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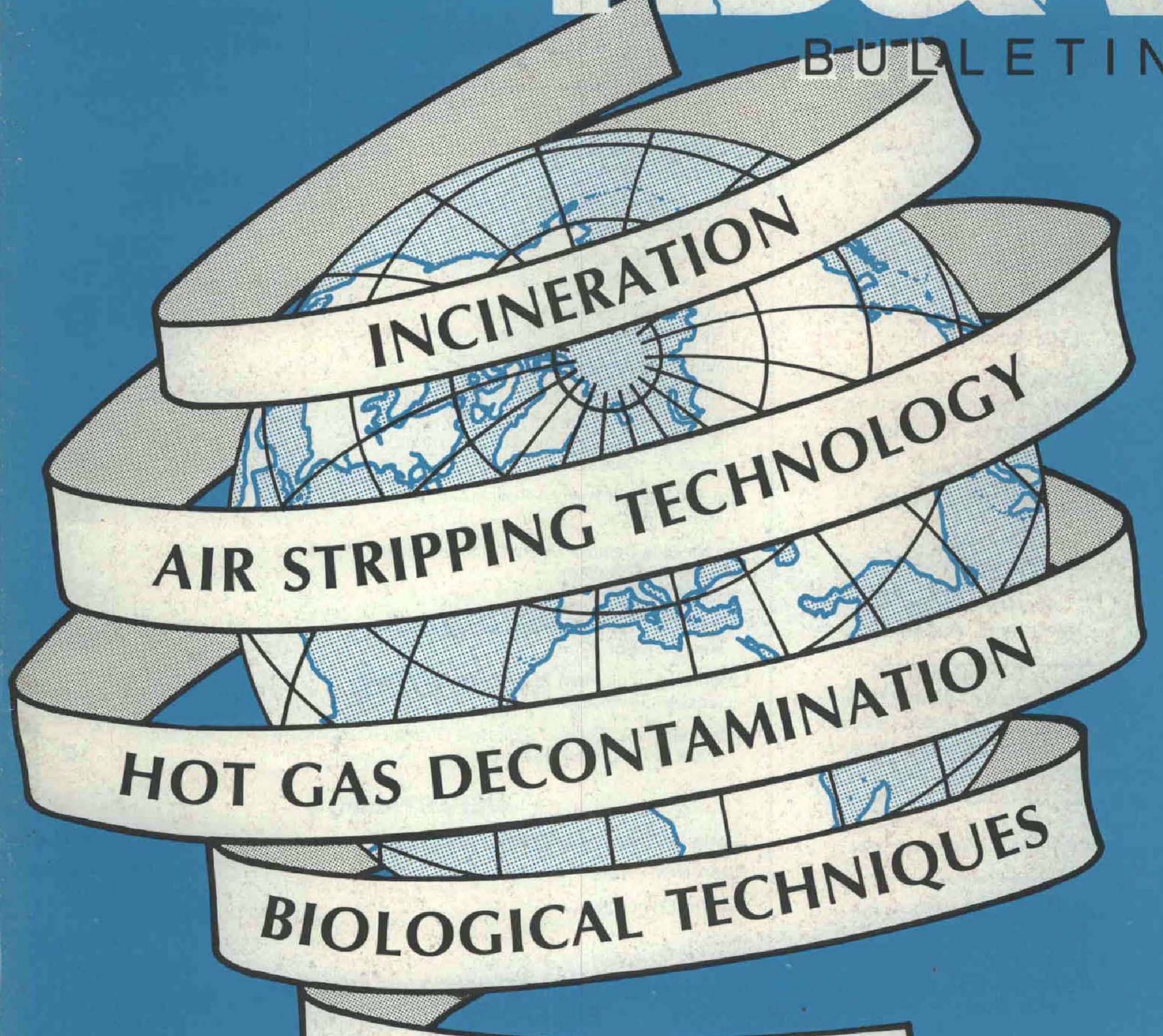

ENVIRONMENTAL QUALITY THROUGH TECHNOLOGY

ARMY
Research
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RD&A

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ENVIRONMENTAL QUALITY THROUGH TECHNOLOGY DEVELOPMENT

By Janet Mahannah

Introduction

As we begin the 1990s, government and industry are faced with substantial challenges to improve and maintain environmental quality. Although most environmental quality issues are not new, regulatory mandate, public safety and health, economics, and growing public demand have increased the emphasis on resolution of these issues.

The U.S. Army leadership, sensitive to the need to meet environmental challenges, has established a technology research and development program designed to successfully and cost-effectively protect, preserve and restore environmental quality.

Need for Environmental Quality

The Army's technology development efforts are focused primarily in two areas:

- Remediation of Army-owned sites which have been contaminated with industrial wastes during operations which predate the present environmental awareness and,
- Generation of hazardous wastes resulting from current Army industrial operations including propellant, explosive, and pyrotechnic manufacture and handling and tactical equipment maintenance.

As we become more knowledgeable of the health and safety impacts of industrial wastes and as the public's environmental awareness increases, it is clear that we must resolve the problems associated with these contaminated sites and hazardous waste generation. More knowledge consistently has resulted in increasingly stringent rules and regulations which govern management and disposal of hazardous wastes. In turn, the ability to remediate, control, detect, and monitor these wastes becomes more exacting. Clearly, a look to the future is necessary to address these growing needs. The Army has dedicated the technical expertise and resources of the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) to conduct a research, development, and implementation program to support environmental quality issues at Army facilities.

Technology Development

The primary evaluation criteria for Army environmental quality technology development are technical merit and cost effectiveness: the technology must achieve the required results for either site remediation or pollution abatement and must do so at a lower cost than other available alternatives. In addition, the ability to monitor and maintain control over the technology is critical. The Army is now challenged with meeting regulatory criteria involving the detection and measurement of part per million, billion, and trillion concentrations, which has placed importance on the development of analytical methodology and techniques capable of complying with these requirements. An additional factor critical to the overall technology development program is the pursuit of technologies which can be implemented in the short term to address immediate needs.

USATHAMA's technology development program employs a phased approach that identifies, evaluates, and tests appropriate technologies. This development pathway has been used to mature a number of technologies that have been fielded at Army installations across the country to meet the needs of site remediation or pollution abatement and hazardous waste minimization.

Site Remediation Technologies

The Army is remediating its contaminated sites through the Installation Restoration Program, managed by USATHAMA. To support these remediation efforts, technologies are required that can cost-effectively and safely treat a wide variety of contaminants and media.

Past operations that contributed to contamination include ammunition manufacturing and handling operations as well as standard maintenance operations, resulting in contamination by propellant and explosive ingredients, industrial chemicals, and metals. These contaminants are found in soil, ground and surface water, and aging, leaking industrial wastewater lagoons. In addition, buildings in which explosive and propellant operations were conducted have been found, in some cases, to be heavily contaminated.

Before the development of effective treatment technologies, options available for managing these contaminated materials were limited. Contaminated soil was contained or excavated and hauled to a licensed disposal facility. Structures were decontaminated by burning: total decontamination being assured only by demolition and destruction of the structure. Technology development has now increased both the number of treatment options and the degree of effectiveness for managing contaminated materials.

Treatment of Contaminated Soil

Among the most common contaminants found in soil at Army sites are explosives from ammunition production and organic compounds from the use of solvents and degreasers. The critical safety aspects of handling soil contaminated with explosives resulted in an extensive effort to select and develop a safe, effective technology to treat the material.

Incineration

After an initial evaluation of many potential technologies, treatment in a rotary kiln incinerator was determined to be the most promising for near-term implementation, from both technical and cost standpoints. In 1982, a program was initiated to demonstrate the effectiveness of incineration to decontaminate explosive-contaminated soils and to determine operating parameters which would factor into a full-scale design. An incineration technology demonstration was conducted in 1983 at Savanna Army Depot Activity, IL, using a transportable rotary kiln incinerator. The feed to this incinerator consisted of soil contaminated with 9 percent to 41 percent total explosives, predominantly TNT, RDX, and HMX. These are the most commonly used explosives in the Army's conventional munitions.

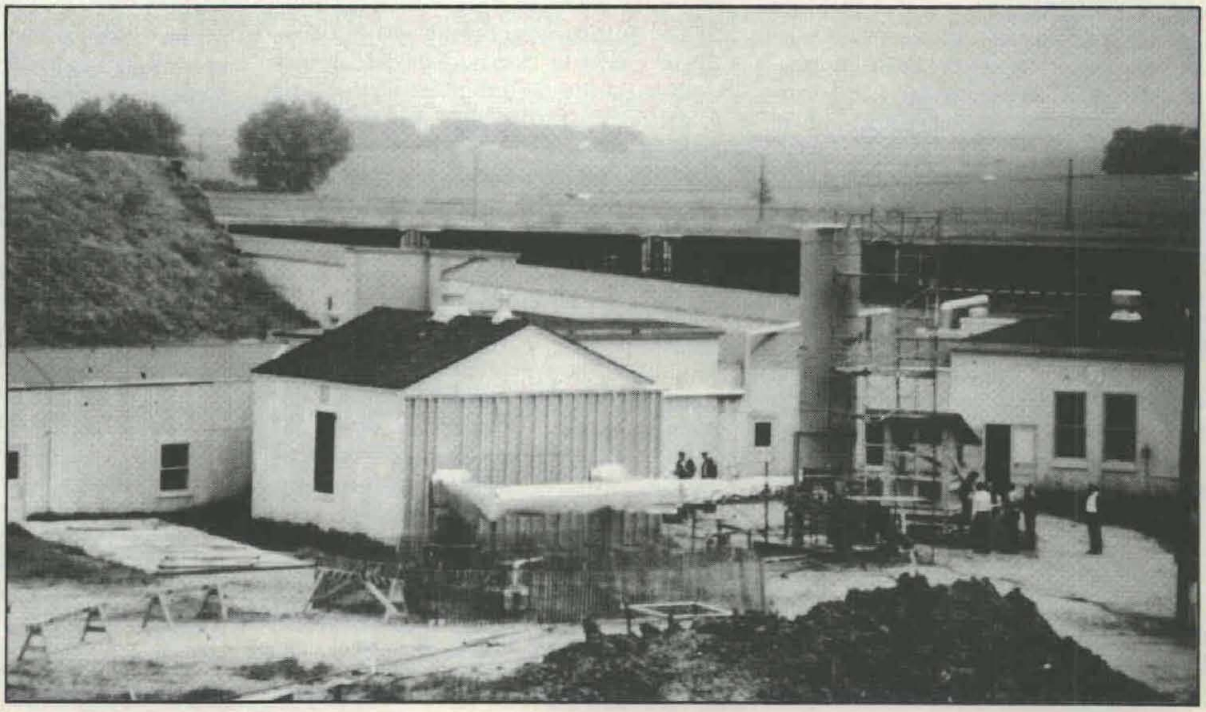
The demonstration proved that explosive-contaminated soils could be safely treated with no adverse environmental impact. The explosives or their derivatives were not detected in air emissions. Stack emissions were in compliance with federal and state regulations and the resulting ash was shown to be non-hazardous with respect to toxicity and reactivity.

One of the most critical issues in treating soil contaminated with explosives is that of material handling. The primary safety considerations in handling this material include minimization of contact with the explosive material, avoidance of initiating sources and confining the soil to eliminate the potential for detonation, and prevention of the spread of contamination.

In response to these safety considerations, a material handling and feed system for explosive-contaminated soil was designed and tested. The system selected by USATHAMA for development consisted of a live-bottom hopper to feed the materials to a series of twin screw conveyors which discharge the explosive feed directly into the incinerator. This system, tested in 1986 at Louisiana Army Ammunition Plant, successfully and safely processed over 300,000 pounds of soil with explosives concentrations often exceeding 25 percent by weight. The system was accepted for use by the Army and Department of Defense safety communities.

The developments described above led to implementation of full-scale remediation projects at Cornhusker Army Ammunition Plant, Grand Island, NE, and Louisiana Army Ammunition Plant, Shreveport, LA. More than 40,000 tons of contaminated soil have

The Hot Gas Decontamination technique was pilot tested at Cornhusker Army Ammunition Plant, NE, to remove explosives from contaminated structures.



been successfully treated at the Cornhusker plant. The remediation at Louisiana, currently in progress, will decontaminate more than 120,000 tons of soil over a two-year period.

Composting

Although incineration has proven to be a successful remediation technology, efforts are being conducted to develop alternatives which will be less costly to implement. The most promising alternative at this time is the biological degradation of explosives in soil by composting.

Composting of explosive-contaminated soils involves the mixture of contaminated soil with organic materials (such as manure) to degrade the contaminants. Two demonstrations of the composting process were conducted in 1988 and 1989.

During the first demonstration, conducted at Louisiana Army Ammunition Plant, lagoon sediments containing TNT, RDX, and HMX were mixed with horse manure, straw, alfalfa, horse feed, and fertilizer and composted. To evaluate the effect of temperature on the composting process, two compost piles were established: one pile was maintained at 35 degrees Celsius, the other at 55 degrees Celsius. After a composting period of 153 days, average reductions for TNT, RDX, and HMX were 99.6, 94.8, and 86.9 weight percent, respectively, for the lower temperature pile and 99.9, 99.1, and 96.5 weight percent for the higher temperature pile.

A similar demonstration was conducted at Badger Army Ammunition Plant in Wisconsin to evaluate composting's effectiveness in treating soil contaminated with nitrocellulose. After 112 days of composting, test results indicated the nitrocellulose had been reduced in excess of 99.5 weight percent.

Solvents in Soil

Routine maintenance operations often require the use of solvents or degreasers. Such operations have resulted in the contamination of soil by these materials and, due to their migration through soil, groundwater has also been adversely impacted.

In the early 1980s USATHAMA began to evaluate alternatives for treating soil contaminated with volatile organic compounds, focusing primarily on trichloroethylene (TCE), the Army's most common solvent problem.

In-Situ Treatment

Investigation of potential technologies led to the development of a process involving the in-place treatment of volatile organics from soil. A pilot-scale demonstration of this process was conducted in 1984 and 1985 at Twin Cities Army Ammunition Plant, MN.

One of the advantages of the in-situ air stripping process, both practically and economically, is that it allows treatment of the soil without excavation. Initial lab-scale testing of this technique was conducted in 1984 to prove out the technology and to design a pilot test system.

The piloted technology involved the injection and extraction of air into and out of the contaminated soil by a group of strategically placed plastic pipes, or wells. As the air passed through the soil, volatile contaminants were stripped from the soil. The contaminated air was then treated through activated carbon before emission.

The pilot demonstration proved the technology effective for stripping TCE, as well as other solvents, from soil. Test results showed that 20 pounds of TCE were removed per day from a 50,000-cubic-foot site. Based on the success of

Front end loaders create a mixture of hay, straw, horse feed and horse manure to make compost piles at Louisiana Army Ammunition Plant, LA.

this demonstration, a full-scale treatment system was designed and implemented at two sites. This system is currently removing approximately 40 pounds of TCE per day from contaminated soil at the two sites at the Twin Cities plant.

Low-Temperature Treatment

Although the in-situ air stripping technology was successfully demonstrated and used in Minnesota, its success is dependent on site-specific geological factors. For successful treatment, air must pass through the soil. At sites with heavy clay soils or geological conditions which preclude the use of the in-situ technology, an alternative technology was required. This led to development of a process involving the low temperature thermal stripping of volatile organics from soil. A pilot-scale demonstration of this process was conducted in 1985 at Letterkenny Army Depot in Chambersburg, PA.

The low temperature thermal stripping process concept is based on the heat-induced volatilization of contaminants from soil followed by their removal from the processor by an air stream. The processor used in the 1985 pilot test was an off-the-shelf indirect heat exchanger commonly used to heat, cool, or dry bulk solids, slurries, pastes, or viscous liquids. Contaminated soil was excavated and placed in the processor, where it was subjected to temperatures ranging from 50 to 210 degrees Celsius and residence times from 30 to 90 minutes. Test results indicated that the process is effective in removing volatile organic compounds from soil and that the system is flexible enough to allow for operation to meet specific treatment objectives by adjustment of temperature, residence time, and/or moisture content.

Contaminated Groundwater

Contamination of our national groundwater supplies is a growing concern among environmental professionals, government leaders and the public.

Because industrial operations at some Army sites have resulted in groundwater contamination, the Army dedicated resources to developing methods to treat groundwater contaminated with organic compounds at Army sites. Using work initially conducted by the Air Force, USATHAMA developed an air stripper designed to remove a variety of organic solvents from groundwater.

The air stripping system, demonstrated at Sharpe Army Depot, CA, consisted of four packed columns in series. Contaminated water was pumped to the top of each tower and allowed to fall through the packed column. Air was supplied at the bottom of each tower and passed through the packed columns, thus stripping contaminants from the water. Based on the success of this pilot demonstration, full-scale air stripping systems were designed and have been implemented at Sharpe Army Depot and Twin Cities Army Ammunition Plant.

Decontamination of Structures

Decontamination of Army structures contaminated from munition handling and processing operations has presented the research community with unique challenges for technology development.

Since previous treatment methods resulted in the structure's destruction, the advantages of decontamination are significant. An effort was undertaken in the early 1980s to develop a technology for non-destructive structural decontamination. This technology employs the use of a hot gas decontamination process. Hot gas is applied to the interior of the structure. Decontamination is achieved by volatilization and decomposition of the contaminants.

Pollution Abatement and Hazardous Waste

The surest way to eliminate future environmental problems which require remediation is to reduce, to the maximum extent possible, hazardous discharges to the environment. This is a goal of technology development in support of pollution abatement and environmental control for ongoing industrial operations within the Army.

Research and development of pollution abatement technology in support of the U.S. Army Materiel Command industrial complex is a critical USATHAMA mission. The agency is researching and developing new technologies that, when implemented, will lead to regulatory compliance as well as waste minimization, recycling, recovery, and reuse of wastes.

Operations supported by R&D efforts include those associated with the manufacture of propellants, explosives, and pyrotechnics; handling and maintenance of conventional munitions; and, production and maintenance of tactical equipment.

During munitions operations, liquid, solid, and gaseous wastes are generated which require treatment. Although many of the contaminants in these streams are common to government and private sector industrial operations, many of the compounds of concern are military-specific: primarily explosives, propellants, and their derivatives.

Hazardous Waste

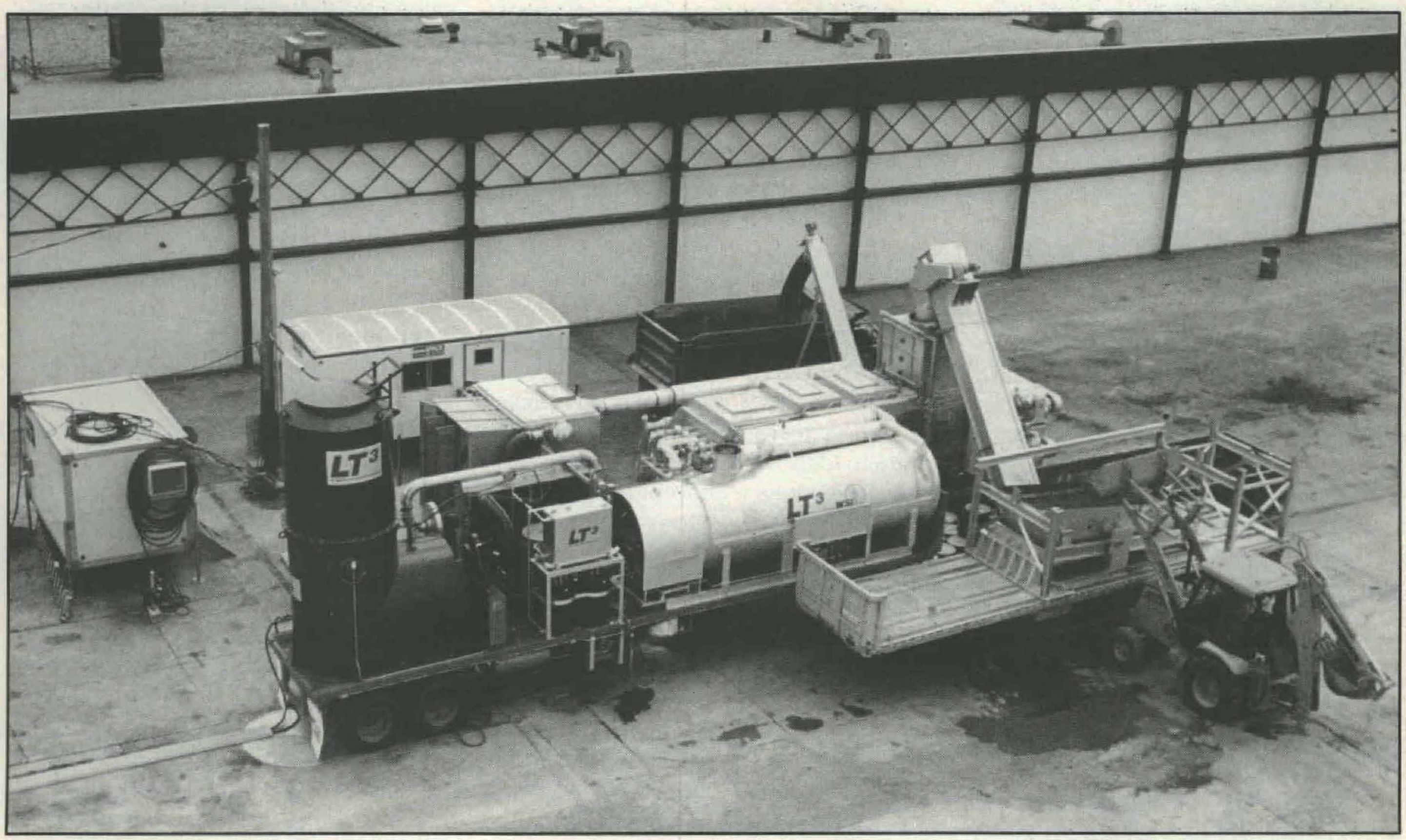
Technologies developed for pollution abatement and hazardous waste minimization in Army industrial operations must meet the needs of prospective Army users, as well as specific technical and cost criteria. Important user considerations include the compatibility of the technology with existing or planned processes, the potential for negative impact of production quality and throughput, and health and safety aspects of the technology. With these considerations in mind, it has been found that the best way to assure acceptance is to include the user in technology development.

