1 of 2 Books

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UXO FORUM 1996

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CONFERENCE PROGRAM

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HOSTED BY:

U.S. Army Environmental Center (USAEC)

IN COOPERATION WITH:

Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV)

U.S. Air Force/Wright Laboratory (USAF/WL)

U.S. Army Corps of Engineers, Huntsville Division (CEHND)

U.S. Army Project Manager for Non-Stockpile Chemical Materiel (PM NSCM)

Western Governors' Association (WGA)

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Williamsburg, Virginia

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UXO FORUM 1996
Conference Program

Williamsburg, Virginia
March 26 - 28, 1996

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April 2007

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FOREWORD

Welcome to Williamsburg, Virginia and the UXO FORUM 1996.

Over the next three days you will have the opportunity to participate in numerous discussions dealing with the topic of unexploded ordnance (UXO). Millions of acres within the continental United States contain UXO as a result of military testing and training. UXO is not only a domestic concern, but a worldwide concern. Therefore, this conference attempts to address many of the diverse, worldwide issues associated with UXO contamination.

During the UXO FORUM 1996, you will hear various presentations about technologies that can be applied to detect, identify, characterize, and remediate UXO. The policies, procedures, and regulations which are applied for UXO management will also be discussed. And, you will learn how the U.S. Department of Defense (DoD) is aggressively addressing UXO issues. An extensive exhibit session will aid in the exchange of information and provide networking opportunities.

This conference program contains an agenda, presentation abstracts, exhibit descriptions, and a list of all the preregistered attendees. The conference proceedings will be published and mailed to you in May 1996. Please complete the conference evaluation form and return it to the registration desk or mail it to the address provided on the form. Your comments and critiques of the UXO FORUM 1996 will help shape future conferences.

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The UXO FORUM 1996 was coordinated by PRC Environmental Management, Inc., for Kelly Rigano [(410) 612-6868], Program Manager, U.S. Army Environmental Center (USAEC), Aberdeen Proving Ground, Maryland under Contract No. N00174-95-D-0009 with Gerard Snyder, [(301) 743-6855] Director, UXO Clearance Technology Program, Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV), Indian Head, Maryland. Special appreciation is given to the Department of Defense Explosives Safety Board for sponsoring the UXO FORUM 1996 and to USAEC for hosting the conference. The UXO FORUM 1996 was coordinated in cooperation with NAVEODTECHDIV, U.S. Air Force/Wright Laboratory, U.S. Army Corps of Engineers, Huntsville Division, U.S. Army Project Manager for Non-Stockpile Chemical Materiel, and the Western Governors' Association.

UXO FORUM 1996
AGENDA

Tuesday, March 26, 1996
Morning Session
Auditorium

8:00 a.m.	Welcome *Kelly Rigano*, U.S. Army Environmental Center
8:05 a.m.	Introductions *Colonel Wright*, Department of Defense Explosives Safety Board
8:15 a.m.	Impact of UXO on Worldwide Environmental Security *Gary Vest*, Principal Deputy Undersecretary of Defense for Environmental Security
9:00 a.m.	UXO Issues From a DoD Perspective *Colonel Wright*, Department of Defense Explosives Safety Board
9:30 a.m.	DoD Efforts to Support UXO Cleanup *Colonel Uyesugi*, U.S. Army Environmental Center
9:55 a.m.	**BREAK**
10:15 a.m.	Non-Stockpile Chemical Munitions Disposal *Colonel Hilliard*, U.S. Army Project Manager for Non-Stockpile Chemical Materiel
10:40 a.m.	Explosive Ordnance Disposal *Captain Bacon*, Naval Explosive Ordnance Disposal Technology Division
11:05 a.m.	Military Munitions Waste Working Group, Western Governors' Association *James Souby*, Executive Director of Western Governors' Association
11:25 a.m.	UXO - The Public's Viewpoint *Ross Vincent*, Military Toxics Projects
11:45 a.m.	**LUNCH**

UXO FORUM 1996
AGENDA

Tuesday, March 26, 1996
Afternoon Sessions

Session A: Auditorium
Detection Technology
Chair - Scott Millhouse, CEHND

1:15 p.m. A Unique Man-Portable, Fluxgate Gradiometer Tracking System for UXO Localization
Greg J. Kekelis, Naval Surface Warfare Center - Dahlgren Division

1:40 p.m. Subsurface Ordnance Characterization System
Ed Brown, Wright Laboratory

2:05 p.m. Mine Detection with Modern Day Metal Detectors
Gerhard Vallon, Vallon GmbH/Security Search Product Sales

2:30 p.m. UXO Characterization Using a Remotely Controlled Vehicle
Donald J. Green, U.S. Army

2:55 p.m. **BREAK**

Session B: Amphitheater
Policies, Procedures, and Regulations
Chair - James Arnold, USAEC

1:15 p.m. Army Requirements for Explosives Safety Submissions for Removal of UXO and Release of Property
Clifford H. Doyle, U.S. Army Technical Center for Explosive Safety

1:40 p.m. EPA's Proposed Military Munitions Rule
David E. Bell, Department of the Army Office of the Judge Advocate

2:20 p.m. The DoD Range Rule
Karen Heckelman, USAEC, Office of Counsel

2:55 p.m. **BREAK**

Session A: Auditorium
Detection Technology
Chair - Betty Neff, CEHND

3:15 p.m. Application of Time Domain Electromagnetic Techniques to UXO Detection
J. Duncan McNeill, Geonics Limited

3:40 p.m. Pulsed Electromagnetic Induction as a Detection Technology
Peter J. Kaczkowski, University of Washington

4:05 p.m. Multi-Sensor Towed Array Detection System (MTADS)
J. R. McDonald, Naval Research Laboratory

4:30 p.m. The Phenomenology of Detecting Buried UXO
David Sparrow, Institute for Defense Analyses

4:55 p.m. Adjourn

Session B: Amphitheater
User Needs/Case Studies
Chair -Vivian Graham, USAEC

3:15 p.m. Explosive Ordnance Disposal Technology Coordination
Christopher O'Donnell, NAVEODTECHDIV

3:40 p.m. UXO Investigations in Limestone Hills, Montana
Clifton C. Youmans Montana Department of Military Affairs; and *Alan T. Frohberg*, Glacier Engineering, P.C.

4:05 p.m. UXO Remediation at the Umatilla Depot Activity
Charles Lechner, USAEC

4:30 p.m. Records Analyses Saves Time and Money
Daniel J. Holmes, U.S. Army Corps of Engineers, Rock Island District

4:55 p.m. Adjourn

UXO FORUM 1996
AGENDA

Wednesday, March 27, 1996
Morning Sessions

Session A:
Auditorium
Remediation and Disposal Technology
Chair - Chris O'Donnell, NAVEODTECHDIV

8:00 a.m.	UXO Remediation and Disposal Technologies *William T. Batt*, UXB International, Inc.
8:25 a.m.	Applicability of Commercial Procedures and Technologies to the Destruction of Chemical Weapons Material *Norman J. Abramson*, Earth Resources Corporation
8:50 a.m	Remediation of Chemical Warfare Materiel Under CERCLA, A Case Study: Defense Distribution Depot Ogden, Utah *Gary Enloe*, Montgomery Watson
9:15 a.m.	Mobile Munitions Assessment System Development *Kenneth D. Watts*, Idaho National Engineering Laboratory
9:40 a.m.	**BREAK**
10:00 a.m	Drill and Transfer Operations of Suspect Chemical Filled Munitions at Aberdeen Proving Ground *Randolph Laye*, U.S. Army Edgewood Research, Development, and Engineering Center
10:25 a.m.	Hydro Abrasive Cutting as an Operational EOD Technique *Major Adrian Wilkenson*, Defense Test and Evaluation Organization
10:50 a.m.	Munitions Assessment and Processing System *Timothy A. Blades*, U.S. Army Edgewood Research, Development, and Engineering Center
11:40 a.m.	**LUNCH**

Session B:
Amphitheater
Case Studies
Chair - Steve Bird, PM NSCM

8:00 a.m	Evaluation of Subsurface Ordnance Detection Systems at a Controlled Site *Carol B. Richardson*, PRC Environmental Management, Inc.
8:25 a.m.	Evaluation of Subsurface Ordnance Detection Systems in a Live Ordnance Environment *Kenneth M. Valder*, PRC Environmental Management, Inc.
8:50 a.m.	Phase II Controlled and Live Site UXO Detection, Characterization, and Remediation Advanced Technology Demonstrations *Kurt O. Thomsen*, PRC Environmental Management, Inc.
9:15 a.m.	Automatic Ordnance Locator (AOL) System - A New Survey Tool for UXO *R. J. Selfridge*, CHEMRAD
9:40 a.m.	**BREAK**
10:00 a.m	A System for Performing Site Remediation for Test Ranges Containing UXO *Captain Walter M. Waltz*, Wright Laboratory
10:25 a.m	A Case Study of an Innovative Assessment Strategy: Tracadie Range - New Brunswick, Canada *Paul Stratton*, ADI Services
10:50 a.m.	Dredging at Eagle River Flats, Alaska: Remediation Study of a Superfund Site in an Impact Area *Michael R. Walsh*, USA CRREL
11:15 a.m.	Time Domain Electromagnetic Metal Detectors - History, Case Histories, Future *Pieter Hoekstra*, Blackhawk GeoSciences
11:40 a.m.	**LUNCH**

UXO FORUM 1996
AGENDA

Wednesday, March 27, 1996
Afternoon Sessions

Session A: Auditorium
Remediation and Disposal Technologies
Chair - Al Nease, Wright Laboratory

1:00 p.m. Emergency Demolition Concept
Allan P. Caplan, PM NSCM; and *William C. Replogle*, Sandia National Laboratories

1:25 p.m. Munitions Management Device 2 for Explosively Configured Chemical Weapon Materiel
Allan P. Caplan, PM NSCM

1:50 p.m. Vapor Containment Structure Development and Use
James P. Manthey, U.S. Army Corps of Engineers, Huntsville Division

2:15 p.m. **BREAK**

2:35 p.m. Detection, Recovery and Destruction of Abandoned UXO from World Wars in Germany
Martina Schneider, BOWAS - GROUP

3:00 p.m. BUGS: An Autonomous "Basic UXO Gathering System" Approach in Submunition and Minefield Neutralization and Countermeasures
Christopher O'Donnell, NAVEODTECHDIV

3:25 p.m. CEG Soft Excavation Technology Applied to UXO Site Remediation
Jerome Apt and *Martin J. Uram*, Concept Engineering Group, Inc.

3:50 p.m. Cost-Effective Approaches to Successful Remediation of UXO at the Idaho National Engineering Laboratory
Terrell J. Smith, Lockheed Martin Idaho Technologies

Session B: Amphitheater
Signal Processing and Data Analysis
Chair - Hank Hubbard, CEHND

1:00 p.m. Prediction for UXO Shape and Orientation Effects on Magnetic Signature
T. W. Altshuler, Institute for Defense Analyses

1:25 p.m. A Comparison of Magnetic Survey Methods
Robert DiMarco, AETC

1:50 p.m. Magnetic Gradient Tensor Signal Processing for UXO Localization and Classification
William Michael Wynn, Naval Surface Warfare Center - Dahlgren Division

2:15 p.m. **BREAK**

2:35 p.m. Automatic Detection and Characterization of Magnetic Anomalies in Total Field Magnetometer Data
Douglas F. DeProspo, AETC

3:00 p.m. Performance of Electromagnetic Induction Sensors for Detecting and Characterizing UXO
Bruce Barrow, AETC

3:25 p.m. Model Based Approach to UXO Imaging and Optimization of Instrument Design for the Time Domain Electromagnetic (TDEM) Method
Eugene M. Lavely, Blackhawk GeoSciences

3:50 p.m. 3-D Localization Using an Electromagnetic Sensor System
Carl V. Nelson, The Johns Hopkins University

Wednesday, March 27, 1996
Evening Reception

4:15 p.m. - 7:00 p.m. Presidents Hall

UXO FORUM 1996
AGENDA

Thursday, March 28, 1996
Morning Sessions

Session A: Auditorium
Detection Technology
Chair - Carol Richardson, PRC EMI

8:00 a.m.	Testing of Surface UXO Detection via an Active/Passive Multispectral Line Scanner System *Hollis H. (Jay) Bennett*, U.S. Army, Waterways Experiment Station	
8:25 a.m.	UXO Detection by Combined Radar/EMS Sensor System *Raymond Harris*, METRATEK, Inc.	
8:50 a.m.	Computer Modeling to Transfer Ground-Penetration Radar UXO Detectability Knowledge Between Sites *Gary R. Olhoeft*, Colorado School of Mines	
9:15 a.m.	Real-Time Man-Portable Synthetic Aperture Ground Penetrating Radar *Raymond Harris*, METRATEK, Inc.	
9:40 a.m.	Applications and Advantages of Two-Frequency Continuous Wave Detectors *Hanns Peter Trinkaus*, Foerster	
10:05 a.m.	**BREAK**	

Session B: Amphitheatre
Signal Processing and Data Analysis
Chair - Pope Burr, NAVEODTECHDIV

8:00 a.m.	SAR Processing of Ground Penetrating Radar Data for Buried UXO Detection: Results from Surface-Based and Airborne Platforms *Jennifer Halman*, Battelle
8:25 a.m.	Ground Penetrating Radar Target Classification via Complex Natural Resonances *Chi-Chih Chen*, The Ohio State University, ElectroScience Lab
8:50 a.m.	High Accuracy CM-Level GPS/INS Positioning for Airborne Ground Penetrating Radar (GPR) SAR Processing *Ren Da*, The Ohio State University, Center for Mapping
9:15 a.m.	Analysis and Results of the 1995 Yuma Proving Ground Penetration Experiments *Check F. Lee*, Massachusetts Institute of Technology
9:40 a.m	Fused Airborne Sensor Technology (FAST) *Delbert C. Summey*, Naval Surface Warfare Center - Dahlgren Division
10:05 a.m.	**BREAK**

UXO FORUM 1996
AGENDA

Session C:
Rooms 2 and 3
Site Management and Decision Analysis
Chair - John Potter, CEHND

8:00 a.m.	OECert, FUDS Risk Based Characterization and Prioritization *Arkie Fanning*, U.S. Army Corps of Engineers, Huntsville Division
8:25 a.m.	Ordnance and Explosive Program Knowledge Base (OE-KB) *Scott Millhouse*, U.S. Army Corps of Engineers, Huntsville Division; *John E. Foley*, Sanford, Cohn, & Associates; and *L. Lynn Helms*, U.S. Army Corps of Engineers, Huntsville Division
8:50 a.m.	UXO Risk Assessment Model *Jonathan Sperka*, NAVEODTECHDIV and *Kristine Kruck*, PRC Environmental Management, Inc.
9:15 a.m.	Risk Assessment Methodology for Use in Managing Sites Containing UXO *Scott A. Hill*, USAEC
9:40 a.m.	Installation Management of Recovered Chemical Warfare Material *Larry E. Wright*, U.S. Army Pine Bluff Chemical Activity
10:05 a.m.	**BREAK**

Thursday, March 29, 1996
Key Note Speaker
Auditorium

10:30 a.m. - 11:30 a.m. Meeting the UXO Challenge: Safety, Technology, Policy, and Regulation
Sherri W. Goodman, Deputy Undersecretary of Defense for Environmental Security

11:30 a.m. **LUNCH**

UXO FORUM 1996
AGENDA

Thursday, March 28, 1996
Afternoon Sessions

Session A:
Auditorium
Detection Technology
Chair - Linda Daehn, PRC EMI

1:00 p.m.	A Transportable Pulsed-Neutron, Non-Intrusive UXO Identification Technique *George Vourvopoulos*, Western Kentucky University
1:25 p.m.	Portable Turnkey UXO Detect System *Gerhard Vallon*, Vallon Gmbh/Security Search Product Sales
1:50 p.m.	An Ultra-Wideband Radar System for Imaging Buried Ordnance *Roger S. Vickers*, SRI International
2:15 p.m.	Field Application of PINS *A.J. Caffrey*, Idaho National Engineering Laboratory
2:40 p.m.	Probing Chemical Contamination from UXO with SIMS *Gary S. Groenewold*, Idaho National Engineering Laboratory

Session B:
Amphitheatre
Marine Detection/Remediation Technology
Chair - Earl Scroggins, NAVEODTECHDIV

1:00 p.m.	The Challenges of UXO in the Marine Environment *Andy Pedersen*, NAVEODTECHDIV
1:25 p.m.	Mobile Underwater Debris Survey System (MUDSS); Phase I - Feasibility Demonstration *Delbert C. Summey*, Naval Surface Warfare Center - Dalhgren Division
1:50 p.m.	Underwater Ultrasonic Acoustic Imaging for Target Threat Assessment *Bruce E. Johnson*, NAVEODTECHDIV
2:15 p.m.	Detection of UXO within a Sand Borrow Offshore of Seabright, NJ *Richard D. Lewis*, U.S. Army Waterways Experiment Station
2:40 p.m	Evaluation of the Use of Existing Marine Geophysical Remote Sensing Systems for the Mapping and Classification of UXO in Coastal Waters *Dave D. Wickland* and *Mike Atturio*, Naval Facilities Engineering Service Center

Session C:
Rooms 2 and 3
Panel Discussion
Chair - Jim Lehr, WGA

1:00 p.m.	UXO Cleanup Issues *Jim Lehr*, Western Governors' Association *Jim Austreng*, California EPA Department of Toxic Substances Control, *Ross Vincent*, Military Toxics Project, *Colette Y. Machado*, Kaho'olawe Island Reserve, *Emma Featherman-Sam*, Oglala Lakota Nation, and *Bob Dworkin*, U.S. Army Corps of Engineers

UXO FORUM 1996
AGENDA

Thursday, March 29, 1996
Closing Remarks
Auditorium

3:05 p.m	Closing Remarks *Colonel Wright*, DDESB *Kelly Rigano*, USAEC
3:30 p.m.	Adjourn

Tuesday, March 26, 1996
Session A
Auditorium

A Unique Man- Portable, Fluxgate Gradiometer Tracking System For UXO Localization

Presenter: Gary J. Kekelis, Ph.D. Dr. Krekelis worked for 17 years under the support of the Office of Naval Research in research and development in the area of magnetic sensors and their application to magnetic anomaly detection. His experience also includes field deployment of magnetic sensors, incorporation into fielded systems, and fusion with complementary detection technologies. His recent interest includes the application of the Unique Man-Portable Fluxgate Gradiometer Tracking System for dual-use initiatives.

Abstract

Current demilitarization will allow the return of large tracts of land to the private sector. It is imperative that all energetic materials be located and removed before public release. A large percentage of this material is associated with significant ferrous content such as bomb shells, steel drums, etc. that can be detected by appropriate magnetic sensors. Due to their vector nature, conventional fluxgate magnetometers are able to both detect and localize such targets. However, in the past these magnetometers have been limited to stationary applications due to large motion noise caused by their movement in the earth's magnetic field. Due to the magnetometers' small relative size and costs, many potential UXO-related applications would be generated if this noise problem could be circumvented.

This presentation describes a hardware solution coupled with software algorithms that allows the use of inexpensive fluxgate magnetometers to collect high quality real-time localization data while the sensor system is in motion. This technology breakthrough was accomplished by connecting four three-axis magnetometers in a series of novel three-sensor gradiometers. A Helmholtz feedback coil system is used to both increase the system's dynamic range and also reduce motion noise. The third sensor in each gradiometer triad is used as a reference sensor with its output used to generate the required feedback currents that place each of the other gradiometer sensors in a nominally zero-field state. This forces all output voltages to very near zero voltage under the condition of zero magnetic gradient. The required highly accurate and sensitive magnetic gradiometric differences may now be accurately derived even in the presence of very large magnetic fields. Coupled with newly developed software algorithms, significant real-time detection and tracking capabilities have been demonstrated against ferrous targets of all types. This technology has many obvious applications in areas where other technologies are limited, such as for buried objects, including underwater targets and targets that are obscured from visual detection. Its ability to be unaffected by media interfaces and provide real-time localization data make it an ideal candidate for sensor fusion with other selected technologies that enhance not only the detection range, but classification and clutter rejection capability as well.

While the described sensor system is still in the prototype development stage, the involved technology has no technical barriers that would prevent it from ultimately evolving into a small, fieldable, man-portable system. The advantages of the technique are its simple implementation and its applicability to a wide variety of targets and scenarios. Several potential areas of application will be reviewed, and the technology's advantages and limitations discussed. The utility of this technology has been demonstrated by a hardware prototype funded by SOCOM and designed for diver applications. The Army Corps of Engineers also instigated a task to apply the laboratory prototype to land-based UXO applications. Results of these efforts and representative data and magnetic tracks are presented.

Subsurface Ordnance Characterization System

Presenter: Ed Brown. Mr. Brown works for the U.S. Air Force, Wright Laboratory at Tyndall Air Force Base as the technical director of robotics.

Abstract

Many government active and formerly used military bases are contaminated with unexploded ordnance (UXO). To determine what remediation efforts are required to clear these areas, decision-makers need accurate site characterization techniques. The Subsurface Ordnance Characterization System (SOCS) was developed as a test platform to evaluate the performance of different combinations of sensors, navigation systems and data analysis techniques for the detection, identification, and localization of buried unexploded ordnance at these contaminated sites.

Because the topography, geology, type and concentration of ordnance present at these contaminated areas are vastly different, the sensors and survey methodologies used to characterize these areas must correspond to the sites' environments. SOCS is a tool developed by the U.S. Army Environmental Center, the Naval Explosive Ordnance Disposal Technology Division and Wright Laboratory/Tyndall Air Force Base that can be used to determine the boundary areas of contamination, the concentration of buried UXO, and the locations of specific targets. SOCS currently utilizes ground penetrating radar, cesium vapor magnetometer sensor technologies, autonomous survey capability, and simultaneous data analysis and storage processes to acquire and store raw sensor data with time and position information. This data can then be post processed to determine the location, identification and classification of buried UXO. SOCS utilizes complex resonance and synthetic aperture radar processing techniques to analyze radar data. These techniques provide a means of distinguishing between actual UXOs and clutter, and can provide better localization techniques. Magnetometer data is processed using an automated processor.

In 1995, SOCS demonstrated at Tyndall Air Force Base in Florida and Jefferson Proving Ground in Madison, Indiana. These two environments are drastically different: one is dry sand, while the other is moist clay. A description of SOCS and system capabilities will be presented in the paper in addition to test results from each of the demonstrations and evaluation of ground penetrating radar and magnetometer sensor technologies at these sites.

Mine Detection With Modern Day Metal Detectors

Presenter: Gerhard Vallon, Dipl.-Ing. Mr. Vallon is president of Vallon GmbH, which has over 30 years experience in the development of magnetic instruments in the areas of UXO and mine detection. Vallon products are considered state-of-the-art and are in use worldwide by EOD professionals. Current developments include computer-aided systems with in-house software data processing programs.

Abstract

Application

To remediate and render safe an area which is contaminated with ammunition and mines, the surface must first be cleared from these explosives. This can be accomplished by two different methods:

1. Mines

   Mines must be detected with a handheld mine detector and immediately removed/deactivated. This work can be very fatiguing for the operator and can only be done manually. So-called efficiency methods which use heavy machinery or explosives are not recommended because it cannot be ensured 100 percent that the mines will be destroyed. Further, a lot of metal fragments will be scattered over the area rendering it impossible to scan the area again.

2. Explosive Waste and UXO

   For the detection of OEW (mines excluded), both metal detectors and magnetometers may be used together to clear surface and subsurface targets. Advanced detection systems are available which will produce target lists and maps to assist with the removal of these items.

Detector Selection

For both of the above-noted methods, metal detectors are required. A large variety of detectors are available on the market. However, only a select few models will meet the safety and detection needs for mine detection requirements.

Commercial advertisement from some companies claim detection statistics which are often only with reference to level ground conditions (i.e. desert sands, roadways). Understandably, under these ideal conditions there are several mine detectors which will produce desired mine detection results with little differences. However, "real world" conditions, often overlooked by novice users, are left out during the detector selection process.

Ground / Shallow Water Conditions

The following field conditions are typical considerations which are commonly encountered:

- Searching on very uneven surfaces
- Searching in brush, high grass, and along narrow pathways
- Searching along embankments and cliffsides
- Searching in muddy soil, magnetite soil, saltwater / soil
- Extreme weather conditions

This means a metal detector (mine detector), should work to its optimum level in all conditions to ensure reliable and safe operation.

Moreover, the detection sensitivity must be very high to detect both small metal items such as firing pins in plastic mines, and larger metal targets at a greater distance below the surface. In warfare scenarios, small AP mines may be placed in close proximity to larger AV mines. The detector should be able to detect and discriminate these different targets to avoid detonation.

These requirements can only be fulfilled by a "modern day" mine detector with highly sophisticated electronics combined with an optimum physical design. For this purpose, Vallon GmbH produces its model ML1620B along with several variations for special user requirements.

Specific details from Vallon, such as the patented "Oval" search head design, are highly suitable for searching under brush and near rocks, etc., and allow the user to maintain a necessary minimum distance between the search coil and the target. Additionally, this open frame design allows a clear view of the search area to the operator and the light-weight design reduces fatigue.

Target Response

As the complete information of a target detection is received from the search head, a very clear and unmistakable audio alarm signal is produced by the ML1620B detector. This signal not only alerts the operator to the target but helps to pinpoint the center of the target with high accuracy.

This means that the produced audio signal must be proportional in volume and frequency to the size of the metal target and to the detection distance and must not contain any other information. Interference from metal debris or other targets outside the detected target must be discriminated or the operator will fatigue quickly and reduce the safety level of the operation.

Measuring Principles

Modern day mine detectors typically consist of one or several induction coils which are controlled by an electronics unit. Each metal detector emits an electromagnetic field which will be influenced proportionally by the amount of electricity and magnetic conductivity within its slope. However, not only mines or other man-made objects belong to the electromagnetic influences of the detector. Mineralized soils, water with chemical contamination, and salt water conditions will produce false alarm effects or reduce the detector's sensitivity level without the operator's awareness.

Therefore, it is absolutely necessary that the metal detector uses a measuring principle which does not produce false signal indications under the full variety of ambient conditions (the detector must also adapt instantaneously to changing ground conditions without the need for operator adjustments). For this purpose, either a single coil design, which serves as both transmitter and receiver, or a multi-coil design (one transmitter coil and two receiver coils) may be selected.

These coils may be supplied by an electronics source of either a "sinewave" or "pulse" induction.

A. Sinewave detectors emit a permanent electromagnetic field which will be influenced by magnetic or electrically conductive materials in amplitude, frequency, and phase. These detectors are directly influenced by the conductivity of the ground conditions. Only via electronic manipulations are the false alarms reduced to lower levels.

   One known hallmark for a sinewave detector is the ability to obtain a high sensitivity detection level.

It is possible to use these detectors in water, but they are really only practical for ground search applications.

B. Pulse principle detectors are useable in both ground searching and underwater conditions. The ambient field conditions do not directly affect the detector's sensitivity settings. Therefore, a direct and reliable evaluation of the detection signal is possible. Typically the pulse detector does not achieve the same high detection sensitivity level as sinewave detectors. However, Vallon R & D has developed an "advanced pulse" detector which can detect at the same high sensitivity levels as the sinewave designs.

Underwater Conditions

Vallon has designed a metal detector for underwater and land use: model MW1630 (MK 29 MOD 0). As with the Vallon model ML1620B, this detector employs an "advanced pulse" principle. As detection signals can be very complicated and cause operator fatigue, many decision features are preprogrammed into the detectors. With the underwater use of these pulse detectors, the operator simply selects a level setting for detection and can concentrate fully on the searching operation. No adjustments are required during the work. The detector automatically adjusts to changing ambient / pressure conditions without loss of sensitivity.

In conclusion, throughout the world there are millions of mines in place which will require detection and removal. Mine detection in itself is a high-risk occupation. Apart from proper training, it is essential to have mine detectors that are both electronically and physically superior for the task at hand as the highest issue is confidence in detection and safety. The proper design and understanding of mine detectors is a highly specialized field with a limited number of manufacturers possessing the proper knowledge to produce top-line equipment. Operators of this equipment need to fully understand the parameters which are available and the value of having the highest reliable instrument possible.

NOTE: Technical graphs, charts, and pictures will be included in the final technical papers.

UXO Characterization Using A Remotely Controlled Vehicle

Presenter: Donald J. Green, MS Environmental Science. Mr. Green has been a project manager since 1990 for remedial investigations, feasibility studies, removal actions, remedial designs, and remedial actions at five study areas on Aberdeen Proving Ground (APG). These study areas include sites contaminated with World War I conventional and chemical munitions, as well as the U.S. Army's major test ranges for chemical warfare materials (post-World War II). Previous work has included GPR, EM and MAG surveys to delineate disposal and impact areas.

Abstract

A remote characterization system (RCS) is being used at APG Edgewood Area, a National Priority List site, to conduct geophysical surveys at Carroll Island. The survey is designed to verify the boundaries of potential burial sites, disposal pits, and munition impact areas as part of a Remedial Investigation being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act. APG is located within the Upper Chesapeake Bay; Carroll Island is a low-lying, flat, undeveloped island surrounded by estuaries. Approximately 20 percent of Carroll Island is uplands and 80 percent of the island is classified as wetland. Carroll Island was acquired by the Army in 1918, but not actually used until approximately 1944 when preparations were made to use portions of the island as a Chemical Warfare Materials (CWM) test site. Areas in the southeastern part of Carroll Island were also used as an impact area for munitions testing. All testing activities continued until 1969, when outdoor testing of CWM was ended by Presidential Executive Order.

The RCS is a prototype, and consists of three components: a remotely controlled low signature vehicle (LSV), a base station, and a Global Positioning System (GPS) antenna. RCS development was a coordinated effort among Pacific Northwest Laboratories, Oak Ridge National Laboratory, Idaho National Engineering Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratory. The LSV is designed with a minimum of ferrous metal to reduce any electromagnetic signature that might interfere with sensor operation. The base station houses the vehicle and system controls and monitors. Sensor readings flow continuously from the LSV to the base station. Differential GPS is used to track the vehicle in real time with an accuracy of less than a meter. GPS data can be processed to achieve centimeter accuracy.

To date, approximately 160 acres have been surveyed at four areas at Carroll Island using a proton precessional magnetometer, an electromagnetic sensor (EM-61), and ground penetrating radar (GPR). The LSV is designed to operate with all three sensors functioning simultaneously, offering an advantage over traditional surveys where each tool must be used independently. The vehicle can survey approximately 3 acres per hour and collects data at a rate of one reading per second.

Preliminary evaluation of the data indicates that the magnetometer is the most effective tool used at this site. The EM-61 is also proving highly successful. GPR data has not yet been fully evaluated, but preliminary results suggest that clay-rich conditions at the site are limiting the depth of radar penetration to a couple of feet. Hundreds of anomalies have been detected. Most anomalies can be attributed to man-made features associated with the sites. However, a handful of large anomalies have been identified that cannot be tied to known features or known past practices. Overall, RCS technology has been proven very effective at Carroll Island. It is more efficient than a traditional geophysical survey because all of the tools operate simultaneously. The greatest benefit of the RCS to APG is that as much data as needed can be collected with complete worker safety in areas with potential for CWM or other unexploded ordnance.

Application of Time Domain Electromagnetic Techniques to UXO Detection

Presenter: J. Duncan McNeill, MA Astronomy. As president of Geonics Limited since 1974, Mr. McNeill has been closely involved with the theoretical development of the non-contacting terrain conductivity instrumentation, the design of the EM33-3 helicopter EM system, and the geophysical aspects of the EM37, PROTEM transient EM system, and EM61, and continues to be very active in the development of all of the new electromagnetic techniques. He has authored several papers, many Geonics Technical Notes, and has presented papers dealing with both mineral exploration and the use of electromagnetic techniques for engineering geophysics at conferences in Europe, the Soviet Union, China and North America. He holds several patents in the application of electromagnetic techniques to geophysical mapping and prospecting. In 1993, Mr. McNeill was awarded the Society of Exploration Geophysicists "Enterprise Award."

Abstract

Detection and identification of buried UXO presents an extremely difficult geophysical problem. To date, magnetometers have been the most successful tools for this application, and are widely used. However, they have certain limitations (poor discrimination between different target types; non-detection of non-ferrous objects; response from induced and remnant magnetization, complicating survey interpretation and calculation of target depth; reduction of survey depth in soils containing patchy ferrimagnetic mineralization). For these reasons, the search continues for complementary or alternative techniques.

Time domain electromagnetic (TDEM) techniques have the potential to overcome many of these limitations. In such systems, a small transmitter loop (typical edge length of 50-100 cm) placed near the ground is energized with a current of several amperes, which is periodically terminated. The collapsing magnetic field from these currents causes small eddy currents to be induced in nearby metallic objects. The magnitude and decay rate of the eddy currents is determined by measuring their magnetic fields with a receiver coil located near the transmitter. The eddy currents decay exponentially with time, with a characteristic time constant which depends on the material, shape, and size of the body. For example, for approximately spherical bodies the decay time constant is determined by the electrical conductivity and the magnetic permeability of the target metal, and by the square of the target radius. For elongated targets, the time constant is also proportional to the conductivity and permeability but is proportional to the target thickness and the smaller of the other two dimensions. It will, therefore, be apparent that TDEM techniques offer, at least in principle, the ability to discriminate between different targets on the basis of their composition, shape, and size, thus overcoming the most significant limitation of the magnetometer. A reduction in the false alarm rate caused by junk metal would constitute a most significant advance in the state-of-the-art.

Further advantages of the TDEM techniques include excellent target location accuracy, good multiple-target resolution, ability comparable to that of a magnetometer to obtain depth to a target, and of course the ability to detect non-ferrous targets. Major limitations of the TDEM technique are that it is an active technique with the (probably very small) chance of detonating UXO, the depth of exploration is somewhat less than that of the magnetometer, and TDEM equipment tends to be bulkier because of the transmitter and receiver coils.

A commercially available TDEM metal detector, the Geonics EM61, was specifically designed to map buried metal at industrial sites. This device, which is a simple "metal detector," integrates under the time-decay response curve with one long time gate to detect the response from buried metal, and is thus incapable of

analyzing the response from different targets in the manner described above. Nevertheless, it has been used for UXO detection, and comparative case histories which illustrate the advantages of the TDEM techniques compared with a magnetometer for the detection of both UXO and industrial buried metal are presented.

Calculations which show the response from spherical targets of different metals and size are described, followed by a summary of the results of an extensive measurement program (using a complete TDEM system which analyzes the entire decay curve) to determine the TDEM response from a variety of dummy ordnance targets ranging from 20mm to 155mm shells. These data illustrate that different targets do indeed present measurably different time responses, suggesting that a TDEM detector, when used in conjunction with a magnetometer, may lead to significant improvements in UXO surveys, particularly with respect to false target discrimination.

Pulsed Electromagnetic Induction As A Detection Technology

Presenter: Peter J. Kaczkowski, Ph.D. Electrical Engineering. Peter Kaczkowski worked as an exploration geophysicist from 1982 to 1987, primarily in mining prospecting. In 1986, he obtained an MS in Geophysics from the Colorado School of Mines in Golden, Colorado, having worked with professors A. A. Kaufman and G. V. Keller on electrical and electromagnetic methods in geophysical prospecting. At the Applied Physics Lab, University of Washington, he worked on inverse problems and had the opportunity to apply geophysical prospecting techniques to the UXO problem. The paper presented at this conference summarizes a 1-year effort to do a preliminary evaluation of a pulsed EM induction technique for UXO detection and characterization.

Abstract

During 1995, a project was completed to assess the potential for the use of a Pulsed Electromagnetic Induction (PEMI) method for localization, characterization, and identification of unexploded ordnance (UXO). This project included modeling, hardware development, field work, and data processing. The final results of the project indicate that the PEMI method has significant potential for use in UXO target classification.

The PEMI method is an active electromagnetic technique that requires a transmitter system, a receiver system, a positioning system, and signal processing to interpret the data. The method works by setting up a primary magnetic field and then abruptly shutting it off, thereby creating an electromagnetic pulse which induces currents in nearby conductors. The currents decay due to resistive losses, creating a secondary magnetic field which can be detected above the surface of the earth. The rate of decay of the secondary magnetic field contains information about the size and conductivity and magnetic permeability of the object, and can be used as a classification tool. The PEMI system operates at very low frequencies compared to radar, and thus does not detect changes in the earth's composition. However, the decay time constant is very useful in determining the size of a metallic object. The spatial character of the secondary field can be used to locate the target. This program has successfully applied this method to characterize UXO targets and to test electromagnetic models describing PEMI responses of simple shapes.

PEMI models were developed as part of this project. This first model was the primary field model, which is used to compute the excitation magnetic field given a specific transmitter loop geometry. The other models were the target response and secondary field models, used for computation of the received signal from the currents induced in a target whose location and size are known.

During development of the models, data interpretation was performed by fitting a thin ring model response to measured data. Finding an optimal fit using the damped least squares (DLS) algorithm was very effective and efficient in both temporal and spatial processing steps. Results indicate that it is a straightforward process to implement such processing in a fieldable system. Accurate sensor position information is needed because of the highly localized target response.

A PEMI hardware system was configured to make basic measurements of responses from several real UXO. The system included a commercially available transmitter, designed for use in geophysical applications. Commercial receiving coils were not suitable for the UXO application since the scale of the geophysical and UXO problems is very different. UXO responses vary over distances which are very short compared to most geophysical features of interest. Therefore, two sets of 3-axis coils and receiver amplifiers were built for this program. Data was collected using a 9-channel Macintosh-based data acquisition system. The data acquisition software was specifically designed for this program to permit in-field monitoring of data quality.

The data acquisition system developed for this test was flexible, but complex to use. The transmitter driver worked, but was not optimized for the problem. The commercial system was designed to measure responses with more rapid decays (broader band) and was overdesigned for this application.

Model validation was accomplished using surface targets (aluminum steel rings). Inert ordnance items were then characterized using the ring model parameterization. Testing and evaluation of the system was accomplished using buried inert ordnance items. This evaluation concluded that additional development is required, but that the PEMI method has application in the localization, characterization, and identification of UXO.

