ARMY
Environmental Quality Technology

OASA (ALT) OASA (I&E)

The Army Environmental Quality Technology Program A(1.6.a) UXO Screening, Detection, and Discrimination Management Plan

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 2002

1. *Description*

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

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

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

1.1 Background:

A preliminary survey, found in the 2001 UXO Report to Congress (Ref. 1), estimates that over 2,000 closed, transferring, or transferred ranges, encompassing 8 to 11 million acres of land, may require a UXO response. A mixture of political, regulatory, and budgetary drivers forces the need to improve the Army's ability to remediate UXO sites. Accurate and efficient site characterization is the precursor to cost effective risk assessment and remediation for UXO contaminated sites.

The traditionally accepted technology for characterizing UXO containing sites and locating buried UXO employs an operator using magnetometers, gradiometers or metal detectors to manually identify anomalies. The operator places a flag at the suspected location for future excavation. The process is generally referred to as "mag and flag". While highly trained and experienced operators can in many cases detect a high percentage of the buried ferrous

ordnance using this technique, "mag and flag" has demonstrated minimal discrimination capability (ability to separate UXO from non-hazardous metallic and geologic clutter).

In the past five years, the DoD has led the industry in transitioning from predominantly "mag & flag" to the use of digital geophysics. Today, approximately three-fourths of all UXO project work is performed using digital geophysical approaches. However, current digital geophysical equipment and analysis methods, as applied to the detection, identification, and discrimination of UXO, remain technically immature. Current UXO remediation efforts indicate that more than 95% of the excavated objects are found to be non-hazardous materials, generally referred to as "false alarms." For example, of nearly 3 million anomalies excavated at the former Fort Ord using a combination of mag & flag & digital geophysics, only about 1.7% were UXO items. (*US Army Engineering District, Sacramento. Pre-Publication Data, 29 Aug 2001*). The result is that most of the costs to remediate a UXO site are spent on excavating these false alarms. Advanced sensing and analysis technologies are urgently needed to rapidly, safely, and cost-effectively characterize the large numbers of potential UXO sites.

1.2 Other UXO-Related Concerns:

Other related Army needs are associated with the routine maintenance and management of active and inactive ranges, the characterization and remediation of shallow underwater sites and of other constituent releases at active, inactive, closed, transferring, or transferred ranges. Although the RDT&E efforts outlined in this ETMP do not directly address these issues, the products and data from this program may be used and leveraged to support these areas in the future.

1.3 Current Cost of UXO Remediation:

Estimating the total cost of remediating UXO contaminated areas within the U.S. has proven to be problematic. Estimates by various DoD agencies have placed the cost as high as $391 billion in current year dollars. A recently completed DoD analysis of the cost of remediating UXO at closed, transferred and transferring ranges states that "based on a variety of factors, DoD estimates the potential UXO response costs associated with ranges that are closed, transferring from DoD control, or already transferred from DoD control to lie between $12B to $84B" (2001 UXO Report to Congress - Ref. 1). Much of the difficulty in determining program cost arises from the fact that no one knows how much of the property currently or formerly controlled by DoD actually contains UXO. It should be noted that this estimate does not include routine maintenance and UXO response actions associated with active ranges, UXO remediation of underwater ranges and former battlefields, and removal of potential toxicological risks associated other UXO other constituents (UXO(C) in the soil and groundwater.

In general terms, current remediation approaches commonly cost between $5,000 and $8,000/acre to clean up a UXO contaminated site (Personal Communication with Mr. Roger Young, U.S. Army Corps of Engineers, Huntsville Engineering and Support Center (CEHNC). The cost can be an order of magnitude higher on highly contaminated or geologically complex sites.

2. ***Objective:***

2.1 Purpose and Goal:

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

FY02 Objectives:

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

FY03 Objectives:

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

FY04 Objectives:

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

FY05 Objectives:

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

Specific technical goals of this program include:

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

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

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

2.2 Technical Concept:

The technical approach consists of quantifying the effects of the environment, geology, and manmade non-UXO objects (clutter) on candidate UXO detection, discrimination, identification, and location approaches and developing and demonstrating technologies to mitigate these effects. Laboratory and field measurements will be conducted to quantify and model electromagnetic, magnetic, and ground penetrating radar signatures emanating from UXO and non-UXO targets under a variety of environmental and geophysical conditions. In addition, after completion of preliminary investigations being conducted by SERDP, acoustic and seismic phenomenologies may be further evaluated and modeled to develop and demonstrate their potential contribution to a UXO multisensor system. The database of information collected, together with validated models, will be used to design and validate multi-signature detection algorithms, data fusion, and other analysis techniques. Sensitivity analyses conducted with these algorithms will provide specifications of sensor selection, detection survey and sampling procedures, and signature analyses based on site-specific environmental and geologic conditions.

An improved understanding of the physics, phenomenology, and signature characteristics of non-contact sensing capabilities will be investigated relevant to the detection of UXO and the discrimination of these targets from non-hazardous natural and man-made objects. Technologies will include: time and frequency domain EMI, high resolution, fully-polarimetric GPR, magnetometers/gradiometers, seismic and acoustic sensors, multisensor fusion, automatic target recognition algorithms, and high accuracy navigation and tracking systems. Advanced signal/image processing algorithms and multisensor fusion techniques will be developed to support expert system or neural network applications (algorithm development) as well as automatic target recognition methods. Prototype sensing and analysis systems, integrated with high-accuracy tracking systems, and evaluated with a variety of platforms (man-portable, vehicular, and hand-held) under controlled target/background conditions and demonstrated at live UXO remediation sites.

2.3 Technology Demonstration Concept:

The technologies developed under this program will initially be demonstrated/validated at the well characterized, Standardized UXO Technology Demonstration Sites currently being established by the Army Environmental Center (AEC), the Aberdeen Test Center (ATC), and the Engineer Research and Development Center (ERDC) under ESTCP sponsorship. These test sites will provide standard test targets in a wide range of environmental/geophysical/clutter conditions to allow scientifically valid methods of determining performance gains of emerging technologies compared to currently available methods. Performance gains will be documented by means of metrics that define each system's Pd vs. false alarm rates, discrimination efficiency, production rates, and estimated costs. Technologies that demonstrate acceptable performance will be demonstrated at actual live UXO remediation sites as part of BA4 Dem/Val and Technology Certification programs.

3. *Need, Significance, and Opportunities:*

3.1 Army Need:

The Army need is based upon the Army AERTA requirement A (1.6.a): UXO Screening, Detection and Discrimination. The detection and clearing of UXO in closed, transferring, and transferred ranges, burning and open detonation areas, and Formerly Used Defense Sites (FUDS) is the Army's highest priority Environmental Restoration requirement. It is estimated that there are currently over 11 million acres in the U.S. that may contain UXO. This includes approximately 763 FUDS sites which must be cleared of UXO for civilian use and 23 Base Realignment and Closure (BRAC) installations which must be cleared of UXO for reuse or must be retained by the Army with restricted access. The characterization and remediation of these sites using currently available technology is prohibitively expensive and hazardous mainly due to the extraordinarily high level of false detections as well as the inability to achieve 100% probability of detection (Pd). Currently, there are normally fewer than 5 UXO targets verified for each 100 indicated UXO detections. New technologies to accurately locate, identify, and characterize UXO at the above sites are urgently needed. Though these issues at these sites are not specifically related to Combat Operations, the US Army Engineer School has recognized the criticality of this problem and has codified it in its Future Operational Capabilities.

The Army will provide integrated multi-sensor systems specifications for specific UXO detection and discrimination applications based on site-specific characteristics of the environment and geophysical conditions. They will develop guide specifications for the conduct of detection surveys using computer assisted guidelines based upon developed models and algorithms. A comprehensive technical data package will be provided containing UXO sensor response (signatures) in a variety of well documented environments.

3.2 Military Significance and Benefits:

The principal objective of this technology effort is to produce more cost effective processes and procedures for detection and discrimination of UXO at Army and other DoD sites. Currently available technologies are inadequate to meet the Army’s needs and the required technologies are not being developed by the commercial sector. Even though almost all UXO remediation is done by contract to the commercial sector, that community does not have the resources and capability to evolve the sophisticated technology required. The projected 90% reduction of the number of false alarms will reduce the cost and the time required to remediate UXO contaminated sites to at least one-third of its current values. The demonstrated detection and discrimination capability for the full range of UXO types to their most probable maximum site dependent penetration depths will enhance acceptance by regulators and local stakeholders and will expedite the transition of closed, transferred and transferring ranges to productive use by the civilian sector.

3.3. Horizontal Technology Integration (HTI) Opportunities:

Horizontal Technology Integration (HTI) opportunities are estimated to be high because technologies developed under this program will readily support requirements in the other four UXO Clearance Mission Areas: Combat Countermine, Humanitarian Demining, Explosive Ordnance Disposal, and Active Range Clearance

4. ***Execution Plan:***

4.1 Exit Criteria:

The systems that are developed must meet realistic performance metrics. To meet all of the user requirements, the systems developed will have 100% detection over all terrains with very limited false alarms. This is not a technically feasible goal for the foreseeable future. Therefore a series of threshold and objective requirements will be established to demonstrate a leap ahead in the capabilities and performance over current technologies.

Metrics that will be used to evaluate this program's progress include Probability of Detection (Pd), Probability of False Alarm (Pfa), False Alarm Rates (FAR), Receiver Operating Characteristic (ROC) curves that define the systems' Pd as a function of Pfa (or FAR), Probability of Discrimination, Discrimination Efficiency, Identification Accuracy, Location Accuracy, Production Rate (Hectares per hour) and Operating Costs. These metrics have been jointly developed by ESTCP, AEC, ERDC, ATC, Joint UXO Coordinating Office (JUXOCO), and the Institute for Defense Analyses (IDA) personnel as part of the Standardized UXO Technology Demonstration Sites Program. The programmatic performance metrics are based on testing to be conducted at the Standardized UXO Technology Demonstration Sites. This was a deliberate decision based on the need for absolute levels for exit criteria. The only means of repeatable testing and to have realistic test scenarios is to use the standardized sites because of the known ground truth and the stability of the sites. Demonstrating the technologies at live sites will complement results from the standardized sites. Demonstrations at live sites will guarantee that there is a correlation between the technologies capabilities at the live sites and the standardized sites.

Milestones and Metrics

Programmatic Exit Criteria – Ground Based Systems

Metric	Threshold	Objective
Detection	95% Ordnance Items At Standardized Site Detected	98% Ordnance Items At Standardized Site Detected
Discrimination	Rejection Rate of 75% of emplaced non–UXO clutter at Standardized Site with a maximum false negative rate of 5%	Rejection Rate of 90% of emplaced non–UXO Clutter Items at Standardized Site with a maximum false negative rate of 0.5%
Reacquisition	Reacquire within 0.25 meters	Reacquire within 0.1 meters
Cost Rates	$4,000 per acre based on Standardized Site Open Field	$2,000 per acre based on Standardized Site Open Field
Accessibility – Platform	Ability to operate in All Standardized Site Scenarios	Unhindered Access to All Scenarios encountered at Live Sites
Production Rate	5 acres per day	50 acres per day

Programmatic Performance Metrics – Shallow Water Systems

Metric	Threshold	Objective
Detection	80% Ordnance Items Buried to One Foot and under 8 Feet Water at Standardized Site Detected	95% Ordnance Items Buried to Four Feet and under 8 Feet Water at Standardized Site Detected
Discrimination	Rejection Rate of 50% of emplaced non–UXO clutter at Standardized Site with a maximum false negative rate of 10%	Rejection Rate of 90% of emplaced non–UXO clutter at Standardized Site with a maximum false negative rate of 0.5%
Reacquisition	Reacquire within 1 meter	Reacquire within 0.5 meters
Cost Rate	$4,000 per acre	$2,000 per acre
Production Rate	5 Acres per day	50 Acres per day

4.2 Proposed Program by Fiscal Year (FY) with Major Milestones:

The proposed program is described in Appendix B and detailed work unit execution plans are included in Appendix C.

4.3 Funding Required:

Funding by Budget Activity and Program Element is as follows:

	Army UXO Program Funding ($K)				
BA/PE/Project	FY02	FY03	FY04	FY05	Total
BA2/622720A/AF25	1902	2044	0	0	3946
BA3/633728A/D03E	0	2129	908	0	3037
BA3/643779/D035	1000	0	0	0	1000
BA4/63779A/D04E	2631	4274	5457	3344	15706
BA6/65857A/M06E	0	106	110	112	328
Total	5533	8553	6475	3456	24017

4.4 Technology Maturity:

Current technology maturity ranges from TRL 1 to TRL 3 (Appendix E). This program is designed to mature all technologies from BA2 through BA6 although technologies can be inserted at any point of the process. Several technologies will be developed and fielded during this effort. In general, technologies will be matured to TRL 5 through TRL 7.

4.5 Leveraging:

The technology efforts conducted under this focused program are linked and leveraged through programs managed and conducted under the Cleanup Technology Thrust Area Working Group of SERDP and ESTCP. This program may also leverages technology developments in the Small Business Innovative Research (SBIR) Program, the Multi-University Research Initiatives (MURI), and the other UXO mission areas (Explosive Ordnance Disposal, Humanitarian Demining, Countermine, and Active Range Clearance).

A number of SERDP funded UXO technology development efforts are expected to transition to the Army's program for further development, evaluation and field demonstration. Examples of such projects are the EMI sensor development efforts and advanced radar and EMI modeling and measurement capabilities under SERDP and ESTCP programs. These advances will be integrated into the Army program.

