wanted to pt out to group that when project was started 3 years ago there was a set budget, now over a 1M less than originally thought. Resulted in some tasks being scheduled.
- Programs are ALWAYS under financial pressure, particularly now that nation is at war.
- Environmental $ not a priority and pales in comparison to money being used to addresses improvised explosive devices (IEDs).

1450-1500
Wrap-up/Adjourn (Dr. M. John Cullinane and Mr. George Robitaille)

- Comments to be captured and included in minutes along w/ presentation to be made available.
- Final comments?
    - We need to include where we are going, where we have come from, where we have gone, etc.
    - Please provide captions on all figures, photographs, graphs, etc.