Multi-Sensor Towed Array Detection System (*MTADS*): An Automated High-Efficiency Survey System for Characterization of Ordnance and Explosive Waste (OEW) Sites

Presenter: J. R. McDonald, Ph.D Chemistry. Dr. McDonald has managed programs for over 10 years to develop technologies for the detection and characterization of unexploded ordnance (UXO) and hazardous, toxic, and radioactive waste landfills. Developed technologies have all been based upon vehicular towed-array sensor surveys directed and correlated using real-time navigation. Work station-based data analysis capabilities have been developed for recognition and characterization of buried objects.

Abstract

The Naval Research Laboratory is developing a Multi-Sensor Towed Array Detection System (*MTADS*) with support from the DoD Environmental Security Technology Certification Program (ESTCP). In this effort, we seek to extend and refine ordnance detection technology to more efficiently characterize OEW sites, to include nonferrous and small ordnance items, to distinguish ordnance from clutter, and analyze clustered targets to identify and locate individual targets within complex target fields. Both magnetic and electromagnetic sensors are employed in arrays towed by a low magnetic signature vehicle. Survey guidance and navigation, based upon DGPS/RTK technology, is supplemented by dead reckoning navigation aids.

Workstations are used for data processing and analysis. Data processing steps merge and time-correlate all data streams, carry out data quality analyses and conditioning, and display data as site maps and images. Data analysis tools are used to spatially process interactively selected targets determining position, size, depth, orientation and inclination. Target information from magnetometers, gradiometers and electromagnetic sensors is correlated and target tables, output maps and images are created using graphics tools. Electronic output files are created for use with the survey vehicle to waypoint targets for remediation.

The Phenomenology of Detecting Buried Unexploded Ordnance

Presenter: Dr. David A. Sparrow, Ph.D Physics. Dr. Sparrow has worked on the detection of targets in cluttered backgrounds in a variety of defense applications. In addition, he has worked on fusion of information from multiple sensors, and the requirements on both signatures and backgrounds necessary for multi-sensor fusion to enhance the performance available from a single sensor. This experience was applied to the Jefferson Proving Ground Demonstration of unexploded ordnance (UXO) detection identification and remediation technologies, and the Environmental Security Technology Certification program.

Abstract

The need for and difficulties associated with clearing land contaminated with UXO is attracting increased attention as a result of the base closure process and as a result of recent high profile clearance activities in built-up areas. The importance of executing a complete clearance, with confidence on the part of both experts and the public that the clearance is complete, places a premium on effective detection of buried UXO. This is equally true for clearance on formerly used defense site already in the public domain, such as Camp Elliot, CA and Camp Springs, Washington DC, and for defense sites in the process of being released, such as Jefferson Proving Ground, IN and Fort Ord, CA.

The resulting increased emphasis on the detection of buried UXO has led to a number of initiatives based on sensing technologies used in other areas, such as environmental monitoring, geological research and prospecting, and military reconnaissance and surveillance. However, the targets, backgrounds and operating conditions in these traditional sensing areas are substantially different than in UXO cleanup. Thus we examined which aspects of targets, background and operating conditions limit the detection capability of current and proposed approaches to the detection of buried UXO.

The paper will cover target signatures, signal propagation from the target to the sensor, system sensitivity, and background discrimination. The effects of target size, depth and orientation, geological character of the ground, available system sensitivity and the sources of background signals will be discussed for magnetometers and ground penetrating radars. Magnetometers are passive sensors, with signal propagation essentially independent of the geology, and recent dramatic improvements in system sensitivity. Ground penetrating radars are active systems with signal propagation which depends on both the geology and the chosen radar frequencies, and recent innovations in signal processing aimed at improved background suppression. We also include brief discussions of the phenomenological issues for induction coils (electromagnetic sensors) and laser, infrared and thermal neutron systems aimed at surface and near surface detection.

Tuesday, March 26, 1996
Session B
Amphitheater

Army Requirements for Explosives Safety Submissions for Removal of UXO and Release of Property

Presenter: Clifford H. Doyle, BS Sociology & Speech Communication. Mr. Doyle has worked in the munitions field for over 20 years, with experience in ammunition production, shipping, storage, maintenance, and demilitarization. He has investigated numerous ammunition accidents and taught extensively in the field. For the past 2 years his efforts have focused on UXO remediation, and he is drafting an Army explosives safety policy on the subject.

Abstract

The Department of Defense Explosives Safety Board (DDESB) must approve UXO removal and property release for property to be released outside DoD control due to BRAC or any other reason. The military service prepares an explosives safety submission and submits it to DDESB for this purpose. DoD 6055.9-STD, DoD Ammunition and Explosives Safety Standards, October, 1992 provides a list of things these submissions must contain. The list is quite general. To provide more specific guidance, the Army is developing a detailed list of submission contents which implement the DoD requirements. These submissions address many aspects of the UXO removal and land disposal process, to include reuse considerations; history of the site which led to presence of UXO; expected types and amounts of UXO; boundaries of areas to undergo UXO removal; removal depths; techniques to detect, recover, and destroy UXO; Anomaly Review Boards; frostline considerations; land use restrictions; work site access control; and for chemical warfare materiel projects, details of PPE, monitoring, MCE, downwind hazard, medical and TEU support.

EPA's Proposed Military Munitions Rule

Presenter: David E. Bell, JD. Since passage of the Federal Facility Compliance Act in October 1992, Mr. Bell has worked as part of the DoD Munitions Rule Working Group. During the past 3.5 years, he has led a multi-disciplinary, quad-services team in developing and articulating the DoD's views on the appropriateness of applying environmental regulation to waste military munitions. His activities have included direct negotiations and discussions with EPA, other federal agencies, state regulators, private corporations, and environmental interest groups. Mr. Bell is also working as part of the DoD team that is developing the DoD's Range Rule, which will set forth a response process for addressing military munitions on closed, transferred, and transferring ranges.

Abstract

On November 8, 1995, EPA published its long-awaited proposal to regulate waste military munitions under the Resource Conservation and Recovery Act (RCRA). The rule stems from Congress' mandate in Section 107 of the Federal Facility Compliance Act of 1992 to propose regulations defining when military munitions become a hazardous waste and providing for their safe transportation and storage. EPA must do so in consultation with DoD and state officials. After 3 years of consultation, EPA must now address the comments received during the almost 3-month formal comment period and publish a final rule by Fall 1996.

This 40-minute presentation will examine EPA's proposal for defining when military munitions become a waste; promulgation of new storage standards; limited relaxation of transporter requirements; exemption for emergency response activities; expansion of the definition of "on-site"; and application of RCRA corrective action to closed and transferred military ranges. The presentation will also address issues raised in the 132 comments that EPA has received, including those of the DoD, the states, industry, and environmental groups.

The DoD Range Rule

Presenter: Karen Heckelman, JD. Ms. Heckelman is the legal counsel on the Range Rule writing team. She was also been a member of the DoD munitions working group for the past 2 years. Ms. Heckelman is currently working at the U.S. Army Environmental Center where she primarily handles hazardous waste and water issues. Ms. Heckelman previously worked for 4 years with the Dow Chemical Company on CERCLA and RCRA issues.

Abstract

Background

Section 107 of the Federal Facility Compliance Act (FFCA) of 1992 amended the Resource Conservation and Recovery Act (RCRA) and required the U.S. Environmental Protection Agency (EPA) to propose regulations identifying when conventional and chemical military munitions become hazardous waste under RCRA. EPA issued its proposed rule on November 8, 1995, and this proposed rule discussed military munitions on ranges. EPA stated in this proposal that munitions remaining on closed and transferred ranges would be considered "solid waste" according to the RCRA statutory definition of RCRA section 1004(27). However, the EPA proposed rule also stated that if the Department of Defense (DoD) promulgates rules, pursuant to DoD's own statutory authorities, that allow for public involvement in addressing closed, transferred (i.e., the range property is transferred from military control), and transferring military ranges and if the DoD rules are fully protective of human health and the environment, then the DoD regulations would supersede RCRA regulations. (See 60 FR 56476 [November 8, 1995]).

The DoD proposal is in response to this EPA "sunset" provision. DoD's proposal would clarify that munitions on closed, transferred, or transferring military ranges are not considered solid wastes under RCRA. Actions to address the unique explosive safety considerations associated with munitions and the need for environmental protection will be addressed under the Defense Environmental Restoration Program (DERP), Department of Defense Explosive Safety Board (DDESB), and CERCLA authorities rather than RCRA.

Summary of DoD Proposal

DoD's proposal identifies a process for evaluating response actions on closed, transferring, and transferred military ranges. These response actions must fully encompass safety, and be protective of human health and the environment.

Closed ranges would include those ranges that are within military control, but are put to a use incompatible with range activities. Transferring ranges include those ranges associated with Base Realignment and Closure (BRAC) activities, and other property transactions to non-DoD entities. Transferred ranges include those identified in the Formerly Utilized Defense Site (FUDS) program.

DoD's propose rule contains a two-part process with presumptive response options. The first part is a Range Assessment, in which a presumptive response involving various protective measures, including monitoring, is implemented. The Range Assessment will determine if the protective measures are sufficient to protect safety, human health, and the environment. If the protective measures in and of themselves are not sufficient at a specific military range, then the second part, the Range Evaluation process, will be initiated. The Range Evaluation process includes data collection to support a safety risk assessment and a site specific human-health risk assessment. At the completion of the Range Assessment and/or Range Evaluation phase, DoD will issue a decision document after input from federal and sate regulators and the public.

DoD expects its proposed rule to be published in the Federal Register in April 1996. This will be followed by a 69-day public comment period and public availability sessions. For further information, contact the DoD Range Hotline at 1-800-870-6542.

Explosive Ordnance Disposal Technology Coordination

Presenter: Christopher O'Donnell, BSME. Mr. O'Donnell is currently Director of Technology for NAVEODTECHDIV, and was Block Manager for EOD Technology from 1992 to 1995. He developed explosive mine countermeasure systems such as DEMNS, APOBS, MICLIC, and lightfoot from 1986 to 1992, and was Panel Chair for EOD Technology for Joint Directors of Laboratories.

Abstract

The Department of Defense, Joint Service Explosive Ordnance Disposal (JSEOD) Program is chartered to provide technology and training for military EOD forces. All of the technologies developed under this program are related to the detection, access to, identification, rendering safe, and disposal of unexploded ordnance (UXO). Coordination of these technologies is accomplished through a yearly planning cycle that culminates with the adoption of a cohesive EOD technology plan by the JSEOD Program Board. This paper will address the factors behind the establishment of the needs for this plan and the technical programs planned to fulfill these needs.

A technology assessment was performed in 1992 to determine the military EOD needs for technology for missions related to UXO. After review of this assessment, a plan was established to address five major need areas: Clearance of Improved Conventional Munitions, Improvement of General Tools, Response to Improvised Explosive Device/Special Improvised Explosive Device Incidents, Standoff Detection of Ordnance, and Neutralization of Underwater Ordnance. These areas provide the framework for coordinating EOD UXO work funded under 6.2, 6.3, MFP-11, 6.4 and OM&N funding.

Improved Conventional Munitions (ICM) are the family of explosive ordnance that are deployed in air-dropped, tube-launched or hand-emplaced canisters and dispensed over a wide area. This family includes mines and anti-vehicle (armor and soft skinned), anti-materials, and anti-personnel submunitions. Many of these ICMs contain Electronic Safe and Armed (ESA) fuses which contain advanced sensors. The major needs in this area are to develop robotic and standoff techniques for determining the status of the fuses and removing the ICM from battlefields, ranges, and formerly used defense sites.

EOD technicians historically have used explosively driven tools and remotely operated vehicles to perform render safe procedures. Needs also exist to reduce the signature of EOD technicians/tools and to provide low influence communication equipment. This areas focuses on providing near-term solutions to these issues.

The EOD technician is called upon to search for, access, diagnose and disable devices that contain conventional and unconventional explosives that have been placed by terrorists or disgruntled persons. Increasing the capability to search for the device and any booby traps, avoid/eliminate booby traps, and examine and disable the device from a standoff distance will allow the EOD technician to counter constantly increasing anti-intrusion sensor threats that are available from local hardware stores and electronic shops.

Detection of deeply buried (>10 ft) ferrous ordnance and shallow buried (>4 in) plastic UXO is a problem for EOD technicians for runway repair and range clearance. The proliferation of ICM provides a surface contamination threat that is difficult to detect with the naked eye in even light foliage conditions. A wide range of Commercial off-the-shelf (COTS) sensors and signal processing algorithms are currently being demonstrated by the Naval EOD Technology Division for the Army Environmental Center. This area extends the capabilities of the most promising of these technologies for use by individual EOD technicians.

The Navy EOD diver is called upon to perform render safe operations against all types of threats located in

shallow to very shallow water. This area focuses on providing the EOD diver with technologies that will increase their ability to find and examine underwater threats prior to performing the render safe operation.

UXO Investigations in Limestone Hills, Montana

Presenter: Clifton C. Youmans, Ph.D. Dr. Youmans has spent the past 3 years working to resolve issues surrounding UXO in the Limestone Hills. His academic background is in large-scale systems analysis and statistics.

Presenter: Alan T. Frohberg, P.E., BS Geophysical Engineering. Mr. Frohberg has managed numerous geophysical, geologic, water-resource, and environmental projects including military ordnance investigations, geological characterization, hazardous waste remediation, environmental site assessments, and engineering design.

Abstract

Past actions by the Montana Army National Guard (MT ARNG) resulted in contamination of Bureau of Land Management (BLM) land in Limestone Hills, Montana with unexploded ordnance (UXO). A limestone quarry and lime plant owned and operated by Continental Lime, Inc. (CLI), of Salt Lake City, Utah was prohibited from expanding its quarry operation and hence faced loss of vital ore reserves due to danger from UXO. The MT ARNG was faced with quantifying the UXO danger with limited funding and resources while under the double threat of litigation from CLI and revocation of its lease with the BLM. An emergency closure of several thousand acres of public land was implemented by the BLM until UXO danger could be adequately addressed. This closure was highly unpopular with the recreating public, further leading to adverse publicity. This paper discusses actions taken by the MT ARNG to preclude litigation and retain continued use of the Limestone Hills for training. Funding limitations imposed by DoD rules are discussed.

When UXO contamination stems from National Guard rather than active component training, assessment and remediation become primarily a state responsibility. Determination of potential risk from UXO on public land is complex and costly and no adequate technology exists to perform a risk assessment based on empirical findings. DoD regulations on UXO assessment and remediation may conflict with statutes governing public land. While DoD remains a responsible party with respect to liability, it has no real authority regarding management of UXO-contaminated public land unless a land withdrawal occurs.

MT ARNG personnel performed the preliminary assessment and the site investigation with technical oversight from the Army Corps of Engineers. This was done at a savings of approximately $500,000 over the cost of contracting the work. A detailed sampling plan was produced by the MT ARNG Environmental Office for subsurface survey of the area using magnetometers. An experienced geophysicist was contracted to provide technical oversight and quality assurance/quality control of the magnetometer survey work. Active, Guard, and Reserve explosive ordnance disposal (EOD) teams from three service branches surveyed 12 percent of the area. Results were analyzed in house and shared with the Guard Bureau Safety and Army Technical Center for Explosives Safety. This work was done at an estimated savings of $750,000 over the cost of contracting. The area was determined to be safe to mine and no shutdown of mine operations was necessary. CLI and the MT ARNG continue to share the Limestone Hills in a cooperative manner.

UXO Remediation at the Umatilla Depot Activity

Presenter: Charles Lechner, Ph.D Chemical Engineering. Dr. Lechner managed the RI/FS at the Umatilla Depot Activity during selection of the ordnance clearance remedy.

Abstract

The Umatilla Depot Activity (UMDA), a National Priorities List site located on almost 20,000 acres in north-central Oregon, contains a 1,750-acre area known as the Ammunition Demolition Activity (ADA) Area, where munitions and propellants have been disposed of by open burning/open detonation (OB/OD). Although recent OB/OD operations were restricted to small areas of the ADA, historic operations were known to have covered much larger portions of the ADA, with specific information being scarce or nonexistent. Because of the uncertainty, all of the ADA was considered suspect for UXO.

The ADA area contains 20 sites that were investigated for soil and groundwater contamination and cleanup as part of UMDA's Remedial Investigation/Feasibility Study (RI/FS), conducted under a Federal Facility Agreement (FFA) with the U.S. Environmental Protection Agency and State of Oregon. The RI/FS included UXO clearance to permit site access and sampling activities. However, no measurement of UXO density was made as part of RI site characterization since UXO was considered a safety matter rather than a contamination issue. During comparison of the cleanup alternatives in the FS, UXO clearance was included and UXO removal costs were estimated as a necessary precursor to safe excavation of the soil contamination sites. Also, because UMDA is a BRAC I site, future non-Army uses of the property are likely and various levels of ADA-wide UXO clearance were considered as necessary precursors to safe property reuse.

During negotiation with the regulatory agencies concerning the extent of UXO clearance, and UXO's applicability to the RI/FS, extensive coordination with the Department of the Army (DA) was performed to help ensure that the position at UMDA was not contrary to the DA CONUS UXO policy. The fact that UXO density was not known, but was the major factor affecting costs, was a concern to the Army. The completion of such negotiations was hastened by the stipulated penalty provisions of the UMDA FFA. The Army and regulatory agencies eventually agreed in early 1994 upon a UXO cleanup standard and documented it in a Record of Decision. This involves an initial surface clearance, and later subsurface clearance to depth ranges to meet various land reuse scenarios. During surface clearance, the Army also planned to perform a subsurface clearance of 10 percent of the ADA area to determine the subsurface density of UXO items and to refine the UXO-removal cost estimates.

The surface clearance work is being conducted in 1995. Significantly higher numbers of ordnance and metallic objects are being found over larger areas than originally estimated. The types, locations, and depths of the items are being recorded in order to prepare a refined cost model. Such refined costs will be used in determining the cost and feasibility of additional subsurface UXO removal, and the types of future land uses that the ADA area can support.

Records Analyses Saves Time and Money

Presenter: Daniel J. Holmes, PE, MS Civil & Environmental Engineering. Mr. Holmes performed and supervised the preparation of archive search reports, expanded site inspections, and safety submissions for the Huntsville Engineering and Support Center for over 5 years.

Abstract

The purpose of this presentation is to provide a summary of one critical step in the ordnance and explosives (OE) program environmental response process. This step provides OE project managers with response strategies and priorities that establish clear and defined subsequent contract actions. This step involves the use of experienced ordnance professionals reviewing historical records, performing site inspections and interviews, and evaluating ordnance usage data. The completed analyses are published in a site-specific Archive Search Report (ASR). These evaluations have been accomplished as part of the Defense Environmental Restoration Program, Formerly Used Defense Sites (DERP FUDS). All OE work has been performed under the direction of the Corps of Engineers' Huntsville Division.

Technical OE Team

Experienced and qualified professionals are the number one mark of performing first-class ordnance evaluations. The OE team is comprised of unexploded ordnance (UXO) specialists who are former active duty EOD persons, Army ammunition specialists, archival record research specialists, chemical engineers, chemists, civil/environmental engineers, industrial hygienists and engineering technicians. There are more than 300 years of in-house technical ordnance experience available as each project is evaluated.

OE Response Process

The OE response process starts with a preliminary assessment of the site to determine if the site is eligible under the DERP FUDS program. An ASR is tasked to the Rock Island District for select sites. If there is an imminent safety threat at any time during the response process, a Time Critical Removal Action (TCRA) for removal of immediate hazards within the site is initiated. For many sites, an Engineering Evaluation/Cost Analysis is performed for the entire site to further quantify ordnance contamination and confirm response strategies/contracting packages. Contracting options are then implemented to complete the response action. The process closely follows the CERCLA remedial response procedures.

OE Records Search

Historical records are searched and obtained from approximately 100 government (federal, state, local) repositories located throughout the United States and another 25 non-government sources (national, state, local). Approximately 50 National Archives and Record Administration Record Groups are searched along with an additional 65 War Department File System files for each site. The search includes both classified and non-classified holdings and involves all types of OE documents. Typical documents include texts/manuals (TMs, FMs, supply catalogues /bulletins, TOEs), reports/studies (past histories, clearance reports, blotter reports), letters/memorandums, real estate documents, aerial photographs, and maps/engineering drawings. Ordnance specialists oversee this phase for document usefulness and relevancy.

OE Records Evaluation

The OE records are analyzed by a team of ordnance specialists. Typical analyses include production/ manufacturing practice (process analysis, waste streams, decontamination procedures), usage (range fans, target hazard zones, trajectory analyses, delivery weapon analyses), storage practice (includes re-conditioning and item maintenance), and disposal practice (burn pits, demolition ranges, burial sites).

Site Inspection

The site is inspected by several ordnance specialists and other professionals as needed. Military ordnance expertise is again critical during this phase to correctly recognize and field evaluate ordnance presence. Field GPS equipment and magnetometers are used for surface/visual searches. Site interviews by the same qualified ordnance specialists (who have a full understanding of common ordnance practice at the time) with local authorities and owners can readily substantiate the truth regarding present day ordnance. Many sites reveal an immediate OE hazard that requires an EOD response.

Response Strategy

The results of the above evaluations and analyses are published in the site ASR. Careful documentation of all sources is provided to allow independent verification of conclusions. Copies of all relevant historical documents are provided along with new OE evaluations and rationale. Particular emphasis is placed on segmenting the entire site into multiple homogenous "OE Project Areas." Homogenous areas are based on considerations of former and present land usage, OE contamination, current land ownership, political boundaries, and real estate standard practice. CAD drawings following tested layout procedures are produced which are then used throughout the remaining phases of the OE response. Overall recommendations include a risk assessment of each OE project area to ensure that high priority areas are addressed first. After completion of the ASR phase, a correctly completed ASR can continue to provide a road map or master plan for all subsequent OE response work.

Wednesday, March 27, 1996
Session A
Auditorium

UXO Remediation and Disposal Technologies

Presenter: William T. Batt, MS Chemical Engineering. Mr. Batt is a retired U.S. Army Chemical Corps Officer and a qualified Explosive Ordnance Disposal Officer. During his career, he was assigned to the PM for Chemical Demilitarization in Edgewood, Maryland, where he was a project engineer on the Chemical Agent Munitions System (CAMDS) project and helped research and write the *Long Range Chemical Demilitarization Concept Study*, USATHAMA, October, 1981. His last position was Lead Engineer during the preliminary concept design phase for the Johnston Atoll Chemical Agent Disposal System (JACADS). He was later assigned to the U.S. Army Technical Escort Unit from 1987 to 1993 as the Executive Officer, Operations Officer and Commander. During this period, TEU responded to hundreds of events involving chemical agents, chemical munitions and conventional ordnance. Mr. Batt was instrumental in the planning and operational phases of the movement of the U.S. chemical munitions from Germany to Johnston Island. He was the commander of field forces during the emergency response phase of the recovery and disposal of WWI chemical-filled and conventional munitions from Spring Valley, Washington, D.C. Mr. Batt has been employed by UXB International, Inc., since June, 1994, as a project manager, senior project manager and now as Director of Operations. UXB was the first commercial unexploded ordnance contractor in the U.S. Since 1984, UXB has provided ordnance and explosives remediation services throughout the United States and in several foreign countries.

Abstract

Until recently, there were no remediation programs to clean up public or private property, or even government property, that may have been contaminated with military chemical agents. What was available was an emergency response capability resident within the U.S. Army Material Command (AMC). Command and control was vested in the headquarters of the U.S. Army Armament, Munitions and Chemical Command (AMCCOM). The field response elements were provided by the U.S. Army Technical Escort Unit (TEU) with agent monitoring and analysis support provided by the Chemical Research, Development and Engineering Center. The remedial action was simply TEU responding to the scene of chemical agent or chemical munition contamination, assessing the problem, packaging the item(s) for transport, and escorting the cargo to a chemical surety material (CSM) site. Soil that was grossly contaminated with a chemical agent was remediated, typically by a limited removal action, and certainly not as a hazardous toxic and radiological waste (HTRW) response action.

In the late 1980s, an ordnance and explosive waste (OEW) program was developed by the U.S. Army Corps of Engineers (USACE) that included chemical munitions. This program became the responsibility of the new Mandatory Center of Expertise (MCX) for OEW within the USACE, Huntsville Division (USAEDH). The MCX quickly learned that CSM remediation sites presented them with unique and challenging problems. The MCX recognized the need to coordinate with AMC and AMCCOM to develop requirements and procedures for investigating CSM-OEW sites. A Memorandum of Understanding was drafted between the MCX, the newly established Chemical and Biological Defense Command (AMCCOM elements) and the newly established U.S. Army Chemical Materiel Destruction Agency (USACMDA). The USAEDH is now in position to award OEW remediation contracts that contain provisions for sites that may contain CSM. Serious policy issues have begun to drive wheels of change.

The USACMDA became involved by way of a newly assigned mission--that is, demilitarization of non-stockpile chemical materiel. A new element of USACMDA was created to oversee this mission; its title is Project Manager for Non-stockpile Chemical Materiel (PM NSCM). The PM NSCM is initially involved with storage, transportation and eventual disposal of chemical material recovered from OEW remediation sites. So we now have a joint CSM remediation alliance comprising contractor, USAEDH and USACMDA elements to discover and recover (with the first two parties) and pack and ship (in coordination with

USACMDA). It soon became obvious to all parties in the CSM remediation program that applying CSM rules to OEW remediation programs was impractical. As Army regulations were reviewed for change, the USAEDH moved ahead with its OEW remediation program and the USACMDA moved ahead with its demilitarization program. Eventually, some rules regarding CSM changed. Now, when chemical agents, chemical munitions or containers of toxic chemical agents are found, they are considered to be hazardous waste. The Resource Conservation and Recovery Act or the Comprehensive Environmental Response, Compensation, and Liability Act now drive recovery actions.

A major step forward in the program to resolve the problem of recovered CSM was the USACMDA release of a procurement action to acquire contractual services for disposal of recovered chemical warfare materiel (CWM)--the new term for previously discarded CSM.

The remainder of the paper is a discussion on where the new contract called "Small Burials Contract" is going. The contract was awarded on June 1, 1995. I will provide current information on the time line and direction of the contract as of the date of the UXO Forum.

Applicability of Commercial Procedures and Technologies to the Destruction of Chemical Weapons Material

Presenter: Norman J. Abramson, MS Industrial Psychology. Mr. Abramson directs the Program Management of Earth Resources Corporation's (ERC) initiatives and government programs involving both high hazard chemical remediation and chemical demilitarization projects, including ERC's role as a member of the *Team Teledyne* Small Burials Program. His experience with ERC includes directing high hazard chemical remediation projects on Department of Defense and Department of Energy facilities. Mr. Abramson has authored a number of published articles on the protocols and systems approach required to safely process/remediate highly hazardous materials.

Abstract

There are a number of chemicals commonly used in a variety of industrial processes that pose dangers which are comparable to or greater than those found in chemical weapons. Phosgene, cyanogen chloride, and chloropicrin all have industrial and agricultural applications and have been safely and effectively managed as hazardous wastes. In addition to these highly toxic compounds, it is not unusual for industrial wastes (in gas, liquid, and solid states) to include combinations of toxicities, pyrophorics, corrosives and oxidizers. Mobile systems specifically designed and developed for accessing, recontainerizing or neutralizing these high hazard chemicals are in commercial operation and have been permitted and successfully used in densely populated areas without incident.

The proposed paper/presentation will touch on the similarities between chemical weapons material and compounds used in industrial processes. The applicability of the protocols, procedures, and the commercial systems employed to manage hazardous chemicals in an industrial context with chemical weapons material will be discussed. Examples of the consequences of using inappropriate techniques and ineffective systems in dealing with hazardous chemicals will also be examined.

The *Convention on the Prohibition of the Development, Production, Stockpiling, and Use of the Chemical Weapons and on Their Destruction*, more commonly referred to as the Chemical Weapons Convention (CWC), has focused a great deal of attention in the past few years on this subject. In this country alone the cost to destroy the stockpiled and non-stockpiled chemical weapons material is being estimated in the tens of billions of dollars.

Programs for destruction facilities at fixed storage sites are receiving a high degree of public attention -- the techniques which will be used to mange on site the non-stockpiled material will quite probably engender even a higher degree of sensitivity and public scrutiny, if possible. The specter of over 2,000 people killed in Bhopol, India by leaking methyl isocyanate 10 years ago looms fresh in the minds of many. More recently, the effects of chemical weapons were illustrated to the international community by Iraqi military forces.

While dealing with hazardous chemicals or chemical weapons presents certain dangers, they are dangers that are well understood and can be mitigated with appropriate systems and procedures.

Chemical weapon agents stored at U.S. Army sites include both organophosphorus ester agents and mustards. The former are nerve agents which interfere with neural functions and the latter are blister agents or vesicants which cause injury to skin, eyes, and respiratory tracts. Exposure to either can be lethal.

Let's turn our attention now to what "works" in the civilian or commercial sector. While "mission" is often the overriding consideration in military operations, personnel safety is or should be a factor that is paramount in determining how a task is performed. In the civilian world, the "mission" is often avoiding litigation or regulatory penalties, with personnel safety the principal consideration in how the job is done.

Protecting people, property, and the environment while "efficiently" processing hazardous chemicals is stock and trade of firms like Earth Resources Corporation.

A number of systems and procedures have been developed as a result of catastrophic experiences or techniques that have been demonstrated to be ineffective. There is no substitute for sound engineering and disciplined procedures based on experience. A reasonably conservative approach when dealing with high hazard chemicals is based on the use of: (1) mobile systems to bring the solution of the problem, (2) multiple levels of containment to mitigate against the possibility of an unintential release, (3) remote handling techniques to minimize the risk to hazardous waste technicians, (4) highly trained and experienced technicians that have demonstrated history of working together as a team, (5) appropriate levels of personal protective equipment for the anticipated hazards, (6) systems designed with enough modularity that they can be reconfigured to adapt to unique circumstances that might be encountered during field operations, (7) on-line emergency treatment capabilities in the event of an unintential or uncontrolled release, and (8) the whole job done right the first time. This last point is comparable to the military's dedication to or priority placed on accomplishing the mission it is assigned. There's also a distinct economic advantage to doing a job just once.

I will show a number of commercial systems that have been successfully employed in dealing with materials that are not only extremely toxic but are often pyrophoric, shock sensitive, or powerful oxidizers.

Remediation of Chemical Warfare Materiel under CERCLA, A Case Study: Defense Distribution Depot Ogden, Utah Operable Unit 3

Presenter: Gary Enloe, BS Geological Engineering. Mr. Enloe serves as the Project Manager for the design and remediation phases of a CWM investigation and remediation. He is responsible for project definition and coordination, and preparation of technical documentation.

Abstract

This technical paper presents a discussion of the Defense Distribution Depot in Ogden, Utah (DDOU) Operable Unit 3 (OU 3) remediation. This project is unique because (1) the primary contaminants of concern include chemical warfare materiel (CWM), and (2) specific protocols for conducting this type of remediation are still being developed. The paper highlights critical considerations for conducting a CWM remediation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

OU 3 consists of several distinct burial areas in which chemical agent identification sets (CAIS) and other miscellaneous items were disposed. Under contract with the U.S. Army Corps of Engineers, Huntsville Division (CEHND), Montgomery Watson conducted the typical actions required under CERCLA, including conducting a Remedial Investigation/Feasibility Study (RI/FS) and preparing associated documentation, preparing a Record of Decision (ROD), and preparing detailed remedial design and remedial action documentation. The associated investigations and remediation were performed as a collaborative effort among DDOU, Non-Stockpile Chemical Materiel Program, CEHND, the U.S. Army Technical Escort Unit, and Montgomery Watson.

The presence of CWM at OU 3 required that the project team establish precedence in identifying those unique issues which require consideration at any CWM site. The following is a summary of key issues and considerations.

- **Disposal of CWM and Associated Soil and Debris** - Land disposal and/or incineration of soil and debris associated with CWM is not addressed by federal and most state hazardous waste regulations (Army Regulation 50-6 specifies that it must be handled in accordance with applicable environmental regulations; CWM itself must be maintained in the control of the military). However, it is highly unlikely that operators of licensed hazardous waste disposal facilities will accept material generated from a site similar to OU 3 because of the general nature of the material and the public's perception. The OU 3 remediation provides a unique case study in that the State of Utah has accounted for CWM in its hazardous waste regulations and has permitted local hazardous waste facilities to accept CWM-contaminated soil and debris. CWM (CAIS components) were transported to the Tooele Army Depot for storage and ultimate destruction.

- **Documentation Requirements** - The Department of Army requires that a "Safety Submission" be prepared for sites where CWM is expected to be encountered. This document presents a detailed description of the protocols to be implemented in the event of an encounter, including requirements for an interim holding facility and logistical considerations associated with transportation of CWM to an appropriate military installation. The Safety Submission and other key remedial documentation must be reviewed and approved by a number of military organizations prior to implementation of any intrusive activities.

- **Coordination** - As in the case of OU 3, stringent schedules are established during a CERCLA

investigation and remediation. Successful schedule maintenance for a CWM remediation under CERCLA requires a solution-oriented approach and a strong sense of partnership among all parties involved.

- **Specialized Training and Monitoring Capabilities** - Department of Army requirements dictate that those parties conducting a CWM investigation and/or remediation perform specialized on-site monitoring for CWM. Depending on the compounds involved, this may require several types of monitoring, including use of mobile laboratories.

The actions at OU 3 typify the standard requirements of CERCLA and establish precedence for other considerations associated with CWM. Successful remediation of this site has provided a valuable learning experience that will benefit future CWM cleanup efforts.

Mobile Munitions Assessment System Development

Presenter: Kenneth D. Watts, MS, Mechanical Engineering. Mr. Watts is currently the manager of the Mobile Munitions Assessment System project at the INEL. He has worked with a team of scientists that developed and tested laser acoustic systems which non-intrusively determined the contents of chemical munitions and containers. He also spent several years developing weapons detection systems for the Department of Energy's arms control program.

Abstract

The United States has been involved in the development, testing, storage and disposal of chemical weapons for nearly 100 years. As a result, there are numerous sites which contain the remnants of the chemical weapon program. These remnants are in the form of buried surplus munitions, munitions that did not detonate during testing and other forms. These items pose a significant human health and environmental hazard and must be disposed of properly.

The U.S. Army has been tasked by Congress with the remediation of all non-stockpile chemical warfare materiel. To help comply with this tasking, the Army Project Manager for Non-stockpile Chemical Materiel is sponsoring the development of a Mobile Munitions Assessment System (MMAS). The system is being developed by the Idaho National Engineering Laboratory and Dugway Proving Ground. The purpose of the system is to assess suspect munitions and containers, identify the fill, evaluate the fusing and firing train and analyze samples from the surrounding area to determine if chemical warfare materiel is present. The information gained from the application of the MMAS is intended to be used to establish the best method to handle and dispose of a given munition.

The MMAS is being developed in two phases. The first phase (Phase I) is the development of an initial response system. This system is intended to respond to emergency situations in cases where small quantities of munitions are found and an immediate assessment is required for safety or other reasons. The Phase I system will include radiography systems to assess the fill level and the status of the fusing and firing train, a Portable Isotopic Neutron Spectroscopy (PINS) system to identify the chemical elements in the fill, computer systems to record and store data, analytical equipment to monitor the immediate environment, a weather station, communication equipment, explosive ordnance detection equipment and all the necessary support equipment for autonomous operation. The PINS system and the radiography systems have been used successfully in the field for several years.

The second phase (Phase II) of the MMAS project is the development of an assessment system that will be used at sites where large numbers of munitions are recovered. The Phase II system will include all the features of the Phase I system and will add Secondary Ion Mass Spectrometry (SIMS) to assess the presence of a chemical agent on the surface of materials near the munitions, phase determination to determine of the fill material is solid or liquid, freezing point determination to establish the materiel freezing point to aid in identification and other support systems required for long term operations. The radiography equipment will likely be upgraded to real-time capability. The goal of the Phase II MMAS system is to use several methods to establish the correct status and identity of the munition contents so that they can be properly handled, stored and disposed of safely.

The MMAS project is currently in the requirements development and preliminary design stage. Several system configurations are being considered. These include housing the system in a truck, motor home, trailer

or shelter. Each configuration is being evaluated against the operational requirements to determine which is the preferred approach. The system must be capable of being driven to a recovery site or being transported on a C130 or larger aircraft. This requirement sets the maximum weight, length and height of the system. The MMAS will be entirely self-contained to allow for autonomous operation. All power and other utilities will be provided. The system is being designed for operation and setup by two operators. Most of the assessment equipment will be deployed outside the vehicle by the operators and the assessments will be completed in the field. The samples for the SIMS system will be analyzed inside the vehicle because of the small size and because the SIMS is less portable. The data will be transferred to the vehicle computers via transferrable media. The data will then be sent electronically from the vehicle computers to a central data collection center for archival and review by the munitions review board. The munitions review board will use the MMAS and other data to decide on the appropriate disposal method for each item. The MMAS is expected to significantly improve safety during remediation activities and also reduce the handling and disposal costs because of correct identification of the munitions and their contents.

Drill and Transfer Operations of Suspect Chemical Filled Munitions at Aberdeen Proving Ground

Presenter: Randolph Laye, BS Geology. Mr. Laye serves as the Chief, Project Management Team which oversees and directs a variety of programs in the area of environmental restoration. He supports the U.S. Army Corps of Engineers and the Project Manager for Non-Stockpile Chemical Materiel in remediation of Formerly Used Defense Sites (FUDS). He is responsible for drill and drain operations of suspect chemical ordnance recovered as a result of Installation Restoration activities at Aberdeen Proving Ground.

Abstract

As a result of Installation Restoration activities at Aberdeen Proving Ground, the inventory of recovered suspect chemical filled munitions continues to grow. With permitted storage space at a premium, the onus has been placed on assessing and removing those munitions that do not contain energetic components. This "short term" approach will provide the necessary relief while a full-up system to address all munitions is being developed and constructed.

Recovered munitions are first evaluated by X-ray to determine if they are explosively configured. This technique also provides information on the characteristics of the fill such as phase and fill level. Items are then interrogated using the Portable Isotopic Neutron Spectroscopy System (PINS). The PINS utilizes a neutron source to bombard the contents of the munition with free neutrons. When the nucleus of an element captures a free neutron, it emits gamma rays that are unique to the element. The gamma ray peaks are then matched to known energy level peaks for certain elements of interest and the fill is identified.