4.6 Risk Management and Mitigation:

4.6.1 Execution Risk:

There is a high risk of meeting the exit criteria posed by AERTA Restoration Requirement A (1.6.a). Many of the technology attributes desired by the user are simply technologically infeasible in the near term. The RDT&E and User Communities are jointly developing an EQT-ORD to ensure that technologies and products developed in accordance with this ETMP are suitable for deployment and meet user requirements. Overall, there is a medium risk of not

meeting all of the technical objectives of this work effort for the full range of site conditions and exit criteria identified in the EQT-ORD. Under certain environmental, geophysical, and manmade clutter conditions, signatures from some types of UXO may be too weak for reliable detection due to the attenuation of the signature below detectable levels and/or background contamination that may mask the target signatures. There is medium to high risk that, in spite of significantly improved sensing and analysis capabilities, the signatures of some man-made metallic clutter items may overlap those of specific types of UXO so that discrimination goals may not be fully met. In order to meet Army user requirements, significant technical breakthroughs in sensing, analysis, and positioning technologies will be required; there is a medium risk that these breakthroughs will not be achieved within the planned program schedule.

However, because of the high cost of UXO site remediation, even incremental technological advancements accruing under this program have the potential to result in substantial cost avoidance for the Army.

4.6.2 Transition Risk:

The Army almost exclusively uses private contractors to conduct UXO site remediation. There is a low transition risk that private industry will not support the specialized production of the advanced, complex sensor systems that result from this technology development and demonstration effort. There is a medium risk that the improved performance of advanced sensing, analysis and positioning technologies developed under this program will fail to meet requirements of federal, state, and local regulators; landowners; land managers; and other stakeholders.

4.6.3 Financial and Schedule Risk:

Financial and scheduling risks are considered minimal since all of the Army performers have extensive experience in this area, they have successfully completed similar efforts and have previously collaborated together and with other DoD, industry, and academic partners in major UXO-related Science and Technology (S&T) and Test and Evaluation (T&E) projects. The risks associated with the planned demonstration schedules are minimal since they have been prearranged with the ESTCP-sponsored Standardized UXO Technology Demonstration Sites Program currently being executed by AEC, ERDC, and ATC. In addition, the US Army Corps of Engineers (USACE) is the DoD Executive Agent for UXO remediation on FUDS and the DoD site managers, working with the site owners, will work to ensure that these installations are available for live site demonstrations of advanced UXO systems developed under this program.

4.6.4 Risk Mitigation:

Technologies will be evaluated and refined through a step-by-step scaled process of bench-scale, pilot scale, controlled field scale, and full-scale field demonstrations. The program also contains enough flexibility to allow entry into appropriate stages of the scaled process

depending on the technologies maturity. Decision points will be established at major milestones during technology development. A DoD Coordination Group will be established to provide input to efforts undertaken by this program. Coordination will begin with an initial kickoff meeting and annual In Process Reviews (IPR) through the life of the program. The panel will consist of members of the DoD's UXO technical and policy communities as well as pertinent representatives as needed. The Coordination Group will be co-chaired by representatives from the ERDC and AEC who will jointly make all final determinations.

To address industry concerns, the DoD is developing a UXO Remediation Program Build to ensure that there is sufficient long term funding to justify investing in advanced technologies and civilian operator training required to meet program goals. In order to mitigate the regulatory transition risks, this program will involve representatives from industry and the regulatory community in planned technology workshops and field demonstrations. The Product Delivery Team (PDT) will conduct outreach programs to involve industry and regulators in this development and demonstration program and to address their concerns and incorporate their recommendations as early as possible in the system design and development process.

4.7 Warfighter Participation:

While this program addresses non-warfighter requirements, a number of the sensing, analysis, positioning, and visualization technologies developed under this program will support warfighter needs in the Combat Countermine, Explosives Ordnance Disposal, and Active Range Clearance mission areas. The PDT routinely interacts with researchers and managers in these other mission areas and share technical data and results via numerous joint conferences such as the annual UXO/Countermine Conference, SPIE conferences, and meetings organized by the JUXOCO, the Army's Night Vision and Electronic Sensors Directorate, and the Army Research Office. Significant technical accomplishments and data derived from this program will be widely disseminated to the warfighter community via these interactions and by regular posting of technical reports and papers on the JUXOCO website.

4.8 Principal Performers and Roles

The efforts described by this ETMP will be executed by a PDT that includes the following members: ERDC, AEC, and CEHNC. The PDT will be co-chaired by representatives from the ERDC and the AEC. The Environmental Technology Integrated Process Team (ETIPT) will provide general oversight and dispute resolution.

The ERDC will have lead responsibility for the S&T (BA1-BA3). The AEC will have lead responsibility for the T&E (BA4-BA6). One person will manage the S&T effort. Another will serve as the S&T Focus Area Manager. One person will manage the T&E effort. And another will serve as the T&E Focus Area Manager.

A DoD Coordination Group will be established to provide advise and counsel on the inter-relationships of the Army's efforts and ongoing RDT&E of the DoD and the other Services. Coordinating Group Members will include: the S&T and T&E Managers; the S&T and T&E

Focus Area Managers; a representative from the CEHNC; a representative from the SERDP/ESTCP; a representative of the JUXOCO; and a representative from the other Services.

4.9 Logistics Implications:

Since the technologies developed under this program will be transitioned to private industry (via CRADA and/or licensing agreements), and implemented by private companies under contract to the Army, there are no logistics implications associated with this technology development and demonstration program.

4.10 Identify Contracting Needs:

A variety of UXO technology developers and academia will be necessary for the successful implementation of this program. A variety of contracting techniques and methods will be applied to get the best value for the program. Examples of mechanisms this program could utilize include research and development contracts via the ERDC Broad Agency Announcement (BAA) as needed or in partnership with SERDP and ESTCP contractors.

5. ***Sponsorship/Endorsement:***

The Ordnance and Explosives Mandatory Center of Expertise (MCX) and Design Center, CEHNC, has responsibility for UXO remediation of Army's CTT ranges and has extensive experience in adapting innovative technologies for UXO cleanup operations.

Endorsing Organizations and POCs include:

U.S. Army Engineer School: Director of Combat Developments
ACSIM: SFIM-AEC-ERA; Tel: 410-436-3921; Fax: 410-436-1548;
CEHNC: CEHNC-ED-SY; Tel: 256-895-1629; Fax: 205-895-1737;
USACE: Director of R&D, HQ, USACE

6. ***Transition Plan Summary:***

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. All technologies will be made available to private industry without restriction, via licensing agreements, and/or cooperative agreements where appropriate.

The products from this program will be transitioned in the form of technical data packages; system specifications; methodologies, procedures, and protocols; and/or system prototypes. Products will be transitioned at the earliest possible time to the end user, including, but not limited to: CEHNC; USACE Ordnance and Explosives Mandatory Center of Expertise (MCX) and Design Center; the AEC; USACE Districts; MACOMS; installations; the other Services; and other stakeholders, e.g., federal, state, and local regulators; landowners; and land managers.

Data packages and specifications generally include guides, criteria, and specifications on the use and application of the specified UXO detection, discrimination, and classification technologies. Technical data and significant findings applicable for use in other UXO mission areas will be shared with the JUXOCO. Special emphasis will be placed on sharing knowledge and findings relative to mine/countermine technology development with the US Army Night Vision and Electronics Sensors Directorate.

The technology transfer process will be accelerated by presenting interim and results at briefings, conferences, and symposia; publication of peer reviewed engineering and scientific papers; and preparation of technical reports, technical notes, and trade publication. 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.

7. *Relationship to Other Service or Agency Programs::*

The Army EQT UXO-ER program is fully coordinated with related efforts being conducted by SERDP and ESTCP, AEC, MURI on Humanitarian Demining, the Night Vision and Electronic Sensors Directorate (NVESD) Countermine Program, and the Naval Explosive Ordnance Technology Division's UXO programs.

The technologies produced under this program directly support environmental restoration programs conducted by the U.S. Army Office of the Director of Environmental Programs (ODEP), the USACE Director of Military Programs (CEMP-M), the USACE Ordnance and Explosives MCX and Design Center, and coordinated through the DoD UXO Center of Excellence (UXOCOE).

This Program is coordinated with the JUXOCO as part of the DoD UXOCOE to ensure this research supports and complements the total UXO program. The work within this Environmental Quality (EQ) program directly supports the UXO Environmental Remediation and Active Range Clearance mission areas. Related requirements in combat development efforts in the Explosive Ordnance Disposal, Humanitarian Demining, and Countermine mission areas are mutually supported where applicable. Technology development for UXO Environmental Remediation focuses mostly on deeply buried ferrous objects while Combat Development efforts have specific interest on small, low-metal content and non-ferrous objects at the surface or at relatively shallow depths. Also, equipment developed for use in combat operations must be rugged, lightweight, and to military combat standards, while EQ UXO equipment are used by commercial contractors and do not require the same robust construction and size/weight/power restrictions. Common to all of these UXO mission areas are requirements for sensor signature data, data fusion methodologies, and site environmental/geophysical characterization/mitigation.
This program supports the Cleanup Sub-Subarea of the Environmental Quality Subarea of the Materials and Processes Technology Area of the *DTAP* and represents the Army submission for

the detection of unexploded ordnance for the *DTO*: MP 18.06: Cleanup of Contaminants. Sensor signature data, data fusion methodologies, and site environmental/geophysical characteristics support work under Army STOs B III.M.08: Vehicular Mounted Mine Detector ATD; III.M.09: Mine Hunter/Killer (Proposed ATD); III.M.10: Advanced Mine Detection Sensors; and III.M.11: Lightweight, Airborne Multi-Spectral Countermine Detection System and the numerous DTOs under the JWSTP Category: Force Projection and Dominant Maneuver including: G-11: Advanced Mine Detection Sensors and G-14: Automatic/Aided Technology for UXO Detection for UXO Clearance. It supports the Army Future Operational Capability *FOC* statements: EN97-009: Operate Freely in a Mine/Unexploded Ordnance Threat Environment; TR97-041: Operations in an Unexploded Ordnance (UXO)/Mine Threat Environment; CM97-015: Environmental Stewardship; and EN 97-027: Environmental Stewardship

8. *Quad Chart:*

Quad Chart is attached as Appendix F.

_____	_____
Focus Are Manager, S&T Date	Focus Area Manager, T&E Date
_____	_____
Co-Chair, Restoration Technology Team	Co-Chair, Restoration Technology Team

Approval:
FOR THE ETTC

_____	_____
Co-Chair, ETIPT	Date
_____	_____
Co-Chair, ETIPT	Date

APPENDIX A

References

1. UXO Response Estimated Costs and Technology Investments – A Report to the Congressional Defense Committees, March 2001

2. Report of the Defense Science Board Task *Force Active Range UXO Clearance, and Explosive Ordnance Disposal Programs*. April 1998.

3. Committee on Armed Services, United States Senate, Report 106-50, National Defense Authorization Act for Fiscal Year 2000, May 17, 1999. Research and Development to Support UXO Clearance, Active Range UXO Clearance, and Explosive Ordnance Disposal.

3. Defense Environmental Restoration Program Annual Report to Congress, FY 1999.

5. UXO Center of Excellence Annual Report for 1999, JUXOCO, 5 April 2000.

APPENDIX B

1. Management Plan:

This RDT&E effort described by the ETMP will be managed and executed using a PDT concept. The PDT will be co-chaired by representatives from the ERDC and the AEC. The ETIPT will provide general oversight and dispute resolution. The PDT will include: ERDC, AEC, and CEHNC. The ERDC will have lead responsibility for the S&T (BA1-BA3). The AEC will have lead responsibility for the T&E (BA4-BA6). The RDT&E will be executed by in-house personnel from the ERDC, the CEHNC, and the AEC; other government organizations; academic institutions; and contractors, as necessary to ensure efficient and cost effective completion of the planned work effort. Technologies will be demonstrated at standardized and live demonstration sites to direct future development efforts, document performance and production rates, validate cost/benefit analyses and support risk assessment efforts.

2. Description of Technologies:

This section describes the technologies to be developed, demonstrated, and implemented under this ETMP. Individual work units, principal investigators, products, and funding requirements are included. The expanding nature and rapid developments in the UXO community requires a certain amount of flexibility to adjust and capitalize on new developments. The program builds on the best technologies and approaches currently available. The PDT will use the DoD Coordination Group to help identify opportunities to capitalize on future emerging technologies. Changes to this ETMP require joint approval of the Programs S&T and T&E Managers.

2.1. Background

During 1QFY01, representatives from the USACE (ERDC, CEHNC, and Sacramento District), AEC, SERDP, ESTCP, and JUXOCO participated in a workshop (Appendix D) aimed at developing this management plan. This document summarizes the major thrust areas, work units, and performers required to execute an integrated Army UXO research development and demonstration program that meets user requirements and is fully coordinated with other ongoing UXO Environmental Remediation programs. Quarterly In-Process Review meetings will be conducted and representatives from the above-listed organizations will be invited to participate. This management plan will be reviewed and updated, if required, annually. The plan is divided into BA2/BA3, BA4, and BA6 thrusts as described in the following paragraphs.

2.2. BA2/3 Thrusts

Funding ($M):	**FY02**	**FY03**	**FY04**
	2.902	4.173	0.908

Four Major Thrust Areas:

I. Site Characterization Issues and Approach Strategy

a. Expedient approaches for assessing key geophysical and environmental site parameters—magnitudes and spatial heterogeneity and scale
b. Sensor/method/system site specific selection guidelines—expert system

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

II. Modeling, Analyses, and Processing

a. UXO models, modeling, and inversion
b. Signature definition and resolution issues
c. Data Acquisition/Data Analysis System (DAQ/DAS) development
d. Complete chemical sensor development.

