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Environmental SECURITY

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compliance
conservation
pollution prevention

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Research Development Acquisition

ARMY RD&A BULLETIN

Professional Bulletin of the RD&A Community

FEATURES

Environmental Security

DEPARTMENTS

COVER

Featured in this issue are a series of articles representing environmental research and development efforts related to the DOD Environmental Security Program. Specific subjects include pollution prevention, cleanup, compliance, and conservation.

DEPARTMENT OF DEFENSE ENVIRONMENTAL SECURITY PROGRAM

By Sherri W. Goodman
Deputy Under Secretary of Defense
(Environmental Security)

Introduction

Demonstrating this Administration's commitment to the environment, the president and the secretary of defense created the DOD Environmental Security Program and elevated responsibility for the program to the deputy under secretary level. The mission of the Office of the Deputy Under Secretary of Defense (Environmental Security) (ODUSD(ES)) is to integrate environmental concerns into our national defense policies. This includes: (1) ensuring responsible performance in defense operations at home with respect to environmental laws, regulations, treaties and agreements, (2) investing in innovative technologies that improve the rate and reduce the cost of environmental restoration and compliance, thereby, reducing the drain of resources from defense readiness activities at home and abroad, and (3) mitigating threats such as ozone depletion or loss of biodiversity that can lead to international instability and global degradation.

Our goals are to bring Department of Defense (DOD) operations into full compliance with all applicable health and environmental standards; to reduce the risk to the public and the environment at inactive sites; to manage responsibly the more than 25 million acres of land the department holds in public trust; to prevent pollution from our activities whenever possible; and to promote the development of innovative environmental technologies that achieve our goals and promote economic growth at home. We intend to achieve these goals while continuing to maintain the strongest and most advanced military in the world. This is the challenge. It is a challenge that ODUSD(ES) and the military departments and defense agencies must work on together to meet.

This broad new mission requires a fundamental change in the way we solve environmental problems. We are committed to a common sense strategy—a strategy that will gain the trust and confidence of the public by fully protecting human health and the environment while at the same time ensuring that DOD is a careful steward of the public's resources. Protecting the environment and revitalizing the economy go hand in hand. We are committed to establishing strong partnerships with the military departments, other federal agencies, the states, industry, and the public to achieve our goals. One of the critical elements in our strategy that we will emphasize is the innovative technology demonstration and validation. This can help us meet our environmental goals while encouraging U.S. economic growth. Environmental security programs encompass four fundamental program areas: cleanup, compliance, conservation and installations, and pollution prevention. Cutting across each of these program areas is environmental technology. This grouping may be referred to as "C3P2+Technology."

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Background

DOD is responsible for environmental contamination resulting from decades of operations in both the U.S. and overseas. Under the first "C", we are currently engaged in cleanup at about 1,800 locations. Ninety-three of our U.S. installations are listed by the Environmental Protection Agency (EPA) as Superfund sites. Our goal is to contain, treat or remove all contamination so that it no longer poses a threat to public health and the environment. Specific initiatives to achieve this goal, include: (1) increasing the use of interim measures that reduce threats to public health and the environment, (2) demonstrating innovative technologies, (3) factoring future land use into cleanup decisions, (4) developing improved management and contracting strategies, (5) using generic remedies to address common pollutants and (6) removing regulatory or statutory impediments to successful cleanup programs.

DOD has identified over 10,000 active hazardous waste sites that will cost an estimated $25-30 billion to cleanup. Since 1984, we have spent $6.5 billion to cleanup 416 of these sites—only four percent of the total in almost 10 years. We are also cleaning up more than 100 military installations scheduled for closure or realignment. In 1994, DOD will, for the first time, spend more money on actual cleanup than on studies and investigations. Clearly, improved means are needed for dealing with and funding environmental cleanup to prevent the underfunding of other defense readiness programs such as training and logistics. To address this problem, we are directing innovative technological solutions to environmental restoration and waste management at military bases, with the objective of accelerating the pace and reducing the cost of cleanup and compliance. The mechanism we have selected to address this problem is the Environmental Security Technology Certification Program (ESTCP), which was established by the deputy secretary of defense in December 1993. The ESTCP will be described later in this article.

The second "C" is compliance. While cleanup deals with our past actions, compliance deals with the present—the daily activities that must meet all applicable laws, regulations, treaties and agreements. It includes the operation of military installations to meet air and water standards, maintenance and repair of waste and water treatment facilities, and construction to meet new environmental standards and increased operational needs. Our goal in this program area is to achieve full and sustained compliance with all legal requirements at all DOD installations. We have dedicated nearly $2.5 billion to compliance, an amount that reflects our commitment to environmentally

> By actively applying the principles of pollution prevention in all operations, we will reduce risks to public health and the environment, reduce environmental costs and future liabilities, and provide a new economic base for U.S. competitiveness.

sound practices and the expansion of new requirements levied in our installations.

The third "C" is conservation. As the second largest federal land holder, the department is steward for over 25 million acres of land across the country—an amount roughly the size of the state of Tennessee. These territories represent every major land type and often contain fragile ecosystems and endangered species, irreplaceable historical and archaeological sites and many other important natural and cultural resources. We face the difficult task of protecting and enhancing the quality of these resources while supporting the military mission. Military operations do not have to result in abuse of the land. In fact, military ownership can provide sanctuaries for many species in locations where industrial and commercial activities have not degraded natural habitats. But because some military operations can cause significant damage, we must seek training methods and innovative technological solutions to lighten these effects. For example, we are increasing the use of computer simulations that will increase readiness and reduce the need for field operations that might cause environmental damage.

DOD is also revitalizing energy resource management and conservation initiatives, including programs to make our energy generation systems models of efficiency and ensure that our consuming facilities comply with all federal energy efficiency and conservation standards. The potential environmental and economic benefits of energy conservation are significant. For example, if we reduce energy use in our buildings and facilities 20 percent below our 1985 baseline, by the year 2000 we will prevent the annual generation of 7.5 million tons of carbon dioxide, 64,000 tons of sulfur dioxide and 27,000 tons of nitrous oxides.

The Future

As the department transitions to the 21st century, we look to the P2 portion of the "C3P2+Technology" equation, i.e., pollution prevention. P2 is preventive medicine for the environment and prescriptive medicine for the economy. By actively applying the principles of pollution prevention in all operations, we will reduce risks to public health and the environment, reduce environmental costs and future liabilities, and provide a new economic base for U.S. competitiveness. Hazardous waste disposal and liability costs have increased tenfold over the last five years. Landfill space has dwindled 80 percent over the past decade—with the siting of new landfills or hazardous waste facilities becoming extremely contentious. These trends encourage the shift from end of the pipeline management to pollution prevention, i.e., eliminating pollution generated at the *source.* As the operator of major installations that are in effect small cities, we can provide waste reduction models for municipalities nationwide.

Similarly, as one of the nation's largest consumers, DOD has a unique opportunity to stimulate markets for environmentally preferable products. This can be achieved by applying environmentally-sensitive life cycle cost criteria across the spectrum of our acquisition decisions, i.e, weapons systems' and facilities' design, production, operation, maintenance and disposal or closure, respectively. In conjunction with the private sector, the department can develop and demonstrate new, environmentally-responsive technologies for inclusion in products and services. Innovative technological solutions hold great promise for cost savings and jobs creation through increased market share. For example, the Hughes Aircraft Company in California, a major defense contractor, is patenting a process to eliminate ozone-depleting chemicals (ODCs) in electronic circuit board manufacturing and testing, while still meeting DOD's product performance criteria. The process involves the use of a non-toxic citric acid-based solvent that is soluble in water. DOD, as the customer, must modify the military specifications which cite the use of ODC chlorinated organic solvents in the manufacture and testing of circuit boards. Concurrently, Hughes is cooperating with other contractors to make the citric acid process available for the manufacture of electronics critical to both the military and private sector worldwide. This is clearly a win-win situation for the environment and our economy.

P2 principles were articulated in a Dec. 10, 1993, memorandum issued by the under secretary of defense (acquisition and technology) (USD(A&T)) to all DOD components. The USD(A&T) memorandum implemented Executive Order 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements," Aug. 3, 1993. In addition to its provisions under the Emergency Planning and Community Right-to-Know Act, the Executive Order requires that the federal government demonstrate pollution prevention leadership by: (1) improving facility management, (2) incorporating environmental principles in the weapons systems acquisition process, (3) establishing comprehensive pollution prevention plans and (4) developing innovative environmental technologies.

Environmental Security Technology Certification Program (ESTCP)

Technology contributes to advancing the objectives of each of the C3P2 thrust areas within the Environmental Security Program. The objective of ESTCP is to execute the most promising environmental technology demonstration projects that target DOD's most urgent environmental needs and have a payback in the short term with regard to cost savings and improved efficiencies. This program responds to:

- Congressional concern over the slow pace of remediation of environmentally polluted sites on military installations;
- Congressional direction to conduct demonstrations specifically focused on emerging new technologies;
- Executive Order 12856 which requires federal agencies to place high priority on obtaining funding and resources needed for the development of innovative pollution prevention programs and technologies for installations and in acquisitions; and
- The need to improve defense readiness, e.g., through investment in training and logistics programs, by reducing the drain on the department's operation and maintenance dollars caused by real world commitments such as environmental restoration and waste management.

As stated in the background, above, the future costs of DOD's cleanup and compliance efforts are estimated in the billions of dollars. Commercialization and implementation of innovative environmental technologies in response to these challenges is expected to result in cost savings many times the original investment.

Preference for demonstrations under ESTCP will be given to those technologies that respond to Environmental Security Program objectives, have successfully completed all necessary research and development objectives, and are dual use, i.e., technologies which both meet government needs and spur growth in businesses and the economy. For each of the technologies demonstrated under ESTCP: (a) time will be needed for site preparation, regulatory permitting and testing, (b) a series of tests and evaluations may be required at a site, and (c) multiple sites may have to be tested to ensure efficacy of the technology in a variety of climates, soil conditions, etc.

When demonstration and validation for a particular technology is completed, and if the technology is found to be effective and affordable by users, regulators and other stakeholders, it will be commercialized and implemented throughout a broad cross-section of DOD sites. In the case of the successful technology, its implementation at DOD sites will result in cost savings and efficiency improvements over processes and materials employed currently, and benefits to DOD can begin to accrue.

Each of the articles that follow in this issue of the *Army RD&A Bulletin* represent environmental research and development efforts within the context of the DOD Environmental Security Program. As noted in the article, entitled "Installation Restoration Research: Maturing Technologies for Installation Cleanup," the authors describe the process whereby research and development efforts within the Army have matured until the point when they are ready to transition to test and evaluation at a cleanup site. Through ESTCP, we hope to provide the science and technology community just such an opportunity to demonstrate and validate environmental technologies for subsequent commercialization and implementation throughout DOD, other federal agencies, the states and industry.

The new Environmental Security Program is expanding its mission to include national, regional and global environmental concerns, with increasing reliance on the demonstration, commercialization and implementation of innovative environmental technologies. This provides a challenge to work as a team within DOD and with other federal agencies, state and local governments, private citizens and industry to promote the environmental and economic health of our planet.

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MANAGING ENVIRONMENTAL QUALITY R&D

By Dr. Robert B. Oswald

The Growing Environmental Challenge

The Army's environmental strategy for the 21st century addresses the challenges of the four pillars: cleanup, compliance, conservation, and pollution prevention. The strategy outlines goals for achieving environmental excellence for both military activities and the civil works activities of the U.S. Army Corps of Engineers.

Failure to achieve these goals will have severe impacts on the Army. Environmental damage to training sites and noise complaints are impacting our ability to conduct effective training. Failure to modify our operations to prevent pollution will result in more notices of violations and future cleanup problems. The cost for fixing these problems will come out of already shrinking operations funding. Ultimately at risk is the public's confidence in the Army's ability to be responsible stewards of the environment.

Management of the Army Enviromental Program is the responsibility of the newly created assistant chief of staff for installation management (ACSIM), Environmental Programs Directorate. The ACSIM provides both policy and oversight of the Army's environmental effort.

The Army Environmental Center (AEC) at Aberdeen Proving Ground, MD, has operational responsibility for implementing environmental policy set by ACSIM. Each major command then is responsible for conducting the day-to-day environmental management activities at its installations. In addition, the U.S. Army Corps of Engineers (USACE) is responsible for environmental concerns relating to the operations of its civil works facilities including lock, dams, and recreational sites. All these organizations serve as proponents for the environmental quality (EQ) research and development (R&D) effort.

The goal of the Reliance Program in civil engineering and environmental quality was to reduce unwarranted overlap and to integrate and optimize the existing science and technology programs among the Services.

Army R&D Support to the Environment

The research and development community has a key role in assisting the Army and other services in achieving its environmental goals. Innovative technologies and processes will reduce the cost and enable the military to be responsible environmental managers. The main goal of the EQ R&D Program is to protect and improve the environment while providing improved mission accomplishment and reducing the costs of operations.

Several Army research organizations are involved in supporting the four pillars of the Army's environmental effort. The USACE Directorate of Research and Development is responsible for overseeing the development and execution of the Army EQ R&D Program.

Three of the four USACE laboratories are heavily involved. The Waterways Experiment Station in Vicksburg, MS, has the lead responsibility for research in installation restoration and civil works. The Construction Engineering Research Laboratories in Champaign, IL, has the lead for research on compliance and conservation issues. The Cold Regions Research and Engineering Laboratory in Hanover, NH, supports the other Corps laboratories' efforts with their unique expertise on the impacts of ice and cold on military activities and the environment.

Within the Army Materiel Command (AMC), the Armament Research, Development and Engineering Center (ARDEC) at Picatinny Arsenal, NJ, has the lead for the pollution prevention R&D effort.

The Army's EQ R&D Program is closely intertwined with those of its sister services as a result of the Department of Defense's Tri-Service Science and Technology Reliance Program. Under the Reliance Program, the EQ R&D efforts of the three services has been integrated under the recently developed Tri-Service EQ R&D Strategic Plan.

Tri-Service Reliance and the Environmental Quality R&D

The goal of the Reliance Program in civil engineering (CE) and EQ was to reduce unwarranted overlap and to integrate and optimize the existing science and technology programs among the Services. The Joint Engineers (JE) is a Tri-Service team responsible for the oversight of both the CE and EQ R&D Programs under Project Reliance. The team consists of General Officer level representatives from each of the three Services engineering elements. The Reliance effort began in 1991.

Early in the Reliance effort, the Joint Engineers established a JE Management Panel (JEMP) to assist them in the management of the CE and EQ Programs. The JEMP is responsible for all phases of staff support and assistance in program development, management, and execution. The JEMP consists of two representatives from each Service plus an executive secretary. The panel chairmanship and executive secretary positions will rotate among the Services every two years. The Army staffed these positions for FY93 and FY94. The Navy will assume responsibility in FY95; the Air Force in FY97.

During the study phase of the Reliance Program, the R&D efforts in the EQ technology area were divided into seven sub areas which were then further divided into a total of 18 sub sub areas. The seven sub areas are installation restoration, pollution prevention, global marine compliance, atmospheric compliance, noise abatement, base support operations, and terrestrial and aquatic assessments.

After the development of the sub areas, each Service provided detailed information on the dollars, manpower, and facilities invested in R&D for each technology sub sub area. These data were compiled and compared to determine the "degree of reliance" and Service participation for each sub area and sub sub area.

The JEMP established technology panels for each of the seven sub areas. These panels serve as both technical and management bodies in their respective technology areas. Each panel is composed of a single representative from each Service. Similarly, technology sub area panels were also established under each panel to assist in planning, formulating, reviewing, and documenting the respective R&D programs.

The Tri-Service Environmental Quality R&D Strategic Plan

The Tri-Service EQ R&D Strategic Plan was developed as a cooperative effort between the Department of Defense's R&D and user communities. The objective of this plan is to provide a technology development and transfer strategy to solve the Services' most pressing environmental problems as rapidly as possible at least cost, and to prevent these problems from reoccurring.

The strategic plan exploits and builds upon the existing Tri-Service Reliance organization to effectively address user requirements through coordinated R&D activity. The Joint Engineers tasked the JEMP and the EQ Reliance technology area panels to produce the EQ R&D Strategic Plan.

The plan was based on about 420 requirement statements, consolidated from a list of over 700 requirements generated by representatives of the Tri-Service user community. The panel grouped the 400-plus tri-service requirements into 86 thrust areas covering the four pillars.

The philosophy of the EQ R&D strategic plan is based upon the following four objectives:

• Enhance user participation in formulating requirements to tighten the focus of EQ R&D on critical technology needs.

• Leverage and integrate DOD's direct-funded R&D programs with other EQ initiatives to include the Strategic Environmental Research and Development Program, the Defense Environmental Restoration Account, and major reimbursable EQ R&D Programs.

• Rely as much as possible on EQ R&D from other federal agencies and public and private organizations.

• Steer technologies through full-scale technology demonstrations with enhanced participation by government users and industry to ensure rapid technology transfer.

The actual program development occurred within the seven EQ Reliance sub panel areas. The panel then consolidated the seven sub area panels into the four DOD pillars. Installation restoration (cleanup) and pollution prevention remained as they were. Global marine compliance, atmospheric compliance, and part of the base support formed the compliance pillar. The remainder of base support operations went into conservation. Finally, parts of terrestrial and aquatic assessment went to cleanup and pollution prevention.

Each Service has assumed a lead responsibility for integrating the three Services EQ R&D efforts within each of the four pillars. The Air Force integrated the program under pollution prevention.

The Strategic Environmental Research and Development Program is driven by the concept of dual-use technology. Its purpose is to apply DOD technology to non-military, research use.

The Navy integrated the compliance program. The Army integrated both the cleanup and conservation programs. The JEMP set guidelines for the multi-Service integration and coordination of selected programs and for the establishment of joint programs.

The final effort in the development of the EQ R&D Plan was the actual preparation and publication of the report. The report describes all individual and joint-Service EQ R&D Programs planned by the three Services. The EQ R&D Plan report was completed and distributed in April 1992.

The programs developed through the EQ R&D strategic plan will be executed by the Services through their respective chains of command with guidance from the Tri-Service EQ R&D Reliance Organization.

The Strategic Environmental R&D Program

Another key component of the Army and other Services Environmental Quality R&D Program is the Congressionally sponsored Strategic Environmental Research and Development Program (SERDP). Congress established SERDP through Public Law 101-510 on Nov. 5, 1990 (10 U.S.C. 2901-2904).

The Army and other Services have made great strides through the Reliance effort in consolidating the individual environmental quality research and development programs into one comprehensive and integrated effort.

The objective of SERDP is to address environmental matters of concern to the Department of Defense (DOD) and the Department of Energy (DOE) through support for basic and applied research and development, demonstration, and technology transfer.

SERDP is driven by the concept of dual-use technology. Its purpose is to apply DOD technology to non-military, research use. SERDP promotes the sharing of information and technologies related to environmental issues between the government and private industry. SERDP encourages the identification and transfer of DOD and DOE environmental data, technologies, and capabilities to other government and private organizations. Similarly, SERDP encourages the transfer of private sector technologies and capabilities into government use.

SERDP encompasses a wide range of environmental issues. The program consists of six technology thrust areas: cleanup, compliance, conservation, pollution prevention, energy conservation/renewable resources, and global environmental change.

SERDP is a multi-agency effort involving DOD, Department of Energy, and the Environmental Protection Agency. The SERDP Council, with representatives from each of these agencies, serves as the principal policy and program decision-making body for the program. Federal laboratories will manage the execution of the research program through in-house research capabilities or contracts and partnering agreements with public and private institutions.

SERDP is being planned as a multi-year program with total funding in FY94 of $160 million. SERDP research efforts complement and enhance the existing Tri-Service EQ R&D Program. It provides additional funding to overcome funding shortfalls in the DOD program. Plus, it broadens DOD's expertise and capabilities by increased involvement with the research capabilities of DOE, EPA, and the private sector.

What's Next?

The Army and other Services have made great strides through the Reliance effort in consolidating the individual EQ R&D programs into one comprehensive and integrated effort. The Tri-Service EQ Strategic R&D Plan represents a merging of research capabilities, individual talents, and funding resources. Plus it provides the framework for improved partnering within DOD and with other federal environmental agencies, and the public and private sector. Research results from the Corps' Civil Works EQ R&D Program, such as in wetlands management, are now being applied to military installations. This integrated program does a much improved job of focusing existing resources to meet the environmental requirements of its military customers.

But there's more to be done. Over the next year the Army and its Service R&D partners will work more closely with its military customers to set priorities for the numerous requirements that have already been laid out. There is currently a tremendous shortfall between the identified R&D requirements and the available R&D dollars in the environmental program. A prioritized set of requirements will enable the R&D community to redirect its resources to focus on the most pressing problems first and solve them as soon as possible.

Finally, the R&D community and its customers must improve their ability to forecast the environmental challenges of the future. As an example, the FY94 EQ R&D Program will add a research effort on identifying alternatives to ozone depleting compounds—a looming environmental challenge in the near future. Identifying these future challenges early enough will assist the R&D community to have a start on solutions ready to assist its military customers in meeting the challenges when they occur.

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INSTALLATION RESTORATION RESEARCH: MATURING TECHNOLOGIES FOR INSTALLATION CLEANUP

By Dr. Raymond L. Montgomery, Dr. M. John Cullinane Jr. and Jerry L. Miller

Background

Throughout its history, the Department of Defense (DOD) has mirrored the practices of society as a whole. As a result, many of our waste disposal practices have resulted in damage to the environment. It is estimated that the DOD has about 1,900 installations worldwide, containing about 11,000 individual sites that will require some form of active remedial action (Table 1). Much of this contamination involves land disposal of explosives and energetics related wastes; petroleum, oils, and lubricants (POL); industrial solvents; heavy metals; and other military-unique contaminants.

Environmental cleanup involves the remediation of soil, sediment, groundwater, surface water, and structures contaminated with hazardous and toxic materials from past military activities. The cost to complete the DOD Cleanup Program is currently estimated to be $24.5 billion. An aggressive research, development, and demonstration program is underway to identify and develop cost-effective waste site investigation techniques and efficient, permanent cleanup technologies. The potential cost savings from this R&D program are enormous.

Management Initiatives

Traditionally, the three Services have conducted independent research and development in support of DOD's environmental restoration programs. In 1989, a new approach to environmental science and technology planning, management, and execution was initiated. This new approach, known as the Tri-Service Project Reliance, increased the efficiency and decreased duplication and overlap in the Service's research, development, test and evaluation (RDT&E) activities. The Army and Air Force share lead responsibilities within the cleanup pillar. The Air Force is the lead Service for fuels and solvents site contamination treatment. The Army is the lead Service for site investigation/characterization; explosives, metals and other organics contamination treatment; and contaminant fate and effects research.

An Environmental Technology Coordinating Committee (ETCC) was established to ensure the exchange of technical and programmatic information among DOD components. The ETCC serves as a working group to coordinate environmental technology research, development and implementation programs among the Services. The ETCC developed a common technical information base among the Services and with other federal departments, helped to avoid unnecessary duplication of development efforts, and enhanced interservice technology transfer. Additional coordination of research takes place through the integrated Tri-Service Environmental Quality Research and Development Plan.

Participation in the Federal Remediation Roundtable provides a forum for exchanging information on remediation technology, to consider cooperative efforts of mutual interest, and to analyze problems and develop strategies using innovative technologies with other Federal agencies, including the Environmental Protection Agency (EPA) and

Department of Energy (DOE). The roundtable synthesizes the technical knowledge that federal agencies have compiled, and provides comprehensive access to performance and cost data.

Technical Thrust Areas

Cleanup technology research supports the Installation Restoration, Base Realignment and Closure, and Formerly Used Defense Site programs. Better, cheaper, faster, and safer methods for site characterization and remediation are developed to increase the efficiency of site characterization, reduce remediation cost, and improve post-closure monitoring. The overall goal of the Cleanup Research and Development Program is to provide cost effective technologies for the protection of human health and the environment. Research is categorized into four thrust areas: site investigation/characterization, groundwater modeling, treatment technologies, and environmental fate and effects (Table 2).

Site Investigation/ Characterization Technologies

Site investigation and characterization is a complex, expensive, and time consuming process. There is a critical need to develop more timely and cost effective site characterization methods. The Army is leading a Tri-Service effort to develop the Site Characterization and Analysis Penetrometer System (SCAPS). This system allows for rapid site screening and characterization. SCAPS is currently capable of providing soil layering, soil strength, soil type, soil resistivity, and three-dimensional subsurface visualization. A first generation sensor for identifying POL plumes has been field demonstrated on a number of sites and the first generation system is currently being transferred to the field. This effort has been truly collaborative, with the Navy, Air Force and DOE contributing significant dollars and technology.

Groundwater Modeling Technologies

DOD's ability to effectively predict the fate, transport, and cleanup of contaminated groundwater resources is directly linked to accurate and efficient use of groundwater modeling technology. Existing groundwater models are generally difficult to use and do not address military-unique compounds such as explosives.

The U.S. Army Engineer Waterways Experiment Station is leading the multiple-agency Groundwater Modeling Program (GMP) whose primary goal is to improve the use of groundwater modeling technology in support of the characterization and cleanup of contaminated DOD sites. The GMP, which was initiated in FY93 based on user requirements from the Army, Air Force, and Navy, is specifically designed to leverage the restoration expertise within the DOD, DOE, and EPA laboratories and academia through technical partnering.

Partners in the GMP include: Air Force Armstrong Lab Environmental Quality Division, DOE's Lawrence Livermore and Sandia National Labs, EPA's R.S. Kerr and Athens Environmental Research Labs, and the Army's Cold Regions Research and Engineering Lab. Leveraging of academic expertise in groundwater fate/transport/remediation modeling has been conducted through establishment of contracts with 14 universities.

In FY94, more than 20 major technical investigations are being conducted within the GMP. Funding for these investigations will exceed $8 million. The

Table 1.
Installation Restoration Program.

Summary of Installations and Sites

Service	Number of Installations	Number of Sites	Number of Active Sites	Closed-Out Sites*
Army	1,265	10,578	5,524	5,054
Navy**	247	2,409	1,688	721
Air Force	331	4,354	3,520	834
DLA***	34	319	192	127
TOTAL	**1,877**	**17,660**	**10,924**	**6,736**

*Formerly "Sites Requiring No Future Action."
**Includes Marine Corps.
***DLA = Defense Logistics Agency.

Table 2.
Installation Restoration Thrust, Objectives and Goals.

Major Thrust	Thrust Objective	Technology Goals
Site Investigation/ Characterization	Develop improved and less costly investigation/ characterization technology and chemical analytical systems for locating and characterizing wastes from past DoD operations.	A cone penetrometer system (SCAPS) has been developed to supplement the use of monitoring wells and minimize site investigative costs. It currently provides real-time soil type and resistivity data. A fiber optic probe which can detect POL contamination in the subsurface via laser induced fluorescence has been fielded. A fiber optic link to the surface and above-ground instrumentation provides spectral response data. The cone penetrometer includes a grout injection system to plug the hole upon removal to minimize potential for cross-contamination of groundwater. Develop improvements to the SCAPS, which is currently being fielded to optimize placement of monitoring wells. Develop or improve additional analytical techniques necessary for assessing and monitoring military unique compounds. Develop real-time contaminant data acquisition capabilities.
Groundwater Modeling Technology	Improve site assessment and remedial alternative evaluation that will reduce the time and cost of site remediation.	Develop the fundamental equations and relationships associated with the flow of groundwater and the transport of subsurface contaminants. Package a comprehensive modeling system for DOD use in site characterization, contaminant assessment, and remediation alternative evaluation/operation. Verify the proposed modeling system through comparison of model predictions with both laboratory and site observations. Develop single- and multi-phase groundwater flow and single-component contaminant transport in a three-dimensional, spatially heterogeneous subsurface environment.
Treatment Technologies	Develop new or improved treatment technologies to reduce the cost of remediating sites contaminated with explosives (e.g., TNT, RDX, nitroglycerin, tetryl) as a result of past explosives production and waste disposal practices by 50 percent.	Demonstrate and field composting technology for treatment of explosives contaminated soils. Develop bioslurry processes to compliment composting on a site specific basis. Develop advanced oxidation processes for treatment of explosives and organics contaminated groundwater. Develop in situ treatment processes that will further reduce the cost and environmental impacts associated with site remediation. Develop new or improved treatment technologies to reduce the cost of remediating sites contaminated with heavy metals. Develop physical separation technologies as a method for reducing the quantity of materials requiring sophisticated treatment technologies. Develop advanced chemical extraction technologies for metals recovery. Develop advanced thermal immobilization technologies.
Environmental Fate and Effects	Develop faster, cheaper, and more effective methods for evaluating the potential health and ecological effects of Army-unique chemicals and chemical mixtures present in contaminated soil and groundwater at Army sites and the assessment of the impact of these materials on the exposed ecosystems.	Basic research efforts explore new, innovative techniques for using non-mammalian species in human health hazard evaluations. Improved prediction and assessment models of ecological and health effects are validated and incorporated into a framework applicable to the Army's needs. Coordination with the appropriate state and federal regulatory agencies is preformed as an important part of the overall research program. Interface is made with site cleanup efforts to validate new treatment technologies, as guidance in clean-up/remediation activities and in the determination of environmental (soil and ground water) concentrations that will not lead to significant ecological damage or degradation endangerment of human health.

Table 3.
Emerging Cleanup Technologies.