Non-explosive items are transported to the Chemical Transfer Facility for drill and transfer operations. These procedures are conducted in the Chemical Agent Transfer System (CHATS). The CHATS is a fully self-contained unit that employs a positive-stop, remotely controlled pneumatic drill to access the munitions body. Glove ports are provided to interface the operator with all manual phases of the operation. The CHATS interior is kept at a negative pressure with respect to the room while over 20 air changes per hour are provided by a dedicated state-of-the-art filtration system.

Once the munition is accessed, a 10 to 20-ml sample is withdrawn to be used in a variety of assays for definitive analysis. The remainder of the contents is then transferred by vacuum to an appropriate container and sealed. The munitions interior is rinsed with appropriate decontaminate and the access hole is sealed with a Teflon plug. The outside of the item is then decontaminated, monitored, and put into storage awaiting results of the analysis of the fill sample. All rinsates resulting from this process are collected in the CHATS waste collection system.

The final disposition of all fill material is handled in accordance with a developed waste management plan. Generally, chemical agent that can be purified by distillation will be reclaimed and returned to the research and development inventory. Non-surety wastes will be disposed of in accordance with state and federal regulations. Munition bodies will be thermally treated and reclaimed as scrap metal.

The benefits of these operations are numerous. They include the ability to validate and further refine the PINS technology, the reclamation of agent to support future research and development efforts, and the freeing up of valuable storage space that will allow the Installation Program to continue unimpeded at Aberdeen Proving Ground.

Hydro Abrasive Cutting as an Operational EOD Technique

Presenter: Major Adrian Wilkinson, RLC. Major Adrian Wilkinson was commissioned from the Royal Military Academy, Sandhurst, in December, 1980. He attended the 1987 Ammunition Technical Officers (ATO) course with the then Royal Army Ordnance Corps (RAOC). Since completion of the course, he has completed operational EOD tours as an EOD/IEDD Operator in Northern Ireland (Belfast) and West Germany. He commanded 421 EOD Company RAOC in the Post Gulf conflict, Kuwait and Saudi Arabia, before being posted as the Senior Ammunition Technical Officer in the Falkland Islands, where he was responsible for advising the Commander on EOD matters. Major Wilkinson has been the Head of Demilitarization at DTEO, Shoeburyness, since May, 1994, where he is responsible for the UK MOD Demilitarization Operations and the development of new Conventional Munition Disposal (CMD) techniques for the three services.

Abstract

DTEO, Shoeburyness, in conjunction with Colt Industrial Services, has developed the first truly portable Hydro Abrasive Cutting system for use in field EOD operations; this system is known as Project MARLIN. The system has been tested at DTEO Shoeburyness, and has now been successfully used on a variety of munitions from aircraft bombs to mine disposal charges. Explosive types that have been cut using this technique include TNT, RDX, TORPEX, ISOLANE and TETRYL.

The use of MARLIN negates the requirement for trepanning and steaming as a UXO access/explosive removal technique, and it is also a safer and quicker technique. Hydro Abrasive Cutting is a heat and spark-free, non-vibratory process that has revolutionized the cutting of materials in hazardous situations and areas.

Over the last 18 months, DTEO Shoeburyness has also developed and successfully tested a low temperature thermite (LTT) for use on EOD operations. This LTT burns below the detonating temperature of the majority of military explosives, which allows its use for the burning out of munitions with the minimal risk of a high order detonation being induced. It has been successfully used on TORPEX, RDX/WAX, RDX, TNT Type A and B, HEXOLITE, TNT, TETRYL and ISOLANE CDB with no high order events resulting.

The use of MARLIN and LTT will give the EOD operator a new tandem attack option for the safe rendering of UXO.

Munitions Assessment and Processing System

Presenter: Timothy A. Blades. Mr. Blades has over 20 years of experience in managing and performing operations involving known CW-related munitions and UXO. He was instrumental in U.S. CW stockpile assessment programs such as the M-55 rocket assessment and "SUPLECAM," as well as assessment and intrusive sampling of UXO. He is currently involved with active remediation of formerly used defense sites, as well as design and operation of UXO assessment and treatment facilities and equipment.

Abstract

Ongoing and future efforts under the Aberdeen Proving Ground (APG) Installation Restoration Program are expected to include the accidental or intentional recovery of conventional ordnance or chemical munitions. Records of Decision (ROD) are being pursued for remedy selection with regard to the Nike Site and other areas of APG. Actions taken pursuant to these RODs are likely to be the primary generators of additional found-on-post munitions. The intended procedure for handling chemical munitions recovered on APG entails the transfer of the agent fill to separate containers and neutralization in the existing RCRA permitted Chemical Transfer Facility (CTF), Building E3832. Currently, the existing Chemical Agent Transfer System (CHATS), located within the CTF, is capable of assessing and draining non-explosively configured munitions. The CHATS configuration does not allow for the processing of explosively configured munitions. A capability for the drilling, draining and decontamination of explosively configured rounds is required. The Edgewood Research, Development and Engineering Center (ERDEC) has been requested by the U.S. Army APG Support Activity's Directorate of Safety, Health and Environment (DSHE) to assume the lead project management role in the development and acquisition of this capability.

Munitions are expected to be recovered by the U.S. Army Technical Escort Unit (TEU), in support of Installation Restoration (IR) projects. Recovered chemical munitions are over packed and transported to the "N" Field bunker by TEU. The ERDEC Chemical Support Division receives all munitions and performs storage and monitoring functions for the "N" Field facility. Recovered items will be assessed by the Munitions Assessment Review Board, and appropriate rounds will be scheduled for processing. The Munitions Assessment Processing System (MAPS) will assess the munition and transfer its contents to standard DOT bottles. The agent fill will be taken to the CTF for neutralization and the munition body will be decontaminated within the MAPS. The CTF has recently obtained its permit for agent neutralization from the Maryland Department of the Environment. Decontaminated explosively configured rounds will be transported to "J" Field for detonation by TEU, per current procedures and permits.

The proposed system is primarily a replication of the existing CHATS design and capability within an explosive-containment structure. Explosive containment is to be provided by a Weatherly Explosive Containment Vessel. The containment vessel is housed in a standard steel frame building. The Weatherly Vessel is designed to maintain its physical integrity should any munition detonate. The vessel is also designed to maintain total vapor containment in the event of a munition leak or detonation. The system will include a pneumatic drill and drain assembly, within a stainless steel and Lexan housing. This housing will provide the framework for glove box capability. The glovebox is comprised of three sections: unpack, drain, and drill. The drill section is designed to separate from the other sections and be moved into the Weatherly Vessel. All drill operations will occur in the Weatherly Vessel. The drill is operated remotely from a control trailer located 100 feet away from the process facility. Agent transfer will be accomplished by vacuum transfer via two drilled holes in the munition. The drained munition will be decontaminated by a high pressure rinse of neutralizing solution. This rinsate will be collected via a gravity-fed sump and disposed of via commercial incineration. Monitoring of the system will be accomplished via the use of gas chromatographs.

Emergency Demolition Concept

Presenters: Allan P. Caplan, BS Mechanical Engineering. Mr. Caplan was first assigned to the PM NSCM in 1993. He is currently a member of the team responsible for the development and testing of mobile systems to treat recovered chemical materiel at the recovery site. Mr. Caplan is the equipment manager for the Munition Management Device 2 (MMD2) and the Emergency Demolition Programs. Before coming to the U.S. Army, Mr. Caplan spent 8 years in the design and testing of ammunition. Mr. Caplan's experience includes mechanical design, testing, and stress analysis.

William C. Replogle, BS Mechanical Engineering. Mr. Replogle is the lead engineer on the ZEEDS (Zero Emissions Emergency Destruction System) team. He co-authored the Interim Emergency Destruction Methods for Recovered, Explosively Configured Chemical Warfare Munitions Phase I Report. Currently, Mr. Replogle is the lead engineer evaluating the field application of a neutralization-based ZEEDS.

Abstract

Occasionally, a munition is recovered at a former test site containing a chemical agent fill, an explosively filled burster tube, and an unstable fuse. Currently, these munitions can only be handled by the use of open burn/open detonation (OB/OD) methods. This technique requires the use of 5 pounds of explosive for every 1 pound of chemical agent. Due to the quantity of explosives required, evacuation would be required if the munition was located in a populated area. Although OB/OD has been shown to be safe, the U.S. Army will only use OB/OD when there are no other options. This is due to concerns from the general public as well as environmental issues.

Sandia National Laboratory (SNL), under contract with the U.S. Army Project Manager for Non-Stockpile Chemical Materiel (PM-NSCM), is developing a mobile system for environmentally acceptable and safe disposal of these munitions. This system will be designed to destroy the fuse and burster without causing a high order detonation. After the explosive threat has been removed, the chemical fill will be treated so that it can be safely disposed of. The system will include an environmentally sealed, explosion-proof chamber to safeguard the environment in the case of an unintentional high order detonation of the burster.

The Emergency Demolition System (EDS) is currently in the early concept stage. A number of methods were researched for breaching the munition, destroying the fuse and treating the chemical fill. In all concepts, the munition is contained in an explosion-proof chamber while there is still a chance of detonation. At this time, the most promising candidate for destroying the fuse and breaching the munition is the use of linear and conical shaped charges. A conical shaped charge would be aimed at the fuse. A linear shaped charge would be used to breach the munition. This will expose the chemical agent as well as unconfine the explosive in the burster well. The two charges would be fired simultaneously. The three most promising methods for the treatment of the chemical agent are neutralization, incineration, and super critical fluid oxidation (SCFO). The first two methods are technologies that are well defined. The third method is a promising method of treating both chemical agents and explosives, but will require more development than either incineration or neutralization.

Based on the conclusions of SNL's research, the U.S. Army has chosen to pursue neutralization and SCFO for the treatment phase of this effort. Phase II will begin with a study to optimize the design of the EDS system. At the end of that optimization study, hardware design, fabrication and bench-scale testing will begin. Phase II is scheduled to last 18 months. Key component fabrication and testing could begin as early as late calendar year 1997.

Munitions Management Device 2 for Explosively Configured Chemical Weapon Materiel

Presenter: Allan P. Caplan, BS Mechanical Engineering. Mr. Caplan was first assigned to the PM NSCM in 1993. He is currently a member of the team responsible for the development and testing of mobile systems to treat recovered chemical materiel at the recovery site. Mr. Caplan is the equipment manager for the Munition Management Device 2 (MMD2) and the Emergency Demolition Programs. Before coming to the U.S. Army, Mr. Caplan spent 8 years in the design and testing of ammunition. Mr. Caplan's experience includes mechanical design, testing, and stress analysis.

Abstract

The mission of Project Manager for Non-Stockpile Chemical Materiel (PM-NSCM) includes the requirement to safely dispose of recovered chemical munitions. A portion of these recovered munitions will contain a chemical agent fill as well as explosives. By virtue of the absence of a fuse, or X-ray confirmation that the fuse is in the "safe" position, these munitions are considered stable and safe for transport. Teledyne Brown Engineering (TBE), under contract to PM-NSCM, has developed a concept for containing, breaching and neutralizing the contents of these munitions. TBE will design, fabricate and test the Munitions Management Device 2 (MMD2) during a 2-year program. Full-scale testing may begin in late calendar year 1997.

The current concept being developed by TBE is a mobile system which will treat the recovered munitions *insitu.* The munition would be loaded into a small container referred to as an Auxiliary Processing Vessel (APV). The AP.V would be loaded into a large explosive containment vessel. This is a precaution in the event of an unintentional detonation during the processing of the munition. The munition would then be tapped and drained of all chemical agent. The agent would be neutralized in an external reactor. Once the chemical fill is removed, the interior of the munition is flushed with a neutralization liquid to decontaminate the munition. After the munition has been decontaminated, it is removed from the APV and the explosives and destroyed using conventional means.

The MMD2 is being designed to handle a variety of chemical-filled weapons. These weapons include mortars, artillery shells, bombs, and rockets. The largest weapon to be treated would be a 125 -pound bomb containing 83 pounds of lewisite. The largest burster charge expected to be encountered is 7 pounds (Comp B).

Vapor Containment Structure Development and Use

Presenter: James P. Manthey, PE, BS Civil Engineering. Mr. Manthey has worked as a structural engineer with a specialty in the field of explosives and ordnance safety design and analysis for over 8 years. He has authored several studies and papers on the subject of explosives safety, chemical warfare, material containment, and UXO removal safety issues and designs. He has extensive experience in fragmentation phenomena, chemical agent vapor containment, explosive containment design, and explosives effects.

Abstract:

The U.S. Army Engineer Division, Huntsville is actively involved in the location and removal of buried unexploded munitions at formerly used defense sites (FUDS). In many cases, these munitions included liquid-filled rounds which may contain hazardous chemical agents.

A critical parameter for safety siting is the downwind hazard in the event of an accidental detonation of a chemical munition. An extensive test program has been conducted to determine the effectiveness of using a typical environmental vapor containment structure (VCS) over a munition removal site in controlling the downwind hazards resulting from the accidental detonation of chemical-filled munitions. This decrease in downwind hazards allows significant reductions in the required evacuation distance.

Tests were conducted using replica scale models of the "Livens" and the 4.7-inch munitions, filled with an inert agent simulant and detonated inside a full-scale steel arch confinement structure. These tests were required for deployment at Wesley Seminary in Washington, D.C., in the community of Spring Valley. Measurements were made of the internal shock and quasi-static pressures, external overpressures, and the interior and exterior simulant dosages.

Prior to conducting the confinement tests, limited arena tests were performed to determine the fragmentation hazards for each munition. As part of the arena tests, measurements were made of the side-on overpressures. A description of the confinement structure, structural features of the structure pertaining to blast and chemical agent containment, the model munitions, as well as an overview of the tests conducted and a summary of the test results, are presented in this paper.

In addition to the initial tests conducted specifically for the Wesley Seminary site, several other projects which were designed to enhance the usability of the VCS are currently under development. These include the development of a partial containment annex to the VCS, which uses open suction hoods near the release point with high suction flow rates to capture a nonexplosive release of a chemical agent. The partial containment system (PCS) is to be used in removal operations where the possible chemical release is to be nonexplosive and a total containment system such as the VCS cannot be used. This project is under development for use at the former Santa Rosa Army Airfield in California for a possible chemical release from chemical agent identification kits. The paper will discuss the development and testing of the PCS.

Another refinement of the VCS is planned to clearly define the limits and use of the VCS for a generic chemical ordnance item. This will be accomplished by first conducting tests to establish the maximum explosive quantity for the VCS and then determining the VCS capture efficiency for a variety of explosive quantities up to the explosive limit. A discussion of the proposed effort will be included in this paper. All efforts were and are conducted in support of the Huntsville Division Ordnance and Explosives Army Mandatory Center of Expertise and the Innovative Technologies Program.

Detection, Recovery and Destruction of Abandoned UXO from World Wars in Germany

Presenter: Martina Schneider, Dipl.-Ing.

Abstract

This paper offers a survey on (1) the status of the disposal of abandoned unexploded ordnance in Germany, and (2) the still open technical and organizational questions resulting from the disappearance of the German Democratic Republic. The responsibility for detection, recovery, and destruction of this ordnance falls to the Department for Internal Affairs of each Federal State of Germany. They are - within their obligation to protect the country - responsible for the detection, recovery and destruction of conventional warfare agents, chemical warfare agents, and materials which are contaminated with these agents, such as soils with high concentrations of these materials.

This abandoned unexploded ordnance includes ammunition used on the European continent during both World War. It consists of many different unstable, partially functional, tactic systems with metal jacket and explosives. Due to the storage in soil and water for decades, the effectiveness, sensibility and handling characteristics cannot be estimated. The origin, igniting mechanism, and storage, technical design of disassembly, and destruction. Apart from private companies for detection and recovery of warfare agents, official companies for detection and recovery of abandoned unexploded ordnance have been founded and the necessary structure and demilitarization of site from the detection/recovery up to the destruction has been established. Each single Federal State is responsible for destruction of its own abandoned unexploded ordnance.

The following example shows the process steps of an official demilitarization facility. The requirements are:

- Transport to the official company
- Storage
- Identification (Classification)
- Disassembly
- Destruction

The destruction of abandoned unexploded ordnance is carried out by means of open burning or a detonation process. Due to the fact that the official companies are now obliged to observe the stricter environmental laws (just to name the most important ones: "Storfallverordnung" [=Incident Regulation]; and the limit values of the law for air pollution abatement [17.BImSchV]), everyone is forced to destruct the abandoned unexploded ordnance in plants with an off-gas cleaning unit and to dispose of the residual materials.

At this time, incineration concepts are being discussed, where abandoned unexploded ordnance is, under the conditions of open burning, which means against air, atmospheric pressure and ambient temperature continuously converted by means of a self-maintained burning. The air is used for cooling of the off-gas peak temperature and as an oxidating agent. The scientific bases of these burning systems are international tests, verifying that the polluted emissions under conditions of open burning are reduced to a minimum value, due to the high flame temperatures in the reaction zone. For disposal of partly disassembled items and igniters with a TNT-equivalent of >200 g TNT, an armored furnace will be used, which is operated with up to 55 g- 60 g TNT-equivalent. In this armored furnace, recovered small caliber ammunition is converted

by means of a deflagration and igniters are converted by a detonation. The feed is carried out continuously via a bucket conveyor. The ammunition to be disposed of falls into an indirectly heated armored muffle at a temperature of 570° to 600° C.

The system is the result of experiences from the disassembly and destruction of different depot ammunition and abandoned unexploded ordnance in hazard group 1.1. It is based on the established German guidelines for destruction of explosive substances, but does not revise them.

BUGS: An Autonomous "Basic UXO Gathering System" Approach in Submunition and Minefield Neutralization and Countermeasures

Presenter: Christopher O'Donnell, BSME. Mr. O'Donnell is currently Director of Technology for NAVEODTECHDIV. He was Block Manager for EOD Technology from 1992 to 1995. He developed explosive mine countermeasure systems such as DEMNS, APOBS, MICLIC, and lightfoot from 1986 to 1992. He is Panel Chair for EOD Technology for Joint Directors of Laboratories.

Abstract

The objective of the Basic Unexploded Ordnance (UXO) Gathering System (BUGS) is to test, evaluate and implement a new technology in small autonomous robots. This project hopes to find a better technology that could replace the current technology through increased cost effectiveness, increased safety, and increased speed and accuracy. The Naval Explosive Ordnance Technology Division (NAVEODTECHDIV) intends to design, develop, test and demonstrate a low-cost, small, disposable autonomous robot BUGS that is capable of detecting mines and gathering small UXO. The BUGS could be used to retrieve data or information from inaccessible areas that would be harmful to personnel.

CEG Soft Excavation Technology Applied to UXO Site Remediation

Presenters: Jerome Apt, Jr., PE, BS Mechanical Engineering. Mr. Apt is one of the four founders of Concept Engineering Group, Inc. (CEG), founded 5 years ago. He was involved from the outset with the design and construction of the Soft Trencher funded by EPRI. This first excavator utilized CEG's "Safe Excavation" technology which incorporates CEG designed supersonic air jets coupled with a high vacuum conveying system. He has been involved with the design of pneumatic conveying systems for bulk materials since the 1950s.

Martin J. Uram, MS Physics. Mr. Uram's past experience includes lead scientist on the Remote Excavator (REX) Project with regard to development of a mapping system to detect underground metal pipe using electromagnetic techniques and expert systems. He also was systems engineer for Concept Engineering Group's Soft Trencher Project for the Electric Power Research Institute (EPRI) and Battelle Memorial Research Institute. The Soft Trencher is a prototype test bed of CEG's Safe Excavation Technology, which is currently being applied to UXO remediation.

Abstract

The technical personnel of CEG have been involved in the technology of "Safe Excavation" for over 10 years. In 1990, the group incorporated and formed the present organization. It was during this period that CEG was contracted to design and construct a prototype machine to safely excavate utility trenches without impacting any type of existing buried utility lines. This project was carried out using CEG's proprietary technology in supersonic airjets coupled with a high vacuum conveying system. The project was funded by the Electric Power Research Institute (EPRI), assisted by Battelle-Columbus.

The mission of this machine, dubbed the "Soft Trencher," was to demonstrate that a trench could be safely excavated without impacting utility lines which were already in place along or crossing the trench's right-of-way. The design parameters were to construct a device which could excavate a trench 6 feet wide and 10 feet deep. The result was a rather large machine that weighs 34,000 pounds, is 27 feet long, 102 inches wide, and 11 feet 6 inches high. It is transportable on a low-boy trailer without placarding. However, it is a test bed and not of commercial size. Currently the machine is being used by CEG, with the permission of EPRI, to demonstrate the technology.

CEG became aware of the UXO Detection & Remediation Technology demonstrations which took place during the summer of 1994. It occurred to us that the use of supersonic airjets coupled with a high vacuum material conveying system might be a very effective combination for safe UXO remediation. A proposal was made to demonstrate the Soft Trencher at Jefferson Proving Ground during the summer of 1995. Our proposal was accepted and even though the Soft Trencher was not the best configuration for UXO remediation, it was felt that it could effectively demonstrate the use of the technology for the neutralization of this environmental problem.

The Soft Trencher was transported to Jefferson Proving Ground in early September 1995, and the machine demonstrated the ability of CEG's "Safe Excavation" technology to remediate UXO for a 3-day period.

This paper discusses the results of that demonstration, the follow-on developments being made to efficiently incorporate this technology into the overall remediation of UXO, and the innovative new designs that are being developed to encase this technology in compact and cost-effective envelopes.

Cost-Effective Approaches to Successful Remediation of UXO at the Idaho National Engineering Laboratory (INEL)

Presenter: Terrell J. Smith. Mr. Smith provides explosive ordnance disposal (EOD) safety and technical oversite to contractors performing ordnance remediation on the Idaho National Engineering Laboratory for the past 3 years. He has evaluated procedures and made adjustments to reduce cost, refine and streamline procedures. Lessons learned after each project have produced methods for cost reduction. DOE is currently reducing redundant procedures and regulations as a direct result of Mr. Smith's input.

Abstract

Over the past 4 years, efforts have been underway to remediate unexploded ordnance (UXO) and explosively contaminated soils at the Idaho National Engineering Laboratory (INEL). Numerous UXO have been discovered by INEL personnel. Lessons have been learned on appropriate approaches to effectively remediate such ordnance explosive waste (OEW) in a cost-effective manner.

Quality checks built into ordnance removal actions have ensured efficient removal of ordnance. The use of obsolete explosive ordnance disposal (EOD) publications have saved time and money by speedily identifying ordnance. Use of a central demolition site has provided cost savings over the traditional approach of blowing each item in place. In addition, an Air Force remote excavator has been used to remediate potentially sensitized ordnance disposal pits in a cooperative technical demonstration arrangement with the Department of Defense (DoD) and the Department of Energy (DOE).

Also, rather than using more expensive laboratory analysis of samples, field screening of explosive-contaminated soil has substantially reduced sampling costs. The INEL has worked with the U.S. Army Corps of Engineering (Corps) in testing and improving the field screening methods originally developed by the Corps.

The use of a Geographic Information System (GIS) to map areas of contamination and Global Positioning Systems (GPS) to identify location of OEW has aided and enhanced the remediation process. GIS and GPS systems have improved the accuracy and quality of the information collected, reducing cost during UXO removal. An innovative computer program developed by the Corps (SiteStats) is being utilized to project concentrations of UXO. This information will assist in further assessments of UXO at the INEL and will form the basis for further cleanup.

As a result of these unique activities, several sites at the INEL have been successfully remediated of UXO/OEW. Continued remediation will be performed in a cooperative arrangement with the DOE, DoD, and the Corps, which will all work toward cost reductions for ordnance removal.

Wednesday, March 27, 1996
Session B
Amphitheater

Evaluation of Subsurface Ordnance Detection Systems at a Controlled Site

Presenter: Carol B. Richardson, MS. For the Naval Explosive Ordnance Technology Division, Ms. Richardson acted as Site Manager for the Controlled Site Phase II Advanced Technology Demonstration. Ms. Richardson coordinated controlled site activities between 17 technology demonstrators from May through September 1995 at Jefferson Proving Ground in Madison, Indiana. Ms. Richardson was responsible for scheduling, oversight, management of personnel and data, and report preparation.

Abstract

PRC Environmental Management, Inc., is currently completing Phase II of the controlled site advanced technology demonstration (ATD) for the Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV) in Indian Head, Maryland. The Controlled Site Phase II Advanced Technology Demonstration program was established to assess the capabilities of state-of-the-art technologies that detect, identify, and remediate unexploded ordnance (UXO). The controlled site is located at Jefferson Proving Ground, Madison, Indiana. Controlled site demonstration contractors were selected to represent a variety of sensor technologies and sensor technology platforms. The controlled site demonstration consisted of 17 demonstrators in the following areas:

- Three airborne systems
- Six man-portable systems
- Six vehicle-towed systems
- Two robotic remediation systems

Demonstrations were evaluated based on their ability to detect emplaced targets. These results are presented in a series of detection probabilities: ability to classify the emplaced targets, ability to discriminate ordnance from non-ordnance, analysis of false positives, analysis of false negatives, ability to characterize ordnance size, and ability to determine ordnance orientation. This paper includes a discussion of applicable target matching algorithms and the rationale for the algorithms used for controlled site data sets. The results will be presented for each demonstrator.

Evaluation of Subsurface Ordnance Detection Systems in a Live Ordnance Environment

Presenter: Kenneth M. Valder, BS Civil Engineering. For the Naval Explosive Ordnance Technology Division, Mr. Valder acted as Task Manger for the Live Site Advanced Technology Demonstration. Mr. Valder coordinated live site activities between nine technology demonstrators conducting site investigations at five sites over an 8-month period between May and December 1995. He was responsible for scheduling, oversight, report preparation, and management of personnel and data.

Abstract

PRC Environmental Management, Inc. (PRC-EMI), is completing a Live Site Advanced Technology Demonstration (ATD) test and evaluation program for the Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV) in Indian Head, Maryland. The ATD program was initially established within a controlled test range to evaluate subsurface unexploded ordnance (UXO) detection, identification, and remediation technologies. Technologies that performed well at the controlled test site were selected for participation in the live site ATD to evaluate the technologies for performance under realistic field conditions.

The Live Site ATD program was conducted at active and inactive impact ranges on military facilities throughout the United States. The selected live sites represent a variety of geologic settings and types of ordnance deployment. The sites include impact ranges at Jefferson Proving Ground, Indiana; Yuma Proving Ground, Arizona; Eglin Air Force Base, Florida; Fort Jackson Military Reservation, South Carolina; and McChord Air Force Base, Washington. Demonstrated technologies include magnetometer, magnetic gradiometer, ground-penetrating radar, and radar technologies mounted on aerial, vehicle, and man-portable platforms.

Each technology demonstrator's ability to detect and identify emplaced and unknown UXO targets was evaluated based on its probability of emplaced UXO target detection (P), its ability to identify detected UXO, and its ability to discriminate UXO from non-UXO. P values for live site demonstrators were evaluated using the same target matching algorithm used when each was evaluated at the controlled site.

In addition, certain demonstrator target declarations were excavated to confirm the presence or absence of subsurface UXO at these locations. The purpose of this validation step is to further evaluate each technology's P as well as to evaluate each technology's "false alarm rate" and ability to correctly identify subsurface UXO. Validation was performed on a small population of the targets designated by each technology demonstrator as "high confidence targets." A total of up to 30 individual demonstrator target declarations were randomly selected for validation. Coinciding target declarations made by more than one technology demonstrator were also selected for validation. In addition, some locations with demonstrator reports of high ordnance density were also excavated.

Validation was performed using four types of remote excavation equipment. The excavation equipment is typically representative of the type of remotely operated excavation equipment used at each particular military installation.

Technology evaluation results for emplaced targets at the live sites are similar to the results for each demonstrator at the controlled test site. In addition, unknown target validation results for each technology vendor are similar to the emplaced target evaluation results.

Geologic anomalies at some of the live sites demonstrate the need for improvement in data analysis and noise suppression algorithms. In addition, demonstrator results from various topographic and climactic environments indicate a range of strengths and weaknesses associated with each technology and sensor platform.

Live site ATD results are currently undergoing evaluation.

Phase II Controlled and Live Site UXO Detection, Characterization, and Remediation Advanced Technology Demonstrations

Presenter: Kurt O. Thomsen, Ph.D. Dr. Thomsen works for PRC Environmental Management, Inc., as program manager for the Unexploded Ordnance (UXO) Advanced Technology Demonstration (ATD) program.

Abstract

Millions of acres of U.S. government property are contaminated with UXO as a result of weapons system testing and troop training activities conducted over the past century at Department of Defense (DoD) sites. Recent DoD downsizing has resulted in the closing of many military bases, many of which are contaminated with UXO. One unexpected result of DoD's downsizing is the attention focused on the unique problems associated with UXO remediation at these closed military bases. The scope of UXO contamination and associated hazards to DoD personnel and the public have created the need for advanced UXO detection, characterization, and remediation technologies. The U.S. Army Environmental Center (USAEC) is the lead DoD agency for UXO clearance technology demonstrations, evaluation, and technology transfer. USAEC's goals include assessment and advancement of the state-of-the-art in UXO detection, characterization, and remediation technologies and the development and validation of data management and decision-making tools.

To accomplish these goals, USAEC directed the Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV) to serve as the technical lead for the ATD program. In 1994, USAEC and NAVEODTECHDIV created controlled test facilities at the U.S. Army Jefferson Proving Ground (JPG) in Madison, Indiana, to demonstrate and evaluate commercial UXO clearance systems and technologies. Phase I controlled site demonstrations were conducted during the summer of 1994. These demonstrations were followed by the Phase II controlled site demonstrations at JPG and live site demonstrations at five different live impact and bombing ranges in the summer of 1995.

This paper presents the results of the Phase II controlled and live site demonstrations. The overall performance of the demonstrators is presented as are the operational characteristics and limitations of the various systems and technologies evaluated. Individual demonstrator performance statistics are evaluated by sensor type and sensor transport method. Field operational performance of the various systems and technologies is also presented.

Automatic Ordnance Locator (AOL) System- A New Survey Tool for UXO

Presenter: R. J. Selfridge, MS Geology & Geophysics. Mr. Selfridge has been involved in Geophysical Surveying to support Engineering, Environmental and Unexploded Ordnance projects for over 15 years. He is the Senior Geophysicist involved in CHEMRAD's technology demonstrations with the Automatic Ordnance Locator (AOL) Program. This program consists of both a man-portable and a robotic platform for performing UXO surveys, as well as specialized processing techniques to aid in target identification.

Abstract

The AOL System[1] is a recently developed automatic tracking and data logging system for use in surveys for UXO. It employs an ultrasonic time-of-flight technique to determine the surveyor's location each second to an accuracy of 15 cm. It also records up to 99 channels of detector data each second in the field computer's memory. These position-correlated data are shown in real time on the field computer's displays providing a graphical aid for on-line quality assurance of the survey's coverage and findings.

The surveyor's location is determined each second by measuring the acoustic travel times from an ultrasonic transmitter carried on the surveyor's backpack to transducers mounted on tripods and distributed across the survey area. The travel times are reported to the field computer via RF transmissions. The data from the survey detectors carried by the surveyor are also reported to the field computer via RF transmissions.

The use of ultrasonics gives the ability to survey in all terrains, including wooded areas, steep ravines, and in and around buildings. No other positioning technology provides coverage equivalent to the AOL System. Differential global positioning system technology, for instance, is of limited use in environments where visibility of the sky is restricted.

The AOL System has been developed specifically for use with the Geometrics G-822L Cesium Vapor Magnetometer, although interfaces are optionally available for other geophysical instruments such as other magnetometers, gradiometers, metal detectors and terrain conductivity meters. Multiple sensors may be used with up to 99 channels of detector data recorded each second.

Dual compass engines provide the ultra high resolution positioning needed for UXO surveys with a magnetometer. The location of the sensor lead is extrapolated from the surveyor's location as often as 10 times per second using the dual compass readings.

The on-line display of the survey's results allows areas of concern to be immediately identified. Since the surveyor's hand held terminal displays the coordinates of his current location, he can easily be redirected back to such an area for further investigation.

Outputs from the AOL System include track maps showing the details of survey coverage, color track maps which reflect the sensor's response at each sampling point, and statistical analyses of the survey area or of selected regions of interest. Color contour maps displaying the isopleths of the sensor's response can also be generated.

The LEAP™ (Layered, Easy-Access Presentation) System, is a graphic user interface to simplify the manipulation and analysis of the many large data files produced by the AOL System's high resolution surveys. An area of interest is selected from an overall site map with a click of the mouse. Track maps, color track maps, color contour maps and site features maps are displayed through menu selections. These

maps can be overlaid to aid in analysis. They may also be linked to databases, such as target characteristic tables, so that the results within an area are displayed following a click of the mouse at the location of interest.

The AOL System was demonstrated in the UXO Technology Demonstration sponsored by The U.S. Army Environmental Center through NAVEODTECHDIV and PRC, Inc. A 2.5×10^5 m^2 site at the McChord Air Force Base in Tacoma, WA, was surveyed using the AOL System during the period of October 23 through November 10, 1995.

[1] The AOL System builds on the design of the USRADS® Model 2100, which was developed through a collaboration of the Health and Safety Research Division and the Instrumentation and Controls Division of the Oak Ridge National Laboratory under contract to the U.S. Department of Energy. Martin Marietta Energy Systems, as the operating contractor of the ORNL for the DOE, subsequently obtained a patent on the USRADS System. The license to this patent has been solely transferred to Chemrad under a technology transfer agreement with MMES.

A System for Performing Site Remediation for Test Ranges Containing UXO

Presenter: Captain Walter M. Waltz, BS Aeronautical & Astronautical Engineering. The system for remediation being presented was purchased, modified and is being upgraded at Captain Waltz's direction. Captain Waltz has accompanied this system at all demonstrations including Jefferson Proving Ground controlled site, September, 1994, Jefferson Proving Ground live site, July, 1995, and Fort Jackson live site, November, 1995. He is the engineer responsible for the implementation of a Controller Area Network bus control system for the next evolution of remote-controlled vehicles. He is also responsible for the development of three other platforms -- the Remote Excavation Vehicle System, the Surface Ordnance Remediation System, and the All Terrain Remote Vehicle System -- which address the excavation and removal of unexploded ordnance.

Abstract

The Government effort to rightsize DoD forces and facilities has some far-reaching implications. As a result, DoD ordnance test range facilities are being turned over to the public sector. It will be DoD's responsibility to ensure that those ranges are free from the hazards of unexploded ordnance. NAVEODTECHDIV is the DoD-designated research facility for explosive ordnance disposal and has accepted the mission to assess and develop the technologies to accomplish the Area Clearance/Range Remediation task. The Area Clearance mission is composed of two separate subtasks: characterize the area of interest, and remediate that area based on the findings of the characterization.

Because of the hazardous nature of the task, one of the program goals is to remove the human operator from the immediate area. This is accomplished through the use of robotic platforms. Wright Laboratory at Tyndall AFB is OSD's designated lead for construction automation. Wright Laboratory has been tasked by NAVEODTECHDIV to develop the robotic platforms that will perform the remediation tasks. One such system under development is the Automated Ordnance Excavator (AOE).

The goal of the remediation task is to render safe the ordnance targets determined in the task of site characterization. There will be three options during remediation which depend on the condition of the ordnance and the type of fusing: (1) a shape charge will be placed on the ordnance; (2) the material surrounding the ordnance will be removed to allow free access for the EOD technician; and (3) the ordnance will be removed from its resting place and placed on a pallet for later disposal. The remediation task can be accomplished by the AOE while minimizing risks to EOD personnel. It starts with a map containing target ordnance locations and proceeds to each target, in turn. It will remove the bulk of the material around the ordnance with a conventional bucket and then expose the ordnance for remediation. Once the ordnance has been identified, a method of remediation can be determined to safely remove the UXO. The AOE uses the same advanced differential Global Positioning System for navigation developed on the Autonomous Tow Vehicle to accomplish its site characterization task.

A Case Study of an Innovative Assessment Strategy
Tracadie Range - New Brunswick, Canada

Presenter: Paul Stratton, BA. Mr. Stratton is a retired Australian Army Officer with over 20 years of experience in the fields of ammunition and explosive ordnance disposal. He received his training in these fields in Australia, the United States, and the United Kingdom. Since joining ADI Limited, Mr. Stratton has conducted explosive ordnance detection and clearance operations in Australia, the United States, Canada, and Europe.

Abstract

The 18,000-hectare (46,000-acre) Tracadie Range in northeastern New Brunswick had been used as an artillery, mortar and air-to-ground training range from 1940 to its closure for those purposes in 1990. In 1994, the Canadian Department of National Defense (DND) proposed to transfer ownership and reopen all or part of the range to public use. However, like other ranges of the vintage, the full extent and level of UXO contamination was not known. Before any transfer could occur, those areas affected must be cleared of the hazard of UXO to the degree required to allow for the next anticipated land use. To this end, DND has initiated a project to undertake a UXO survey and to prepare a clearance plan for the Tracadie Range. The UXO project was issued to Dillon and its prime subcontractor, Australian Defense Industries (ADI), in April 1995. The contract, to be executed over 2 years, will produce a detailed approach and cost estimate to clear identified areas of the range of UXO. The approach to range clearing will be tied to the variety of land uses which are likely to occur on the property after release by DND. The first stages of the project were completed and reported on in December 1995.

In awarding the contract to Dillon and ADI, DND's objective in accepting this assessment approach was to obtain all the information necessary to determine what clean-up alternatives are practical, affordable and acceptable for the Tracadie Range, in view of potential future uses. The assessment will thus provide budget for various clean-up options and accommodate the best use of the clean-up budget. The approach used employed a calibrated, statistical sampling procedure that was developed for measuring the density, extent, type and distribution of ferrous UXO contamination. The procedure was designed for efficient, large-area operations where heavy forest and rugged terrain may be encountered.

