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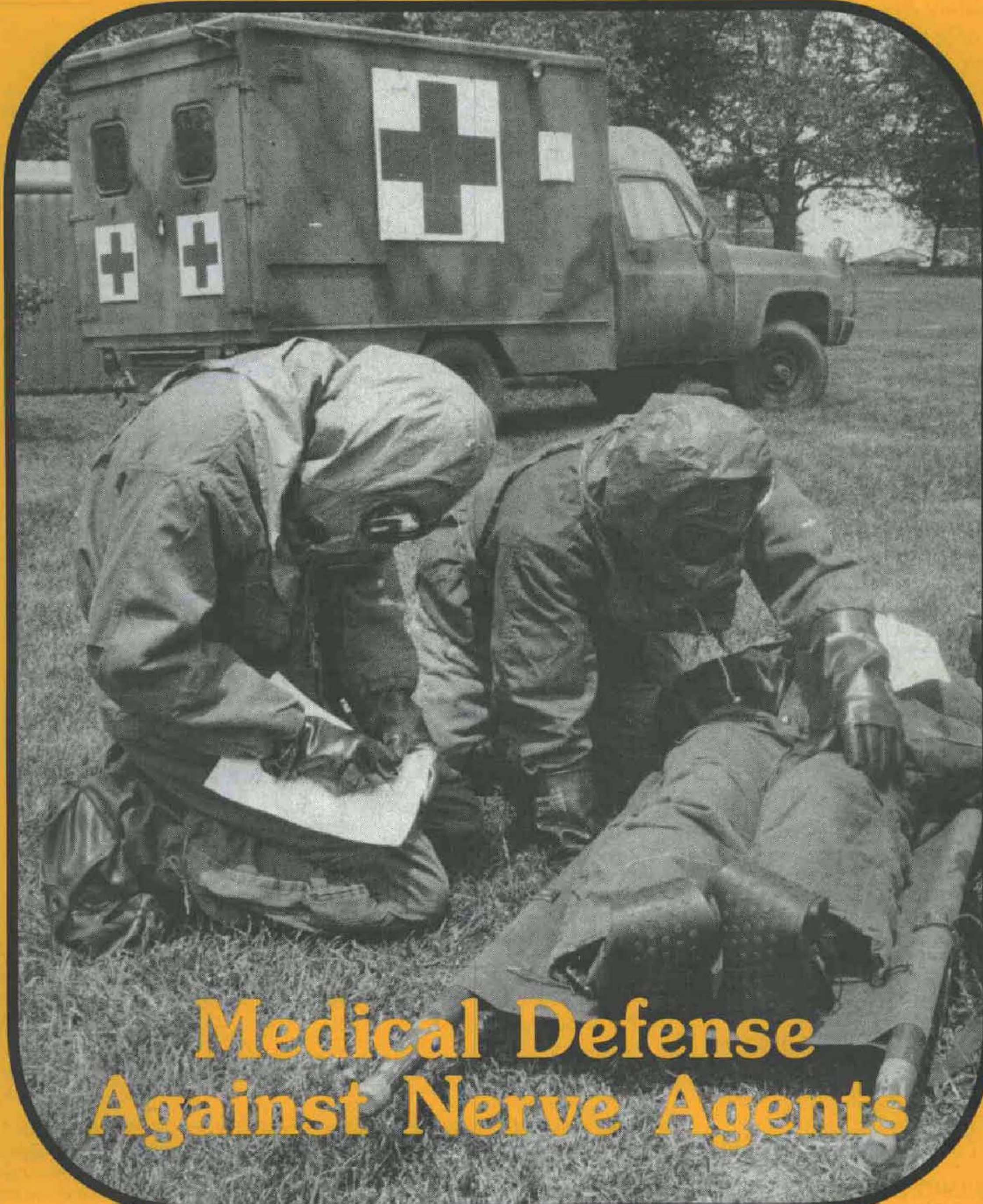

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PB 70-89-4 **JULY-AUGUST 1989**

PROFESSIONAL BULLETIN OF THE RDA COMMUNITY

FEATURES

DEPARTMENTS

ABOUT THE COVER

The front cover shows soldiers monitoring the condition of a simulated chemical casualty in a training exercise. The back cover is a photo related to full-scale crash testing of helicopters to support crashworthiness design criteria formulation.

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Soldiers monitor the condition of a simulated chemical casualty in a training exercise.

NEW MEDICAL DEFENSES AGAINST NERVE AGENTS

Examining Our Current Medical Defense Posture

By COL Michael A. Dunn

Introduction

Nerve agents comprise an extremely potent group of toxic chemical warfare compounds. Although information on their battlefield use has been very limited, they have posed a serious threat for nearly 50 years.

In planning for chemical defense in operations across the spectrum of conflict, our overriding consideration until recent years has been the substantial Warsaw Pact investment in forward-based stocks of weaponized nerve agents. Now, we must also consider recent regional conflicts in which the use of chemical warfare agents has been well established.

Even though the emphasis has been on reporting the effects of blister agents such as sulfur mustard in these situations, there is ample reason to predict that a future third world adversary might opt to produce and employ nerve agents against U.S. or allied forces.

The factors that a potential enemy must use in calculating the likely effectiveness of a weapon like nerve agents are well known. Major considerations are delivery capability, possible retaliation, and the effect of the agent on target. Along with training, detection, physical protection, and decontamination, effective medical treatment may have a decisive influence on whether a potential user can rely on the nerve agents to be a severe casualty producer.

The United States and its allies have made substantial progress in fielding improved medical countermeasures against nerve agents in recent years. This article will examine our current medical defense posture with a system of pretreatment and antidote compounds. Near-term and long-term research and development efforts will also be considered.

How Nerve Agents Work

Nerve agents are all organophosphorus compounds with four reactive groups or side chains attached to a central phosphorus atom. The nature of the attached groups determines the potency of a compound, and whether it will be persistent under normal conditions. We have a good understanding of the effects of nerve agents from animal experiments, very limited data from a handful of accidental human exposures, and additional information from treating agricultural and industrial workers exposed to the related organophosphorus pesticides.

The nerve agents all bind to tissue targets in the nervous system pathways that control voluntary movement and coordination. In addition, the nerve agents affect transmission in critical involuntary pathways that operate without conscious effort, such as those that control breathing, sweating, secretion of fluid in the air passages and lungs, and adaptation of the pupils to light. In all these cases, the critical tissue target of nerve agent action is an enzyme, acetylcholinesterase, that regulates normal impulse transmission by inactivating the key transmitter molecule, acetylcholine. Within the brain, other tissue sites, such as receptor/ion channel complexes, may be important targets of nerve agent action as well.

Mild exposures to nerve agent cause sweating, runny nose, airway congestion, muscle twitching and dim or blurred vision. Severe, fatal exposures kill by causing respiratory arrest. Severe exposures also cause convulsions and brain injury that can lead to long-lasting incapacitation in experimental animals that survive respiratory arrest. Based on animal experiments, the lethal inhaled dose of most nerve agents for a human is on the order of one milligram.

In order to be successful, how many lethal doses of nerve agent should a medical defense protect against? The answer to this key question depends on modeling the expected concentrations of nerve agent after an attack against the capability of trained troops to take at least partial advantage of the protection provided by masks and protective clothing as soon as a chemical attack is recognized. As a practical goal, most workers accept a target of protection against five times the lethal dose of nerve agent as a credible medical countermeasure.

Early Countermeasures

Almost as soon as the first war stocks of the German G class of nerve agents fell into British hands toward the end of World War II, it was learned that their toxic effects could be partially overcome by the use of atropine. Atropine acts at multiple sites in the brain and peripheral nerve pathways as an antidote to many of the effects of nerve agents, without actually removing the agent that is bound to tissue targets.

Some researchers have suggested antidote systems that are based on compounds closely related to atropine. However, atropine itself remains an essential component of all fielded Western nerve agent antidote combinations, both because no other compound is clearly superior to it in all its actions, and because all physicians are thoroughly familiar with its use in clinical medicine.

In the early 1950s, British scientists showed that the organic compound pralidoxime, or 2-PAM, was capable of removing nerve agent from its target binding sites. The enzyme acetylcholinesterase, for example, can be reactivated by removal of bound nerve agent, restoring normal nervous system transmission. The 2-PAM compound is one of a class of related compounds, the oximes, that form the second essential component of all currently fielded nerve agent antidote systems.

All of the oximes have one major deficiency in their action against nerve agents. As time passes, the nature of the binding of the nerve agent to its target changes, undergoing a process called "aging." Once the nerve agent-target bond has aged, the agent can no longer be removed by an oxime. The rate at which aging occurs depends on the specific nerve agent. The agent whose binding ages most rapidly, on the order of two minutes or less in animal experiments, is soman, or GD. A major portion of the Warsaw Pact's war stock of nerve agent consists of soman.

U.S. soldiers carry three Mark 1 Nerve Agent Antidote Kits with autoinjectors of atropine and 2-PAM. By itself, the efficacy of this or any other known antidote combination administered after a casualty has been exposed to soman is limited. One accepted measure of antidote efficacy, the protective ratio, is based on protection of experimental animals against increasing challenge doses of an agent above its usual lethal dose. Thus, a protective ratio of 1.0 indicates a completely ineffective antidote.

Under ideal conditions, the protective ratio of atropine and 2-PAM in animals challenged with soman is only 1.6, well short of the desired level of protection for an adequate medical defense, which could be restated in terms of a protective ratio of five or greater.

Medical Defense Today

An appreciation of how rapidly the aging of the soman-receptor bond takes place led to the realization that prior protection of target sites from attack by the nerve agent might offer the best possibility of improved survival. Fortunately, these sites are present in excess of normal needs in the nervous system, and reversibly blocking access to a fraction of them, on the order of 30 percent for acetylcholinesterase, has no effect on nervous system function.

As these protected sites become uncovered after a nerve agent challenge, they can sustain vital functions if an effective antidote combination, such as atropine and 2-PAM, has been administered. Testing in Britain, the United States, and allied countries showed that a promising pretreatment compound, pyridostigmine, gave excellent protection of several animal species, including non-human primates, against a challenge of over five lethal doses of soman when atropine and 2-PAM were given after challenge. Pyridostigmine provided no protection unless the antidote combination was used as well.

This information led to the first serious consideration of fielding a nerve agent pretreatment compound. Requiring all soldiers to take a pretreatment is a major change from focusing only on antidote therapy of those who become nerve agent casualties.

Since pretreatment will be given to the entire force, it has to be completely free of any detrimental effects on all key physical and mental soldier performance tasks. At the dose needed for protection, pyridostigmine caused no decrements in such tasks as obstacle course performance, leader reaction tests, weapons firing, tank gunnery, and ground and total in-flight simulator pilot testing.

In 1987, the United States fielded contingency war stocks of pyridostigmine bromide tablets as a nerve agent pretreatment. Army fielding is at battalion level, with foil blister packs of 21 tablets for individual issue to be taken on order every eight hours in the presence of a nerve agent threat. The atropine and 2-PAM autoinjectors of the Mark 1 kits are still essential for rapid administration to nerve agent-exposed casualties.

Our success in fielding pyridostigmine as a pretreatment promises that many nerve agent casualties who might have died may now survive. Based on the animal experiments noted earlier, adding pyridostigmine pretreatment to antidote treatment prevents death from respiratory arrest. Unfortunately, pyridostigmine fails to protect another key target of nerve agent action, the brain. The explanation for the lack of any adverse effect of pyridostigmine on soldier performance testing is most likely that this compound does not readily enter the brain.

There are other potential pretreatments which do protect the brain from nerve agent injury. However, all compounds examined thus far that protect brain target sites also have the potential to impair soldier performance to some degree, and are therefore not suitable for use as pretreatments. As mentioned above, nerve agent-induced brain injury is often marked by convulsions and prolonged incapacitation.

Depending on the test animal species and conditions, the brain injury can be reversible or severe and long-lasting, with prolonged loss of normal behavior patterns. Casualties who have survived a nerve agent attack with severe residual brain injury would place heavy new burdens on the field medical system while offering no potential for early return to duty.

Adding protection against brain injury to our medical defense against nerve agents is therefore a critical element for success. There is growing evidence that prompt administration of a compound that blocks convulsions may lessen or prevent nerve agent-induced brain injury and promote rapid recovery of normal function. One anticonvulsant, diazepam, is already available for injection by medical aidmen using a standard syringe and needle.