The technologies briefly described provide basic examples of the types of technologies which have been and are being developed for pollution abatement in the primary waste generation areas.

Munition-Related Wastes

Munition-related wastes include those generated during the manufacture of propellants and explosives and those resulting from loading, assembling, and packing of munitions. These operations generate substantial quantities of liquid and solid wastes containing a variety of contaminants such as the explosives TNT, RDX, and HMX, propellants nitrocellulose and nitroguanidine, other organics, and heavy metals.

One of the areas where R&D has played an important role is in the development of biological techniques for



Low Temperature Thermal Stripping (LT3) was pilot-tested at Letterkenny Army Depot, PA, to remove TCE (a solvent) and at Tinker Air Force Base, OK, to remove JP-4 (fuel).

waste treatment. Included in these are a state-of-the-art activated sludge treatment facility for the treatment of wastewaters generated during the production of HMX and RDX, rotating biological contactors for use in treating wastewater produced during single, triple, and double-base propellant manufacturing processes, and activated sludge systems for the treatment of ball propellant production wastewaters.

Reusing Waste Explosives

One area of waste management that is gaining impetus from the standpoints of hazardous waste minimization, cost, and resource recovery is the recovery and reuse of waste explosives and propellants.

When results from preliminary investigations indicated a potential for substantial cost savings through reuse of these valuable waste materials (generally by-products of off-specification production or obsolescence) a technique was established to resolvate propellants so they could be reintroduced into the production process. Laboratory tests employing this technique were successful and pilot-scale testing is planned.

One method to recover waste explosives currently under development is the blending of waste explosives such as TNT and RDX in fuel oil. The mixture can then be used to feed Army industrial boilers. To address the safety aspects associated with handling explosives and their use as supplemental fuel, tests were conducted to evaluate the chemical compatibility and stability of the mixtures and to identify any tendency for propagation of detonation.

Metal Finishing Wastes

Metal finishing operations generate a significant quantity of wastewater containing total toxic organics (TTO), the discharge of which is controlled by regulations promulgated by the Environmental Protection Agency.

In response to the needs of Army depots with metal finishing operations, USATHAMA initiated an effort in 1985 to determine if simple and inexpensive operations and maintenance modifications could reduce the amount of TTO discharges. This effort was centered on two metal finishing operations located at Tobyhanna Army Depot, PA, and Sacramento Army Depot, CA.

After careful review of metal finishing operations at these depots, recommendations for process changes were made. These changes, relatively minor modifications to isolate rinse tanks to prevent overflow into wastewater discharge systems and omission of processes not critical to product quality, were implemented and waste streams were sampled. Analyses of these waste stream samples indicated that the simple and inexpensive process changes were effective in reducing the TTO concentrations from one-fourth to one-eighth the original concentrations.

The review of metal finishing operations also resulted in an important recommendation to find a suitable replacement for using methylene chloride to chemically strip equipment. In 1987, an evaluation of potential methylene chloride alternatives was initiated. The preliminary effort involved literature and laboratory evaluations of a number of commercially-available strippers with respect to their stripping ability, operating conditions, stripping time, and environmental impact. As a result of this initial evaluation, strippers were selected for large-scale demonstration and are currently being evaluated in production operations at Sacramento Army Depot.

An important aspect of abatement R&D at non-munition Army operations is the application of commercially-available technologies or processes to specific Army requirements.

An example of such application is the use of plastic media blasting for paint stripping. Plastic media blasting, previously investigated and implemented by the Air Force, has potential to result in significant reductions in hazardous waste generation because the media can be recycled. Additional benefits include the potential for greater paint removal rates, reduced risk to human health, and less potential for equipment damage.

USATHAMA conducted a demonstration program in 1988 to determine the suitability of plastic media in Army maintenance operations. Specific goals of this program included the determination of optimum plastic media blasting parameters as well as the identification of instances where plastic media blasting would be a cost-effective alternative to present stripping techniques.

Results of the demonstration were promising. Besides demonstrating that plastic media blasting was effective for Army uses, perhaps the most significant finding of the test was the potential for reduction in waste generation when plastic media blasting was used as an alternative to more conventional paint stripping practices. Based on the testing program, USATHAMA is developing guidance to Army depot maintenance facilities for the implementation of plastic media blasting.

Future Technology

The need for pollution abatement and hazardous waste minimization in Army operations continually changes. Process changes and improvements, the use of different materials in established processes and the continuing development of specifications requires the Army to prepare for the future.

USATHAMA is responding to these changing needs through an active program to identify, test, demonstrate, and implement new technologies to reduce or eliminate hazardous wastes. For example, plans are being developed to demonstrate the use of aluminum ion vapor deposition to replace cadmium plating in Army metal finishing operations. Unlike cadmium plating, which generates a variety of hazardous waste streams, use of aluminum produces no hazardous waste and may provide a superior coating. Another important area of involvement is the development of alternative techniques and processes to replace current methods of paint stripping, including material substitution and process improvements.

Technology Transfer

To make the best use of resources devoted to environmental quality, USATHAMA actively pursues technology transfer. In 1981, the Army was designated to chair the Installation Restoration Technology Coordinating Group (IRTCG), established to aid in the exchange of technical information among Department of Defense components as well as the U.S. Environmental Protection Agency and other federal departments.

The IRTCG sponsors program reviews by the services to highlight current projects and to outline future plans. The IRTCG also sponsors workshops to address technology development and specific installation restoration and pollution abatement problem areas such as paint waste disposal, detection of volatile organic compounds in soil, thermal destruction of wastes, in-situ treatment concepts, and quality assurance and quality control of chemical analyses. In these roles, the IRTCG continues to provide a major technology transfer mechanism for obtaining and maintaining environmental quality throughout the federal government.

Conclusion

Although there may be some differing opinions on how best to achieve environmental quality, no one disputes the need for it. There also appears to be general agreement that technology will play a key role. Continued research and development, like efforts now underway and planned by the Army, can provide needed solutions to environmental problems as well as contribute to the ideal solution — continued pursuit of our national defense with minimal environmental impact.

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MACHINE INTELLIGENCE TECHNOLOGIES IN ARMY LOGISTICS

By BG(P) Malcolm R. O'Neill
and Dr. Som Karamchetty

Modern technology has provided the Army with tremendous capability in terms of the lethality and mobility of combat units. Along with these benefits, however, such technology has made weapon systems extremely complex. The area of logistics illustrates these pluses and minuses. For example, through their increased probability of kill, "smart weapons" and "brilliant munitions" have reduced the burden of transporting large inventories. On the other hand, such complex technologies place great demands on operation and maintenance personnel. It is imperative that we apply appropriate automation techniques to simplify these demands.

The future battlefield, as postulated in the AirLand Battle Concept, would involve highly mobile forces engaged in an extremely hostile environment where opposing forces will rarely fight across distinct lines. Advanced and complex weapon systems would shape that battlefield. Such warfare would pose unprecedented challenges to logisticians. According to Army Chief of Staff GEN Carl Vuono, "the AirLand Battle Doctrine has refocused our thinking from a primarily tactical outlook to a more complete view, the latter including anticipation, integration, continuity, responsiveness and improvisation" (*Army Logistician*, July-August 1988). This shift in thinking puts logistics in a vital role.

Machine intelligence can assist the Army in adopting high technology for the future battlefield. In this article, we examine the potential role of machine intelligence in easing the burden on the logistics community. Machine intelligence is defined, and its role in the Army technology base discussed.

MI and the Tech Base

Machine intelligence (MI) or artificial intelligence (AI), as it is usually called, is computer software that gives a machine (a computer) the ability to use humanlike methods of problem solving — hence the term machine intelligence. Whereas traditional computer programming is strictly procedural, machine intelligence is symbolic and knowledge intensive. In general, the problem-solving methods implemented in the computer are searching, representing knowledge, reasoning, deduction, learning, and understanding.

Types of machine intelligence can be broadly categorized into a number of areas: expert systems, natural language understanding, speech recognition, intelligent pattern recognition, intelligent tutoring systems, and automatic programming. Brief explanations of these areas follow.

Expert systems

An expert system is computer software that captures a domain expert's knowledge and makes it available to novices for use in problem solving. In a particular environment, a given situation will imply that certain situations are true and others false. Given such facts and their previous knowledge, human beings can derive new facts. With expert systems, this capability is bestowed on the machine.

In simple systems, expert knowledge and "tricks of the trade" are represented as rules. These rules are pairs of antecedents ("if" part) and consequents ("then" part). Through the use of available sets of rules, expert system software can logically deduce new facts and add them to a data base of facts. Eventually, the machine can come to a

Figure 1.
Explosive ordnance disposal: the use of machine intelligence techniques coupled with compact disk (CD) memories provides interactive support to EOD technicians and soldiers on the battlefield.

conclusion and present it to an operator for profitable use. As early expert systems proliferated, their deficiencies came into focus. Representing human knowledge about subjects, components, and systems simply in terms of rules was determined to be shallow. Improved, deep knowledge representations were invented. The result is the representation of knowledge through "frames" and "semantic nets."

While the Army has many efforts in the expert systems area, the AirLand Battle Management Program (ALBM) is by far the largest. ALBM is a DARPA/Army joint program managed by the U.S. Army Laboratory Command (LABCOM). ALBM captures the expertise of battle tactics and supply options and runs scenarios. It can make recommendations to a commander in real time, thus allowing him to reach critical decisions inside the enemy's decision cycle.

Where knowledge and information are extensive, such as in explosive ordnance disposal (EOD), compact disk (CD) memories coupled with expert systems have found a ready and beneficial application (Figure 1). Another expert system application that delivers a high payoff in repair and maintenance savings is the Pulse Radar Intelligent Diagnostic Environment (PRIDE) developed at the U.S. Army Missile Command (MICOM) (Figure 2).

Natural Language Understanding

Athough computers are becoming ubiquitous, they can be operated only in their own languages; this restriction places an enormous training and education burden on the community. On the other hand, if computers were equipped to understand human language, such as English, computer usage could be universal. This desire to extend the usefulness of computing has led to efforts toward natural language (NL) systems development. These systems try to follow human ways of understanding language. They contain rules of grammar, syntax, and methods of analysis and synthesis of sentences.

Successive generations of NL systems have shown improvements in knowledge representation and robustness. When syntax alone was found to be inadequate, semantic representations have been undertaken, so that meaning is well represented and correct inferences are drawn.

A number of commercial NL systems have been built to serve as user-friendly interfaces to data bases. They are helpful for the user who needs to query a particular data base without knowing the specific instruction sets that would

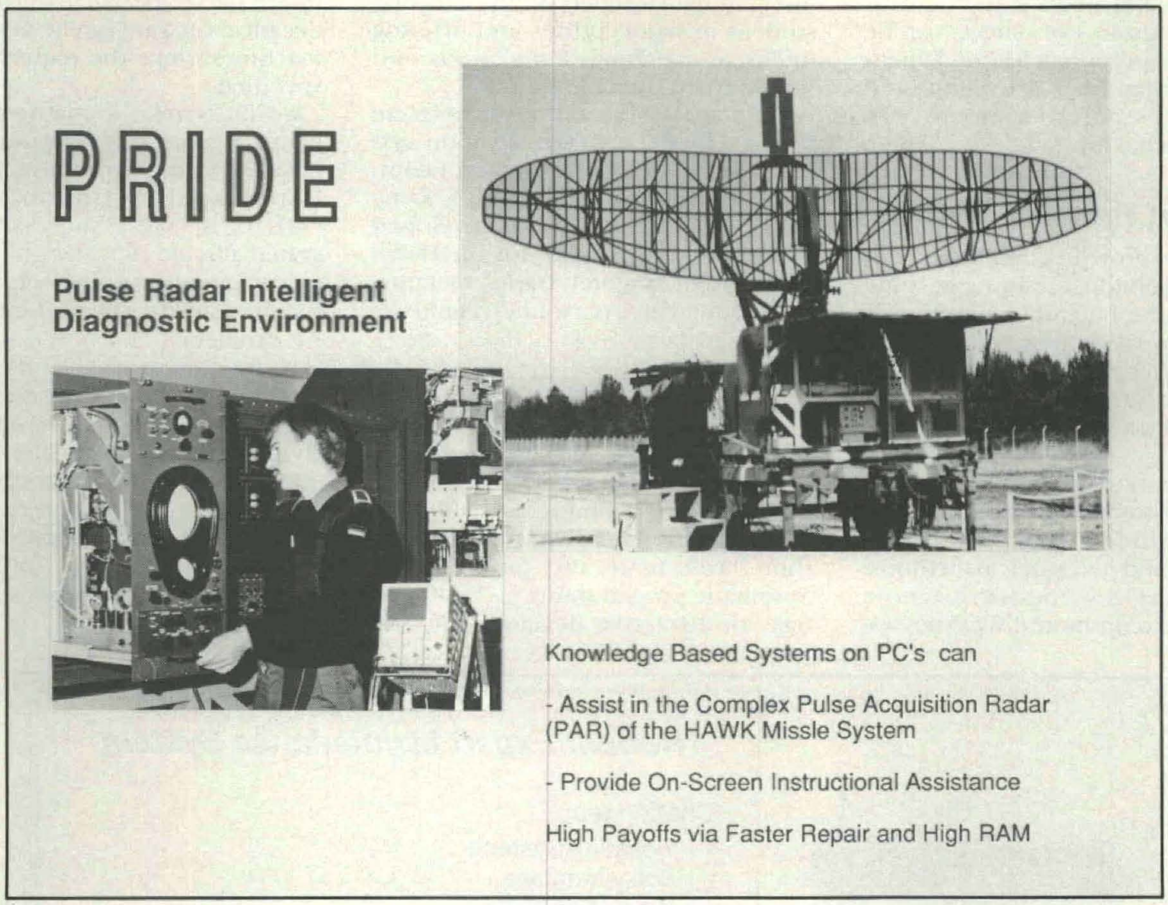

Figure 2.

Hawk missile radar (right); diagnostics module of Hawk system (left); including PRIDE (Pulse Radar Intelligent Diagnostic Environment). Knowledge-based systems on PC's assist in diagnostics and maintenance of the complex pulse-acquisition radar (PAR) of the Hawk missile system (right) and provide on-screen instructional assistance (left).

otherwise be necessary. In military applications, message traffic has been the subject of automatic analysis by NL systems. Despite their promise, however, NL systems have a long way to go before robust applications become a reality.

Speech or Voice Recognition

Computer systems have traditionally been operated by keyboards, although lately mouse and touch screen interfaces are becoming widely used. However, input by human voice commands is the ultimate aim of researchers who see the simplicity of systems that people can "talk" to. While this approach may seem straightforward, human speech is very complex for practical applications. Since different speakers exhibit strong individual characteristics, making systems universally applicable has become a main issue in recent research. Although some commercial products have been on the market, limited vocabulary and extensive speaker training requirements have been their drawbacks.

Voice-recognition technology, in conjunction with natural language systems, holds great promise in command and control situations. By freeing the hands of the operators and combat troops from the keyboard or console buttons, speech systems enhance the users' physical capabilities. The U.S. army Tank-Automotive Command (TACOM) has developed a voice-interactive Robust Expert Maintenance System (REMS) that frees the hands for repair tasks while the operator communicates with the system (Figure 3).

Intelligent Vision or Pattern Recognition

Recognizing visual information enables people to create mental pictures and make comparisons. In the early stages of pattern-recognition research, computer-based pattern-recognition methods employed comparisons at the pixel level. As AI developments matured and human cognition processes were better understood, more sophisticated symbolic pattern-recognition methods came into being.

These symbolic or intelligent pattern-recognition processes depend on identifying features as a first step towards identifying the object. For example, an aircraft is distinguished by such characteristics as the body and wings. By identification of each of these characteristics, the system recognizes the total picture. With such a method, two pictures need not match pixel for pixel. As more features match, confidence increases that the two pictures represent the same object. Similarities can be established between objects, and families and groups of objects can be created. Such an approach is fundamental to understanding, reasoning, and learning — essential elements in intelligent behavior.

Intelligent Tutoring Systems

As systems grow in complexity, not only does individual training become more expensive, but individual training needs increase. Computer-aided training (CAT) systems were first used to fill this gap, but early CAT systems were deficient because of their limited capabilities.

Intelligent tutoring systems (ITS's) derive their strength by incorporating models of student behavior, expert knowledge, and pedagogical methods. In general, an ITS attempts to diagnose a student's strengths and weaknesses, just as human teachers do, by detecting student misconceptions and offering intensive coaching. Simulations and graphics aid the ITS.

Training logistics will be put to severe tests by future complex weapon systems, and ITS's show promise for coming to the rescue. Already the U.S. Army Research Institute (ARI) has developed an intelligent instructor for the Hawk missile system which trains operators and maintenance personnel (Figure 4).

Automatic Programming or AI in Software Engineering

Ever since computers were invented, and throughout their development, the need for programming and software development has been an obstacle to their large-scale and popular use. Automatic programming (AP) is therefore an attractive development. AP researchers hope that in the next several decades software can be developed by machines, once the requirements are specified.

So far, symbolic mathematics programs (algebra, geometry, and calculus) have shown much promise. The VHSIC Hardware Description Language (VHDL) is highly successful in integrated circuit (IC) design. But these achievements are relatively limited by comparison to the difficulty of the AP problem.

As modern weapon and logistic systems become software intensive and their life-cycle costs become prohibitive, AP developments offer economic alternatives. The logistics community can attest to the complexity of maintaining current systems software over its life-cycle and will undoubtedly welcome the relief promised by AI in software engineering.

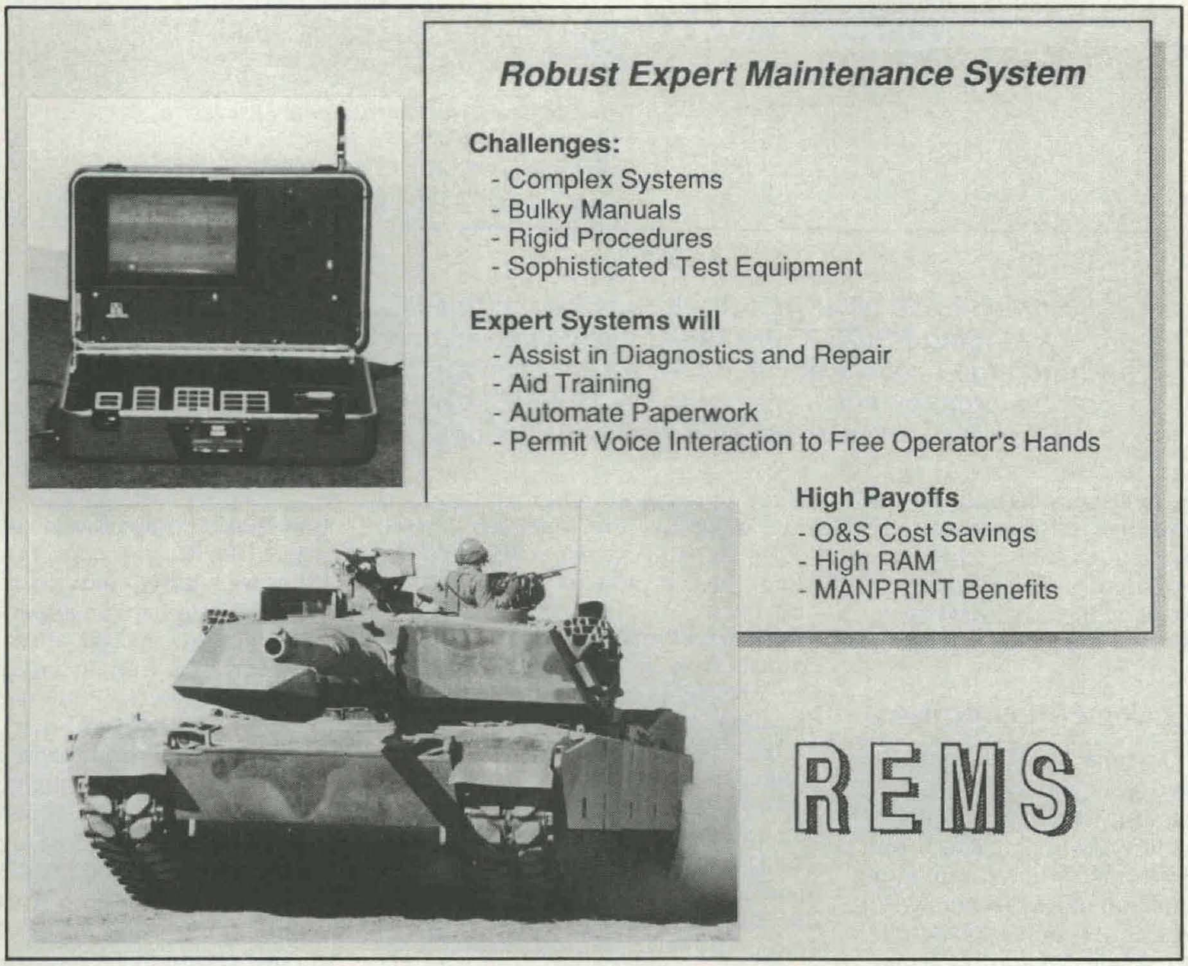

Figure 3.

REMS (Robust Expert Maintenance System) (top): this expert system will assist in the diagnostics and repair of Army vehicles (such as the M-1 tank below), as well as aiding in training and automating paperwork, while permitting voice interaction to free the operator's hands.

