Report Of The

Defense Science Board

Task Force

ON

UNEXPLODED ORDNANCE (UXO) CLEARANCE, ACTIVE RANGE UXO CLEARANCE, AND EXPLOSIVE ORDNANCE DISPOSAL (EOD) PROGRAMS

April 1998

OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR ACQUISITION & TECHNOLOGY
WASHINGTON, D.C. 20301-3140

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OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE BOARD

24 APR 1998

MEMORANDUM FOR THE UNDER SECRETARY OF DEFENCE (ACQUISITION AND TECHNOLOGY)

SUBJECT: Report of the Defense Science Board (DSB) Task Force on Unexploded Ordnance (UXO) Clearance, Active Range UXO Clearance, and Explosive Ordnance Disposal (EOD) Programs

I am forwarding the final report of the Defense Science Board Task Force on Unexploded Ordnance (UXO) Clearance, Active Range UXO Clearance, and Explosive Ordnance Disposal (EOD) Programs.

This report reviews the UXO related policies, programs, and technologies and identifies key issues facing the Department of Defense in UXO remediation. The Task Force finds that UXO remediation is a costly problem facing the Department of Defense, one for which the Department is not well organized to solve, at present. The Task Force also concludes that, for remediation to be successful, new, cost effective remediation technology must be developed to replace current tools, which are up to 50 years old and are labor intensive.

The Task Force has proposed a set of clear recommendations that can be implemented, without adding bureaucracy or new reporting demands. I endorse their recommendations and propose that you review the Task Force Chairman's letter and report.

Craig Fields
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
3 140 DEFENSE PENTAGON
WASHINGTON, DC 20301-31 40

DEFENSE SCIENCE
BOARD

24 APR 1998

MEMORANDUM FOR CHAIRMAN DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Task Force on Unexploded Ordnance (UXO) Clearance, Active Range UXO Clearance, and Explosive Ordnance Disposal (EOD) Programs

The final report of the Task Force on Unexploded Ordnance (UXO) remediation is attached. This report is focused on the Department's need to clean up unexploded ordnance resulting from decades of military training, exercises, and testing of weapons systems. In particular, there is now considerable interest and activity by Federal, state, and local authorities in UXO remediation at formerly used defense and base closure sites.

The DOD has the responsibility to clean up and render such sites safe. It is estimated that there are some 1500 sites within the continental United States involving perhaps 15 million acres of land. The total expenditures required for clean-up of such sites using current technology and practices could exceed tens of billions of dollars. Today's techniques are labor intensive and very expensive because most of the detections that require excavation turn out to be false alarms. This Task Force sees the need to reallocate the current DOD investment which is now heavily focused on actual remediation operations toward one which for the next few years aggressively pursues R&D to reduce the false alarm rate. We believe that reallocation of those resources planned to be spent by the Department over the coming five years will greatly (by a factor of ten) increase the efficiency of UXO remediation efforts.

The Task Force makes six major recommendations for strengthening the Department's UXO Remediation efforts:

1. To provide a DOD internal and external focal point for UXO objectives, policy, plans, and programs, it is recommended the DUSD (Environmental Security) be assigned that responsibility.

2. To dramatically reduce the cost of cleanup, it is recommended that the Department initiate and fund an aggressive program of research and demonstration, primarily by industry and the universities, to reduce the number of false alarms by about a factor of 10 within the next 3 to 5 years.

3. For DDR&E to formulate and direct such a program using up to 20% of the total DOD UXO cleanup funds. It is not a matter of increasing expenditures on UXO, it is a matter of making better use of available funds'.

4. To provide more visibility, flexibility, balance, and control over commitments and expenditures, it is recommended that OSD accounts for UXO remediation and RDT&E be established.

5. As humanitarian UXO remediation is not a warfighting requirement and as the Department cannot afford the costs of establishing and properly resourcing an organic capacity for this effort, it is recommended that contracting incentives be provided to encourage commercialization of promising technologies and to encourage large as well as small companies to participate in actual UXO remediation efforts.

The Task Force co-sponsor, Director, Strategic and Tactical Systems, has informed me that parallel to the DSB Task Force study, the USD(A&T) established the UXO Center of Excellence (UXOCOE) in May 1997 to function as the DOD focal point for UXO clearance and detection technology, following concerns expressed by Congress and the GAO. USD(A&T) had previously released the "Report to Congress: Unexploded Ordnance Clearance - A Coordinated Approach to Requirements and Technology Development," in March 1997, which surveyed the UXO technologies and requirements and outlined the plan for the UXOCOE. The DOD Directive and Instruction for the UXOCOE are currently staffing at the Principal Staff Assistant level. The UXOCOE mission is to foster the exchange of technical information and ensure the coordination of requirements and technology in the UXO arena within DOD and with other U.S. government and international agencies, academia, and industry.

On behalf of the Task Force members, I wish to thank the Government officials, advisors, and all those who made presentations to us for their contributions.

John Foster Jr.

John S. Foster, Jr.

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1. CHARGE TO THE TASK FORCE

The Undersecretary of Defense for Acquisition and Technology requested the Defense Science Board undertake two separate studies on different aspects of landmines and other unexploded ordnance (UXO). Phase I examined US landmines, land mine detection and demining efforts, and alternatives to anti-personnel mines. This Task Force (Phase II) was charged to "examine UXO remediation, active range UXO clearance, and Explosive Ordnance Disposal (EOD) efforts. Include in this examination, the relationship between the UXO/EOD detection/ characterization/clearance and neutralization issues and landmine detection/neutralization issues addressed in Phase One.

In developing its findings and recommendations, this Task Force was tasked to:

- Review 1) UXO remediation, 2) active range UXO clearance, and 3) EOD programs; including the technologies involved, the applicable policies, the pertinent requirements, and the organizations involved.
- Analyze the technologies, development programs, and systems that may improve 1) UXO remediation, 2) active range UXO clearance, and 3) EOD efforts. Focus on means to make remediation, range clearance and EOD operations cheaper, safer, and/or faster. Give particular emphasis to identifying those technologies that can be rapidly developed and matured for selective initiation of engineering development and/or production. Recommend the combination of technologies, strategies, and doctrines that can best cope with the present UXO remediation, UXO clearance, and EOD challenges.
- Analyze the technologies, development programs, and systems that may minimize or preclude the production of UXO, including self-destruct fuzing and self-neutralizing or degradable explosives. Give particular emphasis to identifying those technologies that can be rapidly developed and matured for selective initiation of engineering development and/or production. Recommend the technologies or combination of technologies that could be incorporated in future munitions programs to render them less likely to produce UXO. Assess current munitions stocks and the potential for retrofitting them with technologies that will render them less likely to produce UXO."

2. EXECUTIVE SUMMARY

Contamination of land and sea from unexploded ordnance has grown to a level where it now presents a serious problem in the United States. The contamination prevents civilian land use, threatens public safety and causes environmental concerns. Estimates provided to the Task Force indicate that over 15 million acres in the United States may contain some level of UXO contamination, at about 1,500 different sites. This figure does not include the acreage of UXO contamination undersea.

Virtually all UXO contamination in the United States results from weapons system testing and/or troop training activities conducted by the Department of Defense (DoD). Property containing UXO includes active military sites and land transferring or transferred to private use, such as Formerly Used Defense Sites (FUDS) and Base Realignment And Closure (BRAC) sites. DoD's responsibilities include providing UXO site clean-up project management, assuring compliance with federal, state and local laws and environmental regulations, assumption of liability, and appropriate interactions with the public.

DOD has no specific UXO remediation policy, goals or program. Current UXO site remediation efforts are based on decades-old technology and use several procedures that are inefficient, labor-intensive and costly. Because the suspect sites have not been surveyed, there is great uncertainty about the actual size of the UXO problem. However, even if only 5% of suspect acreage needs cleanup, remediation costs would still be high (possibly exceeding 15 billion dollars) and times would be long (possibly exceeding several decades to complete) using current technologies. UXO site remediation in the United States currently is being funded at about $125M per year, excluding special clean-up programs (such as the on-going clean-up at Kaho'olawe, which has funding projected to total about $400M).

RESEARCH AND DEVELOPMENT

The key to more efficient UXO remediation lies in the products that can come from an aggressive development of cost effective remediation technology to replace currently fielded tools and practices. The Task Force concludes, however, that DOD is not yet positioned to execute the required technology program. Except for the recent Defense Advanced Research Projects Agency (DARPA) initiatives, DoD's RDT&E base lacks a coherent set of technology requirements specifically designed to support UXO remediation needs. The Services' RDT&E base reflect the warfighting needs of the Military Departments, and the UXO support is incidental. DoD's current UXO related RDT&E effort to develop the needed tools is estimated to be about $20M per year.

CURRENT APPROACH: "MAG AND FLAG"

Normandy 1945

Bosnia 1996

The technologies currently used for sub surface UXO remediation requires walking with metal detection devices, placing a flag at each location of a detection and manually digging up detected objects - traditional "Mag and Flag". These techniques are not cost effective for large areas of land nor feasible for all terrain. Most important, "Mag and Flag" surveys are plagued by excessive false alarm rates. Some sites will have more than 100 subsurface non-ordnance items (clutter) flagged and excavated for each actual ordnance item found and removed. Under normal circumstances UXO remediation costs could be as high as $20,000 per acre. However under emergency situations, the cost could be much higher. (For example, UXO remediation efforts at Spring Valley in Washington, DC, performed between Jan 1993-Jan 1995 under RCRA emergency procedures, cost about $45,000 per acre). Highly cluttered sites may require complete excavation due to the number of false alarms. Of the approximately $125M per year spent on UXO remediation, about $70-80M per year is expended by using such labor-intensive practices.

In the near term, the biggest potential improvement in the detection and discrimination of UXO to depths of three feet or more is expected to come from a special configuration of magnetometers, electromagnetic induction (EMI) and data processing. A magnetometer can measure the change in the earth's magnetic field due to the presence of a nearby object having magnetic permeability. An EM1 detector imposes an external, time-varying magnetic field on the region and detects the effect caused by objects which are electrically conducting (magnetic or nonmagnetic). By using arrays of both instruments, and three axis EM1 drive, in concert with appropriate computer algorithms, and fusion of that information, the operator will be able not only to detect and determine the position of an object, but also determine if it is magnetic, estimate whether it is a single piece or a cluster of pieces, and estimate its aspect ratio (length to width) and orientation. The proper development and application of these technologies is expected to ***reduce the false alarms by about a factor of 10.***

To obtain such a capability, the Task Force recommends a two track approach.