Technology	Demonstration	Implementation	Unit Cost
Remediation of Explosives/Organics Contaminated Soils			
Physical Separation	1996	1998	$40-$200/Ton
Composting	1991	1993	$100-$400/Ton
Bio-Slurry	1994	1996	$50-$200/Ton
In Situ Biodegradation	1996	1998	$50-$100/Ton
Chemical Extraction	1996	1999	$50-$200/Ton
Electrokinetics	1997	2000	$30-$75/Ton
Remediation of Explosives/Organics Contaminated Groundwater			
UV/OZONE	1993	1995	$0.5-$10/1000 Gal
Peroxone	1994	1996	$0.10-$2/1000 Gal
Advanced Adsorption	1997	1999	$0.02-$1/1000 Gal
Ex Situ Biotreatment	1997	1999	$0.02-$2/1000 Gal
In Situ Biotreatment	1997	1999	$0.02-$1/1000 Gal
Remediation of Metals Contaminated Soils			
Physical Separation	1995	1998	$30-$200/Ton
Electrokinetics	1997	1999	$20/Ton
Metal Extraction	1995	1996	$40-$125/Ton
Remediation of Metals Contaminated Groundwater			
Ion Exchange	1995	1998	$0.10-$40/1000 Gal
Xanthate Precip.	1996	1998	$0.75-$2/1000 Gal
Site Characterization/Detection of Buried Unexploded Ordnance			
STOLS	1994	1995	$1,600/Acre
RADAR	1994	1995	$1,000/Acre
Multi-Sensor Ground Platform	1996	1997	$600/Acre
Multi-Sensor Airborne Platform	1997	1998	$1,200/Acre
Remediation of Buried Unexploded Ordnance			
Enhanced UXO Tech.	1995	1996	$50,000/Acre
Remote Detection/Removal	1996	1997	$40,000/Acre
Characterizing Contaminants in Soils and Groundwater			
POL	NOW	1993	$10-$40/FT
Explosives/Energetics	1994	1995	$10-$40/FT
Solvents	1996	1997	$10-$40/FT
Heavy Metals	1996-97	1998	$10-$40/FT
Treatment of Fuels/Solvents in Soils			
Bioventing (Fuels)	1993	1995	$5-$30/Ton
RF Heating/Vapor Extraction	1993	1995	$40-$60/Ton
Steam Injection/Vapor Extraction	1994	1995	$50-$80/Ton
Advanced Biotreatment (Solvents)	1996	1999	$70-$80/Ton
Treatment of Fuels/Solvents in Groundwater			
Crossflow Air Stripping with Catalytic Oxidation	1993	1996	$1.5-$5.5/1000 GAL
Liquid Phase Catox	1995	1997	$3/1000 GAL
In Situ Bioremediation	1996	1997	$1-$6/1000 GAL
Plume Retardation	1999	2000	$1-$2/1000 GAL
DNAPL Remediation	2000+	2000+	$15-$30/1000 GAL

technical content of these investigations centers around seven major technical areas: evaluation and improvement of existing modeling technology; investigation of the impacts of subsurface heterogeneity on remedial effectiveness; development of fate/transport descriptions for military-unique contaminants (e.g., explosives); investigation of fate/transport descriptions for remedial alternatives; computational subsurface conceptualization methods development; creation of an integrated user environment to augment modeling tool use; and integration of the products from the above six areas into the DOD GMS. The DOD GMS computational system will result in significantly quicker and more effective evaluation and design of proposed management and treatment strategies than currently available.

Treatment Technologies

As the DOD single Service manager for explosives, the Army has the lead for developing treatment technologies for explosives and propellants contaminated environmental media. In addition, the Army is the lead Service responsible for the development of innovative technologies to treat heavy metals, organic compounds, and chemical agents.

Research is conducted to develop biological, physical, and chemical methods to treat explosive-contaminated soils and groundwater. Technologies currently under investigation include a number of new and innovative contaminated soil treatment technologies to determine their potential as low cost alternatives to incineration. A particularly promising technology is bioremediation. Full-scale testing of bioremediation (composting) for explosive-contaminated soil is now being conducted at Umatilla Army Depot. It is estimated that bioremediation can reduce the cleanup cost at Umatilla by at least 50 percent. Longer range program objectives include the development of in-situ processes for remediation of organic and explosives contaminated soils and groundwater.

The Army is also conducting research on physical separation processes, chemical treatment, in-situ microwave destruction, and metal extraction, and immobilization. Basic research is conducted to better understand the physical, chemical, and biological mechanisms driving proposed remediation technologies.

Under Project Reliance, the Air Force has the lead for developing technologies to remediate sites contaminated with fuels and solvents. Typically, groundwater contaminated with solvents and fuels is pumped to the surface and treated. However, pump and treat technology is economically impractical for renovating aquifers contaminated with large quantities of solvents and fuels.

Ongoing and planned research is toward developing full scale design criteria for complete groundwater remediation systems using physical, chemical, and biological treatment processes. Technologies currently under investigation are soil venting, in situ aerobic/anaerobic bioremediation, bio-reactors, air stripping with catalytic oxidation, pulsed hydraulic flushing, deep thermal decontamination, and steam injection/vacuum extraction.

Following successful pilot and field demonstration of treatment technologies, technical results, cost data, and design packages are distributed to potential users.

Environmental Fate and Effects Technologies

The objective of this research includes the development of quicker, less costly methods for evaluating the potential health and ecological effects of DOD relevant chemicals present in contaminated soil and groundwater at Army sites and the assessment of the impact of these materials on human health and the environment. Basic research efforts explore new, innovative techniques such as toxicological testing using nonmammalian species. As results of this research are validated, they will be incorporated into the Army risk assessment process. These research results will produce a more rapid and accurate determination of the relative hazard of materials in soil and groundwater at a reduced expense. This will result in the determination of more realistic environmental hazards at cleanup sites. The technology would also be used to validate effectiveness of new treatment technologies.

Maturing Technologies

Table 3 summarizes the wide variety of technologies that are currently under development. Many of these technologies are expected to be fielded within the next five to eight years, with significant cost savings provided to the user community.

The DOD and the Services are committed to an aggressive strategy to cleanup our hazardous waste sites. The RDT&E Program continues to move forward in the development of better, cheaper, faster, and safer remedial action technologies.

Summary

The DOD and the Services are committed to an aggressive strategy to cleanup our hazardous waste sites. The RDT&E Program continues to move forward in the development of better, cheaper, faster, and safer remedial action technologies. DOD and Service leadership have established the strategic direction to aggressively develop and demonstrate new cost-effective cleanup technologies to the DOD user community so they may continue to achieve excellence in environmental restoration and protection. We will meet our commitment to environmental stewardship while minimizing the cost to the U.S. taxpayer.

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ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROGRAM: THE COMPLIANCE PILLAR

By Robert C. Lozar and Dana Finney

In this decade, the number of new environmental laws has been increasing geometrically, with no signs of tapering off in the near future. Like the civilian community, the military is bound to comply with laws enacted by Congress and with the resulting guidance issued by the Department of Defense (DOD) and its Services, and with state and local requirements.

Routine DOD activities can generate oil pollution; hazardous and energetics waste; sewage; wastewater; solid waste; air pollution; noise; and contamination of soil, drinking water, and groundwater. DOD's failure to comply with any of the laws governing these activities can incur expensive fines, delay scheduling for mission-related activities, and even threaten to shut down key military facilities.

Many of DOD's compliance issues are similar to those in the civilian sector. However, DOD also uses and generates products which are military-unique based on the requirements of its readiness mission. Thus, while it is possible to adapt many commercial technologies to the military, some research must be done within DOD for specific pollutants and hazardous materials not of concern elsewhere in this society.

The Compliance Pillar within the Strategic Environmental Plan provides a research and development (R&D) initiative that addresses DOD's immediate and long-term compliance needs. This pillar focuses on four major areas: atmospheric compliance, noise, global marine compliance, and base support. The research program is designed to bring the military into compliance as quickly as possible at an affordable cost.

Within the compliance pillar are several research "thrusts" which explicitly state the problem, name the compliance incentive (usually law), define how and to what degree the military mission is impacted, identify the intended technology, and assign a priority relative to the other concerns. A Fiscal-Year Critical Path Chart or "road map" shows how this work relates to other projects and the levels of funding available and needed. Within the compliance pillar it is estimated that the unfunded but needed research will require about 10 times more funding than is currently scheduled (about $4,328 million still needed versus $327 million scheduled).

Atmospheric Compliance

The primary driving force for atmospheric compliance R&D is the Clean Air Act with its 1990 amendments. Numerous military operations contribute to the release of atmospheric pollution. In the past, DOD installations were exempt from complying with Clean Air Act requirements, but this is no longer true. Today fines of up to $25,000 per day can be imposed for exceeding air contaminant emission limits.

Atmospheric pollution can come from mobile and stationary sources. Stationary sources include waste treatment facilities and disposal operations. Many disposal activities are military-unique and include emissions from open burning and open detonation of energetic wastes; airborne contamination from expended ordnance; airborne lead and asbestos from demilitarization operations; and hazardous air pollutant emissions from ordnance manufacturing. Other stationary sources are release of volatile organic compounds from certain treatment processes; ozone-depleting chlorofluorocarbon emissions from routine operation of vessels; and emissions from jet engine test cells. Mobile sources include military aircraft that carry unique fuels such as hydrazine, hydrazine derivatives, and dinitrogen tetroxide.

Major products expected as a result of this research include advanced technologies to reduce current emission levels from daily military operations; instrument upgrades to adequately detect and monitor air pollutants and airborne contaminants as required by the Clean Air Act; a knowledge-based system for air pollution compliance strategies; and control technologies for ordnance manufacturing, fire fighting training facilities, and other operations.

Several technologies recently have been developed and tested to address atmospheric pollution compliance. The Naval Air Emissions Tracking System allows users to track various allowable emissions of air pollutants against actual operational data; these closely monitored operations can avoid emission violations. The Hopper Evacuation System, a modification to conventional mechanical particulate collectors (for coal-fired boilers) makes the standard collectors more efficient. In addition, when installed, new low nitrous oxide (NOx) burner retrofits for smaller (4-30 million Btu/hour) boilers have decreased military installation NOx output by at least 50 percent while increasing thermal efficiency by up to 5 percent.

Noise

Nearly every DOD installation that has a major testing, training, or operational mission has lost some capability due to noise. In some cases, entire operational or training missions have been forfeited because of the noise they produce. DOD-wide, it is estimated that at least 5 percent of the training and testing capabilities have been lost in this way. This represents many tens of billions of dollars in the net worth of major military testing and training installations.

Regulations and public pressure comprise the impetus for noise R&D. Already an important issue, public acceptance of objectionable noise sources and levels is expected to decline even more in the future. At the same time, noise impacts can be expected to worsen. New, larger weapons systems along with mission consolidations at existing installations will further exacerbate the problem. Adjacent land developments will hasten non-military land encroachment, bringing more civilian populations into noise impact areas. Preserving mission readiness will increasingly require credible, defensible information about human and animal response to noise.

The research will focus on active noise cancellation methods, integrated noise management, and the technology to assess noise health and behavioral effects on communities, individuals, and animals. Expected products include enhanced terrain models integrated into real-time noise level prediction; a noise warning system; guidelines for helicopter landing, hovering, and take-off to reduce noise impact at specific locations; and noise mitigation structures for guns.

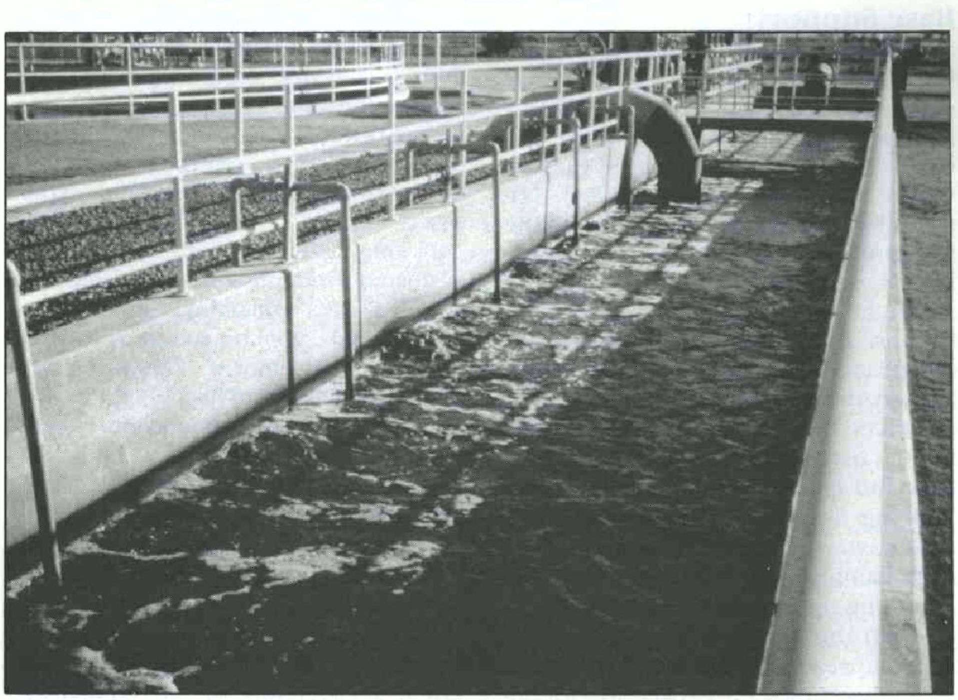
One R&D contribution to the Army's Integrated Compatible Use Zone (ICUZ) program allows prediction of the noise impact levels both within and beyond installation boundaries and characterizes the "hot spots" for noise problems based on existing land uses. Another ICUZ supporting technology is the Total Installation Noise Management Firing Information and Range (FIRE) system implemented at Fort Drum, NY, and Camp Grayling, MI. FIRE will add a noise management feature to the Range Facility Management Support System, which supports day-to-day range management. This integration of systems will place noise management in the trainer's hands. In this example, environmental compliance and mission accomplishment literally become a single package.

Global Marine Compliance

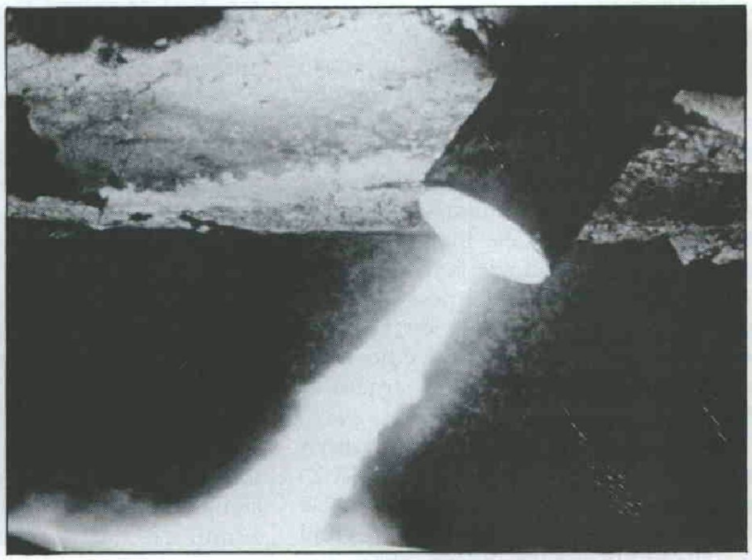
DOD must comply with all existing and anticipated marine regulations worldwide without jeopardizing ship mission, survivability, or safety. DOD ships and crafts produce human and industrial wastes similar to shore facilities. However, ships have a limited capacity to store and treat those wastes. While they traditionally discharged their wastes overboard, stricter environmental regulations at the international, national, and local levels are prohibiting this disposal method. Restrictions on ship waste discharge often interfere with fleet operations by limiting ship movements, requiring special provisions for waste offloading, and creating additional duties and risks for ship crews.

The Navy leads the Tri-Services thrust in marine compliance R&D, but the compliance needs are common to all Services. The need to provide for environmental monitoring/risk assessments, lower shore side disposal costs, and environmentally acceptable maintenance methods is part of the shore management of ships wastes thrust area.

Requirements for this area include the development of: remote sensing of the marine environmental parameters related to military operations; standard protocols for assessing marine environments; an understanding of the processes responsible for transport of contami-



Existing wastewater treatment facilities may not be sized properly to handle extra loading as populations are redistributed under BRAC.



Plasma arc vitrification holds promise for dealing with several hazardous waste disposal problems.

nants between the air marine and water marine sediment interfaces; an environmental contaminant spill and leak alarm; the understanding of the chemical, biological, and physical degradation process of contaminants in the marine environment.

Current work is focusing on the fate and effects of substances in marine environments; neural nets and fuzzy systems for marine ecological risk assessment; remote sensing pollution identification and characterization; and determining of the effect of acoustic emissions on marine mammals.

Base Support

DOD operates more than 100 industrial and training facilities on some 27 million acres of land. The base support area addresses compliance with the Clean Water Act, the Resource Conservation and Recovery Act (RCRA), National Environmental Policy Act, and the Safe Drinking Water Act on these installations.

The most difficult challenges in base support are associated with the RCRA compliance. DOD installations generate military-unique hazardous waste end products such as incinerator residue, lithium batteries, and ordnance, propellant, and explosives production waste. Training operations also generate hazardous wastes such as propellants and decontamination fluids.

Among the specific products expected from this research thrust are guidelines for treatment and control of storm water discharges and procedures for implementing integrated solid waste management at installations. Current research is assessing advanced techniques for end-of-pipe treatment of wastewater from the Army's industrial base such as membrane separation techniques, advanced oxidation, plasma arc vitrification, innovative bioreactors, and preparatory size reduction prior to incineration.

Membrane separation is being evaluated for control of nitrocellulose fines, which enter the wastewater stream from propellant production, and for liquid propellant component separation. Advanced oxidation processes at ambient temperatures are being evaluated for propellant wastewater treatment and for developing a model to predict process effectiveness. Advanced oxidation at elevated temperatures is also under study, including wet air oxidation for wastewater from trinitrotoluene production and super critical water oxidation for waste propellants and explosives.

Plasma arc vitrification also is being evaluated for treating concentrated hazardous wastes containing solids, such as heavy metals, which need to be isolated from the environment. This process is being evaluated for wastes such as specialized batteries, proximity fuses, and contaminated asbestos.

Leveraging

Although the projections for compliance R&D needs far exceed scheduled funding, many unfunded user requirements can be leveraged by taking advantage of reimbursable research. When a DOD site has an immediate, specific need not addressed in the Strategic Environmental Plan in a timely manner (i.e., legal action may be pending), that location may fund research that will provide information and expertise supporting the entire program without additional funding from Congress.

As an example, reimbursable projects from Fort Stewart, GA, and the Army Environmental Center contributed to an understanding of how military noise affects the Red Cockaded Woodpecker, an endangered species. These projects studied sensory stimuli (auditory, visual, vibration, short-term behavioral) versus long-term population responses. Results will provide critical cost-effective indices for later use in response models having the widest possible application in complying with the Endangered Species Act.

Conclusion

With more and more stringent regulations to be met and with severe manpower and budget cuts in DOD, compliance is becoming increasingly difficult. Technologies and management tools developed under the Compliance Pillar will help DOD installations achieve and maintain compliance with these important environmental laws while sustaining mission readiness.

For more information about this research program, contact Robert Lozar at the U.S. Army Construction Engineering Research Laboratories, P.O. Box 9005, Champaign, IL 61826-9005; 217-373-6739.

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ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROGRAM: THE CONSERVATION PILLAR

By Dr. Harold Balbach and Robert Lacey

For all agencies that hold and manage federal lands, the prudent, long-term use of those lands is a matter of extreme importance, both with respect to public opinion and execution of stewardship responsibilities. These responsibilities exist at many levels, including regulatory requirements, traditional land use planning criteria, accommodation of reasonable military mission needs, and fulfillment of professional goals. It is the need to develop tools with which to better manage the natural and cultural resources present on military lands that has resulted in the establishment of the conservation pillar within the Tri-Services Environmental Quality Strategic Research and Development Plan. The term "conservation," as used here, incorporates general land stewardship, preservation of endangered resources, and development of better means to accommodate the military mission uses of the land.

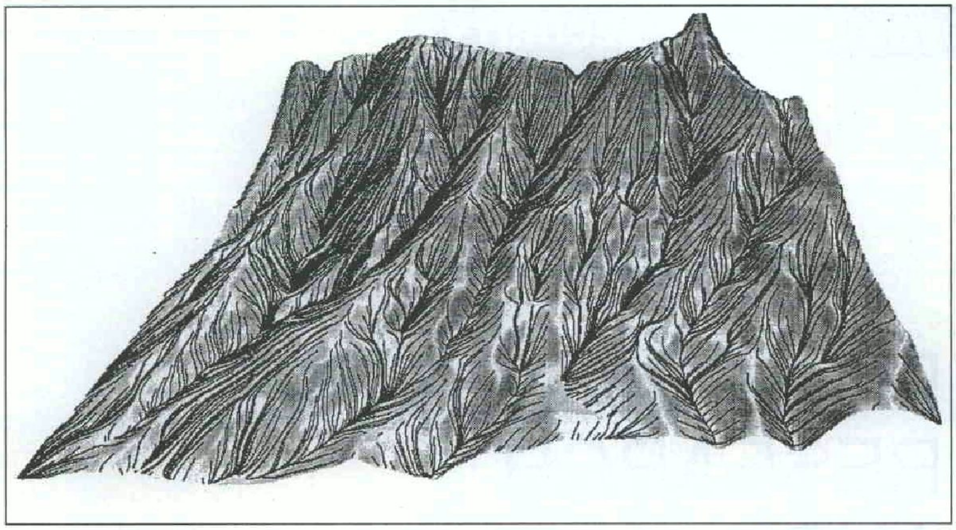
The future capability and function of the Army are being defined by a variety of factors and requirements. Among these are contingency deployment, readiness, downsizing, Base Realignment and Closure (BRAC) initiatives, and fielding of advanced weapons systems, many of which require much larger ranges. The need to effectively use and maintain the remaining military installation training and testing facilities and lands to support this future capability is pressing. These facilities and land will provide the platforms from which the Army must project itself to address future threats. One major concern in maintaining the use of facilities and land is management of their natural and cultural resources. These resources must provide the realistic training environment within which the Army will exercise and test its capabilities.

Conservation of natural and cultural resources is not only driven by functional requirements to maintain the force, but also by a variety of environmental legal requirements, including the National Environmental Policy Act, the Endangered Species Act, the National Historic Preservation Act, and a variety of state and local regulatory mandates. Another major driver in the management of resources is public concern for the environment. Management solutions to maintain readiness in the face of these requirements will often be based on development of new technology.

Within the Army, managed, direct-funded research into problems arising from the management of natural and cultural resources is not a newly identified need. Such research has been conducted by Corps of Engineers laboratories for more than 15 years. Overall, this research has been directed toward the following areas: measurement of the presence, quality, and quantity of natural and cultural resources as they might be affected by military activities; study of basic processes of natural, biological resources, particularly as they are affected by military activities; and development of the technology to mitigate and rehabilitate those impacts which result from execution of the military mission on Army lands, especially those related to field maneuvers.

Basis of the Need

The problems associated with land stewardship and management of the associated natural and cultural resources affect installations of any size, whether they have 10 acres or a million! In the 1990s, the Army must manage some 7 million acres of maneuver training land and another 4 million acres of test areas and proving grounds. At some installations, up to one-third of the maneuver land is eroding in excess of professionally accepted soil loss tolerances—in a few places, at 10 times the acceptable rate! It has also been estimated that, historically, about 0.25 percent of available training land has been lost to training each year due to excessive land degradation. What is "excessive" degradation? As an important example, these may be areas which are so eroded or devoid of vegetation that they can provide



Geographic information system output from an elevation model, where density of flowlines represents the spatial distribution of water flow.

no tactical concealment, thus making them virtually useless for realistic unit maneuver training.

Current, average land rehabilitation costs are as much as $500 per acre and can exceed $4,000 to $5,000 per acre for severely eroded areas. The total cost of the work required to return the Army's currently damaged maneuver lands to an acceptable condition is estimated to be over $1 billion using current technologies. The funds to apply to this need simply are not available. Improved, less expensive repair techniques are clearly needed.

In addition, some traditionally used test and training lands are gradually being lost due to requirements to manage and protect threatened and endangered species and cultural resources sites. This typically takes the form of making areas totally off-limits to training or limiting the type of activity so it may not be consistent with realistic training requirements. Current technology available to the installation training officer and land manager to address these problems and/or reduce their impact is inadequate.

Little is known about the impacts of military-unique activities on habitat and ecosystems. Habitat and ecosystem management techniques currently available for sensitive ecosystems fail to consider the requirements for continued use of an already shrinking land resource base. They tend to be species-oriented, conservative, and maximize the protection of resources at the expense of continued use.

Specific User Requirements

While the research and develoment community has for many years identified problem areas such as those presented above, the current approach being used in the Army to develop requirements for needed research is based on users' statement of their needs. In 1992, this process identified a total of 75 user requirements within the conservation pillar which related to management of natural and cultural resources on military installations. These needs were reflected in the 1993 Strategic Plan, and in the FY94 funded research initiatives. In September 1993, a similar process, involving selected Army installation participants, developed and ranked 51 conservation requirements. The categories into which the requirements are placed were developed by the Corps of Engineers laboratories and the Corps of Engineers Directorate of Research and Development.

Modeling and impact assessment techniques are required to protect and manage resources while allowing continued use for military activities.

Resource Characterization

Standard, scientific methods are needed to inventory, characterize, and monitor natural and cultural resources on military installations so as to: address natural and cultural resources elements such as geology, soils, groundwater, topography, vegetation, wildlife, wetlands, threatened and endangered species, historic resources, archeological resources, coastal and marine resources, climate, and land use; incorporate advanced, automated, remote field data collection and provide for rapid assessment of military impacts on these resources; allow for standard, automated data analysis that is relational, spatial, and temporal. These analyses would provide information on plant and soil interrelationships, wildlife and habitat relationships, evaluation of resource management methods, development of allowable use or carrying capacity estimates, and assessment of the functions and values of resources; and provide for standard, automated upward reporting of data and analyses suitable for use in environmental documentation.

Impact Analysis

Modeling and impact assessment techniques are required to protect and manage resources while allowing continued use for military activities. To this end, there are major identified requirements for: understanding the basic science of natural and biological processes as they might be impacted by military activities; developing techniques to predict and assess the impacts of military activities on cultural resources, including erosion impacts and protection from loss; modeling erosion processes to predict the impacts of military activities on soils and sediments and how these impacts might ultimately affect wetlands, water supplies, habitat, and archeological resources.

Mitigation and Rehabilitation

Technologies and approaches are needed to manage resources to mitigate and repair them when impacts from the military mission are unavoidable. Major needs in this area include: long-term, multiple-use management and land allocation strategies that incorporate environmental considerations into the training planning and scheduling process; standard guidance and management techniques for the assessment and maintenance of cultural resources, to include standards for curation; land rehabilitation techniques including revegetation methods to reduce impacts, manage and control sediments, and enhance training; improved management techniques for protection of threatened and endangered species, improved forest operations, and management of noxious species; and guidance for restoring and enhancing natural and cultural resources.

Current R&D Efforts

Research within the conservation pillar is performed primarily at the Corps of Engineers Construction Engineering Research Laboratories in Champaign, IL. One example of research within the conservation pillar is the effort being conducted by the Tri-Services Cultural Resources Research Center within USACERL which seeks to develop a three-dimensional modeling capability to locate prehistoric archeological sites. It combines the use of geomorphological field data, remote sensing, and analysis through use of a geographic information system (GIS).

All Army installations have known or potential prehistoric and historic archeological sites. If surface surveys have failed to identify these sites, training and construction activities are often halted when a previously unknown site is accidentally disturbed. Delays to evaluate and test the site can be lengthy and costly. The ability to predict and locate areas of high potential for buried archeological sites without requiring blind, total area land excavation, as is now used, could save the Army considerable time and money in complying with the many laws governing management of these sites.

In other research within the conservation pillar, new methods are being developed at USACERL to model and analyze land and water surfaces from point data. A major application of this technology is in preparing significantly improved ways to model precipitation runoff and soil loss from complex terrain. The basic equations will also improve digital elevation models, topographic representation, presentation of the spatial distribution of climatic changes, and the distribution of pollutants in surface and groundwater. As one product, a new method has been developed within the GIS environment to model spatial and temporal distribution of erosion and deposition of soil. This method incorporates the capability to perform erosion risk assessment for large areas of complex terrain, such as maneuver areas. The accompanying illustration shows graphic output of the elevation model.

Research within the conservation pillar is performed primarily at the Corps of Engineers Construction Engineering Research Laboratories in Champaign, IL.

One of the main focuses of the Conservation Program is the continuing development of Integrated Training Area Management (ITAM) methods. ITAM provides a "shopping list" of technologies to inventory and monitor natural resources on military installations; assess the impacts of activities on those resources; and mitigate and manage those impacts through passive means (e.g. interface with training, planning and scheduling activities and environmental education) or active means (e.g., revegetation and erosion control technologies). Elements of ITAM have been fielded at some 50 installations. Current R&D in this area is to enhance technologies through such efforts as refined database applications for inventorying and monitoring data, systems to identify the appropriate revegetation techniques for rehabilitation of lands, and testing of both physical and biological methods to stabilize and reduce erosion on sites that are used intensively (e.g. artillery firing points and bivouac sites). While the Army leads development of these techniques, the other Services, particularly the Air Force, identified requirements to adapt these technologies for their land management issues.

Another new initiative of the Conservation Program is the development of a programmatic strategy for threatened and endangered species (TES) management on installation lands. This strategy outlines the existing and required research needed to successfully address TES issues. Ongoing efforts are examining the width and breadth of TES impacts on installations, initially developing more standard inventory and monitoring techniques and assessing methods to proactively mitigate impacts. An important aspect of this work and the strategy is that it intends to pull in the knowledge and efforts from both the military and Army Civil Works Programs. Further strategic development will involve close cooperation and coordination among all DOD Services as well as those other government and private institutions with TES programs and initiatives.

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ENVIRONMENTAL QUALITY RESEARCH AND DEVELOPMENT: POLLUTION PREVENTION

By Robert Scola

Introduction

The Army's strategy for the 21st century reflects both national and international concern over the environment and an urgency to improve the quality of the environment. For the first 20 years of environmental regulation in the U.S., the focus was on the acute and visible pollution problems of air and water and the rapidly increasing problems of hazardous waste disposal. For years our environmental programs had an emphasis on end-of-pipe solutions. While we continue to manage the waste generated, pollution prevention has emerged as the key ingredient to gaining on reducing further contamination.

Incorporating pollution prevention into everyday activities is a major undertaking of changing both corporate and domestic cultures and having everyone understand that they can prevent pollution, whether at home or in the workplace. Pollution prevention is an evolutionary process and the Army and the Department of Defense have taken an aggressive role in developing both policies and programs to become leaders in this area. This evolution has been further accelerated by the generation of public laws, executive orders and DOD regulations as summarized below.

Key Pollution Prevention Drivers

The U.S. Congress enacted Public Law 101-508 on Nov. 5, 1990, (also cited as Pollution Prevention Act of 1990) because it felt that there are significant opportunities for industry to reduce or prevent pollution at the source through cost-effective changes in production, operation, and raw material use. Such changes offer industry and government substantial savings in reduced raw material, pollution control and liability costs as well as help protect the environment.