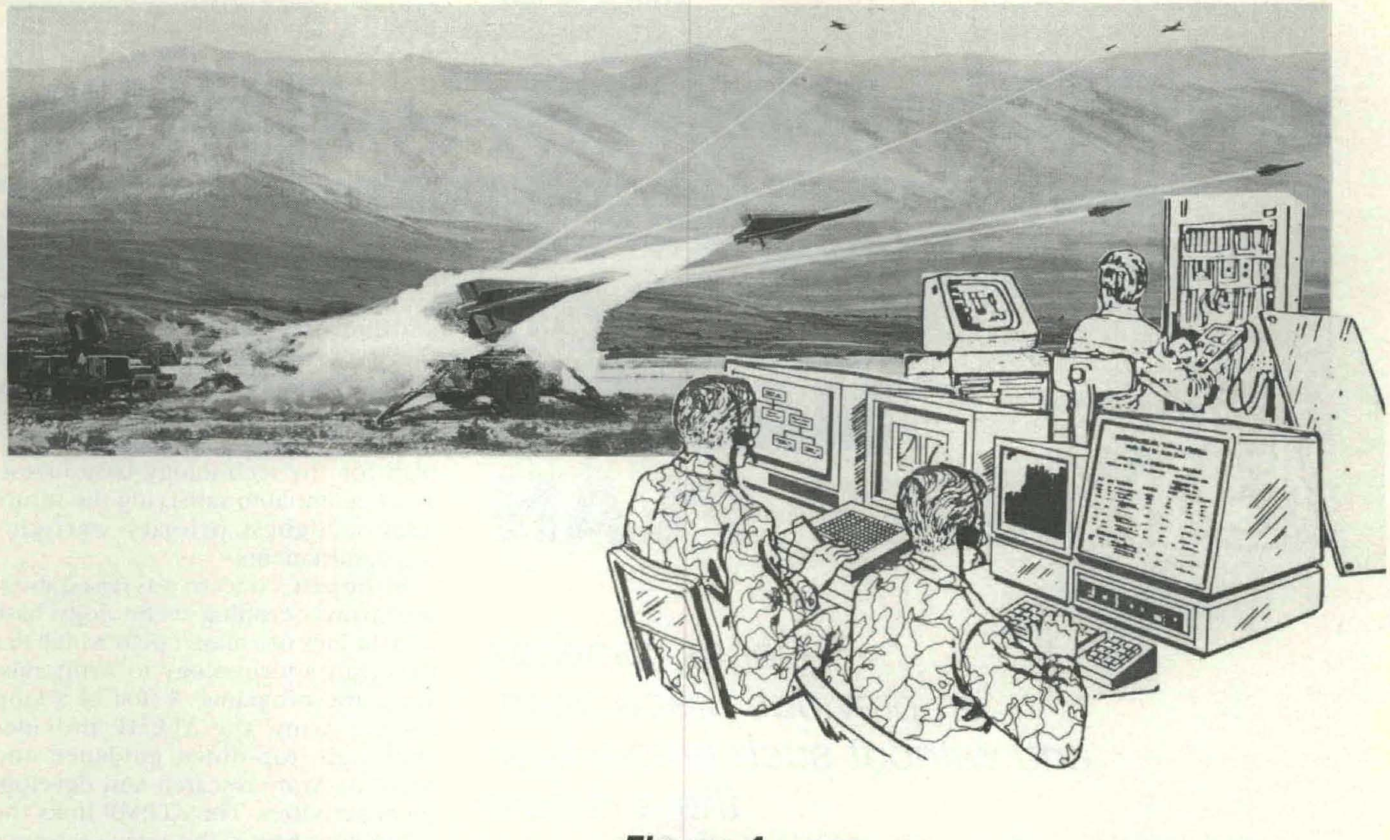

Figure 4.
The Hawk missile system (photo) requires complex training. The Intelligent Institutional Instructor Maintenance Aid for Hawk (MACH III), a $70K training system, replaces $3M of actual hardware and allows virtual one-on-one tutoring.

Promoting MI Technologies

The traditional roles of government and private industry interact strongly and positively to enhance and apply machine intelligence technologies. The Army nurtures technology at the most theoretical and conceptual level through its sponsorship of the AI Center of Excellence at the University of Pennsylvania, as well as a consortium at Brown University, Yale University, and the Massachusetts Institute of Technology. A number of Small Business Innovative Research (SBIR) programs identify excellent ideas and concepts and act as seedbeds for potentially high-payoff developments. In the meantime, private industry spends Independent Research and Development (IR&D) funds to conduct research on areas of potential application to Army systems. Furthermore, the commercial sector has been actively working on its own, marketing many hardware platforms, expert system languages and shells, and generic and specific systems.

Machine Intelligence: Key to Future Systems

Expert systems applications have already demonstrated their power and usefulness for benefiting the Army in the logistics area; the other evolving components of machine intelligence hold great promise to deliver possibly even more benefits to Army systems. Continued support of these technologies will insure that the Army derives the greatest benefits promised by this technology.

Although the Army has undertaken a strong expert systems technology and application program in the logistics area, we have a long way to go to apply machine intelligence effectively and realize the full potential of this technology. This is partially because of the complexity and extent of the logistics area, and partially because of the evolving nature of the machine intelligence field. As described in this article, a number of other components of machine intelligence will be needed and can be usefully deployed as the logistics area embraces this promising technology.

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THE ARMY'S TECHNOLOGY BASE MASTER PLAN

Success depends on previous preparation, and without such preparation there is sure to be failure—Confucius

By Sharon Vannucci
and Brian David

Almost every successful business organization can trace its roots to success back to its business plan. A business plan is essential for planning, marketing, and ultimately providing guidance and direction as the business organization grows and meets the challenges of an increasingly complex world. The Army Technology Base Master Plan (ATBMP) is a comprehensive strategic plan for the technology base investment essential to satisfying the future Army's highest priority warfighting requirements.

In the past, concern was raised about the Army's eroding technology base and the lack of a master plan which ties the Army's technology to Army missions and programs. A first of a kind for the Army, the ATBMP provides thorough, top-down guidance and focus to Army research and development activities. The ATBMP links the technology base to the Army's resource constrained force modernization plans, thereby enabling the Army to seize the initiative and insert technology in a timely fashion throughout the research, development, and acquisition process.

ARMY TECHNOLOGY BASE MASTER PLAN

- TECHNOLOGY BASE INVESTMENT STRATEGY
- RESEARCH AND DEVELOPMENT BALANCE
- FOCUS ON CRITICAL / KEY EMERGING TECHNOLOGIES
- SPEEDING TECHNOLOGY TRANSITION
- LEVERAGING SCIENCE AND TECHNOLOGY OUTSIDE THE ARMY
- QUALITY SCIENTISTS AND ENGINEERS

SCIENCE AND TECHNOLOGY SUPERIORITY:
OUR INVESTMENT IN SHAPING THE FUTURE
AND COMPETING SUCCESSFULLY

Published in April 1989, the ATBMP is a living document which will be periodically updated to respond to changes in the threat, DA/DOD guidance, technology advances/opportunities, and user requirements. Like the Army's force modernization plans, the ATBMP is resource constrained: only programs which are funded at the time of publication are included in the plan.

The Army's technology base represents an indispensable corporate investment to: counter the threat across the spectrum of conflict; maintain our technological superiority on the battlefield; maintain our technological competitiveness; retain an in-house "smart buyer" competency; and avoid technological surprise even in this rapidly changing world. The technology base is divided into three categories. The Basic Research (Program Category 6.1) program exploits and identifies technological opportunities and provides an important interface with university and industry research. The Exploratory Development (Program Category 6.2) program matures technological opportunities and evaluates technical feasibility for increased warfighting capability. The Non-system Specific Advanced Development (Program Category 6.3A) program accelerates the maturation of technology through focused technology demonstrations.

The ATBMP presents our Technology Base Investment Strategy (TBIS) and includes the Army's funded Science and Technology Objectives (STOs). These STOs not only state what specific objectives are to be achieved, but also when. Many of these STO critical milestones are driven by windows of opportunity for technology insertion into next generation and future systems presented in the Army's force modernization plans. The basic principles of the Army Technology Base Investment Strategy are to:

• Ensure the Technology Base Program Supports the Army's highest priority warfighting capability needs.

• Balance the Technology Base: Near, Mid, and Far Term Needs; Technology Push/Requirements Pull; and Between Weapons Systems and other Battlefield Requirements.

• Distribute Technology Base Resources Across Four Areas: Future Systems; Supporting Capabilities; Systemic Issues; and Key Emerging Technologies.

ADVANCED TECHNOLOGY TRANSITION DEMONSTRATIONS (ATTDs)

CRITERIA

- RISK REDUCING "PROOF OF PRINCIPLE" DEMONSTRATIONS CONDUCTED IN AN OPERATIONAL ENVIRONMENT RATHER THAN A LABORATORY ENVIRONMENT
- POTENTIAL FOR ENHANCED MILITARY OPERATIONAL CAPABILITY OR COST EFFECTIVENESS
- DURATION OF THREE YEARS (TYPICALLY)
- A TRANSITION PLAN IN PLACE (APPLICATIONS AND WINDOWS)
- ACTIVE PARTICIPATION BY THE USER COMMUNITY (PROPONENT)
- PARTICIPATION BY THE DEVELOPER (SERVE AS PROJECT MANAGER)

ADVANCED TECHNOLOGY FOR THE SOLDIER

- LIGHT-WEIGHT MATERIALS
- HIGH-STRENGTH POLYMERS
- FLASH PROTECTION
- LOW OBSERVABLES
- ADVANCED COMBAT RIFLE
- PORTABLE ANTITANK WEAPONS
- ELECTRO-OPTICS
- ENERGY DENSE BATTERIES
- MICROELECTRONIC COMMUNICATIONS
- GLOBAL POSITIONING SYSTEMS
- NEW RATIONS, e.g., MRE
- SURVIVABLE NBC CLOTHING
- IMPROVED FABRICS
- MICROCLIMATE COOLING
- AIR PURIFICATION
- MICROSENSOR DETECTION KIT
- MULTIPURPOSE CB DECON

• Seize and Retain Technology Initiative.

• Enhance Return on Investment by Leveraging R&D Outside the Army.

• Reduce the Time from System Concept to Successful Fielding Through Focused Advanced Technology Transition Demonstrations (ATTDs).

• Restore Stability to the Technology Base.

• Provide Top-Down Guidance to Create an Atmosphere Which Fosters Technology Initiative and Pursuit of Promising, Innovative Opportunities.

The Army's strategy for the materiel portion of force modernization requires anticipation of the threat and the design of a defense long before the threat actually appears. It is therefore imperative that the technology base deliver timely and affordable technologies in support of the advanced systems and concepts required by our force modernization plans. This requires a close linkage between Army force modernization and the technology base. These resource constrained modernization plans have greatly improved the focus of the technology base since they provide definite windows of opportunity for technology insertion into the next generation and future Army weapon systems.

The existence of such explicit, resource constrained weapon system development plans allows for planning and execution of Advanced Technology Transition Demonstrations (ATTDs) which speed the maturing of advanced technologies needed by next generation and future systems. Technology transition to Demonstration/Validation (6.3B) or Full Scale Development (6.4) is enhanced by ATTDs.

ATTDs consist of demonstrations that are conducted with early operator and tester involvement in an operational environment to assess potential technology solutions or enhanced capabilities to overcome technological shortfalls or battlefield deficiencies. ATTDs differ from 6.3B Demonstration/Validation prototypes in that they are technology base funded and do not require a requirement document.

Because ATTDs allow the user, tester, and laboratory personnel to work together early to explore advanced technologies and demonstrate their operational potential, more responsive and realistic draft operational requirements can be developed by the user community during the course of the ATTD. The Army has 13 approved ATTDs. Examples include:

• **Component Advanced Technology Test Bed.** This testbed involves integration and demonstration of advanced component technologies on a vehicle. New capabilities include: enhanced lethality, survivability, mobility, and sustainability. The payoff is rapid technology transition.

• **Composite Hull for Combat Vehicle.** This ATTD develops and demonstrates composite structures technology for design and fabrication of future armored vehicles. New capabilities include: 25 percent lighter structure, 22 percent lower cost, and enhanced mobility compared to conventional structures. The payoff is increased mobility, combat load, reliability, and reduced logistics burden.

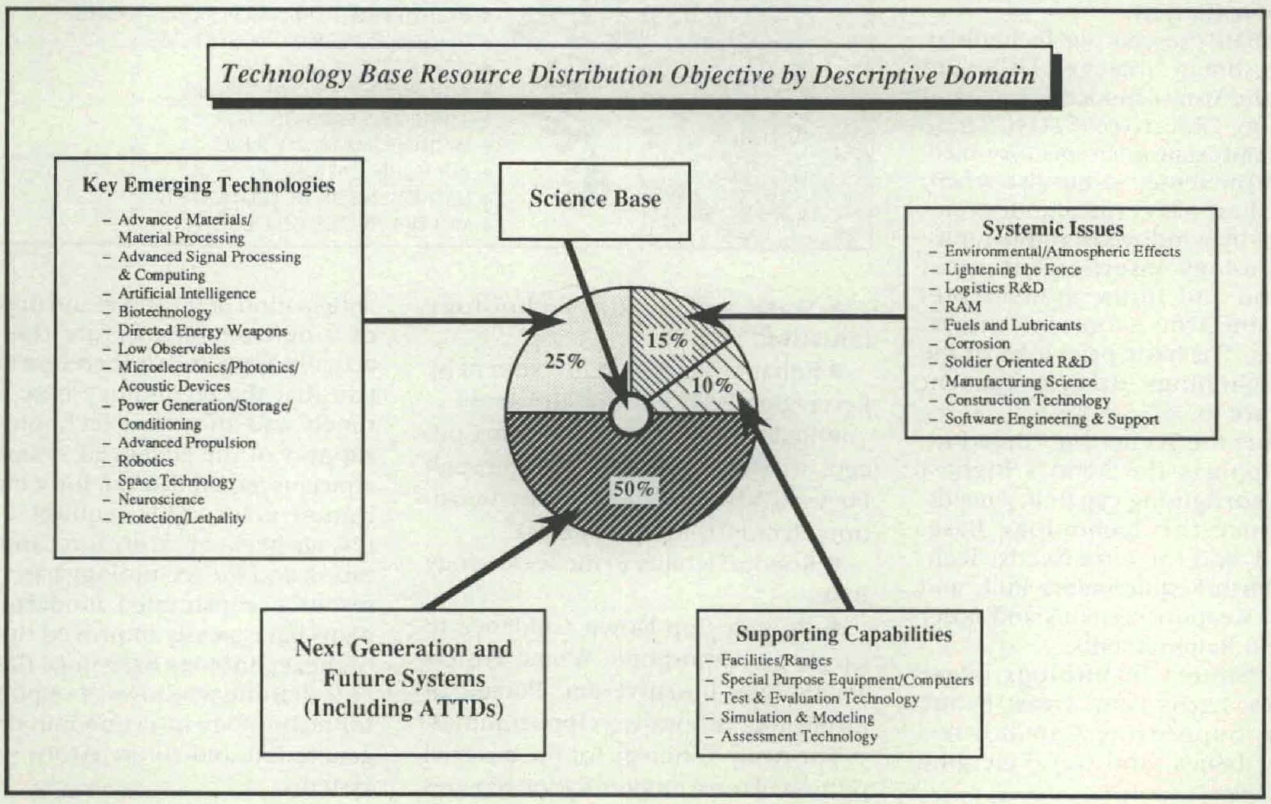
• **Multi-Role Survivable Radar.** This ATTD one demonstrates a radar that can survive intense Electronic Countermeasures (ECM) and Anti-Radiation Missiles (ARM) threats while accomplishing the critical air defense roles of surveillance, missile guidance, high quality data in the Forward Area Air Defense (FAAD) Command, Control, and Intelligence (C2I) network and Non-Cooperative Target Recognition (NCTR). The payoff is increased survivability.

• **Rotorcraft Pilot's Associate.** The Rotocraft Pilot's Associate develops and integrates advanced technologies in the areas of pilotage, mission equipment package/weapons, communications, aircraft survivability equipment and sensors. New capabilities include advanced pilotage for day/night adverse weather operations, and advanced pilotage sensors and displays. The payoff is increased mobility and survivability, and improved communications and exchange ratios.

• **Multisensor Target Acquisition (MTSA)** The MTSA demonstrates multisensor, processor and algorithms for target acquisition. New capabilities include automatic target acquisition recognition and hand-off. The payoff is increased lethality, survivability and supportability; and decreased crew size.

• **Soldier Integrated Protective Ensemble (SIPE).** The SIPE demonstrates a modular head-to-toe individual fighting system for the ground soldier which will sustain combat effectiveness while providing balanced protection against multiple battlefield threats and hazards. New capabilities include improved soldier communication and weapon interface, and a reduction in weight and bulk. The payoff is improved combat effectiveness, survivability and sustainability.

• **Standoff Minefield Detection.** This ATTD operationally demonstrates two competing standoff aerial minefield sensor, processor, algorithms,



DoD Critical Technologies and Army Key Emerging Technologies Crosswalk

DoD Critical Technologies* / Army Key Emerging Technologies	Adv Materials// Materials Processing	Adv. Signal Processing and Computing	Biotechnology	Artificial Intelligence	Directed Energy	Low Observable Technology	Microelectronic, Photonics	Power Generation Storage & Conditioning	Advanced Propulsion Technologies	Robotics	Space Technology	Neuroscience Technology	Protection Lethality
Microelectronic Circuits & Their Fabrication	X	X					X						
Preparation of GaAs & Other Compound Semi-Conductors	X	X					X						
Software Producibility		X		X									
Parallel Computer Architectures		X		X			X					X	
Machine Intelligence/Robotics		X		X						X		X	
Simulation & Modeling		X	X	X								X	X
Integrated Optics		X					X				X		
Fiber Optics	X	X					X						
Sensitive Radars		X				X	X				X		X
Passive Sensors	X	X				X	X				X	X	X
Automatic Target Recognition		X		X		X	X				X	X	X
Phased Arrays	X	X				X	X				X		X
Data Fusion		X		X			X				X	X	X
Signature Control	X	X				X	X		X				X
Computational Fluid Dynamics		X							X		X		X
Air Breathing Propulsion	X						X		X				X
High Power Microwaves	X				X			X					X
Pulsed Power Hypervelocity Projectiles	X							X			X		X
Kinetic Kill Energy	X							X			X		X
High-Temp/High-Strength/Light-Weight Composite Materials	X		X						X		X		X
Superconductivity	X							X					
Biotechnology Materials & Processing	X		X									X	

***Reference: DoD Critical Tcchnologies Plan for the Commitee on Armed Services, United States Congress; March 1989**

Table 1.

Army-Sponsored University Centers

	COMPUTERS, AI, INTELLIGENT CONTROL & MANUFACTURING SCIENCE	ROTARY WING AIRCRAFT	OPTICS	MATERIALS & ADVANCED CONSTRUCTION	ELECTRONICS	PROPULSION & KINETICS OF ENERGETIC MATERIALS	GEOSCIENCES	BIOTECHNOLOGY	MATHEMATICS
PARTICIPATING UNIVERSITIES	U. of Pennsylvania U. of Texas - Austin MIT, Brown, Harvard* U. of Delaware* U. of Minnesota	Georgia Inst. of Tech. Rensselaer Polytechnic Inst. U. of Maryland	U. of Arizona U. of Rochester	U. of California-San Diego* U. of Illinois* MIT*	Columbia U. Georgia Inst. of Tech. MIT Stanford U. U. of Michigan*	U. of Wisconsin-Madison* U. of Southern California*	Colorado State U.*	Cor nell U.*	Cor nell U.
SCOPE	Flexible communications with knowledge bases Natural language processes Reasoning under uncertainty Systems & control theory Robust software Computational architectures Automated manufacturing processes Reliability & maintainability	Rotor Aerodynamics Rotor-airframe interference flows Composite blade models Fatigue in composite tubes Hybrid composite laminates Transonic drag reduction Aeroelastic stability of hingeless blades	Optical communications Optical components Optical computers Remote sensing/target recognition Infrared systems Materials, systems and techniques for optical data storage Photonics	Response of materials to high loading rates Impingement of energy at high densities Analytical material modeling Computer codes for material design Lightweight construction materials Life-cycle costing	Electromagnetics Solid-state materials Large-scale, reliable systems Carrier transport phenomena Optoelectronic devices High-electron-mobility transistors	Engine combustion Fluid mixing Materials for engines Lubrication/tribology Fast reaction kinetics Energetic materials Photophysics of energetic species Transient processes	Atmosheric and terrestrial sciences as they affect near battlefield scales Meteorology Hydrology Geomorphology	Protein structure and function Enzymes and receptors Neurotransmitters and ion channels in the nervous system	Massive automated inference Efficient algorithms Automated battle management Mathematics of robotics
FUTURE RESEARCH PLANS	Reasoning/knowledge representations Intelligent interfaces Prototype software Parallel and distributed architecture development Intelligent nondestructive testing Process simulation Computer-aided manufacturing High performance computing	Aerodynamics for composite rotor blades Composite material tailoring Aeroelastic instabilities & dynamics of composite blades Rotor-body interference experiments Composite material design for rotorcraft structures	Development of optical materials Optical engineering - design tools & testing X-ray free electron laser	Microstructure characterization of materials Micromechanics-based analytical material New materials for high rate loading Explosion effects Non-destructive testing for construction Computer-based design, construction & maintenance	Ultrasmall structures Quantum engineering of materials Data processing tech. Submicron field effect transistors Two terminal MMW devices Quantum well oscillators and resonators	Heat transfer, internal fluid mechanics Turbulence modeling and particle-laden flows Ceramics and fiber reinforced materials Reaction path specificity of condensed materials	Remote sensing of the boundary layer Modeling of cloud dynamics Two-way nested grid computations Satellite microwave analyses	Enzymic modification of membrane proteins Cellular metabolism control Genetic engineering of enzymes Structure/function of acetylcholine receptors	Nonlinear phenomena Computational algebra & algebraic geometry Applications of logic & automated analysis

* Denotes University Research Initiative (URI) Center

Table 2.
University Center Matrix.

communication link and ground station which provide advance notice of minefield obstacles to maneuver units. The payoff is improved mobility and survivability.

The Technology Base Investment Strategy calls for 25 percent of the total tech base money to fund 13 key emerging technologies which offer the highest return on our tech base investment in terms of major improvements in the Army's warfighting capability. These technologies are:

• **Advanced Materials and Materials Processing.** Advanced materials offer a number of different approaches to higher performance and/or lower cost weapons and support systems.

• **Microelectronics, Photonics and Acoustics.** Microelectronics is the family of technologies that makes it possible to put ever increasing electronic capability in ever small packages. Photonic and acoustical devices will support further advances, making possible even more complex operations in smaller, less expensive, more dependable electronic systems with greater capability.

• **Advanced Signal Processing and Computing.** Advanced signal processing involves the technologies for manipulating electronic signals to extract items of interest which would otherwise normally be lost in noise, interference, and jamming.

• **Artificial Intelligence (AI).** AI employs computers and other systems to emulate human processes such as reasoning, analyzing, and recognizing.