The strategy for the Tracadie Range involved three components which were applied by dividing the area into sections that are ranked in priority for assessment, based on the likely availability for early release. A three stage assessment was then applied sequentially to each of these sections. The first stage consisted of systematically mapping and statistically analyzing regularly spaced magnetometer transects covering the entire range. The purpose of this was to identify the number and concentration of ferrous items using a uniform sample density across the range. This operation was aimed at identifying the center of target impact zones. The second stage involved a higher rate of sampling within the impact zones and was designed to define the boundaries of the impact areas. The final stage of the assessment survey involved a thorough detailed survey and intrusive investigation of calibration sites within the area to determine the distribution of magnetic object types that were responsible for the magnetic signatures observed.

The assessment of the priority areas covered to date has enabled DND to make sections of the range available for early hand-over with minimal expenditure, thus accommodating community desires while maintaining community safety.

Dredging at Eagle River Flats: Remediation Study of a Superfund Site in an Impact Area

Presenter: Michael R. Walsh, PE. Since 1994, Mr. Walsh has been involved in the U.S. Army's investigation and remedial investigations at the Ft. Richardson firing range impact area on Eagle River Flats (ERF). As an active firing range and the site where white phosphorous was first discovered to be both persistent and highly toxic, ERF is a case study on remediation investigations in an area containing UXO of various size. While remediation does not involve removal of UXO except in the case where they pose an immediate and obvious danger to investigators, encountering UXO is certain in the remedial investigation Mr. Walsh headed up: dredging of contaminated sediments for on-site treatment.

Abstract

ERF is an estuarine salt marsh located on Ft. Richardson, Alaska. For nearly 50 years, it has been an impact area for the Army and Air Force. In 1982, large, unexplained die-offs of waterfowl were documented, leading to several years of research into the cause of this recurring problem. In 1990, researchers from the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), in conjunction with the Ft. Richardson Environmental Resources Branch, Directorate of Public Works (DPW), discovered the cause of the mortality: white phosphorous[1]. After extensive study of the characteristics of white phosphorous (P_4) and the environment of the ERF, three remediation strategies were earmarked for further study: covering contaminated areas with either geotextiles or bentonite; draining and exposing contaminated areas, allowing natural remediation; or dredging contaminated sediments for later treatment. This paper discusses the work done to date on dredging.

The presence of UXO at ERF and the necessity to disrupt the environment at a minimal level posed serious dredge system design problems. Additionally, the only easily accessible storage and treatment area for the dredge spoils is located on the explosive ordnance disposal (EOD) pad, a RCRA (Resource Recovery and Conservation Act) site. The project was therefore initially divided into two design efforts: the spoils retention and treatment basin, and the design of an appropriate dredging system. This work was accomplished in cooperation with the Alaska District, Corps of Engineers and the Ft. Richardson DPW, with input from the Waterways Experiment Station.

The dredging system utilizes a small, remotely controlled augerhead dredge. The minimum distance from the dredge to the control cab, a hardened, mobile structure, is 40 m. The genset used to power the dredge is shore based, thus minimizing impact in case of a UXO detonation. Other design features include the use of a biodegradable vegetable-based hydraulic oil; locating primary systems, such as the slurry pump and power pack, as far from the dredgehead as feasible; and a cable traverse system to reduce penetrating UXO-laden sediments. An rf transmitter/receiver system transmits video information and sensor data to the shore-based operator. Several strategies were tried for dealing with the UXO, all with the common goal of excluding the objects from the slurry pump and leaving them behind. The most effective method was a cutter-and-grate system incorporated into the dredgehead which excludes the UXO from entering the pump intake line without clogging the grate with vegetation.

The retention basin is a 0.8-hectare structure built into the EOD pad. Some existing material was used, but the presence of UXO within the pad precluded complete construction with native materials. The base structure is constructed of consolidated gravel with 2-meter-high berms. The interior is lined with a peaty-silt material to reduce the hydraulic conductivity to below 10^{-5} cm/sec, acceptable for capping hazardous waste sites. Extensive testing by CRREL verified the liner performance. Two 8-meter-square concrete splash pads were installed in the basin to check erosion from incoming spoils, and a drop inlet structure and

weir was installed in one corner for controlled supernatant decantation. Instrumentation was installed to monitor sediment characteristics for remediation performance. Computer models indicated acceptable system performance.

System performance indicates that dredging is a viable option for consideration as a remediation strategy for ERF. The grate system has allowed dredging to occur while minimizing the problems associated with UXO ingestion. Treatment studies of the P_4-contaminated retention basin sediments have begun, with definitive results anticipated for next season.

[1] Racine, C.H., M.E. Walsh, C.M. Collins, D.J. Calkins, B.D. Roebuck, and L. Reitsma (1992) Waterfowl Mortality in Eagle River Flats, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. CRREL Report 92-5.

Time Domain Electromagnetic Metal Detectors - History, Case Histories, Future

Presenter: Pieter Hoekstra, Ph.D. Throughout his 30-year professional career, Dr. Hoekstra has been active in development and testing of ground and airborne electromagnetic sensors for geophysical investigations.

Abstract

Time domain electromagnetic (TDEM) sensors have been employed in mineral exploration for some 20 years. An important objective for these sensors is to explore for highly conductive targets (e.g. massive sulfide ore bodies). TDEM sensors quickly gained wide acceptance for that purpose, because they allowed definition of position, shape, dimensions, and conductivity of targets. Moreover, targets could be detected in different environments, such as in the resistive rocks of the Canadian Shields, as well as under conductive overburden in the north-central states of the U.S. and under conductive weathering layers in Australia.

The requirements for detection of buried metal objects for unexploded ordnance (UXO) and exploded ordnance waste (EOW) have similarities to exploration for highly conductive ore bodies. In both cases, targets are several orders of magnitude more conductive than the surrounding soils or rocks. The differences are in the dimensions of the target, depth of investigation, and cost constraints.

The first TDEM metal detector, the Geonics EM61, has already proven effective on a number of UXO surveys (Ft. Monroe, Jefferson Proving Ground, and over volcanic rocks in Hawaii). Characteristic features of TDEM sensors for UXO expected from basic principles and proven in practice are:

1) anomaly shape and to some extent amplitude, nearly independent of soil type;
2) low background noise; and,
3) simple anomaly shape.

The Geonics EM61 TDEM metal detector was designed primarily for detection of drums, underground storage tanks, landfills, and trench boundaries delineation and utility detection. The success of the EM61 suggest that instrument enhancements, improved interpretation, and modeling capabilities will lead to better UXO detection sensors. Enhancements can be based on sound theoretical foundations and field experiences, largely developed by the mineral exploration industry. The instrument modifications required to detect smaller UXO targets and to provide better definition of target depths and dimensions will require multi-component measurements (both vertical and horizontal magnetic fields), and recording of a number of time gates. Some experimental measurements made over inert targets confirm this.

Prediction for UXO Shape and Orientation Effects on Magnetic Signature

Presenter: T. W. Altshuler, Ph.D Physics. Dr. Altshuler has worked in magnetic materials and magnetic domain wall theory. He has concentrated on investigation of both magnetic signatures of and magnetic detection methods for unexploded ordnance (UXO). This experience was applied to the Jefferson Proving Ground Demonstration of Unexploded Ordnance Detection Identification and Remediation Technologies, and the Environmental Security Technology Certification Program.

Abstract

Magnetic detection is a commonly used method for the location and identification of UXO. This technology can be used to construct a magnetic field map of a region suspected to contain UXO. The presence of ordnance is determined by magnetic anomalies superimposed on the background geomagnetic field. Similarly, other ferromagnetic materials, both man-made and naturally occurring, will cause magnetic anomalies. In order to enhance detection capabilities using magnetometers as well as assist discrimination of UXO from magnetic clutter, it is valuable to have estimates of the expected magnetic signatures from different types of ordnance items.

Ferrous ordnance is often modeled using an equivalent solid spherical magnetic mass, which permits an analytic solution to the magnetic signature. Although the spherical model yields some information about the magnetic anomaly expected from ferrous ordnance, this approach neglects shape and orientation of the ordnance relative to the geomagnetic field. To provide a more realistic estimate of the signature of buried, ferrous UXO, a model that accounts for the shape, size and orientation of ordnance is presented. This model demonstrates the shape and orientation dependence of the magnetic anomalies caused by ferrous ordnance. The model also is used to compare the magnetic signature of a solid ferrous mass to that of a hollow object (which more realistically approximates ordnance).

The ordnance shape is approximated by a prolate spheroid, to account for the long aspect ratio typical of ordnance, while preserving an analytic solution. The model considers only the magnetization contribution of the total magnetic signature. By employing the prolate spheroidal model, it is demonstrated that orientation of the prolate spheroid relative to the background geomagnetic field results in magnetic signature values that vary by as much as an order of magnitude. The signature maximum occurs when the prolate spheroid is oriented such that the semimajor axis is parallel to the geomagnetic field and the signature minimum occurs when the semimajor axis is oriented in the plane orthogonal to the geomagnetic field. The large difference in signature is a result of the demagnetization field and thus is strongly dependent on the eccentricity of the prolate spheroid. In the limit where the observation point is greater then a couple of semimajor axis lengths away from the center of the prolate spheroid, the signature approaches that of a dipole field.

In the case of a prolate spheroidal shell, it is shown that the magnetic signature is strongly dependent on the outer dimensions, relative permeability and wall thickness of the ferrous ordnance, not the mass. Thus the magnetic signature should not be scaled with the ferrous mass.

A Comparison of Magnetic Survey Methods

Presenter: Robert DiMarco, Ph.D Physics. Dr. DiMarco has over 10 years experience in modeling physical systems, field test design and execution, and data analysis. Currently he is task leader for AETC programs that are providing data analysis for the MTADS and SOCS towed magnetometer arrays, as well as continued physical modeling of UXO signals and sensors.

Abstract

Passive magnetic sensors, including total field sensors, field component sensors, and gradiometers, are currently the preferred method for detecting UXO. In this paper we describe a method for quantifying the detection performance of surveys using passive magnetic sensors and demonstrate the method with examples from three types of surveys. This methodology may be used after a survey to verify that the requirements of the survey have been met. In the survey planning phase this tool can be used to compare proposed sensors and survey methods.

The dipole nature of the passive magnetic signature at the surface for most buried UXO allows physical modeling of the signal amplitude. Combining the signal model and a model for the declaration of detections, with a model for the instrument motion along the survey path allows for calculation of survey performance. Basic to the specification of survey performance is an image of the probability of detection as a function of target size and depth. For shallow targets the probability of detection is dominated by the probability that the sensor will pass nearby over the target. For deeper targets the surface signal is always encountered and the detection probability then depends on the relative amplitudes of the target signal and the detection noise (for example: environmental fluctuations, instrument noise, and noise introduced by the motion of the survey). As is typical for geophysical methods, there is a sharp transition between targets with amplitudes large enough that they are always detected, and slightly deeper and/or smaller targets which are never detected. This sharp transition results from the cubic dependance of the magnetic signal amplitude on target size, and the cubic (total field) or quartic (gradiometer) dependance on target depth.

In this paper we demonstrate the method using data from three types of typical UXO surveys: a total field survey, a gradiometer survey with the sensor held vertical and gradiometer survey with the sensor "swinging" side to side. In all three cases there is good agreement between the performance expected from the model and the results from the field. The comparison of methods shows that the preferred survey technique depends on the objectives of the survey. For instance the technique of swinging the gradiometer from side to side increases the encounter probability for very shallow objects for a given lane spacing. However, this method also significantly increases the detection noise which increases the size of missed targets at all depths. Using the described tool survey planners can trade-off cost items, such as survey lane spacing and sensor type, against the performance needed to satisfy survey requirements.

Magnetic Gradient Tensor Signal Processing for UXO Localization and Classification

Presenter: William Michael Wynn, Ph.D Physics. Since 1970, Dr. Wynn has worked in the areas of magnetic source modeling, magnetic signal processing, and low-frequency electromagnetic sensor applications, primarily for the marine environment. In 1971, he showed that a tensor gradiometer could be used to locate and characterize a magnetic dipole source, and this finding accelerated the development of superconducting tensor gradiometers for mobile applications. These were initially intended for application to airborne antisubmarine Magnetic Anomaly Detection (MAD), but ultimately were used for sea mine detection and localization and characterization of dipoles. Hopefully, these tools will simplify the process of UXO location and excavation.

Abstract

A major portion of the UXO burden consists of ferromagnetic objects that are detectable because they create small changes in the earth's magnetic field. Common methods of detecting these changes with sensors in motion employ total field sensors, which provide a single channel of information that can be difficult to interpret, and interpretation typically requires large data samples over a grid. A more powerful method of detection and interpretation would be available if three-axis vector magnetometers could be used in motion, but the uncontrollable rotations of such a sensor in the large earth's field will produce random variations that greatly exceed the small anomalous fields associated with UXO targets. Thus, to produce multi-channel magnetic measurements in motion, methods must be developed to deal with the background earth's magnetic field.

The U. S. Navy has been developing alternative sensors for magnetic detection in motion for over 20 years. They are tensor gradiometers, which can measure the three spatial derivatives of the three components of the magnetic field at each point in space. The primary thrust has been to develop gradiometers based on superconducting technology, but there have been recent efforts to develop fluxgate technology for short-range, man-portable applications.

The matrix representing the magnetic gradient tensor is symmetric and traceless because of the vanishing curl and divergence of the static magnetic field in air, so each measurement produces five independent quantities. These five quantities can be measured with a variety of geometries, and a configuration using vector fluxgate sensors arranged in a plane is described elsewhere at this conference (UXO Detection Technology, Gary Kekelis, et. al.).

This presentation describes signal processing algorithms that include monitoring the gradient tensor magnitude for proximity of sources, interactive direction finding to a source on a point by-point-basis, and standoff position (including depth of burial) and magnetic moment vector determination with data determined both at separate points, and essentially at a single point. The algorithms use the gradient tensor values, as well as estimates of the gradient tensor rate of change with either time or position.

The algorithms are based on the inversion of the gradient tensor equations for a magnetic dipole, and the inversion of the gradient rate tensor equations for a magnetic dipole, with these procedures used both individually and jointly. The procedures individually provide point-by-point values for the bearing vector to the source, the direction of the moment vector, and the ratio of the moment vector magnitude to a power

of the range-to-source. The individual procedures have multiple solutions which can be sorted by a variety of techniques that generally involve measurements at more than one point. When the procedures are used jointly, they produce a unique solution for the full position vector and magnetic moment vector of the source on essentially a point-by-point basis.

Automatic Detection and Characterization of Magnetic Anomalies in Total Field Magnetometer Data

Presenter: Douglas F. DeProspo, Ph.D Physics. In the last 2 years, Dr. DeProspo has worked extensively on the use of magnetometers for the detection and classification of UXO. His chief experience relates to the development of an automatic magnetometer processor for SOCS. In addition, he has been and continues to be involved in the development of commercial software to process magnetometer data (MAGAID).

Abstract

The Areté Engineering Technologies Corporation (AETC), under contract with NAVEODTECHDIV, has developed and demonstrated an automatic processor for SOCS (Subsurface Ordnance Characterization System) for total field magnetometer data. The processor, *Magproc*, is stand-alone and code-written in ANSI standard C, for portability. *Magproc*, without operator intervention, operates on SOCS-generated GPS navigation, sensor amplitude and sensor platform offset and motion compensation data to produce an output file containing the locations, burial depths and sizes of magnetic anomalies in the coverage region. Although the algorithms employed by *Magproc* were developed originally for the SOCS array, they are sufficiently general to have applicability to other towed array and man-portable systems in both total field and gradiometer configurations.

The *Magproc* processor is divided into several major areas. In the first, magnetometer amplitudes, which exist as time series, are mapped to spatial coordinates (UTM). These positions are corrected for the motion of the platform carrying the magnetometers. Next, sensor noise levels and median levels are estimated using a cumulative distribution function. *Magproc* then intercompares sensors rejecting noisy or dead sensors. In addition each good sensor is corrected for a directional and inter-sensor, zero-level bias. Once an overall noise level has been calculated, target detection is attempted with a novel cluster-based approach. Using the noise level calculated in the previous step, a detection threshold is applied to the data and the location and amplitude of all threshold exceedences are stored. The positive and negative exceedences are separately clustered into groups of adjoining points. Nearby positive and negative clusters are associated to form magnetic dipole candidates. An additional algorithm is then applied to resolve ambiguous pairings. Upon completion of the detection algorithm, target characterization is attempted using a magnetic dipole model. This model is parameterized by location in three dimensions, a dipole moment, and two dipole orientation angles (the inclination and declination). Characterization begins with preliminary estimates of the aforementioned parameters. With the preliminary estimates as a starting point, the target parameters and associated error bounds are estimated with an iterative maximum likelihood fit to a dipole model. In this step the amplitude is scaled out so only the dipole shape is fit. After the shape fit is complete, the dipole strength is determined using a second maximum likelihood fit. The target radius is then estimated under the assumption that the magnetic moment is that of an equivalent induced sphere. Target information is then recorded in a prescribed output format for later downstream processing.

The performance of the automatic processor has been evaluated on SOCS data sets taken at Tyndall Air Force Base in Florida. The processor performs well on compact targets that are reasonably well separated. Generally, position estimates, when compared to ground truth are within 3 ft while depth estimates tend to be accurate to less than 1 foot. However, it has been observed that complicated scenes, with closely spaced targets, confuse the clustering algorithm and extended targets, such as 2000-lb bombs, are not well represented by a dipole model.

Performance of Electromagnetic Induction Sensors for Detecting and Characterizing UXO

Presenter: Bruce Barrow, Ph.D Physics. Bruce Barrow is a member of the research staff at AETC. He is currently involved in the modeling and analysis of the response of magnetometers and electromagnetic induction sensors to buried objects. This work is being applied to an interactive data analysis system that AETC is developing for the Naval Research Laboratory's Multisensor Towed Array Detection System (MTADS). He has previously worked on the evaluation of both oceanographic and non-acoustic ASW sensor data.

Abstract

Electromagnetic induction sensors provide information about buried objects such as UXO that is not accessible to conventional magnetometers. We report the results of modeling and analysis of the performance of the Geonics EM-61 pulsed electromagnetic induction sensor for detecting and characterizing UXO. We have used a series of controlled measurements of various test objects (metal spheres and cylinders with various conductivities and permeabilities) as the basis for a working model of the sensor response as a function of object location, depth, size, shape and material properties. The model can be used to predict the instrument's ability to detect UXO as a function of size and depth. The model has been incorporated into a fitting algorithm to determine the location, size and depth of unknown objects. The performance of the model and the object characterization algorithm have been verified using EM-61 and total field magnetometer survey data from a test field at Fort Devens, MA.

We also discuss design modifications which can improve performance for UXO detection and characterization, such as increasing the transmitter pulse amplitude and changing the transmit and receive antenna size and orientations. The potential for determining object aspect ratio and orientation by using several configurations is specifically addressed. Controlled measurements of various test objects using modified sensor configurations are presented and compared with the corresponding model results.

Model Based Approach to UXO Imaging and Optimization of Instrument Design for the Time Domain Electromagnetic (TDEM) Method

Presenter: Eugene M. Lavely, Ph.D. Dr. Lavely's research background includes studies in global geophysics, seismic exploration, and helioseismology. Geophysical inverse theory has played an important role in many of his theoretical and observational studies in these fields. The detection and imaging of UXO ultimately is based on inverse theoretic considerations, as well as spatial-temporal data processing techniques, much of which can be transferred from the geophyscial context.

Abstract

Improvement of the target detection capability of TDEM sensors requires further work in three major areas: (a) improved technology and instrument design, (b) improved imaging capability, and © improved target recognition algorithms. These problem areas are coupled and depend fundamentally on the development of an accurate and forward and inverse modeling capability. This capability has not been developed to date because of the analytical and/or numerical difficulty in modeling EM scattering in UXO objects that have large conductivity contrasts with the host media. In the following we describe a new development that addresses this problem, and then outline how this new modeling capability can be used to optimize instrument design and provide training data for target recognition algorithms.

Modeling of the TDEM method requires the ability to compute the secondary EM fields scattered by a UXO target. The Born approximation is an example of an EM scattering method and is popular since the scattered field can be computed in terms of an integral that is linear with respect to the properties of the scatterer and the medium. This is advantageous since the forward and inverse problem can be posed simply and computed rapidly. The conductivity contrasts due to UXO can be as large as 10^7. Unfortunately, the Born approximation breaks down for conductivity contrasts as small as a few per cent. However, very recently, researchers in electromagnetic geophysics (Habashy, Torres-Verdin) have developed a theory known as the *Extended Born Approximation* that extends the range of validity of the Born approximation to very large conductivity contrasts, yet retains the numerical and analytical advantages of the Born approximation. This theory is ideally suited for UXO scattering computations.

A benefit of constructing the inverse solution is the ability to analyze the efficiency of the *antenna array*, i.e., the space-time distribution of TDEM observations of the scattered field. The antenna array of a TDEM detector is defined by the orientation, location, and size of the transmitter and receiver coils, the distribution and width of time windows of observation, and system parameters such as base frequencies, transmitter waveforms, etc. The problem of optimized experimental design has been given a strong foundation by physical oceanographers who have designed instrument arrays to optimally map and constrain ocean dynamics and structures. The design optimization problem is cast in terms of the maximization or minimization of some objective function which can take many forms. For example, one may wish to produce a design in which the error of the inverse solution using noise-free data for a given scatter is minimized. Another objective function can be defined by the design that yields minimum covariance among model parameters that characterize the scatterer. Another may be the system design that yields the maximally stable inversion matrix. The enforcement of one, or several, of these criteria produces an objective function in which there is a weighted trade-off between best fit to the data, minimum trade-off between model parameters, minimum sensitivity to noise, maximum matrix stability, etc.

Target recognition algorithms such as neural networks can benefit from forward and inverse modeling capability for at least two reasons. First, training data can be computed synthetically for arbitrary UXO targets and instrument parameters yielding significant cost savings over data training data collected in the

field. Second, inverse modeling can demonstrate which designs and measurements most powerfully constrain a given object. Thus, informed choices can made with regard to the input nodes of the net, and will minimize the size (and computation time) of a given net to be used for UXO detection and imaging.

3-D Localization Using an Electromagnetic Sensor System

Presenter: Carl V. Nelson, MS Engineering Physics. Carl V. Nelson is a Senior Staff Physicist in the Remote Sensing Group, Submarine Technology Department at the Johns Hopkins University Applied Physics Laboratory. He received a BA degree in physics from California State University, Fullerton in 1973 and an MS in engineering physics from the University of Virginia in 1975. He has worked in a variety of areas, including meteorological and wave measurement systems, ocean optical modeling and instrumentation, design and development of buoy systems, air-sea interaction studies, and airborne and underwater electromagnetic sensor systems.

Abstract

The Johns Hopkins University Applied Physics Laboratory (JHU/APL) has developed a unique imaging time-domain electromagnetic (I-TEM) sensor and technique that can resolve and localize buried metallic objects. This technique combines a nearfield electromagnetic holographic imaging process with transient time-domain electromagnetics to image subsurface metallic objects. Developed with JHU/APL internal research and development funds, the I-TEM technique has been successful in localizing multiple, closely spaced, buried metallic targets to a depth of about 1 meter in proof-of-concept demonstrations. Data were gathered for the proof-of-concept demonstrations using leased conventional geophysical prospecting equipment and a JHU/APL-designed I-TEM system.

For conventional (Fraunhofer region) holography, the resolution cannot exceed Rayleigh's criterion, $\lambda/2$. To achieve deep penetration in dissipative media, active electromagnetic sensors operate at extremely low frequencies with wavelengths typically hundreds to thousands of meters in the earth. Long wavelengths would seem to indicate inherently poor resolution. Using nearfield holography, however, the resolution is not theoretically limited by wavelength. Nearfield holography utilizes the evanescent waves in reconstructing the image in addition to the propagation waves which are used in the conventional holography.

In a typical conventional time-domain electromagnetic (TEM) detection system, a current loop transmitter is placed near the target that is to be detected/imaged. A steady current is caused to flow in the transmitter loop for a sufficiently long time to allow turn-on transients in the ground to dissipate. The loop current is then quickly turned off. According to Faraday's Law, the rapid reduction in the transmitter's magnetic field induces an electromotive force (EMF) in nearby conductors. This EMF causes eddy currents to flow in the conductor with a characteristic decay time that depends on the conductivity, size, and shape of the conductor (i.e., target/UXO). The decay currents generate a secondary magnetic field, the time rate-of-change of which is measured by a receiver coil located above the ground.

In the JHU/APL implementation of the TEM technique, the target/UXO's decaying magnetic field is measured at multiple points over a large area near the target using an array of magnetic induction coil sensors. After applying a backward propagation algorithm, the measured data are Fourier transformed, multiplied by a propagator function, and inverse transformed to create an image using near-field holography. The holographic technique can resolve multiple, closely spaced target/UXOs and provides precise information on the target/UXO's location.

The I-TEM sensor system consists of a 6 meter by 6 meter pneumatically driven scanning frame, source and coil receiver array, and a PC-based data acquisition system. The nearfield holographic data processing algorithms have been implemented on a Unix workstation using FORTRAN and Research Systems, Inc., Interactive Data Language (IDL).

This paper describes the I-TEM hardware system, the near-field holographic technique and experimental results.

Thursday, March 29, 1996
Session A
Auditorium

Testing of Surface UXO Detection via an Active/Passive Multispectral Line Scanner System

Presenter: Hollis H. (Jay) Bennett, Jr., MS, Electronic Engineering. For the past three years, Mr. Bennett has worked for the Environmental Sensing Branch in the Environmental Engineering Division of the Environmental Laboratory at the Waterways Experiment Station. He is responsible for the development, installation, testing, and operation of systems for data acquisition of laser and infrared sensor systems. He also manages the data collection and processing of differential global positioning system data for use in geographical information systems. His main interest, at present, is in the development and implementation of sensors for the detection of minefield and unexploded ordnance.

Abstract

Many Department of Defense (DoD) sites with unexploded ordnance (UXO) contamination must undergo cleanup. Existing technologies for detection and remediation of UXO are expensive, dangerous to personnel, labor intensive, and technologically inefficient. The need for dual-use technology is becoming greater with the budget reductions taking place in the DoD. The use of a helicopter-mounted multispectral data acquisition/processing system originally designed for remote minefield detection is being adapted to detect surface UXO. The use of airborne remote detection minimizes the risk to personnel during the environmental assessment and analysis of the site.

The system consists of an active/passive multispectral line scanner, real-time processing and display equipment, and navigational equipment. The scanner collects three channels of optically aligned image data consisting of two active laser channels, one polarized reflectance and the other total reflectance, and one passive thermal infrared channel. The real-time processing and display system is based on parallel processor technology. The system can be flown at low altitude (130 feet) with a forward speed of 30 knots to characterize the site for the presence of surface UXO. This altitude and forward speed allow for the surface resolution to be 1.9 by 1.9 inches square.

The system also incorporates onboard recording and the insertion of differential Global Positioning System (GPS) coordinates. GPS coordinate information will allow contaminated areas to be added into a Geographic Information System (GIS) so that UXO locations can be overlaid on the base maps. The detection is based on the remote identification of surface anomalies and materials which indicate the presence of surface UXO contamination. Results of flight tests performed at Fort Rucker, Alabama on UXO material sent from Jefferson Proving Ground, Indiana and Yuma Proving Ground, Arizona will be presented. The design of the test suite used for the collection of experimental data will also be reviewed to determine the level of classification the system can obtain on UXO materials. The experiment is funded by the Environmental Security Technology Certification Program and managed through the Army Environmental Center. The system shows promise in the dual-use area for surface UXO detection.

UXO Detection by Combined Radar/EMS Sensor System

Presenter: Raymond Harris, MS, EE & MS Management Science. Mr. Harris has led research and development and contractual efforts on GPR and EMS sensors. He has participated in UXO tests at Jefferson Proving Ground, Yuma Proving Ground, McChord Air Force Base, and NAVEODTECHDIV. In addition, Mr. Harris has conducted high-resolution two- and three-dimensional measurements on land mines taken from Kuwait.

Abstract

This paper will describe METRATEK's combined sensor system that was used for the live site demonstrations in Yuma Proving Ground and McChord Air Force Base in July and November, 1995. The system provides coverage rates of up to 5 square meters per second with a combination of imaging ground penetration radar and electromagnetic sensor systems. A real-time kinematic differential GPS system provides navigation and target location. The paper will describe the system, its unique radar sled configuration, GPS performance, and the unique experience gained in 130-degree temperatures at Yuma Proving Ground and in rough, wooded terrain at McChord Air Force Base.

Computer Modeling to Transfer GPR UXO Detectability Knowledge Between Sites

Presenter: Gary R. Olhoeft, Ph.D Geophysics. Dr. Olhoeft has been working on subsurface investigation for a variety of problems since 1969 and on UXO-related problems since 1979. He is mostly interested in electrical and electromagnetic methods (including GPR) and in methods of quantifying how good a survey's date, processing modeling, and interpretation really are.

Abstract

Using laboratory measurements on soils from Jefferson Proving Ground, Yuma Proving Ground, and Kaho'olawe Island, the ground penetrating radar response and detectability of buried objects (pipes, mines, etc.) have been modeled with a 2.5-dimensional program. The model parameters for the subsurface media are taken directly from the frequency-dependent laboratory measurements of the site samples. This allows the response of any object buried at one site to be simulated at another site by changing the model parameters. Laboratory measurements also have been used to extend and test the range of applicability of ground penetrating radar by producing information about the variability of electromagnetic properties with depth, soil type, water content, temperature, and other variables. Combining this with the modeling program allows prediction of the detectability of objects at the same or different sites under varying conditions such as after a heavy rain, at a different depth, in a new soil type, in winter versus summer, or with other changing environmental and site variables.

The modeling algorithm uses a hybrid of ray-tracing and boundary element methods to produce full waveform ground penetrating radar profile responses in a few minutes on desktop Pentium-class personal computers. A separate response is found for every significant frequency in the radar pulse, so the true frequency-dependent signatures of the media can be used. Conductivity and complex functions of dielectric permitivity and magnetic permeability versus frequency as determined by the laboratory measurements are input to the modeling program. Only zero-offset, primary reflections are modeled. The model is assumed to be infinite in the cross-profile direction, and the starting pulse is assumed to be polarized in this direction, so no polarization changes are considered. However, both amplitude and phase changes on the response due to attenuation and velocity variations with frequency are honored, as are complex reflection and transmission coefficients due to conductivity or other loss mechanism contrasts.

The combination of this computer modeling program with material property information that is easily and inexpensively measured in the laboratory, allows not only the transfer of experience and knowledge from location to location. It also allows the rapid testing of hypotheses such as: What would be the detectability of plastic versus metal mines? What if they are buried deeper? What if the soil stratigraphy is slightly different or the water table is higher? What if the survey is performed in winter when the ground is frozen instead of summer? What size object could a UXO survey with these GPR parameters fail to detect under the specified conditions? Each of the three example sites (Jefferson Proving Ground, Yuma Proving Ground, and Kaho'olawe Island) have very different, site-specific soil conditions requiring careful survey design for optimum detectability of unexploded ordnance.

Real-Time Man-Portable Synthetic Aperture Ground-Penetration Radar

Presenter: Raymond Harris, MS, EE & MS Management Science. Mr. Harris has led research and development and contractual efforts on GPR and EMS sensors. He has participated in UXO tests at Jefferson Proving Ground, Yuma Proving Ground, McChord Air Force Base, and NAVEODTECHDIV. In addition, he has conducted high-resolution 2-D and 3-D measurements on land mines taken from Kuwait.

Abstract

METRATEK has developed a real-time, man-portable synthetic aperture system for the U.S. Army Environmental Center under contract to the Naval Ordnance Disposal Technology Division. The system consists of a METRATEK Model 200 radar adapted for use with backpack radar electronics, an antenna sled that is pushed along the ground, and real-time software to provide the operator with an image of buried targets as the operator moves along the ground. This paper will describe the system and test results obtained with it.

Applications and Advantages of Two-Frequency Continuous Wave Detectors

Presenter: Hanns Peter Trinkaus, BS Engineering. Hanns Peter Trinkaus has been active for over 25 years in the development, marketing and sales of mine detectors. He has extensive international experience and is currently senior sales manager of the Search Instruments Division of the Institut Dr. Förster, in Reutlingen, Germany.

Abstract

Continuous wave, all-metal detectors have been developed and used for many years. Some very popular previous examples are the AN/PPS-11 and the METEX 4.125.

Metal detectors working on pulse principle were previously known and used for all-metal treasure hunting only. However, today there are also military mine detectors like the AN-19/2.

The dual frequency concept represents a low frequency range and a high frequency range. Both ranges have advantages in terms of penetration depth and target resolution, but they also have disadvantages like disturbing influences mainly from magnetic, conductive, or salty soil.

Institut Dr. Förster in Germany is the pioneer of the eddy current principle in the field of non- destructive testing (NDT) of metals and in the field of search instruments. When it comes to very stringent and sophisticated quality control-requirements, two or even more frequency-systems are used. This year-long experience has been the source of the Förster MINEX development.

How does the two-frequency principle operate? The eddy current response from metals in the ground is different in electrical amplitude and phase for a low and a high frequency transmission. The same applies for magnetic and conductive disturbances. Whereas a one-frequency detector can evaluate the responses either in the direction of the real or the imaginary axis or just evaluate the amplitude and not the phase, the two-frequency detector can evaluate by signal comparison of the two responses received. By this method, all disturbing influences can be made "zero" whereas signals from metals have a good value, (i.e. the response from metals of all kinds, including the difficult non-magnetic stainless steel) comes with an extremely good signal-to-noise ratio.

However, also from the sensor side you can support an advanced signal-evaluation method. Instead of the simply wound transmitter/receiver coil, the MINEX is using a multilayer, PCB-coil arrangement with extremely balanced differential receiver coils.

For system integration, the Minex Sensors, signal evaluation and processing electronics are used as "components," linked by cable and mounted on platforms. These Minex platforms become part of sensor vehicles and can be combined with FEREX(MK26) or other type of sensor arrangements.

Test have been done showing the sensitivity in centimeter-distance for various objects and the separation of anti-personnel and anti-tank mines when they are typically placed.

As a summary, Förster is proud to know that its two-frequency, all-metal detectors can meet the extreme removal requirement caused worldwide by mines and UXO in magnetic type soils, by providing the means in which the millions of mines and UXO can be removed in a confident and safe manner.

A Transportable Pulsed-Neutron, Non-Intrusive UXO Identification Technique

Presenter: George Vourvopoulos, Ph.D Nuclear Physics. Dr. Vourvopoulos has been working for the last decade on neutron-based applications. He developed the pulsed-fast-thermal neutron analysis (PFTNA) technique which is currently used for the development of instrumentation for on-line coal analysis and detection of hidden drugs.

Abstract

An elemental characterization method is proposed for the differentiation between inert rounds and UXO found in range impact areas. This method identifies in a non-intrusive, non-destructive manner, the elemental composition of the projectile contents. In particular, it measures the carbon/oxygen ratio of the contents, as well as the hydrogen and nitrogen content. A number of other chemical elements such as fluorine, phosphorous, chlorine, calcium, iron, barium, etc. can also be identified.

Since high explosives and projectile inert fillings have different elemental composition, one can, in principle, identify them by measuring their elemental content. The Pulsed Fast-Thermal Neutron Analysis (PFTNA) method is used for this investigation. The method uses microsecond pulses of fast and slow (thermal) neutrons produced from a compact neutron generator. The generator produces radioactivity only during the actual measuring time. Therefore, no radiation shielding during transportation or setup is required, and the operation of the system can be performed from a distance. The neutrons from the neutron generator impinge on the projectile,.and characteristic gamma rays are emitted from the various chemical elements contained within the projectile. These gamma rays act as the fingerprints of the chemical elements.

As proof, several 105 mm and 150 mm projectiles were obtained from the Army Jefferson Proving Ground in Indiana. The projectiles were either empty or contained one of two types of inert material: a wax-based filling or a red epoxy filling. To simulate the three types of high explosives used in these projectiles (TNT, comp B, and RDX), several innocuous chemical materials were mixed and placed in the empty projectiles, resulting to the same elemental composition as the high explosives. The projectiles were interrogated with the neutron source located at a distance of approximately 1 meter from the projectile. The gamma ray detection system was placed at a distance of 20 cm from the projectile.

After analysis of the gamma ray spectra obtained in these experiments, it was possible to determine with high confidence limits whether the projectile was empty or full of explosive simulant, wax, or red epoxy. Data from these experiments will be presented, the various elemental compositions will be discussed and identified, and the experimental setup for a transportable prototype PFTNA system will be described.

Portable Turnkey UXO Detection System; High Quality Data Acquisition → Accurate Navigation → Data Analysis UXO Detection Technology

Presenter: Gerhard Vallon, Dipl.-Ing. Mr. Vallon is president of Vallon GmbH, which has over 30 years experience in the development of magnetic instruments in the areas of UXO and mine detection. Vallon products are considered state-of-the-art and are in use worldwide by EOD professionals. Current developments include computer-aided systems with in-house software data processing programs.

Abstract

System Integration

For several decades, buried UXO has been successfully located by means of portable magnetometer instruments (i.e. cesium magnetometers and fluxgate magnetometers). Specialty expertise has been gained in Germany from extensive UXO detection requirements since the conclusion of WW II (UXO from this period is still detected). Fluxgate magnetometers have been proven to be highly reliable and accurate, especially where high concentrations of UXO are found and in urban areas with ambient problematic conditions.

Recently, the value level of fluxgate magnetometers produced by Vallon GmbH was proven effective during the UXO Technology Demonstration Program at Jefferson Proving Ground, 1994.

An enhanced "turnkey" UXO detection system has been developed by Vallon based on the experiences and needs of the user community. Both military EOD and commercial OEW companies require a system which is highly portable, versatile , easy to operate, and reliable for continuous use in the field.

To ensure that these advantages do not get lost when enhanced with "computer-aided detection," it is absolutely necessary to have an exact navigation system for the applied detection sensors. Therefore, Vallon developed two distinct navigation aids for use by the same detection equipment:

- SEPOS® - Sensor Positioning System
  (manually operated guiding lines with accuracy markers)

  Application: Narrow roads, narrow valleys, forested areas, and boreholes.

- DGPS - Differential Global Positioning Satellite
  (radio link navigation - no guiding ropes required)

  Application: In open areas such as firing ranges where clear satellite links are available.