Based on the accumulating evidence of benefit of rapidly-administered diazepam to nerve agent-exposed animals, and on the fact that diazepam is already approved by the U.S. Food and Drug Administration as an injectable anticonvulsant, the Army Medical Department is developing a diazepam autoinjector for buddy-aid use. The diazepam autoinjector will be given at the time a buddy or aidman administers a soldier's second Mark 1 kit.

In summary, our current medical defense posture against the nerve agent threat includes pyridostigmine as a pretreatment, the atropine and 2-PAM antidotes of the Mark 1 kit, and diazepam to minimize brain injury. Combined with adequate training and use of protective equipment, this program provides a potentially significant improvement in saving lives and regenerating combat power compared with our earlier medical capability.

Near-Term R&D

Given recent progress in our current medical defense against nerve agents, near-term research and development efforts are focused on those innovations that may provide solid improvements at reasonable cost. Two key tools are extensive use of the decision tree concept for analysis of potential new compounds, and scheduling development efforts to match life cycles of fielded products.

In 1987, the United States fielded contingency war stocks of pyridostigmine bromide tablets as a nerve agent pretreatment.

Major responsibilities for medical chemical defense within the U.S. Army Medical Research and Development Command lie with the U.S. Army Medical Research Institute of Chemical Defense as technology base lead laboratory, the U.S. Army Medical Materiel Development Agency as materiel developer, and the director, Medical Chemical Defense Research Program as headquarters staff officer responsible for program guidance and coordination. As the Department of Defense's executive agent for medical chemical defense research, USAMRDC's program is driven by joint-service and service-specific requirements as well as by international agreements. Four near-term efforts have high priority:

First, because of the importance of rapidly fielding an effective pretreatment, existing approved pyridostigmine bromide tablets were selected. The need to take these tablets every eight hours to maintain their protective effect is a major disadvantage. The stress of combat operations poses a severe challenge to satisfactory adherence to an eight-hour dosage schedule. Rapid development of a sustained release, once-daily dosage form of pyridostigmine is an important need.

Second, with respect to the antidote compounds atropine and 2-PAM, there is such a wealth of experience with atropine in the medical community that a potential replacement would have to show a striking improvement in efficacy. On the other hand, newer oximes have become available that may well provide greater efficacy against all of the four known threat nerve agents than does 2-PAM. If solidly improved efficacy and adequate stability of an improved oxime appear likely, full-scale development may be cost effective.

Third, as the clinical anticonvulsant that was available for rapid fielding, diazepam has shown promise in protecting brain function in animal experiments. We are just beginning to define the mechanisms of nerve agent-induced brain injury, and are at the start of our effort to assess rate and completeness of recovery to normal function. Major advances in discovering compounds that protect the brain appear probable.

Fourth, requiring soldiers to use three different autoinjectors for atropine, an oxime, and an anticonvulsant under the stress of combat is an obvious deficiency. We and our allies are considering combination injector approaches to simplify self and buddy-aid. Key requirements are that a combined injection produce rapidly-appearing blood levels of all components, and that injection of an anticonvulsant with sedative effects, such as diazepam, be avoided for the first self-aid for soldiers with only mild symptoms.

The process of cost-effective screening of several thousand new candidate compounds requires a highly structured system that assures rigidly comparable data. That system, however, must have enough flexibility not to miss promising new approaches that do not fit a standard preconception, for example, a pretreatment with strong anticonvulsant efficacy. A series of decision tree networks is now in operation that appears likely to deliver the best improved oxime and most effective anticonvulsant in minimum time.

Timing of these efforts is important in view of the substantial costs of the Army's existing stocks of medical items. For example, proposed production of a new multi-chambered atropine and oxime autoinjector is on schedule to coincide with the expiration of our major stock of Mark 1 kits in FY 1992. Fielding of an improved oxime or anticonvulsant would be expected to coincide with expiration of existing items as well.

Long-Term R&D

Medical countermeasures to nerve agents that depend on basic advances in molecular biology fall well outside the scope of the conventional approaches mentioned above. Over the last 10 years as the medical chemical defense research program has matured, it has supported major advances in our understanding of brain and nervous system receptor function and neurochemistry. Some of this basic research investment now shows promise of very high gains for chemical defense in the areas of scavenger molecules and monoclonal antibodies.

Study of the target enzyme, acetylcholinesterase, and a related enzyme, butyrylcholinesterase, has defined the location and character of the binding of nerve agents to these proteins. In animal experiments, it has been possible to preload mice with an excess of circulating cholinesterase that serves as a scavenger to bind nerve agent before it can reach critical target sites in tissues. Such animals are protected from multiple lethal doses of nerve agent.

Production of enough human-based scavenger protein to safely administer as an effective nerve agent pretreatment in humans is at least theoretically possible, with two potential disadvantages. The material may need to be administered by vein, and pretreatment may need frequent repetition, since the half-life of the enzyme in the circulation is on the order of 12 days.

There are well defined near term research and development objectives that promise to yield clearly needed additional improvements to our pretreatment and antidote system in a cost-effective manner.

Recently, monoclonal antibodies to soman have been produced in mice that show much higher binding affinity for the nerve agent than did earlier antibody preparations. As with the scavenger molecules, it is possible to protect mice against multiple lethal dose challenges of soman with pretreatment. An advantage of the antibody approach is the ability to transfer the code for the binding site of the mouse antibody to a human antibody gene, using existing biotechnology to produce a human-based antibody in large quantity.

In theory, an intramuscular injection of an amount of antibody similar to that already in use in the standard dose of gamma globulin should provide protection against a five lethal dose challenge of soman. A human-based antibody of the IgG class would persist in the circulation with a half life of 40 days, and repeated administration would be free of the potential for allergic responses to a non-human protein.

Catalytic antibodies are produced to bind to an unstable form, the transition state, of a compound. In theory, a catalytic antibody to nerve agent could be produced that would not only bind to the agent but inactivate it and continue to inactivate other molecules of the agent as well.

The main appeal of these biotechnologic approaches to protection against nerve agents is that protected animals do not appear to be affected or impaired in any manner by the agent challenge, in contrast to the transient but definite adverse effect of nerve agents on animals treated with our most effective drugs. Even with successful fielding of a biotechnologic nerve agent defense there would be a need for conventional antidotes for casualties whose nerve agent exposure exceeded the limits of protection.

The freedom from toxic symptoms shown by protected animals at low levels of agent challenge might lead to a redefinition of the circumstances under which masking and protective clothing would be required. The truly revolutionary nature of this form of protection is readily apparent from force-on-force modeling where only one side is able to operate in areas of low level contamination without chemical protective equipment.

Summary

Our current posture in medical chemical defense against nerve agents has recently improved with the fielding of pyridostigmine as a pretreatment and the decision to add the anticonvulsant diazepam to protect brain function. There are well defined near term research and development objectives that promise to yield clearly needed additional improvements to our pretreatment and antidote system in a cost-effective manner. Finally, biotechnologic protection may be an achievable goal that could alter basic assumptions underlying the employment of these chemical warfare agents.

COL MICHAEL A. DUNN, MC, assumed command of the U.S. Army Medical Research Institute of Chemical Defense in April 1987. He has served in medical research assignments in the United States and Egypt and has been assigned as Sinai multinational peacekeeping force surgeon and 3d Armored Division surgeon. He serves as the Army surgeon general's clinical consultant in chemical casualty care.

CRASHWORTHY HELICOPTERS SAVE LIVES AND EQUIPMENT

Designing for Crashworthiness— A Very Positive Return on Investment

By LeRoy T. Burrows and Kent F. Smith

The Issue

The first two U.S. Army helicopters designed to incorporate specific features that provide protection to occupants during a crash — the UH-60 BLACK HAWK and the AH-64 APACHE — have now accumulated sufficient field experience to permit an early assessment of the performance of their crashworthiness design features. It can be stated without reservation that these design features have saved many lives and many aircraft.

A calculated projection of life cycle cost of design for crashworthiness shows a return on investment in four to six years in peacetime operations. It would occur quicker in wartime. This does not include the very important humane aspect of saving lives, which cannot be adequately priced, or the increase in morale and performance of aircrews that know they have protection in case of a crash.

The Aviation Applied Technology Directorate (AATD), U.S. Army Aviation Research and Technology Activity, a field R&D element of the U.S. Army Aviation Systems Command is recognized as the world leader in the formulation of crashworthiness design criteria for rotary winged aircraft and in the development of components that provide crashworthiness.

AATD was instrumental in getting crashworthiness design requirements specified in the UTTAS and AAH Prime Item Development Specifications which led to the BLACK HAWK and APACHE respectively. The "users" happiness with the UH-60's level of crashworthiness has had the very significant result of having this level specified in the LHX specification.

The Problem

Modern-day training and tactical employment requirements for the U.S. Army helicopter dictate that a large percentage of operations occur in the low-speed, low altitude flight regime, with reduced margins of safety normally associated with higher airspeed and high altitude operations in case of emergency. This increased probability of accident occurrence, coupled with the lack of an in-flight egress capability, makes design for crashworthiness essential for Army helicopters.

Research investigations directed toward improving occupant survival and reducing materiel losses in aircraft crashes have been conducted by the Army for more than 25 years. However, up until approximately 15 years ago the principal emphasis within Army aviation survivability was placed on accident prevention. Although this is indeed the ultimate objective deserving priority effort, past experience clearly shows that accident prevention alone simply is not sufficient.

Mishaps of all kinds involving Army aircraft have been, are, and will continue to be a major, expensive problem with significant injuries, fatalities and loss of materiel. There is no easy solution to the problem. Significant gains can be made, however, toward reducing these unacceptable accident losses; but to do so, an aggressive program that addresses key issues of both accident prevention and crashworthiness design must be pursued. Since the helicopter's potential for accident is great, due to its mission and the environment in which it must accomplish that mission, it is impera-

TABLE 1

Summary of Crash Impact Design Conditions for Helicopters and Light Fixed-Wing Aircraft With landing Gear Extended

Condition number	Impact direction (aircraft axes)	Object impact	Velocity Change ΔV (ft/sec)
1	Longitudinal (cockpit)	Rigid vertical barriers	20
2	Longitudinal (cabin)		40
3	Vertical*	Rigid horizontal surface	42
4	Lateral, Type I		25
5	Lateral, Type II		30
6	Combined high angle * Vertical	Rigid horizontal surface	42
	Longitudinal		27
7	Combined low angle Vertical	Plowed Soil	14
	Longitudinal		100

*For the case of retracted landing gear the seat and airframe combination shall have a vertical crash impact design velocity change capability of at least 26 ft/sec.

tive that it be engineered to minimize damage and enhance occupant survival in crashes.

Crashworthiness Design Criteria

In-depth assessment of available crash data was first accomplished in the mid-60s by a joint government/industry review team. The product of that team was the world's first crash survival design guide for light fixed- and rotary-wing aircraft, published in 1967 under AATD sponsorship. Revisions to this guide were made in 1969, 1971, and 1980 and it is currently again being revised with an expected early 1990 publication. This design guide was subsequently converted by AATD into a military standard (MIL-STD-1290) in 1974 which has just been revised.

MIL-STD-1290A addresses five key areas that must be considered in designing a helicopter to conserve materiel and provide the necessary occupant protection in a crash:

- Crashworthiness of the structure — assuring that the structure has the proper strength and stiffness to maintain a livable volume for the occupants.
- Retention strength — assuring that the high mass items such as the transmission and engine do not break free from their mounts and penetrate occupied areas.
- Occupant acceleration environment — providing the necessary crash load absorption by using crushable structures, load limiting landing gears, energy-absorbing seats, etc., to keep the loads on the occupants within human tolerance.
- Occupant environment hazards — providing the necessary restraint systems, padding, etc., to prevent injury caused by occupant flailing.
- Postcrash hazards — after the crash sequence had ended, providing protection against flammable fluid systems and permitting egress under all conditions.

Table 1 presents the MIL-STD-1290A crash design conditions for helicopters expressed in terms of impact velocity change with associated minimum attitude requirements. For maximum effectiveness, design for crashworthiness dictates that a systems approach be used during the initial design phase of the helicopter.

Figure 1 depicts the system's approach required relative to management of the crash energy for occupant survival for the vertical crash design condition. The crash G loads must be brought to within human tolerance limits in a controlled manner to prevent injury to the occupants. This can be accomplished by using the landing gear, floor structure, and seat to progressively absorb most of the crash energy during the crash sequence.

The Army's most recent helicopters, the UH-60 BLACK HAWK and AH-64 APACHE, are both designed generally in accordance with the requirements of MIL-STD-1290A. This was a direct result of extensive research conducted by AATD, which included 38 full-scale crash tests to support crashworthiness design criteria formulation. AATD's efforts to promote design for crashworthiness were enthusiastically supported by the U.S. Army Safety Center and the U.S. Army Aeromedical Research Laboratory.