• **Robotics.** Robotics is the technology of autonomously functioning systems, which sense the outside world, respond through a set of rules or AI, and control an actuator to achieve a desired purpose.

• **Biotechnology.** Biotechnology offers many unique opportunities for the Army, and its full potential has yet to be assessed. At the outset, this technology can provide the protection sought against chemical and biological agents. Soldier performance may be greatly enhanced by vaccines, protective or energizing compounds and enhanced nutrients.

• **Directed Energy.** Directed Energy Weapons (DEW) use lasers, high-powered microwaves, or beams of charged or neutral particles to blind a sensor, or to cause instant catastrophic destruction. Directed energy efforts also include protection of U.S. systems and personnel against enemy weapons.

• **Power Generation, Storage and Conditioning.** Power generation/storage/conditioning technologies enable generation and delivery of electrical power of the right quality and quantity at the time it is needed. It includes advanced generators, batteries, controls, and pulse power storage and waveform shaping devices.

• **Low Observables.** Low observables comprise the technologies that prevent detection and/or identification by sensors. This capability of rendering targets "invisible" is achieved by combinations of materials, design, and operation.

• **Advanced Propulsion.** Advanced propulsion technologies apply to rotorcraft, wheeled and tracked vehicles, and missiles.

• **Space.** The ultimate "high ground," space is a logical extension of the battlefield. Space technology and systems merge intelligence, communications, weather, terrain, positioning and targeting to provide the tactical commander with a comprehensive knowledge of the battlefield.

• **Protection/Lethality.** Protection/Lethality encompasses a wide range of critical efforts focused toward exploiting technological opportunities which will provide our future forces with improved survivability and with warfighting capabilities which will exceed the projected threat.

• **Neuroscience.** Neuroscience technology is an integration of the many subdisciplines that share a common focus: the nervous system and its control of other biological systems. Within these subdisciplines, the Army addresses military specific problems associated with sleep deprivation, combat stress, protection against chemical and biological weapons, casualty care and return to duty, and protection against infectious disease.

Coincidentally with the Army's identification of its 13 Key Emerging Technologies, the DOD was identifying its own Critical Technologies. Table 1 is a crosswalk of the Army's Key Emerging Technologies and DOD Critical Technologies and shows how the Army technology program is structured to support the DOD technologies.

The logic behind the Army's Technology Base Investment Strategy is simple: with limited resources, an ever widening range of technological opportunities, rising international technological competition, rapidly changing world events, and an increasingly more capable third world military threat, the Army must invest where the warfighting requirements and potential improvements are greatest. To supplement these potential benefits of Army technology base investments, the roles of industry and academia are increasingly emphasized and often result in long-term commitments that provide the Army with the leading-edge technology and personnel to assist in highly complicated developments. The Army Centers of Excellence (COE) listed in Table 2. offer unique enhancements to the Army's science base.

Because of rapidly changing world events and the increased third world military capability, our national strategy requires a modern, ready strategic land force for deterrence and defense. The increased uncertainty and risk associated with global events such as the expanding foreign economic and technological challenges demand more than ever a strong technology base. A strong technology base requires a strategic investment plan that strikes the proper research and development balance, exploits critical emerging technologies, and leverages science and technology outside the Army. Resourcing and soundly executing the Army Technology Base Master Plan will ensure our science and technology superiority well into the 21st century.

A copy of the Army Technology Base Master Plan (ATBMP) may be obtained from the Defense Technical Information Center (DTIC), Building 5, Cameron Station, Alexandria, VA 22304-6145. Accession Number: Volume I — C044432; Volume II — C956486.

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THE DECLINING U.S. INDUSTRIAL BASE

By Deputy Secretary of Defense
Donald J. Atwood

The following remarks, which have been slightly edited to meet *Army RD&A Bulletin* format, were originally presented late last year to a government and industry audience comprised of representatives from the Manufacturing Technology Advisory Group and the Industrial Modernization Incentives Program (IMIP). Deputy Secretary of Defense Atwood spoke in Washington, DC, a few days prior to President Bush's summit meeting in Malta with Soviet President Gorbachev.

Thank you very much, I want to spend a few minutes discussing a problem with which we are all too familiar — the general decline in the U.S. Industrial base and what we, both inside and outside the Department of Defense, can do about it.

In a few days, President Bush will meet with President Gorbachev. The importance of this meeting is evident in light of the momentous events that have taken place in the Soviet Union and in Eastern Europe over the past several months. No one should doubt that the powerful forces of democracy taking hold throughout this region of the world have been unleashed as a direct result of the policies of the United States and its allies since the end of World War II. Our steadfast commitment to military strength has permitted the equally powerful forces of free market economies to demonstrate their superiority to the bankrupt economics of communism.

These changes foretell a new standard for measuring power. No longer will a nation's political influence be based solely on the strength of its military forces. Of course, military effectiveness will remain a primary measure of power. But political influence is also closely tied to industrial competitiveness. It's often said that without its military the Soviet Union would really be a third world nation. The new standard of power and influence that is evolving now places more emphasis on the ability of a country to compete effectively in the economic markets of the world.

America must recognize this new course of events. Our success in shaping world events over the past 40 years has been the direct result of our ability to adapt technology and to take advantage of the capabilities of our people for the purpose of maintaining the peace. Our industrial prowess over most of this period was unchallenged. It is ironic that it is just this prowess that has enabled other countries to prosper and, in turn, to threaten our industrial leadership.

The competitiveness of America's industrial base is an issue bigger than the Department of Defense and is going to require the efforts of the major institutional forces in our society — government, industry, and education. That is not to say that the Defense Department will not be a strong force in the process because we will. But we simply cannot be, nor should we be, looked upon by others as the savior of American industry.

The deterioration of America's industrial base is not a new problem. The red flag was first raised in 1980 by the Defense Science Board. They followed up with another report last year [1988]. The Board's conclusions were dramatic.

• First, it noted the continued deterioration of our industrial and technology base.

• Second, it said that our weapon systems have become irreversibly dependent on foreign supplies of materials and components.

• Third, it charged that contractors at all levels of the procurement process have made inadequate long-term investment in modern equipment and facilities. This was mainly the result of the uncertainties surrounding the defense budget and acquisition process and a perceived imbalance between risk and return in the defense industry.

• Finally, it noted that subcontractors of all sizes are either refusing defense business altogether or are separating their older technology and older production lines and applying them to their defense business.

And last year [1988] the Defense Department, with input from 15 government agencies, published a report on the state of the industrial base titled *Bolstering Defense Industrial Competitiveness*, in which the problems affecting the competitiveness of American industry were again highlighted.

Now, there is often confusion over what is meant by the phrase "the defense industrial base." Usually, it is interpreted as meaning only the large prime contractors for our weapon systems. The fact is that the defense industrial base generally comprises the same manufacturers that also produce goods for the commercial sector.

In fact, the Defense Department buys manufactured goods from more than a quarter million firms, encompassing more than 215 industries. As a result, the Department's interest in defense is inseparable from its interest in the U.S. industrial base as a whole. They are one and the same. Said differently, America's security is only partly based on a strong program of defense. It is primarily based on a strong, technology-based economy.

Unfortunately, we are seeing indications of wide-spread decline in the U.S. industrial leadership. Our share of the global machine tool market, for example, is less than half of its 1980 level. Since the early 1970s, American firms have lost two-thirds of the domestic market for machining centers, more than one-third of the market for semiconductors and more than one quarter of the market for ball bearings. Perhaps even more serious is the loss of market share in the whole field of microelectronics, microprocessors and supercomputers. Viewed in total, it's clear that American manufacturing is being overwhelmed at home and abroad by foreign competition.

But a strong, internationally competitive industrial base is absolutely necessary if we want to sustain the effectiveness of our deterrent capability. The greatest destabilizer today would be the disintegration of the U.S. industrial and economic base.

The problems we are having with the defense industrial base are also in large part the result of a lack of incentives contractors have to make investments in advanced technology and equipment. In response to this, we in DOD are taking several actions.

First, we are doing away with fixed price, cost sharing contracts in the development phase of new weapon systems. By fully funding the development phase, we want to reinstate a healthier risk-return balance in the defense business. Companies will continue to bid on defense contracts only if they can expect an equitable profit.

Second, we are seeking more multi-year procurements. We can achieve greater efficiency in defense acquisition by reducing the uncertainty inherent in single-year funding. And even though budget constraints may necessitate adjustments in some of our programs, we will continue to advocate the use of multi-year procurement whenever it is fiscally prudent to do so.

Third, we are developing contracting strategies that will promote relationships with out best performing suppliers by rewarding actual performance. For example, we are looking at our contractor performance review system to find ways we can recognize factors other than cost in the source selection process. We must explore every possible avenue in our effort to give contractors the necessary incentives to make the long-term investments in high-technology equipment and facilities needed to develop and produce today's sophisticated weapons systems.

There are other ways the Department of Defense can help focus the creative talent available in the private sector to strengthen U.S. technological leadership. The Manufacturing Technology Program is a good example. As I'm sure all of you know, this program has an excellent track record for developing innovative manufacturing technologies. Among its many notable success stories are the first numerically controlled machine tool, which has rapidly become the cornerstone of modern manufacturing practices around the world, and the world's first three-dimensional x-ray inspection system used for rocket motors and space system components.

More recent accomplishments include developing the technology to automate the weaving of three-dimensional shapes used in reentry vehicle nosecones and rocket nozzles and improving the technology for producing gallium arsenide wafers used in integrated circuit manufacturing.

Given the constraints that defense spending is currently facing, we should not overlook the tremendous return the investments in Mantech [pronounced "man-teck"] programs offer. The gallium arsenide project alone saved the Navy over six million dollars from 1982 to 1987 with an additional savings of 130 million dollars estimated through 1992, all on an investment of $500,000. We intend to see that this program continues to receive the support it deserves.

The Industrial Modernization Incentives Program is another important Defense Department initiative designed to encourage contractors to modernize their manufacturing processes. Unfortunately, implementing this program has become cumbersome. One measure that would help correct this would be to accept cost estimates prepared in a manner consistent with those used in major weapon system development, thus eliminating the extensive resources now consumed in validating estimated cost savings.

Streamlining IMIP [pronounced "eye-mip"] to foster greater contractor participation is important because its benefits are tremendous. A good example is the Navy's F-18 fighter program. At its plant in Hawthorne, CA, Northrup has created a paperless factory which provides shop personnel with an on-line system for work planning, resource allocation and work performance monitoring and evaluation. The result has been real-time communication that has eliminated over 16,000 pieces of paper per aircraft. And there are equally good examples of Army and Air Force programs where

IMIP investments have also yielded impressive results.

As a further means of improving the U.S. industrial base, the Department of Defense will continue to assist in the transfer of leading edge technologies produced in our defense and national laboratories to the private sector. This is one important function of the Manufacturing Technology Information Analysis Center. Commercial use of defense technologies can greatly enhance America's industrial competitiveness.

However, as I said before, the Pentagon can only do so much to improve the performance of American industry. Many U.S. manufacturers have directly contributed to their own competitive problems. Too many have created inflexible manufacturing processes, established poor quality control systems, paid insufficient attention to customer service, failed to design their products for producibility and quality, and have in general adopted a short-term horizon.

The Department of Defense is a strong supporter of the work being done by the President's Science Advisor and the National Academy of Science to emphasize careers in science and engineering.

The results of this failure are in evidence today. Companies need to reemphasize the basics of good practices in their daily operations. That means dedicating themselves to producing quality products on time and within budget. Firms must also adopt a long-term business strategy and look beyond the next quarter.

In particular, companies should pay more attention to training their employees. Modern, flexible manufacturing processes require a highly trained workforce. The Japanese, for instance, attribute much of their success to the quality of their people. Employee training is a top priority of theirs, and it needs to be a top priority with American firms as well. The needed improvements in quality and productivity will only be realized with a properly trained workforce.

This leads me to my final point — one that deserves the immediate attention of the Defense Department and the defense industry. The decline in our economic competitiveness can be attributed, in part, to the decline of our educational system. We cannot hope to forge a world-class defense industry or any other industry unless we place more emphasis on improving our educational system.

It has been estimated that 300 children a day drop out of school in the U.S. That translates into one million children each year at a cost to our society of at least 240 billion dollars in lost earnings, taxes and extra social services. To make matters worse, the skill levels of many American high school students are inadequate, and approximately 750,000 high school students who graduate each year cannot read their own diploma. As a result, industry and government must often invest in their own remedial math and reading programs.

All of us in government and industry must take an active role in helping to promote education in mathematics and sciences beginning in the earliest school years. In those cases where industry or government have entered into partnerships with the schools, the results have been impressive. But these instances are far too few in number.

At the college-level we need to graduate more scientists and engineers and provide added incentives to remain in graduate school for advanced training, education and research. In 1986, the last year for which this data is available, just over five percent of the population of 22 year olds in the United States received undergraduate degrees in the natural sciences and engineering. This compares to six percent in Japan and about 9.5 percent in the Soviet Union. The National Science Foundation estimates that by 1996 the United States will have a shortfall of 45,000 baccalaureate degrees in science and engineering.

The Department of Defense is a strong supporter of the work being done by the President's Science Advisor and the National Academy of Science to emphasize careers in science and engineering. We have also entered into successful partnerships with academic institutions to increase the availability of scientists and mathematicians for our national security requirements. But we too must do more because in today's highly technical world a strong national defense requires a well-educated society.

Events are changing international politics. The threat of a major conflict is arguably the lowest it's been in 40 years. If these trends persist, we will be able to reduce our military forces. But there is a new struggle taking shape, and it's going to be waged in the economic markets of the world.

There is one constant in this entire process, and that is the need for a technically advanced industrial infrastructure. If the U.S. is to meet the challenges of the next century, both military and economic, it will require a strong industrial base. Toward that end the Department of Defense can help. We intend to do all we can to strengthen the industrial foundation upon which the future of America's security and economic prosperity depend. Thank you very much.

By MAJ Jeff Drifmeyer

HEALTH HAZARD ASSESSMENT

Introduction

The Army Medical Department (AMEDD) Health Hazard Assessment (HHA) program provides medical support to the materiel acquisition decision process (MADP). The purpose of this article is to describe the HHA program after five years of existence, offering ideas for further improving medical support to materiel acquisitions, especially in light of new guidance (revision of ARs 602-2, 40-10, and publication of DODD 5000.53).

Early History

Although there was no formal program or "HHA" acronym, an early concern of the Army was the effect its weapons had on the health of its troops. General George Washington was advised by his staff physician, Dr. Benjamin Rush, on hearing loss among his artillery men.

The Civil War with new weapons technology (e.g., iron clad warships with revolving gun turrets, rail mounted artillery, and repeating or machine guns) meant new, more hazardous man-machine interfaces for the soldier and his weapons. Later, when the internal combustion engine and armor plating were used, soldiers fought from hot, dirty, dangerous, confined spaces as described by one of the first men to go into battle in a tank:

The whole crew are at various guns, which break forth in a devastating fire. By this time, the fumes from the hundreds of rounds which we have fired, with the heat from the engines and waste petrol and oil, have made the air quite oppressive and uncomfortable to breathe in. However, those who go down to the land in tanks are accustomed to many strange sensations, which would make an ordinary mortal shudder.

Simultaneous exposure to physical and chemical agents including heat, noise, blast, by-products or fumes from exploded ordnance and internal combustion exhaust still occur but are much better controlled in today's tank! Those exposed rationalize that they get "used" to the hazards, becoming "tougher" in the process. Although false, such thoughts are not uncommon among today's soldiers.

The French did exemplary early work on carbon monoxide in armored crew compartments, but the U.S. effort began later with the Armored Force Medical Research Laboratory. Staffed by physicians, engineers, and scientists at Fort Knox, KY, their 1942 mission was to: identify and evaluate stressful demands placed on operators of tanks and other weapons; determine limits in soldier capabilities; and find a proper balance between operating demand and human capabilities to avoid breakdown, or failure of the man-weapon system.

The similarity of their WWII mission to today's HHA and MANPRINT programs is striking! Nearly 50 years ago, concern was the man-weapon system: a basic tenet of MANPRINT, i.e., "soldier performance affects system performance." Thus, key concepts of HHA and MANPRINT have been around for years.

The Fort Knox laboratory, which was disbanded after the war, authorized 130 reports on 19 categories of health hazards in its three years of operation. There was no systematic review of health hazards in new armored weapons. HHA was no longer integrated into MADP and fell into disuse.

Current Program

Not until the massive modernization of the 1970s did lack of an HHA program create problems. The M198 155mm howitzer was a turning point which sparked creation of today's HHA program. Late in M198 development the AMEDD investigated field reports of chest-wall pain and blood in the sputum of the soldiers firing the weapon. Impulse noise exceeded permissible exposure levels. Initially, the recommendation was to move soldiers farther from the source of damaging noise — with a 25 foot lanyard! A subsequent recommendation placed a daily limit on rounds fired. This surfaced the urgent need for formal, ongoing, timely integration of HHA into MADP.

Today's HHA program is centrally managed by the Office of the Surgeon General (OTSG) and decentrally executed by elements of both the Health Services and Medical Research and Development Commands (HSC and MRDC, respectively).

As a domain of MANPRINT, health hazards are assessed at decision points throughout MADP. With the drafting of requirements documents (operational and organizational plans, required operational capabilities), and the formation of the system MANPRINT Joint Working Group (MJWG), the combat developer relies upon designated health hazard assessment personnel at AMEDD activities on each installation with a development mission. Essential information is exchanged e.g., the HHA personnel must know what new technologies are planned for future systems, and the developer learns of health hazards that new systems and technologies may impose.

Initially, installation health hazard support did not involve too great a workload, but due to the number of new systems proposed and acquired, health hazard assessment workload has grown substantially. In FY 84 there were less than 50 HHA requests, but by FY 88 requests exceeded 130. Also a backlog resulted when systems were not "grandfathered," when HHA and MANPRINT were implemented.

The AMEDD took on the HHA mission with no additional resources. No new HHA or MANPRINT spaces were created, though requirements were recognized. When the System MANPRINT Management Plan (SMMP) process was recently briefed to the TRADOC CG, various MANPRINT

AMEDD involvement in combat development and MADP is incredibly complex — neither the combat nor materiel developer can turn to a single source for HHA support.

products or "deliverables" (e.g., HHA report) were found to be not fully integrated into MANPRINT. For HHA, this is attributable in part to manpower shortfalls.

It is unrealistic to expect better staffing; DA DCSPER MANPRINT Office policy is "no top down MANPRINT resources." The alternative is to continue to emphasize the HHA mission by raising health issues early in MADP. Thus, unnecessarily high costs to correct health hazards, as expensive engineering change proposals or lengthy delays in fielding, are avoided. It is highly cost effective to identify, eliminate, or control health hazards early in the design stages. Early and continuing AMEDD involvement in MADP, beginning at installations, is essential for an effective HHA program.

Besides limited manpower, other issues include: unfamiliarity of AMEDD personnel with weapons technologies and MADP, and the comparative newness of a mission outside the main stream of patient care. The HHA mission may be perceived as low priority compared to more immediate demands for medical support. Attending an MJWG meeting and reviewing documents on a system that may be fielded several years in the future may not seem like a priority mission relative to patient care. These factors have limited past involvement by some installation HHA personnel in combat developments. This is changing as HSC continues to stress the HHA mission and fund MANPRINT training for their personnel. HHA is a priority AMEDD mission that adds considerable value to the Army warfighting capability.

Concurrent with increased HHA workload, there is also an increase in complexity of the health hazards evaluated. Emerging technologies and materials (such as directed energy, electron beams, rail and vacuum tube guns, liquid propellants, and carbon-composite vehicle and aircraft hulls) are being incorporated into new materiel systems. Such technologies bring new, less well understood health hazards. Major efforts are required to maintain technological literacy. This problem is most acute within MRDC — whose mission includes health hazard research.

Organizational Framework

AMEDD involvement in combat development and MADP is incredibly complex — neither the combat nor materiel developer can turn to a single source for HHA support. Instead, the developer turns to his installation POC (who reports to HSC, not developer MACOMs) to attend the MJWG, forwards his requirements documents to the Academy of Health Sciences (AHS) for medical review, sends his request through his MACOM Surgeon to the Surgeon General's Office where it is sent to USAEHA where the HHA report is prepared, or to MRDC for HHA research. That's five different medical elements in several MACOMs that each provides parts of medical support to MADP. The administrative burden and communication/coordination problems are staggering.

HHA program goals and objectives might be better served by a more effective organizational structure. For example, as discussed above, a central laboratory for health hazards worked well for the WWII armored force as discussed above. Similarly, both the Army Research Institute and the Human Engineering Laboratory support MANPRINT via single centers of excellence with staff POCs assigned at installations with a combat development mission. The HHA program needs to be examined at the most fundamental level, i.e., what organizational framework and program best supports the medical requirements of MANPRINT and MADP given manpower and other resource limitations.

Conclusion

Basic tenets of MANPRINT and its health hazard domain predate today's programs. As early as World War II, the AMEDD had a formal program addressing the health aspects of the man-weapon system. The importance of optimizing system (man-machine) performance by protecting soldier health was, and is, widely accepted as a combat multiplier directly contributing to warfighting. The current HHA program is a relatively recent additional mission for AMEDD — one that has grown phenomally in a few short years as the Army's total force modernization has brought many new high-tech systems into the inventory.

As with many new missions, there have been growing pains. Despite the conscientious hard work of the several AMEDD staff officers involved, there are too many systems embracing rapidly developing technologies making their way through a highly complex MADP to adequately track and resolve all medical issues.

As both the MANPRINT and HHA Army regulations are being rewritten, as MANPRINT is promulgated throughout DOD, and as defense materiel acquisition is streamlined, formation of a medical MANPRINT work group may be of benefit. Under OTSG oversight, this group would comprehensively review the HHA program. Specific areas of focus should include workload quantification at both installation and MACOM levels, and determination of the best organizational structure to accomplish the HHA mission.

Increasingly complex health hazards can be expected as new materiel and technologies create whole new categories of health hazards — some of whose synergistic effects on soldier performance are largely unknown today. Better marketing of health hazards research programs among Army developers is needed.

Lastly, as MANPRINT requirements are promulgated throughout the Armed Forces (DODD 5000.53), lessons learned from the AMEDD HHA program may prove valuable to sister services.