Rationale: Survey and assimilate all available UXO models and modeling efforts. Assess strengths, weaknesses, and gaps. Develop comprehensive suite of forward and inverse (single, constrained, and joint) modeling tools for total field magnetic (TFM), time-domain electromagnetic induction (TDEM), and frequency-domain electromagnetic induction (FDEM) datasets. Examine signature definition and resolution issues for detection and discrimination with various sensor types and configurations. Develop comprehensive DAQ/DAS protocols. Assess available software, e.g., MTADS DAS, U-Hunter, etc., for overall functionality: versatile georeferencing capability; anomaly picking and display; capability for versatile analysis tools, e.g., thresholding, simple analytical/empirical anomaly assessment, and model-based inversion modules; GIS-type display and query, etc. Select and enhance or develop modular and adaptable DAQ/DAS software for fielded capability. The EQT-funded chemical sensor development effort has advanced the fundamental knowledge of the compounds and concentrations associated with the chemical signatures of buried

UXO, and has established processes and metrics that support advanced sensor development. This program will fund the S&T portion of this effort to completion, and will transition this technology to agencies conducting advanced chemical sensor development and demonstration research to address the UXO discrimination problem. This effort will also support follow-on development of sensors to address the requirement for identifying and remediating the environmental problems associated with the releases of other UXO constituents.

III. Sensor Design and Enhancement

a. Space-Frequency surveying and sensor configuration considerations
b. Enhanced and dual-mode sensors
c. Systems issues—positioning, tiltmeters, altimeters, etc.

Rationale: Optimal sensor and survey geometry for buried object "illumination" will be investigated for enhanced detection and discrimination. Requirement or desirability of total field versus gradient information will be assessed. Enhanced sensors will be developed to improve Signal to Noise Ratio (SNR), data throughput, data fidelity, and integrated navigation/positioning. New sensor designs investigated previously, as part of BA1 efforts will be matured as appropriate. Feasibility of dual mode sensors will be assessed, e.g., dual TDEM/FDEM, dual TFM/EM. Key system issues such as versatile navigation/positioning options, from RTK differential GPS to acoustic to radio wave to laser reflectometer, platform stability, sensor standoff (interference) issues, etc., will be investigated. Platform stability issues include variable height above surface and variable tilt and associated requirements for corrections for positions and sensor readings.

IV. Hand Held UXO Detector Design Thrust Oversight

a. Workshops: User Group and Expert Group
b. Umbrella oversight of work in previous thrusts leading to design and ultimate implementation under BA4 of advanced handheld UXO detector prototype

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

Two workshops will be held: (1) a wide range of users to define the "ideal" or near-ideal system capability and operational constraints; (2) a panel of "experts" to brainstorm and define key design and implementation issues.

This thrust to design a hand-held UXO detector system will be managed as an umbrella oversight function of the above three thrusts to insure arrival at a prototype design to

hand off to BA4 by the end of FY03, for prototype completion by the end of FY04, with subsequent field demonstration in FY05.

Key Products:

Thrust I: Guidelines, Expert System
Thrust II: Forward and Inverse Modeling Capability; DAQ/DAS for systems
Thrust III: New/enhanced sensor designs and configurations; Dual-mode sensors; Integrated, adaptable navigation capability; Sensor/platform adaptations to rugged terrain, vegetated terrain
Thrust IV: New hand-held UXO detector prototype design

2.3 BA4 Thrusts

Funding ($M):	**FY02**	**FY03**	**FY04**	**FY05**
	2.631	4.274	5.457	3.44

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

Required BA4 activities fall into the following Thrust areas:

Thrust I. Standardized Sites

a. Standardized UXO Technology Demonstration Site Support
b. Wide Area Survey Standardized Technology Demonstration Site
c. Establishment of Active Response Demonstration Areas

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

Thrust II. UXO Technology Demonstrations

a. Hand Held UXO Detector Design Demonstration and Validation
b. Baseline Handheld/Man Portable System Performance
c. Standardized UXO Technology Demonstration 2005
d. Sensor/Platform Integration and Demonstration
e. Demonstrate UXO Detection Systems in Shallow Water
f. Demonstration of Fill Identification Technologies

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

Thrust III. Hardware/Software Integration

a. Software Demonstration/Validation Assessment
b. Modeling Analyses and Processing Demonstration/Validation
c. MAUDE Demonstration Validation

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

Thrust IV. Geophysical QA/QC

a. Standardized Guidance for Geophysical Prove Outs
b. QC for UXO Sensor Technology Operators

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

Thrust V. Technology Transfer

a. Technology Transfer Support
b. Technology Review and Knowledge Exchange Seminar

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

2.4 BA6 Thrusts

Funding ($M):	**FY02**	**FY03**	**FY04**	**FY05**
	0.0	0.106	0.110	0.112

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

3. Integration with DoD UXO-ER Program:

The Army UXO program detailed above has been designed to complement the DoD Program without duplication of effort. The development of the Army UXO program was fully coordinated with the major DoD UXO managers and performers (See Appendix D) and with the JUXOCO. This section describes how the Army UXO-ER program fits with the overall DoD Technology Objectives and Investment Strategy that was documented in the 2001 UXO Report to Congress.

3.1 DoD Technology Objectives

Figures B.1 to B.4 were taken from the 2001 UXO Report to Congress (Ref. 1) and provide a brief synopsis of the DoD-wide investment areas describing the objectives, needs, benefits, system requirements, plan for future actions, and technology roadmap. The integration of the Army UXO program into the DoD objectives is shown in the highlighted portions.

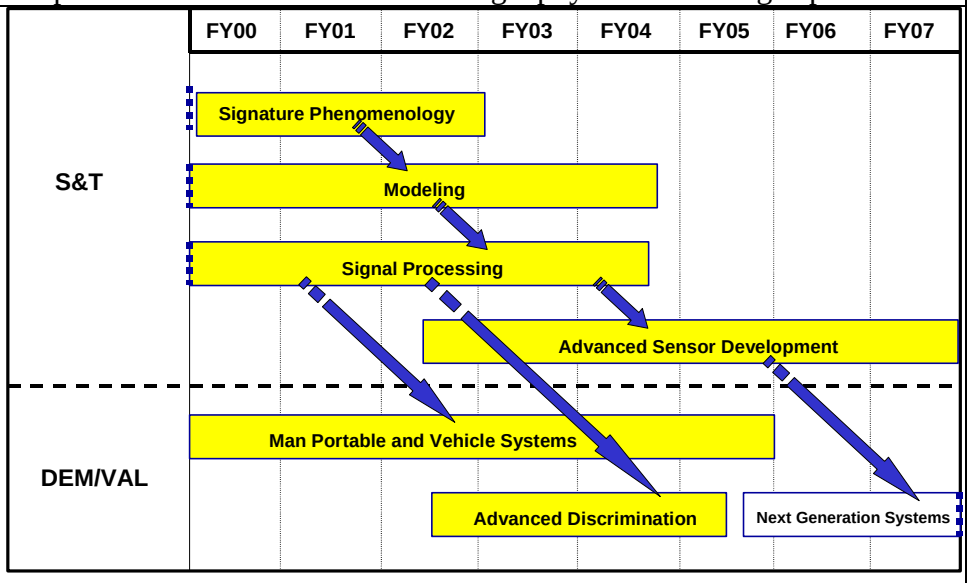
Figure B1: Production Ground Survey	
Objective	▪ Improve existing and/or develop new capabilities for detailed site characterization
Need	▪ Systems to accurately detect individual UXO and discriminate UXO from non-hazardous items ▪ Creation of permanent, accurate geo-referenced data sets
Benefit	▪ Increasing system capabilities with respect to probability of detection and discrimination, coverage rates, and applicability to varying terrain and geology improves confidence in site characterization and may reduce costs
Required System Capabilities	▪ Ability to detect wide variety of UXO types, sizes, and shapes ▪ Operation in varying terrain, vegetative cover, and geology ▪ Arial coverage rates exceeding tens of acres per day (vehicle mounted) or acres per day (man portable) ▪ Detection of both surface and sub-surface UXO ▪ High resolution capability to locate individual UXO and discriminate from non-UXO items ▪ High probability of detection ▪ High discrimination capability to minimize false alarm rate
Future Plan	▪ Improving understanding of the phenomenology of sensor responses to UXO and clutter, advanced modeling, and signal processing ▪ Gather UXO and non-UXO signature data from a wide variety of sensors (e.g., EMI sensors, magnetometers, radar, acoustic sensors) ▪ Couple production ground survey sensors and signal processes and platform advances with advanced geophysical modeling capabilities
Investment Roadmap	

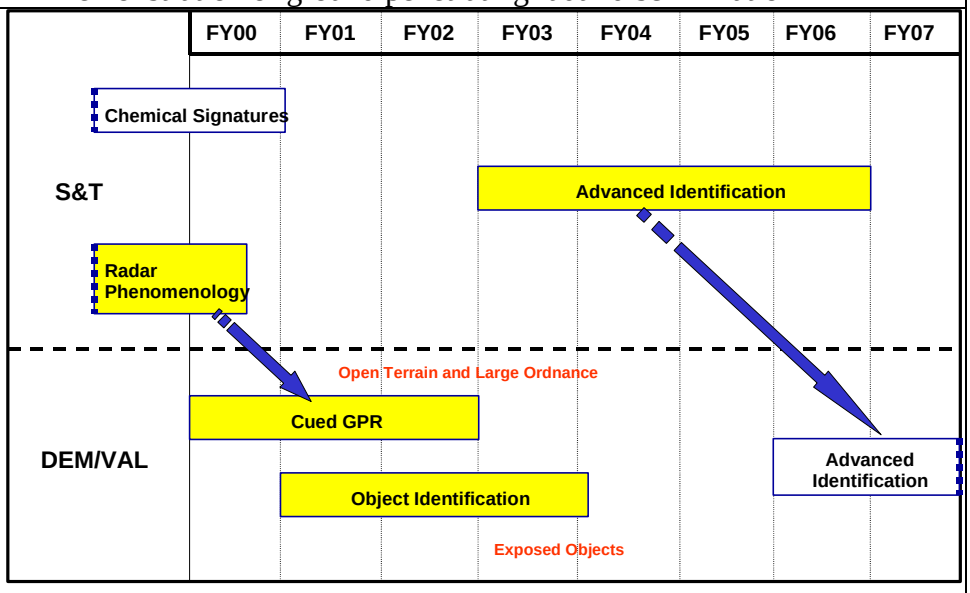
Figure B2: Cued Identification	
Objective	▪ Develop capabilities for non-intrusive, cost-effective cued object identification
Need	▪ Systems to determine whether ordnance objects pose explosive hazards ▪ Provide additional capability to characterize detected anomalies
Benefit	▪ Improves ability to assess explosive hazards ▪ Allows for refined analysis of alternatives to address UXO ▪ Offers opportunity to reducing unneeded excavation
Required System Capabilities	▪ No search capability is required as sensor is cued ▪ Throughput of tens to hundreds of objects per day ▪ Ability to interrogate sub-surface or partially exposed items ▪ Very high discrimination capability as high confidence is needed in determinations of "not ordnance" ▪ Ability to identify ordnance type (e.g., high explosive, pyrotechnic)
Future Plan	▪ Initial work conducted to investigate the trace chemical signature associated with a UXO was terminated because other systems have shown potential to identify the filler directly ▪ Demonstration of a variety of other cued identification techniques (e.g., neutron activation, acoustics) ▪ Development of next generation systems for partially exposed or sub-surface UXO ▪ Demonstration of ground penetrating radar discrimination
Investment Roadmap	