On Aug. 3, 1993, the president signed Executive Order 12856, "Federal Compliance with Right-To-Know Laws and Pollution Prevention Requirements," which requires each federal agency to take the necessary actions for preventing pollution with respect to that agency's compliance with pollution prevention as defined in the Pollution Prevention Act.

> Pollution prevention is an evolutionary process and the Army and the Department of Defense have taken an aggressive role in developing both policies and programs to become leaders in this area.

This includes developing voluntary goals to reduce total releases and off-site transfers of Toxic Release Inventory (TRI) toxic chemicals by 50 percent by 1999 and requires all federal agencies to develop a plan and goals for eliminating or reducing the unnecessary acquisition of products containing extremely hazardous substances or toxic chemicals.

Each federal agency must also establish a plan and goals for voluntarily reducing its own manufacturing, processing, and use of products containing extremely hazardous substances or toxic chemicals. This involves reducing the reliance on materials or processes that generate environmentally degrading pollutants or emissions. Included are life cycle issues in the acquisition of new weapons systems and addressing the environmental requirements of items currently in production. This involves developing new manufacturing processes, testing, maintenance and demilitarization techniques which use alternate processes and materials in support of Army materiel. Major R&D focuses are in the development of alternates for ozone depleting substances and priority toxics and in eliminating volatile organic compounds used in munitions manufacture, surface protection and equipment maintenance.

The U.S. Department of Defense has been proactive in pollution prevention and developed directives (DODD 4210.15, Hazardous Material Pollution Prevention and the revised DOD 5000

MAJOR POLLUTION PREVENTION FUNDING

STRATEGIC ENVIRONMENTAL RESEARCH & DEVELOPMENT PROGRAM (SERDP)

This program focuses on 6.1 (Basic) through 6.3a (Applied) research. The projects funded look for innovative technology solutions for DOD problems, both in industrial and non-industrial applications.

ENVIRONMENTAL QUALITY BASIC RESEARCH PROGRAM

This program focuses on basic research (6.1) in support of Army environmental R&D technology requirements and is closely coordinated with the SERDP program efforts.

SMALL BUSINESS INNOVATION RESEARCH PROGRAM (SBIR)

This program focuses on development of innovative solutions to Army and DOD environmental technology requirements by small businesses.

series for Systems Acquisition) to mandate the life cycle management of hazardous material starting from concept exploration through to ultimate disposal.

Tri-Service Plan

The technology user requirements identified in compliance with the above are being addressed in the Army's pollution prevention program and are incorporated into the Tri-Service Environmental Quality R&D Strategic Plan.

The Tri-Service Environmental Quality R&D Strategic Plan defines the DOD's leadership commitment and its philosophy for meeting present and future environmental challenges. It provides a framework to ensure that environmental considerations are integral to the Army and DOD mission and that an environmental stewardship ethic governs all DOD activities. It establishes a process for prioritizing requirements that define the DOD's R&D program. In addition, it provides an integrated, requirements driven investment strategy that leverages the capabilities of DOD laboratories, federal laboratories, other government agencies and private industry.

Industrial Operations

To support the Army's environmental strategy, the Army Materiel Command is responsible for developing and integrating the pollution prevention pillar of the Army's program. The Armament, Research, Development and Engineering Center (ARDEC), located at Picatinny Arsenal, NJ, has been developing the pollution prevention pillar in close coordination with the Army Materiel Command's Research, Development and Engineering Centers (RDECs), the Army Research Office, the Army Environmental Center and other key Army and DOD environmental and manufacturing technology resources. Close coordination has been kept with the Construction Engineering and Research Laboratories, Champaign, IL, for both the non-industrial portion of the pollution prevention program and to integrate projects impacting industrial operations in both the compliance and prevention pillars.

Very often compliance projects are complemented with a related prevention project which will either eliminate or minimize the waste as the technology is further developed and/or validated for specific applications. The Environmental Technology Office at ARDEC manages both the Army Pollution Prevention Environmental R&D Program and the National Defense Center for Environmental Excellence (NDCEE), an important DOD resource.

The Army and the DOD have many unique requirements that demand specialized, high performance materials that are often hazardous and whose mitigating measures have to be defined over the life cycle of the systems in which used. As environmental regulations and executive orders are further defined and better understood, restrictions on the use of such materials will increase and impact the mission of the Army and the other Services. This will necessitate material substitutions and changes to processes that may have been used for many years. Some examples of the above include: alternatives for ozone depleting chemicals, alternate paint strippers to eliminate the use of methylene chloride solvents and other hazardous constituents, cadmium plating alternatives, alternatives to chromium-based sealers currently used in anodizing of aluminum and enzymatic methods for synthesis of energetics which will eliminate the wastes from mixed nitration acids.

Requirements

Pollution prevention R&D requirements are generated from both current industrial operations and from those materials and processes specified in the product life cycle for new weapons systems. The program is broken into thrust areas focusing on common requirements and attainable technology solutions. The program development process involves collecting and prioritizing requirements, developing R&D projects, conducting user reviews (to bring users and R&D organizations to-

POLLUTION PREVENTION ACCOMPLISHMENTS

- **REVIEW OF SPECIFICATION DOCUMENTS FOR OZONE DEPLETORS**
- **IDENTIFICATION AND PRIORITIZATION OF INDUSTRIAL BASE AND MATERIEL DEVELOPER USER REQUIREMENTS**
- **INTEGRATED PROGRAM ADDRESSING ALTERNATIVES FOR OZONE DEPLETERS, CADMIUM, CHROMIUM AND VOLATILE ORGANIC COMPOUNDS**

gether), and a peer panel review to critique the overall program's technical merit and a program strategy which is then incorporated into the Tri-Service Environmental Quality R&D Strategic Plan.

Thrust Areas

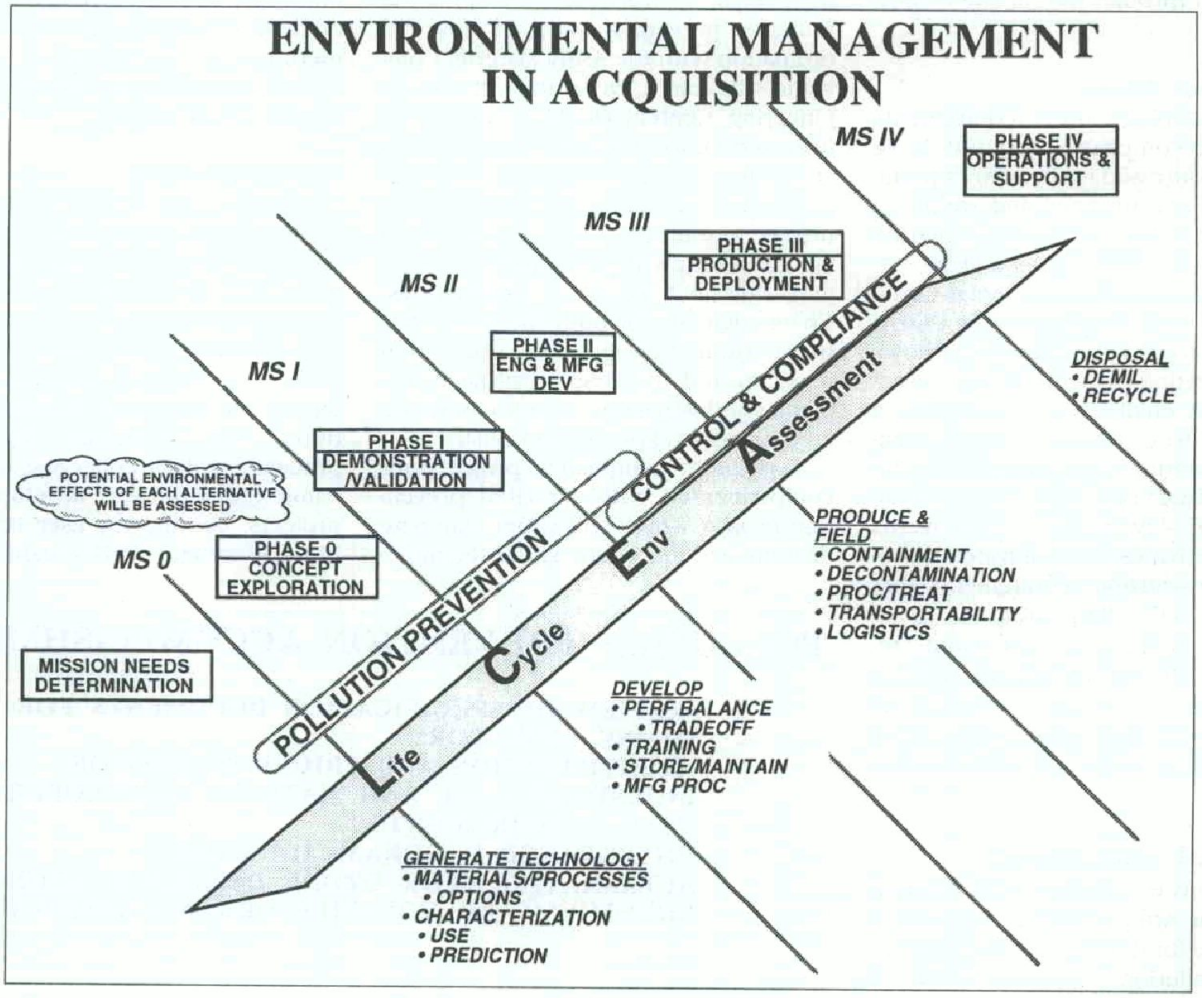
Due to the wide variety of materials and manufacturing processes necessary to support the Army's mission, the pollution prevention R&D program is broken into the following major thrust areas: surface protection, structural materials, energetic materials, ozone depleting chemicals, packaging, fabrication processes and chemical materials. Each thrust is headed by a thrust manger to oversee the timely completion of project definition, refinement and submittal into the various environmental programs with pollution prevention components. Major programs supporting the Pollution Prevention R&D Program are the Strategic Environmental R&D Program, Environmental Quality Basic Research Program, and the Small Business Innovative Research Program.

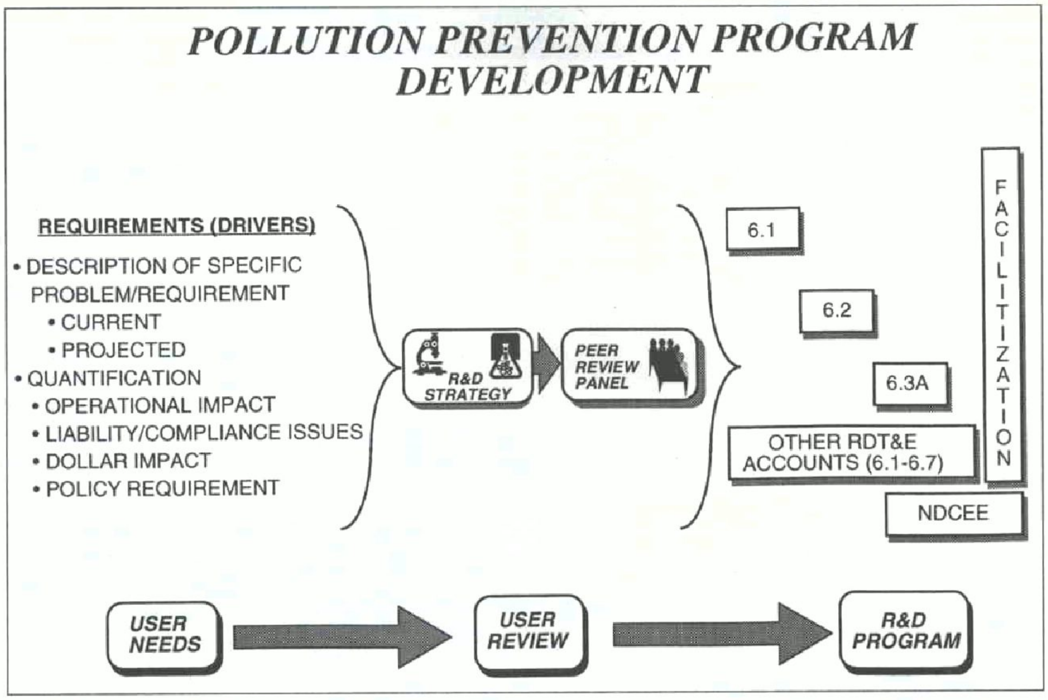
Non-Industrial Installations

The pursuit of materials substitutions and process changes in Army industrial installations can achieve significant reductions in the generation of pollutants emitted to the air, water and land. Targets of research are identified by either the quantity or disposal cost of pollutants generated. Less obvious, however, are the pollutants emitted by non-industrial installations. The criteria of quantity and cost are less specific in the identification of research targets of opportunity because the sources are often individually smaller and ubiquitously diffuse.

Pollution prevention-related research has been conducted for many years at the U.S. Army Construction Engineering Research Laboratories (CERL) in Champaign, IL. CERL has two laboratories which conduct research into the design, construction, operations and maintenance of facilities on Army installations and both laboratories support the concept of pollution prevention at non-industrial installations. The Infrastructure Laboratory conducts research which deals with environmentally-compatible construction materials, use of recycled materials in construction, reuse of materials salvaged from demolition processes, formulation of Army specifications for double-walled piping and tanks for underground storage of potentially hazardous materials including petroleum, oils and lubricants (POL). The Environmental Sustainment Lab has provided a number of tools which relate to minimizing the environmental insult of Army activities. Examples include the Environmental Impact Forecast System, The Environmental Compliance Achievement Program, model hazardous materials and wastes management plans, recycle/diversion of solid wastes to beneficial uses, and waste treatment technologies which in turn generate little residual waste.

Technologies which treat, reduce, or immobilize the residues from primary compliance treatment of wastes can also have the effect of pollution prevention through minimizing release of pollutants to any medium (air, water, or land). Additional opportunities for pol-





lution prevention stem from environmental education of the troops on our non-industrial installations. With proper knowledge of the environmentally-correct way of accomplishing mission-related activities, the troops can avoid creating significant environmental impact.

Center for Environmental Excellence

The National Defense Center for Environmental Excellence is a DOD center located in Johnstown, PA, with the Army designated as the DOD executive agent. The establishment and operation of the NDCEE is a vital part of the overall environmental strategy within the DOD and is a source of expert scientific, engineering, laboratory and demonstration factory services supporting the environmental technology requirements of DOD activities. The NDCEE's mission is to: transition environmentally acceptable materials and processes to defense industrial activities and private industry, provide training that supports the use of new environmentally acceptable technologies, support applied research and development where appropriate, to transition new technologies and to address high priority pollution prevention issues: Alternatives for Ozone Depleting Compounds (ODCs), volatile Organic Compound (VOC) reduction and toxics reduction and elimination.

Initially, the NDCEE will focus on implementing pollution prevention in industrial processes operated by the DOD, its contractors and suppliers. The main challenge in this effort is transitioning advanced, environmentally acceptable technologies from the laboratory to the shop floor. The projects for the NDCEE are solicited from across DOD and are screened by a DOD Working Group for technical merit and to avoid duplication of effort.

The Joint Environmental and Manufacturing Technology Working Group (composed of Service representatives representing both the environment and manufacturing science and technology) review candidate projects gathered from the DOD community. The Working Group then integrates these projects with others in the "Tri-Service Environmental Quality R&D Strategic Plan."

Summary

Operations at Army and DOD facilities (industrial manufacturing, rework and maintenance, and troop support) have to be studied for individual material and process use and involve the review of specification documents that impose either the hazardous material or process. For new systems, analysis early in the acquisition cycle is mandated to identify the use of hazardous materials and processes and to detail the user requirements for either new materials and/or processes. This analysis is to be performed not only by "environmental engineers" but also by the manufacturing, design, logistics, maintenance, facility and quality engineers (to name a few). This effort should be integrated into all quality circles and concurrent engineering and total quality management teams already in place.

The pollution prevention pillar is unique because it crosses not only the environmental community, but also the manufacturing technology and design communities to ensure that appropriate materials are used in all new and existing applications and systems, and that when necessary to continue the use of hazardous materials, that mitigating measures have been identified and programmed as necessary. With the implementation of Executive Order 12856, the integration of pollution prevention into all Army activities will ensure that we are truly stewards of the environment and prevent pollution and not just manage it.

ROBERT SCOLA is chief of the Environmental Technology Office, U.S. Army Armament, Research, Development and Engineering Center, Picatinny Arsenal, NJ. He has a bachelor's degree in industrial engineering from Pratt Institute and a master of science in management engineering from New Jersey Institute of Technology. He is also a registered engineer in New Jersey.

U.S. ARMY CIVIL WORKS ENVIRONMENTAL R&D PROGRAM

The Perfect Complement

By Dr. John Harrison

Introduction

The U.S. Army Civil Works Environmental R&D Program is well into its third decade of providing state-of-the-art technology to help meet national environmental goals. The program is based on the U.S. Army Corps of Engineers' (USACE) civil works missions of flood control and navigation with their many attendant development, regulatory, and stewardship responsibilities. The majority of the program provides unparalleled synergistic technology developments for civil and military applications in such areas as environmental impact analysis, natural and cultural resource management, environmental health fate and effects, non-indigenous species control, and wetlands delineation, evaluation, restoration, development, and stewardship.

The U.S. Army Civil Works Environmental R&D Program includes significant components in aquatic, coastal, wetland, riparian, and terrestrial ecosystems. Each of these areas is unique, but each is obviously interactive with the other and each is critically important to both the civil and military communities.

The next few paragraphs describe some of the principal components of the U.S. Army Civil Works Environmental R&D Program with examples of results and their applications.

Environmental Impact

The Environmental Impact Research Program (EIRP) began in 1970 in support of USACE's response to passage of the National Environmental Policy Act (NEPA). Although prior to NEPA there were significant environmental activities within USACE and the nation as a whole, NEPA required a more extensive and more quantitative understanding of predicted environmental impacts.

The EIRP retains its original focus of predicting and quantifying the environmental impacts of various USACE activities and reducing or preventing adverse impacts. Important areas of EIRP research include habitat management for various target species (including threatened and endangered species), cultural resource management (particularly protection and preservation), and coastal, riverine, lake, and reservoir transition zone protection and enhancement.

Natural Resource Management

Natural resource management research emphasizes the characterization, analysis and stewardship of natural resources and their total environments. This research includes application and integration of remote sensing, image processing and geographic information systems and satellite-based Global Positioning Systems; spatial data analysis and 3-D landscape simulation; environmental site characterization; environmental evaluation; management of public use of natural resources; wildlife ecology and their habitats; and stewardship. Natural resources research also contains a strong component in developing technology to better serve the uses of those who provide outdoor recreation opportunities to the American public. While USACE is the steward of less than 2 percent of the nation's public lands, corps recreational areas and facilities are the hosts to over 25 percent of the annual visitors who enjoy these marvelous resources.

Cultural Resource Management

All USACE offices and other agencies are being provided, for the first time, with extensive, practical guidance in multimedia form on the latest technologies and management strategies for protecting and preserving archeological sites from erosion, vandalism, and other serious threats. Low-cost protection alternatives such as ground cover, wetlands vegetation in riparian zones, log breakwaters, and burial are being perfected for use in upland, riverine, reservoir, and coastal settings. Such measures are urgently needed to enhance our stewardship of cultural resources and to reduce the inadvertent and deliberate destruction of large parts of our nation's historical heritage.

Wetlands

Wetlands research evolved as a separate effort from the EIRP in FY 75. In order to meet increasing national requirements, it was accelerated in FY 90 to provide significant new technology in better understanding wetlands processes, identifying and delineating wetlands, quantifying wetland functions and values, and enhancing, restoring and creating new wetlands. Three examples are representative of the avalanche of technology emanating from the wetlands research areas.

Standards Measuring the Success of Wetland Restoration. In FY 94, standardized demonstrated guidance for monitoring and measuring success of wetlands restoration projects will be furnished to USACE regulators and other federal, state, and local entities for testing. The standards will result in cost savings through faster processing of wetlands permits when restoration is used as a means of mitigation. Guidelines will also be applied to restoration projects used for managing or enhancing wetlands on federal lands.

Cumulative Impact Analysis. A cumulative impacts assessment procedure will be transitioned to all federal agencies. This is the first procedure that quantifies the cumulative impacts on wetlands functions or environmental quality due to loss or degradation of wetlands, wildlife habitat, and other wetland components. Cost savings are resulting from faster, better coordinated decision making throughout DOD and all other federal, state, and local users.

An **Inventory of Federal Wetlands Research** was compiled for the Committee on Earth and Environmental Sciences, Subcommittee on Wetlands Research, as part of the president's Wetlands Implementation Plan. The inventory allows acceleration of interagency cooperative efforts and minimizes unnecessary duplication.

The technology emanating from these and other wetlands initiatives has provided national and international guidance in the wetlands arena. The wetlands delineation manuals, which have been joint DOD, Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service, and Soil Conservation Service publications since 1987, base their technology primarily on the findings of this program.

Corps personnel receive wetlands restoration training at Duck, North Carolina.

Contaminated Sediments and Effects of Dredging and Disposal

Extensive technological advances have occurred over the last 20 years in identifying and assessing the environmental effects of dredging and dredged material disposal. While significantly less than 10 percent of the 400 million cubic yards of material that is dredged annually is seriously contaminated, this R&D has provided methods to effectively manage that small fraction. Furthermore, it has even developed and demonstrated numerous methods to use the material as a beneficial resource.

Although contaminated sediments represent only a small percent of the total, these sediments can pose a serious threat to aquatic organisms and, potentially, to human health through direct toxicity and bioaccumulation of toxic substances (e.g., dioxin) into organism tissues. If these materials cannot be managed successfully, the vitality of highly industrialized areas will be in question. As a beginning step in total sediment management, biological assessments are conducted to assess the extent of toxicity and bioaccumulation. This R&D has provided significant results in measuring and interpreting bioaccumulation results that have important environmental health implications.

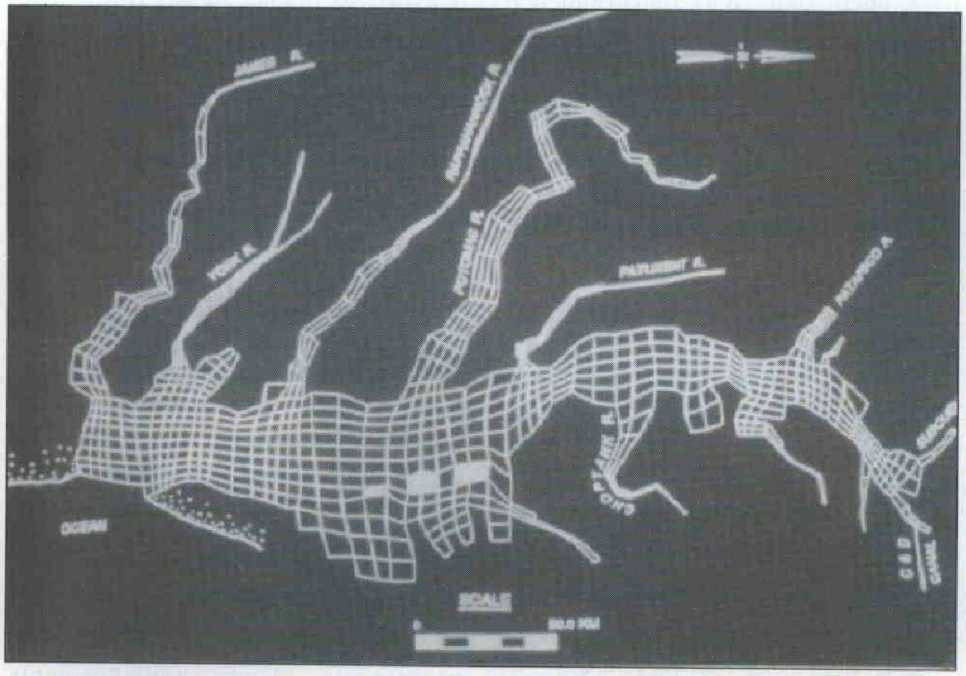
These results, obtained in complete partnership with EPA, have profoundly influenced national and international guidelines for environmentally sensitive waterway development and use. They have allowed the United States not only to maintain the passage of commerce, but also to provide environmental improvements. These enhancements range from providing offshore protection from damaging wave action, to nourishing beaches that need replenishment, to constructing and maintaining wetlands.

Much of the work in defining the fate and effects of contaminants in these sediments is being applied to cleanup problems within Superfund (managed by the EPA), to the Natural Resource Trustee activities managed by the National Oceanic and Atmospheric Administration, and to the cleanup activities within DOD at both active sites (installation restoration) and formerly used defense sites. Current research emphasizes a clear understanding of fate and effects of contaminants in sediment-water systems and risk-based approaches for managing contaminated sediments.

Water Quality

Water quality research that has been carried out since the mid-1970s has provided much-needed answers to help ensure that the planning, design, construction, operation, and maintenance of water resources projects provide the desired water quality. These projects involve impoundments in addition to natural lakes, rivers, estuaries and coastal zones. Closely related efforts are ensuring environmentally sensitive aquatic and marine habitats, including the safe passage of the nation's anadromous fisheries.

A particularly significant result is the recent development and demonstration of a 3-D hydrodynamic/water quality model of Chesapeake Bay. The study area includes the tidal portions of the bay and tributaries and includes parts of Maryland, Virginia, Pennsylvania, and the District of Columbia. Over the last several decades, the Chesapeake Bay has experienced a degradation in water quality marked by decreases in dissolved oxygen, enrichment of nutrients, and increases in organic and toxic constituents. A decline in fish and wildlife resources has also occurred. The EPA administrator requested active USACE involvement in 1986. The Chesapeake Bay Program Implementation Committee also passed a resolution in March 1986, requesting that the corps develop a time-variable model.



Surface cells used in developing the three-dimensional Chesapeake Bay water quality model.

The effort involved developing, demonstrating, and applying a numerical hydrodynamic and water quality model. The model simulates the bay's hydrodynamic circulation and water quality conditions three-dimensionally over time. Predictive scenarios involving numerous alternative management cleanup strategies are now being completed using the model. The USACE funded the hydrodynamic portion of the effort, and EPA funded the water quality portion. This work is the most significant advancement in the state-of-the-art in at least 20 years. Numerous technical "hurdles," considered by recognized experts to be impossible to overcome, were solved in this world-renowned effort. The Chesapeake Bay model is playing a major role in reestablishing our nation's largest estuary.

Evaluation of Environmental Investments

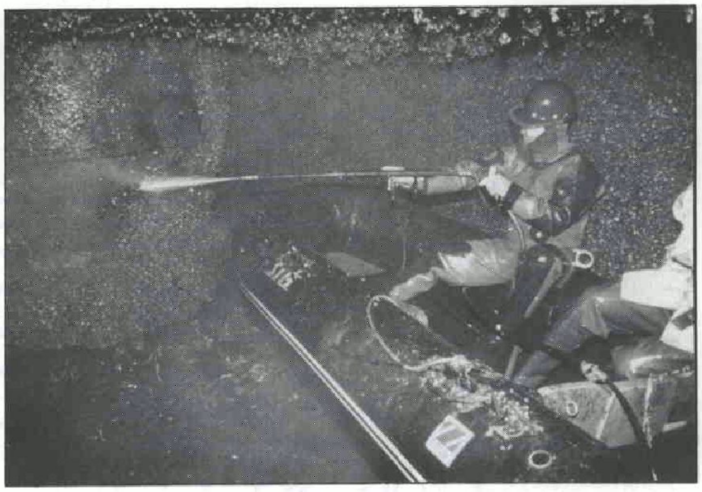
Our nationally increased awareness and concern for the protection and restoration of environmental resources brings with it the need for improved techniques for evaluating and comparing environmental projects and programs. To address these issues the USACE recently initiated a program to provide planners with methods and techniques to aid in developing supportable environmental restoration and mitigation projects and plans. This work will result in a framework to provide decision makers with information to facilitate the allocation of limited funds among a range of proposed projects and programs.

Non-indigenous Species Management

Non-indigenous species management has been focused in recent years on methods to manage nuisance aquatic plants and the recently introduced zebra mussel.

During its history, aquatic plant control research has evolved from providing the most efficient means of control as a mechanical harvester (much like an underwater lawn mower) to current technology which locates the weakest

This pipe filled with zebra mussels is typical of the problems associated with the pest.



Removal of zebra mussels from Detroit Edison's Monroe Power Station using high pressure water.

links in the life cycle of the plants and provides environmentally compatible biological means for attacking those links.

Through R&D and federal and state cost-shared demonstrations, cost-effective techniques for applying aquatic herbicides in flowing-water systems were successfully developed and demonstrated. These methods have provided greater than 50 percent cost savings while providing previously maintained levels of management.

Through partnering with the U.S. Department of Agriculture, effective populations of host-specific insects were established in several specific areas. These populations caused extensive, cost-effective, environmentally compatible management in a number of areas, reducing two of the four major problem plants to maintenance levels throughout the United States.

Basic and applied R&D with accompanying demonstrations is providing demonstrated management techniques for a much more recent invader. Zebra mussels were accidentally introduced in the Great Lakes from Europe in 1987, and have become a significant pest that gives all indications of reaching epidemic proportions in the next decade. The zebra mussel can attach with unbelievable strength to almost any surface with its proteinaceous byssal threads. It reproduces prolifically, and has spread from the Great Lakes to the Gulf of Mexico in the last five years. Its rapidly growing numbers pose a very real threat to block critical structures such as drinking water intakes and hydropower penstocks, attach to ship hulls (decreasing fuel efficiency), and accelerate corrosion on the areas to which they attach. It is estimated that the cost of operating affected facilities will more than double (to approximately $10 billion) by the year 2000 if efficient, cost-effective control methods are not rapidly developed and used.

The Zebra Mussel Research Program is quickly responding to these challenges by identifying and disseminating existing control technologies that are in use in Europe, where the zebra mussel is native, while also developing new control technologies for the organism's new environment.

Summary

The U.S. Army Civil Works Environmental R&D Program comprises a wide variety of efforts directed at solving the nation's civil works requirements assigned by Congress to the U.S. Army. Like its military counterpart, the Civil Works Environmental R&D Program is complemented by a large number of customer-requested efforts (reimbursably funded) to assist with specific problems within the customer's areas of jurisdiction. The interaction of the research program with these customer requests strengthens the R&D program by focusing and refocusing its objectives and priorities to the nation's users. The technology is often strongly synergistic for both civil and military applications in such areas as environmental impacts analysis, natural and cultural resource management environmental health fate and effects, and all aspects of wetlands.