Track 1. The first track calls for the aggressive development and demonstration of a baseline system-of-systems approach to reduce the false alarms by about a factor of 10. In our view, it would be appropriate to conduct a competitive effort by at least two industrial systems integration teams. The development and demonstration efforts are expected to require 3-5 years to achieve the objective and would include demonstration of integrated, ground and aerial precision navigation, aerial survey detections of surface and near surface objects, vehicular and man portable equipment to detect and categorize objects and the appropriate computer architecture, data base and processing algorithms. The Task Force emphasizes contractor integrated, to assure common communications, navigation, data bases, etc. Over the next 3 to 5 years we would expect these activities to average about $20M per year.

Track2. The second track would involve an aggressive research and development effort, running in parallel with the effort described above. The objectives would be to explore some avenues which have received too little attention in the past (e.g., seismic/acoustic, neutron activation, synthetic dog's nose, motion of subsurface objects over time, etc.) and also to conduct research on those pacing elements used in the baseline approach which will benefit from continuing and competitive research, such as the characterization of clutter at different sites, clutter rejection algorithms, design of sensor arrays, etc. The Task Force proposes that this second track be performed largely by universities coupled with industry, and also funded at about $20M per year.

Since the current UXO-related R&D is funded at about $20M per year, the proposed program can be judged as about a two-fold increase. The basic justification for such an increase is that the DOD is spending about $125M per year on UXO remediation using a very inefficient approach. Current understanding of the physics and experimental data to date suggest that by developing the proper tools, DOD will save about $60-70M per year. As such, it would be a good and urgent investment.

Once the baseline program demonstrates the required reduction in the false alarm rate, the Task Force recommends that DOD rely on industry to commercialize the technologies into systems for use in UXO remediation. It will be important to continue the second track activities because of its value to DOD range clearing and countermine operations, specifically the detection of non-metallic landmines and the detection and characterization of more deeply buried objects (5-20 feet).

If DOD is to be successful in introducing major technological improvements, it will be necessary not only to verify the improvements but also to initiate educational and training programs to accomplish two objectives. First, to convince the operational experts that the new systems are safe and can be trusted. And second, to train the operators in the use of the computer and associated software.

EASING FUTURE UXO PROBLEMS

A number of steps should be taken to reduce future deposits of unexploded ordnance and ease its clean-up. For example, the use of navigational and positioning systems can help map UXO locations more precisely, active ranges may employ "fire-finding" instrumentation to accurately track ordnance to impact points during tests, and the development of taggants for ordnance and explosive materials to help identification of specific UXO on-site. Improved data keeping and archiving as well as periodic sweeping at active ranges will also prove very helpful in reducing uncertainties about the type and number of potential UXO on ranges and help prolong the useful life of the range.

The Task Force recommends including "Render Safe Procedures" and "Disposal Procedures" guidance as part of DOD Directive 5000.2R. This action would incorporate these important procedures much earlier than the Milestone III decision point, where they currently begin, and help reduce the number of future UXO.

ORGANIZATION FOR AND EXECUTION OF DOD-WIDE UXO REMEDIATION PROGRAM

The Task Force recommends the following assignments:

- To address DOD'S management responsibilities for UXO, the Task Force recommends the assignment of a focal point within the Office of the Secretary of Defense (OSD) for oversight of UXO remediation activities in the Department of Defense. This focal point would recommend UXO remediation objectives and policy to the Secretary of Defense, formulate an investment strategy for the allocation of resources based upon the expected performance of advanced technology, -promulgate the UXO RDT&E program's priorities (but not set the RDT&E program and budget level), establish goals and requirements, and recommend and support investments in new technology to remedy UXO safety and cost issues. The Task Force believes the Deputy Undersecretary of Defense/Environmental Security (DUSD/ES) is the logical focal point, given its existing responsibilities.
- Current DOD Active Range policy has a number of gaps that need to be filled. These include the inadequate dissemination of some "Top Secret" information to the UXO/EOD community and the cessation of practices that threaten the long term viability of active ranges. The Task Force recommends formation of a DOD-wide Active Range Policy that addresses safety issues, advocates range clean-up initiatives to maintain the long-term viability of the range (e.g. avoids creating areas with permanent UXO contamination), and that improves information management concerning the location and clean-up following the testing/training and emergency drops of "Special Compartmented Ordnance."
- DOD should develop a risk-based priority system, similar to the Relative Risk Site Evaluation Framework for hazardous waste sites, to weigh the many competing UXO needs, based upon explosive risks, other human health risks, ecological concerns, and other pertinent factors, including current and future property use. Such priority determinations should be made in consultation with environmental regulatory agencies and the affected public. The present approach to clean-up varies widely from site to site and does not have clearly established methods for assessing priorities and risks. A two-stage risk management process should be employed, the first stage focusing on immediate responses to UXO risks, and the second designed to provide subsequent responses to risks.

- Many Tribal Lands are Formerly Used Defense Sites (FUDS) and contain substantial amounts of UXO. The Task Force notes that these Lands present an immediate threat to public safety due to insufficient DOD clean-up and lack of tribal government authority to issue land use restrictions. To remedy these immediate safety problems, the Task Force recommends accelerated improvement of UXO remediation efforts on Tribal lands.
- To address the fragmented technology base, the Task Force recommends that the Director, Defense Research and Engineering (DDR&E) develop a DOD-wide RDT&E investment strategy and initiate an aggressive R&D program along the lines of the two track approach described earlier.
- To address technical challenges and RDT&E funding shortfalls, the Task Force recommends establishing a specific UXO RDT&E account controlled by OSD (by Director, Defense Research and Engineering) and coordinated with other related RDT&E efforts. The Task Force suggests funding the increase in this account over the next 3-5 years by using offsets from the total clean-up budget.

Execution of the RDT&E program will occur through the Services and Defense Agencies, in coordination with the Joint UXO Coordinating Office.

OUTSOURCING OF UXO REMEDIATION WORK

As the proposed Range Rule and the new Munitions Rule are implemented, we foresee an increase in the demands for near term remediation. The Task Force is persuaded that UXO remediation is *not now and should not be* a core competence of the DOD. As a consequence it is recommended that incentives be provided to outsource this work to industry. The Task Force believes that it will be necessary for the U.S. Army Corps of Engineers to modify its contracting process for UXO remediation. Current contracting terms tend to discourage the use of new tools (technologies that have not been formally certified by DOD as acceptable for use in the contract). The current use of a time and materials approach does not provide an incentive for efficiency. Strict liability is frequently required of the contractor, creating exposure to long term suits often deemed unacceptable by larger companies. The contracting is generally for small tasks. As a consequence, most of the remediation is performed by Small and Small Disadvantaged Business (8a) set-asides who have no real technology base to offer and very limited technology assets. In summary, the result is a remediation program that does not build or expand present industrial capabilities.

The Task Force recommends that UXO site clean up activities be packaged and outsourced entirely to contractors to achieve more cost effective solutions. Performance-based contracting procedures should be required and the Federal Acquisition Regulations used to relieve private companies of unreasonable third party liability and indemnification burdens. Further contractual arrangements should provide incentives to stimulate industry to invest in and use advanced technology. The objective is to have industry commercialize and apply DOD developed technologies as well as to develop their own proprietary products.

Equally important is the need for *stable* funding. Quarterly funding does not allow the execution of a long-term project, because most work is under the Indefinite Delivery Indefinite Quantity

(IDIQ) concept. This results in needless temporary duty assignments and a significant unnecessary cost in travel.

Future base closures should have full disclosure of any UXO problems, if any, early on, so the public, Congress and the Administration will be aware of any UXO issue and the likely costs for certain land reuse so that property use and transfer plans can be made accordingly.

The Task Force review of UXO (and EOD) technologies currently used at active ranges revealed a dependence on outdated techniques and tools. Improvements are needed in the technology and tools used at these ranges to help ensure better safety of personnel and to maintain long term viability of the ranges.

Scrap material sold to wholesalers has also inadvertently contained UXO. A policy is needed to direct the processing of all scrap material that is potentially contaminated with UXO. Active ranges should have ready access to suitable processing equipment, such as flash furnaces, to process this scrap material.

3. INTRODUCTION AND BACKGROUND

THE UXO PROBLEM: How BIG?

DOD defines "explosive ordnance" as any munition, weapon delivery system, or ordnance item that contains explosives, propellants or chemical agents. For this report, unexploded ordnance (UXO) consists of these same items after they (1) are armed or otherwise prepared for action, (2) are launched, placed, fired, or released in a way that they cause hazards, and (3) remain unexploded through malfunction or otherwise armed.

UXO contamination of land and sea has grown for decades and now presents a serious problem in the United States. The contamination prevents civilian land use, threatens public safety and causes environmental concerns. Estimates provided to the Task Force indicate that over 15 million acres in the United States may contain some level of UXO contamination, on about 1,500 different sites. This figure does not include the acreage of UXO contamination undersea, which may be even larger.

At present, UXO-related injuries in the United States are infrequent. For example, in 1996 CONUS DOD Ranges experienced two injuries and two deaths due to UXO. The situation overseas is much different, however, due to the exposure of large civilian populations to Anti-Personnel Landmines (APL) and UXO contaminated areas. According to the International Red Cross, 2000 people outside the United States are injured or killed every month by landmines. These APL/UXO related casualties demonstrate the dangers inherent to civilian populations when they are exposed to APL/'UXO contaminated land. And some US military peacekeeping and humanitarian operations are conducted in such areas. (Point of clarification: there are definitional distinctions between UXO and Anti-Personnel Landmines. However in the context of this report, UXO related technologies apply across the five functional areas of Countermining, Explosive Ordnance Disposal, Humanitarian De-mining, Active Range Clearance, and Environmental Remediation.)

