



ARMY

Environmental Quality Technology

OASA (ALT)

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The Army

Environmental Quality Technology Program

A(1.6.a) UXO Screening, Detection, and Discrimination EQT-ORD

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)

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Unexploded Ordnance Screening, Detection, and Discrimination

Environmental Quality Technology - Operational Requirements Document (EQT-ORD)
for: A(1.6.a): UXO Screening, Detection, and Discrimination

1. General Description of the Technology Capability.

1.1. Requirement Drivers

1.1.1. The UXO 2001 Report to Congress estimates that over 11 million acres in the U.S. may contain UXO. This includes approximately 763 Formerly Used Defense Sites (FUDS) sites which must be cleared of UXO by DoD for civilian use and 23 Base Realignment and Closure (BRAC) installations which must be cleared of UXO for reuse and others requiring restricted access. 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 screening, detection, and discrimination of UXO at closed, transferring, and transferred ranges, is the Army's highest priority Environmental Restoration requirement.

1.1.2. There are few, if any, currently available technologies to rapidly and reliably screen suspected UXO sites under all types of weather and geophysical conditions. These screening technologies are needed to focus and prioritize the areas that must be fully characterized using slower and more expensive close-in survey technologies.

1.1.3. Current close-in (ground or water based) technologies are unable to detect 100% of the UXO present to required site-specific cleanup depths. As a result, the Army has been unable to close out sites without retaining some level of residual risk.

1.1.4. In addition, current systems lack the capability to differentiate and distinguish (discriminate) UXO signatures from those caused by natural and man-made, non-hazardous items. To illustrate the current lack of discrimination capability, the U.S. Army Corps of Engineers estimates that approximately 75% of the cost associated with remediation result from the excavation of non-hazardous materials.

1.2. Technology Description

Demonstrations at Jefferson Proving Ground and several live sites have identified three basic sensor approaches for the detection of UXO: magnetometry, electromagnetic induction, and ground penetrating radar.

1.2.1. The technologies currently available to detect and/or discriminate buried UXO from natural or manmade clutter fall significantly short of the user's minimum requirements. In addition, there is no "magic bullet" in the foreseeable future that will solve the UXO site characterization and remediation problem. Therefore, the Army is taking a multi-tiered approach to improve the current state of technology and arrive at reliable and cost effective solutions to the UXO Screening, Detection, and Discrimination problem.

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1.2.2. Obstacles standing in the way of reliably and cost effectively increasing detection and discrimination capabilities include inability to detect all buried UXO especially in highly cluttered environments, insufficient sensor information to determine if detected anomalies are clutter or UXO, inability to efficiently characterize large areas of land, inability to rapidly process data, inability to deal with shallow water sites, inability to accurately reacquire anomalies, inability to integrate information from a variety of sensors, lack of ability to conduct surveys in rugged and densely vegetated terrain, and limitations in sensor platforms.

1.2.3. Improvements in each of these areas are underway in Army, DoD, academia, and private industry organizations. Advancements in each of these areas must be made and integrated into complete systems to provide a dramatic improvement in the capabilities to detect and discriminate buried UXO. Demonstrated UXO detection and discrimination capability is critical to establish regulatory and stakeholder confidence that all UXO present are adequately detected to required depths, and that a site is clean of UXO without having to remove 100 percent of the detected buried anomalies.

1.2.4. The Army's Environmental Quality Technology (EQT) program focuses specifically on ground based and shallow water UXO detection and discrimination technologies. The DoD's Strategic Environmental Research and Development Program (SERDP) is also supporting basic and applied research on UXO related innovative technology and signal processing concepts. The DoD's Environmental Security Technology Certification Program (ESTCP) is performing work to address the wide-area screening portion of the UXO problem. ESTCP is also funding projects related to the ground based and shallow water areas. The EQT program managers and researchers are actively involved in the SERDP and ESTCP funded UXO-related projects, and applicable results from these programs will be integrated into the Army EQT program.

1.2.5. Many of the underlying science and engineering principles associated with the detection and discrimination of UXO as it relates to environmental restoration are similar to those associated with the countermine, explosive ordnance disposal, active range clearance, and humanitarian demining mission areas. RDT&E activities addressing these mission areas are coordinated through the Joint UXO Coordination Office. The EQT program managers are cognizant of the ongoing activities in related mission areas and will ensure conservation of RDT&E resources by coordinating across mission areas as appropriate and leveraging RDT&E conducted in other mission areas where possible to meet UXO remediation needs.