Landing Gear

Current crashworthiness design criteria requires that the landing gear must provide energy absorption capability to reduce the vertical velocity of the fuselage under crash conditions. As a minimum, the landing gear shall be capable of decelerating the aircraft at normal gross weight from an impact velocity of 20 ft/sec onto a level rigid surface within an attitude envelope of plus or minus 10 degrees roll and plus 15 degrees to minus five degrees pitch without allowing the fuselage to contact the ground and without gear penetration into an occupied area. In contrast, skid gears are designed typically to withstand an 8 ft/sec vertical impact speed without collapse.

Structure

The cabin structure serves to maintain a liveable volume in a crash, protect the occupants in case of roll over, support the landing gear loads, retain the main transmission and pylon assembly, and support the energy absorbing crew and troop seats.

When designing the airframe to protect occupants in a crash, two fundamental guidelines must be considered:

first a protective shell must be maintained around the occupied area and second, the structure must be crushable and absorb energy, thus reducing decelerative forces on the occupants and large masses. The structure must have sufficient strength to prevent the seat attachments from breaking free.

Seats

A major objective of Army crashworthiness is to attenuate crash loads reaching the occupants to levels within the limits of human tolerance. The Army's UH-60 and AH-64 are equipped with armored, crashworthy, energy attenuating crew seats. These seats are designed to stroke during a crash impact, thus limiting occupant spinal loading. The length of seat stroke is very important. The seat should not be able to bottom out for crashes involving the design impact velocity changes specified in Table 1.

Restraint System

The occupant restraint system is literally the "first line of defense" in preventing aircraft crash injuries. A five-strap belted restraint is required for the pilot and copilot consisting of the lap belts, two shoulder straps with an inertia reel, a negative G strap, and single point of attachment buckle. The negative G strap is permanently affixed to the buckle to ensure against occupant submarining under the lap belt.

The compactness of today's cockpit and the close proximity of mission equipment pose serious crash impact hazards to the aircrew and dictates a restraint system that minimizes the occupants crash impact motion envelope, particularly for the head.

Fuel System

If fuel is allowed to spill during survivable crashes, a postcrash fire is often the result due to the multitude of ignition sources available. Prior to the advent of crashworthy fuel systems, the Army studied 2,382 survivable rotary-wing accidents occurring between 1967-69. Postcrash fires were present in 10.5 percent of the accidents and contributed to 39.3 percent of the fatalities.

Through an intensive effort, AATD developed a crashworthy fuel system (CWFS) consisting of self-sealing breakaway valves/couplings; frangible attachments; self-sealing fuel lines; vent valves; cut, tear and rupture resistant bladders; and a means of preventing fuel spillage at all postcrash attitudes. Though brute strength has some importance, the cut and tear resistence of the fuel tank material is a key issue for successful fuel containment in a deforming aircraft structure.

With application of the CWFS to Army helicopters, what had been the greatest killer in survivable crash impacts has become a non-issue. Since 1970, when the first CWFS retrofit occurred, the Army has not experienced a single thermal fatality in a potentially survivable accident in an aircraft equipped with a CWFS.

It Works

More than an abstract concept, crashworthiness design has been applied to Army helicopters and has matured to a point where tangible benefits are being realized. The following two mishap descriptions are illustrative of "realworld" crashes in which crashworthiness made a measurable difference in the outcome.

Accident #1

A UH-60A with pilot, copilot, and crew chief on board lost all engine power at night. The pilot did a good job of maintaining aircraft control during the subsequent brief autorotation, but excessive bleed-off of rotor RPM led to a high sink speed impact in a small clearing. After clipping several trees a 24 degrees nose-high impact occurred with eight degrees of left roll and 13 degrees left yaw. The horizontal velocity at impact was 34 ft/sec and vertical velocity was 49 ft/sec. This vertical impact condition contained 36 percent more energy than that required to be absorbed by MIL-STD-1920A (i.e., 42 ft/sec).

After tail wheel impact, nose slapdown occurred with both main landing gear stroking their entire 25-inch distance and absorbing energy. The fuselage subfloor then crushed a distance of approximately 6-inches. The helicopter rebounded due to the stored energy in the deformed fuselage and rolled right onto its side with its roof resting against a tree. The pilot and copilot's seats stroked to absorb energy, as designed. The peak vertical acceleration at the aircraft floor was estimated at 50 G. There was no postcrash fire.

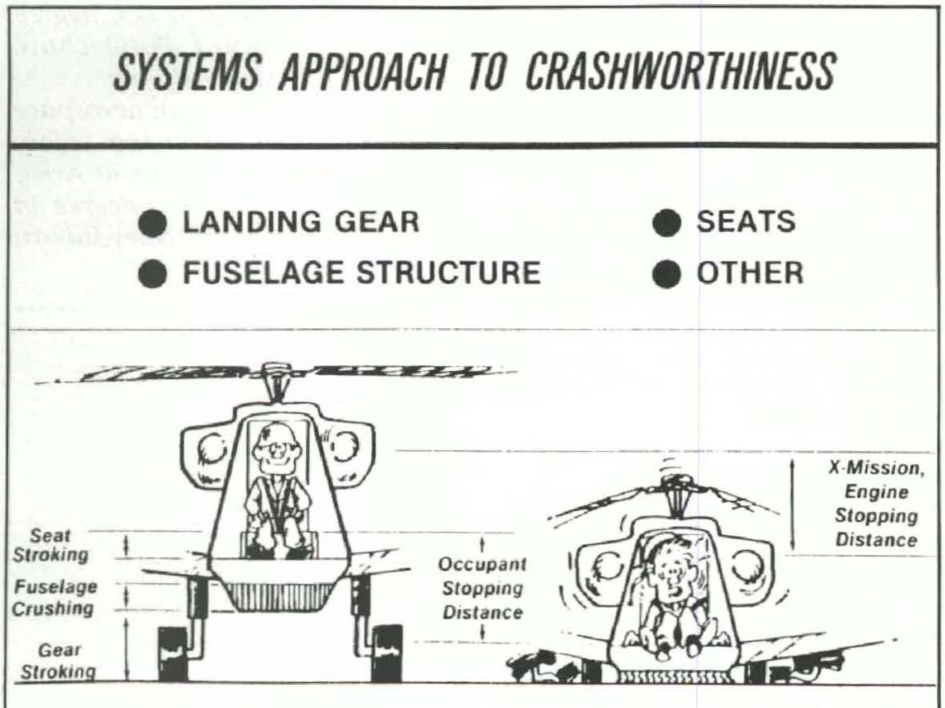

Figure 1

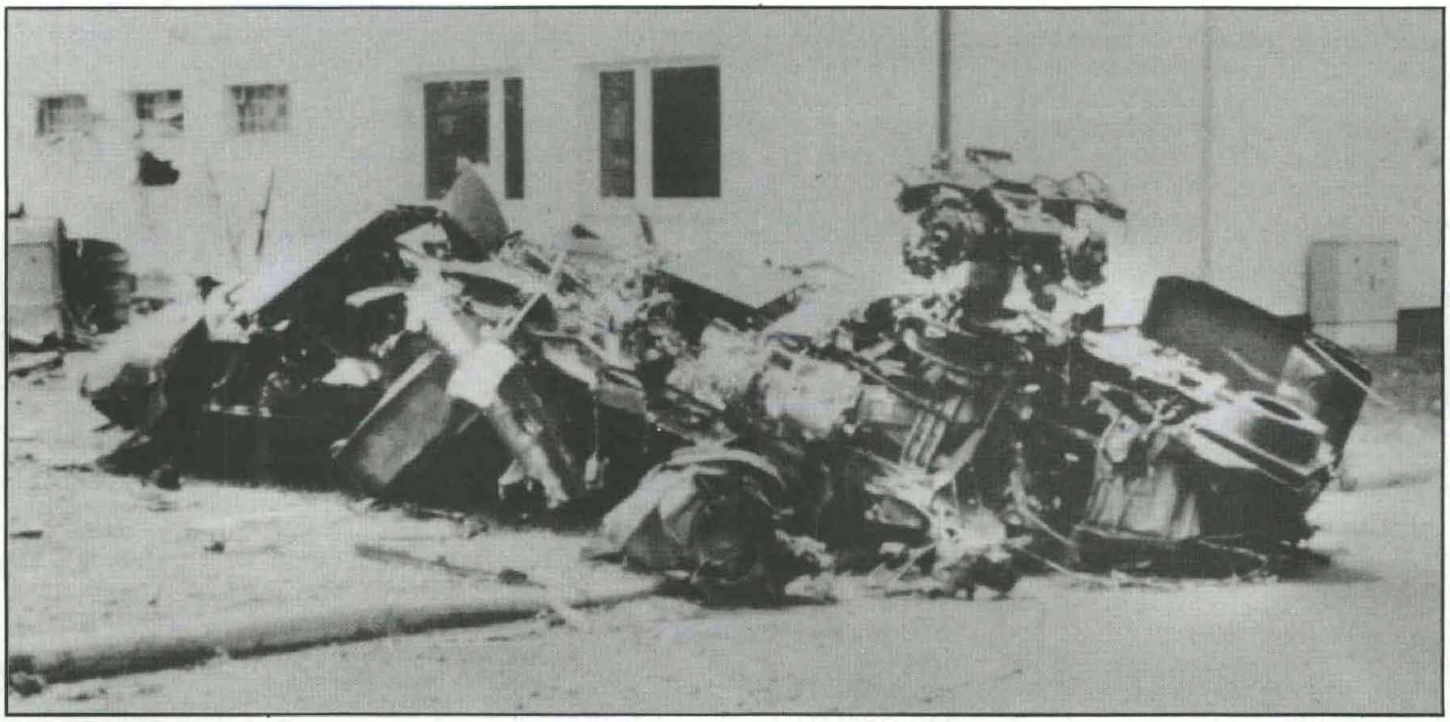

Figure 2
Accident #2 —
Post-Crash Condition

Due to the excessive vertical energy of this crash, the roof structure collapsed significantly under the inertial loads of the engines and transmission. The crew chief's seat could not stroke as designed since it was ceiling suspended and "rode" the collapsing ceiling down before it could stroke.

Except for abrasions and bruises, the copilot had no injuries. The pilot suffered a fractured leg from a flailing collision with the cyclic stick and a fractured elbow and rib, also from flailing. With no seat stroke, the crew chief had a compression fracture in the lower back and broken ribs. Had this crash occurred in one of the older, non-crashworthy Army helicopters, the likely result would have been three fatalities.

Accident #2

A UH-60A began a climbing right turn maneuver from the aircraft's red line speed of 193 knots. An out-of-trim condition developing during the turn resulted in a high rate of sink condition which the pilot was unable to arrest. Ground impact was between two barracks buildings with a horizontal velocity of 80 ft/sec and a vertical velocity of 40 ft/sec. The aircraft was rolled right 20 degrees, pitched up 40 degrees, and yawed right 30 degrees at impact. During the major impact, vertical Gs were estimated at 30 and longitudinal Gs at 42. The aircraft slid at an oblique angle into the barracks wall, slid down the wall for 60-80 feet before rebounding and revolving off the wall to a stop.

Figure 2 shows the wreckage. All six occupants survived. The pilot received only a broken arm while the copilot had just abrasions. Once again, the UH-60's roof collapsed under the excessive vertical loads. Of the four cargo area passengers, two had broken bones, one had a dislocated shoulder, and one had no significant injury. Again, had this crash occurred with a non-crashworthy helicopter, the result would have likely been six fatalities.

Conclusion

There should be no doubt concerning the positive return on investment of the Army's decision to implement design for crashworthiness in its helicopters. Hopefully, future investments in crashwothy designs will result in even greater occupant survival rates and reductions in materiel losses.

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ARMY TEST AND EVALUATION PLANNING AND MANAGEMENT

The Latest Information on the Management Structure at Department of the Army Level and on Long Range Planning for Test and Evaluation (T&E)

By John P. Tyler III

The Army Test and Evaluation Committee

From time to time during past years, centralized coordination of T&E matters had occurred at DA level on an ad hoc and special issue basis. When the issues began to reappear more often on policy and resources, it became increasingly evident that such coordination activity should be accomplished by a standing committee; i.e., "institutionalized" in Pentagon language.

Stimulating the formation of an Army Test and Evaluation Committee (ATEC) was the Army's need to facilitate "speaking with one voice" on all test and evaluation issues and presenting that position to a newly created OSD Test and Evaluation Committee, a committee directly supporting Defense Acquisition Board deliberations.