DR. JOHN HARRISON is director of the Environmental Laboratory at the U.S. Army Engineer Waterways Experiment Station. He has more than 20 years experience in planning, developing, and executing major programs associated with all facets of environmental quality R&D. He holds B.S., M.S., and Ph.D. degrees in civil engineering from Virginia Tech, with graduate specialization in environmental engineering.

JEFFERSON PROVING GROUND UNEXPLODED ORDNANCE DEMONSTRATION PROGRAM

By Kelly A. Rigano

Background

Millions of acres of United States property are contaminated with buried unexploded ordnance (UXO). The UXO contamination (bombs, missiles, mines, projectiles, submunitions, rockets, etc.) has resulted from operations conducted at functional test ranges, impact ranges, training areas, and open burn/open detonation areas. A number of installations with known or suspect UXO contamination have been identified for base realignment and closure; some are formerly used defense sites, and many are active installations that are considering alternate uses for the UXO contaminated areas.

Current technology is labor-intensive, costly, and of questionable reliability. Therefore, the need exists to accurately and reliably assess the extent of contamination and possibly to remediate the contaminated areas. This need has become a priority within the U.S. government and the Department of Defense.

The U.S. Army Environmental Center (USAEC) has the mission of developing new technology which will combat the problems of subsurface UXO. USAEC has developed strategic approaches to develop state-of-the-art technologies for detecting, characterizing and remediating UXO contamination. This scope includes broad-based searches to identify UXO contamination boundaries and surveys for the detection of individual UXO items, all from a variety of air and land based platforms.

Congress, also, has recognized the need for UXO technology development and demonstration. In FY93, Congress specifically appropriated funds to conduct a UXO Technology Demonstration at Jefferson Proving Ground (JPG), IN, in FY94. Because of the USAEC's involvement in UXO research and development (R&D), as well as UXO technology transfer, USAEC was appointed manager of this effort. USAEC, in turn, tasked the Naval Explosive Ordnance Disposal Technology Division to aid in the conduct of this JPG Demonstration Program.

Program Objective

The objective of this technology demonstration program is to identify innovative and cost effective systems for the detection, identification, and remediation of sites which have been contaminated with UXO. These demonstrations are designed to compare data collected by demonstrators to the location of inert ordnance in the controlled test site. Each system will be evaluated and performance data will be documented. With this information, selection of the appropriate systems and organizational activities (both commercial and government) for characterization and restoration of sites can be made in an optimal manner.

JPG Demonstration Program

Site Preparation. Two separate demonstration sites will be located at JPG. One will encompass 40 acres and will be used for ground system (man-portable and surface towed) demonstrations. The other site, 80 acres, will be used for airborne system demonstrations. The test sites will contain documented inert ordnance at known, but unpublished, locations, depths and orientations. Much work has gone into the development of the ordnance layout plan for JPG. The most realistic conditions for ordnance depth and orientation emplacement were established in several ways:

- reliance on former and active duty explosive ordnance disposal personnel expertise;
- reliance on information provided by ordnance testing, training, and clean-up project managers;
- consideration of methods by which ordnance would have been implanted (type of ordnance delivery, whether items had been deliberately buried or abandoned);
- review of numerous technical reports;
- consideration of area geology. Both sites are situated on level ground and are covered with grass, shrubs, bushes, and small trees. Prior to demonstrations, both sites will be mowed to remove most small vegetation. After ordnance emplacement, the areas will be disked to present a uniform appearance.

Technology Demonstrator Selection. Several means have been used to solicit proposals for the JPG UXO Technology Demonstration. Written queries were sent directly to private companies known to be developing UXO detection, identification and remediation technology; synopses were advertised in the *Commerce Business Daily*, newspapers and various trade journals. Over 175 companies and individuals responded by declaring an interest in the program. Information packages have been distributed to all of these interested parties. The information packages contain details concerning the purpose of the demonstrations, objectives of the program, information concerning the preparation of proposals and appropriate details about JPG and surrounding areas. Selection of demonstrators will be made by a government panel based on technology innovation, applicability to meet long range clean-up goals, costs to demonstrate the system, and the history/background of the system development. Technology may be at various stages of development and maturity. All demonstrators will be notified as soon as practicable of the results of the selection process.

Technology Demonstrations. Contracts will be issued to private companies selected to demonstrate their UXO detection, identification and/or remediation technology. Each contractor will demonstrate their system on one of the two sites, attempting to detect all possible targets within their allotted area, or performing remediation of detected targets, and producing verifiable data that will be used to determine the accuracy and efficiency of the demonstrated system. Each demonstration will take place within an allotted five-day period after which the contractor will have up to 30 days to analyze the data and prepare a report that will be entered into the JPG UXO data base (see Data Collection and Analysis). All equipment preparations, system operations, encountered problems, and results achieved during the demonstrations will be recorded. At the completion of all demonstrations, performing contractors will be advised as to the results of their performance.

Data Collection and Analysis. A comprehensive report and computerized data base will be prepared. Documentation will include: site preparations, pre-test and post-test site conditions (e.g., soil moisture content, ambient temperature, humidity), emplacement of ordnance and debris, descriptions of the technology and systems demonstrated, summary of system operations during data collection, data collected during demonstration, and a comparison of data collected to actual site target information. Still photographs and video will also be taken during each demonstration.

Schedule. The timeline for this UXO technology demonstration program is shown below:

Solicitation for, and Selection of, Technology Demonstrators	10/93 to 3/94
Preparation of the Demonstration Sites	10/93 to 4/94
Technology Demonstrations	5/94 to 10/94
Final Reports Generated	8/94 to 11/94

JPG Program Benefits

This large scale demonstration project will allow for a thorough investigation of state-of-the-art UXO detection and remediation technologies. Controversy exists as to the amount of technology that is currently available within the private sector. This demonstration will address this issue. It should also be noted that firms outside the United States may participate in the JPG demonstration, allowing for a worldwide glimpse of available technology.

The systems at JPG will demonstrate their capabilities under realistic field conditions. The development of the ordnance layout plan ensures that realistic conditions for ordnance depth and orientation emplacement were established. Additionally, other items, to include metal fragments and non-ordnance items (beakers, glass bottles, metal cans and drums) will be present on site.

Because of the *controlled* test site conditions at JPG (inert UXO placed at *known* locations), it will be possible to "test" demonstrators. Reliability and accuracy estimates will be generated for each system/technology. Each demonstrator will be on equal footing and the same test conditions will apply for each.

It should be remembered that all technologies that are demonstrated during the JPG program, even if successful, may not be ready for direct field implementation and usage. Many of the systems demonstrated will be prototype versions. They may need hardware changes (field hardened component installation, etc.) or computer software changes, etc., before they are ready to perform detection surveys or remediation efforts on large parcels of land (hundreds to thousands of acres). One further benefit of this program, though, will be the identification of promising technologies not mature or ready for field work—these may be considered for further R&D efforts through USAEC.

The JPG UXO Technology Demonstration Program is an unprecedented opportunity to identify and test UXO detection and remediation equipment. The environmental community and the general public will gain from this program.

KELLY A. RIGANO is the U.S. Army Environmental Center's program manager for the Unexploded Ordnance Technology Demonstration Program. She has a B.S. degree in applied mathematics from the University of Tulsa and she graduated from the Army's School of Engineering and Logistics Product/Production Engineering Program.

Meeting Environmental Obligations...

THE X–RAY FIXER RECYCLING SYSTEM

By LTC James W. Kammerer and MAJ Ronald H. Nelson

The silver recovery system at the U.S. Army MEDDAC at Fort Ord, CA, came under scrutiny in November 1988, when the state of California filed a $1.0 million civil suit against Fort Ord for violations of hazardous waste regulations. Among other things, the state claimed that the unit recovering silver from used photographic fixer discharged from hospital X-ray film processors, placed our hospital in the same category as a hazardous waste treatment facility and was operating without a permit.

Photographic fixer is a liquid chemical mixture designed to stop the developing process, remove undeveloped silver from X-ray film, and harden the film so it has a smooth, hard finish. Exposed film is fed into a commercial film processor and travels through developer, fixer, and wash water. The film is then dried and exits ready for use. New fixer is continually added to the tank to replenish used fixer which, in a conventional system, goes through a silver recovery unit and is discharged to the sewer.

In response to the California suit, the discharge from the silver recovery unit was tested. Results showed that the conventional electrolytic unit connected to the used fixer discharge line was not efficient enough to make the used fixer non-hazardous before it entered the sewer system, let alone meet the local sewer code. The code stipulated that silver concentration in the discharge could not exceed 0.2 milligrams per Liter (mg/L). Equipment provided by the Defense Reutilization and Marketing Office would only extract silver down to 4.0 mg/L, at best.

A search was initiated to find a treatment system that would remove silver to the required level. All commonly used silver recovery technology was tried, including electrolytic plating, metal replacement and ion exchange columns. None was found that would do the job. Finally, the Defense Logistics Agency precious metals recovery representative for central and southern California suggested we contact a Canadian company that specializes in recycling used photographic fixer solution.

In the summer of 1991, representatives from Photochemical Recycling Inc. of Vancouver, British Columbia, proposed a system that recycled fixer while eliminating any discharge whatsoever. This system is designed to not only eliminate the discharge to the sewer, but also to eliminate the need for the system to be permitted or legally exempted as a hazardous waste treatment facility. This saves thousands of dollars in regulatory compliance costs.

Representatives from Photochemical Recycling demonstrated their system on Sept. 22, 1992, and the Silas B. Hays Community Hospital agreed to a no-cost contract that provided for a test and analysis. The equipment provided is a prototype design that is fully automated and is integrated into the radiology film processing system. Two tanks, one for used fixer and the other for reprocessed fixer, are connected in tandem to a central processing unit and a settling tank to collect silver sulfide sludge. A filtration device is also connected to further extract silver sulfide from the processed fixer solution.

To set up the system, an operator, in this case a radiology technician, first uses a color indicator test strip to test the fixer in the used fixer tank to determine the concentration of silver. Based on the reading, the operator sets the rate at which a reagent will be automatically added to the fixer to separate the silver and any other metals the used fixer may contain. The rate is set by pushing a switch on the central processing unit until the correct silver concentration appears on the display. Once the rate is set, the operator pushes a button on the central processing unit to start the cycle.

Used fixer is pumped through the central unit where reagent is added and combines with the silver in the fixer to form silver-sulfide. The mixture continues through a bank of filters to a settling tank where the heavier silver-sulfide settles to the bottom. The amount of silver removed from the fixer is proportional to the amount of reagent added; however, enough reagent is added to remove all but approximately 500 mg/L of silver. This, we believe, allows for minor errors in agent reducing and does not hinder the developing or silver removal process.

After a three-hour settling period, the central unit is programed to automatically pump the clarified fixer to the recycled fixer holding tank. In the event recycled fixer is needed before the three-hour period, the machine can be manually over-ridden by pushing a button. The clarified fixer is then pumped through the bank of filters to the holding tank.

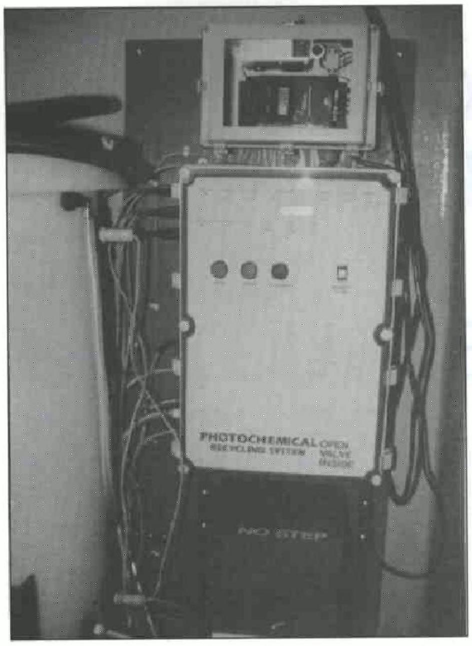
We tested the system with 40 liters of freshly made fixer. Approximately 25 liters of fixer were recycled each time for 10 cycles. The volume was kept low to speed up the recycling and testing process and we were able to recycle the fixer at least once a day.

During the test, we added hardener (aluminum sulfate) and sulfite after each regeneration. The hardener is used up in the fixing process so it must be replaced and the sulfite acts as a preservative. The reagent is mostly water and dilutes the fixer, so after the fifth and 10th rejuvenations, we added fixer concentrate to make up for the fixer removed for analysis.

Records were kept on the amount of fixer recycled in each batch, and on-site tests were made for specific gravity, grams per liter of silver (test strip method), and pH (test strip method). Film quality control tests were run daily to see if there were any changes in the processed film that could be the result of changes in the fixer. No problems were noted during the test with drying, artifacts, tackiness, or processor transport, and fixing times remained constant.

Samples of the test films run during the period were submitted to a film laboratory for analysis of residual silver to determine if the film maintained adequate archival qualities. The results of the analysis showed there were no archival quality problems.

A sample of fixer was taken before and after each regeneration and analyzed for a number of constituents that might indicate if the fixer was doing its job chemically and if the chemical mixture changed in any way when the fixer was regenerated which might cause problems in the future. Not only was silver removal extremely effective, but the pH was within acceptable tolerance levels for reuse.



The fixer recycling processor. Note the settling tank on the left. Fixer is pumped from the holding containers through the central unit where reagent is injected, then out to settling tanks.

Since the beginning of the test in September 1992, not one drop of used fixer has gone down the drain and X-ray film quality has remained constant. Chemical testing of the recycled fixer after the initial 10 generations showed that the chemicals primarily responsible for the fixing and hardening of the film remained at levels in the solution that will do the job. Silver was removed from the solution by the reagent just as desired and predicted.

If the recycled fixer becomes contaminated due to operator error, it can be turned in to the Defense Reutilization and Marketing Office as a hazardous waste. And should this occur, the system deduction is 50 percent because the fixer is reused instead of discarded. At 10 regenerations, the waste reduction was 90 percent. At the final writing of this paper, over 2,500 gallons of fixer have been recycled. No new fixer has been purchased, nothing has gone down the drain, and the system has shown no signs of coming to a limit.

The X-ray fixer recycling system installed at Silas B. Hays is a prototype system still under evaluation. Details must still be resolved relative to disposal of the silver-laden filter cartridges through government or private channels and establishment of a commercial distribution system for the reagent. However, the fact remains that this system, being a part of the X-ray film processing cycle, removes the hospital from the category of a hazardous waste generator or treatment facility. Spent fixer is recycled rather than discharged down the drain.

In summary, the only way to meet our environmental obligations and free our hospital from ever-tightening statutory constraints was not to discharge any waste into the sewer system. Conventional silver recovery technology could not bring residual silver content into compliance. In addition, hauling away spent fixer is cumbersome, costly, and potentially more hazardous in the event of a spill. Consequently, an alternative approach was needed. The system installed at Silas B. Hays Army Community Hospital not only recovers silver from the fixer solution, it recycles the fixer so it can be used again. Nothing goes into the sewer system. The hospital is exempt from hazardous waste permit fees, money is saved from the reuse of spent fixer, and the environment is a little cleaner.

DISCLAIMER: The article expresses the views of the authors, not the Department of Defense or any of its agencies, and does not change or supersede information contained in other Department of Defense publications.

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COMPOSITES FOR BRIDGING AND INFRASTRUCTURE RENEWAL

By Diane S. Kukich

Editor's Note: The University of Delaware Center for Composite Materials is part of a consortium that was recently selected to receive funding through ARPA's Technology Reinvestment Project (TRP). The goal of the collaborative effort is to investigate the use of composites for bridge infrastructure renewal and for the development of bridging systems and components for the U.S. Army.

Background

Over the past three decades, the defense and aerospace industries have helped create a remarkable group of materials known as composites, formed by the reinforcement of a matrix with fibers and/or particulates to achieve tailored performance profiles. Recently, however, stagnant traditional markets and defense cutbacks have led to a significant downsizing of the advanced composites industry in the U.S. Fueled by the fact that advanced composites have been recognized as a critical technology for U.S. national security and economic competitiveness, there is a growing effort to identify and develop new markets and applications for these materials.

At the same time, there is an increasing need for new materials within the civil engineering and "bridging" communities (in both the defense and civil sectors). A 1991 report by the secretary of transportation to the U.S. Congress reported that approximately 39 percent of our bridges are classified as either structurally deficient (23 percent) or functionally obsolete (16 percent), with the cost to eliminate these and future deficiencies estimated at close to $150 billion. (See Figure 1.) The National Research Council's Transportation Research Board recently estimated that improving the infrastructure by as little as one percentage point over a 20-year period would result in savings of $10 to $30 billion.

The DOD also faces substantial challenges in increasing the feasibility of rapid movements across inhospitable terrain. Weight and ease of placement of bridging components under harsh conditions and in combat have led to research in weight and bulk reduction while emphasizing performance gains. The Army has an ongoing need for lightweight portable bridges that can be laid down in the field where needed, crossed, and then re-deployed. (See Figure 2.) In addition, the Army Corps of Engineers is facing increasing needs for rapid bridging and crossing components during natural disasters. Thus, there is a tremendous need, within both the civil and defense sectors, for solutions to the problems of rehabilitating and strengthening current bridges and fabricating lighter and more durable new bridging and crossing components—needs that may be met by composite materials.

New research programs addressing these issues are all part of the current emphasis on dual-use technologies, a term that has come to refer collectively to spin-offs, spin-ons, and dual-use technology development, with technologies developed for one sector being transferable to the other or used simultaneously by both. In fact, the overall goal of the federal government's Technology Reinvestment Project, initiated early in 1993 under the joint sponsorship of five agencies, is "to stimulate the transition to a growing, integrated, national industrial capability that provides the most advanced, affordable military systems and the most competitive commercial products."

A large proportion of the current advanced composites technology, particularly in thick section and low-cost composites, was developed by and for the Army. Tanks and other armored vehicles, as well as bridges, demand materials that are thicker than the thin sections used for aerospace applications. The infrastructure arena is merely providing a new focus, enabling defense subcontractors and Army labs to focus efforts on dual-use technologies that would find immediate application in the civil sector while maintaining and enhancing America's competitive position in a critical technology area.

Figure 1.

The State of U.S. Bridges

Bridge Inventory	**576,665**
Backlog of Deficient Bridges	**225,826**
Structurally Deficient	**134,072**
Functionally Obsolete	**91,754**
Cost to eliminate current & future deficiencies	**$ 91B**
20 year cost	**$ 131B**
Average annual cost to maintain status quo	**$ 4.2B**
Estimated Current National Expenditures	**$ 5.0B**
Replacement / Rehabilitation (ISTEA)	**$ 2.7B**
Other Fed-aid, State and Local Funds	**$ 2.3B**

Civil Engineering Applications

Repair of existing infrastructural systems using concrete and steel is constrained by weight and time—adding weight to a degraded structure like a bridge deck can actually cause its collapse, and traditional repair/retrofit methods usually required closing the structure to traffic for substantial periods of time, which is not only inconvenient but also expensive in times of both peace and war. Therefore, retrofit/rehabilitation using composites is an attractive alternative, as the process is potentially quick and can be done without closing the structures.

Strong and lightweight, composites offer resistance to corrosion and chemical attack as well as increased service life, resistance to seismic events, and reduced maintenance, which translated into significantly reduced life-cycle costs. Other advantages include controllable thermal expansion and damping (vibration-reducing) characteristics and tailorability for strength, stiffness, and toughness. In addition, composites can be designed to be non-magnetic and non-conductive. All of these benefits can lead to safer, more durable structures that cost less to build and maintain if composites are correctly applied in rehabilitation strategies. Led by Associate Scientist Vistasp M. Karbhari, researchers at the University's Center for Composite Materials (CCM)—an Army Research Office/University Research Initiative Center of Excellence in the area of manufacturing science for polymer-matrix composites—are investigating some of the issues associated with transitioning this technology into the civil engineering arena. The research has been enhanced by collaboration with leading industrial firms and with colleagues from the University of California—San Diego. The following provides an overview of the work in this area.

Rehabilitation

One approach to the rehabilitation of columns and piers is wrapping with fiber-reinforced composites as advanced by the Japanese (Mitsubishi-Kasei and Ohbayashi Corporation). Karbhari's team is currently focusing on innovative wrapping methods and materials in an attempt to develop appropriate processes and material forms while simultaneously investigating fundamental issues such as bonding, environmental effects, and damage modes.

In a study funded by Hardcore Composites, the use of a unique resin infusion process is being investigated. Results of the research conducted so far have shown that the method can enhance performance by as much as 100 percent while increasing toughness and ultimate displacement. In other studies, the effects of a variety of environments (including marine and cold regions) on glass, carbon, and aramid wraps are being investigated.

The research indicates that the use of designed hybrids (composites reinforced with combinations of two or more fiber types) can replicate both the initial behavior and the ductile failure modes of reinforced concrete, while increasing the compressive capacity and overall deformation capability. This is significant, because the ideal in replacing one structural system with another is to keep the initial behavior the same while improving the performance. In order to investigate failure modes and damage characteristics, work is being initiated that will build on the results of a study on the influence of constraining pressure on thick-section composites being conducted by a visiting scientist from the Army Research Laboratory (ARL).

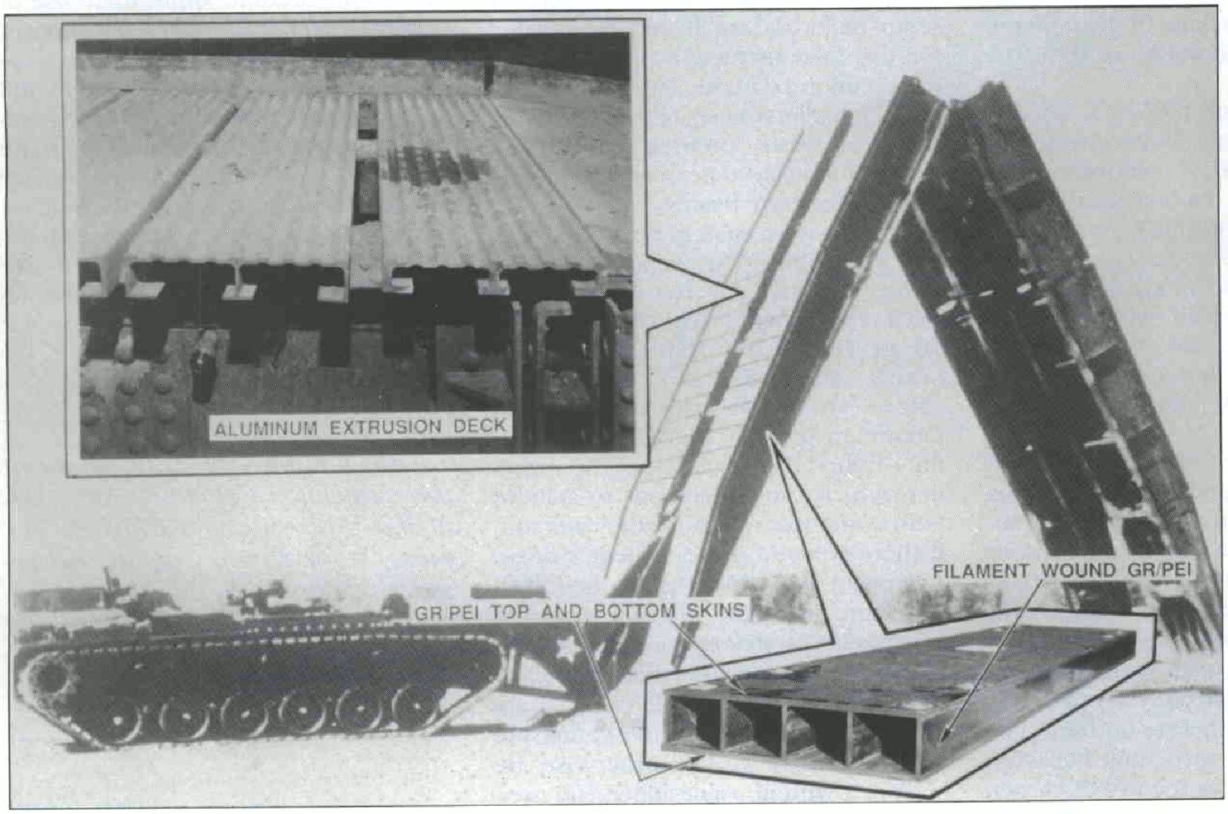

Figure 2. Use of composites in Army applications. Shown here is the Army Vehicle Launched Bridge.

In a project supported by the Delaware Department of Transportation, the researchers are studying the use of composite plates to rehabilitate cracked bridge girders. The goals of the work are to determine the causes of the premature cracking and then to develop a rehabilitation scheme to avoid costly bridge replacement. Preliminary tests indicate the feasibility of using carbon-fiber-reinforced composite plates for retrofit. The major advantage of this approach is that the bridges can be effectively rehabilitated without drastic increases in dead load. In a separate but aligned effort, the use of the resin infusion process for rapid field rehabilitation is being investigated. The technique has the potential to strengthen the structure through external reinforcement while simultaneously filling internal cracks with epoxy—similar to traditional cement grouting.

Reinforcing Elements for Concrete

Although steel is used extensively to reinforce concrete (usually in the form of rebar), it corrodes, particularly in areas like the Northeast Corridor of the United States, where deicing salts are used extensively, and in areas close to marine environments. Corrosion leads to expansion of the steel rebar, which causes tension cracking in the concrete and ultimate deterioration of the structure.

Ongoing research at CCM is aimed at:

- determining the bond characteristics of fiber-reinforced composite rebar;
- showing that mathematical models of fiber debond and pull-out are applicable to fiber-reinforced composites;
- predicting the flexural properties of a beam reinforced with fiber-reinforced composites; and
- developing a design methodology for composite-reinforced concrete structures.

This study is the first step towards establishing design guidelines for composite-reinforced concrete applications; such guidelines are critically needed because composite-reinforced structures cannot be designed using a one-to-one replacement for metals approach.

Karbhari and a team of undergraduate students are currently investigating the effects of weathering on bond efficiency and overall structural behavior. One project involves the use of carbon fiber roving as reinforcement for thin slabs and curtain walls, resulting in performance efficiencies not previously possible. The approach also significantly reduces cross-section and weight and eliminates the corrosion concerns associated with steel reinforcement.

In another project, members of the team are exploring the reuse of scrap composite in construction applications. This work shows promise both for satisfying environmental concerns about the recyclability of composites and for developing an effective, inexpensive composite reinforcing agent. Two classes of scrap materials are being investigated for use in construction applications—fiber-reinforced plastic (waste injection-molding pellets) as an aggregate in concrete and waste "prepreg" (preimpregnated composite tapes) as a reinforcement in concrete beams.

Preliminary results in both programs are promising. The scrap aggregate yielded a lighter concrete, with the optimal replacement level between 25 and 50 percent. The prepreg-reinforced beams were tougher, more flexible, and able to carry higher loads in tension and flexure. In addition, they failed in a ductile—rather than a catastrophic—manner, which can be difficult to achieve with composites because they are stiff. If these types of reuse strategies prove successful, two problems may be solved simultaneously—the waste disposal of composites as well as concrete deterioration and low performance. The technique could even provide a useful application for defense-related composite hardware that would otherwise be scrapped with no value-added end use.

Improved Bridging and Crossing Components

Recent studies have been aimed at the investigation of new materials, configurations, and processes for use in components for heavy assault bridges and traversing beams. With the focus on increased span and reductions in weight, time, and personnel use, the work is aimed at decks similar to those projected for the Army Vehicle Launched Bridge (AVLB) and Heavy Dry Support Bridge (HDSB) programs. Through the use of low-cost processes such as pultrusion and resin infusion, the group hopes to build strong, lightweight panels. Recent work shows significant potential for reducing the cost of components for military bridging and crossing. (See Figure 3.)

Figure 3.
Section of an infusion molded bridge deck.

Conclusion

The area of bridging and infrastruture offers immense potential for the use of composites—from both the civilian and defense perspectives. However, a significant amount of work remains to be done before these applications become reality—work that must be conducted at a developmental level with actual applications in mind by interdisciplinary teams cognizant of the unique problems faced by the civil sector and the military bridging community. Issues such as shape optimization, appropriate use of materials, and appropriate selection of manufacturing processes, as well as concerns related to fire protection and catastrophic failure, have to be addressed. However, it appears that in the next few years, this will be a major growth area for composites. Defense preparedness and bridges may seem unrelated, but the future will probably see these concepts merged through advanced composites technology.

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SECOND GENERATION FLIR: HORIZONTAL TECHNOLOGY INSERTION

By Dennis P. VanDerlaske and Samuel B. McDowell

The military value of first generation thermal imaging technology was proven many times over in Operation Desert Storm—U.S. forces "Owned the Night." Developmental efforts in the 1980s showed that advanced, second generation thermal imaging sensors or FLIRS (forward looking infrared) were ready for fielding and would provide significant performance improvements over currently fielded systems.

This superior technology, coupled with the demand to maintain the best-equipped soldiers in the world, provided the impetus to find affordable ways to introduce this capability into the force. As a result, in February 1993, the Army established a special task force (STF) to investigate and recommend options to lay the groundwork to integrate this upgrade across key Army weapon system platforms.

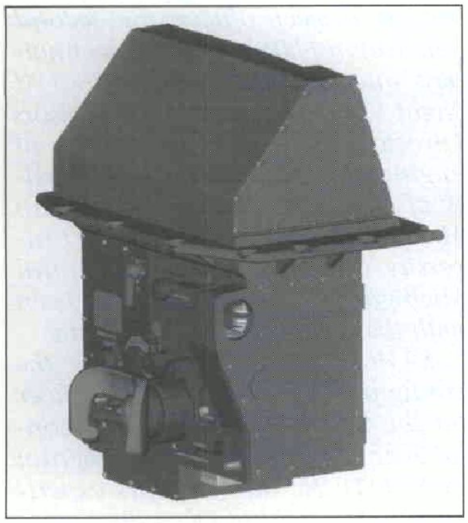
MG Jerry A. White, commandant of the Infantry Center and School, and George Singley, deputy assistant secretary of the Army for research and technology, served as chairpersons of the task force that was headquartered at Fort Benning, GA. Key roles in administering the group were played by the Dismounted Warfighting Battle Lab, Fort Benning, and the U.S. Army Communications-Electronics Command's Night Vision and Electronic Sensors Directorate (NVESD) under the leadership of MG Otto J. Guenther.