Most UXO in the United States is the result of weapons system testing and troop training activities conducted by the DOD. Property containing UXO includes active military sites and land transferred to private use, such as Formerly Used Defense Sites (FUDS), and Base Realignment And Closure (BRAC) sites.

As defined in this report, UXO remediation focuses on efforts to clean FUDS and BRAC sites for private use and to maintain the long term viability of active ranges. Remediation efforts also include developing tools and techniques designed to reduce the number of future UXO.

Adding to its inherent complexity, UXO remediation also involves communities and the full range of government, including Federal, State, Tribal, and local agencies.

The increased concern about the UXO situation has been driven largely by base closure activities and the development of the Range and Munitions Rules. Accordingly, the DOD is in the process of enhancing its capabilities to address the situation.

DoD's UXO responsibility includes providing UXO site clean-up project management, assuring compliance with state and local laws and environmental regulations, assumption of liability, and appropriate interactions with the public.

GOVERNMENT ACTIONS

The government has taken a number of recent actions concerning UXO remediation. In the conference report accompanying the National Defense Authorization Act for Fiscal Year 1994, Congress directed DOD to undertake a large scale detection and clearance technology demonstration. An Advanced Technology Demonstration was mandated by Congress and funded for Fiscal Years 1993 and 1994.

Congress also directed the Army to develop technologies for detection, neutralization and removal of mines for Operations Other Than War in the FY 1995 National Defense Authorization Act conference report. The House Committee on National Security cited the need for a central authority to plan, oversee, and coordinate the research, development and acquisition of the technology applicable to area ordnance clearance.

The General Accounting Office (GAO) in its September 1995 report "UNEXPLODED ORDNANCE: A Coordinated Approach to Detection and Clearance Is Needed," recommended that the Secretary of Defense consult with other agencies involved and then develop a plan on how such a multi-agency clearinghouse would work and urged that an executive agent be designated to serve this clearinghouse function.

GAO identified over 20 US organizations that conduct or fund research and development on systems to detect and clear UXO. The Secretary of Defense was directed to prepare a plan to define research and development priorities, program management, and cooperative activities with international programs.

CHANGING PRIORITIES

The military priorities affecting UXO removal have changed dramatically. Historically, UXO removal was required to improve our warfighting capability and training. The primary mission for traditional Explosive Ordnance Disposal (EOD) is to support the tempo of traditional military operations. This EOD focus is on point-removal of explosive hazards (e.g. dud fired conventional munitions). In those cases where area clearance is needed (such as in ammunition storage areas after a detonation) normally only a surface clearance is performed.

Today, the importance of UXO has been greatly expanded by the emergence of Operations Other than Warfare (OOTW), peacekeeping and other non-traditional missions as primary tasks of US forces. Correct handling of UXO now is a **key** to effectiveness in these new military operations.

UXO IS NOT MILITARY EXPLOSIVE ORDNANCE DISPOSAL OR COUNTERMINE

Currently, UXO remediation is handled as if it were an Explosive Ordnance Disposal (EOD) problem, largely because the EOD community is the closest matching resource presently available for UXO remediation. But major differences exist between UXO remediation and the traditional Explosive Ordnance Disposal (or Countermine) communities in the Department of

Defense. These differences must be understood to effectively address the UXO remediation problem.

UXO remediation involves a complex set of tools, skills, personnel, training and requirements. The ultimate goal of UXO remediation is to permit safe public use of contaminated lands – a problem that requires tools and skills capable of detecting and removing deeply buried UXO (down to 20 feet or more) with high confidence. Required skills will include knowledge of ordnance recognition, computer and associated software, precise mapping, sub-surface geo-physical methods of detection and characterization, Occupational Safety and Health Administration safety training, explosives handling, blaster skills and data management. UXO remediation also requires the expertise to handle complex legal, policy and safety problems involved when transferring UXO sites to private use. UXO remediation efforts could employ EOD-style surface clearance tools, but only as a first step in the full remediation of a site.

Conversely, Explosive Ordnance Disposal/Countermine (EOD/CM) efforts are military missions designed to clear UXO and mines in support of combat operations. Countermine efforts focus on minefield breaching, while EOD efforts normally focus on clearance of UXO on the surface or near surface (but can involve the recovery of test ordnance at ranges). Unlike UXO remediation of sites, which may be studied in-depth by clean-up crews, EOD/CM areas typically must be cleared quickly to support combat operations. Typical non-combat EOD mission involves the elimination of an immediate threat from explosive ordnance to life or property in an emergency response role. EOD/CM operations, skills, tools and methods therefore focus on speed, work to clear a pathway through the area, generally avoid subsurface UXO and do not involve the complex issues associated with past or current land transfer.

ACTIVE RANGE CLEARANCE IS ALSO DIFFERENT

The requirements and practices for UXO clearance at active ranges are different from those for environmental UXO remediation or combat explosive ordnance disposal. Active range clearance is usually surface clean-up, without the urgency of countermine operations. But there are also requirements and additional hazards in the recovery of experimental ordnance, sometimes deeply buried, for which there may be limited descriptions or documentation. Clean-up at active ranges by EOD units also provides training in EOD operations for these units.

PROPOSED RANGE RULE REQUIREMENTS/PROCESS

The Proposed Range Rule, which has been signed by the Office of Management and Budget and appeared in the Federal Register for public comment on September 26, 1997, is a DOD originated, interagency-coordinated document that will set forth a process for evaluating appropriate responses/actions on closed, transferring, and transferred ranges. Closed ranges are on active installations while transferring ranges are in a BRAC status. Transferred ranges are those in the FUDS program.

The Proposed Range Rule process involves five phases through close out.

Phase 1: Inventory the sites

Phase 2: Assess and determine accelerated response needs
Phase 3: Evaluate and take site-specific action
Phase 4: Recurring reviews (includes options for protective processes and monitoring)
Phase 5: Close out

The Task Force wishes to emphasize the importance to DOD of prompt implementation of the proposed Range Rule, especially for the Phase I inventory of sites. It is important for DOD to quickly identify and characterize the universe of UXO sites, and to research, develop and update realistic working estimates of the cost of clearance or other forms of response consistent with anticipated reuse.

MUNITIONS RULE

The military Munitions Rule was signed and released by the Environmental Protection Agency (EPA) on February 3, 1997. The rule became effective on August 12, 1997, The Rule is the culmination of a major effort by the Federal Government (particularly EPA and DoD), States, Tribes and other interest groups. It was developed in response to a Congressional mandate in the Federal Facility Compliance Act.

Several aspects of the Munitions Rule are of particular importance to UXO clean-up. It defines when munitions are waste. This triggers the legal requirements which result in additional administrative actions regarding reporting, storage and disposal which generally increases management costs. It also provides for conditional exemption for storage and transportation of military munitions. Additionally, the Rule codifies long-standing EPA exemptions for emergency response activities involving munitions and explosives. The Rule excludes active and inactive ranges from most Resource Conservation Recovery Act (RCRA) requirements.

It is expected that the Range Rule will be in effect by fall of 1998. Once the Range Rule is promulgated, EPA is expected to modify the Munitions Rule to defer to the Range Rule's requirements for UXO remediation.

4. FINDINGS AND RECOMMENDATIONS REGARDING UXO REMEDIATION

A. Policy

FINDINGS

A review of current policy shows that DOD has no specific UXO remediation policy or program as it is all subsumed in the DOD Environmental Restoration Program DOD1 4715.7. In fact, UXO is not even mentioned in that document. While, there is no uniform DOD UXO Remediation Policy to guide all affected DOD components, DOD Directive 6055.9 does provide specific safety and restoration clean-up standards for all DoD lands to include Formerly Used Defense Sites (FUDS) activities

As a result, there are no specific DOD-wide UXO clean-up goals, objectives, or management plans. Consequently, UXO remediation decisions today are made within the individual Services, where UXO remediation requirements are forced to compete against traditional warfighting and toxic waste clean-up requirements. In the current period of declining budgets, this competition has resulted in UXO efforts being relegated to "housekeeping duties" at the activity or installation level.

There are a number of deleterious consequences of this lack of policy guidance regarding UXO management of training and test ranges which puts the long-term viability of those sites at risk - a problem of particular importance to active test ranges.

Many Tribal Lands are FUDS and today still contain substantial amounts of UXO. The Task Force notes that these lands currently are used for private activities, such as farming, and present an immediate public UXO hazard due to insufficient DOD clean-up and the lack of tribal government authority to issue land-use restrictions.

RECOMMENDATIONS

To address DoD's unmet management responsibilities in UXO, the Task Force recommends the establishment of an OSD focal point for oversight of UXO activities in the Department of Defense.

This focal point would recommend UXO remediation objectives and policy to the Secretary of Defense, formulate an investment strategy that sets the expenditure of resources on remediation (based upon the DDR&E's estimate of the performance to be gained from the application of advanced technology), promulgate the UXO RDT&E program's priorities (but doesn't set the RDT&E program or budget), establish goals and requirements, and recommend and support investments in new technology to remedy UXO safety and cost issues.

The Task Force believes the Office of the Deputy Undersecretary of Defense/Environmental Security is a logical focal point for several reasons. First, because of its long experience in working/partnering with the private sector as well as environmental regulatory agencies, the

Environmental Security Office is well equipped to promote private sector investment, transfer scientific knowledge and technology to the private sector, and win regulatory acceptance/ support.

Second, as DoD's front line in facing communities concerned about environmental and public safety hazards, environmental security is likely to emphasize those aspects of ordnance response technology that are unique to this mission. For example, environmental UXO response requires attention to subsurface UXO.

Third, to leverage DOD investment in technology in related mission areas, as well as share the fruits of environmental UXO research and development, there needs to -be a focal point in Environmental Security. The Task Force notes the Department's recent decision to improve and coordinate such activity. We believe that the entire effort will benefit from the creation of an office within DUSD(ES) to lead OSD's UXO response.

The Task Force recommends that the DUSD(ES) take the policy lead for DOD UXO remediation efforts, in coordination with other relevant DOD components.