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Looking at a New Concept...

AIR DEFENSE AGAINST THE EVOLVING THREAT

By Steven E. Daskal

Air defense remains an important activity for the NATO allies and other nations threatened by the powerful air force of the Soviet Union and radical third world states. The U.S.S.R.'s air forces have become far more capable and militarily significant than they were prior to 1975. Several third world states have also acquired advanced fighter-bombers, including Libya's Su-24 FENCERs and Cuba's MiG-23s.

In the past 10 years or so, two generations of advanced fighters (FLOGGER and FOXBAT, followed by FLANKER, FOXHOUND, and FULCRUM) and an improved airborne warning and control capability (Il-76-MAINSTAY) have been developed and deployed.

Even more significant for land and naval forces was the development and deployment of new generations of supersonic strike aircraft — FENCER and BACKFIRE in the late 1970s, and the BLACKJACK in the immediate future. All three are generally considered to be capable of all-weather, day/night strikes with precision guided munitions including cruise missiles.

Of immediate interest to forward-deployed forces, these advances in Soviet fixed wing aircraft capabilities have been accompanied by a revolution in attack helicopter operational doctrine capabilities, with the various upgrades to the older HIND attack helicopter soon to be complemented by the more agile HAVOC attack helicopter and the HOKUM helicopter interceptor. The net result is that Soviet air forces have become capable of doing more than just tying up Western air forces. They now have the offensive capability to disrupt, delay, or destroy Western ground, naval, and air forces on a massive scale throughout a given theater.

This fleet of advanced aircraft is technically far superior to its predecessors and is close to the level of sophistication and complexity of its NATO counterparts when they were first fielded. In the area of target detection, the Soviets now have look-down, shoot-down and terrain-following radar on fixed wing aircraft, along with improving infrared (IR) laser, and night vision devices, also used on helicopters.

Soviet electronic warfare systems, long considered to rely primarily upon numbers and radiated power, are becoming increasingly sophisticated and more widely deployed, with self-protection jammers now nearly as ubiquitous as chaff/flare dispensers.

In terms of ordnance delivery, accurate longer range missiles (including laser-guided and anti-radiation seekers), coupled with 200 percent improvements in range/payload capabilities and better engine flexibility, have made the Warsaw Pact's airpower a major threat that Western air forces alone will not be able to easily or quickly defeat. Previous Western assumptions of air superiority, may no longer be valid, even over friendly territory.

Current Western air defense systems were designed to serve as a second line of defense against a large but fairly unsophisticated hostile air force that would be generally taken care of by Western air forces. Existing surface based air defense networks, at sea and on the ground, lack both the numbers and responsiveness to defeat the threat as it has evolved in the 1980s.

The U.S. Army's HIMAD (high/medium altitude air defense) has been upgraded with the PATRIOT surface to air missile (SAM). While this system has proven to be effective and fairly reliable, it is not being deployed in numbers sufficient to defeat the massive Soviet bloc air threat, in part due to its high cost and extensive logistical requirements.

Many Western nations cannot afford PATRIOT, and continue to rely primarily on the dated Improved HAWK system and older, obsolescent systems incapable of dealing with the lower operating altitudes, electronic countermeasure (ECM) capabilities, and earlier weapons release points of modern Soviet aircraft.

All HIMAD systems, including the far more numerous Soviet systems, share the handicap of positive target identification. Developing a rugged, reliable, and secure Identification Friend, Foe, or Neutral (IFFN) system has proven to be both technically and politically difficult. Even with NATO, getting agreement on the operational frequency of the next generation IFFN took nearly a decade. Getting neutral states to cooperate to the extent that their aircraft would not inadvertently be labeled as hostile seems likely to be an even more daunting task. Noncooperative IFF has progressed by fits and starts, its potential limited by factors of cost, software complexity, and the combined impact of ECM and low observable technology on effective discrimination in wartime.

Another handicap confronting HIMAD systems is the difficulty of passing target tracks between the various players in the air defense game, including the manned interceptors and SAMS of several nations and numerous air defense control and coordination centers. This difficulty is exacerbated by continuing problems in real-time coordination between the Air Force and Army.

While joint doctrinal and planning coordination has significantly improved, there are still too many layers of liaison and control between the aviator (especially if he is not an organic corps or divisional asset) and the air defense artillery (ADA) gunner. Each of these players has to clearly receive, comprehend, and act upon the rapidly changing situation.

The large sophisticated sensors, extensive command, control and communications (C3) facilities (including the Joint Tactical Information Distribution Systems), and limited numbers of HIMAD systems makes solving the IFFN problem for the corps and above air defenses potentially feasible. The IFFN and other C3I problems facing air defenders at the division and below level covered by the Forward Area Air Defense System (FAADS) are far more difficult.

More fire units with more limited C3I capabilities and busier airspace, including more targets operating in contour flying or nap-of-the-earth profiles, make the wartime "acquisition and sorting" problem one of awesome proportions. While Britain, France, Germany, and Italy deployed reasonably effective close-in air defense systems in the 1970s to protect their field forces, they haven't solved the IFFN and target acquisition and track passing problems. Their forward-deployed SAM and antiaircraft artillery (AAA) fire units are only tenuously connected to a net that can provide a big picture.

The highly effective and widely deployed U.S. Stinger faces similar difficulties. The Soviets do not appear to have any capabilities in this area radically different from our own, but do tend to control their own aircraft, especially their interceptors operating within their own airspace, very tightly. This rigid control reduces the potential for interference between friendly SAMS, AAA, and aircraft. However, it also reduces the potential effectiveness of Soviet manned interceptors and the flexibility of their tactical aircraft and helicopter employment, and has led to an apparent emphasis by the Soviets on a mix of longer ranged fixed wing aircraft intended more for offensive air superiority and strike missions than air defense. The United States has not yet succeeded in developing a viable forward area air defense system of its own, nor has it successfully adopted any NATO systems.

Belatedly, the U.S. Army recognized that the most difficult part of the forward air defense problem was largely overlooked in the U.S. Roland and Sergeant York (DIVAD) efforts: target acquisition, designation, and coordination between dispersed air defense sites and systems with diverse sensors, operating parameters, and fields of view. This problem is exacerbated by the higher speeds and lower altitudes of attacking aircraft and helicopters.

Attack helicopters flying nap-of-the-earth and transonic aircraft flying at 50 meter altitudes in many cases allow less than 30 seconds for this complex process to be completed before the threat has either attacked or left the effective radius of the fire unit. While the available reaction time of the defender has been reduced to a matter of seconds, the time needed to acquire, pass, target, interrogate, and engage has not been significantly decreased despite the advent of computer aids and more modern communications.

The present ground based air defense network works like a massive command guidance system, requiring rapid, precise interface between two separate actions: acquiring and tracking targets with radar, and controlling intercepts via radio, whether voice or digital data link.

Even if the Air Force was willing to accept the risk of increased fratricide inherent in a totally automated, integrated IFFN/fire control system, coordination between friendly air traffic controllers, longer range sensors at and above division level, the air defense battalion HQ, and actual firing units is too prone to electronic interference or jamming, overload, or subsystem failure.

The Army's FAAD C2 effort is attempting to find solutions to these problems. Unfortunately, it may well be that there is no reliable, affordable answer within the realm of conventional fire control and communications technology. A totally different approach to divisional air defense C3 may be needed in the future.

A contemporary one-vs-one (micro-level) approach to radar-controlled firing on maneuvering aerial targets may prove conceptually adaptable to many-vs-many (macro-level) air defense target selection and fire control problem. Command guidance and Semi-Active Homing Radar (SAHR) guidance are two common forms of guidance for both SAMs and air-to-air missiles (AAMs).

Command guidance is the older technology, increasingly found only on shorter ranged missile systems. It requires the host system to locate and track targets, and then direct the missile towards the target by radio, much like flying a remote control model plane. Against maneuvering targets at longer ranges, this form of guidance encounters significant tracking problems.

Increasing delays caused by having to perform extensive data processing to correlate the tracks of the target and missile reduces system probability of kill (Pk) and increases the likelihood of hostile ECM being effective. Over longer ranges, increased broadcast power and wider beamwidths heighten the possibility of the guidance signal being exploited or used as a target beacon by hostile forces.

SAHR guidance reduces the number of processes necessary to track and guide a missile to a target. With SAHR guidance, the host system acquires and tracks a target, illuminating the target with radar energy. Receivers in both the host system and in the missiles fired from the system track on the same reflected radar energy, eliminating the need for the missile to be directed by means of a separate radio command link.

More sophisticated SAHR guidance systems, such as the AWG-9/Phoenix or the APG-65 and other radars able to guide advanced medium range air-to-air missiles (AMRAAM) can illuminate several discrete targets simultaneously, each with a slightly different signal. This allows multiple targets to be engaged simultaneously with one or more missiles. The missiles also have autonomous seekers that, once within range of the target, can guide themselves to fuzing range without further guidance from the fire control system.

The present ground based air defense network works like a massive command guidance system, requiring rapid, precise interface between two separate actions: acquiring and tracking targets with radar, and controlling intercepts via radio, whether voice or digital data link. However, the disadvantages of command guidance present at the single weapon level become more noticeable at the multi-system level. Therefore, it might be worthwhile to investigate applying the SAHR guidance concept to the multi-system, area air defense problem. This method is related to the concept of bi-static radar in which the transmitter and receiver of a given search or track radar are physically separated, reducing the vulnerability of the receiver.

Adapting the bi-static radar concept into a multi-static approach to an air defense acquisition, tracking, and fire control system would entail modifying powerful ground-aerostat-, or aircraft-based acquisition and early warning sensors (both active and passive) to also illuminate their targets (with radio frequency or laser energy) in a manner that uniquely identifies them.

Certain identification flags, whether they be a range of closely grouped frequencies or a pulsed code imbedded in the signal's pulse repetition interval/pulse repetition frequency, would serve as fire unit cueing-key, providing target hand-offs to particular manned interceptor units or SAM batteries. However, the target would be visible to all defender units and sensors within reception range and line of sight of the illuminated target.

If the centers are successfully jammed or attacked, the individual SAM sites and aircraft can still acquire and attack targets independently, with central air defense controllers using secure data links to provide a back-up C2 capability.

Track handoffs would thus be directly linked to the targets themselves, minimizing the off-boresight correlation and correction problem presently encountered when a powerful centralized sensor and control system attempts to hand off targets to dispersed fire units. The direct illumination method would be complemented by a low probability of intercept data link for redundancy, ECCM, or passing additional target information or a general environment picture.

Adopting this multi-static concept of air defense C3 would benefit both Forward Area Air Defense System and HIMAD operations. In the latter case, it could reduce the communications burden on AWACS and ground air defense center controllers, as well as the track correlation and communications challenge to individual SAM units and interceptor aircrews.

The multi-static concept also provides other potential advantages. First, centralized illumination of targets would allow the option of firing SAMs and air-to-air missiles without the fire units' radar even being turned on, or without shifting from the scan to track modes. This would allow individual SAM sites and aircraft to operate passively from relatively vulnerable forward sites while the high-powered sensors are relatively safe in the rear. This distribution of fire units and sensors would reduce the enemy's ability to defeat the defending forces with jamming and short-range anti-radiation weapons.

If the centers are successfully jammed or attacked, the individual SAM sites and aircraft can still acquire and attack targets independently, with central air defense controllers using secure data links to provide a back-up C2 capability. Second, the ability of the controllers aboard AWACS or on the ground to illuminate and designate targets for aircraft will make aircraft with limited radar capability more effective. This could prove valuable for smaller U.S. allies whose aircraft aren't equipped with or able to use beyond visual range (BVR) missiles.

The indirect acquisition and designation aspects of semi-active air defense C3 could also directly benefit U.S. strategic defenses against air-breathing threats. Presently, the Air National Guard and Air Reserve units providing the bulk of CONUS air defense are being upgraded primarily with older F-4 Phantoms and relatively inexpensive F-16As. A multi-static approach to coordinating the operations through AWACS or ground-based regional operational control centers and their associated radar assets could compensate for the limited radar range and small-target detection capabilities of these aircraft.

While extensive development and testing would be necessary to determine if a multi-static air defense C3 concept would be operationally feasible, it is conceptually sound enough to warrant further examination. It might hold the key to effectively and efficiently countering the threat of Soviet airpower.

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MODULAR AZIMUTH POSITION SYSTEM

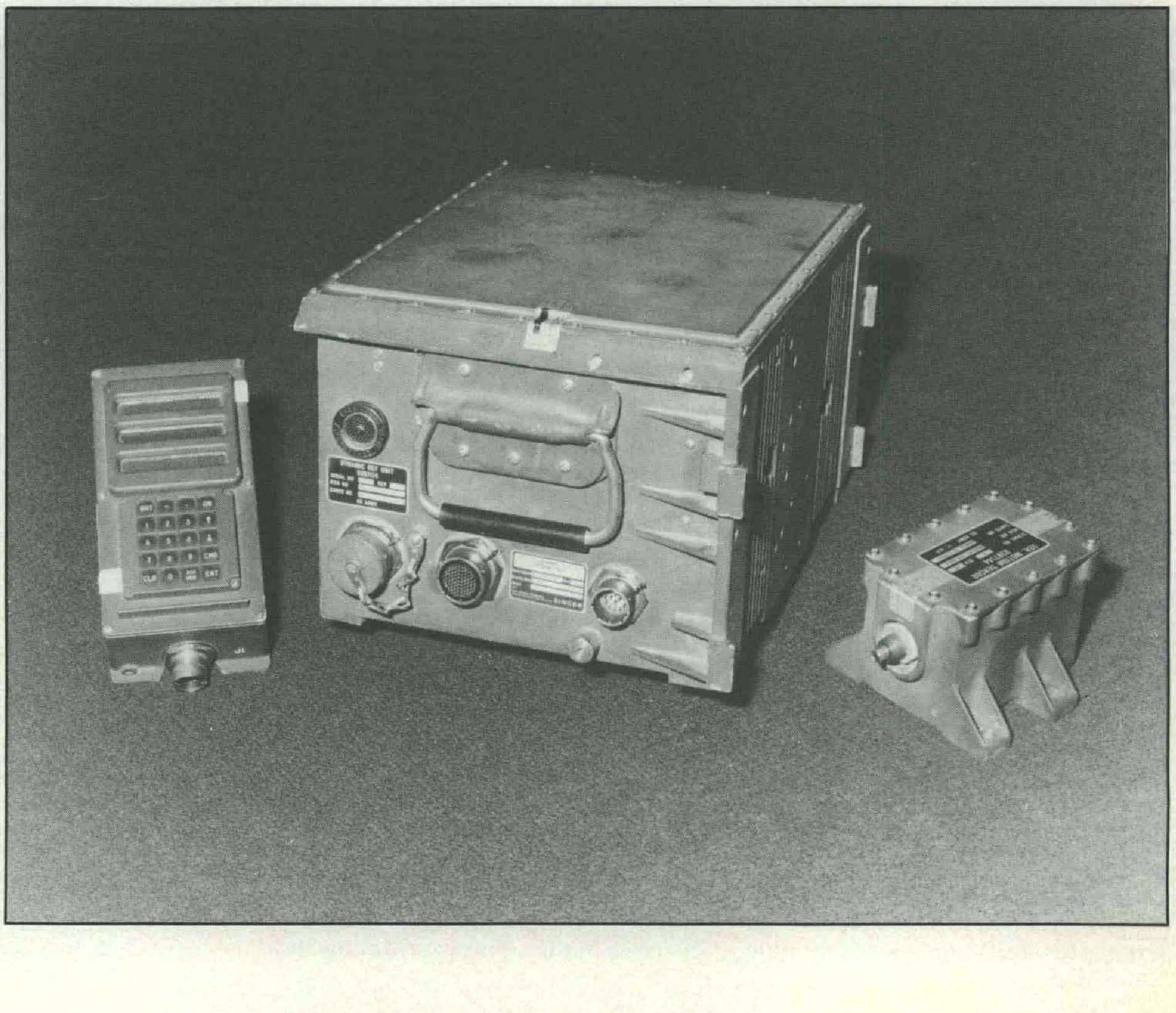
Minimizing Risks for Soldiers and Improving Effectiveness

By Mark K. Ross

Current procedure for deploying a battery of howitzers has many risks, but by using the Modular Azimuth Position System (MAPS) it will be safer and more efficient.

In order for the battery to be effective at hitting their target, first they must know where they are and where to point. To find out where they are, the current howitzers are situated in sight of a survey control point and orienting line previously established by a Position and Azimuth Determining System (PADS) or other conventional survey techniques. Then, a soldier must leave the protected environment of the howitzer to transfer the orienting line azimuth to the gun.

The dangers involved in this scenario are many. Since the vehicles are grouped close together, they make a



The MAPS components include (from left to right) the control display unit, dynamic reference unit and vehicle motion sensor.

vulnerable target. Also, Artillery Survey has limited assets, and often isn't able to meet the needs of frequent battery moves.

The battery has a limited number of rounds they can fire before they must move or risk counterfire. With the new weapon-locating systems on the battlefield, like Firefinder, the location of an artillery weapon can be derived by tracking three to five rounds fired.

The soldier who must leave the howitzer is especially vulnerable, not only from weapon fire, but also from possible nuclear, biological and chemical hazards. MAPS will minimize many of these risks.

In 1982, the U.S. Army Materiel Command tasked the U.S. Army Engineer Topographic Laboratories (USAETL), Fort Belvoir, VA, to investigate whether a single inertial weapon device could be developed to support multiple weapon and sensor systems. At that time, the Army was developing several different positioning systems for various weapon systems. USAETL's study indicated such a standardization was technically feasible.

As a result, the MAPS program was established to create a generic position/orientation capability. The Product Manager — Howitzer Improvement Program Office of the U.S. Army Armament, Munitions and Chemical Command, Dover, NJ, was tasked with developing MAPS in 1983. USAETL was chosen as the technical lab to support development.

"We've been in from the beginning. We prepared the specification for the original development program and participated in the contract awards," said Fred Gloeckler, acting chief of USAETL's Tactical Positioning Branch.

"MAPS is really a set of components. The primary component is an inertial measurement unit or what we call a dynamic reference unit," Gloeckler said. "As MAPS has evolved, it's a full inertial system. It is a strap-down system using ring laser gyroscopes. Its function is to provide the position and orientation of whatever it's mounted to.

"On the howitzer, the MAPS is mounted directly on the gun trunnion, so in addition to telling the position of the gun, it also tells you where the gun is pointed, both in azimuth and elevation," Gloeckler added.

Another MAPS component is the vehicle motion sensor (VMS) that is similar to an odometer. The VMS provides an additional velocity input to the dynamic reference unit (DRU) that controls the inertial system errors.

MAPS, like all inertial systems, is a dead-reckoning system. "They can tell you the change in position, but they don't know where they're starting from until you tell them," Gloeckler said.

A typical scenario of using the system begins when firing up the howitzer at the start of the mission. The MAPS is initialized with a short alignment sequence, which takes about 15 minutes. The weapon is either at or driven to a known survey control point. A soldier enters the coordinates of the position into the fire control system on the howitzer.

With MAPS on board to determine position, this M109 Howitzer fires at its target.

MAPS, like all inertial systems, is a dead-reckoning system.

The Howitzer Automatic Fire Control System (AFCS) can display a screen that shows how far to go and what direction to move. The display is based on the MAPS positioning and orienting information, and information put into the fire control system. The destination of a fire mission, for example, will be sent to the howitzer by radio or wire from the fire direction center. The AFCS directs the chief of section to his destination.

"In that operation, the MAPS is a navigator. You're using it to help you navigate — so that's one of its applications," said David Thacker, former chief of what is now the Tactical Positioning Branch. "When the howitzer arrives at where it is going to fire, it's being used in another mode, which is to point the weapon tube to the right azimuth and elevation."

The system automates many of the functions that are currently done manually. Instead of taking the time to do lengthy calculations, the crew can now get firing information sent from the fire direction center and use MAPS to determine where to point the weapon.

One of the major innovations resulting from using MAPS is the change in tactics of employing howitzers. The units will move around independently in assigned areas of about a kilometer in radius to avoid overlapping with another unit. This tactic of separating the howitzers prevents the total destruction of a battery by counter-battery fire.

"They are going to move around, and they're not going to be bunched up together," Gloeckler said. "They'll constantly move without external control. This makes them a much more difficult target." "It's the shoot and scoot theory," Thacker added. "If I fire once, they pay attention, if I fire twice from the same spot, they're going to start locating me.

"So what I want to do is fire and move. But if I move, I must know where my new position is and get that information back to the fire direction center so they can give me updated firing information," Thacker said.

"One of the strongest arguments for having a dynamic reference unit in the howitzer is survivability," Thacker said. "You can remain inside the weapon buttoned up, and not have to go out of the weapon to do anything. So, if you were in a biological/chemical warfare scenario, obviously you don't want to go out in that environment." By using MAPS, survivability of the crew and weapon is greatly improved — with the new operational tactics for using the weapon that make it harder for the enemy to locate and destroy the weapon, and the elimination of the need for the crew to leave the protected environment of the weapon.

In addition to the added safety of MAPS, when compared to the present procedure of using PADS, MAPS is also less expensive. Because MAPS has a standardized design to fit on any weapon system, a great deal of money is saved.

"Every program manager was trying to solve the positioning and orienting problem for himself, and that's how this project got started. They were creating too many different systems," Thacker said.

Part of USAETL's job in preparing the original specifications for MAPS was to make a form, fit and function specification so it would appear to a prime system to be the same. This ensured the MAPS would have common physical, electrical and communication interfaces.

"This was a fairly extensive engineering effort," Gloeckler said. "This required detailed specification of the communication interfaces, so the commands and messages were the same." USAETL was involved in monitoring the test program, and helping the Product Manager — Howitzer Improvement Program analyze the test data and solve problems. "We assisted with the integration of the MAPS hardware into several potential users," Thacker said.

These potential users include developers of such projects as the PATRIOT and LANCE missile systems; the M110 Howitzer; the Nuclear, Biological and Chemical Reconnaissance Vehicle; and the Elevated Target Acquisition System. USAETL sent personnel to the organizations working on these projects to help mount and use the MAPS.

"We're seeing our efforts result in what we originally intended; the development of a device that can be used by a variety of different weapon systems," Thacker said.