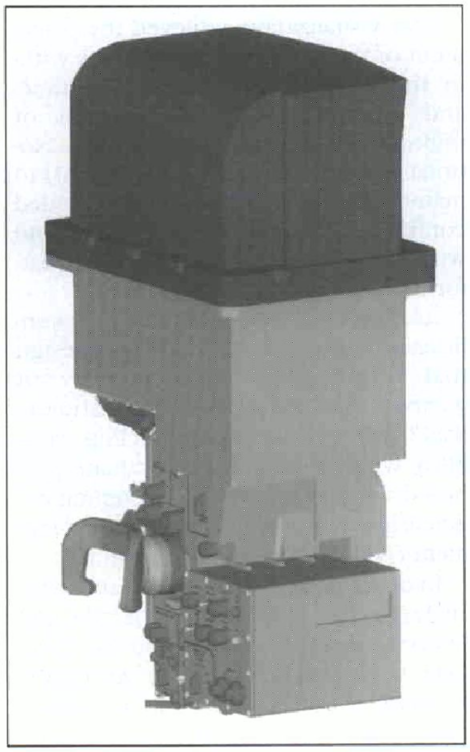
The issue of affordability of improved second generation thermal imaging technology for individual platforms was weighed against the need to provide uniform imaging capability across the battlespace for all participants. Other major considerations impacting affordability were new weapon system program stretchouts or outright cancellations. A new way of doing business was clearly required. The process used to establish requirements, set specifications and acquire weapon systems was investigated.

The STF proposed a multifaceted approach involving the following key elements:

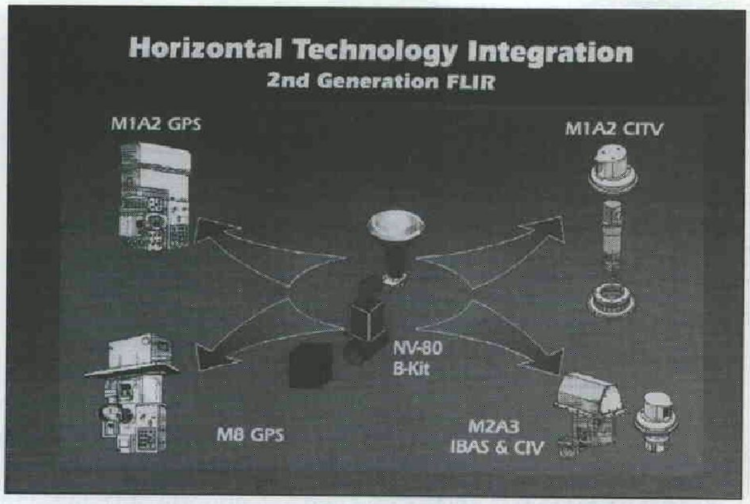
- emphasize retrofits of existing weapon systems or upgrades through engineering change proposals;
- consolidate multiple requirements into common banded requirements for weapon systems classes to allow the Combined Army Team to see the same battlespace;
- maximize commonality of hardware through a kit approach for advanced thermal imaging sensors;
- centralize the acquisition of common FLIR elements by the partnership of a Product Manager (PM)—FLIR with key weapon systems platform PMs (to include program and project managers);
- provide for interface to allow digital transmission of imagery throughout the battlefield;
- allow for other hardware and software improvements.

Participants from key user schools, development centers, program executive offices and PM offices, Army Materiel Systems Analysis Activity, TRADOC Analysis Command and White Sands Missile Range comprised the STF that convened in March 1993. NVESD provided technical matrix support. Consolidated requirements were assessed as to their capability to be met by practical configurations of second generation FLIR technology. Computer-aided solid mechanical modeling was used to eval-





Above is a solid model CAD for the M2/M3 Bradley Integrated Sight Unit. Right is a solid model CAD for the M1 Gunner's Primary sight.



uate opto-mechanical FLIR design approaches against weapon system platform constraints. The result was a "kit" concept that was further defined to meet appropriate banded requirements.

Specifically, the concept of an "A" and "B" kit was established. An "A" kit, comprised of hardware items peculiar to particular weapon system platforms, was designed to mate with a common "B" kit across a class of weapon system platforms. The common "B" kit will simplify logistics and reduce acquisition and life cycle costs, thus allowing the affordability required by new fiscal realities facing the defense community.

Host vehicle schedule constraints required that the STF formulate a program and acquisition strategy that was more than streamlined—it had to be aggressive as well as state-of-the-art at an acceptable risk. It also had to provide a certain confidence level that the approach chosen would meet each vehicle's sight system requirements.

The matrix support group took a concurrent engineering approach in that all elements of mechanical, optical, and electronic interfaces were addressed at the same time. All of these elements working together had to produce a kit design that would be virtually interchangeable among all designated systems.

Specifically, the requirement that the "B" kit work within each of the designated sights meant developing an optical configuration along with the mechanical interface of these optical elements while maintaining specified space limitations of existing hardware systems.

The best approach to achieve this requirement was by use of a computer-aided design (CAD) system that could produce a solid model of the "B" kit as well as all existing individual sight housings. Ten years ago this would have been a monumental undertaking which involved drafting multiple layouts with overlays of the housings and "B" kit designs in single dimensional views and drawings. This type effort is time-consuming and extremely labor intensive.

With solid modeling, the STF could visually rotate and place the notional "B" kit designs within the chosen housings and verify possible interfaces and misalignments with the housings. Three-dimensional views permitted the optical, mechanical, and electrical engineers to visualize what happens when circuit boards or optical mechanical devices are located in relation to one another.

This visualization achieved the placement of the components/modules within the housing, eliminating the time- and labor-consuming generation of multiple one-dimensional drawings. Notional designs were prepared via CAD to manufacturing tolerances and provided confidence that the kit concept would work in M1, M2, M8 and AH-64 platforms.

As a result, CAD gave the STF the confidence that a workable "B" kit design that interfaced with a number of weapon system platform constraints was feasible. This solid modeling capability will also be used to evaluate proposed designs during the upcoming engineering and manufacturing development (E&MD) proposal evaluation.

In-depth risk, wargaming, and cost analyses were conducted in parallel and periodic reviews with a two-star level User Advisory Group (UAG). An E&MD Program with a low-rate initial production option was formulated and briefed in July to the secretary of the Army (research, development and acquisition), deputy chief of staff for operations and plans, and finally the Army acquisition executive.

The E&MD Program will consist of a 33-month effort to build "B" kits and sights incorporating "B" kits (depending on the platform) with an accelerated test and evaluation schedule. The PM-FLIR will manage the procurement with strong NVESD support and UAG oversight.

Initial weapon systems slated to receive this upgraded technology are in the ground-mounted domain. These include the M1A2 Tank (Gunner's and Commander's Sights) and the M2A3 (Improved Bradley Acquisition Sight and Commander's Sight). A design for the M8 Armored Gun System is being pursued. In addition, selected critical component producibility efforts will be further enhanced. Contractual efforts are scheduled to begin in FY94 with initial production "B" kit deliveries scheduled for FY98.

This new concept of doing business is one of the first horizontal technology integration efforts to be undertaken by the Army. It will provide vital equipment and carry the warfighting edge the American soldier now enjoys into the next century in an affordable manner.

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SAMUEL B. MCDOWELL is the configuration management officer for the Generation II FLIR Horizontal Technology Integration Program at NVESD. He has 30 years experience in the field of DOD documentation for industry and government, of which 16 years were devoted to night vision equipment. He has served as an engineering manager, drafting manager and project leader.

WINNING THE INFORMATION WAR

The Army's Answer to Command and Control Warfare

By George Oliva Jr. and Theodore Pfeiffer

Introduction

The problem that the U.S. military faces in the foreseeable future is how to not only maintain, but more importantly, improve its military superiority given the political reality of shrinking defense budgets and down-sized force structures. America's 21st Century Army faces a broad range of challenges, rather than the focused threat previously presented by the Soviet Union.

Today, we are changing in fundamental ways to accommodate the new world and searching for force multipliers as we work to maintain our fighting edge. Defense cuts are dulling the fighting edge. The dramatic changes of an unpredictable and unstable world motivate the Army to examine and exploit advances in information technology.

The Army and its sister services believe that the opportunity to acquire a significant force multiplier lies in the exploitation of the exploding electronic and computer technologies that are at hand. In other words, defeat the enemy by "Winning the Information War."

MG Otto J. Guenther, commanding general, Communications-Electronics Command (CECOM), Fort Monmouth, NJ, has accepted this challenge and stated, "To win the information war, we must own the night, own the spectrum and digitize the battlefield."

Own the Night

To own the night, CECOM is developing new technologies, not only night vision devices, but also traditional and non-traditional sensors, which will enhance the Army's ability to identify targets and detect their movements. This, along with the capability to inhibit the enemy's ability to gather the same type information, provides information so that battle conditions can be assessed around the clock in all types of weather.

Own the Spectrum

Another element to winning the information war is the ownership of the electromagnetic spectrum. If we do not own the spectrum, there is a time delay in transmission and collection of information. We are attacking the time-distance element of warfare, which is pivotal to victory in battle.

To own the spectrum we are capitalizing on Electronic Counter Countermeasures (ECCM) and Low Probability of Intercept (LPI) technologies to protect our transmission of information.

Also, we have signal processing and radio collection technologies to exploit enemy information. This includes adding new capabilities to Guard Rail that will give us targeting accuracy against command, control and communication (C3) centers.

Through the employment of jammers we will deny the enemy the use of the spectrum. These capabilities, collectively, will enable our commanders to communicate when they must and allow the enemy to communicate only at our discretion.

Digitize the Battlefield

The digital battlefield is a total systems approach, integrating communications across all functional areas to provide the RIGHT DATA, at the RIGHT PLACE, at the RIGHT TIME. Digitization will enhance the commander's ability to make decisions in real time and provide a continuously updated "common view" of the battlefield. The other significant benefit will be the potential to reduce "friendly fire" or fratricide, through situation awareness. Situation awareness is the real or near-real time availability of information on friendly and enemy forces, in a battlefield environment.

Our sister services are also moving to adjust to new mission scenarios, requiring rapid troop deployment to trouble spots around the world, peace keeping, disaster relief and anti-drug operations. In an environment of shrinking defense budgets, inter-service cooperation is no longer a goal, it is a requirement.

Digitization of the battlefield will provide information automation across the battlefield, by harnessing the power of the microprocessor and, with insertion at all levels of the battlefield, we will be able to obtain and provide necessary information to those who need it at the right time.

Many military systems currently in use were designed using analog technology, dating back to World War II and do not have the efficiency or speed to cope with today's complex battlefield operations. How do we get from World War II technology to the new computer age?

Emerging digital technology inserted into computerized simulations in live battlefield scenarios will demonstrate battlefield identification, force synchronization, real time screen imagery, situation awareness and reduced fratricide. Maps and voices are converted into computer code and transmitted from one radio to another, which is the first step in implementing the digitized battlefield.

Digitization will not involve the development of new weapon systems but will result in a computerized digital command and control link between existing systems, resulting in one homogenous and integrated communication network.

The Command Control and Systems Integration Directorate (C2SID) at CECOM has established a program office to execute the "Combined Arms Command and Control-Advanced Technology Demonstration" (CAC2-ATD) Program.

The CAC2-ATD Program is the cornerstone project to "digitize the battlefield." In view of the complexity of the concept and the coordination required with other commands, a Special Project Office for Battlefield Digitization was also established.

The CECOM CAC2-ATD Program will establish, refine and evolve the operational requirements of the computerized command and control concept. A series of simulations and demonstrations will determine the architecture and establish proof of capabilities.

The Training and Doctrine Command (TRADOC) Mounted Warfighter Battlespace Lab will formulate the operational and functional requirements for the CAC2 definition and ATD execution. CECOM will develop the architecture, coordinate user requirements, design software to implement the database management information system, assist

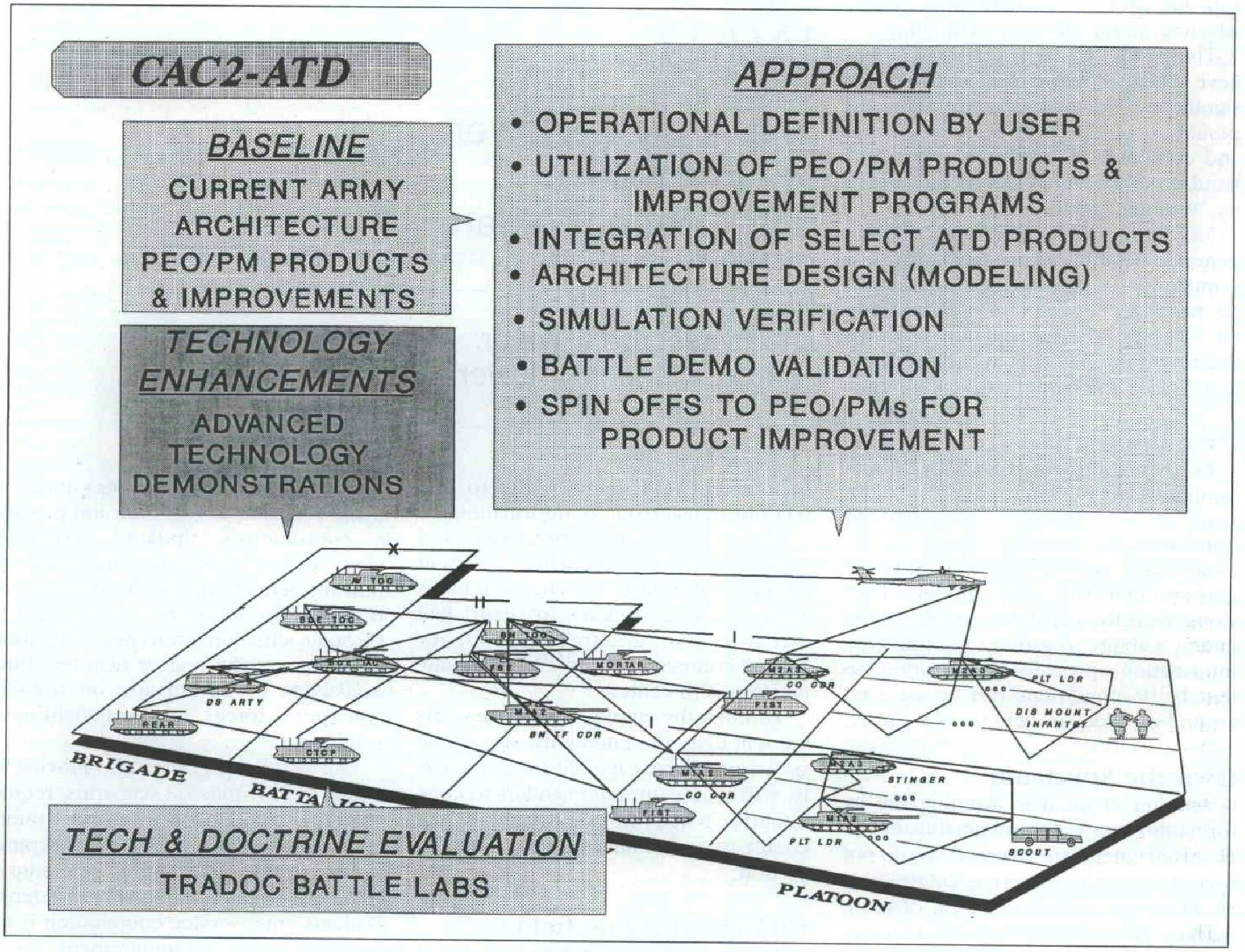
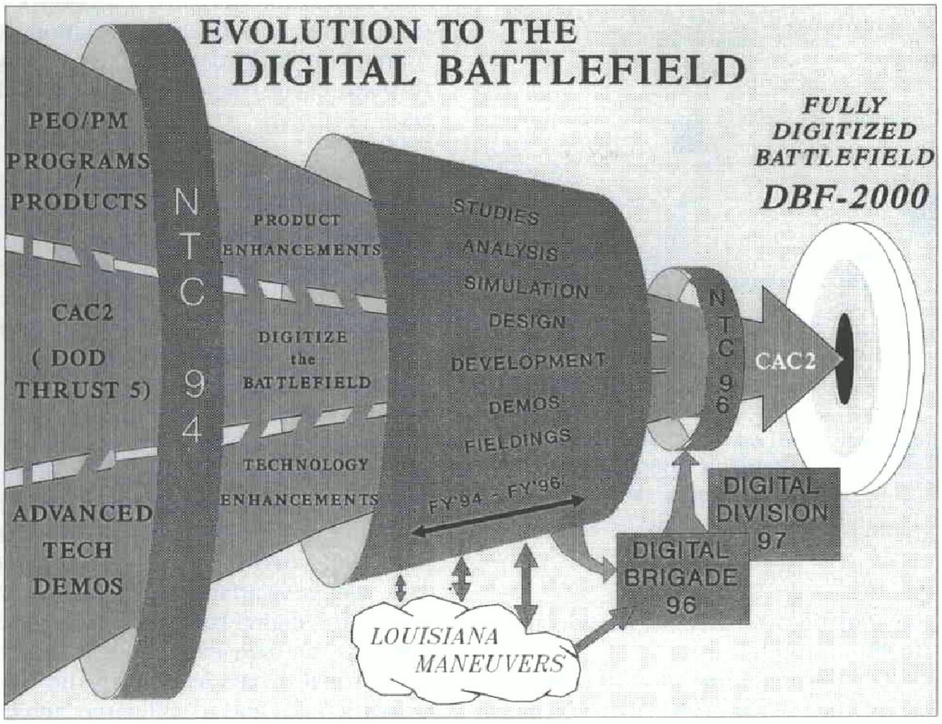


Figure 1.
The various combat elements in the CAC2 Advanced Technology Demonstrations.



in the implementation of TRADOC-approved enhanced simulation and demonstration scenarios, evaluate results of the demonstrations and consolidate the transition process.

The Common Ground Station effort will demonstrate the capability to provide timely and usable combat information and intelligence data to the brigade commander. The Global Grid concept integrates many elements to achieve a seamless network.

The Survivable Adaptive Systems ATD will provide the "pipeline," the communications assets, to enable automated C2 on the future battlefield. It will transfer voice, video and data to bring multimedia services to the warfighter.

The 21st-Century Land Warrior (21-CLW) Program is the latest soldier-machine interface effort to provide data and imagery to the warfighter in the field. In order to support the commader and enable him to get the most out of very powerful information management tools, a family of decision support products, such as the Air Land Battle Management system (ALBM) will provide planning aids to facilitate the execution of the battle.

The CAC2-ATD is closely linked with the Battlefield Combat Identification (BCID) ATD. The BCID-ATD will provide, among other things, a friend or foe identification capability that will be integrated with each platform weapon system. The combination of situation awareness and BCID capability will provide a greatly enhanced ability to reduce fratricide among friendly forces.

The Brigade and Below Command and Control (B2C2) program will provide for an extension of the Army Tactical Command and Control System (ATCCS) to include near-real time situation awareness, a common picture of the battlefield, a shortened mission planning cycle and other command and control (C2) enhancements for brigade and below.

Technology Challenges

The road to achieving a digitized capability is not an easy task, there are many challenges that must be overcome. These include the ability to gather data from many sources and appropriately fuse them into useful information for the commander; the ability to store, manage and distribute that information to the warfighter in a timely manner; the ability to have robust, extended range not only across the region of conflict but throughout our global sphere of influence; the ability to provide information to commanders in a way that satisfies their operational needs, be it a graphical situational awareness display in a fighting vehicle or a complex battle map in a command facility; the ability to know the location of friendly forces through the application of fully integrated Global Positioning System (GPS) and the ability to virtually eliminate casualties caused by friendly fire, by providing positive identification through situational awareness to all firing platforms. And if that's not enough, the ability to do this while on the move. These challenges are significant, and will require a concerted effort to make it happen.

Battlefield Information Architecture

The battlefield information architecture of the future for the lower echelons, while not completely defined today, must have a number of specific attributes. It will have a data base architecture which is distributed and appropriately tailored by echelon. The data base will be closely coupled to a smart communications architecture which will use multiple means to access information not readily available locally. Links to upper echelons will be seamless and transparent to the user. Links to the individual fighting platforms will be near real time and reliable. The end result will be the development and distribution of a common battlefield view that will be tailored to echelon and specific user platforms.

The CAC2 architecture describes the set of elements that, taken together, provide a comprehensive command, control, communications and intelligence (C3I) infrastructure to accomplish the complex battle management mission. The CAC2 architecture will include the following items: information flow requirements (source, priority, frequency, lifetime); message sets; communication protocols, net structure, connectivity; data base node locations; data dictionary; and data base management system.

How Do We Get There?

The CAC2-ATD is utilizing the approach shown below to achieve the objectives of digitization of the battlefield.

For the next several years, there will be studies, analyses, simulations, and warfighter demonstrations. A combined hardware demonstration will be conducted with Combat ID in 1996. Figure 1 illustrates, in scenario form, the various combat elements which are participants in the CAC2-ATDs. The focus is on providing front-line combatants the capabilities listed on the chart. The General Officer Working Group, co-chaired by CECOM and the Armor Center, with representation from TRADOC schools

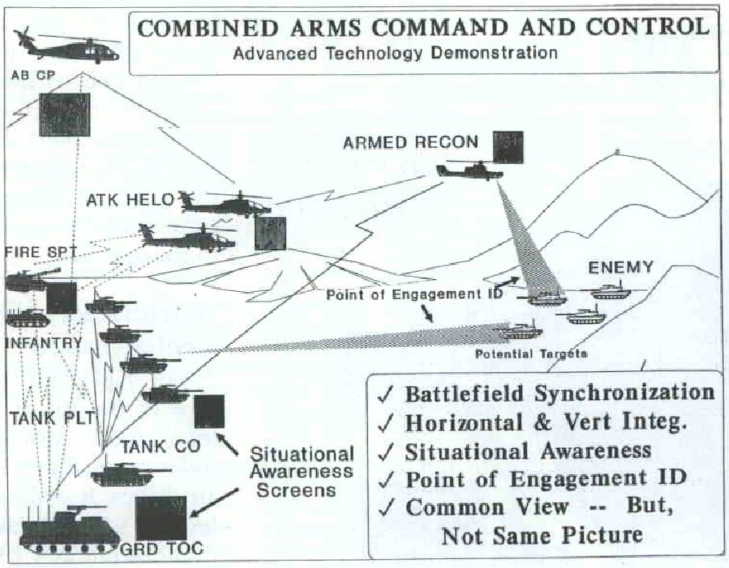


Figure 2.

and BattleLabs, Program Executive Offices (PEOs) and the material development community, will provide general officer guidance and recommendations.

TRADOC's Mounted Warfighter Battlespace Lab will formulate the technical and functional requirements for the CAC2 definition and ATD execution. CECOM, as the material developer, has assembled a number of teams to develop an architecture, coordinate user requirements, design software to implement a data base management information system, participate in simulation and demonstration scenarios, evaluate results of the demonstrations and develop a transition plan.

In addition to materiel upgrades, this development will include enhancements in doctrine, force structure, training and leader development. The "Information Age" has dramatically impacted the way we will fight. The Army will adapt methods of advanced information technology, making them as intrinsic to warfighting as any weapon. The "Information War" requires proper timing, digitized command and control, and integration of land, sea, air and space assets.

CAC2-ATD Program Status

There are currently many systems that are in the field or in development that address pieces of the digital battlefield. The CAC2-ATD is the program that will pull these diverse efforts under a common umbrella. It will seamlessly link these stand-alone systems to provide a lower echelon infrastructure which will build upon the significant hardware and software investment we have made over that last decade and integrate future efforts.

The best example of working together is the March 1993 Battlefield Synchronization Demonstration, which involved close coordination between the PEO Army Systems Modernization (ASM), PEO Aviation, PEO Communication Systems, PEO Command Control Systems (CCS) and CECOM to modify and integrate their systems to achieve horizontal integration. In addition, the Army Research Lab (ARL) is providing support to the data base design and PEO Intelligence Electronic Warfare (IEW) is working closely with us to integrate Combat ID information into the situation awareness capability for the follow-on ATDs.

The Mounted Warfighter Battlespace Lab is responsible for brigade and below in coordination with the Battle Command Battle Lab. To achieve the horizontal and vertical integration, all of the battle labs must be involved and share technical solutions as they emerge. In addition to having the CAC2 ATD conducted in conjunction with the Mounted Battle Lab, CECOM is planning on having all of its Advanced Technology Demonstrations conducted at the Battle Labs.

In order to effectively execute the ATD, the process must begin with a detailed analysis of user requirements. The CAC2-ATD Front End Analysis (FEA) is presently underway to address and define inter and intra-Battlefield Functional Area (BFA) digital information flow requirements resulting from horizontal integration to include Situation Awareness and Combat Identification requirements. Mission threads, functional requirements and User Information Requirements (UIR) data will be extracted through event triggered scenario analysis.

Summary

"Winning the Information War" through computer-generated graphics and software controlled communications architectures gives the field commander state-of-the-art tools to overwhelm a larger enemy force with a smaller synchronized force operation using a common view of the battlefield.

Horizontal and vertical communication integration will provide a real time link from the commander to the warfighter. The CECOM CAC2-ATD effort will answer the challenge of "knowledge warfare" with the realization of the digital battlefield. Figure 2 illustrates the road map of technical and operational events leading to the "digital battlefield" and to ultimately achieve a "fully integrated command and control."

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SMART MINES AND REMOTE CONTROL TECHNOLOGY

By Alan Epstein

Introduction

Modern technology is creating revolutionary new mines which will have a tremendous impact on the conduct of mine warfare. The application of new, high-powered computer chips and sophisticated electronics is creating an electronic battlefield, filled with small, powerful new mines which are intelligent, mobile and which can communicate with each other to network and plan strategy.

New communication systems incorporated into these devices will permit a two-way link-up between the deploying forces and the mine, and the mine will be able to gather and provide intelligence, as well as execute commands. Mines in the next century will be mounted on mobile platforms, will incorporate artificial intelligence, and will create an autonomous, three-dimensional, mobile offensive/defensive capability. This article describes some of the near- and far-term developments which are changing the way mine warfare will be waged.

Background

Mines have been developed to counter the overwhelming high speed mobility and firepower advantages of mechanized armor. New technology, which brought improvements in mechanized armor, also permitted the development of a new breed of small, lightweight, highly effective scatterable mines, known as the Family of Scatterable Mines (FASCAM). Theses mines had built in self-destruct times, and could be deployed from a variety of carriers ranging from artillery to ground vehicles to fixed- and rotary-winged aircraft. FASCAM created new opportunities to use mines in an offensive mode and long-range delivery systems (artillery, rocket, aircraft) permitted emplacement behind enemy lines.

These first generation anti-tank (AT) mines employed very simple magnetic sensors and logic circuits to accomplish their objectives. However, they were unable to distinguish between friendly and unfriendly vehicles and were generally susceptible to countermeasure by magnetic simulation devices.

> Mines in the next century will be mounted on mobile platforms, will incorporate artificial intelligence, and will create an autonomous, three dimensional, mobile offensive/ defensive capability.

Sophisticated anti-personnel (AP) scatterable mines were developed as companion assets to protect the AT mines and make them harder to clear. Unlike the old style conventional mines, which generally defeated the track only, FASCAM mines were full width, functioning in the shadow of the vehicle (required the vehicle to directly pass over the mine in order to be initiated). Side attack mines were also developed using a rocket to fire a projectile into the tank or an explosively formed penetrator (EFP) to penetrate the side of the tank. The Modular Pack Mine System (MOPMS) incorporated a one-way command link which permits remote control mine deployment and command self-destruction or Self-Destruct timer reset of the deployed mines.

Second generation mines have taken advantage of technology advances to use a variety of sophisticated sensors and complex algorithms to identify and track the vehicle and to attack it from a standoff distance. These mines can attack their targets from a non-line-of-sight and are, thus, very difficult to detect and countermeasure. The first of these systems in development, the wide area mine (WAM) has the capability of attacking targets from a 100-meter standoff. WAM differs from previous mines in that it is a top attack, non-line-of-sight munition. The Anti-Helicopter

Mine, currently in tech base, can similarly attack its targets from a 100-meter standoff.

Wide Area Mine

Currently in development is a radically new, intelligent WAM, which is effective over a 100-meter radius. This means that one mine can effectively defend an area of more than 30,000 square meters. WAM consists of a ground platform and explosive submunition, which is launched from the ground platform over the target. The ground platform's seismic and acoustic sensors monitor the environment and provide information to an onboard microcomputer which identifies the target, computes an intercept path and launches the submunition over the target. The submunition's onboard sensor locates the target and fires an explosively formed projectile at the top of the target. The first generation WAM is a hand-emplaced version, which uses the MOPMS command link technology to remotely activate and command self-destruct the mine. WAM also incorporates a self-destruct time feature which permits selection of one of a number of factory preset self-destruct times.

Next generation WAMs will incorporate a new communication system which will permit two-way communication with the mine. This means that the mine may be queried to determine whether the commands have been received and acted upon.

This capability provides the additional required reliability to permit incorporation of a turn on/turn off/turn on feature. This last feature will provide unique tactical possibilities to the battlefield commander, for the mine can be used as a sentinel to permit safe passage to friend while denying the terrain to foe.

Two-way communication also provides the potential of developing a network among various WAMs, deployed in a given area, to insure that only one mine attacks a given target. Networking also offers the possibility of developing an Intelligent Mine Field (IMF), in which mines confer, develop strategy and initiate a coordinated attack upon a group of target vehicles. Second generation WAMs will be deployed from Volcano dispensers and from missiles, in a deep attack mode.

Fielding for the first generation, hand-emplaced, WAM is scheduled for 1997. Second generation WAMs to be deployed from Volcano and missiles will not be available until the early 2000s.