DUSD(ES) should:

Identify the needed Congressional actions that will drive UXO requirements for an improved DOD program, including the likely FUDS/BRAC sites with high congressional priority and those closed ranges that should be converted to more productive uses. To date, neither DOD nor the private sector fully appreciate the magnitude of UXO remediation. Therefore, we recommend the establishment of a closed range UXO remediation line item in the Environmental Security budget. This line item will offer the DOD and Congress the opportunity to determine the proper level of effort for UXO response; it will provide the information that both the DOD and the private sector need in order to develop plans for investment of technology, personnel, and other resources appropriate to the clean-up task; and it will make it easier to apply relative risk principles to the allocation of UXO project money without comparison to totally different kinds of risks. The OSD-managed Program Element would be managed by DUSD(ES), executed by Services/Agencies (or Executive Agent designation) and help ensure transition funding in out years.

Provide recommendations to Congress concerning appropriate clean-up budgets based on a DOD UXO remediation plan:

- Develop a two-stage risk management process.
- Use clean-up budgets as the market incentive to attract industry.
- Provide the needed interface between industry and in-house DOD efforts.

Develop a risk-based priority system, similar to the Relative Risk Site Evaluation Framework for hazardous waste sites, to weigh the many competing UXO needs, based upon explosive risks, other human health risks, ecological concerns, and other pertinent factors, including current and future property use. Such priority determinations should be made in consultation with environmental regulatory agencies and the affected public. The present approach to clean-up varies widely from site to site and does not have clearly established methods for assessing priorities and risks. A two-stage risk management process should be employed, the first stage

focusing on immediate responses to UXO risks, and the second designed to provide subsequent responses to risks.

Accelerate the improvement of UXO remediation efforts on Tribal lands. Many Tribal Lands are Formerly Used Defense Sites (FUDS) and contain substantial amounts of UXO. The Task Force notes that these Lands present an immediate public UXO threat due to insufficient DOD clean-up and lack of Tribal government land use restrictions.

Create a DOD-wide Active Range Policy that ensures the safety of people, directs the use of UXO practices that maintain the long-term viability of the range (e.g. avoids creating areas with permanent UXO contamination), and that improves information management concerning the clean-up from activities involving the expenditure of "Special Compartmented Ordnance." Current DOD Active Range policy has a number of gaps that need to be filled. Some major gaps include the inadequate dissemination of "Special Compartmented Information" i.e., "Top Secret," to the UXO/EOD community and the continuation of practices that may threaten the long term viability of the active range.

Tasks in managing UXO remediation are:

- Prepare a site master plan that establishes the end state for each location that is identified for cleanup, including what should be left in place and what should be cleaned to an agreed upon level to accommodate future land use.
- Identify, evaluate and, where appropriate, remediate the threat from UXO.
- Ensure that "lessons learned" are spread throughout all remediation communities.
- Ensure immediate action to remove imminent threats to public safety.

Risk management strategies are needed to handle the widespread presence of unmapped UXO in areas where members of the public are (or may be) exposed to serious explosive hazards.- While many locations will require facility-specific plans, we believe that the general approach should be to divide responses into at least two stages.

The immediate goal must be to eliminate potential public exposure to UXO. This may be accomplished through surface clearance, physical controls such as fences, and/or legal restrictions (on digging, for example). In areas where subsurface UXO is known to migrate to the surface, these responses must receive periodic maintenance.

Because current remediation capabilities are so inefficient, they should be used primarily on relatively small areas containing surface or near surface, ferrous-based UXO. However, currently there is no safe, reliable, cost-effective method for clearing large areas of subsurface UXO, despite the fact that the intended use of some properties clearly requires large scale, subsurface remediation.

In many areas, current clean-up capabilities cannot render sites safe for their intended reuse. Rather than rush to clear these large areas with current tools, DOD should make it clear that it will conduct an aggressive R&D effort to develop more efficient tools and practices for the more thorough and efficient remediation of the sites within a few years.

Future base closures should have full disclosure of UXO problems, if any, early on, so the public, Congress and the Administration will be well aware of any UXO issue and likely costs for certain land reuse and so that property use and transfer plans can be made accordingly.

Scrap range material sold to wholesalers has also inadvertently contained UXO. A policy is needed regarding the processing of all scrap material that is potentially contaminated with UXO. Active ranges should have ready access to suitable processing equipment, such as flash furnaces, to process scrap material. A full discussion of these issues may be found in the Report from the Office of the Inspector General "Evaluation of the Disposal of Munitions Items," dated September 5, 1997.

To date, neither DOD nor the private sector fully appreciates the magnitude of UXO remediation. Therefore, we recommend the establishment of an OSD account for remediation and one for RDT&E. These line items will offer the DOD and Congress the opportunity to determine the proper level of effort for UXO response; it will provide the information that both the DOD and the private sector need to develop plans for investment of technology, personnel, and other resources appropriate to the clean-up task; and it will make it easier to apply relative risk principles to the allocation of UXO project money without comparison to totally different kinds of risks. The OSD-managed Program Element would be managed by DUSD(ES), responsive to the DDR&E UXO RDT&E plans and programs and executed by Services/Agencies (or Executive Agent designation) and help ensure transition funding in out years.

B. DOD UXO Remediation Requirements

FINDINGS

UXO remediation is generally performed by private sector companies under contract to the government. Typically these are time and material contracts designed for Response Action Requirements as opposed to long-term projects. The guidelines describing their UXO effort largely is found in addenda to government contracts, such as Work Plans. There does not appear to have been a rigorous analysis of UXO remediation tasks. As a result, there is no documentation of the areas with the highest potential payoff for the benefits of technology to be applied.

DOD recently has undertaken several initiatives with the objective of addressing the requirements issue. The first is an in-house effort to develop specific requirements. This effort is closely linked to the ad hoc oversight organization DOD put into place to tie together all the related mission areas dealing with removing UXO contamination from the ground (Counter-mine, EOD Ordnance Disposal, Humanitarian Demining, Active Range Clearance and Environmental Remediation). These efforts are too recent to have yielded measurable results and it's too early to predict their overall contribution to solving the problems.

The lack of formal UXO requirements creates problems involving processes and procedures. An example of such a problem involves the current practice of military aircraft being permitted to drop live ordnance in designated areas (such as military test ranges) during flight emergencies. While current practice permits dropping the ordnance, it does not require sufficiently detailed reporting to operators of the range regarding what and where ordnance was dropped. This means that because of such activities, test ranges may have substantial amounts of UXO that is of unknown type or quantity. In this example, a requirement to provide a timely report on such emergency actions to the appropriate authority is needed.

RECOMMENDATIONS

UXO remediation will compete with other DOD requirements in the annual budget cycle. In order to best use the resources allocated to the UXO remediation efforts, every effort must be made to eliminate the ad hoc approach to UXO rernediation and establish organizational structures and priorities that allow UXO remediation to be accomplished in a safe and timely manner. The Task Force recommends that the DUSD(ES) coordinate the development of a Requirements Document which defines and codifies LJXO remediation missions and tasks, and to also:

- Write, staff, approve and publish materiel requirements documents;
- Define an investment and acquisition strategy (DDR&E to provide the RDT&E portion);
- Designate and define roles and responsibilities;
- Establish an unbiased materiel tester to evaluate results of the R&D program;
- Publish and periodically update the UXO remediation materiel acquisition Master Plan (roadmap showing short-, mid-, and long-term strategy);
- Provide a constant flow of funds to contractors, to maximize planning and staffing on a project basis.

C. Technology

FINDINGS

The technology and practices currently used in the field have not changed dramatically over the last several decades They generally consist of a hand held magnetometer that detects where the earth's magnetic field is distorted by the presence of a nearby object having magnetic properties (e.g. piece of iron). Each time a detection is made, the operator places a flag at the location. At some sites it may be necessary to place flags every five or ten feet and at other sites the flags might be separated by hundreds of feet. Subsequently, operators with a magnetometer and shovel return to each flag and manually dig in the ground to recover the detected object. This is the "Mag and Flag" process.

Current sensor technology "finds" far more "objects" than pieces of ordnance (i.e. the clutter generates false alarms). False alarms greatly increase target removal costs, since each false alarm must be treated (excavated) as actual ordnance.

According to econometric models developed by the Naval Explosive Ordnance Disposal Technology Center, excavation costs for each UXO target will range between $35 - $450, depending upon the nature of the terrain, the type of ordnance being removed and whether mechanical or manual excavation techniques are employed. Using current tools and techniques, Under normal circumstances UXO remediation costs could be as high as $20,000 per acre. However under emergency situations, the cost could be much higher. (For example, UXO remediation efforts at Spring Valley in Washington, DC, performed between Jan 1993-Jan 1995 under RCRA emergency procedures, cost about $45,000 per acre).

Because the suspect sites have not been surveyed, there is great uncertainty about the actual size of the UXO problem. However, even if only 5% of suspect acreage needs cleanup, remediation costs would still be high (possibly exceeding 15 billion dollars) and times would be long (possibly taking over several decades to complete) using current technologies. UXO site remediation in the United States currently is being funded at about $125M per year, exclusive of special clean-up programs (such as Kaho'olawe at $400M, based upon projected Senate action, and Mare Island, CA at $1 OM). Of the $125M/per year we estimate that labor accounts for about $70-80M per year which could be reduced dramatically. These estimates are based on currently used sensors, typical remediation costs, and do not include surface clearance or UXO disposal costs.

Until the last several years, improvements in the remediation of UXO relied mainly on products coming from research and development that targeted EOD and Counter-mine needs. While EOD/Countermine R&D amounts to some $26M per year, in our judgment, the portion applicable to UXO remediation has averaged about $3-6M per year. This funding cannot provide a major improvement to our UXO remediation effort anytime soon.