With creation of the ATEC, the myriad of issues necessary for a comprehensive, efficient test program in support of the prioritized weapons acquisition program may be discussed and credible plans made.

Consequently, Deputy Under Secretary of the Army (Operations Research) Walter W. Hollis had his mission expanded to be the overseer for all Army T&E matters by becoming the chairman of the ATEC. This was done at the direction of the under secretary of the Army who is also the Army acquisition executive. Announcement of the appointment and the establishment of the ATEC was confirmed by memorandum on Sept. 14, 1987. The deputy under secretary also serves as the Army representative to the DOD Test and Evaluation Committee which coordinates triservice T&E planning, policy and resources.

Membership of the ATEC includes T&E involved DA staff agencies, major command headquarters and the commanders of the Operational Test and Evaluation Agency (OTEA), the Army Test and Evaluation Command (TECOM), and the Test and Experimentation Command (TEXCOM). Meetings are on an on-call basis but have been occurring about quarterly. The meetings are conducted in the Pentagon teleconference center with communications links, for example, to: Fort Hood, TX and Fort Huachuca, AZ, permitting the non-Washington, DC area commands and agencies to participate "live" at no travel expense. Agendas typically consist of ongoing major actions which are presented in short briefings followed by discussions for all to observe and provide their input.

The ATEC is a coordinating forum for arriving at follow-on actions or recommendations to be made to the appropriate decision channels. For example, budget needs are identified and ultimately presented to the DA Program and Budget Committee and, as required, to the Select Committee. The ATEC is supported by panels composed of the more involved agencies and commands. These panels accomplish the pick and shovel or detailed activity and their products are provided for ATEC approval before actions are taken.

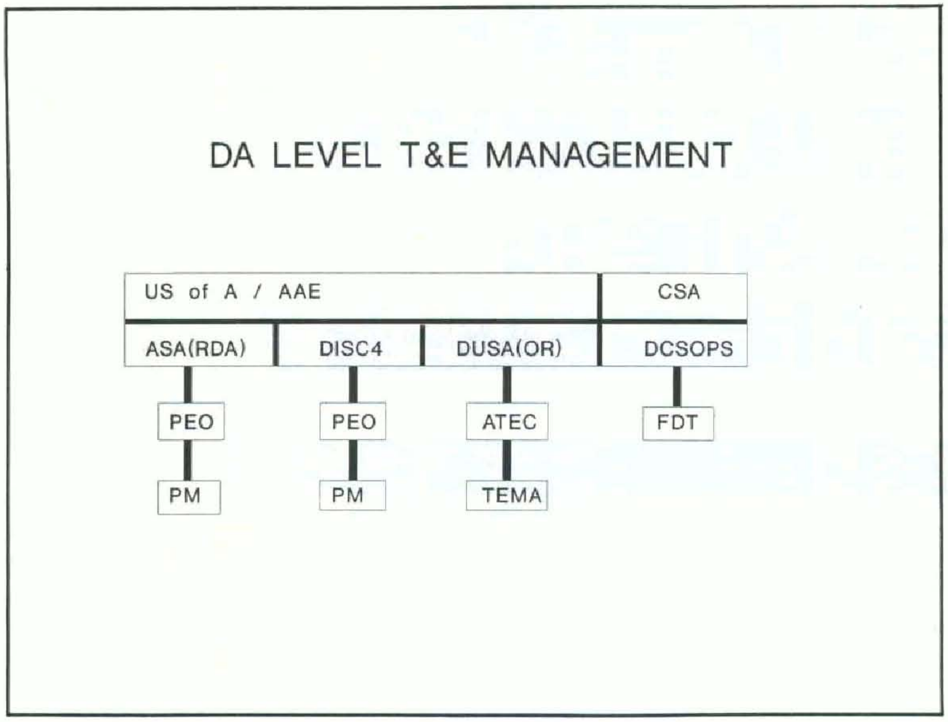

Figure 1

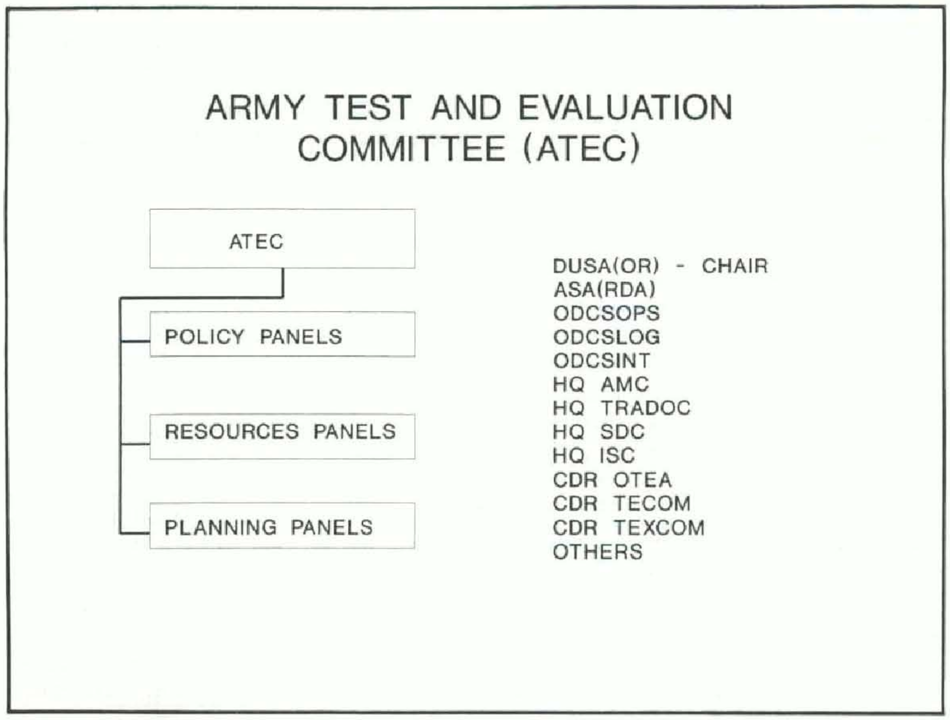

Figure 2

Figures 1 and 2 depict the ATEC, its relationship to the Army Staff structure and representative panels. For example, a panel was organized to develop guidelines for live fire testing. This panel was led by BG Ronald Hite, then the TECOM program manager for live fire testing. It included Air Force and Navy representatives and appropriate Army agencies. The panel developed the DOD guidelines now being used by all Services and published in DODD 5000.3 M-5. Other panels for instrumentation, policy, funding, etc. are assembled on call. The panel management procedure, when coupled with ATEC decisions, is resulting in at least a 50 percent reduction in coordination time with accomplishment by the most knowledgeable T&E personnel.

Test and Evaluation Management Agency

Supporting the ATEC and the deputy under secretary is a newly established staff support group named the Army Test and Evaluation Management Agency (TEMA).

The idea of a centralized office at DA level to coordinate T&E matters has been around for many years and has been proposed in a number of organizational studies. As the two OSD test offices grew, the need for a single Army T&E point-of-contact became greater, particularly for coordinating resources and policy since these staffs had a variety of Army agencies to contact.

Following the FY90-94 Program Objective Memorandum or Army POM review of T&E investments by OSD, it became clear to Army senior management that there was no single office to advise the Army Staff and budget decision makers as to the credibility of the needs for funding T&E test operations and instrumentation. Consequently, TEMA was established on Nov. 1, 1988 at the direction of the under secretary upon the recommendation of the vice chief of staff.

TEMA is a staff support agency assigned to the Office of the Chief of Staff with operational control by the deputy under secretary of the Army for operations research. Major responsibilities are shown in Figure 3 but can be summarized as: to watch over and coordinate all Army T&E planning, policy and resources and to be a T&E focal point for anyone (and everyone) to contact. Another implied major function is to keep senior DA level managers aware of important T&E matters or to assure that someone else does.

As TEMA director, I am assisted by team chiefs for policy and resources. The policy team insures that T&E regulations and pamphlets are updated and interfaces with OSD and Army T&E commands in policy development. The policy team also coordinates major systems' Test and Evaluation Master Plans (TEMP) at DA level and forwards them through Walter Hollis to OSD.

The resources team monitors RDT&E, OMA and OPA funds and budgets and sees to their defense within Army and OSD panels and committees. Test instrumentation, facilities, targets and threat simulators are overwatched by one engineer on the resources team. This illustrates the principle of TEMA being a coordinating and integrating office.

With a total of six individuals, about 50 percent military, TEMA is not intended to be a micro-manager. Team chiefs are the chairmen of the ATEC panels and the Army representatives to the DOD TEC panels on resources and policy. A lot of support must come from existing T&E staff agencies and commands to make the TEMA organizational concept work. After a year, TEMA's effectiveness will be reviewed for changes to missions, procedures and organization.

Long Range T&E Planning

Planning in the T&E world has to be based on the systems to be acquired and their obvious modifications or materiel changes that can be predicted. Since it takes about three to five years to develop and procure a test instrument (e.g., laser optical tracker), one has to base planning on future systems and technology trends. Not only is this difficult to do but it is also hard to convince tough minded budgeteers, who face short range problems in a declining resources environment, that investing in the future makes planning and programing sense.

We know, for example, Army space systems are only 5-10 years into the future; but, try to get anyone to work seriously on plans for space systems test methodology, facilities, instrumentation and funding. Having discussed the foregoing premises for T&E planning, a few illustrative planning activities are highlighted.

In the organizational planning area, the Army has, since Oct. 1, 1987, changed T&E execution roles. For operational T&E, the plan, in brief, is to have the Operational Test and Evaluation Agency conduct the operational evaluation of all major systems and perform an operational assessment on the majority of non-major systems.

TRADOC's Test and Experimentation Command will conduct the operational tests (OT) for both major and non-major systems. For that subset of non-major systems where a separate operational assessment is not necessary, an expanded test report containing conclusions and recommendations is prepared by TEXCOM.

For technical T&E, the plan is to have the Army Materiel Systems Analysis Activity (AMSAA) evaluate major and important non-major systems developmental tests (DT) and for AMC's Test and Evaluation Command to conduct all technical tests. Organizational changes are in place to execute this plan while plans for the Information Systems Command (ISC) to accomplish its T&E are being reviewed.

Although other T&E organizational plans are periodically under conceptual consideration, there are constraints against new major changes. An attitude of "let's see how it works with the latest changes," or "fix minor areas which may be not working as well as expected," continues to be the conservative way the Army revises organizations, roles and missions.

In the policy planning area, planning tends to be evolutionary. Minor exceptions do occur for activities such as live fire test policy, which really was an enhancement of something already being done. Emergence of the OT community and related policy started in 1971 and is still evolving. Actually, we had Service tests in the Army during the 1960s which were meant to be operational tests. We recently have returned the mission to conduct all OT to the same 1960 test boards, now a part of TEXCOM not TECOM.

Note how planning in the policy area meshes with planning in the organizational area. There are policy planning actions under way. TEMA has called for final comments on a single Army T&E regulation, replacing ARs 70-10, 71-3 and 702-9 and OSD has efforts designed to modify DODD 5000.3 and its manual on TEMP guidelines. All of these updates continue to be refinements and will mainly have impact on administrative procedures.