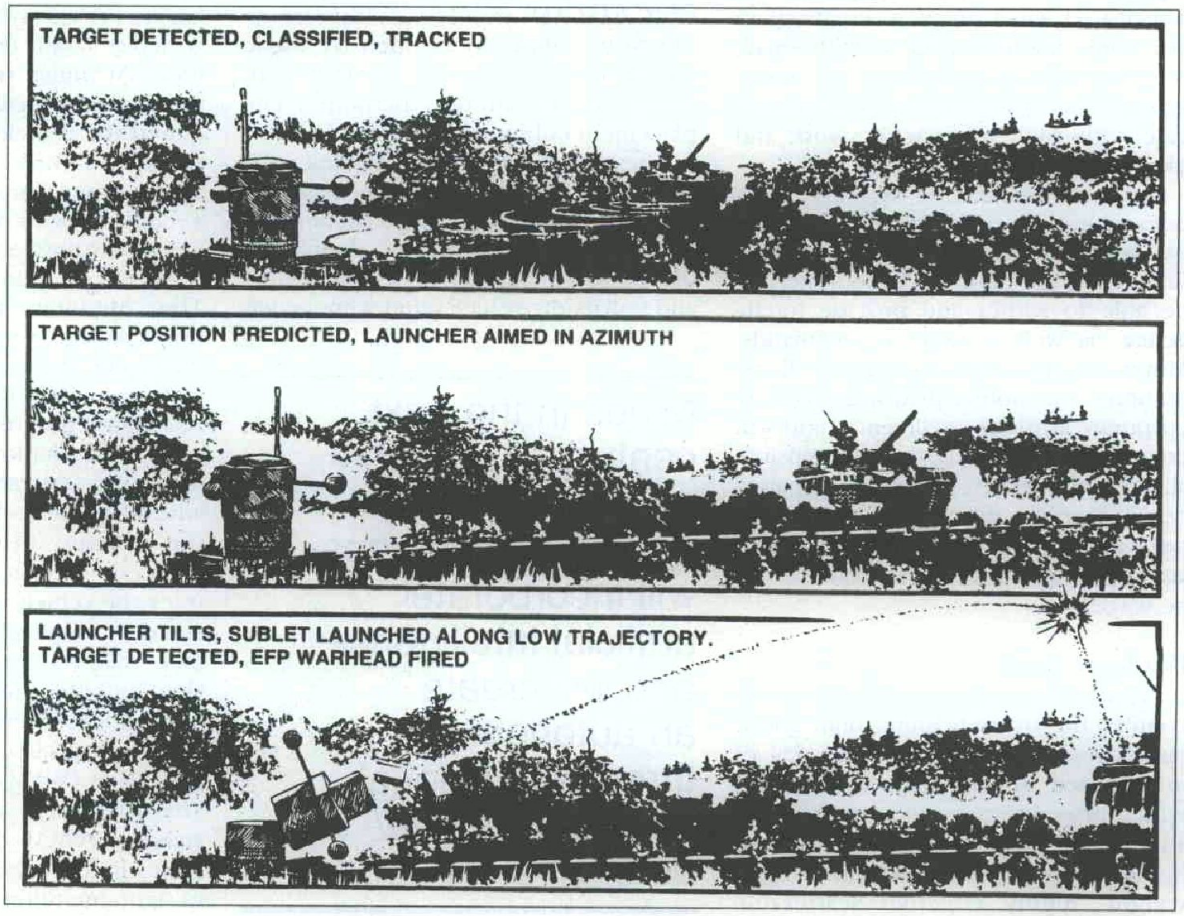
The Anti-Helicopter Mine

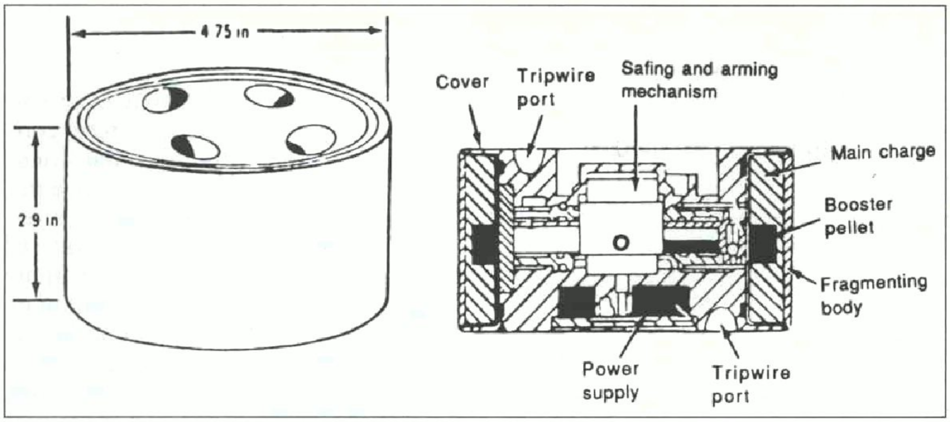
The Anti-Helicopter Mine (AHM) is an area defense mine which will attack helicopters flying nap-of-the-earth. The AHM will attack helicopters within a 100-meter spherical radius. Helicopters attempting to avoid attack will be forced to fly at higher altitudes where they lose the element of surprise and can be acquired by other air defense assets.

AHM uses an acoustic sensor to track the potential target, an infrared sensor to acquire the target and a microcomputer to discriminate between potential friend or foe. Some form of IFF (Identification Friend or Foe) feature, either active or passive, will be incorporated into the system. AHM, like the second generation WAM, will incorporate a two-way command and control communication link and a remote turn on/turn off/turn on capability to allow the use of the munition in various tactical situations.

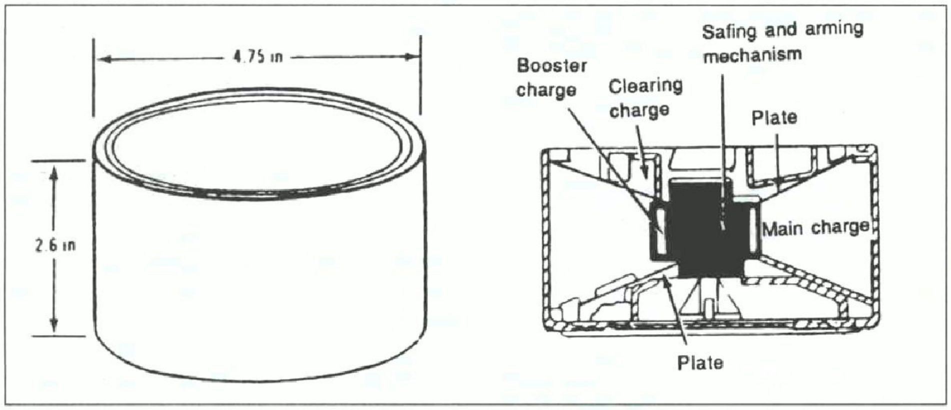
AHM is currently in tech base under Advanced Research Projects Agency management. Fielding of this mine is expected in the post-2000 time frame.

WAM target engagement sequence.





Antipersonnel mine.



Antitank mine.

Future Systems

Systems to be developed in the post-2000 time frame will extend minefield capabilities by increasing range, mobility, autonomy, and communication ability. Advances in sensor technology will result in systems such as a Very Wide Area Mine (VWAM), which can detect, classify, and engage air and ground targets at a range of one kilometer or greater. These systems will use smart maneuvering submunitions and highly lethal warheads to enhance the probability of kill at these ranges. These systems will communicate with each other, with local artificially intelligent controllers, and with user consoles employing artificial intelligence aids to minefield planning and management. This communication capability will enhance the effectiveness of minefields with cooperative tactics, such as ambushing (allowing many vehicles to enter a minefield and then simultaneously engaging all of them), entrapping (activating bands of mines around a penetrating force), and filtering (attacking only selected classes of vehicles).

The ability to communicate with the minefield and turn it on and off with a high degree of confidence will enable the user to control the status of the minefield to attain complete mobility flexibility. Future systems will be deliverable from air and ground manned platforms, as well as from robotic autonomous vehicles. Robotic systems will be used to maintain, as well as recover minefield units. This capability will avoid risk to personnel and reduce manpower support.

The increasing sophistication, mobility and decision-making ability of future mine systems, artificial intelligence modules, and robotic handlers will be combined to create autonomous expert mine systems. These expert mine systems will be capable of networking, conferring, electing a lead module and organizing themselves to plan and execute tactics appropriate to the situation. Expert mine systems mounted onboard unmanned aerial vehicles and unmanned ground vehicles will be capable of patrolling vast areas to gather and report information, and attack unwanted intruders. These robot warriors may well be contending against both enemy-manned and unmanned robotic counterpart systems.

Future warfare may see an increase in both the number and variety of robotic systems to be developed and deployed. As autonomous systems proliferate, new countermeasure devices will be developed. It may be possible to develop autonomous robotic countermine devices, which will stalk and destroy enemy robotic mines. It may be possible for such autonomous robotic countermine devices to implant computer viruses into enemy artificial intelligence systems to confuse, delay, destroy or subvert their operation. Autonomous mine systems which have been so corrupted may provide false information and even directly attack their users.

New Technology

All the systems discussed above rely on the expansion of current technology in sensors, new materials, software, electronics, artificial intelligence and, most especially, improvement in power sources. Limitations due to current battery technology, alone, put these systems years into the future. Future systems will make use of new energy modules to provide them the power and long life required for execution of their missions. The complexity and high cost of future systems will demand increased computer modeling and simulation at each stage of the process. Systems will have to be played off against each other to determine the most effective investment and the implications in investing in a given system.

Extensive care will have to be given to ensure the use of high reliability components to prevent systems from going out of control and attacking their own users. New ethical considerations will become apparent once these autonomous artificially intelligent systems are brought to life and let loose into the environment. The future is interesting to say the least.

ALAN EPSTEIN is a project officer in the Office of the Project Manager for Mines, Countermine and Demolitions, Picatinny Arsenal. He is responsible for the development and acquisition of new mines and demolitions systems.

PROTECTING THE SOLDIER WITH HIGH TECHNOLOGY FIBERS

By Thomas H. Tassinari and Dr. Ronald S. Perry

Introduction

Fibers are the key building blocks in the construction of a vast array of textile materials used to protect the soldier. In recent years, new and improved high-technology fibers have been developed to improve soldier protection. These are used to make advanced materials that are stronger, lighter, more heat resistant and more durable than those made with conventional fibers.

The importance of textiles in protecting the soldier is best exemplified by the work carried out by the U.S. Army Natick Research, Development and Engineering Center at Natick, MA. The Natick RD&E Center and the Navy Clothing and Textile Research Center, also located at Natick, comprise the "DOD Center of Excellence in Clothing and Textile Sciences and Technology" (Project Reliance). The Natick RD&E Center is responsible for a wide range of textile materials that go into hundreds of end-items. Approximately 600 material specifications are managed at Natick to support approximately 1,600 items used to protect and sustain soldiers. An overview of some commodities supported by Natick is illustrated in Figure 1.

The challenge of protecting soldiers is a formidable one and high- technology fibers play an important role in accomplishing this. Requirements for military protective clothing include protection against the environment from the hot, wet tropics to cold, dry arctic conditions, chemical agents, ballistics, flames and detection by surveillance devices. Figure 2 shows the common aspects to these protective clothing requirements such as the need for lightweight, low bulk, durable, minimum heat stress, producible and economical materials. Besides protecting a soldier, this clothing must be functional and comfortable.

When compared to conventional fibers, high-technology fibers are characterized by inherently superior performance properties such as high temperature resistance, flame resistance, corrosive resistance, anti-static properties and resistance to compressive loads. High-technology fibers may not necessarily be extremely strong. Dupont Chemical Company's Nomex is an example of a high-technology fiber widely used by the military for its outstanding thermal properties, but only having the strength of a conventional fiber.

High-technology fibers represent key technologies for the DOD and are indispensable for making advanced materials. Natick has been the DOD leader in developing clothing, helmets, body armor and other items using textile materials for protecting the combatant. High-technology fibers have been extensively investigated as they provide the best combination of physical protection and other properties over a wide array of military environments.

There is also a special category of high-technology fibers referred to as high-performance fibers. High-performance fibers are highly advanced materials noted for their high strength properties and capabilities. In some instances, they are required to perform under hostile conditions, such as high temperatures, corrosive environments, etc. High-performance fibers are characterized by tensile strengths of approximately 20 grams per denier (gpd) or higher, and tensile moduli of approximately 500 gpd or higher. Conventional textile fibers have less than half of these values. Many high-performance fibers have been developed as a result of the discovery of liquid crystal polymers and new and improved fiber manufacturing and processing techniques. Examples of high-performance fibers are listed in Figure 3.

COMMODITIES	
HELMETS	PERSONNEL AND CARGO PARACHUTES
BODY ARMOR	SHELTER, TENTS, TARPAULINS
CLOTHING AND UNIFORMS	CHEMICAL PROTECTIVE GARMENTS AND EQUIPMENT
ROPES, WEBBINGS, FINDINGS	DUFFEL BAGS AND OTHER ORGANIZATIONAL EQUIPMENT
COLD WEATHER GEAR	COATS AND JACKETS
HOT WEATHER GEAR	HATS AND CAPS
WET WEATHER GEAR	SURVIVAL VESTS
SHIRTS AND BLOUSES	STRAPS, TAPES AND SLINGS
NETTING (cargo, insects)	PONCHOS
PANEL MARKERS	AMMUNITION CASES
CORDS, BRAIDS AND THREAD	UNDERWEAR
GLOVES	

Figure 1. Examples of commodities supported at Natick.

This article reviews: several significant technical advances in materials made from high-technology fibers; current R&D in high-technology fibers; the potential, future needs and challenges in this field; and the dual use of this technology for both military and civilian applications.

Previous R&D Advances

Since 1960, high-technology fibers have been investigated for use in a variety of items such as helmets, body armor, clothing and uniforms, shelters, tents and ropes.

Many general chemical classes of high technology fibers and special classes of high performance fibers have been investigated. The aromatic polyamides, specifically the Nomex and Dupont's Kevlar types, are by far the most widely used. These find use primarily for ballistic protective helmets and body armor for ground soldiers, combat vehicle crew members and aviators. The Personnel Armor System for Ground Troops (PASGT), consisting of the helmet and vest, is probably the most well known item having saved many lives in recent conflicts.

The aramids also find use in such items as firefighter's helmet, body armor system for explosive ordnance disposal personnel, parachutist's rough terrain suit and the combat vehicle crew member's face mask. Kevlar KM2, a recent development, is a stronger type of Kevlar and is being used to reduce the weight of combat helmets.

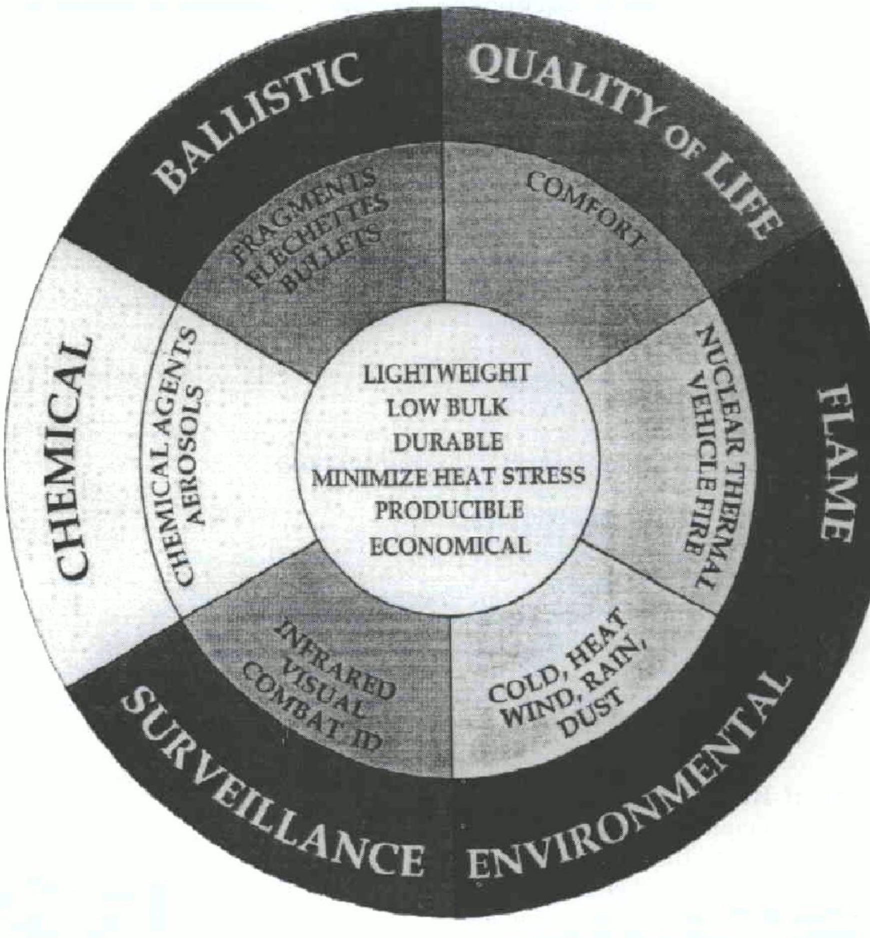


Figure 2.
Requirements for military protective clothing materials.

HIGH-PERFORMANCE FIBERS

FIBER CHEMISTRY	TRADE NAME
AROMATIC POLYAMIDES:	
Polyphenylene terephthalamide) (PPD-T).	KEVLAR (Dupont)
Poly(p-phenylene terephthalamide) (PPD-T).	Twaron (Akzo)
Copoly(p-phenylene/3,4'-diphenyl ether terephthalamide).	Technora) (Teijin)
AROMATIC POLYESTERS:	
Copolymer of p-acetoxybenzoic acid/ 2-acetoxy-6-naphthoic acid (HBA/HNA).	Vectran (Hoechst Celanese)
Polymer of p-acetoxybenzoic acid, 4,4'-diacetoxybiphenyl and terephthalic or isophthalic acid.	Ekonol (Sumitomo Chemical/ Nippon Exlan)
HIGH STRENGTH POLYOLEFINS:	
Extended chain polyethylene.	Spectra (Allied Fibers)
Extended chain polyethylene.	Dyneema (DSM)
AROMATIC POLYIMIDES	
Copolyimide.	Polyimide 2080 (Dow Chemical)
AROMATIC HETEROCYCLIC	
Poly(p-phenylene benzobisoxazole) (PBO).	PBO (Dow Chemical)
CARBON	
Carbon.	Hercules IM-7 (Hercules)
Pitch and Pan based.	Thornel (Amoco Chemical)
INORGANIC	
Silicon Carbide.	Nicalon (Dow Corning)
Silicon-Carbonitride.	HPZ (Dow Corning)
Aluminum, Silicon, Boron Oxide.	Nextel (3M)

Figure 3. Examples of high-performance fiber chemistry.

Current R&D Efforts

There is a rapid evolution in fiber and fabric technology that is leading to the development of a number of promising materials. Examples of this technology are as follows. The extended chain polyethylenes (Spectra types) are currently being extensively investigated for ballistic protection. The Spectra types are the strongest fibers in the world on a weight basis. Besides being strong, these fibers are lightweight, flexible and have a soft feel.

Natick is also investigating the use of high molecular weight polyvinyl alcohol (PVA) fibers for ballistic protection. The objective is to develop improved body armor materials through process variations of PVA fibers that are expected to yield fibers with substantially improved performance characteristics, some of which may be used to enhance impact resistance.

New copolymers are being synthesized to develop materials tailored specifically for ballistic impact resistance. These new polymeric materials will be formed into fibers that can maximize the energy absorption capabilities of textile structures. Further, these materials will be used to reduce weight and bulk, for both soft and hard ballistics protective material systems for personnel body armor and shelters. PBO [poly(p-phenylene benzobisoxazole)] and copolymers of PBO are also being investigated for ballistic impact resistance.

Novel fabrics containing blends of high-technology fibers are being investigated to improve performance properties while keeping costs low. One such blend contains Kevlar, cotton, nylon and an antistatic fiber. The Kevlar significantly improves the field durability while cotton provides a soft feel yet allows the fabric to be dyed and camouflaged using current technology. These fabrics are treated with flame retardant and water/oil repellent finishes resulting in a lightweight combat uniform that affords integrated protection. When worn with a vapor sorptive undergarment, the uniform provides protection against chemical/biological, flame, environmental and electrical hazards while offering visual and near infrared camouflage properties.

Bioengineered materials are being developed and converted into high-technology fibers based on protein chemistry and referred to as "Spider Silk." These high strength fibers have potential for use in ballistics and composites.

Future Needs and Challenges

There is a significant potential for using high-technology fibers in ballistic protection for threats other than fragments, such as flechettes and bullets, and for protection against flame and incendiary weapons. High-technology fibers also have potential for use in making lightweight, durable fabrics for chemical protective suits, battledress uniforms, tentage and parachutes. However, the development of sophisticated fibrous-based materials, from both conventional and high-technology fibers, presents formidable technical barriers. Some examples of the technical barriers that have to be overcome are as follows:

• *Fragmentation/Flechette.* Flexible, lightweight integrated material systems to defeat flechettes need to be developed. Besides materials, a fundamental understanding of energy absorption principles and failure mechanisms is necessary. Also needed is a complete understanding of the relationship of microscopic and macroscopic fiber properties and their ability to absorb energy at ballistic strain rates and the ability to tailor and manipulate those properties to obtain optimum performance. New polymeric fiber-forming materials with higher energy absorption to weight ratios are also needed.

• *Flame and Incendiary Weapons.* The lethality of flame and incendiary weapons and nuclear and thermal threats are increasing. High-technology, heat and flame resistant materials are needed to counteract these threats. The current high-technology materials used to provide this protection are very expensive and are available from only a few suppliers. New and novel, low cost, dyeable and printable, heat and flame resistant polymers that are readily available must be developed to meet this need.

• *Nuclear, Biological and Chemical (NBC).* High strength is not paramount for fibers to protect against these threats. However, garments that can be detoxified through laundering or other means, and be reused, are very desirable. High-technology textiles that can adsorb or adsorb/neutralize threat agents while minimizing heat stress is a priority goal for current NBC systems. Chemical protective fabric systems must offer protection against liquid, vapor, aerosol and particulate chemical agents and also agents of biological origin (ABO). Development of high-technology reactive fibers that can detoxify chemical and biological agents is required.

Dual Use Fibers

There are a number of government developed items incorporating high-technology fibers that have potential for civilian use. Advanced fibers can be used for personal protection in such items as protective vests, jackets and shirts. This technology can also be used for motorcycle and bicycle helmets, for protective gloves for handlers of meat, cut glass and sheet metal, and for use by nurses and surgeons for cut and puncture protection.

These specialty fibers can also be used for apparel applications to protect against heat, molten metal burns, toxic chemicals and radiation. High-technology fibers are used for the reinforcement of plastics, producing composites with physical properties superior to those of unreinforced matrices.

High-technology fibers are the backbone of the advanced composite industry where the principal application is making lightweight, strong and stiff alternatives to metals. These composites are used in the construction of spacecraft, aircraft, buses, trucks, cars, tires, boats and buildings. These fibers are also used in the manufacture of ropes, webbings, cords and tapes for a variety of uses from mountain climbing equipment, aircraft tie-downs, to suspension lines on parachutes.

Summary

High-technology fibers play an indispensable role in protecting the soldier from head to foot from a variety of threats and, at the same time, improve the quality of life by enhancing living and working conditions. Also, high-technology fibers have potential for dual use applications in the civilian sector.

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DR. RONALD S. PERRY is a professor in the Textile Sciences Department at the University of Massachusetts, Dartmouth. He holds an M.S. degree in textile chemistry, an M.S. degree in chemistry and a Ph.D. in chemistry from the Lowell Technological Institute (now the University of Massachusetts, Lowell) and is on temporary assignment at the U.S. Army Natick Research, Development and Engineering Center under provisions of the Intergovernmental Personnel Act.

TARDEC JOINS VEHICLE SIMULATOR NETWORK

By George Taylor

The U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC), Warren, MI, recently became part of a national interactive network of laboratory vehicle simulators that will enable researchers to simulate battlefield environments more accurately than ever before.

Called Distributed Interactive Simulation (DIS), it will consist of all the air, sea and ground defense vehicle simulators at DOD research agencies and contractor facilities throughout the country. DIS connections are established via a physical communications network known as the Defense Simulation Internet (DSI) developed by the Advanced Research Projects Agency. The simulators are being linked by a protocol developed at the DIS Workshops sponsored by the Army's Simulation Training and Instrumentation Command and the Defense Modeling and Simulation Office.

When fully implemented throughout the world, this protocol will allow researchers to use virtual prototyping to simulate the ground, air and sea operations of full-scale battles to assess the readiness and evaluate new vehicle concepts.

In virtual prototyping, computers are used to simulate three-dimensional solid models of vehicle concepts in a real-world battlefield environment. Soldiers are then asked to operate the concepts in simulated battles, evaluate their performance and help design engineers to correct deficiencies before building and testing expensive hardware prototypes.

John Brabbs, in charge of vehicle crew-station simulation in TARDEC's VETRONICS (vehicle electronics) Integration Center, explained, "Up until now, we have had only a stand-alone simulation capability. We could run our simulator by itself. However, we were limited in that we could have war games that only included tanks against tanks.

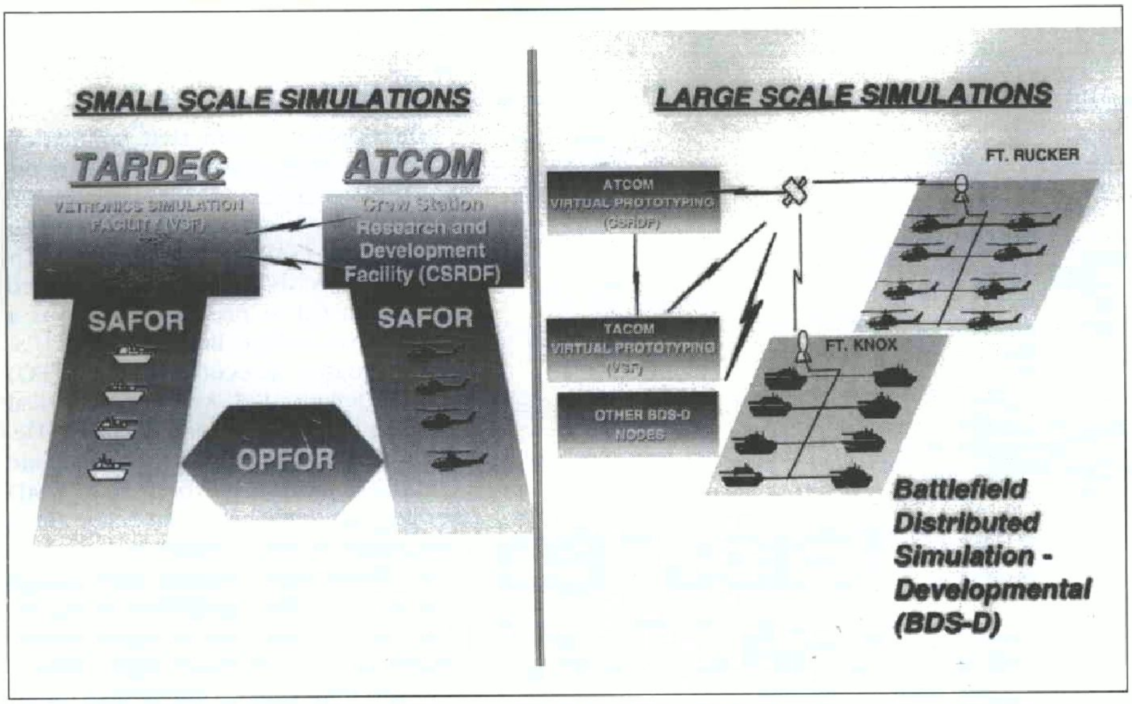
> In virtual prototyping, computers are used to simulate three-dimensional solid models of vehicle concepts in a real-world battlefield environment.

"But in a real war, tanks don't just fight against tanks, and helicopters don't just fight against helicopters. There are tanks, artillery, aviation and other equipment fighting as a combined force. So now that we have a protocol that will allow all the simulators in the country to communicate with each other, we will be able to have more realistic simulations of a whole war," he continued.

TARDEC's DSI simulator is called a VETRONICS Simulation Facility (VSF). In operation since October 1988, the VSF provides a capability to rapidly reconfigure physical and functional characteristics of an operator's crew-station displays and controls. It consists of a reconfigurable crew-in-the-loop simulation, including vehicle subsystems and environments and generic crew stations.

The stations are designed to allow the crew to operate the demonstrator vehicle in an emulated battlefield environment against an interactive threat. The environment includes computer-generated, real-world imagery that is based on crew inputs to the system just as it would be in an actual vehicle.

"The VSF does not simulate vehicle motion," Brabbs said. "But it does pro-



Distributed Interactive Simulation.

vide the soldier with a real-time view of the battlefield. There is also a sound system that can simulate a lot of the sounds that occur on the battlefield, such as a shell dropping nearby."

Brabbs added that plans call for linking TARDEC's turret motion-base simulator to the DSI within the next year. This system consists of a hydraulically actuated platform that can support a combat-vehicle turret weighing up to 25 tons.

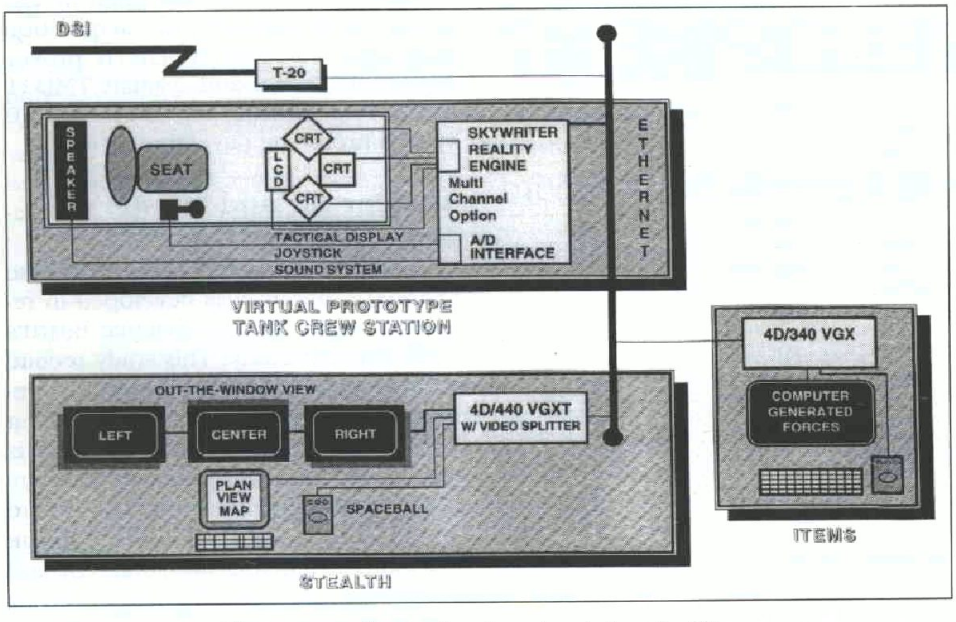
The platform is controlled by a computer, which, when programed with a mathematical terrain model, activates the hydraulic actuators. This causes the platform to produce a full range of vertical, pitch, roll, yaw, forward-and-backward, and side-to-side motions. These motions recreate the dynamic environment a turret would encounter during actual vehicle operation over bumps, hills and other rough surfaces.