The recent interest in UXO remediation has stimulated a number of different R&D efforts related to UXO. We estimate the total current UXO related effort now to be $15-20M per year, with the increase being largely due to the DARPA programs. However, the program still lacks overall technical leadership of objectives, investment strategy, directed funding, and coordinated management. The result is a mixed bag:

- The DARPA program on characterization of the clutter by various sensors and processing of data is exemplary and long overdue, as is its research to develop an "artificial dog's nose" to detect the presence of high explosive.
- Analysis of the UXO technology by the Institute for Defense Analyses is well done.
- The recent OSD-directed establishment of small research contracts with universities on several relevant topics is an important step in the right direction.
- The navigation experiments using differential GPS have demonstrated that the necessary precision can be obtained.
- Recent tests on arrays of magnetometers and electromagnetic induction sensors (EMI) demonstrate the capability to detect and discriminate some objects at useful depths, and

with reasonable extensions, offer the possibility to provide data which can be processed and fused to provide estimations of their location, material properties, shape and orientation.

However:

- Much of the in-house laboratory activity is subcritical, institutionalized and not likely to produce the necessary capability in industry.
- Recent tests of off-the-shelf commercial products have demonstrated marginal improvements but are far short of what is needed.
- There has been too little attention given to some techniques which may provide capabilities important for particular sites (acoustic/seismic for deeply buried objects, fast and thermal neutron activation for detection of high explosives, advanced removal techniques, the migration of underground objects over time, etc.)

Despite the limitations of the current R&D program, there is enough scientific understanding and experimental data to convince the Task Force that an aggressive and well managed program could demonstrate dramatic improvements in cost effectiveness within the next few years. The pacing element is the need to reduce false alarms. From our discussion with many researchers, we conclude that a properly structured and funded RDT&E program executed by the nation's best performers could reasonably lead to a reduction of false alarms by about a factor of 10 in 3-5 years Such an improvement would apply particularly to UXO sites heavily cluttered in the past by human activity and thus cost so much to clean up.

This field of investigation is not "idea" limited. What is needed is an aggressive research and development program to demonstrate an integrated system-of-systems capability, involving precision navigation, communications, new sensors and associated algorithms and fusion of information, to provide discrimination of UXO from other objects.

R&D RECOMMENDATIONS

The Task Force recommends that the Department set as an objective the demonstration of a reduction in the false alarms by about a factor of ten within 3-5 years. To do so, the Task Force recommends a two-track approach:

Track 1. *To provide a baseline capability, conduct an aggressive, competitive industrial development and demonstration program to provide a contractor integrated system-of-systems capability with about a ten fold reduction in the number of false alarms. Because the contaminated sites differ from one another, it will be necessary to provide different combinations of systems to produce the necessary improvement. But whatever combination is chosen to work a particular site, the combination must be integrated and perform as a system.*

For example, the Task Force suspects that following a review of the historical use of a site, the competitive program would have produced a capability to perform an efficient site survey using helicopter or fixed wing aircraft employing Radar and/or infrared detectors of surface and near surface objects. The location of each object would be entered into a common database to an

accuracy of l-3 feet. Appropriate components to provide such a capability have already been demonstrated individually.

Following examination and clean-up of surface objects, the program would also have demonstrated a capability to detect and estimate the characteristics (classification) of underground objects to a depth of at least three feet. Some elements of such a capability already have been demonstrated but major advances are required in the sensors, associated processing and fusion algorithms. Subsequently, advanced techniques would be used for excavations.

The Task Force expects that the required improvements will come from the use of:

- Stabilized or periodically stationary platforms.
- Precise navigation of sensor positions.
- Total field magnetometers, to detect magnetic objects, their location and depth.
- Electromagnetic induction (EMI) sensors with orthogonal transmit coils and digitally controlled waveforms to detect electrically conducting objects and estimate their location, depth, material, length-to-width ratio and orientation.
- Integrated processing to alert and inform the operator as to the target position, depth, magnetic properties and estimates of target size and orientation.

The effectiveness of such a system will depend on the quality of the processing algorithms and especially the calibration of the systems against the clutter and expected ordnance at each site.

While it seems relatively straightforward to deploy such a system-of-systems on a wheeled vehicle, it will be more difficult and may take longer, to provide comparable capability in the man portable system which must be used where vehicle passage is too restricted.

It is estimated that the competitive development and demonstration of such a capability will require about $20M per year for three to five years.

Track 2. *Conduct, in paraIIe1 with the baseline program, a longer range research program to explore the value and limits of approaches that are not chosen for the baseline program and, in addition, to provide an additional, separate, and competitive supporting effort on the most pacing aspects of the baseline program.*

Examples of such activities are: seismic/acoustic detection for the deeper objects, neutron activation and chemical sensing for high explosives ("artificial dog's nose") the migration of buried objects over time, the characterization and discrimination of clutter, sensor specific algorithms, data fusion, advanced excavation techniques etc.

Surface clearance often requires intrusive activity, such as the removal of vegetation. Subsurface clearance, by definition, disturbs the land. To limit the environmental damage of .remediation, it is important to develop sustainable approaches. For example, at Fort Ord — where fire is part of the natural ecosystem — the Army and Department of the Interior have developed a plan for controlled burns to support clearance. In other areas, remediation may be planned to avoid disturbance of sensitive animal populations. For this reason, the remediation technology program should support ecological research to improve the coordination of conservationlresource management and clearance activity.

It is estimated that the Track 2 investigations should also be funded at about $20M per year for the foreseeable future.

The Task Force recognizes that such an aggressive program will require professional focused management and the support of the Congress. An incremental investment of $20M per year over the next 3-5 years represents about a two-fold increase over the present funding. However, remediation efforts currently expend about $125M per year, of which we estimate that $70-80 M is labor intensive. If a ten fold reduction in false alarms is achieved, $60-70 M/year can be saved. Thus the Task Force recommends that the incremental funds to support an aggressive R&D program be provided from offsets to the total UXO clean-up program.

It should be understood that for several decades we have depended on the "Mag and Flag" equipment, procedures and training to remediate UXO contaminated sites. And although these are always potentially hazardous operations, the operators have developed the necessary understanding, confidence and trust in their equipment and procedures. The Task Force is persuaded that even afier new equipment, software and procedures demonstrate about a ten fold reduction in false alarms, a special effort will be required to convince clean-up crews to trust the new equipment and procedures.

To reduce future UXO remediation problems, achieving the lower "dud" rate also should be a requirement when new munitions are developed. A program to examine the capability of self-destruction or self-deactivization fuzing should be initiated in all conventional munitions as a step to reduce duds and subsequent remediation costs.

Specific improvements that should be pursued include development of tags for ordnance that can withstand environmental degradation (and still identify the location or type of UXO), development of self-destructing ordnance to reduce the UXO problem, improvement of the collection and management of site use data, expanding the use of ordnance in-flight tracking systems ("fire finders") to locate impact areas, and better overall documentation and instrumentation of UXO clean-up efforts.

Test ranges must have ongoing remediation programs (not just traditional EOD clearance) to . extend their productivity and decrease the need for the acquisition of new ranges.

The Task Force review of UXO (and EOD) technologies currently used at active ranges discovered a dependence on outdated techniques and tools. Improvements are needed in the technology and tools used at these ranges to help ensure better safety of personnel and to maintain long term viability of the ranges. There should be an emphasis placed on disposal techniques and the availability of processing equipment such as flash furnaces, etc.

D. Program Management

RECOMMENDATIONS FOR THE DIRECTOR, DEFENSE RESEARCH AND ENGINEERING

To initiate an aggressive and effective program, and to better maintain the organizational connectivity between Acquisition and RDT&E, the Task Force recommends that DDR&E develop DOD-wide objectives, RDT&E strategy, plans and programs that emphasize the discovery, demonstration and exploitation of much more efficient methods of detection, classification, removal and safing of UXO's. This must be coordinated across service lines and provide sufficient funding to meet the near term challenges and the long term interests of public safety. The major focus of DoD's R&D program over the coming 3-5 years is to achieve significant out year savings in the Department's UXO remediation efforts.

To ensure program success, stable but flexible funding is required. The funding must be stable to enable the technology efforts to mature, but flexible enough to pursue aggressively highly promising programs as they become evident.

CURRENT MUNITIONS/RDT&E FINDINGS

The Task Force learned that some types of munitions (e.g. submunitions) have rates as high as 10%. We suspect that when the cost of clean-up is included in the life cycle cost it may be appropriate to lower the allowable dud rates.

The DOD 5160.62 (a regulation on operation of the EOD training and technology program) requires munitions Project Managers (PM's) to provide data and hardware to the EOD community (EODTECHDIV) for development of Render Safe Procedures (RSP) and Disposal Procedures (DP) at the Milestone III (Production) decision point. Under these guidelines, an approved RSP/DP will be available when the Service makes the formal decision for Materiel Release, about two years after the Milestone III decision. Interim RSP will be available during the entire RDT&E process, if munitions items are transported and the potential for an accident exists. Ideally, the EOD community should be involved in the entire RDT&E process to ensure the designers consider the requirement for a RSP/DP. Practically, EOD considerations are not included in the munitions design process.

The Milestone III decision point is too late to formally start development of a RSP/DP. At Milestone III, production dollars are committed for the initial production quantities. Any design changes after Milestone III will be minor to accommodate production processes. At this point, the munition has been "Type Classified" or "Accepted for Service Use" and the Technical Data Package (TDP) is fixed; changes to accommodate an EOD requirement are very high in cost and virtually impossible.

The requirements for the RSP/DP are found in the DOD Directive which establishes responsibilities for EOD technology and training. There is no guidance on the need to consider and incorporate an EOD RSP/DP in the capstone DOD acquisition directive DOD 5000.2R. Such guidance needs to be included in this directive.

RECOMMENDATIONS

Make the development of EOD RSP/DP a consideration from the start of a munitions design and have EOD represented at all design reviews. EOD requirements must be formally included in the design process, otherwise it is entirely possible an EOD procedure will be imposed at the expense of safety or workability simply because it was not considered earlier in the design. Making the requirement for a final EOD RSP/DP a part of the type classification package will ensure consideration during design. Placing this in the DOD materiel acquisition guidance will institutionalize the requirement beyond the EOD community.