In both cases the magnetometer data is recorded together with the data of the navigation system. A final target list is produced after evaluation comprises the combined data with a target description and target location (the GPS coordinates are easily converted to UTM).

The use of "conventional" UXO detection has vastly improved with the turnkey system approach, increasing detection performance and detection quality assurance. Current improvements with GPS technology have increased detection accuracy to a very high level. The results of these combined improvements include:

- The EOD personnel operating the system can fully concentrate on the data acquisition.
- The target data collected with GPS values are a reliable reference without the need for physical reference points which could become lost from extreme weather conditions, construction changes, etc.
- Quality assurance can be performed at the data analysis level on a PC. It is not necessary to repeat an area survey.

Data Quality Requirements

Two considerations are very important to obtain the desired results of high quality detection data:

- Reliable data acquisition.
- No change in the "original" measured data during the evaluation.

The reliability of the data survey for UXO is ensured by the use of a data acquisition unit with graphical display information for the operator. With this real-time display, the survey can be "quality checked" for the quality of the measured data. Should an error occur, the localized area of the survey field can be immediately resurveyed. Thus, quality and reliable data are ensured throughout the survey operation.

Vallon GmbH produces a complete detection system which includes the Micro Computer MC1 for data acquisition. The MC1 displays actual true-to-scale nT values at the present survey location of the-magnetometer. At the same time, the last segment-recorded survey tracks (5.4 meters) are also on display.

When the GPS option of the MC1 is in operation, the operator has directional guidelines on the display. This accurately points the way for each surveyed track to be recorded. MC1 programming ensures that all GPS tracks are in order from field coverage and tracks that cannot be repeated are left out. This means that the collected values, which are later transferred to a PC for analysis, are absolutely complete and free of errors.

The nT values of buried ferrous objects can be very different depending on the size, magnetic characteristics, position (angle), and influences of other nearby ferrous objects. Therefore, it is necessary that the nT values are recorded genuine and with absolute accuracy on the MC1 display an experienced operator will recognize the characteristic features of a ferrous object (UXO).

VALLON GmbH produces the signal processing software EVA® (Evaluation and Analysis) as an optimum tool for this purpose. Original data from the MC1 may be displayed in parallel with an"ideal graph" in the EVA program with true-scale representation. With this means, the software operator can evaluate the quality of the data analysis and manually influence complicated signal graphs to avoid any misinterpretation by the computer. On the completion of a data analysis, a final report is produced which includes a target (UXO) list, and a true-to-scale target map. Important information is provided on the target list including target location (latitude and longitude when GPS is used), target depth, inclination, etc. The target map provides an excellent visual representation on the level and areas of contamination.

In conclusion, it is now possible to obtain high quality and reliable data in UXO field survey operations. Having stored and analyzed target data provides baseline information for the present and future survey of a given site. An integrated "turnkey" system is both field usable, and provides a higher level of quality assurance.

NOTE: The complete presentation on this subject will include technical charts, graphs, and photographs of the subject data.

An Ultra-Wideband Radar System for Imaging Buried Ordnance

Presenter: Roger S. Vickers, Ph.D. Dr. Vickers has designed, built and demonstrated radar systems (both SAR and profiling) for detection of buried targets, including UXO.

Abstract

A synthetic aperture radar has been developed and tested for use in detection of shallow buried ordnance. The radar described in this paper is an ultra-wideband system operating in the VHF region of the spectrum. It has a resolution of 0.8 m in range and azimuth. The process of imaging buried ordnance depends on two factors, the ground clutter and the soil attenuation. A parametric illustration of both these factors is presented. Examples of the system's use in both favorable and unfavorable circumstances are given in the paper, and an assessment of the potential and limitations of the technique for buried ordnance detection is given.

Field Applications of the PINS Chemical Assay System for the Identification of Unexploded Chemical Warfare Bombs, Containers, and Projectiles

Presenter: A. J. Caffrey, Ph.D Physics & Astronomy. Mr. Caffrey is an experimental nuclear physicist at the U.S. Department of Energy's Idaho National Engineering Laboratory* in Idaho Falls, Idaho. He has conducted field assays of hundreds of suspect chemical warfare munitions and containers at over 20 former and present defense sites for the U.S. Army. In 1992, he and his research team received the R&D Magazine R&D-100 Award for the development of the Portable Isotopic Neutron Spectroscopy Chemical Assay System.

Abstract

The PINS Chemical Assay System non-destructively identifies the contents of munitions and chemical storage containers. PINS employs neutron radiation as a probe of the chemical elements within the container or munition. The item under test is not opened or drilled; it need not even be touched, and direct sampling and laboratory chemical analysis are eliminated. PINS can reliably identify the contents of items filled with high explosives, smoke-generating compounds and mixtures, and chemical warfare agents, including lewisite, mustard gas, and nerve agents GA, GB, and VX.

PINS has proven particularly valuable in the identification of "non-stockpile" chemical munitions. Often these munitions have been buried for years, and rust has obliterated their markings. In addition to the buried munitions, old "dud" munitions (bombs or projectiles that failed to explode on impact) are often recovered from firing ranges. Duds are also rusted, difficult to identify, and can be extremely dangerous; their fuses may have armed and their casings may be fragile from corrosion and the shock of landing.

Since May, 1992, the U.S. military and civil authorities have requested PINS assays of hundreds of suspect containers and munitions, ranging in size from hand grenades to large bombs. The contents of the assayed items has varied from muddy water to nerve gas. These assays were safely carried out, usually under field conditions, at Anniston Army Depot, Alabama; Fort McClellan, Alabama; Redstone Arsenal, Alabama; Pine Bluff Arsenal, Arkansas; Fort Ord, California; Rocky Mountain Arsenal, Colorado; (former) Camp American University, District of Columbia; Eglin Air Force Base, Florida; Idaho National Engineering Laboratory, Idaho; Rigby, Idaho; Edgewood Area, Aberdeen Proving Ground, Maryland; the Naval EOD Technical Center, Indian Head, Maryland; Fort Devens, Massachusetts; Fort Dix, New Jersey; Defense Depot Ogden, Utah; Dugway Proving Ground, Utah; Tooele Army Depot, Utah; Fort Belvior, Virginia; and Fort Lewis, Washington.

In this paper we will review the basic operating principles of PINS, its application to suspect chemical warfare munitions, and recent improvements.

* Supported by the U.S. Army, Program manager for Chemical Demilitarization; Field Command, Defense Nuclear Agency; and the office of Non-Proliferation and national Security, NN-20, U.S. Department of Energy, under DOE Field Office, Idaho, contract no. DE-AC07-94ID13223.

Probing Chemical Contamination from UXO with SIMS

Presenter: Gary S. Groenewold, Ph.D. Dr. Groenewold has been studying environmental and industrial surfaces since 1990. He uses a technique called static secondary ion mass spectrometry, in which the surfaces of samples are probed with no sample preparation. His research has been focused on the analysis of organophosphorus compounds, specifically chemical warfare degradation products.

Abstract

Potential leakage of unexploded ordnance (UXO) is a significant concern when chemical warfare (CW) materials are encountered. The ability to effectively assess this possibility requires the detection of CW agents and degradation products, which can be difficult because of their high surface adsorptivity, and reactivity. The surface adsorptivity, or "stickiness", of the agents and degradation products can defeat detection technologies which rely upon getting the target compounds into the gas phase (e.g., gas chromatography or ion mobility spectroscopy). On the other hand, a *surface* analysis can be very effective for detection of adsorptive compounds on environmental surfaces.

Secondary ion mass spectrometry (SIMS) is a surface analysis technique which is effective for the detection of CW-related compounds adsorbed to environmental surfaces. The principle behind SIMS is simple: the sample surface is bombarded with energetic particles, which causes adsorbed CW compounds to be 'sputtered' into the gas-phase, much as water droplets are thrown into the air when a projectile hits the water surface. Some of the sputtered compounds will be charged (positive or negative), and their mass can be measured using a spectrometer; the mass can be used to identify the adsorbed compounds.

SIMS is extremely sensitive and selective for the detection of adsorbed compounds, requires no sample preparation and generates no waste. A sample of 1 milligram or less is sufficient for analysis, which is important in cases where samples are hazardous. Samples can be analyzed in under 10 minutes.

Recent advances have dramatically improved the ability of SIMS to detect adsorbed *molecules*, on true environmental and industrial surfaces such as rocks, leaves, soil, gaskets, and charcoal. Research at the Idaho National Engineering Laboratory has resulted in the development of pulsed secondary ion extraction, and a novel rhenium tetroxide (ReO_4^-) bombarding particle; these technologies overcome impediments from sample charging, and improve sputtering. In addition, the construction of prototype ion trap SIMS instruments have resulted in a combination of enhanced analytical selectivity, sensitivity, and small size, thus making the instrument transportable. The latest prototype is mounted on a moveable cart with a footprint of 44 inches by 28 inches, and is 50 inches high. The development effort will result in an instrument for the Mobile Munitions Assessment System (MMAS) currently being developed by the U. S. Army Program Manager for Non-Stockpile Chemical Material.

Applications studies using SIMS have been focused on the detection of alkylmethylphosphonic acids on vegetation surfaces.[1] These compounds are the primary degradation products from G and V agents in the environment. The compounds produce persistent SIMS signatures on a variety of leaf surfaces, which can be observed with no sample preparation other than attaching a disk to a sample holder with double-sided tape.

SIMS was also demonstrated for the detection of long-lived HD condensation ions, which can obfuscate the identification of HD residues.[2] Recent experiments have shown that the simulant tri-*n*-butylphosphate can be detected a levels less than 0.01 monolayer on soil samples, using the ion trap SIMS instrumentation.

[1] Ingram, J. C., Groenewold, G. S., Appelhans, A. D., Delmore, J. E., Dahl, D. A., Anal. Chem., 1995, 67, 187-95.

[2] Groenewold, G. S., Ingram, J. C., Appelhans, A. D., Delmore, J. E., Dahl, D. A., Environ. Sci. Technol., 1995, 29, 2107-11.

Thursday, March 28, 1996
Session B
Amphitheater

SAR Processing of Ground Penetrating Radar Data for Buried UXO Detection: Results from Surface-Based and Airborne Platforms

Presenter: Jennifer Halman, MS Physics. Mr. Halman's experience includes simulation of ground penetrating radar systems and signal processing of airborne and ground-based radar data using FORTRAN, C, C++, and IDL.

Abstract

Battelle and The Ohio State University ElectroScience Laboratory have built and demonstrated two ground penetrating radar systems for locating buried UXO. One system is ground-based, towed by an autonomously-controlled vehicle as part of the Subsurface Ordnance Characterization System (SOCS). The other system is airborne, with the radar mounted on a Blackhawk helicopter provided by the U.S. Army Aviation Technical Test Center. The ground-based system has been demonstrated at test areas at Tyndall Air Force Base and Jefferson Proving Ground. The airborne system has been demonstrated at Tyndall Air Force Base. Radar data from each of the demonstrations has been processed and will be presented. Synthetic Aperture Radar (SAR) processing is used to create a map of the area of interest, indicating the locations of targets. Scientists at ElectroScience Laboratory apply complex natural resonance analysis techniques to SAR-detected targets to discriminate between buried UXO and clutter items.

The ground-based system is a pulsed radar system. The SAR processing is done in the time domain. The raw data is in the form of time-domain waveforms and position coordinates. The processed data is in the form of images with the amplitudes of three-dimensional pixels in the ground indicated in false color.

The airborne GPR is a stepped-frequency system. The GPR antennas are located below and on the sides of a UH-60 helicopter. SAR processing is performed in the frequency domain because of the slow stepping speed of the radar and the constant motion of the helicopter. Position information is obtained from a GPS antenna on the tail of the helicopter and an internal inertial navigation system. This configuration allows positional accuracies on the order of 10 cm with approximately 25 updates per second. The Ohio State University Center for Mapping provided the position information processing and data. The airborne radar sweeps from 50 to 700 MHZ in 4 seconds while the helicopter flies over the test area approximately 80 feet above the surface at the rate of a few feet per second. The transmit antenna is a vertical cone lowered beneath the aircraft. Two receive antennas on either side of the helicopter receive the scattered signal in differential mode. Raw data is in the form of an amplitude and phase at each of the discrete frequencies and the position at which the data point was acquired.

The SAR processing will be described and results will be presented in the form of SAR images and buried target data.

This work was funded by the Naval Explosive Ordnance Disposal Technology Division.

Ground Penetrating Radar Target Classification via Complex Natural Resonances

Presenter: Chi-Chih Chen, Ph.D. Dr. Chen has been working on ground penetration radar problems since 1993. Since then, he has been involved in developing GPR systems for detecting and identifying gas pipes, UXO and mines. He has also designed and constructed various new types of GPR antennas. One of them is currently used on SOCS by NAVEODTECHDIV. He was also involved in data collection and processing for measurements performed at Jefferson Proving Ground, IN and Tyndall, FL. His current research interest is antenna design, UXO and mine detection and classification and ground scattering problems.

Abstract

Most UXO have simple geometry. When illuminated by a radar impulse they tend to resonate like conducting rods. Practically, only a few dominant CNRs can be obtained from the radar data due to the ground loss, radar sensitivity and system bandwidth. Using these dominant CNRs along with the knowledge of soil parameters, one can classify different UXO by estimating their lengths and damping factors. This technique has been used for aircraft classification because of its orientation independency. it was also found that the extracted damping factor is usually too unstable for most GPR data to be used for practical classification. A total-least-square-based Prony method is first used to extract CNRs from time domain. The lowest resonant frequency is then used to estimate the UXO length.

In this paper, a free space UXO under study was first modeled using the body of revolution moment method. The theoretical scatter field was calculated in the frequency domain. The corresponding time domain data was then calculated via discrete Fourier transform (DFT). TLS-based Prony method is applied to extract the CNRs from the time domain data. In the example, the CNRs of conducting pipes and UXOs were also extracted from the measured data collected using the Subsurface ordnance Clearance System (SOCS). The predicted lengths for the pipes and UXO agree reasonably well with their true lengths. During the course of this study, it was found that the environmental clutter such as the ground surface scattering and the medium inhomogeneity scattering was the major source of error in the calculated CNRs. The ground loss was also limiting the signal penetration.

High Accuracy CM-Level GPS/INS Positioning for Airborne Ground Penetrating Radar (GPR) SAR Processing

Presenter: Ren Da, Ph.D. Dr. Ren Da is a research specialist at the Center for Mapping, Ohio State University. He received his degrees in Automatic Control Engineering from Northwestern Polytechnical University. His research work includes investigation and computer implementations of strapdown INS navigation and attitude computation algorithms, INS system error analysis and modeling, mathematical and algorithms aspects of estimate and control, decentralized and nonlinear filtering, hypothesis testing/failure detection, integrated Doppler/GPS system and the fault-tolerant integrated GPS/INS systems, and autonomous GPS integrity monitoring. He has published 14 journal papers in these research areas.

Abstract

Proper focusing of the Airborne Ground Penetrating measurements for Synthetic Aperture Radar (SAR) processing requires high accuracy (~.07 m) and high rate (~25 Hz) positioning. For this purpose, the Center for Mapping has developed a high-accuracy, high-rate GPS/INS positioning system for airborne applications. This system employs on-the-fly ambiguity resolution techniques capable of providing high accuracy cm-level positioning with initialization times of 5 to10 seconds with as few as five satellites in view. This is very important for airborne applications in a helicopter environment, since tracking of all the satellites may not be possible due to the interference of the satellite signals with the rotating blades.

Integration of high accuracy (1 cm-level) GPS positions with inertial navigation measurements provides high-accuracy, high-rate positioning between the 1 sec (1 Hz) GPS position updates, and during periods when GPS positions are not available due to aircraft banking, or due to interference with the rotating blades. This paper describes the integrated GPS/INS system and the positioning accuracies obtained during the airborne GPR demonstration, for UXO detection, identification, and remediation. This demonstration was conducted in November of 1995, at Tyndall Air Force Base in Panama City, Florida. These tests were performed jointly with Battelle of Columbus, Ohio, and the Ohio State University (Center for Mapping, ElectroScience lab). The helicopter and the INS were provided by the U.S. Army Aviation Technical Test Center.

Analysis and Results of the 1995 Yuma Proving Ground Penetration Experiments

Presenter: Check F. Lee, Ph.D. Dr. Lee works in the areas of electromagnetic target signature analysis and modeling, processing of synthetic aperture radar data, and parallel computer technology and algorithms.

Abstract

Over the last few years, there has been a strong interest in applying airborne synthetic aperture radar (SAR) to the wide-area surveillance of underground targets. Many military targets of interest are either concealed in underground shelters or buried; these include buildings, bunkers, tactical vehicles, ammunition caches, weapon storage containers and mines. There are also many buried targets of interest in civilian applications, including underground pipes, utility cables, hazardous waste containers, and unexploded bombs or mines left over from previous warfare and at military test ranges.

As part of the investigation to understand ground penetration radar phenomenology, a large-scale field experiment was conducted by Lincoln Laboratory at the U.S. Army Yuma Proving Ground (YPG) in Arizona from June 4 to 15, 1993. This experiment created a unique and rich source of information concerning ground penetration SAR phenomenology. The targets deployed for the 1993 experiment included a mine field and two similar long wires. One of the wires was laid on the ground surface, while the other was buried. SAR data were collected using the SRI FOPEN II radar, and the data were processed into SAR imagery. The mine field was successfully detected by applying a group detection algorithm to the SAR imagery; a greater than 10 dB target-to-clutter ratio was achieved in the desert terrain. A wire detection algorithm was developed based on the complex image data. Using this algorithm, the target-to-clutter ratio was enhanced and both wires were successfully detected.

To supplement the data gathered in the 1993 YPG experiment, a new ground penetration radar field test was carried out at YPG in July, 1995. A large variety of targets were deployed for this test to achieve various measurement objectives. These can be categorized as tactical, environmental, phenomenological, utility, and calibration targets. Among these targets were unexploded ordnance (UXO) and various types of simulated mines.

The 1995 test, referred to as the Yuma-2 test, was designed to gain further understanding of SAR detection of buried targets and of the underlying phenomenology. There were several principal objectives:

1. To gather field data for investigating wide-area surveillance and detection of underground targets. To support this task, a statistically significant data base of target signature and clutter radar data (plus soil statistics) was collected. Appropriate target detection algorithms will be tested or developed and tested in order to estimate the detectability of selected underground targets in a desert environment.

2. To gather field data for developing and validating models of relevant detection phenomenology such as soil attenuation, buried target signatures.

3. To extend the range of measurement parameters such as polarizations, depression angles, and frequency bands; and to test new sensors.

Polarimetric airborne measurements were conducted over a 200-900 MHZ band and over a depression angle range of 20-50 degrees, using the updated P-3 radar and the SRI FOPEN III radar in July and October, 1995. Measurements will also be conducted using the ARL/MIT-LL BoomSAR over a 40-1000 MHZ band polarimetrically. These data are being processed into SAR imagery with 1 meter to potentially 15 centimeter resolutions.

This paper will present the 1995 summer and fall experiments and discuss preliminary imagery, data processing, and UXO detection performance.

Fused Airborne Sensor Technology (FAST)

Presenter: Delbert C. Summey, Ph.D Mechanical Engineering. Mr. Summey's interest in UXO was derived from the application of Navy mine countermeasures technology to the detection, identification, and location of underwater UXO; sensor processing technology under development by the Office of Naval Research at the Coastal Systems Station (CSS), Dahlgren Division, Naval Surface Warfare Center has direct application. A Mobile Underwater Debris Survey System (MUDSS) program, jointly executed by CSS and NASA's Jet Propulsion Laboratory, was funded by the Strategic Environmental Research and Development Program (SERDP) to demonstrate this multi-sensor technology approach. Drs. Summey and Kekelis are now investigating sensors and sensor fusion approaches for detection of landborne UXO from a helicopter platform.

Abstract

The need for rapid survey and detection of explosive ordnance and explosive waste (OEW) has given rise to a multi-sensor airborne concept for land site survey. The paper describes a rapid helicopter survey approach to site survey which could quickly assess areas for high/med/low/no explosive ordnance occurrences, thus reducing survey and subsequent reclamation costs and schedules. The sensor suite also provides the capability to identify targets, reject clutter, and localize both. The use of a single platform provides for spatial and temporal co-registration of sensor data, thus enhancing data correlation and fusion effectiveness.

Sensors employed for the FAST concept include superconducting magnetic field gradiometer, two-color infrared camera, synthetic aperture radar, and a visible spectrum camera. The combination of these sensors allows for detection, identification, and localization of a wide spectrum of both buried and surface targets in high clutter environments. This FAST concept is derived from a multi-sensor fusion approach demonstrated in mine reconnaissance against buried sea mines; through fusion of multi-sensor data, more than 98 percent of the non-mine targets were eliminated. A similar FAST multi-sensor airborne deployed system offers significant promise for land survey.

The FAST system concept and sensor suite will be described. (The sensor fusion application to the buried sea mine problem will also be discussed briefly as background). The value of spatial and temporal correlation of the fused sensor data will be discussed for both target detection and clutter rejection. A potential operational concept will be identified for the FAST system, and both military and commercial applications will be presented.

The Challenges of UXO in the Marine Environment

Presenter: Andy Pedersen, BS Chemical Engineering. Andy Pedersen has worked over 24 years in the Research and Development Department for the Joint Service Explosive Ordnance Disposal (EOD) Program. His project experience includes developing and testing tools and systems to locate and render safe UXO. He has actively participated in the search for underwater ordnance, and was awarded the Navy Meritorious Civilian Service Award for the technical assistance he provided to EOD Mine Countermeasures Task Force 40.9.3 in the Persian Gulf in 1987. Currently, he is also participating in the development of an improved UXO risk model and the assessment of UXO search systems demonstrated at Jefferson Proving Ground and other live sites.

Abstract

Many active and former military installations have ordnance ranges and training areas that include adjacent marine environments, including ponds, lakes, streams, rivers, estuaries, and coastal ocean areas. Natural erosion or shoreline migration can also convert a land UXO problem into a marine UXO issue. These marine environments are contaminated with UXO that was disposed of or expended to train personnel and develop ordnance technology. Conventional and experimental explosive ordnance and chemical munitions in shallow waters pose an on-site public safety hazard and an ordnance security problem. While generally out of the public view, submerged UXO can be accidentally disturbed by commercial fishermen or salvaged for misuse by motivated individuals. The technological challenges in the detection and disposal of UXO in the water are compounded over those faced in surface remediation.

Navy EOD personnel are uniquely trained to deal with UXO "below the high water mark." Their primary focus is in the specialized field of mine countermeasures: one diver, one mine. The U.S. Navy EOD community lacks the resources to respond to large-scale UXO clearance efforts. Generally, the practice has been to do very little about conventional marine UXO until civilians encounter it or there is an immediate safety concern. Their response is most often limited to rendering safe UXO washed ashore or recovering UXO from dredges and trawlers. In special cases, Navy EOD has responded to U.S. obligations to conduct small boat sonar searches or diver searches for UXO sweep and recovery operations. The more notable of these include the Suez Canal and Kuwait City harbor clearance operations.

The demand to characterize and remediate the hazards of marine UXO exists and is expected to increase. The scope of the demand with its technical and economic feasibility needs to be determined. Are the costs worth the benefits? The base closure process, EPA concerns, and international obligations require continued attention to marine UXO. This paper does not propose solutions to the problem of marine UXO, rather it seeks to identify several key issues. Some of the challenges the Navy EOD community has faced in dealing with marine UXO will be presented. Increased public awareness, the desire to fully utilize our limited water resources, and the closure of more military properties will continue to bring focus on the need to understand the functional limits and economics of marine UXO technology issues.

Mobile Underwater Debris Survey System (MUDSS), Phase I - Feasibility Demonstration

Presenter: Delbert C. Summey, Ph.D Mechanical Engineering. Dr. Summey's interest in UXO was derived from the application of Navy Mine Countermeasures technology to the detection, identification, and location of underwater UXO; sensor processing technology under development by the Office of Naval Research at the Coastal Systems Station (CSS), Dahlgren Division, Naval Surface Warfare Center has direct application. A Mobile Underwater Debris Survey System (MUDSS) program, jointly executed by CSS and NASA's Jet Propulsion Laboratory was funded by the Strategic Environmental Research and Development Program (SERDP) to demonstrate this multi-sensor technology approach. Drs. Summey and Kekelis are now investigating sensors and senor fusion approaches for detection of landborne UXO from a helicopter platform.

Abstract

MUDSS is a three-year technology demonstration program funded by the Strategic Environmental Research and Development Program (SERDP). Its purpose is to demonstrate technologies necessary to successfully survey underwater formerly used defense sites (FUDS) for ordnance and explosive waste (OEW). The program is being executed jointly by the Coastal Systems Station (CSS) of the Naval Surface Warfare Center/ Dahlgren Division and by the Jet Propulsion Laboratory (JPL). MUDSS heavily leverages (1) acoustic, magnetic, and electro-optic (EO) minehunting sensor and signal and image processing technologies under development at CSS for the Office of Naval Research, (2) signal and image processing technologies and visualization technologies under development at JPL for the National Aeronautics and Space Administration, and (3) trace chemical detection technologies under development at JPL for the Federal Aviation Administration.

The MUDSS program is divided into two phases. Phase I, which has just been completed, lasted the first year of the program and culminated in an at-sea feasibility demonstration (FD) of a multi-sensor MUDSS prototype against OEW targets planted in St. Andrew Bay near CSS. The FD, which was successfully executed in August and September of 1995, was a major success and is the subject of this paper. Phase II, which runs through the second and third years of the program, will (1) develop an advanced and refined MUDSS technology demonstration (TD) survey system from the experience with the MUDSS prototype in the FD, (2) build a real-time data analysis and display capability for the advanced MUDSS TD system, and (3) culminate in a MUDSS TD of OEW surveys at a FUD.

The goal of the FD was to demonstrate first that the performance of a prototype MUDSS sensor suite consisting of on-hand acoustic, magnetic, and EO sensors similar to the proposed TD sensors shows good promise against OEW targets and is well characterized by sensor performance models already in place at CSS. The FD also had the goal of providing a multi-sensor data base to be used during Phase II to refine and develop signal and image processing algorithms, to develop the powerful sensor fusion capabilities necessary for successful underwater OEW surveying in difficult environments, and to develop visualization techniques and real-time survey control for the MUDSS TD. These FD goals were successfully achieved and are discussed in the paper.

Underwater Ultrasonic Acoustic Imaging for Target Threat Assessment

Presenter: Bruce E. Johnson, MS Mechanical Engineering. Mr. Johnson has spent the last 5 years as the principle investigator for the Acoustic Imagery Program, an effort of the Office of Naval Research Exploratory Development. The program goal is to investigate technologies that will enable development of a diver-held imaging sonar for target classification. The work has been specifically directed at mine classification, but the underlying technologies also apply to underwater UXO identification.

Abstract

This presentation details the capabilities of different transducer array and acoustic lens configurations to image underwater targets of interest to Naval explosive ordnance disposal (EOD) divers. The paper also discusses the current research effort in two-dimensional array and beamforming technologies, which will enable development of the first generation of two-dimensional point focus imaging sonars.

EOD divers are frequently called upon to classify mine-like targets previously marked by side scan sonar operations. Similarly, underwater remediation efforts will require an assessment of potential ordnance items previously marked by a large-scale search technique. In shallow water harbors, rivers, and the surf zone, the mission is complicated by visibility on the order of an inch. A tool is required that will allow a diver to assess the threat at a standoff distance rather than through physical contact.

The Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV) has been working over the last 5 years to identify, establish the capability of, and improve technologies which will lead to the development of acoustic imagers to assess the target threat. The eventual system must have a power requirement, update rate, size, and weight suitable for diver operations. The small size constraint limits the aperture size to 20 centimeters or less. To get high resolution images with such a small aperture, frequencies in the ultrasonic region are under investigation. Using frequencies in the 2.5- to 3.5-MHZ range dictates a standoff distance of 3 to 5 meters. The capabilities and limitations of point focus, line focus, and Mill's Cross ultrasonic imagers have been established in the laboratory. Laboratory systems have been developed and employed to make images of sections of naval mines both suspended in the water column and positioned on the bottom. The importance of sidelobe reduction and signal multiplexing has been identified and parameters established.

This research has pointed out deficiencies in the current base of two-dimensional array fabrication, interconnect and electronics technology, and lens-based beamforming technology. The development of a point focus imager will depend on an advancement in the current state-of-the-art. On the sensor and electronics technology side, transducer arrays with 10,000 1-millimeter-diameter elements are required along with electrical connection to each element. The information received on 10,000 channels must then be processed to form images. Current acoustic lens beamforming technology applicable to the imaging task is limited to focal length to diameter (f number) ratios of about two. More compact lens designs with f numbers closer to one need to be developed to meet a 2-cubic-foot size requirement for a diver-held imaging system. Also of critical importance is sidelobe reduction of the individual beams. The use of a glossy lens material to apodize the aperture is under investigation. The current state of the research in these technology areas is presented.

Detection of UXO Within a Sand Borrow Offshore of Seabright, NJ

Presenter: Richard D. Lewis, Ph.D Geophysics. Dr. Lewis has served as the senior research scientist on many offshore, coastal and beach UXO investigations. His interests include new and innovative methods to identify, classify, and characterize UXO in harbors, inland waterways and the coastal environment. Many of these project developments have led to methodologies which are directly applicable to UXO search requirements for inland sites.

Abstract

Coastal fortifications and military posts have been located at the northern end of Sandy Hook, New Jersey since the mid-1700s. This strategic location guards the major navigation routes into New York Harbor. Consequently, various generations of large shore-based artillery and mortar batteries were built at Ft. Hancock at the north end of this sand spit. Remnants of the fortifications constructed from the 1890s until the 1940s are still in place at this formerly used defense site (FUDS) and maintained by the National Park Service. From the 1870s until World War I, a 4-mile stretch of beach and coastal dunes extending to the south and offshore in several directions were used as target areas for artillery proving. Various naval and army artillery and experimental rounds were tested along with proof firing of barrels for government acceptance. This long term use of Sandy Hook for military training and artillery proofing has resulted in ordnance contamination of large sections of Sandy Hook. In addition, the nearshore is littered with shells of various calibers and types representative of artillery used from the U.S. Civil War through World War II.

The U.S. Army Corps of Engineers and the State of New Jersey are presently engaged in constructing the largest beach restoration project ever undertaken in the United States. The purpose of this project is to protect many miles of the heavily eroded and developed north Jersey shore from coastal storm damages. The primary source for the required beach quality sediment is an approximate 6-square-mile area located 3 miles offshore of the southern end of Sandy Hook. Ocean-going hopper dredges excavate sediment from the authorized borrow area and, with the assistance of nearshore pump-out facilities, transport the material onto the beaches. Project construction started in 1994. Within a very short period, items of ordnance were discovered on the newly constructed beaches. Expensive clean-up operations were required to locate and remove ordnance from the beach. The source of this material was determined to be ordnance mined along with the borrow, although there had been no pre-project data indicating the presence of the extent of the ordnance contamination. To eliminate further risk of ordnance indigestion, the project dredges were fitted with 1.5-inch square grates over the dredge dragheads. These grates prohibit excavation of the ordnance, thus protecting the dredge and the resultant beach area from UXO contamination. However, the installation of the draghead grates also reduced the efficiency of the dredging operation by approximately 20 percent. Over the 50-year continuing construction project life, the presence of these grates and the reduced dredging efficiency could cost tens of millions of dollars in lost productivity.

It is unknown at this time if the entire offshore borrow area is contaminated or only a fraction contains ordnance. To investigate the possibility that more efficient dredging can be conducted in locations well away from the historical impact areas, a pilot offshore geophysical survey was conducted. The purpose of this pilot study was to test various geophysical and oceanographic techniques prior to conducting the further development required before large-scale application. Two acoustical methods, high frequency side scan sonar and sweep frequency subbottom profiling were employed. The larger "proud" ordnance sized items were detectable with the side scan sonar. Hard point-source targets were evident in the near subbottom by applying sweep frequency profiling methods. To detect the presence of ferrous dipole targets of finite length, a marine cesium vapor magnetic gradiometer was developed and deployed. This instrument had a

noise level of about 0.015 nanoTeslas/meter or about five times less the magnetic gradients generated by relatively quiet coastal wave action. Numerous clusters were identified which contained responses typical of the anticipated ordnance items.

The two acoustical systems did provide excellent information on the site geology and indicated the presence of suspected ordnance (hard target return) relative to bottom features and sediment fields. However, the magnetic gradiometer demonstrated a high degree of ferrous object sensitivity, thus providing a large detection range and target location capability. Potentially the gradient data can be used for basic classification and discrimination of ordnance size.

Evaluation of the Use of Existing Marine Geophysical Remote Sensing Systems for the Mapping and Classification of UXO in Coastal Waters

Presenter: David D. Wicklund, BS Physical Oceanography. Mr. Wicklund has ten years experience as a project engineer or leader with oceans-related work. He performs or manages concept development, design, fabrication, laboratory testing and at-sea testing of hardware and systems in support of Navy-funded programs. Mr. Wicklund is a Navy-certified SCUBA diver who participates in field exercises as a diver, and as a remotely operated vehicle (ROV) crew leader and operator, when appropriate.

Abstract

Many costal marine areas have been used over extended periods by the United States armed services and allies for simulated warfare training using live ordnance. The recent reduction of defense requirements has resulted in the termination of selected live ordnance training activities. Clean-up of unexploded ordnance (UXO) contaminated coastal land areas and their surrounding waters is now required to allow for the safe return of these areas to public use. Before contaminated areas can be cleared, effective means to map (detect/locate) and classify subsea ordnance must be developed and demonstrated.

The Naval Facilities Engineering Service Center (NFESC) was tasked by the Environmental Security Technology Certification Program (ESTCP) to investigate the applicability of marine geophysical remote sensing systems for the mapping and classification of underwater USO. ESTCP's goals are to demonstrate and validate the most promising innovative technologies that target the Department of Defense's most urgent environmental needs and that are projected to pay back the investment through cost savings and improved efficiency.

During fiscal year 1995, NFESC established a highly calibrated test range offshore of PMRF, in Barking Sands, Kauai. The objective of the range was to provide a calibrated site which could be used to validate the performance of commercially available geophysical sensing systems. The range included a calibration site and an operational site, and covered an area of 5.3 square kilometers. The calibration site was designed to provide demonstrators with known targets at known locations so they could prepare for their demonstration. The location of targets in the operational site was not provided to demonstrators. A total of 249 inert ordnance items and 41 false targets were precisely placed on and under the sea floor in water depths from shore out to 50 meters. Targets ranged in size from groups of 7.62 mm cartridges to single Mk 83 bombs.

This paper discusses the design and installation of the range, the criteria used to evaluate the demonstration activities, and the results of demonstration evaluations.

Thursday, March 28, 1996
Session C
Rooms 2 & 3

OECert (Ordnance and Explosives Cost Estimating and Risk Tool) FUDS Risk Based Characterization and Prioritization

Presenter: Arkie Fanning, B.S. Engineering, M.S. Engineering Management, M.S. Operations Research. Mr. Fanning has extensive experience in use of probability and statistical theory applications to Ordnance and Explosives problems. He was project manager and technical manager over the development of Ordnance and Explosive Cost-Effectiveness Risk Tool (OECert) and Site Statistical Sampling Based Methodology (SiteStats) for investigation of ordnance problems. These tools allow the Government to define the public risk that ordnance and the site represents. These tools allow the Government to gather data more cost effectively and to characterize sites for considerations more efficiently. Mr. Fanning is a Registered Professional Engineer in the State of Alabama and has over twenty years of engineering experience.

Abstract

OECert is a riskbased decision model for use in characterizing and prioritizing formerly used defense sites (FUDS) remediation work. OECert has been jointly developed by the Huntsville Division Corps of Engineers and QuantiTech Inc. The model uses several factors at a site (density of ordnance, type of ordnance, terrain features, population density, and many others) to determine the risk to public safety at the site. The model uses many of these same factors, as well as other factors, to develop rough order of magnitude life cycle costs for the site. The model is being used to determine the public risk represented by the various remediation alternatives that are generated during the Engineering Evaluation and Cost Analysis phase at a FUDS. The model allows the Government to determine the risk reduction for dollar spent for the remediation alternatives under consideration. The model is also currently being used to prioritize work areas at a site (which areas of a site should be cleaned first) and may in the future be used to develop a prioritized list of sites for remediation. OECert is more discriminating than are Risk Assessment Codes and can be used to compare the potential public risk at varying sites, plus it can compare the potential public risk both before and after remediation at any given site. It can also be used to determine when it becomes economically unfeasible to further remediate a site. The mathematics and engineering required to ensure the accuracy of the model has been developed and gone through peer review. The peer review found the model theoretically correct and operationally usable. A menu driven computer program has been written that will allow non-technical personnel to update and run the model.

Ordnance And Explosive Program Knowledge Base (OE-KB)

Presenters: Scott Millhouse, PE, BA. Scott Millhouse is a Civil Engineer with PE registration in Alabama and Pennsylvania. He works as a Group Leader and GIS coordinator for the U.S. Army Corps of Engineers Engineering and Support Center, Huntsville (CEHND) in the Site Development Branch. He has been working with CADD mapping and civil design since 1978 and with GIS systems for the last 4 years. The GIS has been in support of the Ordnance and Explosive (OE) Program with recent emphasis on using advanced geophysical techniques for the location and discrimination of ordnance. He graduated from Mansfield State University in Pennsylvania in 1977 with a BA in Geography/Regional Planning with an Associate in Civil Engineering. He has 20 years total service with CEHND in design and GIS application, Baltimore District in Civil works construction, and Europe Division in Frankfurt, Germany in design.

John E. Foley, Ph.D Geophysics. Dr. Foley is Director of SC&A's Geoscience Division and manages geophysical and GIS technology development and UXO services. With expertise in the development of geophysical sensor systems, digital signal processing, data fusion, and GPS, Dr. Foley has developed several UXO and countermine detection and analysis technologies for both government and industry.