TARDEC displayed its virtual prototyping and simulation capabilities in May 1993 at the Association of the U.S. Army's Louisiana Maneuvers and Simulation Initiatives Symposium in Orlando, FL.

Louisiana Maneuvers, or LAM, is a modernized version of a series of general headquarters-level exercises conducted during 1940 and 1941 in Louisiana and in other parts of the South to assess the Army's readiness. The present-day version will demonstrate the focus areas of the Army's current capabilities by exploiting simulation, communication and analysis technologies.

In the demonstration, the TARDEC VETRONICS crew station was a part of a simulated live air-ground war game with the Aviation Test-Bed located in Fort Rucker, AL; the Aviation and Troop Command's crew station Research and Development Facility at Moffitt Field, CA, and the Comanche Simulation Facility, Stratford, CT.

In November 1993, TARDEC participated in a larger demonstration in Orlando that involved Army, Air Force and Navy simulators.



First generation vetronics simulation facility.

GEORGE TAYLOR is a technical writer-editor for the U.S. Army Tank-Automotive Command. He has a bachelor's degree in journalism and a master's degree in communications from Michigan State University.

DISTRIBUTED INTERACTIVE SIMULATIONS FOR THEATER MISSILE DEFENSE SYSTEM DEVELOPMENT

By Raymond B. Washburn

Introduction

Distributive interactive simulation (DIS) concepts may be applied to potentially generate a synthetic battlefield for the purpose of analyzing theater missile defense (TMD). This application is illustrated by the advanced distributed simulation (ADS) proposal, which is a cooperative effort between the U.S. Army Program Executive Office (PEO) Missile Defense, U.S. Army PEO Tactical Missiles, Army Space and Strategic Defense Command, and the Army Missile Command. The framework for the TMD architecture has been formulated along five broad capability areas:

- a lower tier (terminal, endo-atmospheric) intercept capability providing point and limited area asset protection against tactical ballistic missiles (TBM);
- an upper tier (mid-course, high endo/low exo-atmospheric) intercept capability providing extended intercept envelopes and broader area defense;
- a boost phase intercept or TBM intercept in the early flight phase capability;
- an early warning and surveillance capability of launch detection, extended range tracking, and netted surveillance to support cuing/intercepts and broader defense coverage;
- Command, Control, Communications, and Intelligence (C3I) capability to tie together and manage the TBM intercept and surveillance/warning activities.

The ADS proposal described in this article will support the acquisition process of the TMD system by providing a tool to refine and evaluate TMD element requirements and to assess TMD system prototype development.

Theater Air and Missile Defense Proposal

A Theater Air and Missile Defense (TAMD) proposal was developed in response to the Defense Science Board's 1992 Summer Study. This study recommended ADS demonstrations be conducted in 12 different areas including TAMD. The Defense Science Board suggested that the TAMD demonstration include: TBM target detection, launch site coordinated attack, and battle damage assessment; timeline measurement and evaluation; and a broad range of sensor and intelligence inputs, new technology impact assessment.

The objective of the Army's TAMD demonstration is to provide a capability to conduct comprehensive TMD analyses linking live exercises in a realistic C3I environment with constructive and virtual simulations. These exercises will include threat missile target launches at White Sands Missile Range (WSMR), NM. Also, this demonstration will provide an accurate representation of threat and TAMD interactions for field training exercises via a DIS network. Finally, the combined live exercise and simulation demonstration will provide an environment to assess TAMD prototype development and to refine requirements in support of the acquisition process of TMD systems.

A key element of the TAMD demonstration concept is the integration of a DIS-based network (distributed simulation internet) into the live missile firings and sensor interactions at WSMR. The primary mission of the DIS-based network is to create a synthetic, virtual representation of the TMD warfare environment by systematically interfacing separate, stand-alone simulations located at separate geographic locations. The incorporation of the DIS architecture into the Army's TAMD demonstration will ensure interoperability with other simulations and continued compatibility with future developments.

Three-Phased Approach

One proposed approach to the Army's TAMD demonstration includes three phases and is designed to be a building block approach to reduce risk and provide an early proof-of-principle that will verify the concept. The first phase, planned for FY94, begins with TBM launches at WSMR. Various theater and national sensors will observe the launches and provide real-time data to the Combination and Dissemination of Experiment Data System (CADEX). The CADEX, now located at WSMR, will function as a sensor data collection and analysis tool and will provide data interface between the participating platforms at WSMR.

The CADEX is currently being developed by the Army TMD Program Office as a sensor data collection and analysis and fusion tool used to assist in evaluating sensor technology demonstrations conducted at WSMR. CADEX will provide the interface between the live data collection from the various sensors to simulations and directly to joint military tactical data links. The direct tactical data link connection will provide data to support PATRIOT sensor cuing demonstrations and to provide real-time launch point and impact point information to counterforce elements such as Army Tactical Missile System fire units. The CADEX will also be linked, via the DIS architecture, to the Extended Air Defense Simulation (EADSIM) and to the PATRIOT Tactical Operations Simulator (PTOS).

The PTOS, located at Fort Bliss, TX, is a virtual, man-in-the-loop emulation of the PATRIOT Information and Control Central or Engagement Control Station, or a HAWK fire unit. Reconfigurable console touch screens enable the PTOS to provide a virtual emulation of these air defense systems. PTOS provides a high fidelity representation of air surveillance, engagement decision logic, weapon assignments, identification-friend-or-foe, interceptor guidance, and message traffic.

The EADSIM is a many-on-many air defense simulation that models the effectiveness of various C3I, TMD, and air defense architectures. The EADSIM is a joint model used by the Army, Air Force and Navy, plus NATO organizations and allied countries. The Army TMD Program Office recently implemented an interface between EADSIM and PTOS via an Ethernet connection. (A DIS-based interface is planned.) With the PTOS/EADSIM interface, PATRIOT/HAWK battalion simulation can be accomplished in an integrated air defense environment including higher echelon command and control generated by EADSIM. The PTOS provides man-in-the-loop operations and higher fidelity air defense weapon system modelling.

The first phase of the Army's proposed TAMD demonstration planned for FY94 will link CADEX at WSMR via the DIS architecture to EADSIM and PTOS at Fort Bliss to demonstrate the integration of live track data including missile launch and impact point information. The objective for the first phase of this demonstration is the proof-of-principle illustrating a network of live exercise data being fed into simulations via the DIS architecture. The CADEX, besides providing the real-time data to the constructive and virtual simula-

The PATRIOT Tactical Operations Simulator provides a high fidelity representation of air surveillance, engagement decision logic, weapon assignments, identification-friend-or-foe, interceptor guidance, and message traffic.

tions, will provide tactical data link information to:

- Army Depth and Simultaneous Attack Battle activities;
- a PATRIOT Engagement Control Station examining the capability of PATRIOT to use external sensor data for radar cuing; and
- an Air Force modular control equipment passing TBM launch point and launch time to support the counterforce mission against the TBM launcher.

The second phase, scheduled for late FY94, will build upon the first demonstration by adding additional assets to live exercises at WSMR. First, a prototype Joint Tactical Ground Station will be included in the demonstration and will receive and process early warning satellite data and provide TBM launch, trajectory, and impact prediction data.

The third phase, scheduled for FY95, further refines the DIS capabilities by linking live fire exercises with the Extended Air Defense Testbed in Huntsville, AL, to the Corps Battle Simulator, to the Air Force's Air Warfare Simulator and the Attack Helicopter Virtual Simulation. The third phase will culminate in the complete integration of theater air and missile defense exercises and simulations through a distributed network.

The Army's TAMD demonstration concept will link live TBM firings at WSMR to constructive and virtual simulations from various locations into a shared synthetic battlefield for joint warfighting. This proposed capability will provide a realistic tactical ballistic missile threat for training exercises. In addition, this capability can be used to support the acquisition process of the TMD system. Specifically, the DIS-based simulation proposal linking live exercises to EADSIM/PTOS can be used to evaluate the Theater High Altitude Area Defense (THAAD) BM/C3I requirements interfacing the THAAD tactical operations center (TOC) including tactical operations shelters and launcher control stations with the TMD lower tier systems.

The Army's Theater Air and Missile Defense demonstration concept will link live tactical ballistic missile firings at White Sands Missile Range to constructive and virtual simulations from various locations into a shared synthetic battlefield for joint warfighting. This proposed capability will provide a realistic tactical ballistic missile threat for training exercises.

Virtual Prototyping Applied to the THAAD BM/C3I System

The THAAD BM/C3I elements are required to provide cuing, or directing data, e.g. target state vectors or impact point predictions to assets defending the underlay or lower tier air defense system in a timely manner in order to support the engagement of TBM that leak through the THAAD defense layer.

In a multi-tiered engagement firing doctrine, the THAAD system will be required to perform kill assessment functions in support of multiple TBM engagements. Also, the THAAD BM/C3I system will be required to provide kill assessment information to external BM/C3I interfaces for distribution to other (lower tier) air defense systems, e.g. PATRIOT and HAWK. The THAAD system will be required to perform engagement operation activities, such as air surveillance, track correlation, target classification, target identification, track updates, mission control, air picture processing, and missile/launcher management.

With modifications to the PTOS software, representative THAAD TOC consoles can be produced with touch screen consoles emulating the planned THAAD battalion BM/C3I elements. This 'simulated' THAAD battalion TOC with man-in-the-loop will be linked to the TMD lower tier, e.g. PATRIOT via EADSIM. The lower tier system would consist of a series of PATRIOT battalions consisting of man-in-the-loop Information and Coordination Central and Engagement Control Station consoles. The TMD battle would be simulated by EADSIM. The individual battalions, i.e. THAAD or PATRIOT would be simulated by PTOS. The TMD BM/C3I requirements of a stressing scenario of many TBMs attacking a two-tiered defended area can be assessed and refined using the proposed DIS-based architecture. The timelines associated with the multi-tiered engagement firing doctrine including kill assessment, engagement of "leakers" by the lower tier, and external BM/C3I interfaces can be assessed and requirements of THAAD and PATRIOT improvements assessed and refined.

Summary

The ADS proposal described in this article will provide a virtual representation of the tactical ballistic warfare environment and provide a tool to refine and evaluate TMD element requirements and to assess TMD system prototype development. A virtual TMD warfighting environment will be established which will be capable of providing the human factor into TMD system development.

RAYMOND B. WASHBURN is employed in the Army Theater Missile Defense Program Office, Program Executive Office Missile Defense in Huntsville, AL. A registered professional engineer in Alabama, Washburn holds a B.S. in industrial engineering and an M.B.A. from Wayne State University, Detroit, MI.

Guest Editorials

THE ROLE OF R&D IN SUSTAINING THE ARMY ENVIRONMENTAL ETHIC

By Dr. Robert B. Oswald
Director of R&D, U.S. Army Corps of Engineers

As the Army implements its environmental strategy over the next decade it faces many challenges. The magnitude of these challenges is overwhelming. The installation cleanup bill is staggering and likely to increase. Restrictions on training activities continue to result from public complaints on training noise and the need to protect threatened and endangered species. Failure to modify our operations to prevent pollution will result in additional nctices of violation, heavy fines, and future cleanup problems.

The Army cannot shirk from its responsibility to be model stewards of the environment. The public demands it from us. Congress has tasked us to comply with numerous environmental laws. Future military operations and training missions depend upon it. And, most importantly, our conscious tells us it's the right thing to do...to preserve the environment for the generations to follow us.

The Army's research and development community has a critical role in assisting the Army in achieving these environmental challenges. Over the last few years, the Army has taken great steps towards becoming model stewards of the environment. Improved environmental management, operational changes, and an increased awareness of our environmental responsibilities have made a big impact. But the Army needs more.

The Army needs better tools to help them achieve their environmental goals. Critical military unique problems such as unexploded ordnance; impulse noise; soils and aquifers contaminated by explosives, fuels, and solvents need innovative answers. The Army R&D community needs to not only provide those answers, but provide them as quickly as possible.

I'm pleased to report the Army's R&D environmental research community is responding to this challenge. We're responding through improved partnering with the Army's environmental leaders in the newly created Office of the Assistant Chief of Staff for Installation Management and the Army Environmental Center. We're partnering with other Department of Defense environmental agencies to learn from their work and perform joint R&D on problems common to the Services. Finally, we're partnering with universities and industry to take advantage of their environmental innovations and to enlist their assistance in conducting our R&D Program.

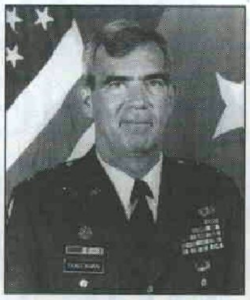
The Tri-Service Strategic Environmental Research and Development Plan was developed under the Reliance effort. This strategy will optimize environmental R&D resources and efforts among the Services. New initiatives such as the Congressionally directed Strategic Environmental Research and Development Program will be integrated with the DOD environmental R&D strategy—again improving program effectiveness and the use of limited R&D resources.

A new initiative this year will be increasing the role of the Army and DOD environmental leadership and the user community in the Environmental R&D Program. We'll be working with the Army's leaders and user community to prioritize the numerous R&D requirements currently identified. Once prioritized, we in the R&D community can do a better job of focusing our research efforts to provide more responsive and timely solutions. These same Army leaders and users will also participate during the execution of the R&D Program to provide their unique insight and ultimately ensure the timely transfer of the technology once it's developed.

The environmental challenges will remain in the forefront over the next several years for the Army. The Army will successfully meet these challenges through our increasing acceptance and awareness of our responsibilities, improved management of the environment, and innovative R&D solutions providing the tools to do the job better.

What Should the Army Emphasize in Developing Its Environmental R&D Plan?

MG Richard W. Tragemann
Commander, U.S. Army Test and Evaluation Command
Aberdeen Proving Ground, MD



Testing military weapons systems can have significant effects on environmental quality. To prevent that from happening, the U.S. Army Test and Evaluation Command (TECOM) has institutionalized the consideration of environmental effects BEFORE a test program is started.

TECOM project managers work with materiel developers to identify environmental concerns related to a test item. Test officers use that information, along with knowledge of local conditions, to prepare site-specific environmental documents describing the likely effects of the test, along with mitigation actions to reduce the severity of these effects. These documents are prepared in accordance with the National Environmental Policy Act, and public participation is encouraged as appropriate for the level of documentation being prepared.

One result of TECOM's efforts has been development of test facilities to contain the potentially adverse environmental effects of weapons testing. At the Combat Systems Test Activity, Aberdeen Proving Ground, MD, we built a facility called the Super Box to test armor-penetrating ammunition. This large test chamber contains the explosive energy and debris created by impact of depleted uranium penetrators onto armor plate. Filters remove uranium dust and fumes from the air before the chamber is opened to the environment.

At Yuma Proving Ground, AZ, we are constructing catch boxes to capture depleted uranium penetrators fired through cloth targets in accuracy tests, effectively eliminating a source of controlled low-level radiation from the environment. At Dugway Proving Ground, UT, TECOM built a rubber igloo equipped with sampling devices and instrumentation for identifying emissions given off by the burning of detonation of high explosives. White Sands Missile Range, NM, is suspending a cable between two mountains to eliminate much of the need for towed and remotely controlled targets. This aerial cable will greatly reduce aircraft emissions and will confine target debris to a relatively small area of the range. Redstone Technical Test Center, AL, is pioneering computer modeling of missile flight characteristics to eliminate much of the necessity of firing missiles in order to test guidance systems.

TECOM willingly accepts its environmental responsibilities. Command philosophy dictates that environmental issues be dealt with openly and expeditiously. This attitude is good for the environment and for the test mission. Instead of increasing costs, efforts to find an environmentally better way to do things often lead to discovery of more economical ways to accomplish TECOM's test mission.

BG Gerald C. Brown
Director, Environmental Programs
Assistant Chief of Staff for Installation Management
Pentagon

The Office of the Director, Environmental Programs (ODEP) was established under the Assistant Chief of Staff for Installation Management (ACSIM) to develop, coordinate, and oversee environmental programs and policy for the Total Army. This provides one office that can respond to most any environmental issue that arises. The office oversees environmental issues that impact all Army functions, installation management, acquisition, training and RDT&E. The Environmental Quality R&D Program is a major component of the environmental programs, responsible for research, development, testing and evaluation of technologies to restore, maintain and enhance ecosystems on Army installations.

The emphasis in the development of the environmental R&D plan should be on meeting user needs. Users include installation environmental and logistics staff, the acquisition community, and designers in Corps Districts and Divisions. Being on the front line of environmental stewardship, these users are the best source for identification of environmental R&D needs. During September and October of 1993, ODEP conducted a series of meetings in which users were brought together to identify their environmental needs. Four sessions were held; one for each of the pillars in the environmental program (conservation, compliance, pollution prevention and restoration). These one week sessions, conducted by a moderator using electronic groupware, identified numerous needs for each pillar. These needs were then refined to 218 individual requirement statements. R&D laboratory personnel were in attendance during these sessions. Ranking criteria included impact of the requirements on readiness, quality of life, extensiveness of the problem, regulatory time limit, annual cost and environmental impact. This ranking process, which was used at each meeting, resulted in prioritized user needs for each pillar using one consistent methodology. Prioritized environmental requirements provide the primary component for the development of the R&D program to meet Army needs.

Close interaction between users and the R&D community is essential to execution of an efficient and effective R&D program that addresses users needs. As the R&D community develops and executes environmental R&D programs, periodic program reviews with users should be emphasized to ensure their needs are being addressed. The experience of the users with new and developing technology will also assist the R&D community in program execution and modification to provide the latest feedback on R&D technologies. These program reviews will also provide a valuable link for technology transfer, providing the users with technology developments as they occur. They will also be used to develop the Army's SERDP proposals and the Tri-service Strategic R&D Plan. OSD, like the Army, is placing much more emphasis on user needs in development of R&D programs.

The Army user community and R&D community benefit through successful execution of R&D programs that emphasize active participation from the user community. This close interaction between users and the R&D community will enable the Army to meet current and emerging environmental problems into the next century.

Mr. Lewis D. Walker
Deputy Assistant Secretary of the Army (Environment Safety and Occupation Health) Pentagon

A key part of our total environmental strategy is our vision and its influence on future programs. A well thought out and executed environmental R&D plan will ensure that we can sustain our momentum into the future. The Army's environmental strategy model "pillars" each have a definite interest in R&D. The four "pillars" or thrust areas are restoration (cleanup), compliance, prevention and conservation. Without a solid R&D foundation, these pillars cannot provide the necessary technological support for the future. Technology and innovation are needed to reduce the ever increasing costs needed to achieve the Army's environmental goals.

Our objective is clear. It is to provide a technology development and transfer strategy to solve the most pressing environmental problems as rapidly as possible, at least cost, and to prevent these problems from recurring. The U.S. government is responsible for the largest, most expensive, and the most complex cleanup problem in the nation that has a projected cost of more than 500 billion dollars.

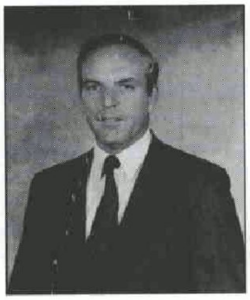
The environmental R&D program must focus on four areas. The first area is developing cleanup technologies to treat the contamination caused from past activities. They must be cheaper than current cleanup methods. They should be technologies that operate at the point of contamination to the maximum extent possible with a major emphasis on biotreatment. To support the cleanup effort, there must be an emphasis placed on developing analytical chemistry and instrumentation that can be used for site characterization and remedial action monitoring. The current practice of taking samples in the field and shipping them to a laboratory for analysis is too time consuming and costly.

The second focus area that is equally important is reducing or preventing the production of hazardous waste. The mind set of "this is the way we do it" will not accomplish this effort. All operations and new procurements must be examined to identify the raw materials and operations that produce the hazardous waste. New or substitute materials as well as process and procedural changes must be identified and carried out to the maximum extent possible. This focus area must include recycling of the item at the end of its service life. Our waste must begin to be thought of as raw material for another use—not material to be disposed of.

The third focus area is compliance. Expanding environmental regulations at the international, federal, state and local levels are increasingly more demanding and stringent. We must ensure that we emphasize technology and "good idea" sharing with EPA, OSHA, DOI, industry, and other DOD components. We have to work closely with communities to develop trust and capitalize on the positive aspects of our environmental efforts in this area.

The final area is conservation. The Army has to effectively manage and maintain its vast maneuver and testing areas. Future requirements to fully utilize these capabilities are increasing. Our R&D plan will enable the Army to mitigate and rehabilitate areas affected by training and testing activities. In addition, we need to be able to predict the presence, quality, and quantity of natural and cultural resources as they might be affected by military activities.

Again, the focus of our R&D Plan should be to quickly solve the immediate environmental problems, while simultaneously focusing our efforts to ensure we sustain our momentum into the future.



Stephen L. Kistner
Scientific Advisor
U.S. Army Environmental Hygiene Agency

The costs associated with addressing the myriad of environmental issues currently facing this country totals to a staggering figure. The concept of proactive strategic planning over a longer term (beyond five years) has to establish our overall priorities. It is only by prioritizing the worst problems that we can attack these issues systematically, and optimize the available fiscal and manpower resources. The idea that health concerns should be the prime driver in such a prioritization process is critical in assessing "worst first" problem areas. To this end, there is a serious lack of coherent health risk assessment tools applicable to DA problems.

Preventing the generation of pollutants in the first place holds the key to the long term quality of the environmental program. As such, there needs to be R&D technology in the area of pollution prevention to ensure that process changes are not only effective relative to reducing discharges, but also effective in reducing related health hazards (i.e., it is not effective to replace benzene with trichloroethylene, but rather to change the process to not require an organic solvent). Halon replacement and chlorofluorocarbon (CFC) issues are very relevant in the military's day-to-day business. In all such pollution prevention efforts, it is essential to incorporate procurement/logistics into such initiatives.

From a DOD perspective, there should be concerted efforts to emphasize R&D technologies that are truly military-unique. Increased communication and coordination among the Services is essential for focusing such efforts and avoiding any duplication. Partnering by agencies with specialized expertise should be stressed both within and even outside of DOD. A major priority for such initiatives should be in the area of detection and removal of unexploded ordnance. Remediation technologies for cleaning up contaminated soils and groundwater resulting from defense-related chemicals is of prime importance not only in installation restoration projects (DOD's Superfund), but also in base closure investigations and in the evaluation of formerly used defense sites.

In addition, there seems to be a significant need in the area of transferring R&D breakthroughs to the field users. Researchers should be encouraged to collaborate with the commercial industrial base, and should build on the successes developed in the commercial sector. In this era of DOD "downsizing" and reduced fiscal resources, all research efforts have to be implemented with forethought and in a coordinated fashion. Focus should be on military-unique problem areas with partnering efforts emphasized among the scientific and logistics communities.

From The AAC Career Manager...

In response to numerous requests from our readers to provide more topical career information related to the Army Acquisition Corps (AAC), a new section titled, "From the AAC Career Manager," is being established with this issue of Army RD&A Bulletin. We are inaugurating this new section with answers to a series of often asked career development questions. If you have an Acquisition Corps subject you would like addressed in this column or a question you would like answered, send your requests to: Deputy Director, Acquisition Career Management, SARD-AC, Room 3E360, 103 Army Pentagon, Washington, DC 20310-0103. Questions may also be datafaxed to DSN 224-3690 or (703)614-3690. Please include your name, address and phone number in case additional clarification is required. This information will not be published.

Q: Given the mobility clause for Army Acquisition Corps (AAC) [critical acquisition people], how often do you anticipate that civilians will have to move?

A: There are three types of mobility:

(1) Functional: A new assignment within the same commuting area, but to a position in (a) another acquisition career field; (b) another functional area within an acquisition career field; or (c) a subspecialty within a functional area or acquisition career field.

(2) Organizational: A new assignment within the same commuting area to a different office or command level.

(3) Geographical: Relocation outside the commuting area.

Voluntary mobility of all three types is desirable, encouraged and should be career enhancing.

The Defense Acquisition Workforce Improvement Act (DAWIA) encourages the rotation of members of the AAC serving in critical acquisition positions to new assignments after completion of five years. This will normally be accomplished via functional or organization moves within the same commuting area. Involuntary geographical mobility is not envisioned and would only be imposed in cases of utmost importance to the Army; i.e., a case where only one AAC civilian has the right qualifications to serve as project manager for a top priority program.

Q: How is the AAC doing on general officer selections for the corps? Is the percentage about right?

A: AAC general officer selections have improved in the last year. Selection rates are:

	Army	AAC
Major General	29.5 percent	30.0 percent
Brigadier General	2.2 percent	1.4 percent

Because of the large number of eligibles versus the small number selected, these percentages can vary widely year to year.

Q: When will a centralized referral list for vacancies be announced for critical acquisition positions?

A: Until the AAC membership inventory is fully populated (late spring 1994), any candidate registered in the Army Civilian Career Evaluation System (ACCES) or Engineers and Scientists (E&S) (Resources and Construction) central referral systems or who apply under announcements for E&S (Non-Construction), quality and reliability assurance, or other critical acquisition positions, may be referred for selection if otherwise eligible and willing to become a member of the AAC. All selections of non-members of the AAC are tentative selections, subject to accession into the AAC before entering on duty for a critical position.

Q: I have a master's degree. Am I still eligible to attend the Naval Postgraduate School for a second master's?

A: No. Individuals who already have a master's degree should focus their efforts on attending the Program Management Course or the Senior Service College Fellowship Program at the University of Texas at Austin.

Q: I am not familiar with commercial specifications and I'm not sure that my industry counterparts are either. Will there be a training program that will teach me about existing commercial specifications?

A: The U.S. Army Logistics Management College at Fort Lee, VA, currently offers two specification courses:

(1) The Defense Specification Management Course is two weeks in length, offered nine times per year, and is open to civilians GS-7 and above.

(2) The Defense Specification Users Course is one week in length, offered twice per year, and is open to civilians GS-7 and above.

An additional course to be taught at various locations is under consideration.

Q: Must I be a member of the AAC to apply for critical acquisition positions?

A: No. All individuals are eligible to compete for a critical acquisition position; however, selection of non-AAC members for the position is tentative, subject to a current signed AAC mobility agreement and written confirmation of a proposed selectee's entry into the AAC.

Q: When a weapon system transitions to AMC, will the critical acquisition positions also transfer? When would a civilian know that a position would transition?

A: Critical acquisition positions would not necessarily transfer to AMC when a weapon system transitions. Position and personnel information is required as a part of the weapon systems transition plan which must be approved by the Army Acquisition Executive. This transition plan is required early enough to provide adequate time for individuals to plan ahead.

Q: To progress in the AAC, certain courses must be completed to be qualified for positions. In many cases, these courses do not exist. Will this have an impact on my career opportunities?

A: Career opportunities will not be impacted, nor will AAC members be penalized, for courses that do not exist.

Q: Where are the requirements outlined for a GS-13 to get into the AAC?

A: Eligibility requirements are outlined in DAWIA and its implementing guidance, DoDI 5000.58 and DoD 5000.52-M.

Q: How does a GS-12 get prepared to be accepted into a GS-13 acquisition position?

A: DoD 5000.52-M outlines the certification standards for Level II and III. GS-12s (Level II) should be certified at their respective level prior to consideration for Level III positions. For those individuals already qualified for certification at Level II, begin taking the mandatory courses for certification at Level III.

Q: Are GS-13s being asked to apply to the AAC? I haven't seen anything on this.

A: We have had only one open announcement for GS-13s to join the AAC. Our efforts have been concentrated on accessing incumbents of critical acquisition positions into the AAC. Another open announcement for GS-13s to become members of the AAC is expected to be available in March or April 1994.

Q: I have a Master's of Science in Engineering. Do I still have to have 12 hours in business-related courses?

A: Yes, DAWIA mandates at least 24 semester hours in a person's career field and 12 semester hours in business-related study. The tuition reimbursement program, centrally funded by the Director, AAC, has been established to assist individuals to meet the AAC education requirements.

Q: I'm a GS-13 and I have been grandfathered into my critical acquisition position. Why should I join the Acquisition Corps?

A: First, there are no GS-13 critical acquisition positions within the Army. Secondly, GS-13s should join the AAC if they meet all eligibility requirements. The benefits of AAC membership are increased opportunities for education and training, increased promotion rates, greater number of higher pay grades, and special reduction-in-force policies.

Q: Will the existing three MOSs (51, 53 and 97) be collapsed to a single career field for AAC members?

A: The establishment of one functional area for military AAC members is under consideration.

Military PEOT Policy

Defense Acquisition Workforce Improvement Act (DAWIA) implementation requires many new career management concepts. One such concept involves acquisition position certification requirements. Requirements range from entry level certification in an Acquisition Career Field (ACF) to a General Officer and SES 10-year experience requirement.

To properly count acquisition experience and to ensure Army compliance with DAWIA, the Army's accounting system uses four experience categories represented by the acronym PEOT. This stands for the Program, Education, Other and Total acquisition experience categories which we developed to satisfy statutory and DOD requirements.

DAWIA requires program office or similar organization experience—"P" time— for certain jobs so we account for this time separately. Also, DAWIA allows only 12 months academic training and education experience, therefore, we count up to 12 months education, or "E" time. Time not spent pursuing a program of academic training and education or in a program office or similar organization counts as other acquisition experience—"O" time. The sum of Program, Education, and Other experience is Total acquisition experience—"T" time.

DAWIA requires two years "P" time to be assigned as an ACAT I program manager (PM). This requirement is moot since all ACAT I PMs will have been PMs or acquisition commanders as a lieutenant colonel. These positions all accrue "P" time.

Level 3 certification in the Program Management Career Field (ACF A) also requires two years "P" time. This applies to lieutenant colonels and colonels assigned to ACF A positions. We have 18 months to meet position requirements, therefore, an officer only needs six months program time upon entering the position. In the ensuing 18 months the officer will meet the two year requirement.

Sixty-six percent of the current Military Acquisition Position List (MAPL) positions are in organizations which accrue 'P' time. Under the current Army Acquisition Corps Leader Development Model, an officer will have two acquisition assignments before attaining the rank of lieutenant colonel. PERSCOM assignments officers will work with each officer to ensure that he/she attains the two years program time required for Level 3 certification in the Program Management Career Field.