In the resources area, much planning needs to be done to assure that test costs for operational and technical testing are adequately funded and that

TEST AND EVALUATION MANAGEMENT AGENCY
MISSIONS AND FUNCTIONS

- COORDINATE T&E POLICY AND RESOURCE ACTIONS WITH OASA(RDA), OTHER HQDA AGENCIES, OSD, CNO, HQUSAF, AMC, TRADOC AND SDC
- SERVE AS THE HQDA COORDINATION AGENT FOR ALL T&E POLICY, RESOURCE PROGRAMMING AND RELATED PROGRAMMATICS
- DEVELOP AND MONITOR ARMY MAJOR RANGE AND TEST FACILITY FUNDING POLICY
- COORDINATE AND FACILITATE COMMUNICATIONS WITH OSD ON TEST AND EVALUATION MATTERS

Figure 3

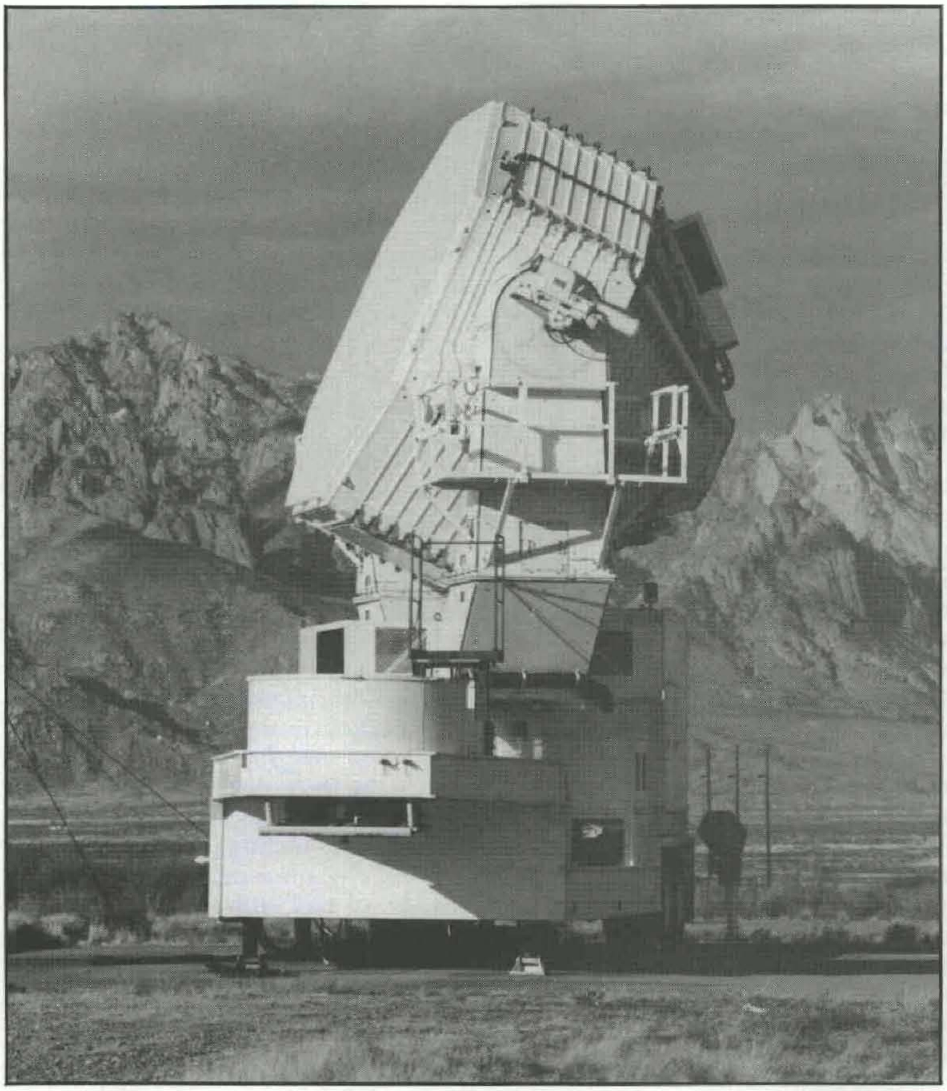

Figure 4
MOTR Radar Unit C Station

timely investments in future facilities and instrumentation are being made. T&E funds have been programed on a level of effort basis since 1982 as a part of the overall RDA management support base. Consequently, T&E modernization programs have been largely constrained to selective replacement of worn-out instrumentation. For example, acceptance testing of the first multiple object tracking radar, AN/MPS-39, Figure 4, began in 1988 at White Sands Missile Range, NM, about 20 years after phased array radar technology was demonstrated. Using this technology, permits accurate tracking of 10 missiles, aircraft or drones, dramatically lowering the numbers of single object tracking radars to be operated and maintained.

We need to do more. The inventory of our major T&E equipment is variously estimated to be 40 to 60 years old. Consequently, Army instrumentation budget requests to Congress have increased and OSD has set up two investment accounts to complement the Service programs while major overtures are being made to Congress to fund for both.

The cost of major tests continues to increase, particularly for operational tests. Realistic OT calls for force-on-force tests as opposed to system-versus-system tests. This resulting requirement to instrument each test player and to reduce volumes of data have caused test costs to rise as much as tenfold in extreme cases. We have programed some increases in funds and have increased modelling and simulation activities to reduce test costs but we must build credible test operations and investment plans and supporting strategies to justify our real needs. This is a continuing coordinating challenge for TEMA as it works with the test commands and the Army Staff in building POMs and the Long Range Research, Development and Acquisition Plan out to 15 years.

TEMA will also integrate Army T&E resource plans with the OSD testers' long range planning activity. TEMA will, of course, be dependent on many individuals from the Army T&E commands to serve on both ATEC and DOD TEC panels.

Summary

Coordination of T&E planning has been improved by the establishment of the ATEC and its overwatch support agency, TEMA. As the functions of these new management activities evolve, better T&E should result and better tested materiel will be fielded that meets the soldiers' demands for suitable (in every sense of the word) equipment. Another way of stating the above is that the Army T&E planning and management community is getting its act together. The troops should benefit!

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T800 REMEMBERS THE SOLDIER

By LTC Sandy Weand and Paul Thagard

Several requests to further explain the impact Manpower and Personnel Integration (MANPRINT) had on the T800 acquisition strategy as reported in my article in the March-April 1989 issue of the *Army RD&A Bulletin*, prompted me to enlist the help of an industry expert.

At the start of the program in December 1984, the Army was developing the MANPRINT concept. MANPRINT evolved because the Army and industry team traditionally developed sophisticated systems and then attempted to adapt the soldier to the system. A significant data base of inefficient systems proved that concept didn't work. We have now realized that the soldier and his capabilities must be considered from the very outset of the acquisition program to develop an effective system.

MANPRINT is a coordinated effort to influence system design to ensure safe system operability, maintainability, and supportability within available resources. Resource constraints are particularly significant. The strength and funding levels are basically fixed for the Army, demographics easily dictate the type of soldiers that will be available in the future. MANPRINT influence on system design is achieved through the application of the six domains: Manpower, Personnel, Training, Human Factors Engineering, System Safety, and Health Hazard Assessment.

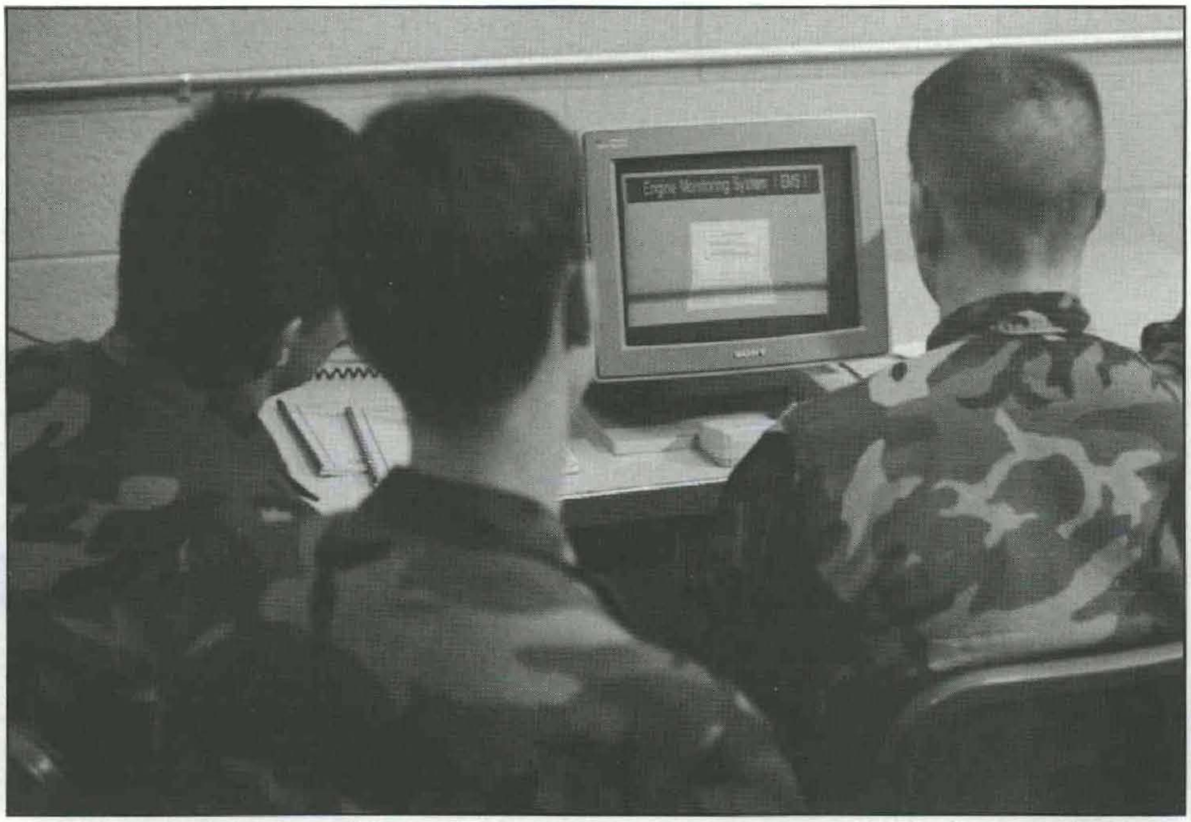
The T800 full-scale development (FSD) program was one of the first Army acquisition programs to which MANPRINT was applied. Because of the streamlined acquisition and the performance oriented approach, the RFP did not specify how the contractor teams were to apply MANPRINT to the T800 program. This philosophy, plus MANPRINT being a new concept, allowed the contractor to design and tailor his MANPRINT program to best support his approach to the T800 competition.

The winning T800 contractor team, the Light Helicopter Turbine Engine Co. (LHTEC), a partnership of the Allison Gas Turbine Division of General Motors and the Garrett Engine Division of the Allied-Signal Aerospace Co. aggressively established a dedicated MANPRINT team soon after the award of the FSD contract to rapidly bring MANPRINT on-line.

The LHTEC MANPRINT team was created by selecting highly-qualified and experienced technicians, maintenance officers, and pilots, as well as individuals qualified in both the turbine engine maintenance and manpower/personnel or training areas. A cadre of personnel encompassing both the technical and managerial qualifications is a prerequisite to a successful MANPRINT effort. To meet the needs of the future T800 maintainer, MANPRINT analysts must have been "in the trenches" themselves and be able to recognize design inadequacies.

To facilitate the integration of MANPRINT into the engine design, LHTEC formed a MANPRINT Working Group early in FSD. This group consisted of personnel from Integrated Logistics Support, Logistics Support Analysis, Technical Publications, and Systems Engineering. They worked closely with personnel from Design Engineering and Air Vehicle Support. This close working relationship fostered communication and coordination on the program and provided a strong, synergistic approach to problem solving.

As stated before, manpower is a very critical resource to the Army. A standard constraint of any new system acquisition effort is that the system require no increase in manpower over the system it will replace. Early analysis of the T800 engine design indi-



Army students at the U.S. Army Aviation Logistics School receive computer-based training during the MANPRINT field survey.

cated there would be a significant reduction in the manpower requirement when compared to currently fielded engines such as the T53 series.

As the design matured, the efforts of the designers and the MANPRINT team paid off in even lower manpower requirements. This was accomplished by meticulous review of drawings and mock-ups, which resulted in supportability design recommendations to relocate components, consolidate the functions of two or more components into one, add maintainability features, and implement other improvements to enhance the design.

Personnel issues address the quality of the soldier and the logistics of recruiting and training the number of soldiers to maintain the manpower needed in the field. LHTEC expended a great amount of effort in this area to ensure the maintenance tasks required on the T800 engine would be within the capabilities of the soldiers the Army could expect to recruit and retain. LHTEC created specific analytical methodologies designed to ensure any task was within the target soldier's capabilities. In addition, several surveys were performed to evaluate the T800 design in the hands of the projected maintainers.

T800 MANPRINT Analytical Tools

LHTEC MANPRINT personnel created a Cognitive Requirements Model which is used to assess the mental demand placed on the maintainer when performing T800 user-level tasks. The results of each individual task analyses are addressed in aggregate to determine the minimum aptitude area score required to ensure successful task performance.

Another methodology used to align the engine design with the soldier's capabilities is the Functional Allocation Analysis. This analysis determines which T800 resource — hardware, software, or maintainer — should perform a particular segment of a maintenance task. Functional allocation is particularly relevant to the fault isolation process, where sensors and/or software may be used to replace or reinforce the decision-making process. Proper use of each resource is imperative. Over use of the human decision making capability could predispose the system to failure, whereas, under use could result in excessive hardware and software costs.

LHTEC developed a document titled "LHTEC MANPRINT Specification of the Soldier." This document facilitated the methodology to properly align the three resources — hardware, software, or soldier. It describes the mental capabilities of Army personnel with a particular aptitude area score and defines performance within these constraints which will ensure successful task accomplishment. Not exceeding these constraints will result in the proper allocation of fault isolation task segments among the soldier, software, and hardware.