L. Lynn Helms, MS Geological Engineering. Mr. Helms has been involved in shallow geophysical, remote sensing, and geotechnical applications since 1979. This work includes collaboration with the Waterways Experiment Station in REMIDS evaluations, with the Navy Coastal Systems Station in laser detection systems, and with Stanford Research Institute in a radar detection system. He has worked with several A-E firms on various projects characterizing sites with respect to ordnance detections, and evaluation. Mr. Helms co-authored HNC's current Innovative Technology Program Plan in 1994.

Abstract

Background - The CEHND is the Mandatory Center of Expertise (MCX) for ordnance and explosives.

An OE-GIS standard was created for CEHND and has been applied to several projects. The GIS assembles all the data required to associate the non-intrusive subsurface geophysics investigative data to its correct geographical location, the relational database, mapping and remote sensing data. The purpose is to use the GIS tools to manage the project, assemble data for the administrative record, help determine areas requiring further investigation and to discriminate OE from background anomalies. The discrimination is being done by a program that uses a subset of the GIS data called the OE-KB. The KB's purpose is to collect and analyze investigative information for ordnance from multiple ordnance GIS systems and compile it to establish a knowledge base (KB) of characteristics of investigated ordnance.

Problem: The OE project sites are geographically dispersed, having differing environmental characteristics and widely varying types of ordnance and dispersion patterns. In addition they may utilize various geophysical investigative instruments, sensors and technologies for subsurface investigations. These techniques can identify but not discriminate geophysical anomalies. A profile or fingerprint of a specific ordnance item should be established to assist in anomaly evaluations that could then be applied to future projects. This is the primary purpose of the KB techniques.

Solution:

KB-1

The KB-1 product was created and tested using computerized and manual methods to measure the shape and characteristics and perform database manipulations to assist in ordnance discrimination. The GIS system provided the mechanism for input, queries and output of mapping, modeling, and related project data. The KB objectives are to document and archive the occurrence of OE and related specific site conditions for each project and to enable a quantitative analysis of characteristics, such as mass and depth, from non-intrusive geophysical surveys using the analysis tools. Instrument data from the Geonics EM-61 conductivity meter, and the TM-4 magnetometer provided the base input for analysis. The specific type of data manipulation applied depends upon the geophysical instrument or other sensor employed. These filters included statistical, ratios, Fourier, matrices and Intergraph GIS software routine. Anomaly characteristics interpreted image signatures to further streamline the OE investigation.

KB-2

The KB has been enhanced to the KB-2 so that the computer now uses artificial intelligence and shape recognition routines to assist in anomaly identification.

The KB-2 is a multipurpose program that accepts geophysical data in a generic format, prepares the data for submission to an analytical engine, submits the data to the engine, and prepares the results for presentation to the user. The current analytical engine in KB-2 is a complex domain neural network. The architecture is a multiple-layer feed-forward network. It is designed to easily accept other analytical engines as the need arises. Different geophysical techniques as well as different environmental terrains will require unique approaches.

The system is currently optimized to provide mass and depth estimates for targets identified by the Geonics ERM-61. Work is under way to provide for analysis of total field magnetometer and gradiometer data.

KB Summary:

The KB is part of a comprehensive decision support system. The intent is to provide the tools to enable well-informed decisions on OE investigations. These tools are intended to be used with a data visualization methodology that facilitates fusion of the analytical results of the KB modules with more qualitative analysis. During use it will incorporate geophysics and project data from multiple sites to promote continued development and enhancement. This enhancement will include additional technologies, incorporation of data fusion from multiple geophysical instruments, and a statistical analysis of previous and current project OE field and geophysics data.

UXO Risk Assessment Model

Presenters: Jonathan Sperka, BS Engineering. Mr. Sperka is an engineer for the Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV) under the Unexploded Ordnance (UXO) Clearance Technology Program. He has several years research and development experience in the EOD area.

Kristine Kruck, BS Engineering Science. Ms. Kruck has 4 years experience in preparing and reviewing human health and ecological risk assessments for the Navy and the U.S. Environmental Protection Agency, Region 5. Her experience includes identifying risks associated with chemicals of concern, developing exposure scenarios, calculating risks associated with a site, and evaluating uncertainties associated with risk evaluation according to EPA protocol.

Abstract

There are many active ranges, Base Realignment and Closure (BRAC) sites and Formerly Used Defense Sites that are contaminated with (UXO). There is a strong need to estimate the level of risk associated with these areas. A risk assessment of an area can be used by decision-makers to prioritize areas for cleanup, determine what remediation efforts are needed and to aid in end land use options. The UXO risk assessment model was designed by members NAVEODTECHDIV, PRC Environmental Management, Inc., of the Naval Explosive Ordnance Disposal Technology Division, PRC and ARS. The risk assessment model has been incorporated into the Site Management Model and will be utilized for several other projects currently being conducted at the NAVEODTECHDIV.

To establish a framework for estimating UXO risk, the team agreed to pursue a probalistic methodology that is capable of generating a risk probability distribution, under this probability of UXO detonation given an encounter. There are many parameters which drive the risk associated with UXO. These parameters include UXO density, activity of the receptor, awareness of the receptor, amount of energy imparted into the area of concern and the UXO radius of influence. The most important parameter which has not been included in any of the previous UXO risk models studied is the faze sensitivity associated with the different ordnance types. The designed methodology groups specific faze families into sensitivity levels. Expert elicitation has been used to determine the distribution associated with the probability of detonation; the faze sensitivity level, activity and the depth of contamination were used. The probability of encounter is combined with the probability of detonation to yield a probability distribution for UXO risk. For easy comparison, the risk distribution was divided into five levels, "extreme to very low" risk.

The UXO risk assessment has been implemented into the Site Management Model which is scheduled to go into field testing at the Marine Corp Air Ground Combat Center at 29 Palms, California in mid-December. A description of the model and its capabilities will be presented in a paper.

Risk Assessment Methodology for Use in Managing Sites Containing UXO

Presenter: Scott A. Hill, BS. Mr. Hill has served as the U. S. Army Environmental Center's project manager for the Fort George G. Meade Base Realignment and Closure environmental restoration program since 1991. In that capacity he has managed the Unexploded Ordnance (UXO) surveying of 8,000 acres of range/training area and has implemented the UXO risk assessment at Fort George G. Meade. Additionally, Mr. Hill currently serves as the USAEC Base Closure Division's subject matter expert for UXO.

Abstract

This paper describes the development of a landmark method for assessing risks presented by UXO. The method was developed by the USAEC for use on Fort George G. Meade in Maryland, a BRAC. Fort George G. Meade formerly included 8,1099 acres of range and training lands that contain a variety of munitions UXO. Legislation mandated the transfer of these 8,100 acres to the U.S. Army and the U.S. Department of Interior for use as a wildlife refuge. As a result, the U.S. Army and the U.S. Department of Interior entered into an agreement to transfer these lands to the Patuxent Environmental Science Center (PESC). PESC assumed control of the lands while the Army's environmental restoration of the property continued.

The USAEC has developed this method to evaluate the risk present at this site and to form the basis for risk management decisions with the goal of creating an acceptably safe reuse of the property as a wildlife refuge. The theory of this approach is based on traditional human health risk assessment methods modified to reflect UXO exposures and evaluations. The risk assessment method uses both deterministic and probabilistic risk estimation techniques and uses a variety of land reuse and exposure scenarios. In probabilistic assessment, a Monte Carlo simulation was used to generate a distribution of possible values for the input parameters of the risk assessment, and the outcome was then used to interpret the deterministic results. The risk assessment methods only look at the relationship between the presence of UXO and likelihood of exposure and does not make any finite distinctions between type of ordnance, depth of ordnance and likelihood and outcome of detonation. As such, the results present a worst-case risk estimate for exposure to UXO for likely exposure scenarios. Actual or most probable risks are expected to be significant, possibly orders of magnitude lower than those presented in this study. The risk estimates are presented as the probability of encountering one UXO item per day of activity in a matrix of eight different land uses and seven geographic subdivisions. Additionally, this study presents an evaluation of estimated risk reduction gained from UXO removal actions. In this case, this evaluation quantifies the risk reduction expected from different exploded ordnance removal programs including no actions, removal of UXO up to 6-inches in depth, and a 12-inch removal. The results of this comparative evaluation can be used to evaluate and determine appropriate UXO removal depths to allow for safe reuse of the property.

Installation Management of Recovered Chemical Warfare Materiel

Presenter: Larry E. Wright, BS Chemical Engineering. Mr. Wright has 15 years experience at Pine Bluff Arsenal and has extensive knowledge of many facets of chemical weapons storage and disposal. He is currently responsible for management of the Chemical Stockpile Disposal Program and the Non-stockpile Chemical Materiel Program (NACMP) at the Pine Bluff Arsenal. Mr. Wright has a BS in Chemical Engineering and is a registered professional engineer in the State of Arkansas..

Abstract

During the past two decades, the U.S. Army has discovered significant quantities of buried chemical warfare materiel at multiple locations throughout the United States. These items, because of their differing configuration and condition, present unique characterization challenges, a prerequisite to safe and efficient disposal. Fundamental characterization challenges include positive identification of the chemical agent fills and determination of explosive configurations. Recovered items range from Chemical Agent Identification Sets in serviceable condition (containing dilute quantities of chemical agents and surrogate chemical agents) to suspect chemical agent-filled explosively configured munitions of unknown origin that have been buried in excess of 30 years.

Pine Bluff Arsenal became a participant in the management and disposal of recovered chemical warfare materiel (RCWM) at the close of World War II, when chemical weapons captured from German forces were transported to Pine Bluff Arsenal for intelligence evaluation and disposal. Contemporary (circa 1950) disposal practices included chemical neutralization (and sometimes burning) and burial of the items in trenches or pits. Cleanup of all confirmed chemical burial sites at Pine Bluff Arsenal occurred in the 1970s and 1980s. These pioneering remediation efforts resulted in the development of recovery expertise and management practices applicable to recovered chemical warfare materiel. RCWM items are currently stored in earth-covered igloos, visually inspected, and air-monitored utilizing absorptive sample collection methods and gas chromatography/mass spectroscopy sample analysis.

Upon determination of the magnitude of remediation and disposal challenges facing the Department of Defense, the Army established and resourced the NSCMP to manage, direct, and accomplish the dynamic recovery and cleanup challenges. The NSCMP called upon Pine Bluff Arsenal to be an active partner in the Army's development and execution of disposal plans, procedures, and technologies. In the winter of 1993, a housing developer in the Spring Valley area of Washington, D.C. accidentally discovered old chemical munitions. Personnel from Pine Bluff Arsenal supported the remediation and recovery of the suspect chemical weapons. Buried chemical weapons, dating from World War I, were safely removed from the Spring Valley burial sites, preliminarily examined on site, packaged and transported to Pine Bluff Arsenal for storage.

Spring Valley operations, and ongoing research and development efforts managed by the NSCMP, demonstrated the potential and successful application of contemporary non-intrusive inspection technologies toward the characterization of recovered chemical warfare materiel. As a part of field operations, contemporary non-intrusive inspection technologies have been integrated into the recovery process, to include chemical agent air monitoring, Portable Isotropic Neutron Spectroscopy, and radiographic inspections.

Enhanced characterization of the RCWM items was determined to be prerequisite to safe and efficient disposal operations; however, useful application of the non-intrusive inspection technologies requires direct

access to the items to be inspected. Unfortunately, the RCWM items that were previously in storage were placed in overpack containers, denying direct access to the items and prohibiting the use of non-intrusive testing. To ensure worker, public, and environmental safety and to accomplish RCWM inspection objectives, a custom-built facility incorporating inspection equipment, environmental engineering controls, and security features should be constructed and operated at Pine Bluff Arsenal.

The RCWM Enhanced Examination Facility, currently under design, will incorporate controlled and filtered ventilation, unpacking and repacking capability, non-intrusive inspection capability (i.e., visual, Portable Isotropic Neutron Spectroscopy, and radiography), and data collection equipment. Upgrading and utilizing the existing structures at Pine Bluff Arsenal was determined to be an acceptable and cost-effective approach to satisfying facility requirements. Safety was the primary criteria for selecting a facility and location; after satisfying human and environmental safety considerations, the cost of construction and operation was included in the analysis. A seven-factor decision matrix was created to identify and optimize the selection of acceptable facilities and locations, as follows: safety requirements, environmental considerations, security requirements, facility selection, site selection, site terrain, and utility availability. The optimum facility decision resulted in selection of a pair of existing igloos in a remote region of Pine Bluff Arsenal.

Construction and operations will be accomplished by a team comprised of both government and contractor personnel. Construction and operational efficiencies will be recognized by establishing a self-sufficient facility with the potential to host planned on-site pretreatment systems. The Examination Facility at Pine Bluff Arsenal will enhance the Army's responsiveness and provide life-cycle management capability for RCWM.

UXO Cleanup Issues - Panel Discussion

Moderator: Jim Lehr, MS Chemistry. Mr. Lehr serves as a principle staff member at the Western Governors' Association, working with states and tribal governments to address regulatory and cleanup issues associated with military munitions. Mr. Lehr also facilitates two Restoration Advisory Boards addressing UXO remediation.

Panelists: Jim Austreng, BS Engineering. Mr. Austreng is a professional engineer and a Project Manager for DTSC, and since August, 1992, has been with DTSC's Office of Military Bases with responsibility of overseeing the investigation and remediation of hazardous substances (including UXO). He was assigned duties as the State's Coordinator for UXO on November 1, 1995.

Ross Vincent. Mr. Vincent is a member of the Military Munitions Working Group of the DOIT Project which has been addressing UXO cleanup issues over the past 3 years. He also serves as a representative of the Military Toxics Project, an organization of communities affected by military installation impacts to the local environment.

Colette Y. Machado. Ms. Machado is a member of the Kaho'olawe Island Research Commission, which was established to have policy and management oversight of the UXO remediation effects on the island of Kaho'olawe. This cleanup is governed by the May 9, 1994 Memorandum of Agreement between the Navy and the state. A pilot UXO cleanup was completed in early 1996 to help identify and address key issues.

Emma Featherman-Sam. Ms. Featherman-Sam is director of the Badlands Bombing Range Project, which provides tribal management and oversight to the environmental restoration of a former Air Force bombing range. She is also a member or the Restoration Advisory Board addressing community issues at this cleanup.

Bob Dworkin. Mr. Dworkin is directly responsible for the Corps of Engineers cleanup activities at the Black Hills Army Depot UXO restoration site. He is also Army Co-Chair of the Restoration Advisory Board providing community input to the restoration activities at this formerly used defense site.

Abstract

The public is presently exposed to ordnance and explosive waste (OEW) at uncontrolled, abandoned, and other sites used by the military for defense purposes. Some sites have been released from control by the Department of Defense, some have been returned to private ownership, and some are managed by other federal or state agencies, and some are owned by tribal government. The Department of the Interior estimates that some 8 million acres of lands under its management are contaminated with UXO. The Department of Defense estimates some 9 million acres are active and inactive ranges, and that 1,200 - 1,700 impact ranges on formerly used defense sites have ordnance and will require a response including OEW cleanup. Some of these installations or sites are in the process of being released and converted to other uses under the Base Realignment and Closure (BRAC) Program.

With increased public awareness of this problem, the demand for safe, speedy, and cost-effective cleanup of installations being returned to public and private ownership has grown. Delays in returning these lands to safe alternative uses have a major economic impact on neighborhood communities as well as continuing potentially serious environmental and public safety risks.

The issues concerning the cleanup of UXO at these sites are compounded by the lack of uniform standardized policy and regulation governing the cleanup. Congress addressed the need for regulation of this UXO cleanup in the Superfund Amendments and Reauthorization Act of 1986 (SARA) in establishing the Defense

Environmental Restoration Program (DERP), which empowered the Secretary of Defense to develop regulations under Title 10 of the Code of Federal Regulations. These regulations have not been promulgated, but DoD has plans to do so presently. The status of this activity will be described and alternative approaches will be discussed. In 1992, the Federal Facilities Compliance Act ordered the Environmental Protection Agency (EPA) to promulgate the regulation of munitions waste as a hazardous waste. EPA proposed regulations for public review in November 1995. Promulgation is expected in the spring of 1996. The proposal is controversial in that some think the requirements are not far-reaching enough and state agencies object to their inability to regulate munitions waste more stringently than the federal requirements as they can for other hazardous waste. The status of this EPA rulemaking will be discussed. In the absence of national regulation, several states have established state policies and regulations which govern munitions management and cleanup. A survey of the array of state approaches to this regulation is being conducted by the Western Governors Association and will be reported. Tribal and island governments are expanding the criteria guiding UXO cleanup to provide for protection of historic and cultural values as well as the protection of public and environmental health. The Kaho'olawe Island Reserve Commission, for example, is empowered by federal statute and through a memorandum of understanding with the Navy to identify and establish cleanup criteria to protect historic, cultural and educational values for the restoration of Kaho'olawe Island.

In addition to the confusing array of ordnance cleanup requirements that result from lack of agreement among state, tribal and federal agencies, most bases and formerly used defense sites that have additional requirements or recommendations to address form the Restoration Advisory Boards or citizen groups that are being established to participate in the cleanup decisions at federal facilities. Local concerns often transcend the public and environmental health and safety consideration to include concerns over liability for accidents or injury that might occur during field and remediation work on land that may have been returned to private, tribal, local or state ownership or to the management of another federal agency such as the Bureau of Land Management. Citizens at cleanup sites also worry over the economic impact an ordnance restoration project has on their community. This includes pressing for speedy cleanup to free property that cannot be used for productive purposes to insisting that certain of the cleanup jobs be reserved for locals to help compensate for the negative impacts of having UXO near their community. The common public perception of a range containing UXO as a time bomb, with rapidly deteriorating ordnance that may be leaking hazardous and toxic residue to groundwater and surface water drinking supplies, leads to community outrange and impatience at the injustice and untrustworthiness of federal government actions. Local public perceptions and concerns will be discussed and clarified by the panel.

Finally, a collaborative process of addressing these issues will be proposed as an approach to ease the rhetoric and increase the cooperation and mutual sharing of information on best approaches for UXO remediation. The conference participants will be able to question the panel members to understand fully the status of munitions regulation and community and agency concerns over UXO remediation.

Exhibit and Poster Descriptions

Exhibits

ADI

Address: 7918 Jones Branch Drive, Suite 600
City, State, Zip Code: McLean, VA 22102
Telephone No.: 703-918-4948
Contact: Paul Stratton

ADI offers leading edge technology to apply geophysical techniques to the detection of UXO. ADI uses the TM-4 Imaging Magnetometer system, the EM-61 Deep Metal Detector, GPR, and other geophysical systems. Following clearance, ADI is prepared to offer evidence to authorities and to insurance underwriters that all items of a particular size have been cleared to a specific depth.

Blackhawk GeoSciences

Address: 301 Commercial Road, Suite B
City, State, Zip Code: Golden, CO 80401
Telephone No.: 303-278-8700
Contact: Pieter Hoekstra

Blackhawk GeoSciences specializes in providing geophysical contracting and consulting services over the full spectrum of geophysical technologies. Improving geophysical technologies for detection of UXO and EOW is one area of geophysical applications in which the company is active through services and government-sponsored research and development.

Bristol Aerospace

Address: 660 Berry Street
City, State, Zip Code: Winnipeg, Manitoba, Canada R3C 2S4
Telephone No.: 204-788-2952
Contact: Bob Palmer and John Funk

During the UXO FORUM, Bristol Aerospace Limited will be presenting both the Barracuda and Jingoss unmanned vehicles. The Barracuda is a programmable naval boat target system that can be configured for maritime mine sweeping operations. Jingoss operates as a robotic ordnance detection system, accurately detecting and marking both surface and deeply buried metallic ordnance, separating the human operator from the threat posed by hazards of unexploded ordnance and mines.

Exhibits (Continued)

CASDE Corporation

Address: 1901 N. Beauregard Street
City, State, Zip Code: Alexandria, VA 22311
Telephone No.: 703-845-9221
Contact: Steve Galloway

CASDE Corporation will display mine warfare technology applications.

Chemrad

Address: 739 Emory Valley Road
City, State, Zip Code: Oak Ridge, TN 37830
Telephone No.: 423-481-2511
Contact: Bob Highfill

Chemrad's Automatic Ordnance Locator (AOL) system will be exhibited. Chemrad sells the AOL system and performs UXO surveys using the AOL system.

CMS Environmental, Inc.

Address: 4904 Eisenhower Blvd., #310
City, State, Zip Code: Tampa, FL 33634
Telephone No.: 813-882-4477
Contact: Bill Lewis and John Chionchio

CMS Environmental, Inc., is a market leader in the restoration of sites contaminated with ordnance and explosives (OE). Both site characterization and remediation are performed, including OE detection, removal, and disposal; archival searches; surveying; and mapping. Remediation of soil and water contaminated with explosives such as TNT and RDX is also performed.

Exhibits (Continued)

Concept Engineering Group, Inc.

Address: 610 William Pitt Way
City, State, Zip Code: Pittsburgh, PA 15233-1332
Telephone No.: 412-826-3191
Contact: Martin J. Uram

Concept Engineering Group, Inc. (CEG), is an engineering-based company specializing in the development and sale of safe excavation equipment, including prototype systems adapted to meet a customer's specific needs. CEG's proprietary safe excavation technology uses a combination of high flow, pneumatic vacuum transport and supersonic air jets to safely dislodge and remove soil. This technology is particularly suited for excavation of any buried object where great care must be taken, such as UXO, hazardous waste, archaeological artifacts, or underground utility pipes or cables. This technology recently participated in the USAEC UXO Advanced Technology Demonstration Program at Jefferson Proving Ground.

EA Engineering Science and Technology, Inc.

Address: 5500 Fox Lair Lane
City, State, Zip Code: Alpharetta, GA 30201
Telephone No.: 770-663-9987
Contact: John Thompson

Earth Resources Corporation

Address: 1227 Marshall Farms Road
City, State, Zip Code: Ocoee, FL 34761
Telephone No.: 407-877-0877
Contact: Norman Abramson

Earth Resource Corporation (ERC) specializes in the remediation and management of highly hazardous chemicals, chemical weapons materials, and compressed gases. ERC designs and operates mobile systems that feature multi-level containment, remote sampling, analysis, recontainerization, treatment, and emergency treatment capabilities.

Exhibits (Continued)

EG&G ORTEC

Address: 100 Midland Road
City, State, Zip Code: Oak Ridge, TN 37831-0895
Telephone No.: 423-482-4411, or 483-2122
Contact: Karen Lavender and Craig Johnson

EG&G ORTEC is the sole supplier of the PINS, a neutron activation analysis (NAA) system for munitions. The PINS examines, non-intrusively, the contents of munitions and identifies them by their chemical agent. This chemical agent can be a nerve agent, explosive, or military smoke. The PINS performs a reliable measurement no matter the age or geometry of the munition.

EnSys Environmental Products, Inc.

Address: P.O. Box 14063
City, State, Zip Code: Research Triangle Park, NC 27709
Telephone No.: 919-941-5509
Contact: Deb Smith

At EnSys Environmental Products, Inc. (EnSys), we are dedicated to developing innovative, rapid tests for on-site detection of environmental contaminants. Our goal is to provide our customers with products that offer superior quality, reliable performance, and ease of use. Using innovative technologies, EnSys develops and manufactures state-of-the-art, cost-effective environmental analytical solutions.

EnSys currently has seven rapid tests accepted under EPA methods, all of which EnSys was instrumental in creating. These include tests for PCBs, petroleum hydrocarbons, polyaromatic hydrocarbons, pentachlorophenol, and nitroaromatic explosives.

EnSys is committed to working closely with environmental professionals to meet today's challenging environmental testing needs. We maintain strict quality standards carried out by every member of our team. Products are manufactured internally to ensure that they meet our customers' needs. Our highly experienced sales and technical staff are committed to providing prompt technical support to all of our customers.

Exhibits (Continued)

Environmental Chemical Corporation

Address: 1240 Bayshore Highway
City, State, Zip Code: Burlingame, CA 94010
Telephone No.: 415-347-1555
Contact: Kathy Lee

Environmental Chemical Corporation (ECC) is a full-service environmental remediation, construction, and management firm consisting of three operating divisions: the Environmental Division, the Ordnance Explosive Waste Division, and the Chemical Analysis Division. ECC has extensive experience in hands-on remedial activities, including UST removal and replacement, hazardous materials management, construction, water and soil treatment, and OEW remediation. About 95 percent of ECC's work consists of remediation projects for the U.S. government, and 50 percent of this work has been for active military installations. ECC has concurrently performed more than 20 projects at 15 different geographic locations worldwide. ECC has developed and refined management and operating procedures tailored for the compliant, timely, cost-effective performance of environmental remediation projects.

Foerster Instruments Inc.

Address: 140 Industry Drive, Ride Park
City, State, Zip Code: Pittsburgh, PA 15275-1028
Telephone No.: 412-788-8976, ext 59
Contact: Mike Kuharik or Charlie Wharton

Foerster Instruments Inc., will display search instruments and a towed vehicular array. The following is a list of equipment that will be displayed: Ferex 4.021 (MK 26), Ferex 2000 S/L Ferrous locator, Minex 2000P all metal locator, and Minex 2000 S/L 2 freq.

Geo-Centers, Inc.

Address: 7 Wells Avenue
City, State, Zip Code: Newton Centre, MA 02159
Telephone No.: 617-964-7070
Contact: Linda Hain

Geo-Centers, Inc., has developed and patented (U.S. Patent No. 5469126) a unique focused array (FAR) ground penetrating radar (GPR) which detects and displays, in real-time, buried metallic and non-metallic objects. This GPR has proven to be effective in vehicular applications. With its fully integrated global positioning system (GPS), detections are precisely located and archived for incorporation into a geographical information system (GIS). This system has been used in conjunction with other sensors, specifically pulsed electromagnetic induction and forward looking infrared optics. This multisensor system is configured by a custom data correlation integration processor. It marks the surface, on-the-fly and in real-time, to visually "tag" detected items.

Exhibits (Continued)

Geometrics, Inc.

Address: 395 Java Drive
City, State, Zip Code: Sunnyvale, CA 94089
Telephone No.: 408-734-4616, ext. 8245
Contact: Peter Lilley

Geometrics, Inc., the well-known international manufacturer of magnetometers, will exhibit its Model G-858 portable cesium magnetometer/gradiometer. This instrument is one of the primary instruments being used in the detection and identification of buried ordnance by many worldwide organizations. In addition, Geometrics, Inc., will demonstrate the recently introduced MagAID software package that identifies and analyzes magnetic anomalies for position, depth, and target size.

Geonics Limited

Address: 8-1745 Meyerside Drive
City, State, Zip Code: Mississauga, Ontario, Canada L5T IC6
Telephone No.: 905-670-9580
Contact: Simon Boniwell

Geonics Limited (Geonics) is a leading manufacturer of electromagnetic geophysical instruments for a wide range of subsurface investigations. Geonics will exhibit its high sensitivity - high resolution EM61 metal detector. Geonics will also display case histories from various environmental and buried ordnance test sites, along with comparisons of the Geonics technology with other regularly used buried metal detectors.

GP Environmental Services, Inc.

Address: 202 Perry Parkway
City, State, Zip Code: Gaithersburg, MD 20877
Telephone No.: 301-926-6802
Contact: Mike Stockert

GP Environmental Services, Inc., is a full-service laboratory with 14 years experience in the chemical analysis of soil, water, waste, air, and biota. Experience includes 11 years as an EPA CLP Laboratory (SAS or RAS), full U.S. Army Corps of Engineers certifications (including explosives), IRDMIS deliverable capabilities, agent degradation analysis facility, USDA permit to import soils from foreign countries, HAZWRAP experience, NEESA certification, and various state certifications.

Exhibits (Continued)

Hydro-Innovation's Inc.

Address: 5 Harrison Ave. - Buckeye
City, State, Zip Code: Mt. Vernon, OH 43050
Telephone No.: 614-392-4643
Contact: Chip Street

Hydro-Innovation's, Inc., is an ultra high pressure (40k - 55k) contractor that builds remotely operated cleaning and cutting systems.

ISSI Unexploded Ordnance, Inc.

Address: P.O. Box 11
City, State, Zip Code: Huntsville, AL 35804-0011
Telephone No.: 205-247-7050
Contact: Bob Fay

ISSI Unexploded Ordnance, Inc., provides UXO/CWM remediation and investigations, explosive safety services, and related training. The company provides master level UXO personnel for government, environmental, and engineering firms to perform UXO surveys, access, ordnance avoidance, demining, range clearances/maintenance, and explosive/UXO hazard feasibility/evaluations and consulting.

LESCO

Address: 654 Discovery Drive
City, State, Zip Code: Huntsville, AL 35806-2802
Telephone No.: 205-971-7165
Contact: Jack Thomas or Paul Smith

In 3 short years, LESCO has grown from scratch to a highly successful 8(a) firm, earning over $2 million in 1995 alone. LESCO now enters the OE arena, bringing a highly experienced UXO and engineering staff to complement exceptional business practices. LESCO offers the following services:

- OE & RCWM location, removal, and disposal
- HAZMAT/HAZWASTE inventory and support services
- Environmental assessment, remediation, and training
- Munitions demilitarization
- Health and safety planning and administration
- Document digitization and electronic manuals

LESCO: Certified 8(a); Registered A&E, AEC certified UXO firm.

Lockheed Martin Advanced Environmental Systems

Address: 103 Chesapeake Park Plaza, MS 600
City, State, Zip Code: Baltimore, MD 21220
Telephone No.: 410-682-0892
Contact: Von Ayre Jennings

Lockheed Martin Advanced Environmental Systems provides turnkey environmental solutions including remediation, technology development, technical support, and engineering services, primarily to federal customers. The emphasis is on providing systems engineering solutions and program management skills for complex environmental problems, including radioactive waste remediation, decommissioning and decontamination, and unexploded ordnance remediation.

METRATEK, Inc.

Address: 12330 Pinecrest Road
City, State, Zip Code: Reston, VA 22091
Telephone No.: 703-620-9500
Contact: Richard Harris

METRATEK, Inc. (METRATEK), the "We Innovate for You" company, is a small business that develops high-technology solutions to real world problems. METRATEK manufactures high performance radar systems, particularly for imaging aircraft with low radar cross-sections and for performing radar measurements for government and industry. METRATEK will display its Real-Time-Man-Portable Synthetic Aperture Ground Penetrating Radar System and portions of the Ground Penetrating Radar and Electromagnetic Sensor System that was evaluated at the live site demonstrations at Yuma Proving Ground in July 1995 and at McChord Air Force Base in October and November 1995.

MTA, Inc.

Address: 688 Discovery Drive
City, State, Zip Code: Huntsville, AL 35806
Telephone No.: 205-922-1110
Contact: Mike Moran

MTA, Inc. (MTA), was the first minority firm to be awarded a contract for remediation of ordnance explosive waste and chemical warfare materials by the U.S. Army Engineer Division, Huntsville in 1992. Since then, MTA has planned and successfully executed a conventional interim removal action on 65 acres at the former Fort Hancock in Sandy Hook, New Jersey, and has completed a surface investigation for chemical warfare materials at the former Fort Segarra in Water Island, U.S. Virgin Islands. MTA has recently completed a conventional ordnance waste remediation at Culebra, Puerto Rico and is awaiting approval of its work and safety plans to conduct an intrusive investigation of selected sites again at the former Fort Segarra. In addition, MTA is now providing UXO services at the former Morgan Depot in Sayreville, New Jersey.

Exhibits (Continued)

Naval Explosive Ordnance Disposal Technology Division

Address: 2008 Stump Neck Road
City, State, Zip Code: Indian Head, MD 20640
Telephone No.: 301-743-6850 ext. 276
Contact: Earl Scroggins

This exhibit will demonstrate the various types of unexploded ordnance (UXO) that can be encountered during UXO remediation projects worldwide. The exhibit will consist of both domestic and foreign ordnance, involving the full spectrum of both currently deployed and obsolete ordnance.

Naval Explosive Ordnance Disposal Technology Division UXO SMM

Address: 2008 Stump Neck Road
City, State, Zip Code: Indian Head, MD 20640
Telephone No.: 301-743-6850
Contact: Jonathan Sperka

In 1994, the Marine Corps Air Ground Combat Center (MCAGCC) in Twentynine Palms, California, requested an automated tool for collecting and managing detailed, site-specific information related to UXO from deployment of ordnance through cleanup of the firing range by explosive ordnance disposal (EOD) personnel. Additionally, MCAGCC requested that this tool provide a standard method for determining EOD and residual hazards in a UXO-contaminated area and estimating cleanup costs. As a result, MCAGCC established a partnership with the U.S. Army Environmental Center and Naval Explosive Ordnance Disposal Technology Division to create the UXO SMM.

The UXO SMM consists of four modules: historical data survey, ordnance deployment, EOD calls, and decision analysis. The historical data survey allows MCAGCC EOD range management personnel to input estimated UXO contamination due to past training operations that were not documented. A current record of the types and quantities of ordnance deployed to a particular range or training area is entered into the ordnance deployment module. The EOD calls module archives all information collected by the local EOD unit during cleanup operations. This information includes data on UXO types, quantities, and locations, as well as manpower, special equipment, and tools used during all incident calls, including cleanup. Finally, the decision analysis module compiles data from the input modules to assist MCAGCC decision makers in EOD planning, range management, risk assessment, resource allocation, and cost estimating.

Exhibits (Continued)

OAO Corporation

Address: Robotics Lab, Door 2
10289 Aerospace Road
City, State, Zip Code: Lanham, MD 20706
Telephone No.: 301-306-8961
Contact: Joseph W. Foley

OAO Corporation (OAO), will exhibit a variety of photographs and show videotapes of several remote controlled, teleoperated vehicles for the purpose of sensing and working in hazardous environments. OAO has configured vehicles for several EOD applications, including land mine removal and artillery test range clearance. The vehicles range in size from 100-pound platforms to teleoperated excavators.

Oilton, Inc.

Address: 1821 University Ave., W., Suite 461 N
City, State, Zip Code: St. Paul, MN 55104
Telephone No.: 612-646-5747
Contact: Zeno Leier

Oilton, Inc. (Oilton), is a small corporation that provides an innovative advanced detection technology service, locating and mapping subsurface petroleum pipeline leaks and surface or buried unexploded ordnance munitions. Oilton's Advanced Infrared Detection System (AIRDS) uses an airborne platform and combines multiple sensor technology, yielding multi-spectral data. The key to the AIRDS capability is Oilton's unique image enhancement software.

Exhibits (Continued)

Ordnance/Explosives Environmental Services, Inc.

Address: Executive Plaza Office Park
500 Wynn Drive, Suite 504
City, State, Zip Code: Huntsville, AL 35816
Telephone No.: 205-830-4847
Contact: John Stine

Ordnance/Explosive Environmental Services, Inc. (OES), was established to provide cost-effective, professional unexploded ordnance/ordnance and explosives/chemical warfare material (UXO/OE/CWM) investigation, remediation, and related services. These services are offered to both the Department of Defense (DOD) and private industry. OES project managers and staff have extensive experience in the location, identification, removal, and disposal of UXO/OE at numerous sites throughout the United States and its territories. These operations include characterization of suspected CWM sites for DOD. Senior OES UXO technicians, all of whom are graduates of the Naval Explosive Ordnance Disposal (EOD) School in Indian Head, Maryland, are among the most experienced personnel available in the UXO field. These personnel have managed, supervised, and conducted UXO/OE operations ranging in size up to some of the largest UXO/OE investigations and remediation projects ever undertaken in the United States. OES presents a highly skilled team capable of managing and conducting operations involving a wide variety of contaminants and ordnance encountered by DOD and private industry.

Orincon Technologies

Address: 9363 Towne Centre Drive
City, State, Zip Code: San Diego, CA 92121-3017
Telephone No.: 619-455-5530, ext. 271
Contact: Harry Keane

Orincon Technologies (Orincon) is a high-technology research and development firm dedicated to developing advanced, innovative solutions to real world problems. Founded in 1973, this small business originally focused on the application of advanced signal processing and data fusion techniques to sonar problems. Today, it has successfully diversified in many areas, including financial, commercial software, highway traffic management, manufacturing, and semiconductor etch process management. Orincon has developed an extremely inexpensive, remotely operated platform for the detection of buried ferrous metal objects using fluxgate gradiometer sensors and advanced signal processing techniques. The technology makes use of DGPS localization to produce a map of magnetic anomalies. Orincon is seeking both commercial opportunities and associations with industry leaders for joint projects.

Exhibits (Continued)

Parsons Engineering Science, Inc.

Address: 10521 Rosehaven Street
City, State, Zip Code: Fairfax, VA 22030-1899
Telephone No.: 703-591-7575
Contact: Josh Bowers

Parsons Engineering Science, Inc. (Parsons ES), is a multi-disciplined engineering firm that has a proven history with the UXO community. Parsons ES has proven abilities in UXO detection and data analysis, OEW and HTW sampling, database management, risk assessment, and GIS development.

S.M. Associates, Inc.

Address: 6701 Democracy Boulevard, Suite 300
City, State, Zip Code: Bethesda, MD 20817
Telephone No.: 301-571-9389
Contact: Leonard Seigel

S.M. Associates, Inc., will exhibit its environmental decision support system, which can serve as a vital and integral component of current as well as future UXO programs.

Schiebel

Address: 106 Hillif Terrace
City, State, Zip Code: Poughkeepsie, NY 12603
Telephone No.: 914-462-8780
Contact: Walter Dubuque

Schiebel will display the AN-19/2 Mine Detecting Set, the VAMIDS, and the AN-23/2 Bomb Locating Set at the conference. The AN-19/2 Mine Detecting Set has been developed to meet today's requirements for mine clearance in the battlefield. It is in service in numerous countries worldwide, including many NATO countries, and is the U.S. Army standard mine detector under the designation AN/Pss-12. The AN-19/2 Mine Detecting Set is designed to detect very small metallic objects, typically mines with a minimum metal content.

VAMIDS is designed to detect metallic landmines and UXO from a vehicular platform, including those landmines with a minimum metal content. With the use of special array segments, VAMIDS can detect buried UXO to depths of several meters. VAMIDS is also a high-performance mine detection system capable of fast and efficient wide area survey and marking. The system also facilitates post-processing and archiving of target data.

The AN-23/2 Bomb Locating Set is designed to locate ferromagnetic objects underground and underwater. The maximum search depth depends on the size and extension of the item to be detected. The unit is fully microprocessor-controlled and comprises automatic settings of measuring ranges, making it unnecessary to set the measuring range manually, thus enhancing the detection performance.