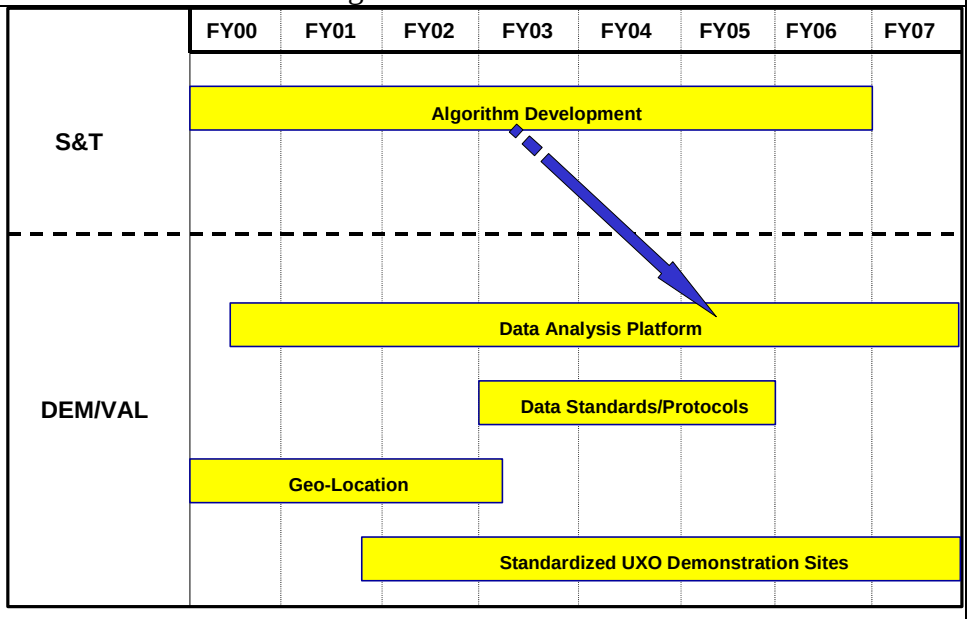
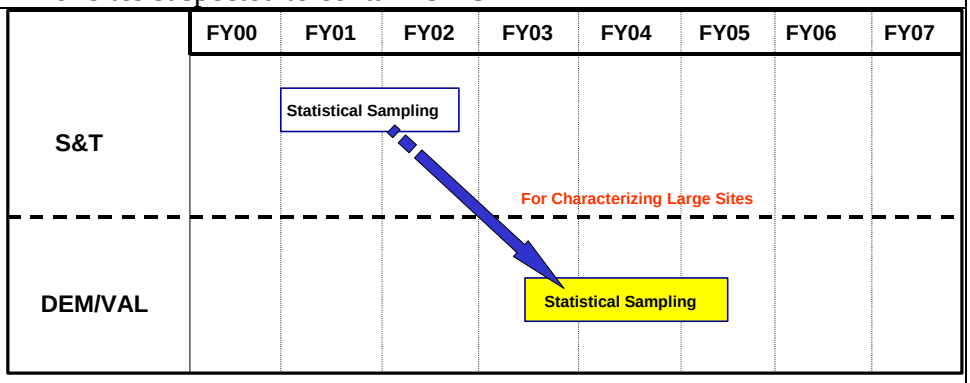
Figure B3: Standards and Protocols	
Objective	▪ To develop methods for collection and management of standardized, high quality archival data
Need	▪ Advances in supporting technologies and the development of technical standards and protocols to support subsequent analysis, actions, QA/QC, and review by stakeholders
Benefit	▪ Standardized data collection and management improves confidence in response activities, improves legal defensibility, allows for reevaluation, and improves ability to evaluate data over time
Required System Capabilities	▪ Must accommodate systems that operate in a variety of terrain and vegetation, using different navigation/geo-location systems ▪ Ensure collected data meets performance requirements ▪ Advanced cost-effective geo-location technologies that can operate in varying terrain and vegetation and provide for highly accurate registration of sensor data ▪ Standard software and visualization tools to assist stakeholder understanding of analyses and decisions ▪ Standards for data archiving ▪ Standardized technology test sites and protocols
Future Plan	▪ Improve geo-location technology for terrain where differential global positioning satellite (GPS) access is unavailable ▪ Transition data management standards and protocols to the "user" communities ▪ Continue effort to develop and transition standards, protocols, and software for data management
Investment Roadmap	

Figure B4: Hazard Assessment	
Objective	▪ To develop capabilities to assess and quantify explosives hazards
Need	▪ Systems to assess the hazards presented by UXO prior to, during, and after a response
Benefit	▪ The ability to quantify the hazards associated with UXO is a required component in making informed, defensible decisions
Required System Capabilities	▪ The ability to assess the hazard presented by UXO, its potential to migrate, and the effectiveness of potential management actions ▪ Statistically defensible procedures to assess sites through sub-sampling techniques that reflect the unique aspects of UXO and account for such factors as lateral and vertical distribution ▪ The ability to assess the potential for future exposure and effectiveness of potential response actions
Future Plan	▪ Development of tools to support the appropriate statistical sampling of sites suspected to contain UXO
Investment Roadmap	

APPENDIX C

EXECUTION PLANS FOR INDIVIDUAL WORK UNITS

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

I. Site Characterization Issues and Approach Strategy

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

TITLE: Identification and Evaluation of Key Site Parameters Impacting Technology

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

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

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

MILESTONES:

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

PRODUCTS:

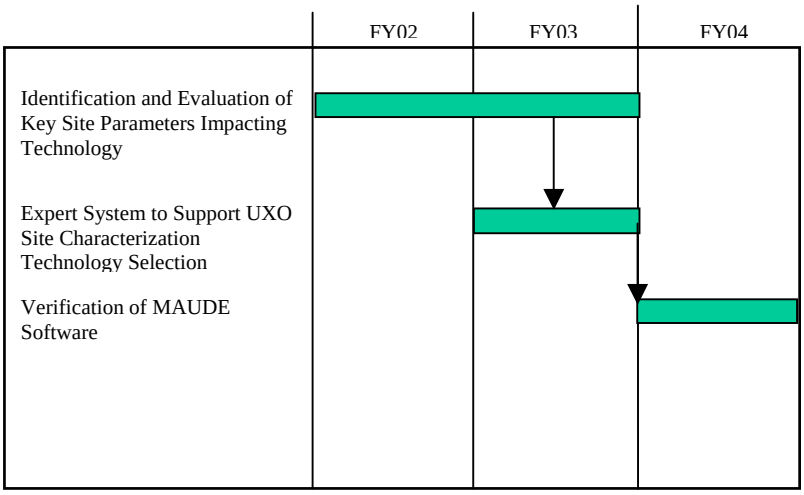
Product	Delivery Date
Guidelines for UXO detection survey planning	03/03

EXECUTION:

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

FUNDING:

	Fiscal Year ($K)	
	FY02	FY03
ERDC VBG	232	175


FY02
FY03
FY04
Identification and Evaluation of Key Site Parameters Impacting Technology
Expert System to Support UXO Site Characterization Technology Selection
Verification of MAUDE Software

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

TITLE: Expert System to Support UXO Site Characterization Technology Selection

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

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

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

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

MILESTONES:

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

PRODUCTS:

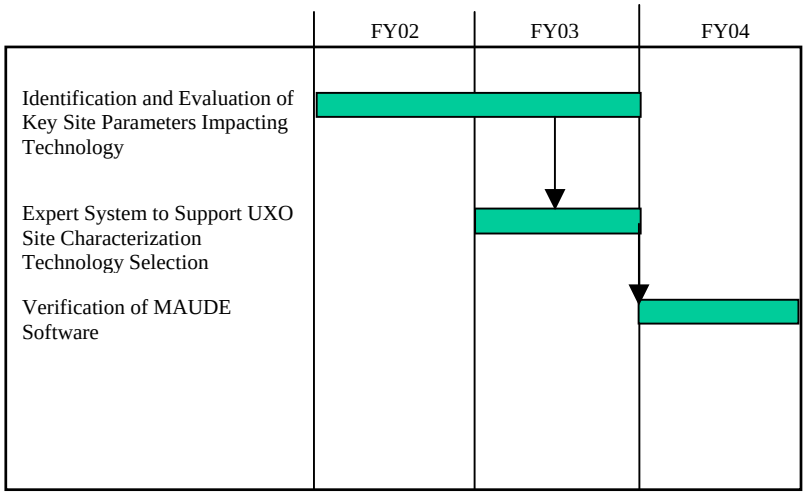
Product	Delivery Date
Management Aid for UXO Detection Efforts (Beta version)	4Q03

EXECUTION:

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

FUNDING:

	Fiscal Year ($K) FY03
ERDC VBG	250



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

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

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

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

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

MILESTONES:

Milestone	Scheduled Completion
Select first Standardized UXO Technology Demonstration Site and test MAUDE	1Q04
Select second Standardized UXO Technology Demonstration Site and test MAUDE	2Q04
Modify and improve MAUDE	3Q04

PRODUCTS:

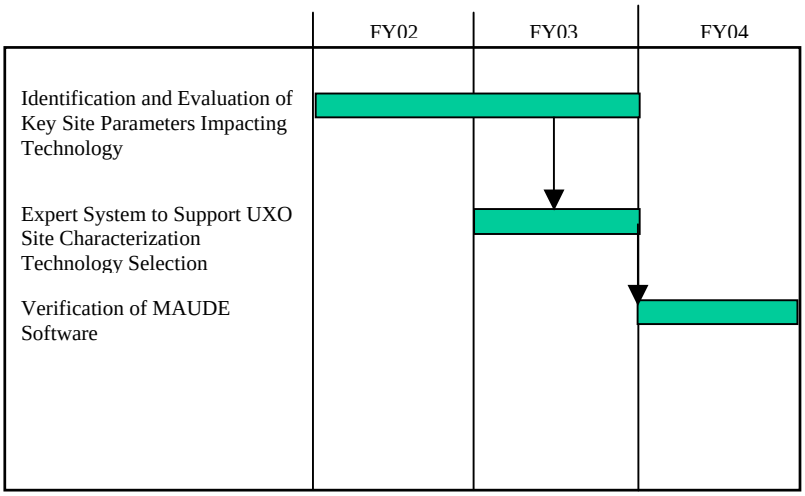
Product	Delivery Date
Enhanced and verified MAUDE software	03/04

EXECUTION:

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

FUNDING:

	Fiscal Year ($K) FY04
ERDC VBG	100



II. Modeling, Analyses, and Processing

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

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

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

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

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

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

MILESTONES:

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

PRODUCTS:

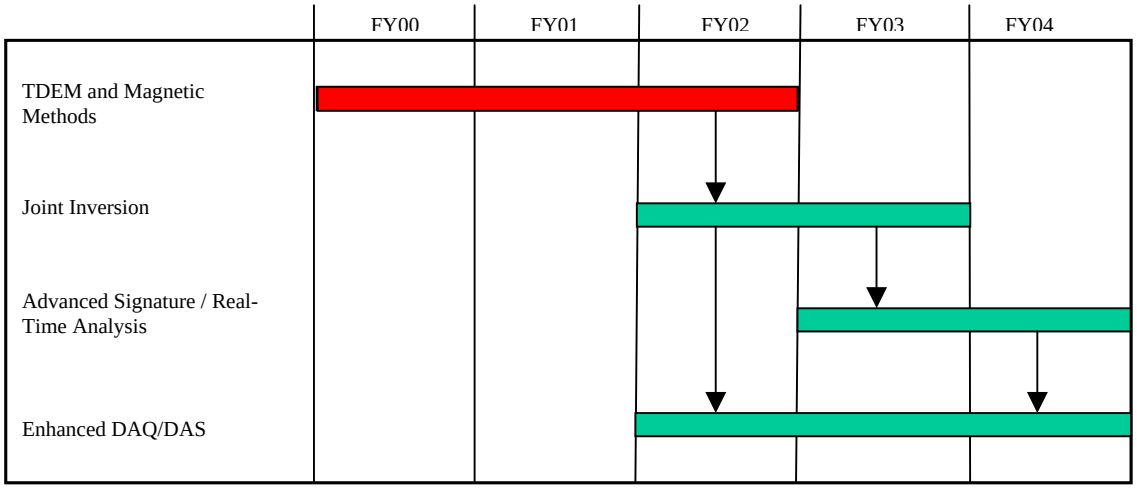
Product	Delivery Date
Documentation of phenomenological impacts of background on UXO detection and discrimination	09/30/99
Forward and inverse TDEM modeling capability	09/30/01
Forward and inverse magnetic modeling capability	09/30/02
Documentation of field performance of advanced geophysical technology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

EXECUTION:

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

FUNDING:

	Fiscal Year ($K)			
	FY99	FY00	FY01	FY02
ERDC VBG	280	244	275	210
UBC		56	60	120
Other-BAA				70



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

TITLE: Evaluation of Advanced Signature Models and Inversion Technologies

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

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

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

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

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

MILESTONES:

Milestone	Scheduled Completion
Manual and automated anomaly selection and Cross-correlation between multiple datasets	09/03
Implementation of various data processing and inversion algorithms in a real-time analysis algorithmic framework	09/04
Artificial intelligence guides to selection of optimum analysis approaches	09/04

PRODUCTS:

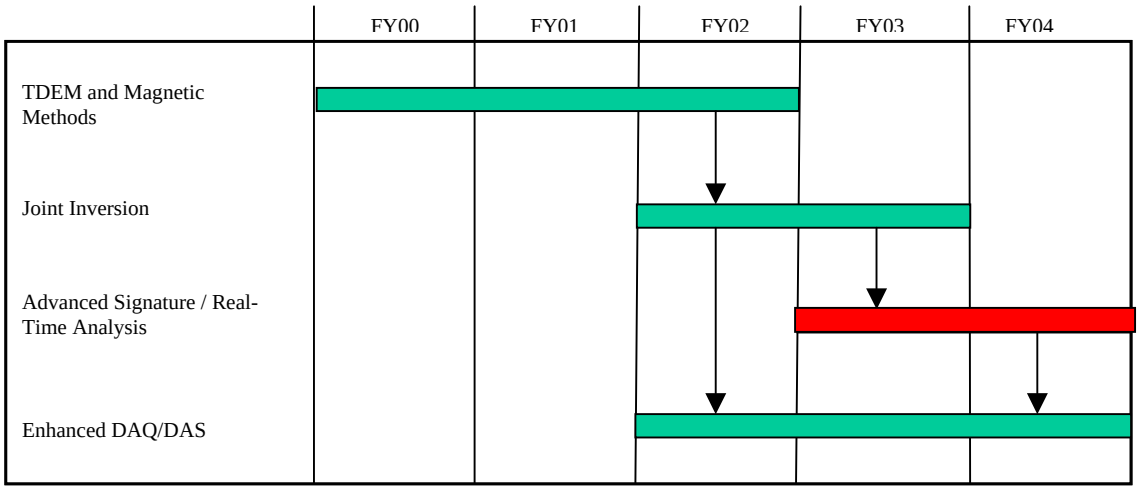
Product	Delivery Date
Real-time analysis algorithms for geophysical anomaly selection and classification and constrained, cooperative, reduced parameter, and joint inversion of multiple geophysical data types, with AI guides	09/04

EXECUTION:

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

FUNDING:

	Fiscal Year ($K)		
	FY02	FY03	FY04
ERDC VBG	45	373	200
UBC	0	100	100
Other-BAA	0	100	100


FY00
FY01
FY02
FY03
FY04
TDEM and Magnetic Methods
Joint Inversion
Advanced Signature / Real-Time Analysis
Enhanced DAQ/DAS