Another analytical tool used to ensure successful task performance is a computer program to evaluate written material to determine its scholastic reading grade level or RGL. The methodology is based on the Flesch Reading Ease Method and was programed for use on LHTEC personal computers. RGL analysis is performed on all written material the maintainer uses. This includes maintenance task narratives, technical manuals, training materials — including Computer Based Training (CBT) and Engine Monitoring System (EMS) screen displays. RGL analysis of these media ensures the maintainer will be able to comprehend the material, thus alleviating comprehension errors.

MANPRINT ensured all maintainer tasks could be performed in the most harsh environment the soldier will experience. Two soldiers are shown performing maintenance tasks in NBC protective clothing during a maintainability demonstration.

Another analysis tool of profound effect on the T800 design was the Human Engineering Design Approach Document-Maintainer (HEDAD-M). The HEDAD-M effort used computerized task analysis worksheets which allowed various scenarios of tasks to be reviewed as design modifications were evaluated. Human factors engineers used these task worksheets to conduct tests to validate removal and installation task elements for external components and other user-level tasks. These tests generated additional design influence and provided rationale for making design decisions.

Practical Verification of MANPRINT Influence

LHTEC MANPRINT personnel surveyed students at Dobson High School in Mesa, AZ in early 1987. The purpose of this "maintainer of the future" survey was to determine if the LHTEC T800 engine could be maintained by individuals available for future Army service.

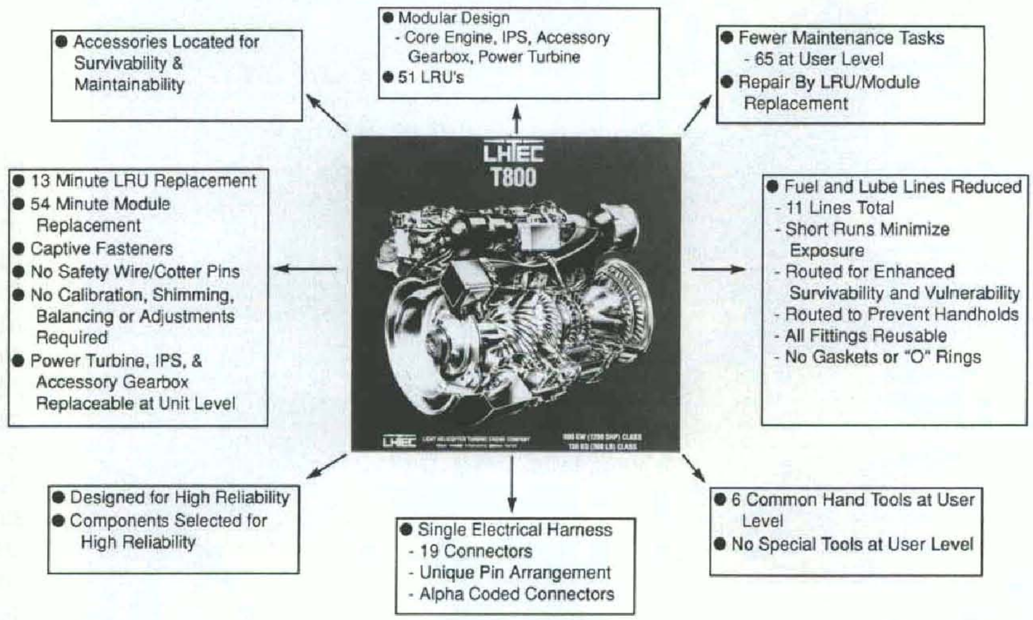
The survey participants were 19 juniors and seniors from industrial arts classes. These 17 males and two females represented the spectrum of aptitudes (Category I-IV), available to the Army. Some of the students had taken the Armed Forces Qualification Test (AFQT) and their scores were used in the analysis. Others had taken the Scholastic Aptitude Test (SAT). SAT scores were converted to equivalent AFQT scores.

The students were given a short training course on general turbine engine theory, then trained to perform T800 user-level component removal/installation tasks. After this brief training, each student performed a removal/installation task on a T800 component. The students were guided by simulated EMS screen displays. All of the participants performed the T800 user-level tasks satisfactorily. While one individual performed a task, the other students used a LHTEC checklist to evaluate the maintainer's performance and critique the T800 design. Several improvements proposed by the Dobson High students were incorporated into the design.

During January and February 1988, LHTEC MANPRINT personnel visited five Army installations and one Coast Guard facility to perform a T800 MANPRINT field survey. The project was designed to evaluate the T800 user-level maintenance task performance of maintainers trained and guided by state-of-the-art computerized training and technical manual delivery systems, see photo 1. The participants were trained on three T800 line replaceable unit removal/replacement tasks by the CBT system. This system allows maximum student participation during the training session through the use of an interactive video disc, as well as superior graphic displays and audio.

After completing the CBT course, each participant performed the task on which he was trained, photo 2. An EMS computer, functioning as a paperless technical manual, provided technical guidance on the tasks. The

LHX ▶ T800 DESIGNED FOR MAINTAINABILITY



tasks were performed on a metal mock-up of the T800. Each participant was then asked to complete a survey form which contained both objective and subjective questions pertaining to the CBT, EMS, and the LHTEC T800 design. The maintainers were asked to compare the CBT and EMS to conventional training methods and technical manuals. All participants responded with positive replies to the survey questions. Additional questions concerning the maintainability of the T800 design rated it easier to maintain than current engines.

System safety and health hazard assessment considerations in design were achieved through several analyses and reports. Safety engineers reviewed drawings to ensure safety design requirements were incorporated. Identified hazards were eliminated or else the associated risks reduced to an acceptable level. Analyses were performed at all levels; preliminary hazard, system/subsystem hazard, and operating and support hazard. These resulted in a positive safety assessment report. Additionally, the failure mode effects and criticality analysis, developed as part of the reliability program to evaluate each significant component and the modes in which it can fail or malfunction, was used to assist the safety effort.

Summary

The efforts of the LHTEC MANPRINT Working Group significantly influenced the engine design to reduce manpower and personnel requirements, lower the training burden, lessen the number of tools required for maintenance of the engine, and reduce the potential for human error during maintenance of the T800, see photo 3.

The manpower analyses gave the Army visibility for force structure planning and identified the LHTEC T800 as a powerplant with extremely low maintenance man-hours per flying hour. The use of the cognitive requirements model produced accurate predictions of task mental demand. Analytical tools ensured maintenance tasks were within the capability of the projected maintainer. Human factors engineering and safety evaluations and analyses resulted in an effective soldier-machine interface and a system which is safe to operate and maintain.

These MANPRINT efforts contributed significantly to the design of an engine which is indeed operable and maintainable within the manpower and personnel constraints of the Army. The overwhelming success of the T800 MANPRINT program clearly demonstrates that designing a system to the soldier increases the system's effectiveness and ensures operational availability.

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By CPT Ralph G. Hay

THE UNIFORMED SCIENTIST—AN UNCERTAIN FUTURE

Introduction

The future of the Army officer with advanced scientific or engineering educational training remains uncertain even after years of discussions and proposals. Today's Army offers this officer no coherent professional development program and no assignment placement mechanisms. This article presents my perspective on the "scientific" officer's situation in today's Army and proposes some solutions.

To understand this topic in its full context, it is important to first review why uniformed scientists are needed in the Army, what qualifications those scientists have, and how these officers are managed today. Finally, a proposed science officer career track is presented, along with some of the decisions needed to implement a coordinated policy for uniformed scientists.

Why the Army Needs Uniformed Scientists

A strong, effective armed service requires the ever-increasing use of sophisticated and state-of-the-art technologies in future Army systems. The development of these systems (including the rapid, cost-effective, and reliable insertion of all appropriate scientific advances) requires a number of uniformed scientists. They are needed to ensure that the Army is using all of the country's research resources to its advantage, and to ensure that the chosen technology meets all battlefield requirements for state-of-the art, integrated, and usable field systems.

Expert scientific knowledge and experience must also be available to our leadership and policymakers. A commanding general must be able to call upon scientists to respond to a problem immediately, especially in time of war when the research environment may extend to the battlefield. This may mean anything from a brief tour of duty to remedy a helicopter failure to inquiring scientifically into the development of a sophisticated new weapon system. Having a scientific officer whose principle duty is to meet the Army's technical and equipment needs and who can be swiftly called upon in times of both war and peace is essential to performing such practical missions.

The need is also critical for officers who have developed from the laboratory trenches on up to serve as laboratory leaders. A competent, scientific military cadre is also necessary to control the direction and responsiveness of both the Army laboratory and industry resources. This is crucial in the upcoming years of expected fiscal austerity.

The ability of an officer to move from one assignment location to another is an added reason to maintain a group of science officers. Army laboratories are spread over the entire country. (The labs should be consolidated in one geographical location to better facilitate collaboration among researchers and to allow sharing of equipment and facilities common to different research efforts.) Someone who has served at numerous laboratories can provide a new perspective on what is best for the Army and can be instrumental in maintaining the exchange of scientific information, experience, and programs. Civilian scientists are still required to do most of the research and development. However, civilian scientists often spend their entire professional life at one Army laboratory and may base decisions on the local research environment without objectively considering the views and developments of other (often competing) laboratories.

Military scientists provide a greater flexibility and can more fully comprehend the military field environment and innovate necessary solutions. Turf wars on politically sensitive programs would be minimized and cooperation among laboratory research efforts enhanced by the reassignment of mobile military scientists from one lab to another.

Up until the most current decade, the Army has recognized and nurtured the scientific officer. The atomic bomb and the digital computer are only two of the many important projects that were developed in part by Army scientists. The Army had a vast array of science officers who contributed scientifically to many systems that are now in actual field use. Many of these people eventually stayed on as laboratory civilians and are now retiring. Replenishing these dwindling resources will take many years.

It is interesting to note that the Soviet military has been able to keep up with NATO hardware despite their lower standard of technology because the Soviet military has immediate access to the top scientific talent of its nation. The U.S. Army must have a similar capability to be able to better direct and accomplish needed research.

Military scientists with an understandng of the applicable science are needed to accurately formulate the detailed materiel specifications for future systems from projected integrated military battlefield requirements. These people must be able to understand what is technologically possible and cost-effective and monitor the development of major systems through the procurement stage to ensure that the science and technology are properly integrated and supported.

The current method of contracting out of house much of the Army's systems research and development by officer program (contract) managers who are skilled more in program and budget matters than military scientific requirements and advancements is wasteful and detrimental to future Army systems.

Military scientists, whose promotions are dependant mostly on the technical capability of systems instead of competition and budget constraints, should work side-by-side with contract officers during the development of systems to ensure that the Army's needs are fully met. In part because military managers of the large systems generally do not have a working background in the field of science applicable to the system, initially developed technical requirements are often eventually waived for cost and competition reasons. This impacts the Army at large since deficiencies in one component affect reliability and usefulness of associated equipment.

It is often difficult to assess if multiple changes and waivers of technical requirements in different systems add up to significant overall disadvantages. Only by having performed research in the applicable field will officers be able to apply scientific considerations to a system. This also emphasizes the need for Army labs to maintain strong, effective in-house research programs in all fields of science with applications to future field systems.

Today's Army Science Officer

The uniformed scientists referred to in this article are officers who have attended a reputable graduate program in science, mathematics, or engineering. Some go directly from college into graduate school and enter the active duty ranks as lieutenants after earning an advanced degree. These students acquire their own graduate-school funding and are thus a very inexpensive asset. Others earn degrees through Army-sponsored graduate programs.

In all cases, the officers bring to the Army the latest scientific advances, techniques, and ideas from universities and industry. They also have valued scientific connections to universities, industry, national laboratories, etc. These officers want to apply their talents and education to the requirements of the Army while simultaneously becoming leaders among their peer scientists.

What the Army Currently Offers Scientists

The positions (slots) currently available to Army scientists are presently so limited that the few new officers who come on active duty each year have enormous difficulty obtaining a scientific job in the Army. In the recent past, officers have ended up working for the other services and not remaining after their initial obligation. The current method of finding science assignments is "each officer for himself." The pressure for an officer to leave research for military schooling and field "greening" is great and contradictory to maintaining scientific competence. Years of field and command time are incompatible with scientific productivity. PERSCOM career advisors, seeming to recognize that high-tech skills are needed at all military levels, encourage officers to study in high-technology fields yet provide little assurance that the Army will be able to make use of the acquired skill.