CONTRACTING: FINDINGS

The Task Force is persuaded that humanitarian UXO clean-up is not and does not need to be a DOD core competence. The Task Force contends that the fiscal reality is that the Department cannot afford the costs of establishing and properly resourcing an organic capacity for this effort nor is this a warfighting requirement . We believe that invigorating private sector involvement in UXO remediation is critical to the success of the DOD UXO clean-up effort. But to encourage private sector participation, a UXO remediation "market" must first be more evident. The Task Force recognizes that the DOD must sustain a core competency in countermining and explosive ordnance disposal (EOD) which are tactical missions narrower in scope than broad area UXO clearance .

In the absence of a well-defined DOD program, Congressional actions heavily influence the UXO remediation market. Such actions have usually focused upon specific FUDS, BRAC sites, and other situations of Congressional interest..

UXO remediation necessitates a vigorous, continuing dialogue among numerous federal agencies, state, local and tribal governments, local communities and civic groups. DOD must achieve an effective level of communication and interaction with all entities in this dialogue.

Past and current UXO projects procured by the US Army Corps of Engineers, US Navy and others generally do not offer the contractor indemnification or relief from third party liability. While insurance can be purchased within specific limits, it is expensive and costs are passed back to the government (which is already self-insured).

Even with added insurance, larger companies are reluctant to accept undefined third party liability. Large firms see themselves potentially as "deep pocket" targets. (At least one major firm declined to bid the Kaho'olawe clean-up project specifically because of the indemnification/third party liability issue). Smaller firms have accepted third party liability and contracts without indemnification, in part because they have far fewer assets at risk.

The Government develops and/or approves all requirements, specifications, work plans and procedures. Technology and project methodology is either directed by the government or defaulted to "current best technology". Ongoing quality control is performed by the contractor and repeated by the government. Because of this contracting approach, it would seem the government has assumed continuing responsibility.

Current Federal Acquisition Regulations offer indemnification and relief from third party liability, however the contracting offices are not encouraged to use them. To the larger

companies, the indemnification and third party liability issue is potent enough to discourage participation in UXO projects. This tends to limit participation to smaller firms with limited resources and technology development capability.

Most of the contracts issued are time and materials IDIQ for Response Actions, which are typically single small jobs (or level of effort projects) that may be attractive to the small firms, but not the larger ones. As a consequence, the larger firms have little incentive to invest in advanced technology or to bring to bear their considerable capability in management systems engineering and integration. Larger sites should be treated as "Projects" and managed with a semi-permanent staff.

RECOMMENDATIONS

To effectively include the use of integration contractors, and to encourage the development and use of advanced capabilities, current contracting procedures must change.

The Task Force recommends employing performance/objective/criteria-based contracting procedures that provide incentives to the private sector to participate more efficiently and aggressively in UXO clean-up effort.

The Federal Acquisition Regulations should also be used to relieve private companies of unreasonable third party liability and indemnification burdens.

Develop a contractual remediation plan that requires the clean-up of several appropriate sites and encourages the participation of larger contractors and economies from their management and integration capabilities.

The US Army Corps of Engineers should modify its contracting process to provide incentives to deploy advanced technology as it becomes available. The use of IDIQ's should be reserved for Response Actions only. Sites should be handled as "Projects" with a constant flow of funds.

Develop a baseline standard of performance metrics to measure cost and quality, applicable to all instruments and processes. This would become the unit of measure for judgiug the acceptability of new technologies and improvements to existing methods. Furthermore, a standard for UXO clean-up should be implemented so technology developers work with one set of rules.

UXO remediation is a potentially life threatening task that uses technology largely unchanged over the past 50 years. DOD must play a leading role in training and proving to UXO clean-up crews that new systems (and their associated procedures) are safe and effective.

PERSONNEL: FINDINGS

The Task Force concludes that existing tools, methods, and training for uniformed EOD personnel are insufficient to fully address the total scope of the UXO problem. EOD has become a center of mass for this within the DOD, yet this is more a default practice than an actual solution. The private sector presently relies upon retired EOD personnel for the supervisory skills necessary for site remediation. (This reliance is driven by DOD contractual requirements.) The reality appears to be that military EOD experience, coupled with on-the-job training in the private sector, provide the necessary skills required for large scale UXO clearance. Unfortunately, recent statistics indicate that only about 30-40 EOD personnel per year enter the UXO business arena after retirement.

RECOMMENDATIONS

The Task Force makes the following recommendations concerning personnel to support UXO remediation efforts:

- Support and provide incentives for the expansion of industrial capabilities and capacity for UXO remediation.
- Encourage and support, as appropriate, private/public based non-DOD training. This support should include related publications, lesson plans and training aides as may be available within the DOD and other Federal agencies.

E. Public Involvement

FINDINGS

Public involvement is required for environmental projects within the DOD, including UXO remediation projects. A primary element of the public involvement program is the Restoration Advisory Board (RAB) which is established for each geographical area.

Public involvement is far broader than "Public Information" because it includes inviting the public to participate and often "approve", not just to be informed. The threat of explosions injuring civilians often prompts a justifiable emotional response by members of the public.

State and Tribe regulators have a significant impact on the success of the project because they apply exposure scenarios based upon "reasonably anticipated land use" and establish the acceptable levels of clearance/clean-up criteria. They also inherit any future problems. The continuing debate over the "Munitions Rules" and the "Range Rule" is evidence of the lack of agreement between the State regulators and the DOD. State and tribe regulators have formed a group to work on the Range Rule specifically called the "Range Rule Partnering Initiative". Members include State regulators from various States and Tribal governments.

Risk management systems that are designed to balance risk reduction with the availability of resources for range remediation need public involvement and support to be successful.

RECOMMENDATIONS

To encourage constructive input from concerned populations, all military representatives who interact with the public in these situations should be trained in "two-way" communications. State and Tribe regulators should be acknowledged and treated as a group separate from public involvement stakeholders.

Public stakeholders, including local government entities (such as local reuse authorities) and property owners (and prospective transferees) should play a lead role in the establishment of land use plans for UXO-contaminated property.

Clearance to levels less protective than those required to meet land use preferences of affected communities should be accompanied by a promise to reconsider remedies once more cost-effective technologies become available.

Land owners, planning agencies and potential transferees should play a role in the determination of certification of UXO-cleared land-and the negotiation of indemnification.

Public interest groups, natural/cultural resource trustees, as well as other Federal, State and Tribal agencies, with an interest in the protection of natural or cultural resources should have the opportunity to help ensure that responses minimally threaten those resources.

F. Minimizing Exposure

FINDINGS

Reducing risk depends heavily upon educating the public about UXO hazards and the minimization of potential exposure pathways. Some work has already been done to educate the public about the hazards of UXO. For example, Fort Ord has developed educational brochures, Tierra Santa, a clean-up site in southern California, has produced educational videos and the Huntsville Division of the Army Corps of Engineers has developed informational materials suitable for children.

RECOMMENDATIONS

In areas where UXO exposure is likely, people exposed to UXO, including children, should be educated to recognize and respond properly to UXO.

Physical controls, including fences, barriers, and signs should be constructed where necessary, and will require on-going maintenance.

Deed restrictions designed to limit potential exposure pathways on land with (potential) residual UXO contamination should be supported by zoning restrictions and/or environmental regulatory authority.

G. Project Restoration

FINDINGS

UXO remediation efforts will have long term impact on a site. Many UXO sites will require restoration work well after the UXO safety issue has been successfully mitigated. Significant future problems may arise on these sites as a result of the UXO remediation effort if sufficient planning is not made.

For example, no standards currently exist to mitigate the contamination of soil caused from nitro aromatic compounds (common to high explosives). UXO site clean-up may require substantial deforestation; yet no reforestation standards currently exist. Furthermore, water and air surrounding or contained within a UXO site may need continuous monitoring to confirm the safety of the site and to protect the communities surrounding it.

RECOMMENDATIONS

Require the site remediation plans to consider possible need for restoration in later years. Develop standards to mitigate soil contamination, reforestation, etc.

H. Closed Ranges on DOD Property

FINDINGS

In addition to ranges at former or closing bases, numerous Department of Defense installations contain closed ranges that will never again be used as impact areas. At some of these facilities, the presence of UXO is the major reason that such closed ranges remain in the DOD inventory. Since these closed ranges are usually off-limits to the public, they pose less of a threat to public safety than transferred or transferring ranges. Nevertheless, much of this property could be put to other uses once cost-effective remediation technologies are developed.

RECOMMENDATIONS

Develop and implement a risk management strategy for such closed ranges, and create a funding stream — other than base operations and maintenance — to support appropriate responses.

APPENDIX A: TERMS OF REFERENCE

THE UNDER SECRETARY OF DEFENSE
30 10 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3010

AQUISITION AND
TECHNOLOGY

14 JUN 1996

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference -- Defense Science Board Task Force on Anti-Personnel Landmine Alternatives, Landrnine Detection and Demining, and Unexploded Ordnance (UXO) Clearance Operations.

Request that you establish a Defense Science Board Task Force on anti-personnel landmine alternatives, landmine detection and demining, and UXO clearance operations. This Task force shall be conducted in two phases. Phase one will study U.S. landmine, landmine detection, and demining efforts, and alternatives to anti-personnel landmines. Phase two will study UXO remediation, active range UXO clearance, and explosive ordnance disposal efforts.

PHASE ONE:

Examine U.S. landmine, landmine detection and demining efforts, and alternatives to anti-personnel landmines. In developing its findings and recommendations, the Task Force will:

- Review U.S. Anti-Personnel Landmine (APL) programs, including the technologies involved, the doctrine for their employment, the military need they fulfill, and applicable international law governing their use.
- Review 1) U.S. landmine detection and 2) U.S. humanitarian demining programs, focusing the technologies involved, the doctrine for their employment, and the military and/or humanitarian needs they fulfill.
- Review and analyze the broad strategic situation facing the U.S. in Southwest Asia, North Korea, Africa, Central America, and the Third World countries. Focus on the potential/likelihood of the U.S. military's use of APL in operations in those areas and the need for landmine detection capabilities in those areas.
- Analyze the technologies, development programs, and systems that may provide viable alternatives to APL. Viable is defined as militarily effective, affordable, and consistent with applicable International Humanitarian Law. Give particular emphasis to identifying those technologies that can be developed and matured for selective initiation of engineering development and/or production. Recommend the combination of technologies, strategies, and doctrines that can best cope with the capabilities that will likely be acquired by hostile nations five to ten years from now. This should include not only defensive capabilities but revolutionary offensive capabilities as well.
- Analyze the technologies, development programs, and systems that may improve 1) landmine detection capabilities and 2) demining efforts. For demining, focus on means to make it cheaper, safer, and/or faster. Give particular emphasis to identifying those technologies that can be developed and matured for selective initiation of engineering development and/or production.