Unlike PADS, which is fielded as a single, finished product, MAPS will be an integral part of a prime system. When the prime system is fielded, MAPS will be fielded. The lead user for the MAPS, the M-109 Howitzer Improvement Program, is still undergoing technical tests.

"Based on what we've found in the development process, we're making some changes in the production system, which still needs to be proven," Gloeckler said. "That'll be done in spring 1990 — when we will do our first article testing on the production dynamic reference unit.

"As far as the howitzer goes, we fully expect MAPS to meet the need," Gloeckler said. "The troops have been very pleased with it in operational tests." He said the new system is easier to learn and use than the present method of using pre-established survey.

USAETL is still working to improve MAPS by researching new technology and innovations that can be incorporated to improve the system. One idea is to use the Global Positioning System (GPS) as a position initializing device with the MAPS. Combining GPS and MAPS may eventually make the manual initialization process of MAPS unnecessary. It also could eliminate the need to make periodic stops to update position to correct any errors.

Another possible future improvement is the use of a fiber optic gyroscope in place of the ring laser gyroscope. "It certainly holds high hopes for inexpensive sensors that could at least be used to support navigation, and has the potential for being highly reliable," Thacker said.

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THE NATIONAL DEFENSE SCIENCE AND ENGINEERING GRADUATE FELLOWSHIP PROGRAM

By W. Davis Hein

Background

The United States is on the verge of losing its preeminence as the world's technology leader. So says more than one study in recent years. One of the reasons for this decline is the parallel decline in the number of U.S. scientists and engineers.

Since 1976, employment of scientists and engineers is up 85 percent. This trend is expected to continue. However, the demographic trend shows that the number of 22 year olds — the near term source of future Ph.D.s — to be declining. Further adding to the problem is the increased competition for these candidates from other fields — law, medicine, business, etc. While the number of U.S. Ph.D.s in science and engineering declines, the award of Ph.D.s to foreign nationals is increasing rapidly.

Our inability to motivate students to pursue science and engineering careers at the graduate level is compounded because of the intense demand industry has for bright bachelor's and master's degree holders. Too often, promising Ph.D. candidates, confronting the cost and financial sacrifice of pursuing their education, find the lure of industry irresistible.

As one means to reverse this trend, Congress enacted legislation in 1988 for the National Defense Science and Engineering Graduate (NDSEG) fellowship program. The Army, Navy, Air Force, and the Defense Advanced Research Projects Agency (DARPA) all participate in this DOD program. The focus of the fellowships is on those fields which have the greatest payoff for national security requirements. Figure 1 shows the DOD disciplines supported. This differs from the more broadly directed fellowship programs of the National Science Foundation.

The Diversity of DOD Graduate Support

The DOD annually supports approximately 8,000 graduate students. This support is provided in a number of ways. First and foremost is the support of thousands of graduate students who are members of research teams funded through DOD grants or contracts. Such support is often called research assistantships. The students are selected by the university research faculty. They engage in fundamental studies under the leadership of a senior researcher. Commensurately, they earn advanced degrees.

Another method of support, fairly unique to the Army, is via Army sponsored university centers. An integral part of these centers is the award of fellowships to graduate students for study and research in support of the centers' multidisciplinary research objectives. These fellowships are funded by the Army but the fellows are selected by and are associated with the university.

The NDSEG fellowships represent the third mechanism for graduate student support. Unlike the research assistantships and the center-based fellowships, the NDSEG fellowships are awarded on the basis of nationwide competition. Only 122 NDSEG fellows

NDSEG FELLOWSHIP PROGRAM
DISCIPLINES OF INTEREST TO DOD

- AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
- BIOSCIENCES
- CHEMICAL ENGINEERING
- CHEMISTRY
- COGNITIVE, NEURAL, AND BEHAVIORAL SCIENCES
- COMPUTER SCIENCE
- ELECTRICAL ENGINEERING
- GEOSCIENCES
- MANUFACTURING SCIENCES AND ENGINEERING
- MATERIALS SCIENCE AND ENGINEERING
- MATHEMATICS
- MECHANICAL ENGINEERING
- NAVAL ARCHITECTURE AND OCEAN ENGINEERING
- OCEANOGRAPHY
- PHYSICS

Figure 1.

DISCIPLINE	FELLOWS
AERONAUTICAL ENGINEERING	4
BIOSCIENCES	4
CHEMISTRY	4
COMPUTER SCIENCE	2
ELECTRICAL ENGINEERING	4
GEOSCIENCES	2
MATERIALS SCIENCE AND ENGINEERING	4
MATHEMATICS	3
MECHANICAL ENGINEERING	2
PHYSICS	2
TOTAL	31

FY89 NDSEG FELLOWSHIP PROGRAM
ARMY SELECTED DISCIPLINES

Figure 2.

ARMY FY89 NDSEG FELLOWS
SELECTED UNIVERSITIES

UNIVERSITY	FELLOWS
UNIVERSITY OF ALABAMA, BIRMINGHAM	1
UNIVERSITY OF ARIZONA	1
CALIFORNIA INSTITUTE OF TECHNOLOGY	2
UNIVERSITY OF CALIFORNIA, BERKELEY	2
UNIVERSITY OF CALIFORNIA, DAVIS	1
UNIVERSITY OF CALIFORNIA, LOS ANGELES	2
UNIVERSITY OF CINCINNATI	1
CORNELL UNIVERSITY	2
GEORGIA INSTITUTE OF TECHNOLOGY	1
UNIVERSITY OF ILLINOIS	3
MASSACHUSETTS INSTITUTE OF TECHNOLOGY	3
UNIVERSITY OF MARYLAND	1
UNIVERSITY OF MICHIGAN	1
UNIVERSITY OF NORTH CAROLINA	1
PENNSYLVANIA STATE UNIVERSITY	2
PRINCETON UNIVERSITY	1
UNIVERSITY OF SOUTH CAROLINA	1
STANFORD UNIVERSITY	4
UNIVERSITY OF WASHINGTON	1

Figure 3.

were selected for the FY89 program from approximately 4,200 applicants. Accordingly, the NDSEG fellowships are among the most prestigious awards in the country. One other distinction from the other two methods of graduate student support is that the NDSEG fellows pursue their studies at universities of their own choosing.

Program Administration

The Army is the lead Service for administering the NDSEG fellowship program. This is done by the U.S. Army Research Office (ARO) through a contract to Battelle Memorial Institute at their Research Triangle Park, North Carolina office. Battelle has responsibility for getting the word out about the program. This involves printing and distributing nearly 10,000 posters and brochures to nearly all university departments throughout the country. They also handle the processing and evaluation of the applications.

Eligibility

In keeping with the Congressional objective of increasing the pool of U.S. scientists and engineers, the NDSEG fellowship program is open only to applicants who are U.S. citizens. Applications are encouraged from women, minorities and persons with disabilities. In fact, 10 percent of the awards must be to members of minority groups which are under represented in the sciences and engineering. The Army more than doubled that percentage in its awards for FY89.

NDSEG fellowships are intended for students at or near the beginning of their graduate study. Last year, approximately half of those selected were in their senior year of undergraduate study. The remainder were generally in their first or second year of graduate studies. However, four fellows left industry to take advantage of the NDSEG fellowships. Fellows do not incur any military obligation.

Evaluation and Selection

The evaluation process is rigorous. Nearly 100 university faculty members are invited to serve on evaluation panels for the 15 NDSEG disciplines. These panelists evaluate the applicants based on all available evidence of ability, including academic records, recommendations regarding the applicant's qualifications, and scores attained on the Graduate Record Examination, if available.

Although the panelists serve to recommend and prioritize the applicants, each Service makes the final selection. Figure 2 shows the number of Army fellows selected by discipline.

The FY89 program was very successful in attracting qualified minority and women applicants. In fact, over 20 percent of the fellows selected were minorities and 30 percent of those were women. Seven of the 31 Army fellows were minorities.

Stipends and Allowances

The normal tenure of a NDSEG fellow is three years. The stipend for the FY89 program was $14,000, $15,000 and $16,000 for each of the three academic years. In addition, the NDSEG fellowship pays full tuition and fees to the university selected by the fellow plus $1,000 for various administrative expenses. For FY89, the full three year cost ranged from $66,000 to nearly $100,000 depending on the university selected. Figure 3 shows the universities selected by Army fellows.

Summary

The NDSEG fellowship program was initiated by Congress to increase the pool of U.S. citizens trained in science and engineering disciplines important to national defense needs. This program is administered by the Army Research Office for all of DOD. Additional information on the NDSEG fellowship can be obtained by contacting Dr. George Outterson at 200 Park Drive, Suite 211, P.O. Box 13444, Research Triangle Park, NC 27709, or telephone (919) 549-8505.

In its first year, the program received over 4,000 applications and selected only one in 35 applicants. The NDSEG fellowship program is truly one of the most competitive and prestigious fellowship programs in the nation.

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TACOM EYES BATTLE-RESISTANT VEHICLE RADIATOR

By George Taylor

The U.S. Army Tank-Automotive Command's RDE Center is evaluating a unique radiator concept which, according to its developer, Beltran Associates of Brooklyn, NY, can continue to effectively cool an engine after sustaining damage from small-arms fire. Such a radiator would enhance troop survivability by allowing a vehicle crew to complete a mission and move to a safe location before repairing the damage, thereby avoiding a potentially life-threatening situation.

A radiator concept study was conducted for TACOM by Beltran Associates. The concept differs from a conventional radiator in that it does not use the traditional tube-and-fin core. Instead, its core consists of an arrangement of heat pipes and fins. Each pipe is partially filled with water or other fluid and hermetically sealed. Its lower end is then inserted into a hole in the top of a rectangular-shaped engine-coolant tank and sealed in place to prevent coolant leakage.

As hot coolant flows from the engine into the tank, it touches the ends of the pipes and transfers heat to them. This converts the liquid in the bottom of the pipes to steam. As the steam rises, the heat travels along the entire length of the pipes and is dissipated by the engine's cooling fan.

"The concept looks promising," said RDE Center engineer Mary Lynn Goryca, who heads the radiator project. "Heat pipes are extremely high in thermal conductivity, lightweight and maintenance free. Preliminary testing," she added, "showed that performance remained nearly constant with 30 percent damage to the core, which would be enough to give a vehicle a limp-home capability."

Beltran proposed its radiator concept in 1988 in response to a TACOM Small-Business Innovation Research (SBIR) Program solicitation. SBIR is a Department of Defense program which Congress established in 1983 to assist small businesses. It requires federal agencies whose annual R&D budgets are $100 million or more to award at least 1.25 percent of their R&D contracts to small businesses.

Thirty-two proposals were submitted in response to the solicitation. Of these, TACOM concluded that Beltran's had the greatest potential and, in July 1988, awarded the company a Phase One contract to build and demonstrate a working small-scale model of the radiator in a laboratory setting. That effort has since been completed, and Goryca said the project status is being reviewed.

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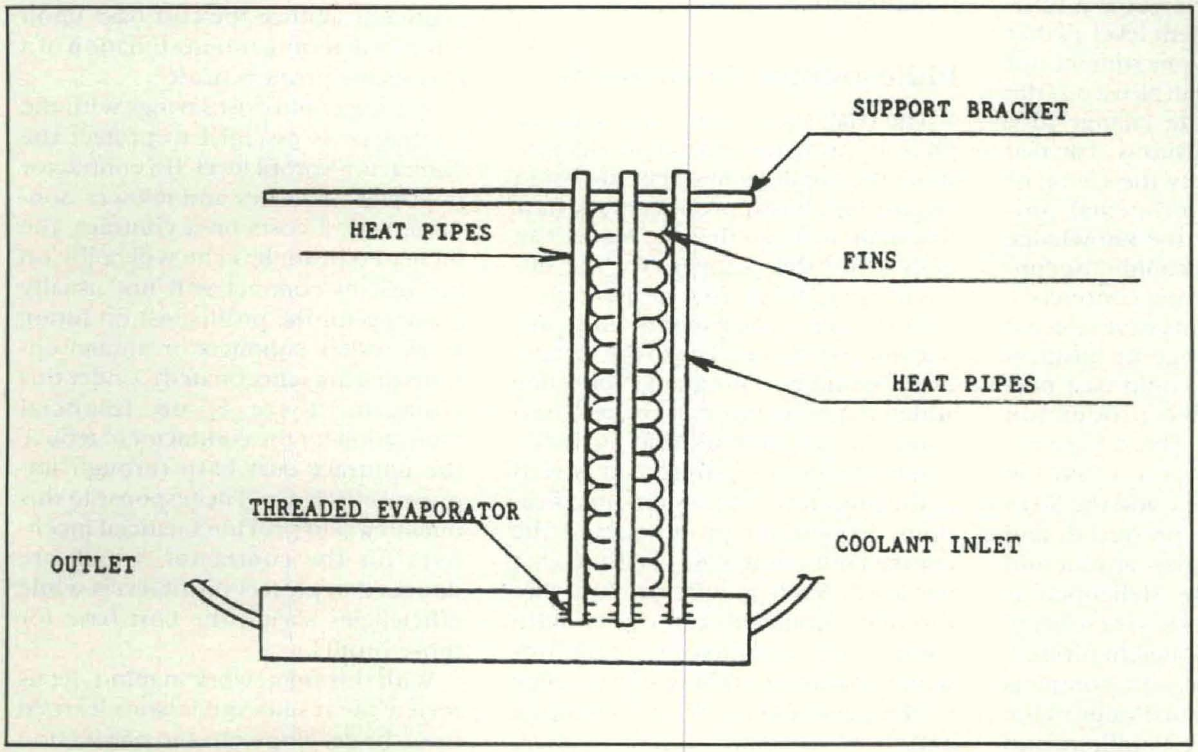

Single Window Heat Pipe Radiator Concept

LESSONS LEARNED FROM ARMY COULD-COST TRIALS

By Maxwell E. Westmoreland

Introduction

An article by the author was published in the January-February 1989 issue of *Army RD&A Bulletin* on the Army Could-Cost Initiatives. That article was based on experience gained in implementing the Army could-cost experiments. It discussed how to approach could-cost in the acquisition environment, what elements of could-cost should be addressed by a contractor, how could-cost could be contractually applied, and what types of incentives could motivate contractor achievement of could-cost objectives.

In mid-December 1987, Dr. Robert Costello, then the under secretary of Defense for acquisition, requested the Services to undertake trial could-cost programs. The purpose was to conduct experiments with oversight at a sufficiently high management level so that experience from both government and industry participants can be used as the basis to institutionalize change to a better way of doing business. The real objective was not solely the saving of dollars on these experimental programs, but the use of the knowledge gained to leverage the could-cost concept throughout all Army contracts.

The Army experiments were selected to sample the full range of business opportunities where could-cost payoffs might result. Two production efforts were selected. These were the FMC facility at San Jose, CA, where the Bradley Fighting Vehicle and the M113 Personnel Carrier are produced, and the McDonnell Douglas production facility for the Apache Helicopter at Mesa, AZ. These facilities were selected because they are dedicated to production on Army programs, the contracts are sole source, the annual value of the production exceeds $150 million, and three years of production remains.

The Advanced Anti-Tank Weapon System — Medium (AAWS-M) was selected to provide experience on a development program. The fourth effort involved government-owned, contractor-operated (GOCO) Army Ammunition Plants (AAPs). This effort was intended to provide experience on how well the government and the AAP operating contractors can improve efficiency and business practices to reduce costs. This article addresses the results and the lessons learned from the trials on the production and development programs, since they have direct applications to improving the acquisition process.

Philosophical Framework

The trials were structured within a philosophical framework to demonstrate the application of could-cost in acquisition. It is appropriate to review this framework so that the reader can understand the rationale for the different approaches used in the trials.

Customer requirements and producer incentives are key to the success of any could-cost program. Non-value added requirements must be removed from the documents that formally communicate our (government) needs to the producer. The system specifications, request for proposal, and the contract must be devoid of all but what we need. Such requirements, if not carefully stipulated, can cause inefficiency in a contractor's operations while providing nothing of real value to the government. While procuring activities normally scrub requirements to the bare bones, it is unreasonable to expect that the government has sufficient knowledge to know exactly what does and does not add avoidable costs to a contractor's operations. As a matter of logic, it is also unreasonable to insist the contractor remove non-value added costs where the basis of some of those costs are government requirements that add nothing but avoidable program costs.

The other element of non-value added costs is contractor operations that are inherently inefficient and add costs that are avoidable. These operations are an integral part of the contractor's business and the costs associated with them are totally allowable and rightly find their way into the cost of doing business with that contractor. The root cause for continued use of these inefficient operations is lack of sufficient incentive to reduce the cost base upon which a determination/estimation of a reasonable profit is made.

Sharing could-cost savings with the contractor is essential to protect the contractor's profit level. If a contractor improves efficiency and reduces non-value added costs on a contract, the increased profit level he will enjoy on the instant contract will not usually make up for the profits lost on future work (other contracts or annual options that are renegotiated). Under this situation, there is no financial motivation for the contractor to reduce the contract cost base through improved efficiency. The response to this dilemma is to provide financial incentives for the contractor, which are designed to protect profit levels while efficiencies shrink the cost base for those profits.

With this framework in mind, let us review the results and lessons learned from the development and production trials as of the end of Nov. 1989.

Results and Lessons Learned

The Production Trials. It was decided to begin the could-cost trials at FMC and McDonnell Douglas before the next contract award. Some means had to be used to interject could cost into the on-going contractual effort in a way which did not disrupt contractor performance. The method chosen was to execute a parallel stand-alone business arrangement. This arrangement would specify general terms and conditions and sharing for savings generated. For each candidate could-cost effort, the business arrangement would specify the scope of each effort, the estimated savings, the schedule for negotiating the details, how the efforts will be applied (the on-going contract, future contracts, or both), and when they would take effect.

McDonnell Douglas Helicopter Company (MDHC) Results. MDHC initially provided the Army Aviation Systems Command (AVSCOM) a list of 147 candidate ideas. This list did not show cost savings for the candidates. AVSCOM functional elements reviewed the list and selected 57 candidates which appeared to have potential for generating cost savings. MDHC was asked for a proposal on each candidate. MDHC then added four more candidates to the list. In Feb. 1989, a proposal was submitted by MDHC for eight candidates. A second proposal for nine candidates followed in April. MDHC suggested cancellation of the remaining candidates, since they had no demonstrable savings. The overall feasibility, potential in-house savings, a negotiating range for contractor savings, and a recommended saving share ratio for the 17 candidates was determined by an independent Army review, which was completed by Sept. 1989.

The 17 candidates involved the following functional areas (number shown in parentheses): engineering (9), production support (3), procurement (3), process operations (1), and program management (1). The candidates can be viewed another way. Eleven involved removing government requirements from the contract in the following areas: engineering (5), production support (3), and procurement (3). MDHC internal improvements were addressed in engineering (3) and process operations (1). Two candidates involved joint MDHC and Army improvements in engineering and program management. Thus, the majority of the candidates involved the removal of government requirements and the functional area of engineering.

MDHC initially purported savings in APACHE program production costs to be in the range of 5-10 percent. However, the estimated savings from the 17 candidates is around one percent.

One of the basic tenets of application of could-cost is program stability. Unfortunately, during the course of the MDHC trial, a high degree of uncertainty concerning future APACHE production surfaced. This made it extremely difficult for MDHC to define could-cost savings with any degree of precision. This situation also probably contributed to loss of program momentum.

Results of the FMC Trials. FMC submitted 59 candidate ideas to the U.S. Army Tank-Automotive Command (TACOM). Ten ideas were subsequently withdrawn by FMC. Of the 49 that were reviewed by TACOM and Headquarters, U.S. Army Materiel Command (AMC), 33 were approved for implementation and two are under consideration. This represented an approval rate of 67 percent of the ideas submitted.

Forty-eight of the 49 ideas recommended removal of government requirements in these areas (numbers of ideas are shown in parentheses): engineering (20), process operations (10), procurement (11), program management (2), materials (2), and financial management (3). One idea was for a joint FMC and Army improvement in the engineering functional area. For the 33 approved ideas and the two under consideration (total of 35), 15 were in engineering, five in process operations, eight in procurement, two in program management, one in materials, and three in financial management.

Four of the ideas dealt with elimination of government inspection and reliance on the contractor's quality system to assure delivery of quality hardware. These were not accepted due to the lack of contractor process controls that were deemed necessary to provide an acceptable risk to the government of not conducting inspection prior to hardware delivery. Recognizing that reduction or elimination of inspection is a desirable goal, TACOM has taken action to develop a plan to certify FMC's quality processes under the AMC CPC Program.

FMC did not propose any ideas for increasing the efficiency of their internal operations. However, FMC had made cost reductions prior to the trial as a result of a shrinking business base. The negotiated FMC cost per Bradley vehicle was reduced by 21 percent. Material cost per Bradley vehicle was reduced by 30 percent. Energy cost was reduced 10 percent, and there was a 10 percent annual reduction in support costs. Further, there was a 31.5 percent decrease in FMC personnel at San Jose from 1985-1988. FMC had continuing cost reduction initiatives at the start of the trial in manufacturing job restructuring, statistical process control, a vendor performance rating system, and organizational realignment.

Estimated savings from the proposed ideas were either recurring or one-time. Of the 33 accepted for implementation, two thirds had recurring and one third had one-time savings. These 33 accounted for 83 percent of the total estimated savings from the 49 ideas, after subtracting implementation costs. One idea, to adopt multiyear contracting for the Bradley vehicle, accounted for 72 percent.

The proposed multiyear savings were about 59 percent of all estimated savings from the 49 ideas. If the balance of 41 percent attributable to the remaining 48 ideas is considered as the baseline, the accepted ideas accounted for 58 percent. Twenty percent of these were from 21 accepted ideas with recurring savings, and 38 percent were at tributable to ideas with one-time savings. The ideas with recurring savings tended to have smaller amounts than did the ideas with one-time savings. Further, 31 percent of the ideas with recurring savings were not accepted, compared to 21 percent of the ideas with one-time savings.

Considered in terms of the FY89 buy for Bradley vehicles, the estimated savings from the accepted ideas were about 19 percent. Without the multiyear savings, the estimated savings were about five percent. It should be noted that the savings are based on rough-order-of-magnitude estimates. More precise estimates will result from the final business arrangement.