Sensors & Software

Address: 1091 Brevik Place
City, State, Zip Code: Mississauga, Ontario, Canada L4W 3R7
Telephone No.: 905-624-8909
Contact: Michelle Rudra

Sensors & Software manufactures the pulseEKKO family of GPR systems. Applications are widespread, including pipe and cable locations, concrete inspection, archaeological surveys, as well as UXO investigations. The pulseEKKO systems cover the frequency ranges of 10 MHZ to 1200 MHZ. These lightweight, modular systems are readily adapted to man-portable or vehicle-mounted applications. Open data structure permits integration of GPR data with other mapping sensors and positioning systems for use with artificial intelligence and fuzzy logic target discrimination schemes.

Exhibits (Continued)

TDW - Gesellschaft fur verteidigungs-technische Wirksysteme mbH

Address: Postfach 13 40
City, State, Zip Code: 86523 Schrobenhausen, Deutschland, Germany
Telephone No.: 011-49-8252-99-6600
Contact: Rainer Haßfurter

U.S. Army Engineering and Support Center, Huntsville

Address: P.O. Box 1600
4820 University Square (35816-1822)
City, State, Zip Code: Huntsville, AL 35807-4301
Telephone No.: 205-895-1607
Contact: Scott Millhouse

The U.S. Army Engineering and Support Center, Huntsville (the Center) will highlight ordnance and explosive applications with geographic information systems (GIS). The Center will also demonstrate a product called the Knowledge Base (KB), which is used to discriminate geophysical anomalies. This exhibit will show how the Center uses the KB and GIS for their OE projects.

U.S. Army Environmental Center
and
Naval Explosive Ordnance Disposal Technology Division

Address: 2008 Stump Neck Road
City, State, Zip Code: Indian Head, MD 20640
Telephone No.: 410-612-6868 and 301-743-6850 ext. 260
Contact: Kelly Rigano and Jerry Snyder

The U.S. Army Environmental Center (USAEC), with support from the Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV), the U.S. Air Force/Wright Laboratory (USAF/WL), and PRC Environmental Management, Inc. (PRC EMI), has established a comprehensive UXO Clearance Technology Program. This Program addresses the testing, evaluation, and characterization of technologies that can be used to detect and remediate UXO. In addition to technology demonstration and evaluation, the Program has ongoing technology transfer and technology enhancement efforts in the following areas: sensors, data fusion and analysis, information management and decision analysis, robotic remediation, and underwater detection/remediation.

Exhibits (Continued)

U.S. Army Fort McCoy

Address: ATTN: AFZR-DE-E
Building 2170
City, State, Zip Code: New Sparta, WI 54656-5000
Telephone No.: 608-388-4790
Contact: Steve Stokke

Fort McCoy, located in New Sparta, Wisconsin, is a U.S. Army reserve training center. The 88th ORD CO (EOD) (Prov), located at Fort McCoy, is responsible for demilitarization of munitions by open detonation (OD) at Fort McCoy. OD is a hazardous waste activity and requires a license from the state. Fort McCoy has obtained this license, which is one of the first in the Army for OD operations.

The Fort McCoy exhibit will provide background on Fort McCoy's mission and the need for OD treatment capability. The service area of the 88th ORD (EOD) (Prov) will be shown. Information on the hazardous waste licensing process and license requirements for the OD unit will be outlined. A copy of the license will be shown along with treatment capacity.

U.S. Army, Night Vision Directorate Humanitarian Demining Technologies Development

Address: ATTN: AMSEL-RD-NV-CD-ES (B. Brigs)
10221 Burbeck Road, Suite 430
City, State, Zip Code: Ft. Belvoir, VA 22060-5806
Telephone No.: 703-704-1086
Contact: Beverly Briggs and Hap Hambric

In 1994, Congress provided $10 million to the Department of Defense to conduct research in the area of humanitarian demining equipment. The U.S. Army Communications Command, Night Vision and Electronic Sensors Directorate at Fort Belvoir, Virginia was selected to perform the research under the oversight of the Office of Assistant Secretary of Defense for Special Operations and Low Intensity Conflict. Thirty separate items of enhanced demining equipment ranging from on- and off-route mine detectors, *in situ* mine neutralization devices, mine clearance equipment and specialized individual demining components were developed and evaluated under the 1995 program. Several of the prototypes have since been deployed to Europe and Asia to assist in demining and peace enforcement missions. This program has very high visibility and support at all levels of government. Program funding is projected through 2001.

Exhibits (Continued)

U.S. Army Project Manager for Non-Stockpile Chemical Materiel

Address: Public Affairs Office, PM for Chemical Demilitarization
City, State, Zip Code: Aberdeen Proving Ground, MD 21010-5401
Telephone No.: 1-800-488-0648
Contact: Louise Dyson

The U.S. Army Project Manager for Non-Stockpile Chemical Materiel (PM NSCM) at Aberdeen Proving Ground, Maryland, provides centralized management and direction for disposal of NSCM in a safe, environmentally sound, and cost-effective manner.

U.S. Army Research Laboratory

Address: 2800 Powder Mill Road
City, State, Zip Code: Adelphi, MD 20783
Telephone No.: 301-394-3110
Contact: Vince Marinelli

The U.S. Army Research Laboratory's (ARL) innovative research in sensor and aided target recognition (ATR) technologies, which will advance the Army's ability to acquire, locate, identify, and engage the enemy, may also be applied to detect and discriminate UXO. The ARL exhibit includes information on our low-frequency, ultra-wideband synthetic aperture radar (UWB SAR); laser radar; optical detection and processing; SAR ATR; and multi-sensor fusion projects. Also included is detailed information on our high-quality, state-of-the-art UWB SAR which ARL developed under the Defense Intelligence Agency's Steel Crater Ground-Penetrating Radar and the Army's UWB SAR programs. The ability to generate high-resolution imagery with this very sensitive radar may provide a capability to detect small buried and surface targets. Recently collected subsurface target data (including UXO) is presented. Finally, the ARL exhibit includes an illustration of a national system approach for finding UXO, one which employs multiple sensors and multi-sensor fusion coupled with efficient discriminating algorithms.

Exhibits (Continued)

U.S. Army Technical Center for Explosive Safety

Address: ATTN: SIOAC-ESL
City, State, Zip Code: Savanna, IL 61074-9639
Telephone No.: 815-273-8741
Contact: Cliff Doyle

The U.S. Army Technical Center for Explosive Safety (USATCES) executes the Army's explosives safety policies, intended to prevent unintentional detonation of ammunition, explosives, and chemical weapons. USATCES provides Army-level approval of explosives safety submissions for UXO removal projects and for the construction of ammunition facilities. USATCES is the Army Hazard Classifier for ammunition and explosives and in partnership with the U.S. Army Corps of Engineers performs historical records searches, prepares site health and safety plans, conducts site OE/UXO assessments and inspections, and prepares technical Archives Search Reports (ASR) in support of the Defense Environmental Restoration Program (DERP) for formerly used defense sites (FUDS) and base realignment and closure (BRAC) installations.

UXB International, Inc.

Address: 14800 Conference Center Drive, Suite 100
City, State, Zip Code: Chantilly, VA 22021
Telephone No.: 703-803-8904
Contact: Denise Gebhart

UXB International, Inc. (UXB), was established in 1984 and is headquartered in Chantilly, Virginia. UXB's Ordnance and Explosive Remediation Program consists of the following services: OE investigation, minefield clearance, transport and disposal, operations quality compliance/quality assurance, technical design center, safety and escort, geophysical, live-fire ranges maintenance and management, underwater unexploded ordnance, comprehensive program and project management, and public affairs. UXB is experienced in handling all types of energetic and reaction materials, including military chemical warfare material.

VALLON/SECURITY SEARCH

Address: 7 Amaranth Drive
City, State, Zip Code: Littleton, CO 80127-2611
Telephone No.: 303-933-7955
Contact: Ron Hitchler

Various VALLON instruments for the detection of UXO and mines will be displayed.

Exhibits (Continued)

Wyle Laboratories, Inc.

Address: 1841 Hillside Ave.
City, State, Zip Code: Norco, CA 91760
Telephone No.: 909-737-0871, ext. 214
Contact: Drexel Smith or Janine Carpenter

Wyle Laboratories, Inc. (Wyle), has conducted testing and evaluation of weapon systems at its facility for over 45 years. More recently, Wyle has been involved in the dismantling of weapon systems. Wyle offers a complete array of services to identify, dismantle, and remediate OEW/UXO. These services include all environmental and safety work plans, UXO surface and subsurface detection, OEW destruction, RDX/TNT soil remediation, and site restoration.

Wyle is a leading provider of testing, research, and engineering services to industry and government. Wyle also supplies special test systems and support services to the aerospace, defense, energy, and automotive industries and is a manufacturer of enclosures for the electronics industry and power cables and connectors for the airline and oil industries.

Posters

Harding Lawson Associates

Address: 105 Digital Drive
City, State, Zip Code: Novato, CA 94949
Telephone No.: 415-884-3168
Contact: Bruce Wilcer

Harding Lawson Associates performed a remedial investigation/feasibility study (RI/FS) at Fort Ord Site 39 - Inland Ranges, to evaluate potential soil and groundwater contamination from ordnance-related chemicals resulting from past Army activities. The poster will describe areas of concern at the 8,000-acre ordnance range, and present a summary of the RI/FS results. Illustrations will include a site map, photographs, and graphical representations of the data collected.

Waterways Experiment Station

Address: 3909 Halls Ferry Road
City, State, Zip Code: Vicksburg, MS 39180
Telephone No.: 601-634-2803
Contact: John Simmers

Ingestion of white phosphorus (WP) particles was found to be a cause of waterfowl mortality in the impact area wetlands of Fort Richardson, Alaska. As a result, the U.S. Army Environmental Center (USAEC) identified installations in the continental U.S. where impact areas contained wetlands. Nine of 23 Army impact areas were found to contain WP as a wetland contaminant in concentrations that ranged from the analytical detection limit to 450 mg/kg wet weight. The presence of WP may constitute a risk to waterfowl at only four installations where there are either extensive open wetland areas or where impact craters have formed numerous ponds; however, there has not been any documented waterfowl mortality. WP contamination in wetlands of Army impact areas in the continental U.S. can be addressed through range management strategies, and waterfowl mortality due to WP ingestion can be averted without extensive remediation.

Preregistered
Participant List

Norman Abramson
Earth Resources Corporation
1277 Marshall Farms Road
Ocoee, FL 34761
407-877-0877
FAX: 407-877-3622

George Allen
Naval Surface Warfare Center - Dahlgren Division
Coastal Systems Station, Code 110B
Panama City Beach, FL 32407-7001
904-235-5458
FAX: 904-235-5462

Aasmund Andersen
Royal Norwegian Navy
Naval Base Haakonsvern
P.O. Box 5
5078 Haakonsvern Norway
011-47-55-50-3600
FAX: 011-47-55-50-3731

Joseph Argento
U.S. Army, ARDEC
Industrial Ecology Center
Bldg. 172, AMSTA-AR-ET
Picatinny Arsenal, NJ 07806-5000
201-724-2428
FAX: 201-724-6759

Jorge G. Arroyo
EA Engineering Science & Technology
15 Loveton Circle
Sparks, MD 21152
410-771-4950
FAX: 410-771-4204

Richard G. Auld
HQ ACC/CEXE
129 Andrews Street, Suite 102
Langley AFB, VA 23665-2769
804-764-2706
FAX: 804-764-3566

Serpil Ayasli
MIT Lincoln Laboratory
244 Wood Street
Lexington, MA 02173-9108
617-981-7478
FAX: 617-981-0721

Tim Alexander
USAEC
ATTN: SFIM-AEC-BCA
Bldg. 4480
Aberdeen Proving Ground, MD 21010-5401
410-671-1628
FAX: 410-671-1635

Thomas Altshuler
Institute for Defense Analyses
1801 N. Beauregard Street
Science and Technology Division
Alexandria, VA 22311-1772
703-578-2715
FAX: 703-578-2877

Jermone Apt, Jr.
Concept Engineering Group, Inc.
610 William Pitt Way
Pittsburgh, PA 15238
412-826-3191
FAX: 412-826-3193

James Arnold
USAEC
Bldg. E4430
Aberdeen Proving Ground, MD 21010-5401
410-671-2466
FAX: 410-612-6836

Mike Atturio
Naval Facilities Engineering Service Center
560 Center Drive
Port Hueneme, CA 93045-4328
805-982-1191
FAX: 805-985-1197

Jim Austreng
Cal EPA - Department of Toxic Substances Control
10151 Croydon Way, #3
Sacramento, CA 95827
916-255-3702
FAX: 916-255-3697

Captain William B. Bacon
NAVEODTECHDIV
2008 Stump Neck Road
Indian Head, MD 20640-5070
301-743-6803
FAX: 301-743-6947

Bruce Barrow
AETC
1725 Jefferson Davis Highway, #707
Arlington, VA 22202
703-413-0500
FAX: 703-413-0512

William T. Batt
UXB International, Inc.
14800 Conference Center Drive, Suite 100
Chantilly, VA 22021
703-803-8904
FAX: 703-803-9355

Howard M. Beardsley
USATEU
5 Goddard Street
Aberdeen Proving Ground, MD 21040
410-676-8442
FAX: 410-671-3601

Thomas H. Bell
AETC
1725 Jefferson Davis Highway, #707
Arlington, VA 22202
703-413-0500
FAX: 703-413-0512

David E. Bell
U.S. Army
901 N. Stuart Street, Suite 400
Arlington, VA 22203
703-696-1592
FAX: 703-696-2940

Hollis Bennett
U.S. Army EWES-EE-S
3909 Halls Ferry Road
Vicksburg, MS 39180
601-634-3924
FAX: 601-634-2732

Willibald Berenda
MOI-EOD-Austria
Herrengasse 7
P.O. Box 100
A-1014-Vienna, Austria
011-43-1-531-26-2782
FAX: 011-43-1-531-26-2706

Donald F. Bickhart
Headquarters, U.S. Army Training & Doctrine Command
ATTN: ATCD-SB
Fort Morroe, VA 23651-5192
804-727-4411
FAX: 804-727-2520

Major Richard M. Bingman, Jr.
52nd Ordnance Group (EOD)
Fort Gillem, GA 30050-5000
404-363-5971/5978
FAX: 404-362-3338

Steven Bird
Project Manager for Non-Stockpile Chemical Materiel
ATTN: PMNSCM
Aberdeen Proving Ground, MD 21010-5401
410-671-4577
FAX: 410-612-8737

Kornelia Birner
CMS Environmental, Inc.
4904 Eisenhower Blvd., Suite 310
Tampa, FL 33634
813-882-4477
FAX: 813-884-1876

Timothy A. Blades
Edgewood Research, Development, and Engineering Center
Bldg. E3942, ATTN: SCBRD-ODC
Aberdeen Proving Ground, MD 21010
410-671-4676
FAX: 410-671-4684

Victor M. Bonilla
HQ FORSCOM
ATTN: AFPT-BC
Ft. McPherson, GA 30330-6000
404-669-6346
FAX: 404-669-7040

Simon Boniwell
Geonics Limited
8-1745 Meyerside Drive
Mississauga, Ontario, Canada L5T 1C6
905-670-9580
FAX: 905-670-9204

Robert J. Boonstoppel
USAEC
Beal Road, ATTN: SFIM-AEC-JA
Aberdeen Proving Ground, MD 21010-5401
410-671-1551
FAX: 410-671-3132

Miro Bosnar
Geonics Limited
8-1745 Meyerside Drive
Mississauga, Ontario L5T 1C6 Canada
905-670-9580
FAX: 905-670-9204

Wilbur Boutin
Ogden Environmental and Energy Services
3211 Jermantown Road
P.O. Box 10130
Fairfax, VA 22030
703-246-0500
FAX: 703-246-0589

Captain Philippe Boutinaud
General Delegation for Armament
GGM 10, Place Georges Clemenceau BP 19
92211 Saint-Cloud, Cedex, France
011-33-1-47-71-41-85
FAX: 011-33-1-47-71-47-20

Ronald J. Bowers
Parsons Engineering Science, Inc.
10521 Rosehaven Street
Fairfax, VA 22030-1899
703-591-7575
FAX: 703-591-1305

Eric M. Brandt
U.S. Army Corps of Engineers
Environmental Remediation Resident Office
Gunpowder Branch, P.O. Box 56
Aberdeen Proving Ground, MD 21010
410-671-6003
FAX: 410-671-6151

Yuri Bregman
Soreq Nuclear Research Center
Applied Remediation Technology Division
Yavne 81800, Israel
011-972-8-434366
FAX: 011-972-8-439716

Joseph Brown
IMS Corp
8298 D Old Courthouse Road
Vienna, VA 22182-3808
703-448-4487
FAX: 703-847-6430

Edward H. Brown
Wright Laboratory, Air Base Technology Branch
Construction Automation (FIVCF-OL)
Bldg. 9738
Tyndall AFB, FL 32403-5323
904-283-3725
FAX: 904-283-9710

Arnold Pope Burr
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172
Indian Head, MD 20640
301-743-6850, ext. 270
FAX: 301-743-6947

Gary A. Bury
NAES
Code 84323, B5-2
Lakehurst, NJ 08733
908-323-1014
FAX: 908-323-2718

Fenoy W. Butler
Geo-Centers, Inc.
10903 Indian Head Highway
Fort Washington, MD 20744
301-292-1010
FAX: 301-292-8717

A.J. Caffrey
Idaho National Engineering Laboratory
2525 North Fremont Avenue
Idaho Falls, ID 83415-3600
208-526-4027
FAX: 208-526-9267

Chester Canada
Department of Defense Explosives Safety Board
Hoffman Building
2461 Eisenhower Avenue
Alexandria, VA 22331-0600
703-325-0891
FAX: 703-325-6227

Allan Caplan
Department of the Army
PM for Non-Stockpile Chemical Materiel
Aberdeen Proving Ground, MD 21010-5401
410-612-8733
FAX: 410-612-8737

Alison Chaiken
Lawrence Livermore National Lab
Mail Stop L-350
Livermore, CA 94551
510-422-7129
FAX: 510-422-6892

Chi-Chih Chen
Ohio State University Electro Science Lab
1320 Kinnear Road
Columbus, OH 43212
614-292-7981
FAX: 614-292-7297

John Chionchio
CMS Environmental, Inc.
4904 Eisenhower Blvd., Suite 310
Tampa, FL 33634
813-882-4477
FAX: 813-884-1876

Les Clarke
Wyle Laboratories
1841 Hillside Ave.
P.O. Box 160
Norco, CA 91760-0160
909-737-0871
FAX: 909-735-4030

Hanceford E. Clayton
Lockheed Martin Idaho Technologies
P.O. Box 1625
Idaho Falls, ID 83415-4146
208-526-8197
FAX: 208-526-8053

Terry L. Clayton
Fish and Wildlife Service
P.O. Box 25207
Denver, CO 80225-0207
303-275-2341
FAX: 303-275-2333

Lynn S. Clements
U.S. Army Forces Command
ATTN: AFPI-SO
Fort McPherson, GA 30330-6000
404-669-5764
FAX: 404-669-6756

Vivian K. Clifton
DOJ/FBI
ERF, Bldg. 27958A
Quantico, VA 22135
703-640-7800
FAX: 703-630-6693

Terry Cochran
HAZWRAP
831 Tri-County Blvd.
Oliver Springs, TN 37840
423-435-3487
FAX: 423-435-3400

Larry J. Coe
SC&A
1355 Beverly Road, Suite 250
McLean, VA 22101
703-893-6600
FAX: 703-821-8236

Danny L. Comer
DOJ\FBI
Bldg. 27958-A
Quantico, VA 22135
703-630-6477
FAX: 703-6306693

Lionel Cooper
U.S. General Accounting Office
Los Angeles World Trade Center
350 S. Figueroa Street, Suite 1010
Los Angeles, CA 90071
213-346-8113
FAX: 213-346-8142

Jim Coppola
Corps of Engineers
P.O. Box 76886
Washington, DC 20013
202-761-4992
FAX: 202-761-8895

Alan Crandall
Geo-Centers, Inc.
7 Wells Ave.
Newton, MA 02159
617-964-7070
FAX: 617-527-7592

Larry Crane
Tsuu T'ina Nation Administration
911 Chula Blvd.
Tsuu T'ina, Sarcer, Alberta, Canada T2W 6H6
403-281-4455
FAX: 403-251-5871

Joseph D. Craten
U.S. Army
Aberdeen Proving Ground, MD 21005-5001
410-278-7685
FAX: 410-278-8759

Steven W. Crusinberry
U.S. Army
Commander 144th Ordnance Detachment
Ft. Meade, VA 20755
301-677-9770
FAX: 301-677-9245

Colonel Walter J. Cunningham
U.S. Army Corps of Engineers - Huntsville
4820 University Square
P.O. Box 1600
Huntsville, AL 35807-4301
205-895-1300
FAX: 205-895-1910

Ren Da
Center for Mapping - OSU
1216 Kinnear Road
Columbus, OH 43212
614-688-3415
FAX: 614-292-8062

Linda Daehn
PRC EMI
6th and Last Chance Gulch
Helena, MT 59601
406-442-5588
FAX: 406-442-7182

Richard S. Dale
Fort McCoy
1436 South M Street
Fort McCoy, WI 54656
608-388-3403
FAX: 608-388-2164

Bill Dana
Oregon Department of Environmental Quality
811 SW Sixth Ave.
Portland, OR 97204
503-229-6530
FAX: 503-229-5830

Joseph W. Dauchy
PRC Environmental Management, Inc.
330 South Executive Drive, Suite #203
Brookfield, WI 53005
414-821-5894
FAX: 414-821-5946

Mark Daugherty
Umatilla Chemical Depot
Hermiston, OR 97838-9544
503-564-5294
FAX: 503-564-5371

Richard C. Davis
ATG, Inc.
47375 Fremont Blvd.
Fremont, CA 94538
510-490-3008
FAX: 510-651-3731

Les Davis
Sensors & Software
1091 Brevik Place
Mississauga, Ontario, Canada L4W 3R7
905-624-8909
FAX: 905-624-9365

Richard S. Dehart
NAVEODTECHDIV
2008 Stump Neck Road
Indian Head, MD 20640-5070
301-934-3191
FAX: 301-743-6947

Vid Dekshenieks
Westinghouse Savannah River Company
227 Gateway Drive
Aiken, SC 29803
803-652-1865
FAX: 803-652-1898

Douglas DeProspo
AETC
1725 Jefferson Davis Highway, #707
Arlington, VA 22202
703-413-0500
FAX: 703-413-0512

Narendra N. Desai
Dir. Safety, Health, and Environment
STEAP-SH-ER
Aberdeen Proving Ground, MD 21010-5423
410-671-4569
FAX: 410-671-3010

Jacques Desilets
The S.M. Group International Inc.
3705, Industrial Boul.
Sherbrooke, Quebec Canada J1L 1X8
819-566-8855
FAX: 819-566-0224

Oskar Dietz
Vallon GmbH/Security Search
Im Grund 3
D-72800 Eningen, FR Germany
011-49-7121-98550
FAX: 011-49-7121-83643

Pat H. Dillon
DoD EOD Technology and Training
2008 Stump Neck Road
Indian Head, MD 20640
301-743-4018
FAX: 301-743-6997

Al Dilz
KDI Precision Products, Inc.
3975 McMann Road
Cincinnati, OH 45245
513-825-5745
FAX: 513-943-2321

Robert DiMarco
AETC
1725 Jefferson Davis Highway, #707
Arlington, VA 22202
703-413-0500
FAX: 703-413-0512

Hien Q. Dinh
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172, Code 50A12
Indian Head, MD 20640-5070
301-743-6850, ext. 257
FAX: 301-743-6947

Deborah C.Dixon
Law Engineering & Environmental Services, Inc.
114 TownPark Drive, #300
Kennesaw, GA 30144
770-499-6891
FAX: 770-421-3593

Tim Doherty
U.S. Army Ordnance Missile & Munition School
Redstone Arsenal, AL 35897-6095
205-876-9178
FAX: 205-876-5979

Raymond Dominguez
Special Operation Low-Intensity Conflict
2500 Defense Pentagon, Room 1A674A
Washington, DC 20301-2500
703-693-4073
FAX: 703-693-3039

Robert J. Donnelly
Los Alamos Technical Associates
8550 Arlington Blvd., Suite 301
Fairfax, VA 22031
703-698-5580
FAX: 703-698-0523

C. David Douthat
U.S. Army Engineering and Support Center, Huntsville
P.O. Box 1600
Huntsville, AL 35807-4301
250-895-1510
FAX: 205-722-8709

Clifford H. Doyle
US Army Technical Center for Explosives Safety
ATTN: SIOAC-ESL
Savanna, IL 61074-9639
815-273-8741
FAX: 815-273-8731 or 8769

R.A. Drake
Geo-Centers, Inc.
2614 Artie Street, Suite 25
Huntsville, AL 35805
205-534-5431
FAX: 205-536-8622

Walter Daniel Dubuque, II
Schiebel Instruments, Inc.
106 Hillif Terrace
Poughkeepsie, NY 12603
914-462-8780
FAX: 914-462-8652

Richmond H. Dugger, III
UXB International, Inc.
14800 Conference Center Drive, Suite 100
Chantilly, VA 22021
703-803-8904
FAX: 703-803-9355

Bob Dworkin
U.S. Army Corps of Engineers
Omaha District
215 North 17th Street
Omaha, NE 68102-4978
402-221-7716
FAX: 402-221-7838

Spenser C. Eason
Foster Wheeler Environmental Corp.
1892 McFarland Ave.
Rossville, GA 30741
706-866-8990
FAX: 706-861-2531

Gary Brian Enloe
Montgomery Watson
4525 S. Wasatch Blvd., Suite 200
Salt Lake City, UT 84124
801-272-1900
FAX: 801-272-0430

Robert Enman
Xtech Explosive Decontamination Inc.
5419 Ladbrooke Drive SW
Calgary, Alberta, Canada T3E 5X9
403-240-7029
FAX: 403-240-7180

Stanton Enomoto
Kaho'olawe Island Reserve Commission
33 South King Street, Suite 501
Honolulu, HI 96813
808-586-0761
FAX: 808-586-7589

William J. Ervin
Battelle
505 King Avenue
Columbus, OH 43201-2693
614-424-7891
FAX: 614-424-3918

George Esposito
DataChem Laboratories
10 Juliet Lane, #203
Baltimore, MD 21236
410-529-5675
FAX: 410-529-5355

Keoni Fairbanks
Kaho'olawe Island Reserve Commission
33 South King Street, Suite 501
Honolulu, HI 96813
808-586-0761
FAX: 808-586-7589

Arkie Dean Fanning
U.S. Army Corps of Engineers, Huntsville
4820 University Square
P.O. Box 1600
Huntsville, AL 35807-4301
205-895-1762
FAX: 205-895-1798

Robert T. Fay
ISSI Unexploded Ordnance Inc.
P.O. Box 11
Huntsville, AL 35804-0011
205-247-7050
FAX: 205-247-7030

Emma Featherman-Sam
Badland Bombing Range Project
P.O. Box 1310
Pine Ridge, SD 57770
605-867-1271
FAX: 605-867-5044

Jim Ferris
UXB International, Inc.
14800 Conference Center Drive, Suite 100
Chantilly, VA 22021
703-803-8904
FAX: 703-803-9355

Gordon P. Fields
CMS Environmental, Inc.
4904 Eisenhower Blvd., Suite 310
Tampa, FL 33634
813-882-4477
FAX: 813-884-1876

Frank R. Finch
Search Technologies, A Division of Geo-Centers, Inc.
6116 Executive Boulevard, Suite 120
Rockville, MD 20852
301-231-6144
FAX: 301-816-8647

Donald C. Flyer
Charles Stark Draper Lab
555 Technology Square
Cambridge, MA 02139
617-258-4291
FAX: 617-258-4293

George Focsaneanu
SCHIEBEL Instruments, Inc.
2127 California Street, NW, Suite 804
Washington, DC 20008
202-483-8311
FAX: 202-483-8316

Joseph W. Foley
OAO Corporation
Robotics Lab, Door 2
10289 Aerospace Road
Lanham, MD 20706
301-306-8961
FAX: 301-306-8966

John Edward Foley
Sanford Cohn and Associates
15 Douglas Road
Lowell, MA 01852
508-458-8059
FAX: 508-458-2960

Timothy D. Foote
MCAS Yuma
HHS Squadron
MCAS Yuma, AZ 85369
520-341-2303
FAX:

Dwayne Ford
U.S. Army Corps of Engineers - Fort Worth District
P.O. Box 17300
Ft. Worth , TX 76116
817-334-9924
FAX: 817-334-2991

Boyd Foster
National Defense Headquarters
101 Colonel By Drive
Ottawa, Ontario, Canada K1A-OK2
613-945-7807
FAX: 613-992-3349

Arnie Franz
Wyle Laboratories
1841 Hillside Ave.
P.O. Box 160
Norco, CA 91760
909-737-0817
FAX: 909-735-4030

Randy L. Fraser
U.S. Army Corps of Engineers
ATTN: CELMS-PM-M
1222 Spruce Street
St. Louis, MO 63103
314-331-8268
FAX: 314-331-8828

Alan T. Frohberg
Glacier Engineering P.C.
104 Second Street South, Suite 300
Great Falls, MT 59403
406-727-3748

John Funk
Bristol Aerospace
1501 Gershaw Drive, SW
Medicine Hat, Alberta, Canada T1A 7V1
403-529-0353
FAX:

Ronald J. Furze
Milsearch PTY LTD
191-203 Anicetell Street
P.O. Box 1339
Tuggeranong ACT Australia 2900
011-61-6-293-2999
FAX: 011-61-6-293-1966

Steve Galloway
CASDE Corporation
1901 N. Beauregard St., #400
Alexandria, VA 22311
703-845-9221
FAX: 703-845-9812

Elizabeth N. Galvez
Kaho'olawe Island Reserve Commission
33 South King Street, Suite 501
Honolulu, HI 96813
808-586-0761
FAX: 808-586-7589

Curt Gandy
Dept. of the Army
Presidio of Monterey
P.O. Box 3115
Carmel, CA 93921-3115
408-375-9464
FAX: 408-375-9464

Terence Gant
MTA, Inc.
2760 Eisenhower Avenue, Suite 200
Alexandria, VA 22314
703-317-3212
FAX: 703-317-0223

Denise Gebhart
UXB International, Inc.
14800 Conference Center Drive, Suite 100
Chantilly, VA 22021
703-803-8904
FAX: 703-803-9355

Vivian George
Institute for Defense Analyses
1801 N. Beauregard Street
Science and Technology Division
Alexandria, VA 22311-1772
703-578-2867
FAX: 703-578-2877

Dave Gill
NAVEODTECHDIV
2008 Stump Neck Road
Code 50B23
Indian Head, MD 20640
301-743-6850, ext. 251
FAX: 301-743-6947

Robert O. Ginaven
SAIC
4161 Campus Point Court
San Diego, CA 92121
619-458-5289
FAX: 619-458-5252

Marjorie A. Gonzalez
Lawrence Livermore National Laboratory
7000 East Avenue
P.O. Box 808, L-165
Livermore, CA 94550
510-423-5630
FAX: 510-423-5029

Sherlyn Franklin Goo
ALU LIKE, Inc.
1656 Pankiki Street
Kailua, HI 96734
808-262-7650
FAX: 808-262-7650

Paul A. Gorski
Waste Abatement Technology, L.P.
1300 Williams Drive, Suite B
Marietta, GA 30066-6299
770-427-1947
FAX: 770-427-1907

Bill Graft
EC III, Inc.
Bldg. 2023E, Yuma Proving Ground
P.O. Box 6546
Yuma, AZ 85366
520-328-6690
FAX: 520-328-6994

Vivian M. Graham
USAEC
Bldg. E4430
Aberdeen Proving Ground, MD 21010
410-612-6869
FAX: 410-612-6836

Donald J. Green
U.S. Army Garrison
ATTN: STEAP-SH-ER
Bldg. E4430
Aberdeen Proving Ground, MD 21005
410-612-7313
FAX: 410-612-7311

Ronald F. Green
EOD Team, White Sands Missile Range NM
202 Deacon Ave.
WSMR, NM 88002
505-678-2035
FAX: 505-678-6228

Doug R. Greenwell
Lockheed Martin Idaho Technologies
P.O. Box 1625
Idaho Falls, ID 83415-3953
208-526-0858
FAX: 208-526-6852

Robert G. Gregory
ERM Program Management Company
855 Springdale Road
Exton, PA 19341
610-524-3405
FAX: 610-524-3718

Gary S. Groenewold
Idaho National Engineering Laboratory
2351 North Blvd.
P.O. Box 1625
Idaho Falls, ID 83415-2208
208-526-2803
FAX: 208-526-8541

Thomas G. Groggett, 1LT
259th Ordnance Detachment (EOD)
ATTN.: 1LT Groggett
P.O. Box 105651
Ft. Irwin, CA 92310-5051
619-380-4092
FAX: 619-380-4097

Yanping Guo
The Johns Hopkins University
Applied Physics Laboratory
Johns Hopkins Road, Room 25-258
Laurel, MD 20723-6099
301-953-5000, ext. 7541
FAX: 301-953-5980

Rainer HaBfurter
TDW
Postfach 13 40
86523 Schrobenhausen, Deutschland, Germany
011-49-8252-99-6600
FAX: 011-49-8252-99-6116

Linda Hain
Geo-Centers, Inc.
7 Wells Avenue
Newton Centre, MA 02159
617-964-7070
FAX: 617-527-7592

Jennifer Irene Halman
Battelle
505 King Ave.
Columbus, OH 43201
614-424-7791
FAX: 614-424-3962

Harry N. Hambric
Night Vision Directorate, Countermine Division
10221 Burbeck Road, Suite 430
Ft. Belvoir, VA 22060-5806
703-704-1086
FAX: 703-704-2432

Erik Hangeland
USAEC
ATTN: SFIM-AEC-ETP
Aberdeen Proving Ground, MD 21010-5401
410-612-6858
FAX: 410-612-6836

Douglas Hanson
AMA Analytical Services
4485 Forbes Blvd.
Lanham, MD 20706
301-459-2640
FAX: 301-459-2643

Per Chr. Hanssen
Royal Norwegian Navy
Naval Base Haakonsvern
P.O. Box 5
5078 Haakonsvern Norway
011-47-55-50-3618
FAX: 011-47-55-50-3731

Alison Harlick
Lockheed Martin Energy Systems
831 Tri-County Blvd.
Oliver Springs, TN 37840
423-435-3556
FAX: 423-435-3400

Michael W. Harper
U.S. Army Technical Center for Explosives Safety
ATTN: SIOAC-ESL
Bldg. 252
Savanna, IL 61074
815-273-8749
FAX: 815-273-6009

Raymond L. Harris
METRATEK, Inc.
12330 Pinecrest Road
Reston, VA 22091
703-620-9500
FAX: 703-620-9696

Jack K.Hartwell
Idaho National Engineering Laboratory
P.O. Box 1625
Idaho Falls, ID 83415-2114
208-526-9366
FAX: 208-526-9267

Mary D. Hassell
Brown & Root Environmental, Inc.
910 Clopper Road
Gaithersburg, MD 20878-1399
301-258-8522
FAX: 301-258-2568

S. Stewart Hattie
Dillon Consulting LTD
Suite 700, 2701 Dutch Village Road
Halifax, Nova Scotia, Canada B3L-4G6
902-453-1115
FAX: 902-454-6886

Ronald E. Hawkins
Milsearch PTY LTD
191-203 Anicetell Street
P.O. Box 1339
Tuggeranong ACT Australia 2900
011-61-6-293-2999
FAX: 011-61-6-293-1966

Charles H. Heaton, Jr.
U.S. Army Engineering & Support Center, Huntsville
4820 University Square
P.O. Box 1600
Huntsville, AL 35807-4301
205-895-1544
FAX: 205-895-1378

Karen E. Heckelman
U.S. Army Environmental Center
ATTN: SFIM-AEC-IA
Aberdeen Proving Ground, MD 21010-5401
410-671-1551
FAX: 410-671-3132

Ronald P. Heflin
MWSS 371
MCAS Yuma, AZ 85369
520-341-2303
FAX: 520-341-2112

Paul Henning
Quadrel Services, Inc.
1896 Urbana Park, Suite 20
Clarksburg, MD 20871
301-874-5510
FAX: 301-874-5567

Steven J. Herman
Combined Arms Support Command
3901 A Avenue, Suite 230
Fort Lee, VA 23801-1809
804-734-0257
FAX: 804-734-1342

Jorge A. Hernandez
USA HQTECOM, Safety Office, AMSTE-ST
Ryan Bldg, Room 247
Aberdeen Proving Ground, MD 21005-5055
410-278-1306
FAX: 410-278-3735

Robert W. Hickman
Allied Technology Group
14347 Hunter Road
Harvest, AL 35749
205-233-0302
FAX: 205-233-5045

Bob Highfill
Chemrad
739 Emory Valley Road
Oak Ridge, TN 37830
423-481-2511
FAX: 423-483-9528

Scott Hill
USAEC
SFIM-AEC-BCB, Bldg. E4480, Beal Road
Aberdeen Proving Ground, MD 21010-5401
410-671-1607
FAX: 410-671-1635

Colonel Robert E. Hilliard
Project Manager for Non-Stockpile Chemical Materiel
ATTN: SFAE-CD-N. Bldg. E4405
Aberdeen Proving Ground, MD 21010-5401
410-671-1083
FAX: 410-612-8737

Ronald A. Hitchler
Security Search Product Sales/Vallon
7 Amaranth Drive
Littleton, CO 80127-2611
303-933-7955
FAX: 303-933-7955

Robert E. Hoag
The Pennsylvania State University
Applied Research Laboratory
P.O. Box 30
State College, PA 16804
814-863-3207
FAX: 814-863-1183

Pieter Hoekstra
Blackhawk Geosciences
301 Commercial Road, Suite B
Golden, CO 80401
303-278-8700
FAX: 303-278-0789

Owen C. Hofer
SPARTA, Inc.
4901 Corporate Drive
Huntsville, AL 35805
205-837-5282, ext. 2600
FAX: 205-890-2041