Recommend the combination of technologies, strategies, and doctrines that can best cope with 1) the mine capability presently held by hostile nations and those likely to be acquired five to ten years from now, and 2) the present demining challenge.

- Assess, where appropriate, the potential impact of Task Force recommendations on military readiness, to include training, operational concepts, organization, and tactics. Recommend and prioritize areas that should be explored including C3I, SOF, unmanned vehicles, unattended sensors, non-lethal weapons, and equipment that would improve our capability to operate in built-up areas.
- Review U.S. and international law governing the potential transfer of technologies, systems, etc., that the Task Force recommends for landmine detection and humanitarian demining.

Phase one interim recommendations are desired to support the PPBS process in the September 1996 timeframe. The phase one final report should be completed by December 13, 1996.

PHASE TWO:

Examine UXO remediation, active range UXO clearance, and explosive ordnance disposal (EOD) efforts. Include in this examination, the relationship between the UXO/EOD detection/characterization/clearance and neutralization issues and landmine detection/neutralization issues addressed in Phase One. In developing its findings and recommendations, the Task Force will:

- Review 1) UXO remediation, 2) active range UXO clearance, and 3) EOD programs; including the technologies involved, the applicable policies, the pertinent requirements, and the organizations involved.
- Analyze the technologies, development programs, and systems that may improve 1) UXO remediation, 2) active range UXO clearance, and 3) EOD efforts. Focus on means to make remediation, range clearance and EOD operations cheaper, safer, and/or faster. Give particular emphasis to identifying those technologies that can be rapidly developed and matured for selective initiation of engineering development and/or production. Recommend the combination of technologies, strategies, and doctrines that can best cope with the present UXO remediation, UXO clearance, and EOD challenges.
- Analyze the technologies, development programs, and systems that may minimize or preclude the production of UXO, including self-destruct fuzing and self-neutralizing or degradable explosives. Give particular emphasis to identifying those technologies that can be rapidly developed and matured for selective initiation of engineering development and/or production. Recommend the technologies or combination of technologies that could be incorporated in future munition programs to render them less likely to produce UXO. Assess current munitions stocks and the potential for retrofitting them with technologies that will render them less likely to produce UXO.

Phase two will begin in September 1996. A phase two interim report is desired in the February 1997 timeframe. The phase two final report should be completed by April 25, 1997.

The Director, Strategic and Tactical Systems will be the lead sponsor for this Task Force and the Deputy Under Secretary of Defense (Environmental Security) will be a co-sponsor. The Chairman will be Mr. Robert Parker. Mr. Peter ONeill, OUSD(A&T)/S&TS-M, will serve as the lead Executive Secretary. COL Paul Ihrke, DOD Explosives Safety Board, will be co-Executive Secretary. The Defense Science Board Secretariat representative will be LTC T. Van Horn.

This Task Force will be operated in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DOD Directive 5104.5, the "DOD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U. S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

Paul Kaminski

Paul G. Kaminski

APPENDIX B: TASK FORCE MEMBERS AND GOVERNMENT ADVISORS

TASK FORCE MEMBERS

Chairman:	Dr. John S. Foster*
Members:	LtGen James Brabham, USMC Ret.
	LTG Marvin D. Brailsford, USA Ret.
	Mr. Bert Fowler*
	Dr. Robert Frosch
	BrigGen Roy Goodwin, USAF Ret.
	COL Richard H. Johnson, USA Ret.
	Dr. Gene H. McCall
	MajGen Mike Myatt, USMC Ret.
	Mr. Lenny Siegel
	Mr. Drexel Smith
	Mr. Lewis D. Walker
	Dr. George Whitesides*
Executive Secretary:	CAPT Monty Mathews, USN

DSB Member

GOVERNMENT ADVISORS

Mr. Jim Arnold
Mr. Doug Bell
Ms. Christine Crabill
Dr. John Cullinane
COL Joseph Daves, USA
Mr. Dave Douthat
Dr. Regina Dugan
Mr. Scott Edwards
Mr. Hap Hambric
Mr. Dwight Hempel
COL Bob Hilliard, USA
Mr. Tom Hitchcock
Mr. Ron Hoffman
Mr. Andy Hooper
Ms. Tayna Lynch
Dr. Jeff Marqusee
Mr. Chris O'Donnell
Mr. John Potter
Ms. Maureen Raley
Ms. Kelly Regano
Mr. Leo Shanley
Mr. Bob Taylor
LTC Michael Winzeler, USA
Mr. Jim Wollford
COL Dick Wright, USA
Dr. Roger Young
COL George Zahaczewsky, USA

APPENDIX C: ALTERNATIVE TECHNOLOGIES SUPPORTING UXO REMEDIATION

A variety of sensor and signal processing technologies have been proposed for use in UXO remediation. Table A-l lists the major sensor approaches presented to the task force. The table organizes these approaches broadly by whether their primary strength is detecting objects on the surface, near-surface or deeper subsurface. Some of these technologies are novel; others are adaptations of approaches that have proven effective in other applications. The table includes a brief commentary on each approach, addressing issues such as:

- Is the approach capable of wide area searches or for locating individual UXO?
- Can the technology provide valuable depth, size and orientation data on UXO?
- At what depth can the technology reliably detect LJXO?
- Are there any serious limiting factors in the technology (environmental, etc.)?

There are important trade-offs to be made in developing a cost-effective UXO remediation capability. For example:

- Designs that are effective for wide-area searches tend to be unsuitable for local UXO identification.
- The deeper a sensor system penetrates the ground, the less precision it tends to have on valuable depth, size and orientation data, especially for smaller objects.
- The use of "active" (radiating) systems (such as radar and electromagnetic induction systems) will tend to provide more insight on size and orientation of UXO than do "passive" (non-radiating) systems, but will have their own cost and deployment limitations (e.g., they may not be suitable for all soil types).
- The more sensitive detection approaches tend to have more difficulty in eliminating false alarms.

The demand for cost-effective UXO remediation drives the need for improvement in our UXO remediation capability - determining whether a suspect site actually contains UXO, determining what kind of UXO is on the site, locating individual UXO at reasonable cost and with high confidence, and determining the depth, size and orientation of the suspect UXO. The table highlights the fact that substantial technology progress must be made to achieve cost-effective UXO remediation. It is also important to note that no single technology can address all remediation needs. The UXO community must develop and exploit a variety of sensing approaches to their fullest if the Department of Defense is to obtain its objective of cost-effective remediation. This is a fundamental finding of this task force.

Table 1 No "Silver Bullet" -- Alternative Technologies All Have Strengths and Limitation

Alternative Technologies	Availability	Overall Effectiveness	Cost (to purchase, use and maintain)	Comments
Detection/ Remediation of Surface UXO				
Electra-Optical/Thermal Imaging.	+	**0**	**0**	A surface detection system that can provide wide area search for UXO. Best concept is combined active laser system with passive IR. Can detect ferrous and non-ferrous objects, and provides high resolution data on shape and orientation. Has difficulty in foliage. EO needs direct line of sight to UXO.
Synthetic Aperture Radar.	**0**	**0**	-	Primarily a surface detection system, suitable for surveying very large areas (and detecting large objects and providing 2-D images). Best suited for detecting minefield areas rather than for locating individual ordnance. Best against metal objects.
Biological Detectors (including artificial)	(dogs) + **(artificial dogs) -**	+	+	A surface detection system, perhaps useful against shallow-depth UXO, but primarily for mines and explosives; include trained canines or surrogates. Best for identifying individual UXO; does not measure depth, size or orientation.

Key: + high feasibility/value/lowest cost; 0 moderate; - marginal

Alternative Technologies	Availability	Overall Effectiveness	Cost (to purchase, use and maintain)	Comments
Detection/ Remediation of Near-Surface UXO				
Thermal Neutron Activation	+	O	-	Detection is limited by background signal; provides x-ray resolution. The main problem is discrimination between photons from Silicon-29 and Nitrogen-14; nitrogen contained in the soil may also contribute. Other sources of background include pulse pile-up and cosmic rays. Neutron absorption in boron, rare earth elements or rich soils can also be a problem. System performance may be quite good for large shallow ordnance, but detection of all relevant size/depths will only be fair.
Fast Neutron Activation	O	-	-	May provide size, depth and orientation information, but suffers from severe attenuation and poor discrimination of UXO from carbon, hydrogen and nitrogen and oxygen.
Ground Penetrating Radar	O	O	O	Provides depth, size and orientation data; useful signatures and resolution to depths of about 1 foot. Greater depth possible at 5GHz or lower, but requires increasingly sophisticated processing. Very high false alarm rates. Corrected Pd often statistically indistinguishable from 0. Best on roads or in homogeneous media.
Trace Chemical Detectors.	O	O	+	A subsurface detection system that senses a chemical signature left by UXO (e.g., mass spectrometry, GC-ECD, IMS, dogs, etc.). Provides no depth, size or orientation information, and may have very high false alarms due to local environmental conditions.

Key: + high feasibility/value/lowest cost; O moderate; - marginal

Alternative Technologies	Availability	Overall Effectiveness	Cost (to purchase, use and maintain)	Comments
Hyperspectral imaging	+	O	-	It is primarily used to detect changes in surface soil properties due to a mine burial. For newly emplaced mines on road beds, -this technique should be very good, but is not likely to work in foliage and fields. Can detect ferrous and non-ferrous objects.
Bulk Chemical Detectors.	O	O	0	Includes chemical interaction with x-rays and Nuclear Quadrupole Resonance (NQR). In principal, can measure size, orientation and depth; severely limited by soil attenuation. NQR may achieve very low false alarm rates, but ineffective against radio frequency (RF) shielded explosives.
Detection. Remediation of Deeply Buried UXO (>10 feet)				
Passive Magnetometers	+	+	_	Most widely used subsurface detection system today; capable for near-surface and deep objects; discrimination better deep given highly cluttered environment near the surface (except in highly magnetic soils). Fair to poor capability for discrimination, very good depth accuracy, fair to good information on size. Orientation of the magnetic moment can be determined, but this does not map one-to-one with the ordnance orientation. Performance degrades significantly in highly magnetic soils. This can be improved by magnetic gradiometry. Limited to ferrous materials; since mine-like targets not typically deeply buried, not a significant limitation. Biggest cost factor is wide area survey.