2. Threat.

2.1. The principal threat driving the need for restoration of sites containing UXO is to human health and safety, both the acute (catastrophic explosion) and chronic (long term interaction with UXO related chemical residuals). Whether the acute, chronic or a combination of both is the main threat is site specific. Although environmental risk to natural and cultural resources is an important issue on many UXO sites, the primary

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driving requirement is to protect human health and safety. The current lack of discrimination capability wastes financial resources and significantly increases both the time and effort required to remediate Army sites for reuse and associated disturbance of the habitat.

2.2. This threat will affect the Army's readiness by restricting either the Army's use of certain lands, limit the Army's ability to train because of environmental restrictions, or restrict the public or developers use of former Army properties. The UXO issue is also a very politically charged and sensitive issue, especially when there is some future potential for public involvement with UXO that may have been left in place. The Army must be proactive and aggressively demonstrate to the community that it is working towards viable solutions to UXO.

3. Shortcomings of Existing Technology/Capability

3.1. The current suite of technologies cannot meet the user requirement as appearing in the FY99 version of the AERTA. This has been demonstrated at a variety of site-specific demonstrations and restoration sites include Jefferson Proving Ground, IN; Kaho'olawe, HI; Fort Ord, CA; and Fort AP Hill, VA. Airborne systems for wide area site screening, while improving, continue to not meet user requirements. Advanced ground based systems have shown ordnance detection capabilities greater than 90 percent during Advanced Technology Demonstrations, but at virtually all levels of detection, continue to exhibit extremely high false alarm rates and minimal or poor discrimination ability. Technologies are also limited by mature vegetation, uneven topography, and difficult geology. Underwater UXO screening, detection, and discrimination technology is in its infancy and relies mainly on "waterproofed" land based systems.

3.2. Current technology cannot effectively or efficiently cover large tracts of land and wide areas under all weather and geophysical conditions for the purpose of screening and identifying areas that potentially contain UXO. The lack of efficient wide-area characterization technologies makes site specific planning and remediation difficult. As mentioned above, the SERDP and ESTCP programs are funding efforts to develop and demonstrate airborne systems for wide area screening. The Army EQT program will rely on these programs to advance the state of the art in wide area survey and will develop advanced sensing, analysis, and positioning technologies that could transition to airborne platforms

3.3. After screening technologies have identified areas that may contain UXO, there are no current technologies available to cost effectively detect a very high percentage of UXO to required depths. In low-clutter sites, high detection rates are possible, but this level of success requires multiple sweeps and excavation of a substantial number of non-UXO items (false alarms). Current technologies are not cost effective and the associated economics make it impossible for DoD and the Army to apply universally. In addition, recent technology demonstrations in difficult clutter conditions such as those encountered at Kaho'olawe have shown that current state-of-the-art UXO technologies

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failed to detect over 50% of the buried UXO, clearly demonstrating that the detection ability of state-of-the-art technologies is site specific.

3.4. Current sensor systems have very limited capabilities to discriminate clutter from UXO. As a result, nearly every anomaly must be excavated to determine if it is in fact a UXO.

3.5. Wide area screening with airborne platforms demonstrates the capability to detect UXO for limited applications, however, additional development and demonstration is needed to advance this approach and to mature the technology to enhance its use.

3.6. To date a minimum number of shallow water detection and discrimination technology demonstrations have occurred but they did not gather enough data, nor identify technology capable of meeting the user's needs. A demonstration must be conducted to determine the current state-of-the-art for shallow water applications.

3.7. The UXO Report to Congress 2001 states that preliminary estimates to detect, discriminate and remediate UXO on closed, transferring, and transferred ranges in the billions of dollars. Even marginal improvements in the ability to detect and discriminate buried UXO could lead to significant savings in remediation costs and the potential for greater land reuse at a higher number of sites.

3.8. Current technology has only limited ability to identify the material that is contained within the munitions for example, inert fill, conventional explosives, chemical warfare materiel, smoke, etc. 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 EQT-ORD will leverage other EQT-ORD efforts to improve capability for the detection of the material contained within the munitions.