Franklin D. Hoffman
342 Regal Drive
Abingdon, MD 21009
410-612-8728

F. Dennis Holmes
Montgomery Watson
4525 South Wasatch Blvd., Suite 200
Salt Lake City, UT 84124
801-272-1900
FAX: 801-272-0430

Daniel Holmes
U.S. Corps of Engineers, Rock Island District
Clock Tower Building, CENCR-ED-DO
P.O. Box 2004
Rock Island, IL 61204
309-794-6080
FAX: 309-794-6187

David Johns Hopps
David Hopps Associates/Hadleigh Bee Farm
Pond Hall Road, Hadleigh
Ipswich, Suffolk, Great Britain IP7 5PT
011-44-1473-652612
FAX: 011-44-1473-652612

Gary Howard
Oilton, Inc.
1821 University Ave., W., Suite 461N
St. Paul, MN 55104
612-646-5747
FAX: 612-646-5303

Josephine S. Huang
Hazardous and Medical Waste Services, Inc.
10001 Derekwood Lane, Suite 115
Lanham, MD 20706
301-577-9339
FAX: 301-577-9616

Henry C. Hubbard, Jr.
US Army Engineering and Support Center
4820 University Square
Huntsville, AL 35816-1822
205-895-1586
FAX: 205-722-8709

John W. Hunt
Michigan Army National Guard
Environmental Office, Bldg. 30
Camp Grayling, MI 49739
517-348-3600
FAX: 517-348-3786

Colonel Ihrke
Department of Defense Explosives Safety Board
Hoffman Building
2461 Eisenhower Avenue
Alexandria, VA 22331-0600
703-325-0891
FAX: 703-325-6227

Kevin J. Ingram
Geo-graphics, Inc.
31 Central Street
Bangor, ME 04401-5115
207-947-8446
FAX: 207-947-2848

Ken Ives
GP Environmental Services
202 Perry Parkway
Gaithersburg, MD 20877
301-926-6802
FAX: 301-840-1209

Mark Iwanowski
Quantum Magnetics, Inc.
11558 Sorrento Valley Road, #7
San Diego, CA 92121
614-481-4015
FAX: 619-481-5879

Kirk James
U.S. Army Corps of Engineers
ATTN: CELMS-PM-M
1222 Spruce Street
St. Louis, MO 63103
314-331-8790
FAX: 314-331-8828

Von Ayre Jennings
Lockheed Martin Advanced Environmental Systems
103 Chesapeake Park Plaza, MS 600
Baltimore, MD 21220
410-682-0892
FAX: 410-682-3648

Captain Steven K. Johnson, USN
Special Operation Low-Intensity Conflict
2500 Defense Pentagon, Room 1A674B
Washington, DC 20301-2500
703-693-5223
FAX: 703-693-3039

Bruce M. Johnson
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172
Indian Head, MD 20640-5070
301-743-6850, ext. 248
FAX: 301-743-6947

Craig Johnson
EG&G ORTEC
100 Midland Road
Oak Ridge, TN 37830
423-482-4411
FAX: 423-483-0396

Jerry Jones
LMES
831 Tri-County Blvd.
Oliver Springs, TN 37840
423-435-3206
FAX: 423-435-3704

R. James Jones
DataChem Laboratories
690 West LeVoy Drive
Salt Lake City, Utah 84123
801-266-7700
FAX: 801-268-9992

Christine N. Jordan
Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria, VA 22311
703-578-2716
FAX: 703-845-2211

Bertrand Jourlin
General Delegation for Armament
ETBS Route de Guerry, BP 712
18015 Bourges, Cedex, France
011-33-48-20-41-81
FAX: 011-33-48-20-02-18

Kenneth Juris
USAEC
Beal Road/Bldg. E4460
ATTN: SFIM-AEC-CO
Aberdeen Proving Ground, MD 21010-5401
410-671-2434
FAX: 410-671-3132

Peter Kaczkowski
Applied Physics Laboratory
University of Washington
1013 NE 40th Street
Seattle, WA 98105-6698
206-543-1300
FAX: 206-543-6785

Harold G. Keane
ORINCON Corporation
9363 Towne Centre Drive
San Diego, CA 92121
619-455-5530, ext. 271 or 258
FAX: 619-452-4258

Major Bryan Keifer
U.S. Army Pacific
ATTN: APLG-MV-EOD
Ft. Shafter, HI 96819
808-438-8125
FAX:

Dean Keiswetter
Geophex, Ltd.
605 Mercury Street
Raleigh, NC 27603
919-839-8515
FAX: 919-839-8528

Major R.D. Kelly
National Defense Headquarters
101 Col By
Ottawa, Ontario, Canada K1A 0K2
613-945-7715
FAX: 613-996-2244

Alain Kirschbaum
S.M. Group International, Inc.
2111, Boul. Fernand-LaFontaine
Longueuil, Quebec, Canada J4G 2J4
514-651-0981
FAX: 514-651-9542

Erik Kjell
Swedish Defense Materiel Administration
P.O. Box S-11588
Stockholm, Sweden
011-46-87825502
FAX: 011-46-87824222

John Klotz
U.S. General Accounting Office
441 G Street, NW, Room 4 E14
Washington, DC 20548
202-512-8628
FAX: 202-512-2501

Douglas Knight
ALU LIKE, Inc. - Native Hawaiian Voc. Ed. Program
1024 Mapunapuna Street
Honolulu, HI 96819
808-839-7922
FAX: 808-836-0704

Kristine Kruk
PRC Environmental Management, Inc.
200 East Randolph Street, Suite 4700
Chicago, IL 60601
312-856-8700
FAX: 312-938-0118

Mike Kuharik
Foerster Instruments, Inc.
140 Industry Drive, Ride Park
Pittsburgh, PA 15275-1028
412-788-8976
FAX: 412-788-0437

James J. Kulesz
DOE/HAZWRAP
831 Tri-County Blvd.
Oliver Springs, TN 37840
423-435-3219
FAX: 423-435-3271

Albert Lafontaine
Protech Armored Products
158 Hubbard Avenue
Pittsfield, MA 01201
413-684-3104
FAX: 413-684-4166

CDR James R. Lake, USN
Naval School, Explosive Ordnance Disposal
309 Strauss Avenue
Indian Head, MD 20640-5040
301-743-4476
FAX: 301-743-4559

Enrique M. Lastra
U.S. Army STRICOM - PM-ITTS
12350 Research Parkway
Orlando, FL 32826
407-381-8809
FAX: 407-380-8327

John Lathrop
Coastal Systems Station - Dahlgren Division
6703 West Highway 98
Technology Demonstration Office (Code 10T2)
Panama City, FL 32407-7001
904-234-4667
FAX: 904-235-5462

Eugene M. Lavely
Blackhawk Geosciences
301 Commercial Road, Suite B
Golden, CO 80401
303-278-8700
FAX: 303-278-0789

Randolph G. Laye
Edgewood Research, Development, and Engineering Center
ATTN: SCBRD-ODC
Aberdeen Proving Ground, MD 21010-5423
410-671-4677
FAX: 410-671-4684

Howard Lazarus
Foster Wheeler Environmental Corporation
1290 Wall Street, West
Lyndhurst, NJ 07071-0661
201-842-7062
FAX: 201-842-7025

Eugene R.Leach
Eugene R.Leach & Associates
1356 W. Second Avenue
Columbus, OH 43212
614-488-6073
FAX: 614-488-6073

Wayne Lechelt
Battelle Pacific Northwest National Laboratory
Battelle Blvd.
P.O. Box 999
Richland, WA 99352
509-375-2926
FAX: 509-375-3621

Charles A. Lechner
USAEC
Base Closure Division
ATTN: SFIM-AEC-BCA, Bldg E4480
Aberdeen Proving Ground, MD 21010-5401
410-671-1605
FAX: 410-671-7635

Captain Francois Leduc
National Defense Headquarters
101 Colonel By Drive
Ottawa, Ontario, Canada K1A-OK2
613-945-8014
FAX: 613-992-3349

Check F. Lee
MIT/LL
244 Wood Street
Lexington, MA 02173
617-981-5318
FAX: 617-981-0721

Jim Lehr
Western Governors' Association
600 17th Street, Suite 1705
Denver, CO 80202
303-623-9378
FAX: 303-534-7309

Zeno Leier
Oilton, Inc.
1824 University Ave, W., Suite 461N
St. Paul, MN 55104
612-646-5747
FAX: 612-646-5303

Richard D. Leonard
Battelle
505 King Avenue (JN-4)
Columbus, OH 43201
614-424-5574
FAX: 614-424-4905

William Lewis
CMS, Inc.
4904 Eisenhower Blvd., #310
Tampa, FL 33634
813-882-4477
FAX: 813-884-1876

Richard Lewis
U.S. Army Corps of Engineers, WES
3909 Halls Ferry Hall Road
Vicksburg, MS 39180
601-634-2217
FAX: 601-634-3080

Peter Lilley
Geometrics, Inc.
395 Java Drive
Sunnyvale, CA 94089
408-734-4616, ext. 8245
FAX: 408-745-6131

Brian Lloyd
Tsuu T'ina Nation Administration
911 Chula Blvd.
Tsuu T'ina, Sarcer, Alberta, Canada T2W 6H6
403-281-4455
FAX: 403-251-5871

Kevin Lombardo
UXB International, Inc.
14800 Conference Center Drive, Suite 100
Chantilly, VA 22021
703-803-8904
FAX: 703-803-9355

Randy Long
Pine Bluff Chemical Activity
10020 Kabrich Circle
Pine Bluff, AR 71602-9500
510-540-3963
FAX: 510-540-3886

Katherine A. Lukinic
PRC Inc.
4481 Indian Head Highway
Indian Head, MD 20640
301-753-5719 or 301-283-2853
FAX: 301-753-9053

Colette Y. Machado
Kaho'olawe Island Reserve Commission
33 South King Street, Suite 501
Honolulu, HI 96813
808-586-0761
FAX: 808-586-7589

Claude Manley
NAVEODTECHDIV
2008 Stump Neck Road
Indian Head, MD 20640-5070
301-743-6850
FAX: 301-743-6947

James P. Manthey
U.S. Army Engineering and Support Center, Huntsville
P.O. Box 1600
Huntsville, AL 35807-4301
205-895-1663
FAX: 205-895-1602

Vincent R. Marinelli
U.S. Army Research Laboratory
2800 Powder Mill Road
ATTN: AMSRL-SE-RC
Adelphi, MD 20783
301-394-3110
FAX: 301-391-4605

Jim R. McDonald
Naval Research Laboratory
4555 Overlook Ave., SW Code 6110
Washington, DC 20375
202-767-3340
FAX: 202-404-8119

Ronald B. McGough
Alliant Techsystems
6500 Harbour Heights Parkway
Mukilteo, WA 98275
206-356-3224
FAX: 206-356-3186

John C. McIlrath, P.E.
Foster Wheeler Environmental Corp.
P.O. Box 104
Aberdeen Proving Ground, MD 21010
410-671-6015
FAX: 410-671-6018

J. Duncan McNeill
Geonics Limited
8-1745 Meyerside Drive
Mississauga, Ontario Canada L5T 1C6
905-670-9580
FAX: 905-670-9204

Peter J. Mellinger
Battelle Pacific Northwest Laboratories
P.O. Box 999
Richland, WA 99352
509-373-0576
FAX: 509-373-1153

Robert Menke
Parsons Engineering Science, Inc.
10521 Rosehaven Street
Fairfax, VA 22030
703-591-7575
FAX: 703-591-1305

Linda G. Millar
Indian Head Div/NSWC
101 Strauss Ave.
Indian Head, MD 20610
301-743-6331
FAX: 301-743-4187

James P. Miller
Parsons Engineering Services
100 W. Walnut Street
Pasadena, CA 91124
818-440-6137
FAX: 818-440-6195

Paul Miller
Corps of Engineers - WES
3909 Halls Ferry Road, GG-YH
Vicksburg, MS 39280
601-634-3247
FAX: 601-364-3453

Scott Millhouse
U.S. Army Engineering and Support Center, Huntsville
ATTN: CEHNC-ED-CS-S
P.O. Box 1600
Huntsville, AL 35807-4301
205-895-1607
FAX: 205-895-1602

Charles L. Mitchell Jr., Major
U.S. Army Technical Detachment
2008 Stump Neck Road
Indian Head, MD 20640
301-743-6820
FAX: 301-743-6866

Thomas M. Moore
Wright Laboratory/FIVCF
139 Barnes Drive, Suite 2
Tyndall AFB, FL 32403-5323
904-283-3725
FAX: 904-283-9710

Mike Moran
MTA, Inc.
688 Discovery Drive
Huntsville, AL 35806
205-922-1110
FAX: 205-922-1888

Barbara Nabors
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive
HMWMD-RP-B2
Denver, CO 80209
303-692-3390
FAX: 303-759-5355

Allen D. Nease
Wright Laboratory/FIVCF
139 Barnes Drive, Suite 2
Tyndall AFB, FL 32403-5323
904-283-3725
FAX: 904-283-9710

Betty Neff
US Army Engineering and Support Center, Huntsville
4820 University Square
P.O. Box 1600
Huntsville, AL 35816-1822
205-895-1778
FAX: 205-895-1798

Carl Nelson
John Hopkins University
Applied Physics Laboratory
11100 John Hopkins Road
Laurel, MD 20723-6099
301-953-5949
FAX: 301-953-5026

Thomas S. Nelson
JOI at ONR
Room 407, 800 N. Quincy Street
Arlington, VA 22217-5000
703-696-4396
FAX: 703-696-2007

Major Nestico
Ispettorato Logistico
2° Reparto - 4° Ufficio - 4ª Sezione EOR/EOD
viale della Universita 4
00185 Roma , Italy
011-39-6-4986-6257
FAX: 011-39-6-4986-5451

Robert Newburn
Department of Defense Explosives Safety Board
Hoffman Building
2461 Eisenhower Avenue
Alexandria, VA 22331-0600
703-325-0891
FAX: 703-325-6227

Edward Newell
Dir. Safety, Health, & Environment
STEAP-SH-ER
Aberdeen Proving Ground, MD 21010-5423
410-671-4328
FAX: 410-671-3010

Tuan Nhat Nguyen
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172
Indian Head, MD 20640-5070
301-743-6850, ext. 281
FAX: 301-743-6947

Ed Nicholson
Applied Ordnance Technologies
4001 Indian Head Highway
Indian Head, MD 20640
301-753-5600
FAX: 301-753-5604

Debra N. Nissen
Sandia National Laboratories
7011 East Avenue, MS 9221
P.O. Box 969
Livermore, CA 94550
510-294-2145
FAX: 510-294-3418

Daniel Norby
DOJ/FBI
Bldg. 27958A
Quantico, VA 22135
703-630-6431
FAX: 703-630-6693

Jack K.Norris, II
Human Factors Applications, Inc.
700 Old Line Centre, Suite 210
Waldorf, MD 20602-2513
301-705-5044
FAX: 301-705-7561

Christopher C. O'Donnell
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172
Indian Head, MD 20640-5070
301-743-6850, ext. 262
FAX: 301-743-6947

Gary R. Olhoeft
Colorado School of Mines
1500 Illinois Street
Golden, CO 80401-1887
303-273-3458
FAX: 303-273-3478

George R. Overby
Rust Environment & Infrastructure
15 Brendan Way, P.O. Box 24000
Greenville, SC 29615
864-234-2293
FAX: 864-234-3069

Steven D. Palomo
DOE - Idaho Operations Office
850 Energy Drive
Idaho Falls, ID 83402
208-526-7028
FAX: 208-526-0160

Philippe Pannetier
ONERA
29 Avenue de la Division Leclerc
P.O. Box BP72
92322, Chatillon, Cedex France
011-33-1-46734019
FAX: 011-33-1-46734151

Jerry Parkin
Division of Solid and Hazardous Waste - Utah
288 North 1460 West
P.O. Box 144880
Salt Lake City, UT 84114-4880
801-538-6170
FAX: 801-538-6715

Jason A. Parks
U.S. Army Corps of Engineers
Environmental Remediation Resident Office
Gunpowder Branch, P.O. Box 56
Aberdeen Proving Ground, MD 21010
410-671-6003
FAX: 410-671-6151

LTC David L. Partain
Combined Arms Support Command
3901 A Avenue, Suite 230
Fort Lee, VA 23801-1809
804-734-0257
FAX: 804-734-1342

Jim Pastorick
IT Corporation
302 N. Alfred Street
Alexandria, VA 22314
703-548-5300
FAX: 703-548-5350

Jim Patton
U.S. Army Corps of Engineers
430 10th Street, NW, Suite S206
Atlanta, GA 30318-5768
404-892-3099
FAX: 404-892-9381

T.J. Paulus
EG&G ORTEC
100 Midland Road
Oak Ridge, TN 37830
423-482-4411
FAX: 423-483-0396

Marvin A. Pedersen
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172
Indian Head, MD 20640-5070
301-743-6850, ext. 250
FAX: 301-743-6947

William C. Peila
Sandia National Labs
P.O. Box 969, MS 9101
Livermore, CA 94551-0969
510-294-2077
FAX: 510-294-1539

John A. Pensy
HRB Systems
800 International Drive
Linthieum, MD 21090
410-850-7890

Douglas Perkins
Oilton, Inc.
1821 University, Ave., W., Suite 461N
St Paul, MN 55104
612-646-5747
FAX: 612-646-5303

Alex Perry
Alex Perry Associates
50A Addison Road
Melksaam, Wiltshire, Great Britain
011-44-1225790524

Keith Persons
Western Kentucky University
Department of Physics
Bowling Green, KY 42101
502-745-5277
FAX: 502-745-5062

Barry W.Peterman
Ordnance/Explosives Environmental Services, In.
P.O. Box 1703
Gainsville, FL 32602-1703
352-332-3318
FAX: 352-333-6633

Mark Pflaging
CASDE Corporation
1901 N. Beauregard St., #400
Alexandria, VA 22311
703-845-9221
FAX: 703-845-9812

Donald R. Phoenix
Horne Engineering and Environmental Services
2108 Emmorton Park Road, Suite 204
Edgewood, MD 21040
410-761-6200
FAX: 410-671-6206

Lanette Pickeral
Parsons Engineering Science, Inc.
10521 Rosehaven Street
Fairfax, VA 22030
703-591-7575
FAX: 703-591-1305

William T. Piper
U.S. Air Force
4CES/CED
1140 Brooks Street
Seymour Jackson AFB, NC 27534
919-736-5151
FAX: 919-736-5622

Charles Poppe
The Onyx Group Inc.
1199 North Fairfax Street, Suite 600
Alexandria, VA 22314
703-548-6699
FAX: 703-548-4008

Richard Posey
Environmental Chemical Corporation
1240 Bayshore Highway
Burlingame, CA 94010
415-347-1555
FAX: 415-347-4571

John C. Potter
U.S. Army Engineering & Support Center
P.O. Box 1600
Huntsville, AL 35807-4301
205-895-1888
FAX: 205-895-1737

Robert M. Printy
HQ Air Force Civil Engineering Support Agency
139 Barnes Drive
Tyndall AFB, FL 32403-5319
904-283-6410
FAX: 904-283-6383

Gerhard Proksch
MOI-EOD-Austria
Herrengasse 7
P.O. Box 100
A-1014-Vienna, Austria
011-43-1-531-26-2782
FAX: 011-43-1-531-26-2706

Cesar O. Pruneda
Lawrence Livermore National Laboratory
7000 East Ave., L-282
P.O. Box 808
Livermore, CA 94550
510-422-0460
FAX: 510-424-3281

M.R. Pugh
EOD Tech Info Centre,
Lodge Hill Camp
Lodge Hill Lane
Chattenden, Rochester, Me3 8NZ England
011-44-01634-822698
FAX: 011-44-01634-822609

James Reifsnyder
U.S. General Accounting Office
441 G St. NW, Room 4228
Washington, DC 20548
202-512-4166
FAX: 202-512-2501

Christian Reim
SCHIEBEL Instruments, Inc.
2127 California Street, NW, Suite 804
Washington, DC 20008
202-483-8311
FAX: 202-483-8316

William C. Replogle
Sandia National Laboratories
P.O. Box 969, MS 9105
Livermore, CA 94551-0969
510-294-2140
FAX: 510-294-1217

Carol B. Richardson
PRC Environmental Management, Inc.
330 South Executive Drive, Suite 203
Brookfield, WI 53005
414-821-5894
FAX: 414-821-5946

W. Ian Ridley
U.S. Geological Survey
Denver Federal Center
P.O. Box 25046, MS 973
Denver, CO 80225
303-236-5558
FAX: 303-236-3200

Kelly Rigano
USAEC
ATTN: SFIM-AEC-ETP
Aberdeen Proving Ground, MD 21010-5401
410-612-6868
FAX: 410-612-6836

Ed Roberson
Global Environmental Solutions
4100 South 8400 West, Annex 16
Magna, UT 84044
801-251-6527
FAX: 801-251-6254

Richard Robertson
Hughes Associates, Inc.
Overlook Ave., Code 6110
Washington, DC 20375-5342
202-767-3556
FAX: 202-404-8119

Gerard Orlando Robinson
OAO Corporation
10289 Aerospace Road
Lanham, MD 20706
301-306-8964
FAX: 301-306-8966

Tim Ross
Department of the Army
Pueblo Depo Activity
Pueblo, CO 81001-5000
719-549-4547
FAX: 719-549-7318

Derek Ryter
RUST E&I
Number 2 Garden Center, Suite 200
Broomfield, CO 80020
303-469-6660
FAX: 303-469-6665

Jusleen Sabharwal
Environmental Chemical Corporation
1240 Bayshore Highway
Burlingame, CA 94010
415-347-1555
FAX: 415-347-4571

Brain A. Safigan
METRATEK, Inc.
12330 Pinecrest Road
Reston, VA 22091
703-620-9500
FAX: 703-620-9696

Lydia E. Sanchez
DDESB
2461 Eisenhower Ave., Room 856-C
Alexandria, VA 22331-0600
703-325-1373
FAX: 703-325-6227

Mary F. Saras
Brown & Root Environmental
910 Clopper Road
Gaithersburg, MD 20878-1399
301-258-5834
FAX: 301-258-8679

Bill Scarbrough
USAF, 23 CES/CED
802 2nd Street
Pope AFB, NC 28308
910-394-2517
FAX: 910-394-2564

Jeffrey Schley
7th CES CED
Dyess AFB, TX 79607
915-696-4108
FAX: 915-676-4838

William C. Schneck
Night Vision Directorate, Countermine Division
10221 Burbeck Road, Suite 430
Ft. Belvoir, VA 22060-5806
703-704-2446
FAX: 703-704-2432

Martina Schneider
BOWAS - Group
Office Cologne
Schallstr. 14
50931 Koln, Germany
011-49-221-400-9221
FAX: 011-49-221-4000-9331

Wolfgang H. Schwartz
CMS Environmental, Inc.
4904 Eisenhower Blvd., Suite 310
Tampa, FL 33634
813-882-4477
FAX: 813-884-1876

Lisa Scola
PRC Environmental Management, Inc.
200 East Randolph Drive, Suite 4700
Chicago, IL 60601
312-856-8799
FAX: 312-938-0118

Cory E. Scott
Wenck Associates, Inc.
1800 Pioneer Creek Center
P.O. Box 428
Maple Plain, MN 55359-0428
612-479-4261
FAX: 612-479-4242

Earl W. Scroggins
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172
Indian Head, MD 20640-5070
301-743-6850, ext. 276
FAX: 301-743-6947

Debra Marie Scroggins
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172, Code 50A11
Indian Head, MD 20640-5070
301-743-6850, ext. 247
FAX: 301-743-6947

Arthur J. Seaman
PRC Inc.
4481 Indian Head Highway
Indian Head, MD 20640-1905
301-753-9194
FAX: 301-753-9053

Leonard M. Seigel
S.M. Assocates, Inc.
6701 Democracy Blvd., Suite 300
Bethesda, MD 20817
301-571-9389
FAX: 301-434-7435

R.J. Selfridge
Chemrad
739 Emory Valley Road
Oak Ridge, TN 37830
423-481-2511
FAX: 423-483-9528

Edward Seuter
ECI
4923 Americana Drive, Suite 207
Annandale, VA 22003
703-256-1569
FAX: 703-256-0953

Leo B. Shanley, Jr.
Department of the Army
Office of the Dep. Chief of Staff for Logistics
500 Army Pentagon
Washington, DC 20310-0500
703-697-4791
FAX: 703-697-7032

Robert Shokes
SAIC
20 California Street, Suite 400
San Francisco, CA 94111
415-399-0140
FAX: 415-399-0299

Terrell Smith
Lockheed Martin
P.O. Box 1625
Idaho Falls, ID 83415-3953
208-526-5692
FAX: 208-526-9473

Drexel Smith
Wyle Laboratories, Inc.
1841 Hillside Avenue
Norco, CA 91760
909-737-0871, ext. 214
FAX: 909-735-4030

Deborah Levitt Smith
EnSys Environmental Products, Inc.
4222 Emperor Boulevard, Royal Center, Durham NC
P.O. Box14063
Research Triangle Park, NC 27709
919-941-5509
FAX: 919-941-5519

Robert J. Smith
UXB International, Inc.
14800 Conference Center Drive, Suite 100
Chantilly, VA 22021
703-803-8904
FAX: 703-803-9355

Paul D. Smith
LESCO
654 Discovery Drive
Huntsville, AL 35806-2802
205-971-7164
FAX: 205-971-1766

Frank Snelgrove
Geonics Limited
8-1745 Meyerside Drive
Mississauga, Ontario, Canada L5T IC6
905-670-9580
FAX: 905-670-9204

Jerry Snyder
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172, Code 50B22
Indian Head, MD 20640-5070
301-743-6850, ext. 260
FAX: 301-743-6947

Richard Soilleux
Chemical, Biological Defense Establishment
Porton Down
Salisbury, Wiltshire SP4 05Q England
011-44-1980-613-582
FAX: 011-44-1980-611-777

James M. Souby
Western Govermors' Association
600 17th Street, Suite 1705 South Tower
Denver, CO 80202
303-623-9378
FAX: 303-534-7309

Bert H. Spalding
US Army Technical Center for Explosives Safety
1744 Shutter Street
Thomson, IL 61285
815-273-8805
FAX: 815-273-6009

David Sparrow
Institute for Defense Analyses
1801 N. Beauregard Street
Science and Technology Division
Alexandria, VA 22311-1772
703-578-2992
FAX: 703-578-2877

Jonathan Sperka
NAVEODTECHDIV
2008 Stump Neck Road
Bldg. 2172
Indian Head, MD 20640-5070
301-743-6850
FAX: 301-743-6947

Gary Spichiger
Western Kentucky University
Department of Physics
Bowling Green, KY 42101
502-745-5277
FAX: 502-745-5062

Bruce Stalcup
PRC Inc.
1500 PRC Drive, MS 5S3
McLean VA, 22102
703-556-1307
FAX: 703-556-1174

Pat Steranka
Pueblo Depot Activity
Pueblo, CA 81001-5000
719-549-4982
FAX: 719-549-4318

Robert E. Stevens
Morrison Knudsen Corporation
1500 West 3rd Street
Cleveland, OH 44113
216-523-2129
FAX: 216-523-5271

John Stine
Ordnance/Explosives Environmental Services, Inc.
Executive Plaza Office Park
500 Wynn Drive, Suite 504
Huntsville, AL 35816
205-830-4847
FAX: 205-830-4153

Michael Stockert
GP Environmental Services
202 Perry Parkway
Gaithersburg, MD 20877
301-926-6802
FAX: 301-840-1209

Steven P. Stokke
HQ Fort McCoy
2160 South "J" Street
Fort McCoy, WI 54660
608-388-4790
FAX: 608-388-4704

Janet R.Strathman
U.S. Army Defense Ammunition Center and School
ATTN: SIOAC-ASC
Savanna, IL 61074-9639
815-273-8818
FAX: 815-273-8788

Paul Joseph Stratton
ADI
7918 James Branch Drive, Suite 600
McLean, VA 22102
703-918-4948
FAX: 703-821-9251

Chip Street
Hydro-Innovation's, Inc.
5 Harrison Avenue - Buckeye
Mt. Vernon, Oh 43050
614-392-4643
FAX: 614-392-4513

Delbert Summey
Coastal Systems Station. Dahlgren Division
Naval Surface Warfare Center
Panama City, FL
904-234-4472
FAX: 904-234-4133

Jeff Swanson
Colorado Department of Health and Environment
4300 Cherry Creek Drive South
HMWMD-KP-B2
Denver, CO 80222
303-692-3416
FAX: 303-759-5355

Jack C. Swearengen
Sandia National Laboratories
P.O. Box 969, MS 9105
Livermore, CA 94551-0969
510-294-3022
FAX: 510-294-1217

Tanya A. Swiderski
USAEC
Bldg. E4430
Aberdeen Proving Ground, MD 21010-5401
410-612-6862
FAX: 410-612-6836

Robert L. Tarno
Libra Group
P.O. Box 3894
Littleton, CO 80161
303-589-3589

Captain Paul Taylor
Army School of Ammunition
Temple Herdewyke
Leamington Spa, Warwickshire England CV33 OUL
011-44-1-869-257574
FAX: 011-44-1-867-257361

David W.A.Taylor
ENSCO, Inc.
P.O. Box 41107
Greensboro, NC 24704
910-632-1200
FAX: 910-362-1225

Gregory D. Teese
Westinghouse Savannah River Company
Building 773-A, SRTC
Aiken, SC 29808
803-725-2051
FAX: 803-725-7369

Fred Tejan, III
EOD Team, White Sands Missile Range NM
211 Tooele Ave
WSMR, NM 88002
505-678-2035
FAX: 505-678-6228

John Theis
US Army - Industrial Ecology Center
Bldg. 172
Picatinny Arsenal, NJ 07806
201-724-5795
FAX: 201-724-6759

Elizabeth H.Theisen
Human Factors Applications, Inc.
4950 Rt. 202, Building 1, Suite 2
P.O. Box 615
Holicong, PA 18925-0615
215-794-3535
FAX: 215-794-7353

Charles J.Theisen, Jr.
Human Factors Applications, Inc.
4950 Rt. 202, Building 1, Suite 2
P.O. Box 615
Holicong, PA 18925-0615
215-794-3535
FAX: 215-794-7353

Jack L.Thomas
LESCO
654 Discovery Drive
Huntsville, AL 35806-2802
205-971-7165
FAX: 205-971-7166

John T.Thompson
EA Laboratories
5500 Fox Lair Lane
Alpharetta, GA 30201
770-663-9987
FAX: 770-663-8092

Tom Thompson
USA TEU
5101 Hoadley Road
Aberdeen Proving Ground, MD 21010
410-612-8533
FAX: 410-671-3634

Kurt O. Thomsen
PRC Environmental Management, Inc.
200 East Randolph Drive, Suite 4700
Chicago, IL 60601
312-856-8799
FAX: 312-938-0118

Martin Toomajian
Battelle
2012 Tollgate Road, Suite 206
Bel Air, MD 21078
410-569-0200
FAX: 410-569-0588

Timothy J. Tope
Radian International
1093 Commerce Park Drive, Suite 100
Oak Ridge, TN 37830
423-483-9870
FAX: 423-483-9061

Peter Trinkaus
Foerster
140 Industry Drive
Pittsburgh, PA 15275-1028
412-788-8976
FAX: 412-788-8984

Ken L. Tschritter
Sandia National Laboratories
P.O. Box 969, MS 9105
Livermore, CA 94551-0969
510-294-2971
FAX: 510-294-1217

Ken Underwood
Defense Test and Evaluation Organization (DTEO)
Blackgate Road
Shoeburyness, Esses, UK SS3 9SR
011-44-1702-292271, ext. 3252
FAX: 011-44-1702-292868

Ravindra Upadhye
Lawrence Livermore National Laboratory
7000 East Ave., L-282
P.O. Box 808
Livermore, CA 94550
510-423-1229
FAX: 510-424-3281

Martin J. Uram, Jr.
Concept Engineering Group, Inc.
610 William Pitt Way
Pittsburgh, PA 15238
412-826-3191
FAX: 412-826-3193

Philip S.Urban
USAF, 23 CES/CED
802 Second Street
Pope AFB, NC 28308
910-394-2517
FAX: 910-394-2564

Colonel Daniel F. Uyesugi
USAEC
Beal Road
Aberdeen Proving Ground, MD 21010-5401
410-671-2657
FAX: 410-671-3132

Kenneth M. Valder
PRC Environmental Management, Inc.
330 South Executive Drive, Suite #203
Brookfield, WI 53005
414-821-5894
FAX: 414-821-5946

Gerhard Vallon
Vallon GmbH/Security Search
Im Grund 3
D-72800 Eningen, FR Germany
011-49-7121-98550
FAX: 011-49-7121-83643

Lance Vander Zyl
U.S. Army Yuma Proving Ground
1217 South 19th Avenue
Yuma, AZ 85264
520-328-2124
FAX: 520-328-3785

Ton A. Verhoeven
TNO Prins Maurits Laboratory
Lange Kleiweg 137
P.O. Box 45
2280 AA Rijswijk, The Netherlands
011-31-15-284-28-42
FAX: 011-31-15-284-39-61

Roger Vickers
SRI International
333 Ravenswood Ave., Bldg. G
Menlo Park, CA 94025
415-859-4422
FAX: 415-859-5149

Ross Vincent
Military Toxics Project
504 Starlite Drive
Pueblo, CO 81005
719-561-3117
FAX: 719-561-1179

Geroge Vourvopoulos
Western Kentucky University
Department of Physics
Bowling Green, KY 42101
502-745-5277
FAX: 502-745-5062

John T. Waldrip
Utah DEQ
288 North 1460 West
P.O. Box 144880
Salt Lake City, UT 84114-4880
801-538-6814
FAX: 801-538-6715

Michael Walsh
USA CRREL
72 Lyme Road
Hanover, NH 03755
603-646-4100
FAX: 603-646-4720

Captain Walter M. Waltz
Wright Laboratory Air Base Technology Branch
Construction Automation (FIVCF-OL)
Bldg. 9738
Tyndall AFB, FL 32403-5323
904-283-3725
FAX: 904-283-9710

Stephen E. Wampler
Dir. Safety, Health, and Environment
STEAP-SH-ER
Aberdeen Proving Ground, MD 21010-5423
410-671-4843
FAX: 410-671-3010

Ronald Patrick Warren
RSP Inc.
P.O. Box 858
Indian Head, MD 20640
301-753-9751
FAX: 301-743-5965

JoAnn Watson
National Guard Bureau
Bldg. E4430
Aberdeen Proving Ground, MD 21010-5420
410-671-1804
FAX: 410-671-1788

Kenneth Watts
Idaho National Engineering Laboratory
P.O. Box 1625, Mail Stop 3123
Idaho Falls, ID 83401
208-526-9628
FAX: 208-526-2061

LTCOL Ralph Way
Marine Corps Detactment, NAVEODTECHDIV
2008 Stump Neck Road
Indian Head, MD 20640-5098
301-743-6814 or 6815
FAX: 301-743-6970

John H. Weidner
Jet Propulsion Laboratory
4800 Oak Grove Drive (523-3660)
Pasadena, CA 91109-8099
818-306-6429
FAX: 818-306-6912

Chuck Welk
Environmental Chemical Corporation
1240 Bayshore Highway
Burlingame, CA 94010
415-347-1555
FAX: 415-347-4571

Harvey L. Wetzel
PRC Inc.
4481 Indian Head Highway
Indian Head, MD 20640-1905
301-753-9194
FAX: 301-753-9053

Charlie Wharton
Foerster Instruments, Inc.
140 Industry Drive, Ride Park
Pittsburgh, PA 15275-1028
412-788-8976
FAX: 412-788-0437

David M. White
Johns Hopkins University
Applied Physics Laboratory
11100 Johns Hopkins Road
Laurel, MD 20723
301-953-5949
FAX: 301-953-5026

A. James Wilkins
DOE/HAZWRAP
831 Tri-County Blvd.
Oliver Springs, TN 37840
423-435-3459
FAX: 423-435-3271

Major Adrian Wilkinson
Defense Test and Evaluation Organization (DTEO)
Blackgate Road
Shoeburyness, Esses, UK SS3 9SR
011-44-1702-292271, ext. 3252
FAX: 011-44-1702-292868

Eric G.Williams
Harding Lawson Associates
707 17th Street
Denver, CO 80202
303-293-6070
FAX: 303-292-5411

John Wilson
Ogden Environmental and Energy Services
5510 Morehouse Drive
San Diego, CA 92121
619-458-9044
FAX: 619-458-0943

Todd Woerner
AMA Analytical Services
4485 Forbes Blvd.
Lanham, MD 20706
301-459-2640
FAX: 301-459-2643

Jared N.Worstell
U.S. Air Force
1140 Brooks Street
Seymour Johnson AFB, NC 27534
919-736-3151
FAX: 919-736-5622

Colonel Wright
Department of Defense Explosives Safety Board
Hoffman Building
2461 Eisenhower Avenue
Alexandria, VA 22331-0600
703-325-0891
FAX: 703-325-6227

Clifton C. Youmans
Montana Department of Military Affairs
1100 N. Main
P.O. Box 4789
Helena, MT 59604-4789
406-444-7974
FAX: 406-444-6973

Col. George Zahaczewsky
US Pacific Command
Commander and Chief
USCINCPAC, ATTN: J423 Box 64020
Camp H.M. Smith, HI 96861-4020
808-477-2912
FAX: 808-477-0936

Richard J. Wold
Geometrics Inc.
395 Java Drive
Sunnyvale, CA 94089
408-734-4616
FAX: 408-745-6131

Larry Wright
U.S. Army
Pine Bluff Chemical Activity
10020 Kabrich Circle, Bldg. #51-420
Pine Bluff, AR 71602-9500
501-540-2421
FAX: 501-540-2409

Mike Wynn
Naval Surface Warfare Center - Dalhgren Division
Coastal Systems Station. Code 110B
Panama City, FL 32407-7001
904-234-4682
FAX: 904-235-5462

Walter Youngblade
Geomet Technologies, Inc.
20251 Century Blvd.
Germantown, MD 20874
703-642-0535
FAX: 703-642-6228