The FMC/TACOM could-cost agreement includes provisions for sharing the savings with FMC from all accepted initiatives. The sharing base is defined as the total direct and indirect cost savings to be realized from the effective date of an initiative over a one year period for all TACOM contracts issued to FMC. The sharing period is one calendar year beginning on the effective date that an initiative starts reducing indirect costs and upon first delivery under any and all contracts affected by an initiative which reduces direct costs. The agreement specifies the contractor's share shall be 50 percent of the total savings. The agreement is being negotiated.

Lessons Learned from the Production Trials. Since these trials were among the first to be done, there was no established procedure on how to accomplish the task. Procedures had to be developed as events occurred. For future applications of could-cost in an on-going production contract, the following procedure should be useful:

- Formulate a Memorandum for Agreement with the contractor detailing the objectives of the program, method of implementation, time frames to achieve results, the method of agreement on savings and basis of how savings would be shared.
- Upon receipt of the initial ideas list, organize and conduct a functional review to screen the list for feasibility and acceptability.
- Based on the results of the functional review, construct a final list of viable candidates for submission to the contractor for proposal.
- Issue a Request for Proposal for a final list of candidates, which would include detailed descriptions, implementation schedules, savings to be achieved and sharing ratios expected.
- Conduct an in-depth evaluation, savings assessment, and functional review of the proposal.
- Negotiate the proposal.
- Modify affected contracts for implementation.

Systems requirements related to audits and reviews, quality, engineering, cost reporting and other functional disciplines should be reviewed at the highest levels to determine if the requirements are non-value added in nature. Although functional office feedback is important, since such requirements are generally institutionalized in agency regulations and specifications, the requiring office should justify the need, not the functional office charged with implementation.

On mature production programs, cost reduction opportunities solely from removal of government requirements appear to be very limited when compared to overall production costs. While any cost savings should be pursued, more savings could possibly be realized through increased efficiency in contractor production operations, such as reduced scrap and rework.

The Development Trial. The AAWS-M program was selected to provide a trial on a development program and to test integrating could-cost provisions in the contract award process. The objective was to reduce contract costs and effort by reduction of non-value added requirements, wherever practical. Offerors were required to propose, as separately priced options which could be individually exercised, any change to business, contractual and technical aspects of the request for proposal. The changes were not to compromise any legal or mission essential requirements, and offerors had to demonstrate that the changes would result in a more cost effective approach to contract performance.

A savings sharing arrangement was included for the full scale development (FSD) and low rate initial production (LRIP) phases. In FSD, savings were shared in the Cost-Plus-Incentive-Fee portion of the contract with a contractor to government ratio of 25/75 percent. In LRIP, the contractor to government sharing ratio is 40/60 percent on Fixed-Price-Incentive-Fee portions of the contract. After adjustment of the contract target cost, target fee/profit and total cost, the target fee will be increased to reflect the contractor's share of the savings. The government's share is returned by decreasing the firm fixed price by 60 percent.

The could-cost proposals were evaluated by the Source Selection Evaluation Board (SSEB) in accordance with the cost/price area criteria. Proposals could be submitted at any time on any subject during both the FSD and LRIP phases of the contract.

All contractors were briefed on the could-cost program, and how it would be implemented prior to receiving the draft request for proposal (RFP). The draft RFP contained all the could-cost provisions for comment.

Results of the AAWS-M Trial. Three contractor teams responded to the RFP and each submitted could-cost proposals. A total of 65 proposals were submitted initially. These were evaluated by the SSEB, and presented to the Source Selection Advisory Council and Source Selection Authority, and approved by the Program Executive Office. Twenty-three could-cost proposals were included in the model contracts. Of the initial 65 proposals, 59 were categorized as technical or reporting/review requirements with the others categorized as schedule and economic.

In general, the rejected could-cost proposals were related to reduced Scope of Work requirements which were unacceptable to the cognizant office, reduced system performance requirements unacceptable to the user, reduction in the frequency and number of meetings, reviews and reporting requirements, and reductions in the number of test quantities. Many of these issues had been discussed during the RFP streamlining effort and rejected prior to issuance of the RFP.

Following selection of the technology for FSD, 16 (of an initial 40 for this technology) remained in the model contract for final evaluation by the project office. Of the final 16 proposals, six were recommended for adoption by the project office reflecting approximately $494,000 total savings. An additional three are being reviewed for partial acceptance following contract award showing a maximum savings of $23,835,000. The six proposals recommended for adoption will be implemented within 90 days of contract award. In general, those not recommended for acceptance involved a change to requirements not acceptable to the user.

One additional proposal was submitted by the contractor following contract award. It pertains to combining two training devices into one. It was accepted for $294,000 in FSD savings.

Lessons Learned from the Development Trial. Requiring the contractor to submit the RFP and could-cost proposal concurrently degrades the could-cost response. The RFP is the contractor's prime focus and consequently the best resources are concentrated in this area. Submission of could-cost proposals was delayed until 30 days after submission of the RFP.

Industry has claimed that there are many government contractual requirements that are not considered to be value added. Based on the small number of substantive proposals received from the six contractors, industry claims were not supported. This may in part be attributed to comments received from the contractors on the draft RFP and to the intense RFP streamlining effort conducted prior to RFP release; i.e., the more streamlined the program is initially the less potential for substantial could-cost savings solely from removal of non-value added Government requirements.

In order to achieve full benefits of some of the could-cost proposals, the contractors requested that several be implemented at contract award rather than within 90 days following contract award. This requires that the government obtain all coordinations and approvals necessary to prepare contract modifications for implementation at contract award. Sufficient time to accomplish the actions necessary to implement a could-cost proposal needs to be considered in the scheduling process.

Evaluation of the proposals and construction of the model contract was difficult due to the lack of cost/savings data detail submitted with the initial proposals. The inability to interface directly with the contractor to clarify or obtain additional detail on a timely basis prior to contract award also inhibited the evaluation process. In addition to the problem of general language of most could-cost proposals, some could-cost proposals contained some desirable and undesirable elements. Could-cost proposals structured at the lowest practical level would assist in the evaluation process as well as permit flexibility in acceptance.

The exercise period of the could-cost options was defined as "within 90 days after contract award". For a Development program, this seems somewhat unrealistic for some options. The decision made has the potential of impacting the entire life cycle of the program and needs to be made with utmost care. In some cases this may mean evaluating DOD or Army policy (such as cost reporting) and effecting a major change to policy in a very short period of time. A different avenue of challenge (other than could-cost proposals at contract award) for higher level policies should be developed or used for these items.

Once a contract is awarded, the could-cost program is in competition with other cost reduction programs, such as value engineering. The contractor can choose the program offering the most return for the same effort. The structuring of the could-cost incentive may also create a situation of conflicting incentives, such as performance incentive versus could-cost incentive.

If the baseline cost changes during the life of the contract (unless it is a firm fixed price contract), there is no provision for review or modification of could-cost savings claims. This has the potential for causing difficulties in determination of savings and fees. A method of adjustment is needed in the contract provisions.

Some Observations

The could-cost approach can help overcome what I view as a structural impediment to cost reduction on contracts. If a provision, such as value engineering, is not included in the contract which enables contractor cost reduction on the contract; the contractor, like it or not, becomes susceptible to defective pricing allegations by the auditors if he performs at a cost less than the contract price. Thus, the contractor is not motivated to initiate continuous process improvements during the course of the contract to enhance his performance. This means that a contract price is set at the outset based on the efficiency of the contractor's design and production processes as they existed at the time of his bid. Competition may force improvements in efficiency during contract performance, but only to the extent the contractor deems sufficient to counter the threat from his competitors.

Since we know that defense contractors generally invest much less in capital improvements to increase efficiency than occurs in the commercial sector, we usually find that a residual of inefficiency will always be present, regardless of competitive pressures. A could-cost provision in the contract would encourage the contractor to undertake absolutely anything during contract performance to save money. A predetermined sharing arrangement for the savings may provide an incentive for continuous improvements. If this process is recognized contractually, then the threat of defective pricing allegations should not inhibit cost reduction.

The savings share from could-cost efforts could also be a source of capital for contractors for investment in more efficient processes. If a contractor undertakes continuous improvement under the could-cost banner, then he should be rewarded for taking on more risk. If he should become more competitive in the process, then he deserves the rewards of more future business. It is in the government's best interest that contractors become more competitive, and be provided every incentive to do so.

During the course of these trials, the argument has been put to me that the could-cost approach will encourage contractors to propose on less efficient processes to capitalize on could-cost savings. This is naive, since the existing mechanisms of competition, price and costing data disclosure, should cost, and negotiations are all designed to arrive at a fair and reasonable cost for a contract.

The could-cost approach can provide a mechanism for contractor-originated streamlining. Government RFP scrubs and contractor draft RFP reviews are very effective streamlining techniques. A could-cost provision in a solicitation, however, focuses the contractor's talents on streamlining issues during the proposal preparation process. And that is some of his best talent, since he has his best team on the job.

As we have seen from these trials, removing non-value added government requirements alone only addresses one source of could-cost savings. Emphasis should also be placed on contractor design and production process improvements to generate cost savings. Also, the most effective method of incorporating could-cost is at the outset in the solicitation. Integrating could-cost in an on-going contract is time consuming, principally because of the lengthy review and coordination process. With the solicitation approach, a government commitment is made to exercise the could-cost options within a specified timeframe after contract award. This commitment places emphasis on timely review and coordination of the proposals during the contract award process.

Could-cost under any guise will not work unless government and contractor personnel managing and executing the program want it to work. It takes vision and determination to make changes happen. Could-cost is a way to help achieve continuous improvement in acquisition, and I am confident we can make it happen. Plans are already underway to incorporate could-cost in solicitations for a Hellfire development effort and a production program for air conditioners.

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ROBOT IMPROVES SAFETY OF EXPLOSIVE ORDNANCE DISPOSAL

By Frank W. Kearney,
Robert A. Weber,
and Dana L. Finney

A Twilight Zone episode in the 60s depicted a gloomy future when robots and computers rendered the human labor force obsolete. Some poor fellow shows up at work only to discover he's been replaced by gadgetry, which reduces him to utter despair.

Obviously, that man was not an explosive ordnance technician.

Military personnel responsible for disarming live munitions are welcoming the news that a robot will be able to take their place in the hazardous zone near unexploded material. Researchers at the U.S. Army Construction Engineering Research Laboratory (USACERL) have developed a robotic system that allows render safe procedures (RSPs) to be performed remotely — up to 500 feet away from the munitions.

The explosive ordnance disposal (EOD) robot is designed to disable the firing mechanism without an explosion. During maneuvers or after an accident, blow-in-place disposal is rarely an option; the potential danger to personnel, equipment and environment is too great. Moreover, exploding one munition can set off others, creating a very hazardous uncontrolled situation. Until now, the only alternative has been to assemble a three-man team of EOD experts to disarm the device — an extremely high-risk occupation that can result in loss of life.

USACERL developed the robotic system at the request of the project manager for ammunition logistics at the Army Research, Development, and Engineering Center (ARDEC). Actually, the system combines two technologies that hadn't been used together before — a robot and a waterjet cutter. The engineering team knew that a waterjet cutter could sever the casing from the high explosive, but not if it would do that without an explosion.

A prototype robotic system was engineered for a proof-of-principle experiment. To be practical for use in the field, the robot had to be lightweight and sophisticated enough to mimic the human hand, yet powerful enough to hold the munition and remove the firing mechanism.

Most robots have a weight-to-load ratio of about 100-to-1. That means the robot's weight is 100 times as great as the heaviest load it can handle. Something lighter than that was needed.

The robot finally chosen for the system had been developed by Advanced Technology and Research Corp. in conjunction with the University of Maryland. Its weight-to-load ratio is about 5-to-1. This robot is a tripod with an arm extended from each leg toward the center, where they are connected (see Figure 1). The connection point forms the "wrist" that can manipulate a fairly complex tool such as would be needed to defuse explosive material.

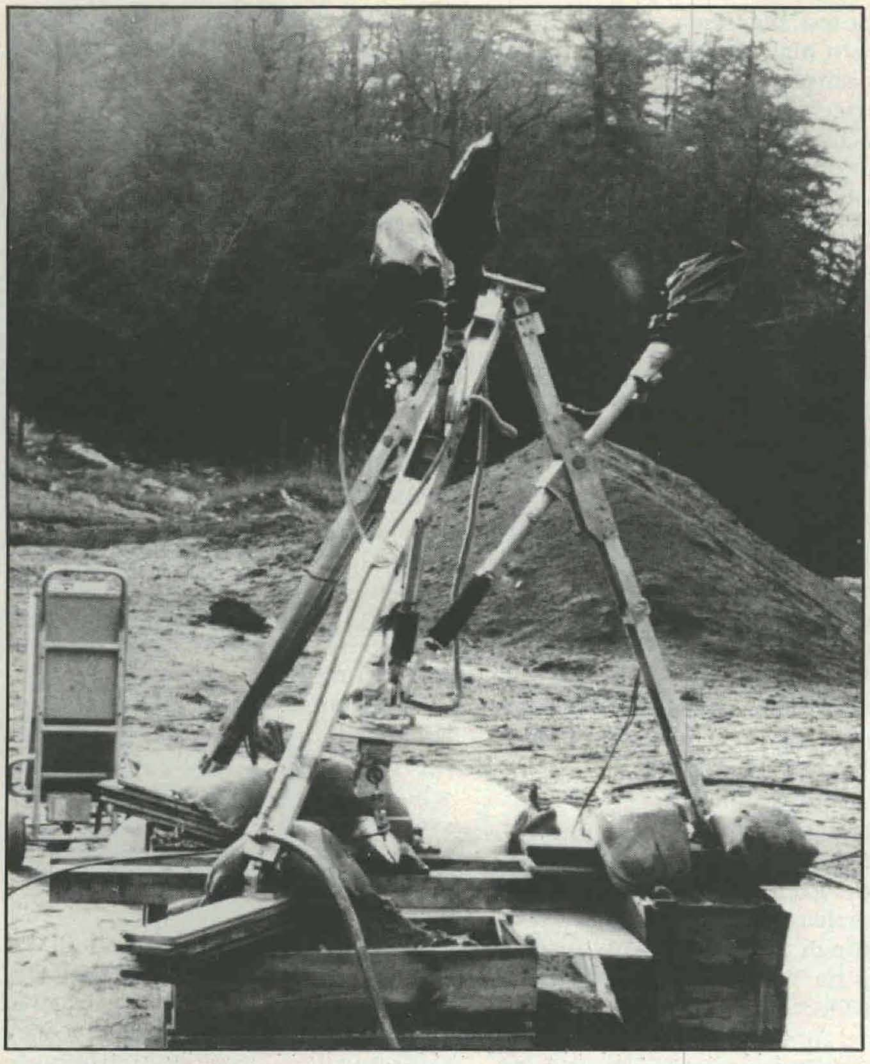
The tool that the robot would use had to be efficient, adaptable to automation, and safe — it must not detonate the explosive.

The team was looking at waterjet cutters as one possible method. The auto industry has been using this technology for some time and has found that it adapts very well to automation.

The waterjet cutter head is lightweight as required by the robot. The system also offers the potential for high efficiency since water alone could sever the high explosive. However, something was needed to help the waterjet cut through the munitions' steel casing in a reasonable amount of time.

Garnet sand is the most common abrasive used with the cutters. The trouble is, it causes sparking on contact with a surface and that would have been unacceptable.

USACERL decided to test the system using copper slag (i.e., copper oxide) as the abrasive. The rationale was that copper is softer than garnet sand and would greatly reduce the number of sparks per second.



Left, Figure 1. Shown is the robot tripod with an arm extended from each leg. Below, Figure 2. Trailer-mounted Water Pump.

To make the system portable, the pump for the waterjet cutter had to be mobilized. Ingersoll-Rand Co. manufactures trailer-mounted water pumps as shown in Figure 2. These units can be rented and offered the best available transportation for the prototype system.

A vision system on the robot gives the operator feedback on what's happening so he can direct the cutting process. This vision system was developed by the National Institute of Standards and Technology and consists of a projection lamp and a video camera which are set at precise angles with the cutting head. The operator uses a joystick to control the cutter.

The robotic system constructed for the proof-of-principle test had a five degree of freedom tripod robot, a computer controller, controller software, vision system, and high-pressure waterjet cutter. The water stream delivered to the material reaches pressures of 30,000 to 50,000 pounds per square inch from a 0.02 inch orifice. Abrasive is fed to the stream from a reservoir (also mounted on the trailer) through a plastic hose.

USACERL tested the robotic system at Picatinny Arsenal, Dover, NJ, during January 1989. Because such a device had never been used to disarm munitions, a stepwise experiment was devised, beginning with inert rounds and working up to live ammunition.

The explosive selected for the test was a 105mm M1 artillery projectile. It's important to note that operation of the robotic system requires knowledge of the type of munition to be disabled.

Unfortunately, this system can't be used to disarm a terrorist type of bomb because the packaging varies so much with those explosives. But that wasn't the intent of the robotic system. The munitions expert will almost always know what he's dealing with, whether it's one of our explosives or an enemy's.

It should be emphasized that the robot does not actually replace the EOD technician. The operator's expertise in knowing how to handle these munitions is still very important. What the robotic system does is to take personnel out of a very dangerous position. The expert does what he normally would, only from 300 or 500 feet away and with a waterjet instead of a bandsaw.

For the test, the 105mm M1 body was filled with high explosive. The firing mechanism used in the test is a mechanical device that has a striker and a booster charge. The point of the projectile has a supplementary charge which is ignited by the booster charge and which in turn ignites the high explosive.

The robotic system disarmed the 105mm explosive successfully without detonation, proving the feasibility of such a method.

"This experiment was unique because it was the first time a waterjet cutter had been used to sever the whole munition," notes COL Carl Magnell, commander and director of USACERL. "By showing that it works, we've not only given the military community a much safer procedure, but have pioneered a completely new approach to RSPs." The test showed that the waterjet cutter can sever the fuze from the body of an artillery round safely. Separate parts of the munitions, including the highly reactive booster and supplementary charges, can also be cut.

The test at Picatinny revealed another advantage of the waterjet cutter: the vibration was lowered somewhat compared to that when using a bandsaw to cut through munitions. This further reduces the likelihood of detonation.

USACERL's concept has many other potential applications for EOD. For example, a drill injector being investigated at the lab would cut a small hole in an explosive and inject a glue-like substance that would quickly harden, freezing the firing mechanism.

The robotic system produced for the test was expensive, with materials alone costing about $58K and the total price exceeding $100K. However, the cost will decline dramatically once the industrial hardening is complete and the system can be mass produced. USACERL is currently seeking cooperation from private industry to optimize the design. There is a need to have the electrical components sealed so they'll be waterproof. And there are still some problems with bulkiness and weight.

Another improvement that could be added is telescoping legs to allow the robot to adjust to different terrains. In addition, the system could benefit by having a computer program that allows the operator to "teach" the robot a correct cutting path.

When the robotic system has been enhanced, USACERL hopes to transfer the technology through the Navy, which is the lead agency for EOD. The system would most likely be made available to the services through the Navy EOD Technology Center in Indian Head, MD.

There is a good chance that the USACERL robot will replace the EOD technician in the explosive zone of live munitions. But when it comes to render safe procedures, that's one job nobody will mind losing to a machine.

FRANK KEARNEY is team leader and principal investigator on the USACERL Engineering and Materials Division Metallurgy and Quality Assurance Team. He headed the Remote Water/Abrasive Jet Cutting project under which the robot and waterjet cutter were tested.

ROBERT WEBER is a principal investigator on the Metallurgy and Quality Assurance Team and is responsible for research and development on welding, materials, and quality assurance/quality control.

DANA FINNEY is a marketing communications assistant with the USACERL Public Affairs and Marketing Communications Office.

Frank Kearney and Robert Weber received the 1989 Army Research and Development Achievement Award for their work on the robotic EOD system.

Army Acquisition Corps Approved

In the May-June (1988) issue of the *Army RD&A Bulletin*, LTG Jerry Max Bunyard, Robert O. Black, and LTC Daniel D. Ziomek introduced readers to significant career development changes that were being planned for both military and civilian participants in Army acquisition. In January of this year, Secretary of the Army Michael P. W. Stone, and Army Chief of Staff General Carl E. Vuono formally announced the establishment of the Army Acquisition Corps. Following is the formal Army statement announcing the Acquisition Corps and a series of questions and answers about the new program.

The Army Acquisition Corps (Formal Army Announcement)

The Army depends on the quality of its materiel and weapons systems to meet its national security responsibilities. It is imperative that our development and acquisition processes permit us to exploit fully the great promise of American technology while at the same time maintaining streamlined and efficient management structures.

In order to accomplish this, we must have a corps of dedicated professionals who are experts in systems development and acquisition. The Army Acquisition Corps (AAC) is the Army's program to develop military and civilian acquisition specialists and leaders. This program is designed to enhance and sustain the acquisition skills of a select group of military and civilian experts who are well grounded and experienced, both operationally and technically. The program will integrate education, training, experience, selection and promotion processes for the acquisition corps, both military and civilian.

Some of the key aspects of this program for the officer corps include selection for program manager and program executive officer opportunities in place of brigade and battalion command opportunities. Officers will enter this program at their eighth year of service after gaining branch operational experience. Officers will also require advanced degrees. Those officers who do not possess an advanced degree will be provided fully-funded programs. Promotion policy and guidance will be structured to ensure potential for advancement from company grade to general officer rank.

The civilian program is similar to the military program. Civilians will enter the AAC from existing career programs at grades GS-13 and above. Civilians will also be provided a military orientation course to enhance their understanding of the operational needs of the Army. Generally, operational and technical experience will be fully developed prior to entry into the acquisition specialty and during acquisition-related assignments. Advancement opportunities from GS-13 through SES will be provided. Civilians will be required to agree to mandatory mobility requirements to ensure that the Army needs can be met.

The military and civilian acquisition corps programs will be parallel and complementary. The AAC will be a Total Army program. A single management structure will be used to oversee, direct, and administer this program. Military and civilian specialists will be jointly managed under a single DA-level Executive Board, a common program proponent office, and a centralized personnel administration office within the U.S. Total Army Personnel Command.

Developing, producing and fielding the very best systems for our soldiers necessitate creation of a corps of highly qualified military and civilian specialists. At the same time, this initiative will resolve the acquisition management concerns expressed in the Defense Management Review, as well as address regulatory requirements which dictate establishment of specialized training and development for specific acquisition positions and personnel.