Within the Army laboratories, very few positions exist for Army officers, and many of those positions are filled by officers without advanced degrees or laboratory experience. Many competent officers who do obtain laboratory assignments are sometimes dismayed by the contract monitoring jobs that they are ultimately required to perform. Quality and productivity can be enhanced by using these talented science officers to bolster in-house laboratory programs.

Although in recent years some Army laboratories have been declining in performance overall, the opportunities for significant improvement and revitalization are great. Positions can easily be found to place most science officers in their field of expertise. The Army could expect excellent quality and quick results from these officers, and, in the future, the productivity, relevance, and image of the scientific research laboratories could easily be enhanced by filling management and research positions with more skilled uniformed scientists.

The decision of the scientist to ultimately leave the officer ranks is never only a matter of salary. Opportunities and job satisfaction are usually more important. The Army offers less funding pressure than industry laboratories and provides the opportunity to participate in directing the course and emphasis of the nation's research programs. While these opportunities do exist, they are presently not routinely made available to officers.

The Army estimates that it costs about $55,000 per year to provide an officer with an advanced degree. Unfortunately, decisions involving both the number of officers to educate and the assignments afforded such officers are often dictated by weighing this dollar figure against each job. Often, the Army does not benefit directly from the education because the officer is placed in an assignment outside the Army command structure and then required to obtain a field assignment to meet promotion or schooling guidelines. Long-term considerations such as increased competence, promotions, and career planning are ignored when providing opportunities for advanced-degree officers. Education plus the salary/benefit costs make the Army officer a source of inexpensive research talent, especially compared to civilian manpower costs.

A Scientific Track for Officers

Ideally, there should be a system to place officers in an assignment in which they can use their learned scientific talents to maximum advantage for the Army. They should have a career path that will carry them up through research leadership positions where they can influence the direction of Army research. A career model with a specific listing of available assignments and schooling, appropriate to military research programs, is needed. Care must be taken to maximize an officer's contribution by allowing an officer to mainly work in his or her field of expertise (as long as the Army has a direct research need in that field). The only way to obtain and retain scientific officers is to provide them with appropriate science assignment opportunities beginning as a lieutenant and progressing through leadership positions.

It is certainly true that uniformed officers should gain some field experience. This experience should be aligned, as much as possible, with new advanced systems or existing research needs of the Army. Officers should be able to spend their field time solving Army materiel problems or experiencing the Army in action by partaking in field exercises, not competing for critical command positions in order to be selected for advancement in a scientific career track.

The research track can be similar in structure to the present functional-area system. However, different military schooling requirements and assignment rotation guidelines need to be established. The requirement for basic branch qualification also needs to be eliminated and replaced with suitable familiarity schooling. The officer making research assignments within this track should be a uniformed scientist.

The variety of assignments necessary to support such a research track is readily available. AMC laboratories currently offer the most diverse opportunities for science assignments. Other assignments within the military can be found at the U.S. Military Academy and in joint military programs. Greater emphasis should also be made at placing these officers at DOE national laboratories, other service laboratories, and private companies working in ongoing Army research programs.

What Needs to be Done

The very first thing that needs to be done is to determine whether the Army wants uniformed scientists. The Army must start supporting the science officer with action, not merely words. Presently, officers are encouraged to seek advanced scientific degrees and are told that the Army recognizes a need for such talent. However, there is no program to use these officers and there is very little effort to permanently establish one. A decision to not require and support uniformed scientists is possibly better than the present situation. However, such a decision will affect the availability of high-caliber scientific officers far into the future. Scientists will never enter an officer corps knowing that the possibility for career development in well defined scientific positions does not exist.

If the Army decides that it does want uniformed scientists, then assignments must be identified that provide both laboratory research and leadership opportunities. A structure, as discussed above, that supports promotions and a career path from junior to senior officer must be approved and implemented. The scientists must be involved in this process of developing and implementing a career path.

An important step is to distinguish Army materiel acquisition management from science. Although functional area 51 is called research and development, it actually does not provide the science career structure suggested here. This is not to say that both knowledgeable FA51 officers and uniformed scientists should not work side by side on major military procurements, but only to imply that the expertise of each officer is maximized by having career paths tailored to each specialty.

Conclusions

It is agreed that officers who aspire to be commanders of soldiers and leaders in most branches of the Army should not spend the greater part of their careers outside their branch. Their early years should be spent primarily in the field doing tasks with soldiers, learning to command by leading, and maturing through actual field experience. This is, after all, both their chosen career path and the requirement of the Army for experienced troop commanders.

Professional uniformed scientists differ only in that they aspire to command the resources of science and technology rather than troops. The first years need to be spent in the science laboratories honing their newly developed scientific talents and learning to command the vast research resources of the Army. Similarly, their laboratory leadership capabilities decline with assignments that do not complement their career goals.

The Army has the responsibility to make the most of its personnel and equipment assets, especially in the upcoming years of increased materiel sophistication. This should mean applying resources where they have the most talent (i.e., let lawyers be lawyers). The return on the investment for the Army is greater if the uniformed scientist is made productive in the laboratory instead of losing his hard-earned scientific skills with extended field assignments.

Using scientific officers in assignments inappropriate for them does not produce the best officer and is a waste of Army resources. It should also be recognized that the individual's motivation to contribute his talents to the Army will be very difficult to maintain if the officer is prohibited from making use of his years of technical education with continued non-research assignments.

The Army has a limited number of scientists still within its active-duty ranks who have performed recent research in their fields of expertise. It is possible to establish an officer research career program for these and future officers without detracting from other Army capabilities and mission requirements.

I believe that the future of the Army vitally depends, at least in part, on the military scientist to research and develop new and sophisticated technologies to meet critical needs. The Army must take the steps necessary to attract and retain top scientific officers.

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ITEM-LEVEL WEAPONS MODELING: PREDICTIVE SIGNATURES

By Dr. Paul H. Deitz

Introduction

In the two previous issues of *Army RD&A Bulletin*, the topic of item-level weapons analysis was introduced and then illustrated with methods used in vulnerability/lethality analyses. In this article, some techniques of predicting military signatures will be described. The methods used can be considered variations on the general approach to item-level modeling.

Optical Lighting

The U.S. Army Ballistic Research Laboratory (BRL) has developed a lighting model (described in earlier articles of this series) which is used to create simulated optical images of various military targets. The amount of specular (shiny) or diffuse (rough-surface) reflections can be adjusted in the lighting model calculations to simulate virtually any material, covering or illumination condition. Transparency is illustrated with glass armor.

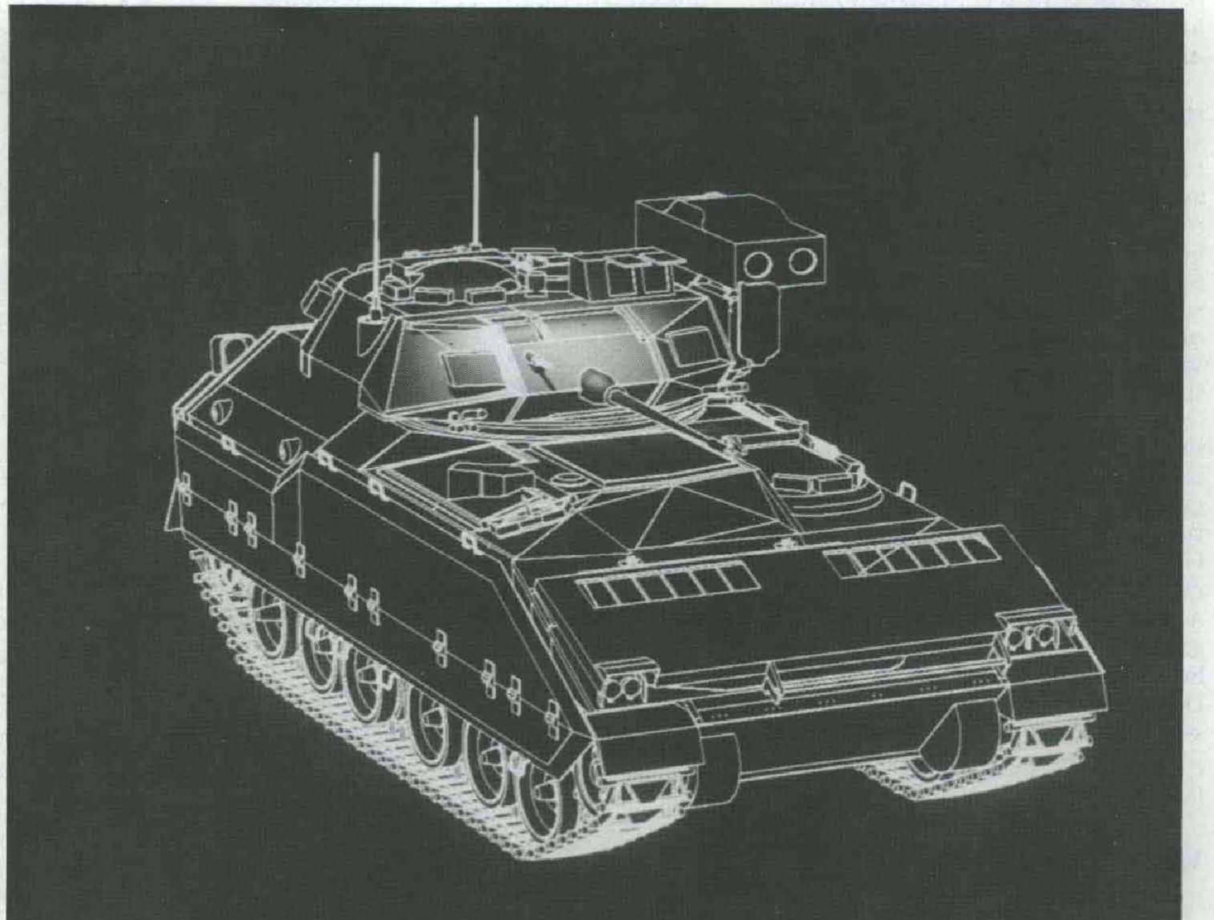

Figure 1. *Simulation of a laser designator on the Bradley vehicle. Using the model, any target surface condition or illumination/viewer orientation can be used.*

The lighting model can also support a geometric configuration in which an optical beam is directed towards a target from one direction while viewing takes place from another. This configuration is typical of laser-designator studies of the type needed to support the Copperhead laser-guided artillery projectile. The Bradley vehicle description is used to illustrate this capability in Figure 1. The optical scattering pattern is distributed across the turret while the target outline is rendered in wire-frame mode so that its orientation can be inferred.

A second optical prediction result is shown in Figure 2. Here the Bradley target description is used to show the view from an overhead optical sensor as might be encounted in a smart-munitions simulation. The Bradley has been placed on a ground plane and an optical source simulating the sun positioned above. Image 2a (upper left) shows a high-definition image, complete with ground shadow. To illustrate the processing methods used to simulate noise and resolution constraints, the image given in 2a was modified via an algorithm which introduces noise. The result is shown in Figure 2b (upper right). Next, a sequence of two optical filtering operations was performed to reduce the image resolution. The final result is shown in Figure 2c (lower left).

There are also methods to take a two-dimensional image (such as a camouflage pattern) and transfer it onto the surface of a target description. This procedure might be used to support optical pattern recognition studies.

Infrared Modeling

Predictive signature modeling can be extended to other wavelength regions. Figure 3 illustrates a simple procedure which shows how the utility of measurements can be extended greatly. In the upper image, an infrared (IR) image is shown of an actual Soviet T62 tank. The temperatures inferred by measurement are made visible by false-color imaging. A calibration bar below the image gives the appropriate color-temperature associations.