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

TITLE: Joint Inversion Investigations for UXO Discrimination

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

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

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

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

MILESTONES:

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

PRODUCTS:

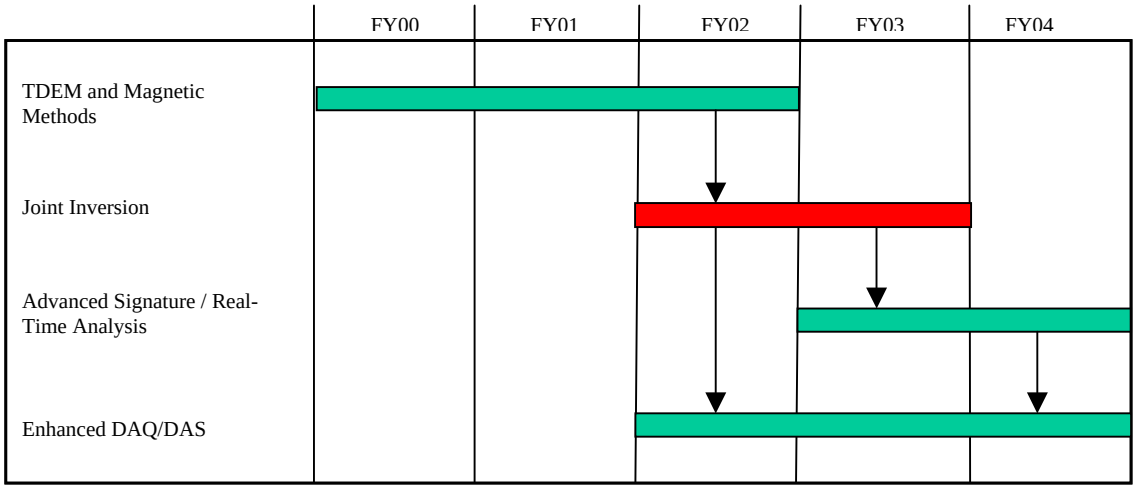
Product	Delivery Date
Algorithms for constrained, cooperative, and joint inversion of multiple geophysical data types and analysis of uncertainties	09/03

EXECUTION:

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

FUNDING:

	Fiscal Year ($K)	
	FY02	FY03
ERDC VBG	183	300
UBC	100	200
Other-BAA	50	100


FY00
FY01
FY02
FY03
FY04
TDEM and Magnetic Methods
Joint Inversion
Advanced Signature / Real-Time Analysis
Enhanced DAQ/DAS

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

TITLE: Algorithms For Inferring Shape Of Composite Targets (UXO)

OBJECTIVE: Develop processing schemes to enable discrimination of UXO-like shapes in composite targets.

DESCRIPTION: Many if not most UXO contain more than one metal type. Electromagnetic induction sensors respond differently to different metal types. This creates uniqueness problems for inversion schemes designed to tell whether something is a UXO or UXO-like object. The same general shape can produce very different signatures depending on the particular metals involved, and on how completely they are in contact. This project will produce data processing schemes to allow inference of basic object geometry whether or not composite metallic targets are involved. To do this will require the use of relatively high frequency or "early time" sensors. These emit signals that bounce off the surface of metallic objects and thereby produce signatures depending only on external shape, not internal content. The two sensor types that do this are EMI and GPR. Multi-axial receivers will probably also be required. This project will implement material that develops in the PI's basic research program on composite objects.

BENEFIT: Because so many UXO consist of composite materials and because this can muddle discrimination and inversion schemes, this project will significantly advance our ability to distinguish UXO-like objects from clutter.

MILESTONES: Note, the “new or modified instruments” are those developed under other projects within the program, including Improved UWB Survey Protocols, Processing Algorithms, and Sensor Designs (below)

- 3Qtr02. Assess relative benefits of existing and prospective sensor systems from different sources: Geophex, Zonge, Geonics, Jentek, Carl Nelsen, Ben Sternberg, Frank Morrison... OSU, SSS, GSSI....
- 4Qtr02. Complete first design of new algorithms; complete simulations and analysis needed to test new algorithms; assemble available data and acquire new data with available instruments; perform first test of new algorithms on this data.
- 2Qtr03. Revise algorithms; Report.
- 2Qtr03. Test revised algorithms using new backyard measurements on representative buried UXO and clutter targets, to the extent possible with new or modified instruments.
- 4Qtr03. Revise algorithms; test final version using backyard measurements on representative buried UXO and clutter targets, using new or modified instruments.
- 1Qtr04. Report on / documentation of algorithms and their testing.

- FY04. Test algorithms on representative buried UXO and clutter targets, using new or modified instruments, at Standardized UXO Technology Demonstration Site Program (under B4).

PRODUCTS:

- One journal article and one conference paper per year; detailed reports on algorithms and their development 2Qtr03, and on testing 1Qtr04, and on field tests at standard test sites 1Qtr05.

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

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

EXECUTORS: ERDC in house; contractors from list above (5A) and any others, assessed at the beginning of the project without predisposition.

FUNDING: By organization, $K. (*Instrument purchase)

Performer	FY02	FY03	FY04
ERDC	65	125	200
Academic	45	95	
GPR contractor	45	75	50*
EMI contractor	0	130	50*

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

TITLE: Improved UWB Survey Protocols, Processing Algorithms, And Sensor Designs

OBJECTIVE: Develop improved ultra-wideband (UWB) survey protocols, associated sensor designs and processing algorithms for enhanced discrimination of buried UXO from clutter.

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

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

b) Realization of the most promising new instrument configurations

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

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

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

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

- 3Qtr02. Assess availability and relative benefits of sensor systems from different sources: Geophex, Zonge, Geonics, Jentek, Carl Nelsen, Ben Sternberg, Frank Morrison... OSU, SSS, GSSI....

- 3Qtr02. Complete simulations and design calculations for modifications of these systems or for alternative new ones to fill the needs, and for survey new techniques using them.

- 1Qtr03. Complete simulations and algorithm development for new discrimination techniques using both EMI and GPR.

- 2Qtr03. Realization of new instrument designs.

- 3Qtr03. Test algorithms using backyard measurements on representative buried UXO and clutter arrangements, using new or modified instruments.

- FY04. Test algorithms on representative buried UXO and clutter targets, using new instruments, at Standardized UXO Technology Demonstration Sites (under BA4).

PRODUCTS: Note, at the end of the B2 part of this project the government would not own the technology. Purchase of the instrumentation would be done under B4, budgeted here in FY04.

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

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

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

EXECUTORS: ERDC in house; contractors from list above (5A) and any others, assessed at the beginning of the project without predisposition.

FUNDING: by organization, $K. (*Instrument purchase)

Performer	FY02	FY03	FY04
ERDC	50	90	200
Academic	50	50	
GPR contractor	66	80	50*
EMI contractor	66	80	50*

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

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

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

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

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

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

MILESTONES:

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

PRODUCTS:

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

EXECUTION:

1. ERDC, Environmental Laboratory, Vicksburg, MS
2. Geophex Ltd., Raleigh NC, through BAA

FUNDING:

	Fiscal Year ($K)		
	FY02	FY03	FY04
ERDC VBG	70	0	0
Geophex Ltd.	80	0	0

III. Sensor Design and Enhancement

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

TITLE: Frequency Domain EM Enhancements

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

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

This work unit represents the last year of the AF-25 project funded under the original STO for UXO Environmental Remediation. This project has produced significant improvements to the GEM-3 system, and the development of the first GEM-5 prototype. In addition, extensive laboratory and field testing of these sensors have been performed and significant progress has been made in the development of UXO signature databases to support phenomenology studies, modeling, and algorithm development. This project has leveraged funding and results from related SERDP, ESTCP, and SBIR projects. The primary goal of the FY02 portion of this effort is to implement all of the hardware/firmware/software improvements in an improved GEM-3 prototype to hand off to BA4 field demonstrations to be performed during 4Q FY02. The improved GEM-3 will have increased frequency range, improved data acquisition electronics, enhanced real-time analysis capabilities, and improved display. Also under FY02 funding, laboratory investigations will be conducted to evaluate the capability of operating the GEM-3 in a dual TD/FD mode. In addition, different receiver configurations such as magnetoresistive(MR)/giant magnetoresistive (GMR) vs. coils, will be evaluated to determine the feasibility of operating the GEM-3 as a dual-mode (passive magnetometer/FDEM) sensor. If successful, this work would extend the GEM-3 frequency range to D.C. to over 100 kHz.

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

MILESTONES:

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

PRODUCTS:

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

EXECUTION:

1. ERDC, Environmental Laboratory, Vicksburg, MS
2. Geophex Ltd., Raleigh NC, through BAA

FUNDING:

	Fiscal Year ($K)		
	FY02	FY03	FY04
ERDC VBG	250	0	0
Geophex Ltd.	100	0	0
IITRI	50	0	0

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

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

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

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

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

MILESTONES:

Milestone	Scheduled Completion
Complete Dual Mode Data Acquisition system prototype	09/02
Complete fabrication of Dual Mode Data Analysis System Prototype	05/03
Complete field evaluations of DA/DAS prototypes	09/03
Complete fabrication of handheld, man-portable, and shallow water DAQ/DAS systems	12/03

Transition optimized DAQ/DAS systems to BA4 field evaluations 09/04

Final report documenting system specifications and field performance capabilities of the optimized DAQ/DAS prototypes 09/05

PRODUCTS:

Product	Delivery Date
Design specifications for multi-sensor DAQ/DAS prototypes	09/04
Documentation of field performance of advanced DAQ/DAS Prototypes	09/05

EXECUTION:

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

FUNDING:

	Fiscal Year ($K)		
	FY02	FY03	FY04
ERDC VBG	200	225	150
AEC	7	25	25
ATC	25	25	25
BAA	150	281	0

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

TITLE: UXO Sensor Positioning and Tacking Technologies

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

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

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

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

MILESTONES:

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

PRODUCTS:

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

EXECUTION:

1. ERDC, Environmental Laboratory, Vicksburg, MS
2. CEHNC
3. Contractors through BAA

FUNDING:

	Fiscal Year ($K)		
	FY02	FY03	FY04
ERDC VBG	29	100	0
CEHNC	20	100	0
Contractors (BAA)	190	400	0

IV. Hand Held UXO Detector Design Thrust Oversight

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

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

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

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

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

MILESTONES:

Milestone	Scheduled Completion
Conduct technology workshop to identify "ideal" dual sensor	05/02
Conduct technology workshop to define key design and implementation issues	10/02
Complete design and fabrication of Dual Mode handheld and man-portable system prototypes	07/03

Complete field evaluations of prototype systems	12/03
Complete design of optimized multisensor vehicular and/or waterborne system prototype	09/04
Final report documenting system specifications and field performance capabilities of the optimized prototype systems	12/04

PRODUCTS:

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

EXECUTION:

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

FUNDING:

	Fiscal Year ($K)		
	FY02	FY03	FY04
ERDC VBG	204	220	170
AEC	25	25	20
ATC	5	95	18
BAA	100	354	0

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

I. Standardized Sites

A. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Standardized UXO Technology Demonstration Site Support

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

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

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

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

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

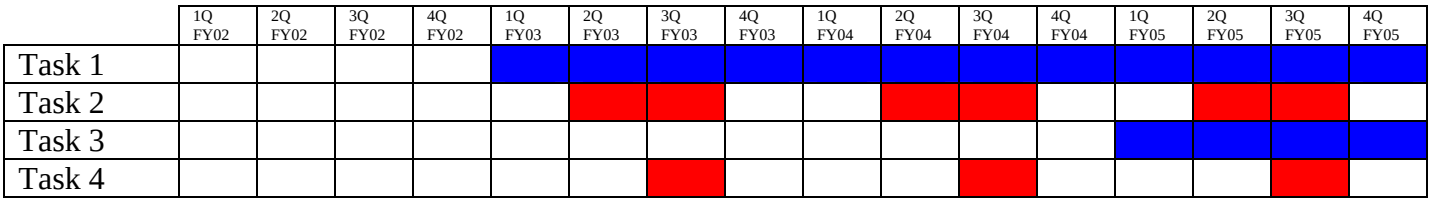
MILESTONES:

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

EXECUTION:

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

TIMELINE:



FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
AEC	50	50	50	50
ATC	75	75	75	75

Task 2

Organization	FY02	FY03	FY04	FY05
ATC		20	20	20
YPG, MMR		40	40	40

Task 3

Organization	FY02	FY03	FY04	FY05
ATC				200
ERDC				100

Task 4

Organization	FY02	FY03	FY04	FY05
ATC		30	30	30
ERDC		70	70	70

B. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Wide Area Survey Standardized Technology Demonstration Site

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

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

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

MILESTONES:

Task	Milestone	Scheduled Completion
1	Leverage ESTCP Efforts	4Q FY02
2	Leverage JUXOCO Efforts	1Q FY03
3	Leverage Protocol Development From NDCEE	2Q FY03
4	Procure Standardized Targets	3Q FY03
5	Construct Standardized Sites	1Q FY04
6	Open Sites	2Q FY04

EXECUTION:

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

TIMELINE:

	1Q FY02	2Q FY02	3Q FY02	4Q FY02	1Q FY03	2Q FY03	3Q FY03	4Q FY03	1Q FY04	2Q FY04	3Q FY04	4Q FY04	1Q FY05	2Q FY05	3Q FY05	4Q FY05
Task 1																
Task 2																
Task 3																
Task 4																
Task 5																
Task 6																

FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
ATC	75			

Task 2

Organization	FY02	FY03	FY04	FY05
AEC	25	25		
ATC		25		
ERDC		25		

Task 3

Organization	FY02	FY03	FY04	FY05
AEC		25		
ATC		25		
CEHNC		25		

Task 4

Organization	FY02	FY03	FY04	FY05
ATC		100		

Task 5

Organization	FY02	FY03	FY04	FY05
ATC	200			

Task 6

Organization	FY02	FY03	FY04	FY05
AEC			25	
ATC			25	

C. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Establishment of Active Response Demonstration Areas

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

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

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

MILESTONES:

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

EXECUTION:

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

TIMELINE:

	1Q FY02	2Q FY02	3Q FY02	4Q FY02	1Q FY03	2Q FY03	3Q FY03	4Q FY03	1Q FY04	2Q FY04	3Q FY04	4Q FY04	1Q FY05	2Q FY05	3Q FY05	4Q FY05
Task 1																
Task 2																
Task 3																
Task 4																
Task 5																
Task 6																

FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
ATC		75		

Task 2

Organization	FY02	FY03	FY04	FY05
CEHNC		10		

Task 3

Organization	FY02	FY03	FY04	FY05
ATC		400		
ERDC		150		
CEHNC		200		

Task 4

Organization	FY02	FY03	FY04	FY05
AEC			100	

Task 5

Organization	FY02	FY03	FY04	FY05
AEC				35

Task 6

Organization	FY02	FY03	FY04	FY05
AEC				15

II. UXO Technology Demonstrations

A. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Hand Held UXO Detector Design Demonstration and Validation

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

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

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

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

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

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

MILESTONES:

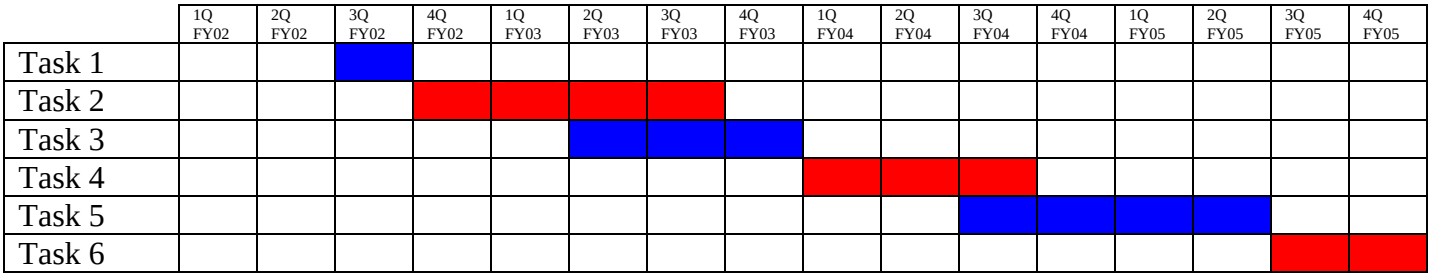
Task	Milestone	Scheduled Completion
1	Facilitate Dual Mode Sensor Workshop	3Q FY02
2	Complete COTS Demonstrations at Standardized Sites	3Q FY03
3	Complete Army Prototype Dual Mode Hand Held Field Testing	1Q FY04
4	Complete Army Dual Mode Hand Held Demonstration	4Q FY04

5	Complete COTS & GOTS at Active Response and Standardized Sites	2Q FY05
6	Transition and Final Report of Dual Mode Sensor Systems	4Q FY05

EXECUTION:

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

TIMELINE:



FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
AEC	50			

Task 2

Organization	FY02	FY03	FY04	FY05
ERDC		25		
ATC		25		
BAA – ERDC		300		

Task 3

Organization	FY02	FY03	FY04	FY05
ERDC			100	

Task 4

Organization	FY02	FY03	FY04	FY05
ERDC			25	
ATC			300	

Task 5

Organization	FY02	FY03	FY04	FY05
ERDC			20	20

ATC			200	200

Task 6

Organization	FY02	FY03	FY04	FY05
CEHNC				50

B. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Baseline Handheld/Man Portable System Performance

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

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

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

MILESTONES:

Task	Milestone	Scheduled Completion
1	Contract field performance of UXO sensor systems at Standardized UXO Technology Demonstration Sites	3Q FY03
2	Transition performance matrix (MAG, TDEM, FDEM)	4Q FY04
3	Reevaluation of UXO Sensor Performance Leverage Standardized UXO Technology Demonstration 2005	2Q FY05
4	Final Report of Sensor Performance Leverage Standardized UXO Technology Demonstration 2005	4Q FY05

EXECUTION:

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

TIMELINE:

	1Q FY02	2Q FY02	3Q FY02	4Q FY02	1Q FY03	2Q FY03	3Q FY03	4Q FY03	1Q FY04	2Q FY04	3Q FY04	4Q FY04	1Q FY05	2Q FY05	3Q FY05	4Q FY05
Task 1																
Task 2																
Task 3																
Task 4																

FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
BAA - ERDC	980			
ERDC	100			
ATC	100			

Task 2

Organization	FY02	FY03	FY04	FY05
AEC		50		

Task 3

Organization	FY02	FY03	FY04	FY05
Leverage				

Task 4

Organization	FY02	FY03	FY04	FY05
Leverage				

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

TITLE: Standardized UXO Technology Demonstration 2005

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

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

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

MILESTONES:

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

EXECUTION:

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

TIMELINE:

	1Q FY02	2Q FY02	3Q FY02	4Q FY02	1Q FY03	2Q FY03	3Q FY03	4Q FY03	1Q FY04	2Q FY04	3Q FY04	4Q FY04	1Q FY05	2Q FY05	3Q FY05	4Q FY05
Task 1																
Task 2																
Task 3																
Task 4																

FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
CEHNC		15		15
ERDC		40		40
ATC		50	100	150
BAA		129	200	250

Task 2 - Funding Shown Includes BA4 Work Accounts for some projects not included in the Sensor/Platform Design and Enhancement Program

Organization	FY02	FY03	FY04	FY05
ATC		50	375	550
BAA		100	225	275

Task 3

Organization	FY02	FY03	FY04	FY05
AEC				15

Task 4

Organization	FY02	FY03	FY04	FY05
AEC				75

BA6 Funding in ($K)

Task 4

Organization	FY02	FY03	FY04	FY05
AEC				32

D. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Sensor/Platform Integration and Demonstration

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

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

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

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

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

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

Finally, BA4 technology demonstrations for Platform Evaluations will provide the S&T community with a good baseline when developing the man portable and vehicular platform for the dual mode sensor integration.

BENEFITS: The demonstration and validation of the Sensor/Platform Design and Enhancement focus area will provide a marked advancement in the state of the art. At the completion of this effort there will be a demonstration of the improved GEM-3 Prototype, Fully transitioned dual mode man portable and vehicular platforms, transitioned optimized navigation/position system to be used in difficult environments, validated ultra wide band processing algorithms and sensor designs, and an evaluation of platforms for housing sensors.

MILESTONES:

Frequency Domain EM Enhancements

Task	Milestone	Scheduled Completion
1	Demonstrate Improved GEM-3 Prototype	3Q FY02

Enhanced Data Acquisition/Data Analysis System

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

UXO Sensor Position and Tracking Technologies

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

Spatial Pattern Survey Strategies and Sensor Configuration

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

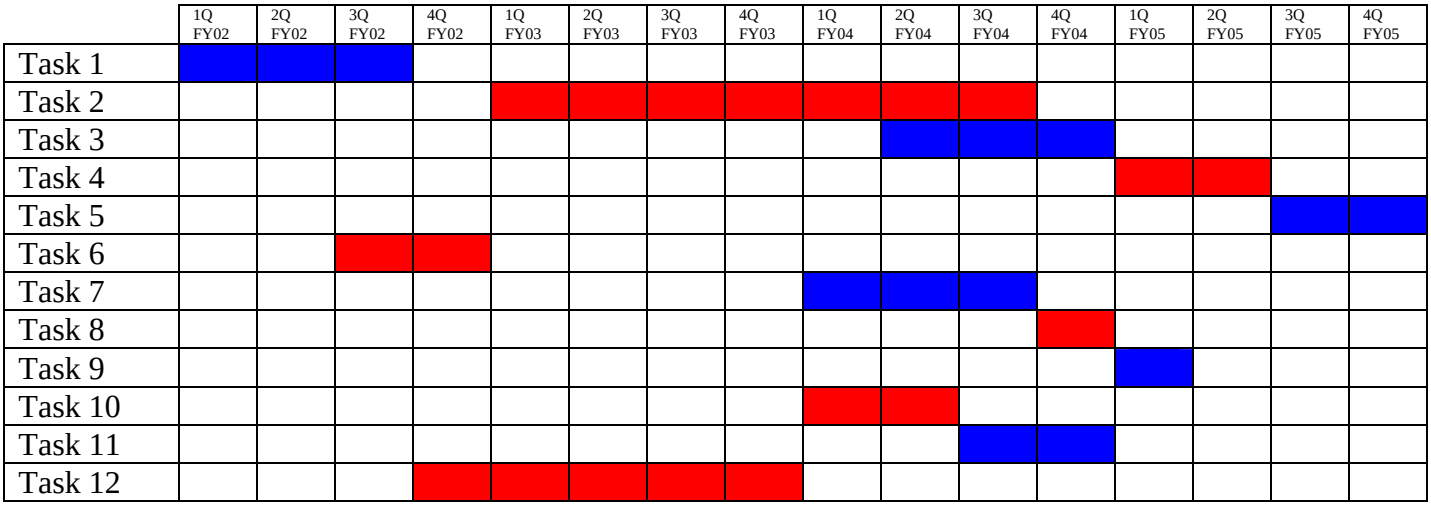
Platform Evaluation

Task	Milestone	Scheduled Completion
12	Field Demonstrate Man Portable and Vehicular Based Systems	4Q FY03

EXECUTION:

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

TIME FRAME:



FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
ERDC	100			

Task 2

Organization	FY02	FY03	FY04	FY05
ERDC		400	600	

Task 3

Organization	FY02	FY03	FY04	FY05
ERDC			300	

Task 4 – Funding Shown Does Not Count Against Focus Area. Funding is accounted for In Standardized UXO Technology Demonstration 2005

Organization	FY02	FY03	FY04	FY05
ERDC			25	25
ATC			275	400

Task 5

Organization	FY02	FY03	FY04	FY05
ERDC				25
ATC				25

Task 6

Organization	FY02	FY03	FY04	FY05
CEHNC	80			

Task 7

Organization	FY02	FY03	FY04	FY05
CEHNC		100		

Task 8

Organization	FY02	FY03	FY04	FY05
CEHNC			100	
ATC			100	
ERDC			50	

Task 9

Organization	FY02	FY03	FY04	FY05
CEHNC				50

Task 10

Organization	FY02	FY03	FY04	FY05
ERDC			25	
ATC			50	

Task 11

Organization	FY02	FY03	FY04	FY05
ERDC			50	
CEHNC			50	
ATC			25	

Task 12

Organization	FY02	FY03	FY04	FY05
ERDC	50	150		
ATC		100		

E. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Demonstrate UXO Detection Systems in Shallow Water

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

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

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

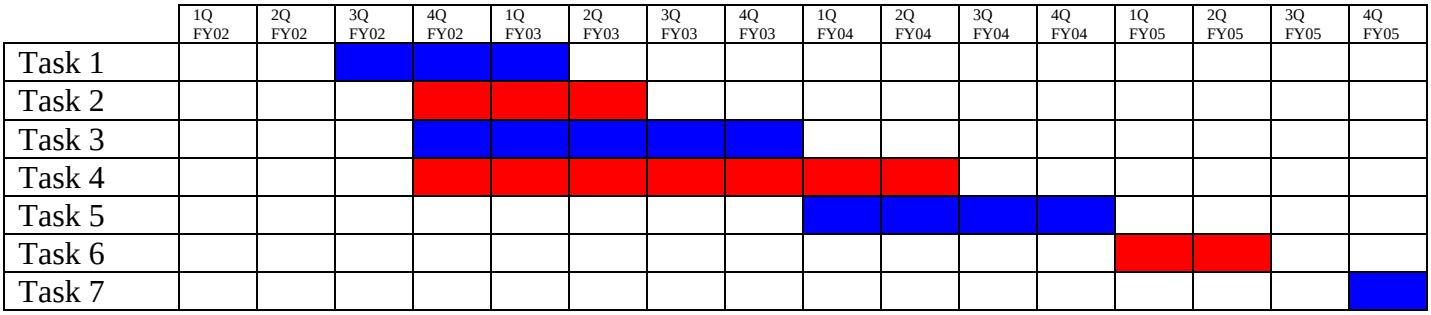
MILESTONES:

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

EXECUTION:

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

TIMELINE:



FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
ATC	25			

Task 2

Organization	FY02	FY03	FY04	FY05
AEC	25			
CEHNC	25			

Task 3

Organization	FY02	FY03	FY04	FY05
AEC	25			
ATC	100			
ERDC	25			
CEHNC	25			

Task 4

Organization	FY02	FY03	FY04	FY05
ATC	50	300	100	

Task 5

Organization	FY02	FY03	FY04	FY05
AEC			25	
ATC			50	
CEHNC			25	
BAA – ERDC			600	
ERDC			50	

Task 6

Organization	FY02	FY03	FY04	FY05
AEC				50
ATC				10
ERDC				10
CEHNC				10

Task 7

Organization	FY02	FY03	FY04	FY05
ATC				50

F. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Demonstration of Fill Identification Technologies

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

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

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

MILESTONES:

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

EXECUTION:

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

TIMELINE:

	1Q FY02	2Q FY02	3Q FY02	4Q FY02	1Q FY03	2Q FY03	3Q FY03	4Q FY03	1Q FY04	2Q FY04	3Q FY04	4Q FY04	1Q FY05	2Q FY05	3Q FY05	4Q FY05
Task 1																
Task 2																
Task 3																

FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
ATC		5		
SBCCOM		5		
CEHNC		15		

Task 2

Organization	FY02	FY03	FY04	FY05
ATC			50	
Contract – ATC			100	
SBCCOM			20	
CEHNC			22	
BAA		25		40

Task 3

Organization	FY02	FY03	FY04	FY05
ATC				20
SBCCOM				10
CEHNC				10

III. Hardware/Software Integration

A. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Software Demonstration/Validation Assessment

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

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

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

MILESTONES:

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

EXECUTION:

1. AEC
2. CEHNC
3. ERDC

TIMEFRAME:

	1Q FY02	2Q FY02	3Q FY02	4Q FY02	1Q FY03	2Q FY03	3Q FY03	4Q FY03	1Q FY04	2Q FY04	3Q FY04	4Q FY04	1Q FY05	2Q FY05	3Q FY05	4Q FY05
Task 1																
Task 2																
Task 3																

FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
CEHNC	15			
ERDC	15			

Task 2

Organization	FY02	FY03	FY04	FY05
CEHNC		75		
ERDC		40		

Task 3

Organization	FY02	FY03	FY04	FY05
CEHNC			20	
ERDC			20	

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

TITLE: Modeling Analyses and Processing Demonstration/Validation

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

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

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

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

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

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

BA4 technology demonstrations for Joint Inversion Investigation for UXO Discrimination will evaluate the ability to used advanced geophysical data integration and interpretation approaches to enhance the ability to discriminate UXO. The algorithms will be used against datasets collected at the standardized sites. Since the algorithms should be ready for the user

community, independent operators of the technology systems on two standardized sites will conduct the demonstrations. Not only will the capabilities of the algorithms be tested but also their ease of use and field friendliness evaluated.