We must develop the leadership and expertise to acquire the materiel and weapons our Army will need in the next century. We are committed to providing our soldiers with the best equipment possible.

Carl E. Vuono
General, United States Army
Chief of Staff

M.P.W. Stone
Secretary of the Army

Army Acquisition Corps Questions and Answers

Q What is the Army Acquisition Corps?

A The Army Acquisition Corps (AAC) is the Army's program for addressing that portion of the Defense Management Review concerning development of a dedicated corps of acquisition specialists. In so doing it complies with Public Law 99-145 and Department of Defense Directive 5000.52 which established specialized training and development requirements for specific acquisition positions. These "critical positions" include about 1,350 military and civilian positions located in Program Executive Offices, Program Management Offices, and selected support and staff positions in support commands and headquarters offices. The AAC includes military and civilian specialists occupying these positions as well as the development of approximately 2,900 candidates to compete for future assignment to these critical positions. The Army Acquisition Executive will serve as a functional chief and proponent of the Army Acquisition Corps.

Q Why should an officer or civilian view this as a lasting program and not a reflection of current priorities?

A This program responds to a national priority that, given the budget implications of defense systems, is not likely to diminish now or in the future. Top Army leaders describe it as a strategic initiative to carry the Army into the 21st century. Further, because it is under a common management structure it is unlikely to undergo constant change and modification. This supports the Army's decision to make a long term investment in some of it's best officers and civilians.

Q Is it not unusual for the office administering military and civilian career management to be combined into one organization?

A Yes. This is a key feature of the program. First, it validates the commitment to a single Army system. Second, it takes advantage of the efficiencies of joint program planning and management and reinforces the focus on what is beneficial for the Army acquisition system.

Q How many acquisition personnel does the Army have and how does that relate to the Army Acquisition Corps?

A The Army has a community of approximately 35,000 personnel serving in acquisition related positions. The Army Acquisition Corps is intended to address the development and staffing needs of only those critical acquisition positions located in Program

Executive Offices, Program Management Offices, and selected support and staff positions located in matrix support commands and headquarters offices. Enhanced acquisition training for the remainder of the community is being addressed through the military functional area and civilian career programs with which those positions are identified.

Q What are the key features of the program?

A The program provides for the competitive selection of military and civilian candidates into a common developmental pool; it develops them in accordance with public law and DOD guidance; it also provides for competitive promotion, from within the pool, into critical positions.

Q What are the provisions of the law and DOD directive?

A PL 99-145 requires that program managers of major programs have eight years of acquisition experience of which two years must have been acquired within a procurement command (i.e., Army Materiel Command, Information Systems Command, Strategic Defense Command). They also must attend the Defense Systems Management College (DSMC) Program Management Course or a comparable course. This criteria is extended by the DOD directive, with some modification, to other positions.

Q How does the Army Acquisition Corps relate to the previous Materiel Acquisition Management (MAM) program?

A First, the program for military is narrowed to the development of product/project managers (PM), program executive officers (PEO), general officers, and other designated critical positions. The Army anticipates a reduction of the current 3,000 plus 6T (CPT-COL) positions to approximately 350 4Z (LTC-COL) positions. Skill "4Z" is the new code for both certified officers and critical positions. The "4M" code only identifies candidate officers. The steady-state inventory or pool for certified and non-certified acquisition specialists will be approximately 3,000 (CPT through COL). The size of the inventory is based on the number of validated positions and accounts for officer attrition and promotion over time. The current 6T inventory will be realigned to meet the new program strength levels via PERSCOM and DA selection boards in the near future. Second, the acquisition career developmental base will consist of Functional Areas 51 (Research, Development and Acquisition), 52 (Nuclear Weapons), 53 (Systems Automation), 97 (Contracting and Industrial Management), and 15C/35 (Aviation/Intelligence). *All* FA 51 and 97 positions are considered developmental. *Designated* FA 52, 53 and 15C/35 positions are also developmental. Third, the Army gains the capability to fully implement personnel life cycle management functions throughout an officer's career (CPT through GEN). These functions include structure management, accession, individual training and education, distribution management, sustainment, professional development and separation. Fourth, the LTC and COL promotion boards will be given floors for 4Z and 4M, requiring them to select a minimum number of fully qualified acquisition officers for promotion. This ensures the Army the requisite number of experienced acquisition officers. Fifth, assignment priority for acquisition officers will be shifted from branch qualifying assignments to acquisition developmental assignments.

Q How does this program relate to traditional Army civilian career programs.

A Traditional programs focus on single occupational areas (e.g., ADP, Comptrollership, etc.) and guide the careerist from entry level through the top positions within the occupation. The Army Acquisition Corps actually operates as a separate career track that draws participants, who are already at middle levels, from multiple occupational areas and provides them with broader acquisition training and development and applies the same structure as the military. These civilians will still have the opportunity to compete within their traditional career programs.

Q How does this program relate to the Army's Logistic and Acquisition Management Program (LOGAMP)?

A The LOGAMP program serves a much broader area of logistics and acquisition and is therefore not affected by this program. LOGAMP participants will, however, be one source of candidates for this program.

Q When will these changes go into effect?

A Implementation of the program has begun. The U.S. Total Army Personnel Command (PERSCOM) has designed accession, development, utilization, career management and promotion procedures which will go into effect during 1990.

Q How will these changes be implemented?

A In a series of steps. The first steps currently taking place involve (a) validating through the major commands the selection of critical civilian positions — a step already completed for the military and (b) screening all current officers and civilians in critical positions to determine their qualification/non-qualification with the more stringent requirements of Public Law 99-145 and DODD 5000.52. In the next step, new officers and civilians are selected for the developmental portion of the AAC. Remaining steps include development of training and education programs, writing selection and promotion board guidance, implementation of personnel procedures, and publication of the new program.

Q What role will advanced college degrees play in this program?

A The Army has established a goal of 100 percent advanced civil schooling for all Acquisition Corps members — the first step in their development. The law prohibits training for or paying for a degree for civilian employees. However, about one third of the civilian population from which candidates would be drawn already have advanced degrees. Legislation is pending that would permit paying for civilian degrees. If this occurs and the Office of Personnel Management agrees, the advanced degree requirement will be initiated for civilians as well as military.

Q What will happen to those people currently assigned to critical positions that are scheduled to be filled by the Army Acquisition Corps?

A Their background will be evaluated against the criteria of PL 99-145 and DODD 5000.52. Those that satisfy the criteria will be certified under those requirements. Those that do not will be provided, to the extent practical, the opportunity to satisfy the requirements or be reassigned to a functional area or career program position. This review is a priority action. It is already underway for the military and will begin for civilians concurrent with finalizing the critical position identification.

Q What role will mobility and rotation policies play in this program?

A The law provides that for selected positions the specialist should remain in place for four years or until the next major acquisition milestone is achieved. The Army is also concerned that flexibility exists to adjust to changing skill and experience needs of the position over a program or product life cycle. It is envisioned that military rotation and civilian mobility programs will be used to satisfy these needs.

Q Can you give a brief synopsis of an officer's career pattern in the new AAC program?

A Once an officer is accessed into the AAC program at the eighth year of service, he/she will be awarded the 4M skill code. Every effort will be made to get the officer into the Army Advanced Civil Schooling (ACS) Program and possibly a Training With Industry (TWI) tour, after which the officer will attend the nine-week Materiel Acquisition Management Course at the Army Logistics Management College. The officer will then be assigned to an acquisition job in his/her functional area. After completion of this tour and promotion to Major, officers will attend MEL-4 schooling. Selection rates for resident attendance at Command and Staff College (CSC) is expected to mirror the Army average. Officers not selected for resident attendance will be strongly encouraged to enroll in the non-resident Command and General Staff Officer Course (CGSOC).

Following attendance at CSC, the officer can expect to be utilized in an acquisition user assignment at the field grade level. This assignment is important for acquisition officers to update their knowledge on current weapons, tactics, and doctrine of their branch as it relates to their later development as acquisition experts for their branch.

Following this tour, the officer will attend the Defense Systems Management College (DSMC) Program Management Course (PMC). After completing the PMC, the officer will serve a second acquisition tour. During this tour, the officer should be considered for promotion to LTC, certification as a 4Z, and selection as a Product Manager. Officers selected for LTC, but not PM, will be utilized in critical AAC positions.

Annually, board certified MAJ(P)s and LTCs will be considered for selection as PMs. During this most important three-year tour, the officer applies the extensive acquisition schooling and experience he/she has gained to the development of weapons systems in his branch.

After this important acquisition tour, the officer should be considered for, and if selected, attend the Senior Service College (SSC). Selection rates for acquisition officers for resident attendance at SSC are expected to reflect the Army average. Officers not selected for resident attendance will be strongly encouraged to enroll in the Army War College Corresponding Studies Course (AWCCSC).

Following SSC, the officer should be considered for promotion to COL. Once selected, he/she will be considered for project manager selection and utilization. If not selected for COL or PM, the officer will continue to be utilized in AAC or Functional Area positions until he/she retires.

After successfully completing the COL PM tour, the officer could be selected for promotion to General Officer, with a subsequent tour as a Program Executive Officer or in another general officer acquisition position. If not selected for General Officer, the officer will continue to be used in critical AAC positions until he/she retires.

A similar progression applies to the civilian members of the Acquisition Corps in that they will receive leadership, DSMC training and the acquisition assignments described above.

Project Management Office Changes

A major realignment of the Army Materiel Command Project Management Office (PMO) took place on Jan. 1, 1990. Effective that date, the PM/PEO structure began receiving direct resourcing of manpower authorizations from Headquarters, Department of the Army (HQDA). Concurrently, the manpower/personnel functions are now managed through the Provisional Army Acquisition Executive Support Agency (AAESA). COL John Bramblett, former chief of the Project Management Office, is director of the agency, which will remain under operational control of the Army Acquisition Executive until the administrative details are finalized, assigning the PMO to the AAESA. When the AAESA is formally established as a HQDA staff support agency, it will have the PEO/PM structure assigned to it. Current plans also call for the MAM Proponency function and the *Army RD&A Bulletin* to move with the PMO to AAESA. COL Bramblett has tasking authority to all members of the PEO/PM structure, and PEOs are authorized to deal directly with his office on manpower and personnel matters at AV 284-9570/1/5.

Military Critical 4Z Positions

The approved restructuring of the MAM program and establishment of the Army Acquisition Corps have resulted in top loading skill identifier 4Z, Certified Materiel Acquisition Management Officer, to The Army Authorization Documentation System (TAADS). In TAADS, 4Z identifies those positions which must be filled by certified officers. Upon completion of the top loading process, it is anticipated that approximately 360 military critical 4Z positions will be documented in Army TDAs. Civilian critical 4Z positions are also being identified. An updated 4Z list for both military and civilian positions will be published in an upcoming issue of *Army RD&A Bulletin*.

For those interested, preliminary information about specific 4Z positions is available from the Army MAM Proponent, AV 284-9570/9571.

Army Acquisition Corps Points of Contact

In response to the Defense Management Review, the Army recently established the Army Acquisition Executive Support Agency and the Acquisition Corps. The following listing of organizations and individuals directly involved in the management of the Acquisition Corps (proponent/assignment officers) is provided for your information and use.

CAREER DEVELOPMENT UPDATE

Army Acquisition Executive Support Agency
ATTN: AAESA
5001 Eisenhower Avenue
Alexandria, VA 22333-0001

		(202) 274-
COL John R. Bramblett	Director	284-9710
Robert L. Michellon	Deputy Director	284-9570
LTC Daniel D. Ziomek	MAM Proponent Ofcr	284-9570
Dale R. Fradley	PM Spec (Policy)	284-9571
M. Susan Hubbard	PM Spec (PM Boards)	284-9571
CPT Kevin R. Norgaard	FA51 Proponent Ofcr	284-9572
Karen A. Walker	FA51 Proponent Ofc	284-9572
James M. Welsh	MAM Proponent Ofc	284-9575
Harvey L. Bleicher	RDA Bulletin	284-8978
Melody B. Ratkus	RDA Bulletin	284-8978
Janet M. Jones	Administrative Ofcr	284-9575
Elaine F. Schalow	Secretary	284-9710

U.S. Contracting Support Agency
(FA 97 Proponent Office)
ATTN: SFRD-KM
Washington, D.C. 20310-0103

		(202) 756-
COL Al Greenhouse	Ch. Procurement Mgt	289-1700
CPT Andy Mills	FA97 Proponent Ofcr	289-2796
Jim Vann	Procurement Analyst	289-1700
Janet Wolfinger	Procurement Analyst	289-1700

U.S. Combined Arms Center
(FA 52 Proponent Office)
ATTN: ATZL-CAD-N
Fort Leavenworth, KS 66027-5300

		(913) 684-
MAJ Frank R. Mann IV	FA52 Proponent Ofcr	552-2133

U.S. Army Signal Center and School
(FA 53 Proponent Office)
ATTN: ATZH-POO
Fort Gordon, GA 30905-5300

		(404) 791-
LTC Doyle A. Buck	FA53 Proponent Ofcr	780-7388
Dallas Grimes	ACS/TWI Coordinator	780-2267

U.S. Total Army Personnel Command
ATTN: TAPC-OPB-A
200 Stovall Street
Alexandria, VA 22332-0411

		(202) 325-COL
Glen R. Skirvin	Ch, FA & Dev Division	221-0217
MAJ Thomas W. Resau	FA51 Assignments Ofcr	221-2128
MAJ Charles F. Vondra	FA52/97 Assignments Ofcr	221-2801
MAJ Donald E. Ramsey	FA53 Assignments Ofcr	221-3114
Richard C. Yager	MAM Staff Officer	221-3127
CPT Thomas H. Hogan	FA51 Force Read Ofcr	221-3130
CPT Donald J. Blodgett	FA51 Force Read Ofcr	221-3130
CPT Diana L. Davis	FA97 Force Read Ofcr	221-3130
Lee Goeke	Civilian Acq Corps	221-2145
Mike Patterson	Civilian Acq Corps	221-3096
COL Roy Beauchamp	COL Div, Assignment Ofcr (TAPC-OPC)	221-7878

RD&A NEWS BRIEFS

New Pamphlet Supports Action Officers

The Army Materiel Command recently published AMCP 70-18, *Sources of Expertise During the Army Materiel Acquisition Process.* This document contains a matrix of more than 600 line items. It supports the materiel acquisition action officer in identifying areas of expertise and includes proponent organizations, addresses, telephone numbers, and reference documents. In addition, the new pamphlet contains two floppy disks which automate the user's search of this data base. The disks are useable on any IBM compatible (MS DOS) personal computer.

AMCP 70-18 can be obtained through normal distribution channels or by contacting the proponent, Gerald Malakoff, Attn: AMCDE-AR-P, HQ, U.S. Army Materiel Command, Alexandria, VA 22333-0001, AUTOVON 284-9198 or commercial (202) 274-9198.

Robot Programming Software

The U.S. Army Research Office has announced that a review has been prepared summarizing the current state of robot programming, and highlighting research trends (including graphical, voice, and automatic program development, and the use of artificial intelligence).

The operating environment of a manufacturing robot is more constrained and predictable than that of a mobile, autonomous robot. However, many of the required capabilities are common to both, such as planning, collision avoidance, sensory input and interpretation, and handling uncertainty.

Those interested in robot applications may wish to relate required robot capabilities to progress in robot software. A copy of the paper can be obtained by calling MAJ Mary C. Berwanger at the Army Research Office, AV 935-3331 (ext 357) or commercial (919) 549-0641 (ext 357).

RD&A NEWS BRIEFS

7th Infantry Division (Light) Receives New Howitzers

The U.S. Army Armament, Munitions and Chemical Command (AMCCOM) has completed the fielding of 36 new M119 Howitzers to two battalions of the 7th Infantry Division (Light) at Fort Ord, CA. GEN William G. T. Tuttle, commander, Army Materiel Command (AMC) and MG Carmen J. Cavezza, commanding general, 7th Infantry Division (Light) removed a muzzle cover from an M119 Howitzer, symbolically "handing off" the howitzer from AMC to the Forces Command (FORSCOM) and the 7th Infantry Division (L).

The 7th ID is the first of the Army's light infantry divisions to receive the new towed 105mm lightweight cannon. The two battalions which received the howitzer on Dec. 7, 1989 are the 2nd Battalion, 8th Field Artillery, and the 6th Battalion, 8th Field Artillery. The division's three battalions will get a total of 56 howitzers.

The United Kingdom's Royal Ordnance, Plc., designed and developed the weapon to the same specifications used by the British Army. The only modification made to the howitzer is to incorporate a digital readout on the fire control system. Under the current plan, Royal Ordnance, a wholly owned subsidiary of British Aerospace, will produce approximately 150 of the howitzers by January 1991 at a cost of about $54 million. Peter Kenyon, managing director for Royal Ordnance, stated that the M119 Light Howitzer ". . .will provide the enhanced force capability deemed necessary in these days of increasingly changing circumstances where rapid deployment is essential." MG M.D. Brailsford, commanding general of AMCCOM, the organization responsible for fielding the new weapon system, said "Fielding the M119 is significant only because it enhances our combat capability but also because it marks cooperation between two governments." In a unique licensing agreement, the United States will produce the howitzer after about 150 are produced by Royal Ordnance. Watervliet Arsenal, NY, will produce the M119's cannon tubes. Rock Island Arsenal, IL, will produce the recoil mechanism and assemble an additional 398 weapons. The M119 Howitzer will replace the aging inventory of M101A2 and M102 towed howitzers which served during the Vietnam conflict.

CORRECTION

Due to an editorial error on page 17 of our January-February 1990 issue (article titled The Noncommissioned Officer and Heavy Force Modernization), we incorrectly stated that NCOs have direct access to a 3-star general PEO and his 2-star deputy for future systems. The sentence should have correctly indicated that the PEO is a 2-star and his deputy a 1-star. We apologize for any inconvenience caused by this error.

Before emplacement, the right tire is removed to allow the M119 Howitzer to swing from its folded position to its firing position. The tire is then remounted and locked into place.

R&D STRATEGY IN WWII

In the November-December 1989 issue of *Army RD&A Bulletin*, COL W. H. Freestone, Jr. reminds us in "The Copernicus Syndrome" that the writers of requirements must be knowledgeable of systems technology. For even more fundamental reasons, these writers must be cognizant of the strategy the equipment is being built to support. As basic an assumption as this would seem to go without saying, but in no less an effort than World War II such was not the case.

Ever since the Civil War, U.S. Army planners had almost universally accepted General Ulysses Grant's strategy of annihilation as being the key to victory. This belief manifested itself in the 1939 revision of FM 100-5 which stated "an objective may sometimes be gained through maneuver alone; ordinarily, it must be gained through battle." The Army's position was clear. War would be won by confronting the enemy's main forces and overwhelming them with superior power.

World War II planners religiously adhered to this theme in their proposed strategies to defeat Germany. From the ABC-1 meeting of March 27, 1941 throughout all the Allied conferences, American strategists insisted upon the need for a direct cross-channel invasion rather than the plans for peripheral operations offered by the British. The strategy was to engage the main German army as quickly as possible and destroy it.

Unfortunately, the development of the U.S. Army's weaponry, particularly its armor and anti-armor systems, was not designed to support such a strategy. Rather than emphasizing the protection and firepower necessary for a direct confrontation with the main enemy forces, General Lesley McNair, chief of staff of General Headquarters and later commander of the Army Ground Forces, had pressed for light, mobile systems. The result was a family of weapons that was not suited to support the Army's well-known and undeviating strategy.

McNair's firm belief was that tanks were infantry weapons. As such they had to be light enough and mobile enough to go wherever the infantry could. American tanks thus became machine gun carriers designed to travel with the infantry and protected only against enemy machine guns. Tanks were not expected to fight other tanks. Instead they were to destroy more vulnerable targets such as infantrymen. However, in the cross-channel invasion demanded by American strategy, tank to tank battles would be inevitable.

Ordnance Department officials cautioned that U.S. tanks were falling behind their European counterparts in terms of guns and armor, but their warnings went unheeded.

Guidance to the developers continued to stress mobility and lightness instead of protection and firepower. Until 1940, weight limits fixed tank size at 25 tons, preferrably just 15. Even after these restrictions were lifted, they were generally followed voluntarily out of habit. To emphasize just how much firepower had been ignored, it was not until July 1940 that the War Department approved a design for a tank with a 75mm howitzer.

Since tanks were obviously not designed to kill enemy tanks, the Army had built special tank killers for this purpose. However the same demands for lightness and mobility had limited gun size to 37mm. This gun could not kill modern armor which rendered the system's mobility rather moot. By 1944 the size gun had expanded to just 57mm which was still far behind German 75mm and 88mm models. In an attempt to upgrade the tank killer, McNair pushed for the M10 tank destroyer which incorporated a 3-inch high-muzzle velocity gun mounted on a Sherman chassis. The requirement for still more gun power brought about the M18 with a 76mm gun on the M24 light tank chassis and the M36, an M10 redesigned to house a 90mm gun. However, the difficulties involved in combining mobility and gun power at the expense of protection soon became obvious.

McNair's emphasis on mobility also generated a requirement for a portable anti-armor weapon for the infantry. The answer was the bazooka, but, like the other anti-armor weapons, it was too small to penetrate the heavy front armor of German tanks. Many soldiers preferred to capture and use the more powerful German 88mm Panzerfaust than to rely on the bazooka.

Thus, the entire family of U.S. armor and anti-armor weapons, from the tanks themselves to the man portable anti-armor models, all suffered from the same flaw. The proclaimed Army strategy required concentrated firepower capable of overwhelming the enemy's main resistance. Certainly the weapons that had been developed were more suited for a strategy of maneuver. U.S. Army strategy and the weapons that would be called upon to support that strategy did not complement each other.

Thus, R&D specialists must not only be aware of the technological capabilities as COL Freeman explains. They must likewise be aware of the strategy for which the weapons and equipment are being designed. Our current AirLand Battle Doctrine has numerous implications for our equipment just as the strategy for a cross-channel invasion had during World War II. Weapons and equipment must be designed with these considerations in mind.

The preceding article was submitted by CPT Kevin A. Dougherty, assistant chief of staff, G-3 training, APO, NY 09742.

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