3.9. The public and environmental regulators have expressed the need to accurately and fully characterize and remediate sites potentially containing UXO. In general, the public and regulatory communities are not familiar with the capabilities and limitations of UXO screening, detection, and discrimination technologies, resulting in extremely close scrutiny and skepticism when the DoD remediates a site. The expectation for both is zero risk at all former UXO sites. There is a statistical impossibility to get to a level of zero risk. The public and regulators must be continuously trained and educated in the capabilities and limitations of UXO technologies.

4. Capabilities Required

4.1. The systems that are developed must meet realistic performance metrics. To meet all of the user requirements, the systems developed would need to demonstrate near 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

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requirements will be established to demonstrate a leap ahead in the capabilities and performance over current capabilities.

4.1.1. The program performance metrics are based on testing to be conducted at the Standardized UXO Technology Demonstration Sites. The Standardized UXO Technology Demonstration Sites are found at Aberdeen Proving Ground, Camp Edwards, and Yuma Proving Grounds. Descriptions, standardized procedures, and protocols are clearly established in the Standardized UXO Technology Demonstration Site Program Protocols, January 2002 (Ref 1). This was a decision based on the need for absolute levels in the exit criteria. The only approach to ensure repeatable testing and realistic test scenarios is to use standardized sites because of the known ground truth and the stability of the sites. Additional demonstrations will be conducted at live sites to be established through the EQT program, to ensure a correlation between the validated capabilities at the live sites and the standardized sites.

4.1.2. Program Performance Metrics – Ground Based Systems (Ref 1)

| 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 | \$400 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 |

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4.1.3. Program Performance Metrics – Shallow Water Systems (Ref 1)

| 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 | \$400 per acre |
| Production Rate | 5 Acres per day | 50 Acres per day |

4.1.4. Program Performance Metrics – Wide Area Screening Systems (Ref 1)

| Metric | Threshold | Objective |
|--------------------------|--|--|
| Detection | Correctly detect 25 metal objects per 10,000 square meters | Correctly detect 10 metal objects per 10,000 square meters |
| Relocation | Relocate within 10 meters | Relocate within 2 meters |
| Cost Rate | \$500 per acre | \$50 per acre |
| Accessibility – Platform | Operate at low vegetative cover | Operate at All Scenarios encountered at Live Sites |
| Production Rate | 50 Acres per day | 500 Acres per day |

4.1.5. The technologies developed and demonstrated under this program shall be required to operate in a wide range of environments where ambient temperatures may range from -30 to +50 deg. C and relative humidity can reach 99%. The systems must be capable of operating in the vicinity of power lines and other sources of electromagnetic interference. In addition, ground-based systems must be water resistant to allow operation during rain/snow conditions. Systems shall have sufficient battery and data storage capacity to allow for 5 hours of continuous operation without recharging/downloading.

4.2. Performance

4.2.1. The technologies will be, for the most part employed by private industry that will use the technologies to provide UXO remediation services to the DoD. The use of the technologies will need regulatory and user acceptance to ensure that the technology, if properly implemented, will meet the established performance metrics. Therefore within this program, regulatory concerns, buy in, and input will be sought and incorporated.

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4.2.2. The stakeholder and regulatory communities are most concerned with the inability to detect a large portion of the buried UXO. Due to the considerable impact on costs due to false alarms, the DoD is very concerned with developing and demonstrating a reliable UXO discrimination capability. A goal of this program is to demonstrate to stakeholders/regulators that advanced UXO technologies can reliably detect and discriminate UXO from clutter, thereby, reducing remediation costs without increasing the residual risk of leaving UXO in the ground.

4.2.3. The three focus areas, ground based detection and discrimination, wide area screening, and shallow water detection and discrimination have differing metrics. The ground based detection and discrimination performance requirement is typically very stringent and driven by actual or contemplated site anticipated future land use. Wide area screening requires considerably higher coverage rates with lower acceptable Probability of Detection (Pd)'s to highlight areas that are most likely to need further investigation. Shallow water detection and discrimination require Pd's and rejection rates similar to the ground based systems, but must function in significantly different signal propagation and operating conditions.

4.3. Logistics and Readiness

Technologies developed under this program will, for the most part, be transferred to contractors to own and operate. The technologies may also be useful to support active range clearance, countermine, humanitarian demining, and explosive ordnance disposal mission areas. Technologies will be able to be operated by personnel with adequate training, experience, and under proper supervision. Technologies should be designed to accept upgrades in computer hardware and software. The technologies should be self-sufficient, be able to operate in areas with little logistical support, and be hardened enough to withstand fieldwork.