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

MILESTONES:

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

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

Investigation of Time Domain EM and Magnetic

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

Evaluation of Advanced Signature Models and Inversion Technologies

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

Algorithm for Inferring Shape of Composite Targets

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

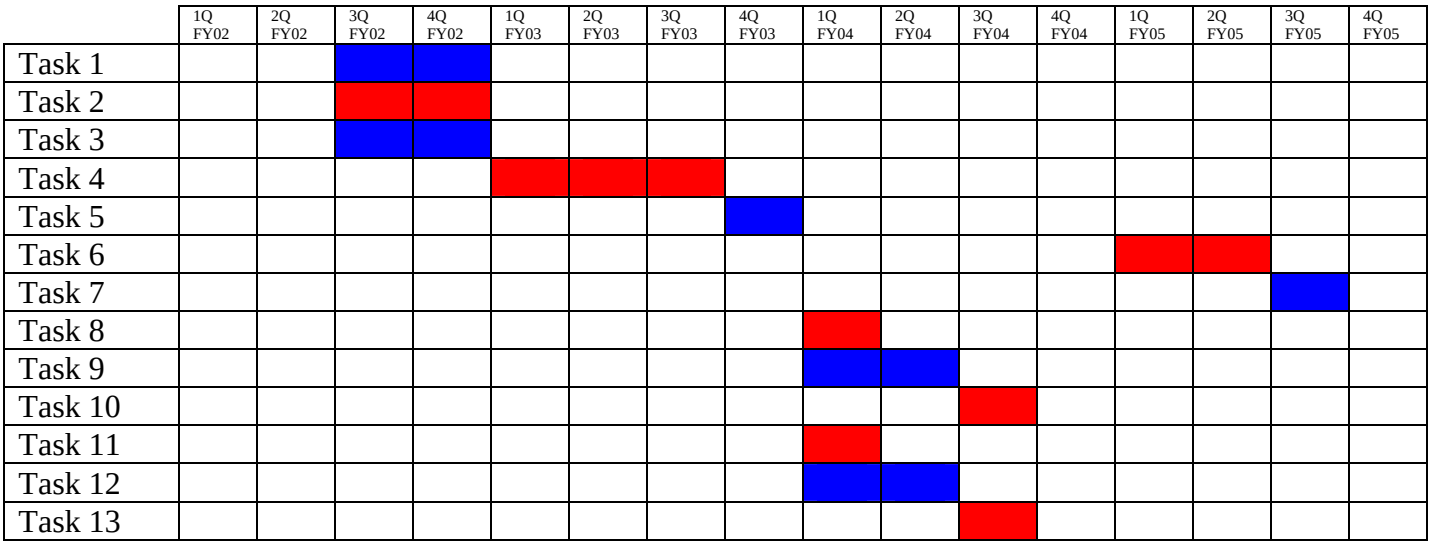
Joint Inversion Investigation for UXO Discrimination

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

EXECUTION:

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

TIME FRAME:



FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
ERDC	100			

Task 2

Organization	FY02	FY03	FY04	FY05
ERDC	25			

Task 3

Organization	FY02	FY03	FY04	FY05
ERDC	25			

Task 4

Organization	FY02	FY03	FY04	FY05
ERDC		50		

Task 5

Organization	FY02	FY03	FY04	FY05
CEHNC & ITRC		50		

Task 6

Organization	FY02	FY03	FY04	FY05
ATC				150
ERDC				50

Task 7

Organization	FY02	FY03	FY04	FY05
ERDC		100		50

Task 8

Organization	FY02	FY03	FY04	FY05
ATC			120	

Task 9

Organization	FY02	FY03	FY04	FY05
ERDC			40	
CEHNC			40	

Task 10

Organization	FY02	FY03	FY04	FY05
ERDC			40	

Task 11

Organization	FY02	FY03	FY04	FY05
ATC			120	

Task 12

Organization	FY02	FY03	FY04	FY05
ERDC			40	
CEHNC			40	

Task 13

Organization	FY02	FY03	FY04	FY05
ERDC			40	

BA6 Funding in ($K)

Task 5

Organization	FY02	FY03	FY04	FY05
CEHNC & ITRC		30		

Task 10

Organization	FY02	FY03	FY04	FY05
ERDC			30	

Task 13

Organization	FY02	FY03	FY04	FY05
ERDC			30	

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

TITLE: MAUDE Demonstration Validation

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

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

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

MILESTONES:

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

EXECUTION:

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

TIME FRAME:

	1Q FY02	2Q FY02	3Q FY02	4Q FY02	1Q FY03	2Q FY03	3Q FY03	4Q FY03	1Q FY04	2Q FY04	3Q FY04	4Q FY04	1Q FY05	2Q FY05	3Q FY05	4Q FY05
Task 1																
Task 2																
Task 3																

FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
ERDC			100	

Task 2

Organization	FY02	FY03	FY04	FY05
ERDC			20	
ATC			100	

Task 3

Organization	FY02	FY03	FY04	FY05
AEC				40

BA6 Funding in ($K)

Task 3

Organization	FY02	FY03	FY04	FY05
ITRC				40

IV. Geophysical QA/QC

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

TITLE: Standardized Guidance for Geophysical Prove Outs

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

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

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

MILESTONES:

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

EXECUTION:

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

TIMEFRAME:

	1Q FY02	2Q FY02	3Q FY02	4Q FY02	1Q FY03	2Q FY03	3Q FY03	4Q FY03	1Q FY04	2Q FY04	3Q FY04	4Q FY04	1Q FY05	2Q FY05	3Q FY05	4Q FY05
Task 1																
Task 2																
Task 3																

FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
AEC	11			
ATC	5			
ERDC	5			
CEHNC	5			

Task 2

Organization	FY02	FY03	FY04	FY05
AEC		15		
ATC		5		
ERDC		5		
CEHNC		5		
ITRC		25		

Task 3

Organization	FY02	FY03	FY04	FY05
AEC			15	
ATC			5	
ERDC			5	
CEHNC			5	

BA6 Funding in ($K)

Task 3

Organization	FY02	FY03	FY04	FY05
ASTM		56	30	

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

TITLE: QC for UXO Sensor Technology Operators

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

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

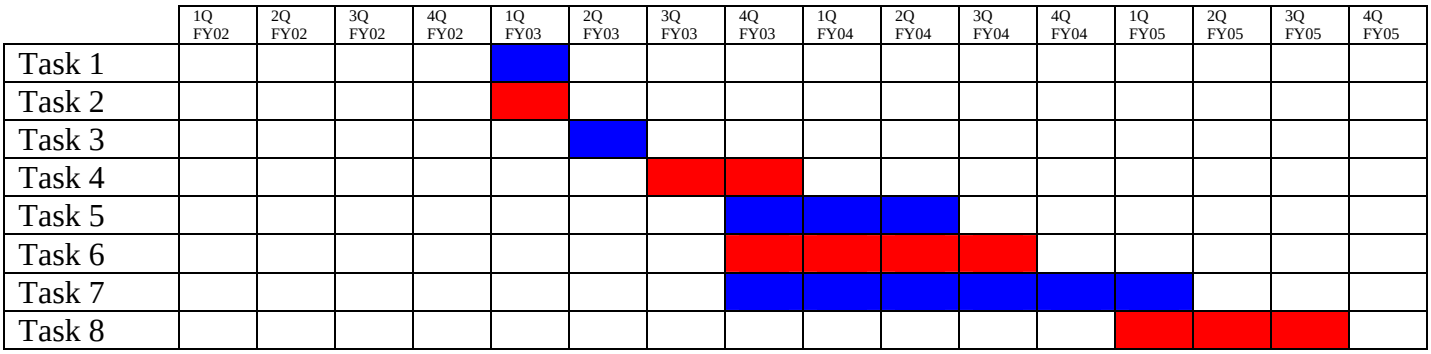
BENEFITS: Technologies that can only be operated at a high level by the experts and manufactures are not of much use to the user community. The proper training and transfer of detection and discrimination technologies is as important as the capability of the technology. This project will quantify the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

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

EXECUTION:

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

TIMELINE:



FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
AEC		10		
ATC		10		
CEHNC		10		

Task 2

Organization	FY02	FY03	FY04	FY05
ATC		15		
CEHNC		15		

Task 3

Organization	FY02	FY03	FY04	FY05
ATC		30		
CEHNC		10		

Task 4

Organization	FY02	FY03	FY04	FY05
ATC		50		
CEHNC		10		

Task 5

Organization	FY02	FY03	FY04	FY05
ATC		10		
CEHNC		10		

Task 6

Organization	FY02	FY03	FY04	FY05
ATC		50		
CEHNC		50		
Contract		30		

Task 7

Organization	FY02	FY03	FY04	FY05
ATC				60
CEHNC				20

Task 8

Organization	FY02	FY03	FY04	FY05
CEHNC				44

BA6 Funding in ($K)

Task 8

Organization	FY02	FY03	FY04	FY05
CEHNC				32

V. Technology Transfer

A. BA4 EQT Military RDT&E Project Execution Plan

TITLE: Technology Transition Support

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

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

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

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

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

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

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

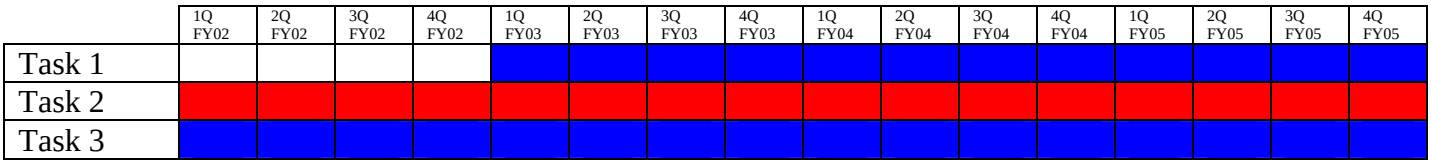
MILESTONES:

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

EXECUTION:

1. AEC
2. ITRC
3. ERDC

TIMELINE:



FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
ITRC		100	100	100

Task 2

Organization	FY02	FY03	FY04	FY05
AEC	200	200	200	200

Task 3

Organization	FY02	FY03	FY04	FY05
ERDC	25	25	25	25

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

TITLE: Technology Review and Knowledge Exchange Seminar

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

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

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

MILESTONES:

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

EXECUTION:

1. U.S. Army Environmental Center

TIMELINE:

	1Q FY02	2Q FY02	3Q FY02	4Q FY02	1Q FY03	2Q FY03	3Q FY03	4Q FY03	1Q FY04	2Q FY04	3Q FY04	4Q FY04	1Q FY05	2Q FY05	3Q FY05	4Q FY05
Task 1																
Task 2																
Task 3																
Task 4																
Task 5																

FUNDING:

BA4 Funding in ($K)

Task 1

Organization	FY02	FY03	FY04	FY05
AEC	15			

Task 2

Organization	FY02	FY03	FY04	FY05
AEC		15		

Task 3

Organization	FY02	FY03	FY04	FY05
AEC			15	

Task 4

Organization	FY02	FY03	FY04	FY05
AEC				15

Task 5

Organization	FY02	FY03	FY04	FY05
AEC				30

BA6 Funding in ($K)

Task 2

Organization	FY02	FY03	FY04	FY05
AEC		20		

Task 3

Organization	FY02	FY03	FY04	FY05
AEC			20	

Task 4

Organization	FY02	FY03	FY04	FY05
AEC				20

Task 5

Organization	FY02	FY03	FY04	FY05
AEC				20

APPENDIX D
UXO WORKSHOP MINUTES

Background

A workshop was held at the U.S. Army Engineer Research and Development Center (ERDC), Environmental Laboratory, Vicksburg, MS on 31 October and 1 November 2000. Representatives from the Army Corps of Engineers (ERDC, Huntsville Engineering Center, and Sacramento District), the Army Environmental Center, SERDP, and ESTCP participated in the workshop. A list of attendees is attached as Appendix A.