Positions which count as 'P' time include the 618 in the Army Materiel Command and its major subordinate commands, 414 in the PEO structure, 132 in the Information Systems Command, and 125 positions in the Defense Logistics Agency. Other organizations which have positions which count as 'P' time include the Office of the Assistant Secretary of the Army for Research, Development and Acquisition, the Space and Strategic Defense Command, the Defense Information Systems Agency, and the Ballistic Missile Defense Organization.

Organizations which count as 'O' time include TRADOC with 222 positions. These positions were placed on the MAPL in order to allow these organizations to benefit from the assignment of acquisition officers and to allow acquisition officers to influence the acquisition process in the requirements determination stage. These positions are extremely valuable to the development of our acquisition officers. Other organizations which count as 'O' time are field operating agencies of the Army Staff and the Operational Test and Evaluation Command. We also have officers on the OSD and Joint Staffs, in the Special Operations community, and the CINCS Staffs.

The after action reviews of Operation Just Cause and Operation Desert Storm indicated the importance of placing contracting officers in our Division and Corps Headquarters to deploy with those units. Therefore, we now have 61 contracting officers assigned to FORSCOM units as contingency contracting officers. These are valuable acquisition positions which will contribute to the development of a well-rounded acquisition officer.

Unfortunately, these categorizations of acquisition experience have led to many misconceptions. Many officers feel that Category P jobs are inherently better than Category O jobs. THIS IS NOT TRUE! Category O jobs are just as valuable to the Acquisition Corps as Category P jobs. An officer's *manner of performance* in a *variety of jobs* is the most important factor for success in the Army. Developmental assignments in both Category P and Category O jobs coupled with outstanding performance is the formula for success in today's Army.

Editor's Note: The May-June issue of Army RD&A Bulletin will include the FY 95 MAPL listing.

Nominations Requested For 1994 MAM Course

Army Acquisition Workforce employees GS-11-13 and Army Acquisition Corps members GS-13 who are involved in the lifecycle materiel acquisition management process, and possess at least a baccalaureate degree, are eligible to attend the Materiel Acquisition Management Course. Supervisors of these employees are encouraged to submit nominations for those employees wishing to attend. The course is held at the U.S. Army Logistics Management College at Fort Lee, VA. Funding for attendance will be provided by the Army Acquisition Corps. The schedule for the remainder of FY 94 is as follows:

Class 94-3 Apr. 4–May 27, 1994
Class 94-4 Jun. 27–Aug. 19, 1994

This course is designed to provide a broad spectrum of knowledge pertaining to the materiel acquisition process to include: acquisition concepts and policies; research, development, test and evaluation; financial and cost management; integrated logistics support; and force modernization and production management.

Class nominations must be submitted on a DD Form 1556, with a supervisor's endorsement nominating the individual, not later than 45 days prior to class start dates. Forward nominations to: Headquarters, Department of the Army, ATTN: SARD-AC, Room #3E360, 103 Army Pentagon, Washington, DC 20310-0103. Point of contact for military officer applications is Richard Yeager at (703)325-3127 or DSN 221-3127. For civilian members, point of contact is Willie Lanier at (703)805-4042 or DSN 655-4042.

71 Graduate From MAM

Seventy-one students recently graduated from the Materiel Acquisition Management (MAM) Course, Army Logistics Management College, Fort Lee, VA.

Deputy Director for Acquisition Career Management Dr. Bennie H. Pinckley gave the graduation address and presented diplomas. CPT Albin Majewski of the Theater Missile Program Office, Huntsville, AL, received the Distinguished Graduate Award.

The eight-week MAM Course provides a broad knowledge of the materiel acquisition function. It covers national policies and objectives that shape the acquisition process and the implementation of these policies by the U.S. Army. Areas of study include acquisition concepts and policies; research, development, test and evaluation; financial and cost management; integrated logistics support; force modernization; production management; and contract management. Emphasis is placed on developing mid-level managers so that they can effectively participate in the acquisition process.

The graduates will move into assignments in weapon system acquisition, such as research and development, testing, contracting, requirements generation, logistics, and production management.

AAC Officers Promoted to Major

Congratulations to the following Army Acquisition Corps (AAC) officers who were recently selected for promotion to major. The AAC had a selection rate of 82.4 percent for those in the primary zone compared to an Army average of 73.4 percent.

NAME	FA	BR
ABRAMS, Lawrence J. Jr.	51	FA
ADAMS, Dan L. Jr.	97	QM
ALTAVILLA, Peter A.	97	FA
ANDERSON, David P.	51	SF
ANDERSON, Elijah	97	IN
AZENAR, Jacques A.	97	EN
BAKER, David P.	51	AR
BASHAM, Charles S. Jr.	51	OD
BASS, James Doyll	53	AG
BASS, Joseph L.	97	QM
BEARDEN, David B.	51	IN
BEDELL, Cynthia M.	51	CN
BELL, Joseph M.	97	TC
BEST, Robert F.	97	OD
BIEGA, Michael J.	51	SC
BOELKE, Ross D.	51	AR
BORGARDTS, Allen L.	51	IN
BORHAUER, Rachel D.	53	FA
BROWN, Alvin V.	53	SC
BROWN, Clayton E.	51	AV
BROWN, Robert L.	51	AV
BRYANT, Thomas H.	51	AV
BRYNSVOLD, Richard A.	51	OD
BULLINGTON, Johnny R.	51	MI
BURNS, Donald F. III	51	SC
BUTLER, Dwight D.	51	AD
BUTLER, Preston A. Jr.	97	OD
CALLAHAN, Michael O.	51	FA
CELLINI, Joseph A.	51	FA
CHAPPELL, Andrew P.	51	AV
CHATMAN, William T.	51	SC
COLTHART, Thomas M. IV	51	SC
COLWELL, Vincient J.	51	MI
CONLEY, Mark A.	51	IN
COOK, David A.	51	AD
COTTRELL, Daniel T.	51	AR
CRABB, Jeffrey A.	51	AV
CUMMINGS, Terrence	51	IN
CUNNANE, John L.	53	QM
CUNNINGHAM, William J.	51	SC
CURL, Jefferson M.	97	SF
DEVER, Douglas A.	97	FA
DODGE, George E.	51	MI
DOLLOFF, Scott C.	97	IN
ENSLEY, Trent K.	97	FA
ERNEST, Harold L.	51	OD
FINCH, Mary M.	51	AV
FLETCHER, James P.	51	AR
FOLK, William D. Jr.	51	FA
FREAR, Deborah L.	51	AD
FREEDMAN, David H.	97	AR
GANT, Dean A.	51	SC
GARCIA, Nestor	53	SC
GOON, Charles K. H.	53	SC
GREEN, Dwayne S.	53	OD
GREENE, Bradley D.	51	MI
GUYANT, Glenn E.	51	AD
HANSEN, Jacob B.	51	OD
HANSON, Eric E.	97	QM
HARRIS, Jamie A.	97	EN
HERNANDEZ, Luis	53	SC
HIGGINS, Scott Y.	97	AR
HOLZMAN, Simon L.	53	IN
HOPPE, William C.	53	IN
HORWITZ, Charles M. III	97	EN
HUTZELL, John A.	53	IN
JACKSON, Steven A.	51	AD
JAMES, Mark O.	51	SC
JAMES, Robert L.	51	SC
JENNINGS, Theodore L.	51	EN
JEROME, David H.	97	QM
JIMENEZ, Raleigh S.	97	OD
JOHNSON, Clarence E.	51	AD
JOHNSON, David W. Jr.	51	FA
JONES, Garvey P.	51	SC
JONES, Mark C.	51	OD
JONES, Robert R.	51	FA
KIRNES, Andre C.	51	AD
KUEHL, Douglas D.	51	SC
KUKES, Scott D.	97	SC
KWAK, Michael J.	51	SC
LAMB, William L.	51	AD
LAMBERT, Charles S.	53	FA
LARRABEE, Mark E.	51	AV
LEHMAN, Greta P.	53	AG
LEISENRING, Stephen B.	97	CM
LESSLEY, Douglas W.	51	SF
LEWIS, Bruce D.	51	AD
LINDAHL, Stephen D.	51	QM

NAME	FA	BR
LIPSCOMB, Jeffrey M.	53	SC
LOCKHART, David E.	51	SC
LUCAS, Robert B.	51	IN
MALAPIT, Jeffrey E.	51	EN
MALHAM, Mark C.	51	AR
MASON, Reginald P.	51	AV
MATTHEWS, Hunter B. Jr.	53	AD
MATUSEWIC, Fred J.	51	FA
MCDANIEL, Michael A.	97	AR
MCDANIEL, Thomas J.	51	AV
MCELROY, Terence J.	97	TC
MCGEE, Flossie P.	51	TC
MCGUINESS, John J.	51	IN
MILLER, James F. III	51	MI
MILLS, James B.	51	SF
MULLEN, Michael R.	97	EN
MYERS, Roger E.	51	IN
MYRICK, Paul E.	51	FA
NELSON, Michael T.	53	IN
NUTBROWN, Curtis H.	97	FA
OBLAK, Thomas H.	51	IN
OBRIEN, Mark L. Sr.	51	FA
OGBURN, George E. Jr.	51	TC
PARKER, James H.	51	AR
PARSONS, Julian L. III	97	FA
QUEENHARPER, Patty J.	51	CM
RAGUINDIN, Ferdinand H.	51	SC
RASMUSSEN, Christopher M.	51	AD
REEVES, Robert B. Jr.	97	OD
REGAN, Michael D.	51	AD
REID, John A.	51	OD
RENNER, Donald A. II	53	AV
RIDDLE, Duane H.	51	IN
ROETZLER, Carol A.	51	OD
ROGERS, Stephen A.	51	OD
SANTENS, Michael G.	97	FA
SCANTLAN, Donald L. Jr.	51	AV
SCHULZ, Robert R.	51	AV
SCHVANEVELDT, Kent N.	97	AV
SHANER, Brooke M.	53	AG
SHEFFLER, Carol M.	53	TC
SHELTON, Gary B.	51	AV
SHIPE, Richard T.	51	TC
SHUFFLEBARGER, Newman D.	51	AV
SMITH, Perry R.	51	AD
SNODGRASS, Joseph W.	51	EN
SPEAR, Ronald L.	53	MI
STIENE, Joseph F.	51	OD
STOCKEL, Eugene F.	51	IN
STOKES, George M.	53	SC
STREETER, Mark B.	51	EN
STURGESS, Keith A.	51	FA
SUTHERLAND, Patrick J.	51	FA
THOMAS, Robert C.	51	OD
TINKLER, Bobby Ray Jr.	51	AV
TOY, David J.	53	AG
TRANG, Jeffrey A.	51	AV
TURNER, Thomas E. Jr.	97	QM
VIOLETTE, Jeffrey F.	51	SC
WALTER, Jon C.	53	AR
WARE, Walter A.	97	EN
WARSHAWSKY, Christopher	51	FA
WASHECHEK, Mark G.	51	IN
WATSON, Herbert D.	97	SC
WENRLI, Friedrich N.	51	TC
WELCER, Stephen A.	51	CM
WENDT, Todd R.	51	IN
WHEELOCK, Douglas H.	51	AV
WHITE, Karen K.	97	AV
WHITFIELD, Samuel R.	51	FA
WILLIAMSON, Michael E.	53	AD
WILSON, Jeffrey K.	51	OD
WILSON, John M.	97	AV
WRIGHT, Charles M.	51	FA
WRIGHT, John S.	51	AV
YACOVONI, Phillip M.	97	QM
ZIEGLER, George W. Jr.	53	SC

PERSONNEL

Salomon Assumes Duties As AMC Commanding General

GEN Leon E. Salomon, former deputy chief of staff for logistics, Department of the Army, Washington, DC, was recently promoted to four-star and named commanding general, U.S. Army Materiel Command, Alexandria, VA. He succeeds GEN Jimmy D. Ross, who retired after more than 35 years of active service.

Backed by more than 34 years active commissioned service, Salomon has also served as deputy commanding general for Combined Arms Support Command, U.S. Army Training and Doctrine Command; commanding general, U.S. Army Combined Arms Support Command and Fort Lee, VA; and deputy chief of staff for readiness, U.S. Army Materiel Command.

Salomon holds a bachelor of science degree in chemistry from the University of Florida, and a master of science degree in management logistics from the U.S. Air Force Institute of Technology. His military education includes the Chemical Officer Advanced Course, the U.S. Army Command and General Staff College, and the Industrial College of the Armed Forces.

Salomon is the recipient of several awards and decorations, including the Distinguished Service Medal with one Oak Leaf Cluster (OLC), Legion of Merit, Bronze Star Medal, Meritorious Service Medal with two OLC, Air Medals, Army Commendation Medal with two OLC, Expert Infantryman Badge, and the Army General Staff Identification Badge.

BOOKS

GPO Publishes Free Catalog On Military History Books

Now available from the U.S. Government Printing Office is a free catalog of U.S. government books about military history, listing books about World War II, Korea, Vietnam, the Civil War, women in the military, turmoil in the Middle East, America's fighting ships and more. These official military history books feature detailed descriptions of key battles, personal memories of participants, information on strategy and tactics.

To request your free catalog of *U.S. Government Books About Military History,* please write to the Superintendent of Documents, Military History Catalog, Room 3095, Mail Stop: SM, Washington, DC 20401.

TARDEC Seeks Improved Vehicle Fire Protection

The U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC), Warren, MI, is coordinating research efforts aimed at finding new fire suppressants that are environmentally friendly and more effective in extinguishing vehicle fires than Halon 1301, the chemical now in use.

Halon 1301 is a gas belonging to a larger family of gases and liquids known as Halons, a name which is a contraction of the words halogenated hydrocarbons.

Halon 1301 was introduced to troops during the early 1980s after it was found to be safer to use and more effective than alternative fire suppressants such as carbon dioxide. Tests have revealed that it is safe to breathe for up to 15 minutes at the low concentration levels required to extinguish fires.

Tests also have indicated that when used in an automatic fire-detection and suppression system capable of releasing the suppressant the moment a fire starts, it is especially effective in extinguishing explosive fires. Such a fire usually occurs the instant an ammunition round penetrates a vehicle's fuel tank or hydraulic system. And, if not extinguished within a quarter of a second, it produces a fireball large enough to create the catastrophic internal vehicle temperatures and overpressures that accompany hydrocarbon fuel fires.

Despite its effectiveness in arresting explosive fires, Halon 1301 has two drawbacks. The one considered to be the most serious is that it is suspected of being an ozone-depleting chemical or ODC, which many scientists believe may be contributing to adverse global changes by damaging the protective ozone layer in the stratosphere. The other shortcoming is that Halon 1301 is less effective than other suppressants in putting out deep-seated fires—those caused by such things as electrical short circuits, or flammable materials coming in contact with hot engine surfaces.

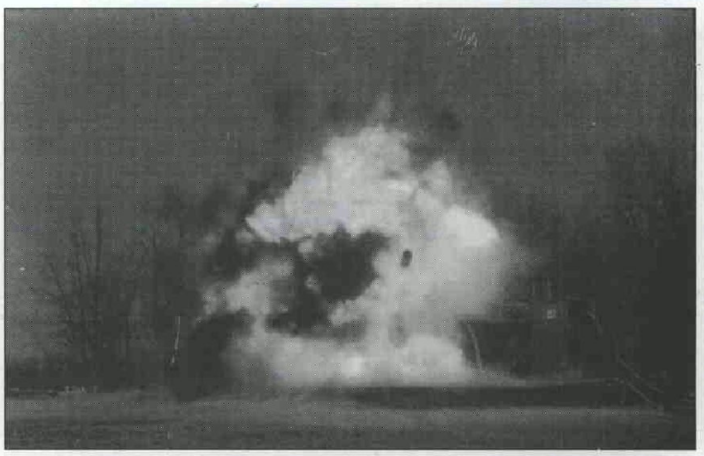
In an effort to resolve these problems, the U.S. Congress passed the Clean Air Act, which has directed industry and government agencies to find suitable replacements for Halon 1301 as soon as possible. DOD has responded to the Clean Air Act by ordering defense research agencies to work toward that end, and has required the military to reduce its use of Halon 1301 by 50 percent by the end of FY94.

To achieve these goals, TARDEC is working with various Army, Navy, Air Force and Marine Corps agencies, along with research organizations from Canada, Great Britain, France and Sweden, to find new fire suppressants.

According to TARDEC's Michael J. Clauson, program engineer for engine-compartment fire suppressant research, at least 12 candidate chemical agents will be tested in FY94 at Aberdeen Proving Ground, MD, for use against engine-compartment fires. He said two of these are dry-powder chemicals—sodium bicarbonate (baking soda) and polyammoniumphosphate—which so far appear to be quite effective.

But Clauson said that the big challenge will be to find a chemical that is both safe to breathe when used inside a crew compartment and capable of arresting explosive fires.

"We currently do not have a chemical other than Halon 1301 that will meet these requirements," said Clauson. "We do have one agent—trifluoro-methyl iodide (CF3I)—that looks very promising. At this point, it appears to be non-toxic and it puts the fire out very well. But it will take several years for any suppressant to pass all the required testing making it acceptable for use in crew compartments, and we will use Halon 1301 until then."



A survivable event.

After: "We're still there."

Clauson explained that the big stumbling block in getting a fire suppressant approved for crew-compartment applications is the toxicology studies that have to be done. "We have to go through at least three years of testing," he said, "and if you go two years, nine months and fail, then you are back to square one."

When asked if the Army will be able to meet the DOD-imposed deadline for cutting Halon 1301 consumption by 50 percent, Clauson said that as an interim measure, efforts are now under way to replace all portable Halon 1301 fire extinguishers with carbon dioxide units. "It's the best choice we've got right now. It is available off the shelf and it will enable us to meet the DOD-driven deadline," said Clauson.

The preceding article was written by George Taylor, a technical writer in the Marketing Office of the U.S. Army Tank-Automotive Research, Development and Engineering Center.

M1 Abrams Upgrades Keep Armor Forces Charging

When the shells are flying and U.S. soldiers are looking to punch through enemy defenses, the M1A1 Abrams main battle tank is usually called upon to be a big part of that punch.

The M1 has undergone several major changes since it was added to the Army's inventory in the early 1980s. The tank has been significantly improved during that time, its designation being changed from the M1 to the M1A1. The smaller 105mm gun on the M1 was replaced with a 120mm on the M1A1 for better accuracy. The M1A1 also sports a better suspension and increased armor, giving it greater mobility and protection than the previous version.

A newer version, the M1A2, has among its new features an independent thermal viewer and weapons station for the tank commander as well as navigation and positioning instruments. It is currently being tested and evaluated by the Army's Tank-Automotive Command.

However, the current workhorse of U.S. armor forces is the M1A1. This potent weapon has proved itself in a variety of theaters, but nowhere more capably than the deserts of Saudi Arabia and Kuwait where U.S. and coalition forces crippled the Iraqi army in 100 hours of quick, fierce fighting.

Though the M1A1 is virtually unstoppable by enemy rounds, it can be vulnerable to weather and terrain elements. The heat and sand of the Middle East could have brought armored forces to their knees in the Gulf War.

This is but one of many problems that have been corrected by Product Improvement Verification Testing (PIVT) conducted at U.S. Army Yuma Proving Ground (YPG). YPG engineers work hand-in-hand with engineers from the Tank-Automotive Command to test new ideas and parts to make the M1A1 a better tank.

"What we do is similar to automakers who make improvements on a car after the initial production," said Brian T. Grimes of YPG's Materiel Test Directorate, Tank Automotive Division, Engineering Branch. "We test the vehicle with new features for approximately 6,000 miles to check the durability of newly-designed features. These new items can range from components of the track or suspension to the engine—it can really be anything."

The current PIVT tests being conducted include 58 piggybacked items on two M1A1s. The items range from newer, lighter road wheels to improved suspension items, and elements of crew comfort such as a device that enables crew members to heat meals-ready-to-eat while the tank is "buttoned up."

Also being tested is a pulse jet air cleaner that will eliminate the need for crews to change the filters for the turbine engines. Elimination of this time-consuming task will allow crew members more time to spend on mission-essential tasks.

In addition to the air cleaner, seven engines that have been overhauled at Anniston Army Depot are being tested for durability. The purpose of this is to determine the reliability of the depot level maintenance.

An M1A1 makes its way through one of the tank hills courses at U.S. Army Yuma Proving Ground.

"We give the manufacturers a tailor-made test environment to test their product on the M1. Whatever they need; the fording basin, the hills course, vertical slopes, whatever. We provide the tank and they provide the test parts," said Grimes.

Uniquely, PIVT testing on the M1A1 is conducted only at YPG. Certain items, such as road wheels, are sent to Fort Knox, KY or the National Training Center in Fort Irwin, CA, for additional miles, but all testing is conducted from and at YPG.

According to Grimes, the main reason for testing at YPG is the amount of natural courses and the terrain at the installation. "We get very accurate results here. The terrain here is especially brutal on tanks. We have a harsh range that is full of both rocky terrains and soft sand; both of these do terrible things to metal parts. We have tested so many different components of the suspension and the tracks I can't remember them all."

How important is this? It is very important according to Grimes. "The testing conducted at YPG keeps improving upon the best main battle tank in the world," he said. "With the Army not buying as many tanks, it's important to keep the ones we have running well. The testing we do here accomplishes that task very nicely," Grimes added.

The preceding article was written by SPC John S. Paramore, a U.S. Army photojournalist with the Army Yuma Proving Ground Public Affairs Office.

ARL Houses 'SMART' Program

Shawn Walsh, a scientist in the Polymers Division of the Army Research Lab, Watertown, MA, was recently asked to brief Director of Defense Research and Engineering Dr. Anita Jones on SMARTweave, a technology he invented in 1988.

SMART stands for Sensors Mounted as Roving Threads. The technology assesses the integrity of a structure by detecting the resin flow (known as resin transfer molding) of fiber-reinforced materials. The results then transfer to a computer, which displays them.

Walsh has received a patent for his invention, which has commercial as well as military applications. Jones has cited SMARTweave as one of two vital technologies DOD-wide and critical to the advancement of imbedded sensors and intelligent processing.

According to Walsh, SMARTweave combines performance with cost-effectiveness.

TARDEC Develops Infrared Tire-Testing Technique

Scientists at the U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC), Warren, MI, are developing a novel method for endurance-testing pneumatic tires that will significantly reduce testing, repair, and support costs, and increase tire reliability.

Testing tires for the Army to see that they comply with military specifications and to validate industry tests is the responsibility of the TARDEC tire laboratory. This facility includes a computer-controlled system consisting of two large dynamometers and four tire-testing stations. The system can test tires at speeds up to 100 mph at temperatures up to 100 degrees Fahrenheit.

According to William A. Moncrief, chief of the tire lab, the current endurance-testing procedure is a continuous 47-hour test, in which samples of tires are rotated under a simulated vehicle load on a dynamometer. If the samples do not fail during the 47-hour observation period, the tires are approved for use on Army vehicles.

The new procedure, which can be completed in less than four hours, reveals additional defects that eventually lead to tire failure, and are not typically detectable with the present test or by visual inspection. The technique involves using a patented high-speed infrared imaging system developed by Dr. Steven M. Shepard and David T. Sass of TARDEC's Advanced Imaging Laboratory.

It consists of an infrared camera, a computer and dedicated software and hardware developed by Shepard and Sass. In operation, the camera creates a video snapshot of the temperature distribution within the tire while it is rotating. These images are then fed into the computer for analysis. The temperature in an area of the tire containing a defect is greater than in areas free of flaws, and the computer is programed to detect the existence of flaws by observing these temperature differences.

Shepard said, "So far, our experiments indicate that we can accomplish in a few hours what the endurance test does in 47 hours. Beyond that, we have seen small subsurface defects that the standard endurance test fails to detect, and we have seen evidence that these small defects can lead to premature tire failure. This could be very important in cost reduction, and in improving the survivability of Army vehicles."

Shepard said the next step in developing the system will be to build a data base of infrared signature standards from tires having various kinds of failures and from others known to be free of defects. By storing these signatures in the computer's memory, it will then be possible for the computer to compare them with signatures of test tires to determine the type and severity of any defects that may be present.

Moncrief stated, "We see this system as a real money saver for the Army. By reducing the test time from 47 hours to four hours, it will mean a substantial saving in manpower and overtime needed to run a test. Also, it will be a big help for Army depots and contractors, particularly for evaluation of retreads and remanufactured tires."

Contracts Provide Training Products, Courses

The U.S. Army Training and Doctrine Command can provide a wide variety of training products and courses not only to Army schools and units, but to the entire federal government.

The service is made possible through five-year contracts with three companies that create products at fixed prices. The Army Training Support Center's Acquisition Support Branch (ASB) oversees the program.

Mary Carpenter of the ASB said, "Through the contracts, we can obtain print media, interactive courseware, training aids and other products. One of the companies can develop new training from front-end analysis through to a full course."

According to Carpenter, the service is particularly beneficial as Department of Defense and other government agencies downsize.

"When training centers and units do not have the capablity, or in-house resources (such as personnel), we can help them," she said. Agencies requesting the work must provide funds for work to be accomplished. ASB recently helped the Federal Emergency Management Agency acquire a training course for its employees.

The contractors performing the work are Carley Corporation of Orlando, FL, PROSOFT, Newport News, VA, and Logicon Eagle Technology Inc., Winter Park, FL. Each company specializes in creating certain training products.

For information on specific services available or how to request service, call DSN 927-4701, commercial (804) 878-4701 or fax (804) 878-4705.

ADPA Announces Acquisition Reform Symposium

Representatives from government, industry and academia are invited to attend a Defense Acquisition Reform Symposium, April 26, 1994, at Fort Lesley J. McNair, Washington, DC. Sponsored by the American Defense Preparedness Association (ADPA) and the Association of the Industrial College of the Armed Forces, the symposium is intended to provide a forum to discuss strategies for genuine reform of the defense acquisition process.

This symposium is a follow-on to the 1993 ICAF Symposium "Government, Industry, and Academia: Partnership for a Competitive America." This year's meeting is hosted by the National Defense University, The Defense Acquisition University, The Industrial College of the Armed Forces, and The John M. Olin Institute for Strategic Studies, Harvard University.

For additional symposium details please write to: ADPA, Attn: Ms. Mary Murphy, 2101 Wilson Boulevard, Suite 400, Arlington, VA 22201 or call (703) 247-2582.

Upcoming Conferences

• The 48th meeting of the Mechanical Failures Prevention Group (MFPG) will be held April 19-21, 1994 in Wakefield, MA. Consistent with the goals of the White House Technology Reinvestment Project, this year's theme is "Advanced Materials and Process Technology for Mechanical Failure Prevention." The host and one of the sponsors of the conference is the Army Research Laboratory, Watertown, MA. Other sponsors include the Office of Naval Research, Naval Surface Warfare Center, Naval Civil Engineering Laboratory and the Vibration Institute.

Inquiries about exhibits may be addressed to Marc Pepi, U.S. Army Research Laboratory, AMSRL-MA-CB, 405 Arsenal Street, Watertown, MA 02172-0001; (617)923-5334. For additional details, write Henry C. Pusey, 4193 Sudley Road, Haymarket, VA 22069-2420, or call (703)754-2234.

• A conference on "Advances in Modeling and Simulation" will be held April 26-28, 1994 at the Redstone Arsenal Rocket Auditorium, Redstone Arsenal, AL. Sponsors include the Defense Intelligence Agency-Missile Space Intelligence Center; Simulation, Training and Instrumentation Command; U.S. Army Missile Command Research, Development and Engineering Center; U.S. Army Research Laboratory; U.S. Army Research Office; and U.S. Army Space and Strategic Defense Command. The conference will address issues related to applications of modeling and simulation, and will identify and prioritize research efforts needed to advance this technology.

The workshop will include both classified and unclassified sessions. Anyone planning to attend classified sessions must send security clearance to: Commander, U.S. Army MICOM, ATTN: AMSMI-SI-CI-SO-VC, Redstone Arsenal, AL 35898-5160, fax (205) 876-3303. For additional information, call Susan T. Caldwell on (205)895-6343, extension 277. All non-government attendees must present a copy of a properly executed DOD Form 2345, "Export Controlled Technical Data Agreement" authorizing their organization access to export controlled material.

• The University of Delaware's Center for Composite Materials (CCM) and Department of Mechanical Engineering will co-host the American Society for Composites Ninth Technical Conference, to be held September 20-22, 1994 in conjunction with CCM's 20th Anniversary Research Symposium. The theme of the conference, which will be held at the University of Delaware, is "Composites Science and Technology for the 21st Century." For additional information contact Dr. Tsu-Wei Chou at (302) 831-2904 or Dr. Jack R. Vinson at (302) 831-2338.

Call for Papers

The U.S. Army Missile Command, in cooperation with the U.S. Navy, the U.S. Air Force, the Office of the Secretary of Defense, and the Defense Logistics Activity, will sponsor a conference on "Diminishing Manufacturing Sources (DMS) and Material Shortages" Aug. 8-11, 1994, at the Jupiter Beach Resort, Jupiter Beach, FL. The theme of this year's conference is "A Proactive Approach to Obsolescence." The objective of the conference is to develop a more innovative strategy to solving this many faceted dilemma. By bringing together the best of industry, government, and academia, cooperative strategies may be formulated to solve the obsolescence problem through preventive techniques, more effective communications, and enhanced system design. Topics will be addressed from the viewpoints of government, original equipment manufacturers, and component manufacturers.

Unclassified presentations are being solicited to include the following general topic areas:

• Innovative strategies for combating the obsolescence problem, to include: preventative techniques, proactive vs. reactive DMS management, obsolescence reduction through standardization, technology insertion, and the role of concurrent engineering for minimizing DMS.

• The importance of communication in resolving DMS, to include automation of DMS information management and methods to strengthen the communication process between the contractor and project manager.

• Specific roles addressing DMS, to include: distribution, aftermarket sources, test houses, DESC, GIDEP, etc.

• Future concerns impacted by obsolescence, such as nuclear hardness, ODCs, manufacturing processes, mechanical components, materials, logistics, offshore manufacturing, etc.

Persons desiring to present a paper at the conference are invited to submit an abstract (200-300 words) no later than Mar. 31, 1994. Abstracts must include the title, author(s), complete return address and telephone number. They should be mailed to Susan T. Caldwell, The University of Alabama in Huntsville, Research Institute E-47, Huntsville, AL 35899, or faxed to (205)895-6581. A final paper in publishable form must be provided for inclusion into the proceedings no later than July 15, 1994.

For additional conference information, call Susan Caldwell at (205)895-6343, ext. 277.

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