4.4. Other Characteristics

The technologies will not require extra safety parameters above those normally encountered on an active range or cause explosive safety issues such as sympathetic detonation. The technologies should gather information digitally and discrimination decisions should be made based on standardized processing with limited human decision input.

5. Program Support

5.1. The capability to be demonstrated typically consists of a sensor or suite of sensors, a platform, an operator, a positioning device, and a signal analysis/interpretation component. The individual components will be tested and demonstrated and can stand on their own. These components must operate in unison and be tested as such to make sure that they work within the larger UXO detection and discrimination system.

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5.2. Maintenance Planning

Maintenance and upkeep will be the responsibility of the contractor or the manufacturer of the equipment.

5.3. Support Equipment

Support equipment, computers, and basic supplies will be readily available off the shelf items. The technology will be easily calibrated using standardized calibration lanes (Ref 1) and self-diagnostic tests. The calibration will be able to be done on site and be performed by the operator.

5.4. Human Systems Integration (HSI)

Contractor personnel will operate the final versions of the technology. Individuals shall receive adequate training, supervision, and practice on the technology before utilization. The technology will not require more than a team of six individuals on site to operate. The technology shall minimize, to the extent possible, the human element in making decisions and determinations of detection and discrimination. A highly qualified individual will be required to make the final determination. The technology will be designed to be OSHA compliant.

5.5. Computer Resources

The data and output of the all technologies will be compatible with and interface to DoD computer systems. The interface shall use commercially available off the shelf software packages available to a wide variety of Government agencies. Data gathered will be made readily available in digital electronic off the shelf formats. The contractor will operate and maintain their computer and support systems.

5.6. Other Considerations

Regulatory and stakeholder acceptance is a key component of successful technology transfer. An advisory panel will ensure the acceptance to the maximum extent practicable.

5.7. Command, Control, Communications, Computers, and Intelligence

This area was considered but not required.

5.8. Transportation and Fielding

The contractor will transport all materials required. No special equipment should be necessary on site. Each site will need to establish test areas for geophysical prove outs (Ref 1).

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5.9. Standardization, and Installation Interoperability

The technologies developed and demonstrated are designed for applications that are driven by specific site conditions. The technologies will be used for the detection and discrimination of buried UXO. Other mechanisms and technologies are necessary to extract or dispose of the buried UXO. The technologies developed in this program should be integrated with the disposal technologies used to remediate UXO contaminated sites.

5.10. Mapping, Charting, and Geodesy Support

The technologies will rely on digital topographic data and geodetic data for successful technology employment. This support also includes the geo location technologies to identify and mark the location of possible UXO for future reacquisition. The technologies shall comply with Tri Service Computer Aided Drafting and Design (CADD) requirements and the Federal Geographic Data Committee and National Spatial Data Infrastructure Standards.

5.11. Atmospheric and Oceanographic Data Support

This area was considered but not required.

6. Force Structure

The DoD for the most part will transfer the technology to the contracting community; but a limited number of the technologies may be purchased for the purpose of QA/QC. There may be a limited amount of system acquisition and some personnel training required.

7. Schedule Considerations

The timeframe for meeting the threshold objectives is important but not considered critical. The extent and the size of the problem allows for some flexibility in meeting the threshold and objective exit criteria.

8. References

Reference 1: Standardized UXO Technology Demonstration Site Program Protocols, January 2002

Reference 2: The Army Environmental Quality Technology Program A(1.6.a) UXO Screening, Detection, and Discrimination Management Plan, April 2002

Reference 3: The Army Environmental Quality Technology Program A(1.6.a) UXO Screening, Detection, and Discrimination AERTA Requirement, July 1999.

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9. Coordination

Organizations Participating in EQT-ORD Development

US Army Environmental Center
US Army Corps of Engineers Engineer Research and Development Center
US Army Corps of Engineers, Engineering and Support Center, Huntsville

Voting Members of Restoration Technology Team

US Army Forces Command
US Army Pacific Command
US Army Training and Doctrine Command
US Army Material Command
Office of Director of Environmental Programs
US Army Environmental Center
US Army Corps of Engineers
US Army Aberdeen Test Center Test
US Army Test and Evaluation Command
US Army Center for Health Promotion and Preventative Medicine
US Army Reserve Command
National Guard Bureau

Co Chairs of Restoration Technology Team

US Army Environmental Center
US Army Corps of Engineers

Approved:

Date

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