Key: + high feasibility/value/lowest cost; 0 moderate; - marginal

Alternative Technologies	Availability	Overall Effectiveness	Cost (to purchase, use and maintain)	Comments
Electromagnetic Induction Magnetometers	+	+	-	The drop off in the transmit to receive field is between $1/d^3$ and $1/d^6$ depending on the size of the transmit coil and the depth of the UXO. There is potential to discriminate clusters of UXO from a single item (early in the research at this point). Limited to good electrical conductors (brass, iron etc.); since mine-like targets not typically deeply buried, not a significant limitation. Biggest cost factor is wide area survey.
Seismic/Acoustic	O	O	O	Inherently poor spatial resolution; best suited for locating large objects at depths greater than 10 feet in variety of environmental conditions; little capability to characterize depth, size and orientation.
Signal Processing and Data Fusion				
Signal Processing	-	+	O	Future sensors will incorporate Automatic Target Recognition (ATR). ATR software is emerging which can interpret subtle signatures, where humans are not as effective.
Data Fusion	-	+	O	ATR software is also being used to fuse information from multiple sensors. Such ATR software will be used to augment human performance.
Real-Time Differential GPS	O	+	-	Use of Differential Global Positioning System (DGPS) will enable much more effective UXO remediation operations spanning wide area search through remediation. The UXO community is beginning to use this technology. This technique needs a lot of expansion. Field work indicates that DGPS with real time kinetic (RTK) corrections is required for resolution sufficient to investigate sensor fusion approaches.

Key: + high feasibility/value/lowest cost; O moderate; - marginal

Alternative Technologies	Availability	Overall Effectiveness	Cost (to purchase, use and maintain)	Comments
New Concepts				
Acousto-Electromagnetic Sensor	*0*	Unknown until further research	?	Stimulation of UXO with surface acoustic wave; sensing of the UXO vibrations (down to 20 microns) using 10GHz radar.
Ultrasonic Stimulation with Chemical Detection	-	Unknown until further research	?	Stimulation of UXO with ultrasonic radiation and detection of chemical particulates/vapor emitted from UXO (concept uses particle sampler with Micro-Electra Mechanical System (MEMS) actuator).

Key: + high feasibility/value/lowest cost; 0 moderate; - marginal

APPENDIX D: PRESENTATIONS TO THE TASK FORCE

SEPTEMBER 6, 1996

"Charge to the Task Force", Ms. Sherri Goodman, DUSD(ES) and Dr. George Schneiter, D, S&TS

"Phase I Presentation", Mr. Peter O'Neill, Phase I Executive Secretary

"Phase II Task Force Deliverables", Dr. John Foster, Phase II Chairman

"The UXO Problem - an Overview", COL Dick Wright, USA, ODUSD(ES)

"The UXO Clearance Information Briefing", BG Roy Beauchamp, Army Materiel Command

"The Joint Service EOD Program Board", RADM George Yount, NAVSEA

NOVEMBER 21-22, 1996

"ESTCP UXO Investments", Dr. Jeff Marqusee, ODUSD(ES)

"Detection Technologies Introduction", Dr. Jeff Marqusee, ODUSD(ES)

"Magnetometry", Dr. Thomas W. Altshuler/Institute for Defense Analyses

"Induction Coil Technology", Dr. White/APL

"Ground Penetration SAR for Detection of Shallow Buried Targets", Dr. Serpil Ayasli, MIT-Lincoln Laboratories

"Traditional Analytical Chemistry Techniques for Mine Detection", Dr. Wayne A. Bryden, Johns Hopkins University

"Olfaction and Array Based Detection", Dr. Kauer, Tufts

"Multi-University UXO Research Initiation", Dr. Lawrence Carin, Duke University

"Ultra-wide UHF/VHF", Dr. Ron Stocks, NRO

"UXO Prevention - Enhanced Munitions Detection Working Group", Mr. John Rosamilia, ARDEC

"Risk Assessment Model", Dr. Arkie Fanning

"Countermine R&D", Dr. Tom Broach, NVL

"Cost Analysis/Benefit Model", Mr. Richard A. Johnson, Executive Vice President, Strategic Analysis, Inc.

DECEMBER 17-18, 1996

"Cost Analysis/Benefit Model Update", Mr. Bradford L. Smith, Jr., President, Strategic Analysis, Inc. for Mr. Richard A. Johnson

"FUDS Program Time Line and Costs", Mr. Roger Young, US Army Corps of Engineers

"DOD K-9 Work", Col. Andrew Corso, USAF/MSgt Dave Kontny, USAF

"Green Bullet Program", Mr. Robert Scola, Director, Industrial Ecology Center, US Army

"JDL UXO Plan", Mr. William Konick, US Army TACOM-ARDEC

"UXO Permanent Committee/International", Mr. Andy Hooper, YPG

"DARPA Chemical Sensor Program", Dr. Regina Dugan, DARPA

"Location & Recovery of Buried Bombs", Dr, Bahktar

"SERDP UXO Investments", Bradley P. Smith, Executive Director, SERDP

"R&D Strategy for UXO Detection", Dr. Cullinane/Dr. Bernadette Johnson, MIT Lincoln Laboratories

"FUDS Matrix", Dr. Charles Theisen, NAOC

JANUARY 22-23,1997

January 22,1977 was held at EODTECHDIV

"EOD Mission & Functions", CDR Dee, USN Joint Service EOD

"Overview of JSEOD Technology & Training Program and NAVSCOLEOD" (Video)

"Joint Service EOD Training"' CDR McLawhorn, USN

"NAVEODTECHDIV Brief', CAPT McCarley, USN

"Technology Roadmaps", Mr. O'Donnell

"EOD Ordnance Threat Briefing"' Mr. Gjeming, Mr. Behm

"EOD Procedures Development", Mr. Hayes

"LIDDS/MCD", Ms. Sherlock

"BUGS Program" and "DIODE Pumped Laser Technology for Neutralization of IJXO", Mr. Christopher Debolt

"JPG I/II/III/IV Discussion", Mr. Snyder

"Kaho'olawe Island UXO Clearance", Mr. Hersey

"EOD Detection Technologies Demo", Dr. Manley, et. al.

EOD Tools Display/Brief/Demo

January 23, 1997 was held at Strategic Analysis, Inc.

"EOD Technology (Magnetics)", Dr. Claude Manley

"UXO Countermeasures Computer Modeling and Simulation," Mr. Richard Gold, EODTECHDIV

"Joint DEMIL Technology", Jim Wheeler, JDPO

"Army BRAC UXO Briefing", Mr. Hud Heaton, US Army Corps of Engineers

"Navy BRAC UXO Program", CAPT David Jones, CNOBO

"Air Force BRAC UXO Briefing"' Dr. A. Naim Qazi, AFBCA

"Accoustic Technology for Detection"' Dr. Tom Muir, Naval Postgraduate School

"UXO Clearance: The Report to Congress", MG Roy Beauchamp, USA

FEBRUARY 12-l 4, 1997 (AT YUMA PROVING GROUNDS, YUMA, ARIZONA)

"UXO Contamination of Test Ranges", Mr. John Kruger, Director of Plans, YPG

"Overview of Training Range Operations Related to UXO-CMS", Mr. Hank Domme, Luke AFB

"Active Range Clearance Technology Requirements"' Mr. Michael Kolodny, Army Research Laboratory

"Potential for Test Ranges offered by Munitions Tracking Technology", Mr. Andrew Ladas, ARL and Mr. Andy Hooper, YPG

"Enhanced Detectability of Future Ordnance", Mr. Leon Springer, Army Fuze Management Office

"Site Management Model", Jim Ingram, 29 Palms

"Range Management"' Mr. Ron Pierce, MCAS, Yuma

"Improved Robotics", Capt. Walter M. Waltz, WL/FIVC

"Range Residue", Capt. Jara Lang, USAF, 99th Air Base Wing, Nellis AFB, NV

"Overview of ARL Detection Sensor Testing at YPG", Mr. Marc Ressler, Army Research Laboratory

"Minimizing Rounds Fired", Mr. Andy Hooper, YPG

"Tribal Concerns Associated with Unexploded Ordnance" - Ms. Emma Feather-man-Sam, Director, Badlands Bombing Range Project, Oglala Lakota Nation, Pine Ridge South Dakota

"Department of Interior UXO Issues", Mr. Dwight Hempel, Dept. of Interior

"UXO RDT&E Investments"' Dr. Jeff Marqusee, ODUSD(ES)

MARCH 26-27, 1997

"UXO Remediation Contracting, COE Huntsville", Mr. Dave Douthat, Army Corps of Engineers

"UXO Remediation Issues, NAOC", Mr. Kevin Lombardo, National Association of Ordnance Contractors

"Untitled", Dr. David Heberlein, Deputy Director, Night Vision Electronics Sensors Directorate, US Army CECOM

"Update on DARPA Background Clutter Research", Dr. Thomas W. Altshuler, IDA

"Opportunities to Leverage Counter-mine RDT&E", Mr. Jim Campbell

"Comparison of Tech Requirements for Countermine Req. Vs. UXO Remediation Req.", Mr. Lawrence J. Nee, Chief, Counter-mine Division Program Manager Mines, Counter-mine & Demolitions

"JPG Update, Phase III Results", Ms. Kelly Regano/Mr. Jim Arnold

"Update on UXO RDT&E Funding", Dr. Jeff Marqusee, ODUSD(ES)

"Summary of Funding for UXO Remediation", Ms. Patricia A. Rivers, Assistant Deputy Under Secretary of Defense, (Environmental Clean-up)