Briefings

After a brief welcome and introductions, the first of a series of formal briefings to provide background and set the stage for follow-on discussions were presented. Copies of the briefings presented are included as attachments. It was explained that the purpose of the workshop was to develop an integrated Army UXO research, development, and demonstration program that meets Army requirements and is fully coordinated with other ongoing UXO programs. Also presented was an overview of the Army's Environmental Quality Technology (EQT) Research program. Then, the Army's UXO RDT&E program and detailed the funding increases scheduled for FY02-05 in the BA2 and BA4 areas were briefed. He also described the Army's UXO requirements and how the Army program now fits with other DoD programs. A member of JUXOCO then proceeded to brief the role of the UXO Center of Excellence's Joint UXO Coordination Office (JUXOCO) in coordinating RDT&E activities throughout all five UXO mission areas (Countermine, UXO Environmental Remediation, Humanitarian Demining, Active Range Clearance, and Explosive Ordnance Disposal). The last formal briefing was presented described the roles, objectives, and investment strategies of the SERDP and ESTCP programs in the UXO area. His briefing included detailed information on ongoing and new UXO projects.

Program Development

Following the briefings, there was a general brainstorming session intended to identify high priority needs/concerns that the Army EQT program should address. It was suggested that, initially, a suitable platform for development and demonstration be identified. Some of the advantages of doing so would include:

a. It would focus the RDT&E program so that it would not break down into a number of small, independent work units that would make little overall progress toward our goal of demonstrating a reduction of false alarms by a factor of 10 by the end of FY05.
b. It would facilitate collaboration and integration with other ongoing programs such as the successful MTADS effort (if we chose to proceed with a vehicular system).

c. It would facilitate the parallel development and ultimate integration of R&D products emerging from the EQT BA2 program to develop enhanced sensing, analysis, and positioning/navigation technologies.
d. It would speed the technology transition to the user if we demonstrate a complete UXO detection, location, and analysis system on a field-capable platform.

This proposed approach generated significant discussion both pro and con. Among the most significant concerns/suggestions discussed were the following:

a. Vehicular systems such as MTADS are applicable on only 25% of the suspected UXO contaminated areas. It was offered that to provide a breakdown of areas accessible by each type of platform (airborne, vehicular, man-portable, and handheld).
b. MTADS is continuously evolving and by the time the Army develops a compatible platform, it may be a generation or two behind.
c. It may be more prudent to initially focus on a man-portable platform that still allows for the integration/evaluation of arrays of sensors as well as generic navigation/positioning, and data acquisition/analysis subsystems. It was suggested that we delay the development of the vehicular platform until FY04.
d. Handheld systems are still a very high priority user requirement and significant improvements are needed in the sensing and positioning subsystems. It was recommended that the Army program should address this need.
c. ESTCP is already investing significant resources in airborne systems so the Army program should concentrate on the ground-based technologies.

The brainstorming discussion then tried to focus on identifying specific technology areas that the Army EQT program should be addressing. A discussion of possible sensor technologies resulted in the consensus that the Army EQT program should concentrate on magnetometry, EM induction, and radar, with seismic/acoustic as a future possibility. The coordination and possible co-funding of the Army Program with the ESTCP-funded Standard UXO Test Sites program was also discussed but no conclusions were reached. The further development and demonstration of the U-Hunter software system was also discussed.

On the second day, it was decided to split up into two work groups to address the following four focus areas and to attempt to flesh out a program down to the work unit and principal investigator level.

a. Modeling, Analysis, and Joint Inversion
b. Sensor Development
c. Advanced System Integration
d. Technology Demonstration/Validation

It was decided that the first two focus areas would fall into the BA2 category and the last two into BA4 so that each of the two groups would tackle one of these categories. The members of these groups and a summary of their conclusions follow.

6.2 Team Members:

Four Major BA2 Thrust Areas were identified as follows:

I. Site Characterization Issues and Approach Strategy

a. Expedient approaches for assessing key geophysical and environmental site parameters—magnitudes and spatial heterogeneity and scale
b. Sensor/method/system site specific selection guidelines—expert system

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

II. Modeling, Analyses, and Processing

a. UXO models, modeling, and inversion
b. Signature definition and resolution issues
c. DAQ/DAS development (MTADS DAS; U-Hunter; other?)

Rationale: Survey and assimilate all available UXO models and modeling efforts. Assess strengths, weaknesses, and gaps. Develop comprehensive suite of forward and inverse (single, constrained, and joint) modeling tools for TFM, TDEM, and FDEM datasets. Examine signature definition and resolution issues for detection and discrimination with various sensor types and configurations. Develop comprehensive DAQ/DAS protocols. Assess available software, e.g., MTADS DAS, U-Hunter, Oasis, Surfer, etc., for overall functionality: versatile georeferencing capability; anomaly picking and display; capability for versatile analysis tools, e.g., threshholding, simple analytical/empirical anomaly assessment, and model-based inversion modules; GIS-type display and query, etc. Select and enhance or develop modular and adaptable DAQ/DAS software for fielded capability.

III. Sensor Design and Enhancement

a. Space-Frequency surveying and sensor configuration considerations
b. Enhanced and dual-mode sensors
c. Systems issues—positioning, tiltmeters, altimeters,

Rationale: Optimal sensor and survey geometry for buried object "illumination" will be investigated for enhanced detection and discrimination. Requirement or desirability of

total field versus gradient information will be assessed. Enhanced sensors will be developed to improve SNR, data throughput, data fidelity, and integrated navigation/positioning. New sensor designs investigated previously, as part of BA1 efforts will be matured as appropriate. Feasibility of dual mode sensors will be assessed, e.g., dual TDEM/FDEM, dual TFM/EM. Key system issues such as versatile navigation/positioning options, from RTK differential GPS to acoustic to radio wave to laser reflectometer, platform stability, sensor standoff (interference) issues, etc., will be investigated. Platform stability issues include variable height above surface and variable tilt and associated requirements for corrections to positions and sensor readings.

IV. Hand Held UXO Detector Design Thrust Oversight

a. Workshops: User Group and Expert Group
b. Umbrella oversight of work in previous thrusts leading to prototype fabrication and ultimate implementation under BA4 of advanced handheld UXO detector prototype

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

Two workshops will be held: (1) a wide range of users to define the "ideal" or near-ideal system capability and operational constraints; (2) a panel of "experts" to brainstorm and define key design and implementation issues.

This thrust to design a hand-held UXO will be managed as an umbrella oversight function of the above three thrusts to insure arrival at a prototype to hand off to BA4 by the end of FY03, with subsequent field demonstrations beginning in FY04, and transitioning to users by the end of FY05

Key products for each thrust areas are:

Thrust I: Guidelines, Expert System.
Thrust II: Forward and Inverse Modeling Capability; DAQ/DAS for systems.
Thrust III: New / enhanced sensor designs and configurations; dual-mode sensors
Integrated, adaptable navigation capability.
Sensor/platform adaptations to rugged terrain, and vegetated terrain.
Thrust IV: New hand-held UXO detector prototype design.

BA4 Team members

Required BA4 activities fall into the following categories:

1. Generic support activities (which are independent of the final sensor/platform configuration). These activities include development and evaluation of enhanced navigation/positioning system, data acquisition system, gridding and visualization software, processing hardware, etc. Integrate with ongoing U-Hunter development and SERDP/ESTCP projects.

2. Develop and demonstrate systems on selected platforms. Start with man-portable platform that can support all of the above subsystems as well as sensor arrays. Proceed with vehicular platform after second year of BA4 funding. Include a handheld version of the selected sensing/processing system and address the difficult tracking/positioning problems associated with HH sensors.

3. Conduct demonstrations at standard UXO test sites and at selected live sites TBD.

4. Conduct outreach activities to involve stakeholders, regulators, and users in all phases of the development/demonstration activities.

5. Develop and rapidly transition protocols, results, lessons learned, operational capabilities/limitations, guidelines for appropriate application of technology, and training manuals.

It was previously envisioned that this workshop would progress to the point of producing detailed technology roadmaps and individual work unit descriptions. However, the topics discussed and the factors to be considered were so numerous that a two-day meeting was not adequate to complete all planned activities. It was decided instead that minutes of the workshop would be prepared and briefing materials distributed to all participants and that additional coordination meetings would be conducted in the future.

List of Attendees

COE/Huntsville	256-895-1629
ERDC/WES/GL	601-634-2127
ERDC/CRREL	603-646-4312
AEC/Platinum Int'l	703-916-7987
SERDP/ESTCP	703-696-2120
AEC	410-436-6865
JUXOCO	703-704-1095
ERDC/WES/GL	601-634-3164
COE/SPK	831-884-9932/247
ERDC/WES/CHL	601-634-3034
AEC/Platinum Int'l	703-916-7987
COE/ERDC/WES/EL	601-634-2655
SERDP/ESTCP	703-736-4508
ERDC/WES/EL	601-634-3723

APPENDIX E

TECHNOLOGY MATURITY LEVELS

Definitions of Technology Readiness Level (TRL) for Hardware/Subsystems and Draft for Software

Technology Readiness Level	Description
1. Basic principles observed and reported. .	**HW/S**: Lowest Level of Technology Readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties. **SW**: Lowest level of software readiness. Basic research begins to be translated into applied research and development. Examples might include a concept that can be implemented in software or analytic studies of an algorithm's basic properties.
2. Technology concept and/or application formulated.	**HW/S/SW**: Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there is no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
3. Analytical and experimental critical functions and/or characteristic proof of concept.	**HW/S**: Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative. **SW**: Active research and development is initiated. This includes analytical studies to produce code that validates analytical predictions of separate software elements. Examples include software components that are not yet integrated or representative but satisfy an operational need. Algorithms run on a surrogate processor in a laboratory environment.
4. Component and/or breadboard validation in laboratory environment.	**HW/S:** Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in the laboratory. **SW:** Basic software components are integrated to establish that they will work together. They are relatively primitive with regard to efficiency and reliability compared to the eventual system. System software architecture development initiated to include interoperability, reliability, maintainability, extensibility, scalability and security issues. Software integrated with simulated current /legacy elements as appropriate.
5. Component and/or breadboard validation in relevant environment.	**HW/S**: Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components. **SW:** Reliability of software ensemble increases significantly. The basic software components are integrated with reasonably realistic supporting elements so that it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of software components. System software architecture established. Algorithms run on a processor(s) with characteristics expected in the operational environment. Software releases are 'Alpha' versions and configuration control initiated. Verification, Validation and Accreditation (VV&A) initiated.
6. System/subsystem model or prototype demonstration in a relevant environment.	**HW/S:** Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment, or in a simulated operational environment. **SW:** Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in software demonstrated readiness. Examples include testing a prototype in a live/virtual experiment or in

	simulated operational environment. Algorithm run on processor or operational environment integrated with actual external entities. Software releases are 'Beta' versions and configuration controlled. Software support structure in development. VV&A in process.
7. System prototype demonstration in an operational environment.	**HW/S:** Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment, such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft. **SW:** Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in a command post or air/ground vehicle. Algorithms run on processor of the operational environment integrated with actual external entities. Software support structure in place. Software releases are in distinct versions. Frequency and severity of software deficiency reports do not significantly degrade functionality or performance. VV&A completed.
8. Actual system completed and "flight qualified" through test and demonstration.	**HW/S:** Technology has been proven to work in its final form and under expected conditions. In almost all cases, TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications. **SW:** Software has been demonstrated to work in its final form and under expected conditions. In most cases, this TRL represents the end of system development. Examples include test and evaluation of the software in its intended system to determine if it meets design specifications. Software releases are production versions and configuration controlled, in a secure environment. Software deficiencies are rapidly resolved through support structure.
9. Actual system "flight proven" though successful mission operations.	**HW/S:** Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of system development. Examples include using the system under operational mission conditions. **SW:** Actual application of the software in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of system development. Examples include using the system under operational mission conditions. Software releases are production versions and configuration controlled. Frequency and severity of software deficiencies are at a minimum.

*Quality attributes include reliability, maintainability, extensibility, scalability and security

APPENDIX F

Unexploded Ordnance (UXO) Screening, Detection and Discrimination

Objective and Justification

- UXO contamination is a complex environmental problem affecting millions of acres throughout the U.S.
- UXO environmental remediation costs are driven by high false alarm rates.
- User driven exit criteria in the A(1.6.a) EQT-ORD
- Cost effective UXO detection/discrimination technologies must be developed and validated.
- Ultimate goal is a tenfold decrease in false alarm rates (Ref.- DSB Feb 98)

Program Schedule

Thrust Area	FY02	FY03	FY04	FY05	FY06	FY07	FY08
Site Characterization Issues and Approach Strategy							
Modeling, Analyses, and Processing							
Sensor Design and Enhancement							
Hand Held UXO Detector Design							
Standardized Sites							
UXO Technology Demonstrations							
Hardware/Software Integration							
Geophysical QA/QC							
Technology Transfer							
Total $(K)	5,533	8,553	6,475	3,456			

BA2/3 BA4 BA6 Leverage

Approach and Accomplishments

- Development of Advanced FDEM, TDEM, GPR and Mag UXO signature models and improved FDEM sensors.
- Leverage with ESTCP for Standardized UXO Technology Demonstration Sites and EMI baseline demonstrations
- Develop and incorporate models of Mag, EMI, and GPR.
- Develop and demonstrate enhanced sensors and platforms.
- Develop, integrate, evaluate, demonstrate, and transition advanced multi sensor technology systems.
- Develope and demonstrate technologies as identified within the R&D and S&T Management Plan Thrust Areas