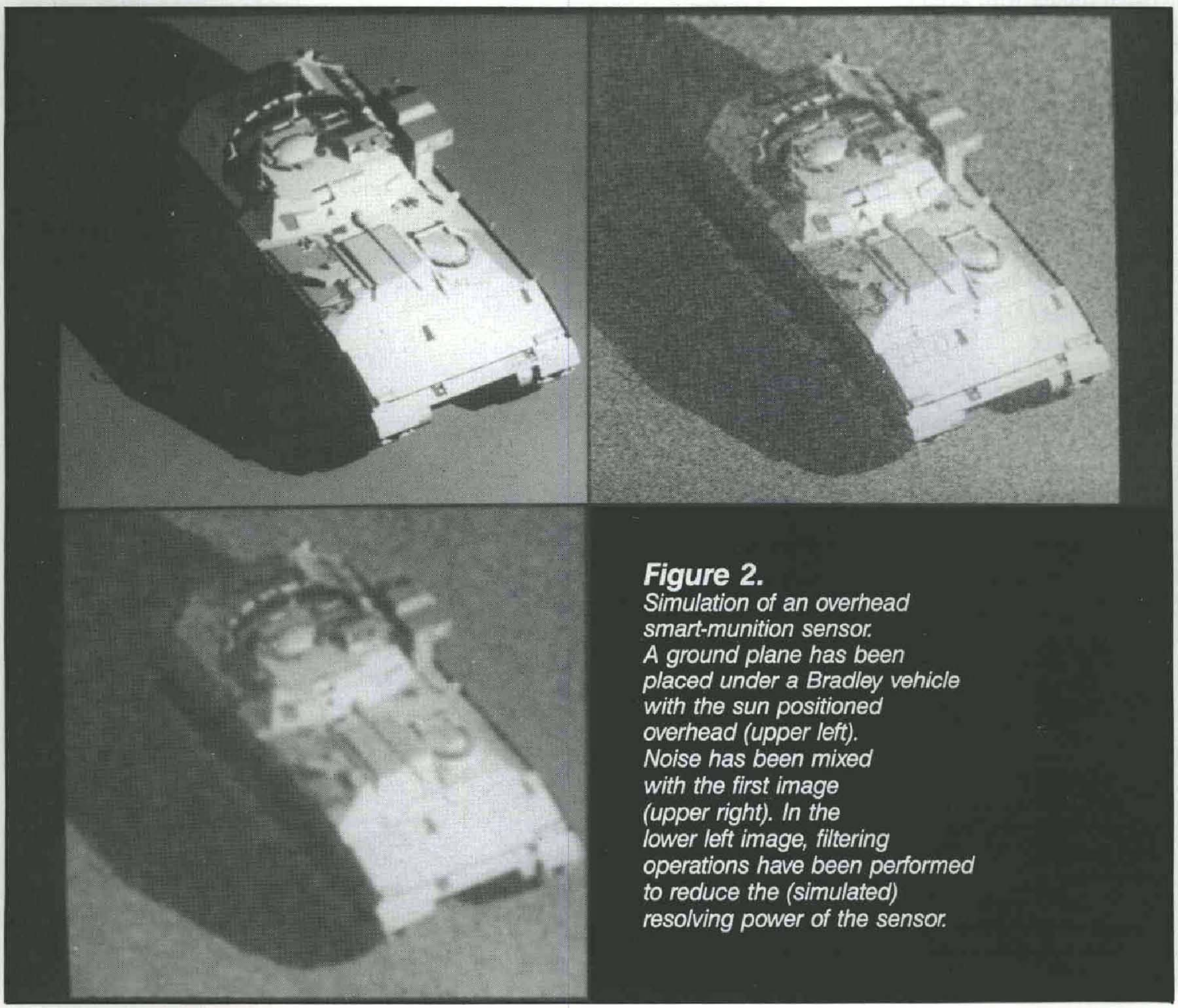

Figure 2.
Simulation of an overhead smart-munition sensor. A ground plane has been placed under a Bradley vehicle with the sun positioned overhead (upper left). Noise has been mixed with the first image (upper right). In the lower left image, filtering operations have been performed to reduce the (simulated) resolving power of the sensor.

To give greater utility to these measurements, a target description of a T62 has been configured identically to the measured vehicle to include the same gun-elevation angle. In a special mapping procedure, the measured temperatures (top) have been (transferred) to the target geometry (below). Through this procedure, the target can be viewed from angles other than that of data capture. In addition, the target thermal performance can be extrapolated to other IR bands via standard algorithms of radiation physics.

Over the past few years the Keweenaw Research Center and the U.S. Army Tank-Automotive Command have developed a predictive IR model. Work is currently in progress to replace many of the tedious manually prepared inputs with geometric and material data converted automatically from BRL-CAD target files.

Radar Modeling

The final examples of predictive signatures involve the calculated radar properties of military targets. Historically, radars were used to infer target range and closing rates. For the early radars, a figure of merit, the radar cross section, was of key importance, as it represents the efficiency with which radar waves are scattered back to the receiver. Certain modern radars, when placed on moving platforms such as aircraft, can be used to form a two-dimensional image of targets. Radar imagery of this class is called synthetic aperture radar (SAR).

A description of an M48 tank has been analyzed with a SAR program, and the results are shown in Figures 4 and 5. In the upper right of figure 4, the orientation of the target vehicle is shown as seen with respect to the radar. A horizontal flight path (left to right) is assumed.

The properties of SAR processing are such that following signal detection and manipulation an image is derived which resolves the target in range and cross-range (along the flight path) but not in the remaining orthogonal direction. Thus, the final SAR image orientation is similar to the optical rendering shown in the bottom left of Figure 4.

A pair of computer SAR images for the M48 is shown in Figure 5. The labels vv and vh represent two combinations of transmit/receive polarization (vertical/horizontal) states. In addition, these calculations have been made in a high-resolution mode (about 2-inch resolution) and are not constrained by practical frequency or coherence considerations of realizable radar systems. In each of these images, the radar signal is propagating from left or right. Range information is plotted along the abscissa and cross-range data along the ordinate.

The scattering of radar waves is determined by both target shape and material composition. Flat surfaces, particularly in combination, tend to reflect radar waves efficiently in preferred directions. A number of programs have been written to extract from target description those surface shapes which are: (1) flat only and (2) have dihedral (right-angle) elements. The information provided by these programs can be used as inputs to certain radar models as well as providing guidance in the minimization of signal return from U.S. systems under design.

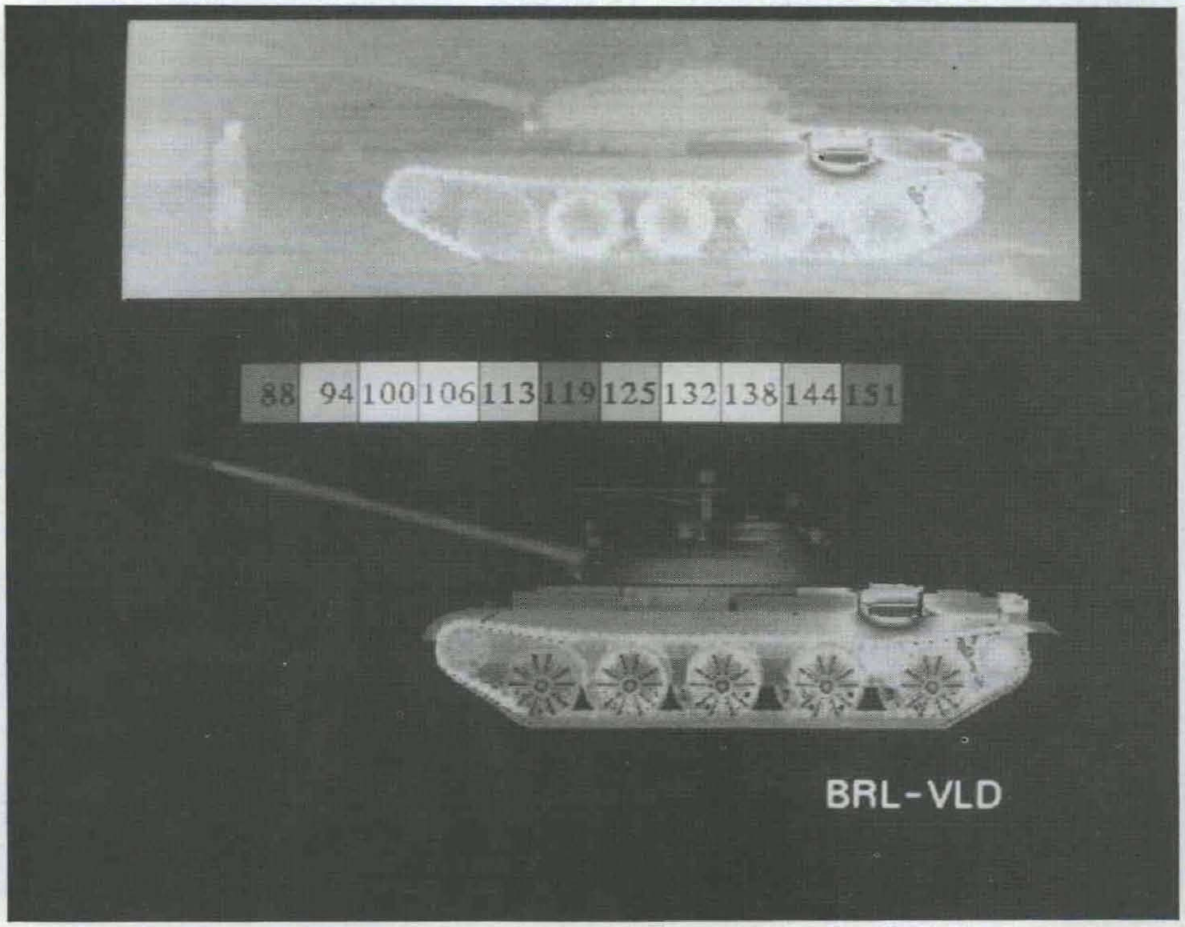

Figure 3
Upper image shows IR field data of Soviet T62 tank. Lower image shows the field data mapped onto the surface of a target description. With this method, thermal images can be generated for other viewer positions and thermal regions.

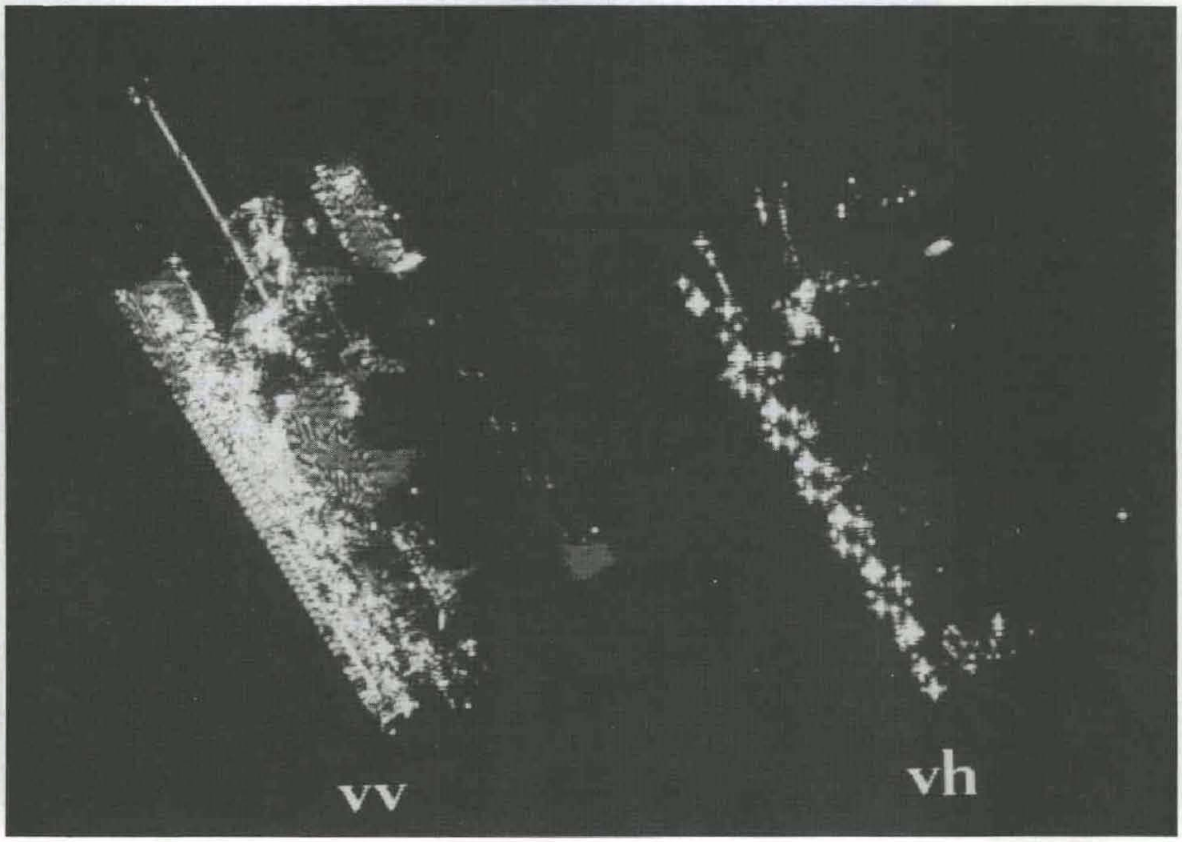

Figure 4. *Two images of an M48 tank which illustrate the synthetic aperture radar (SAR) process. In the upper right is the target as viewed by the radar. Below is the image orientation after radar processing.*

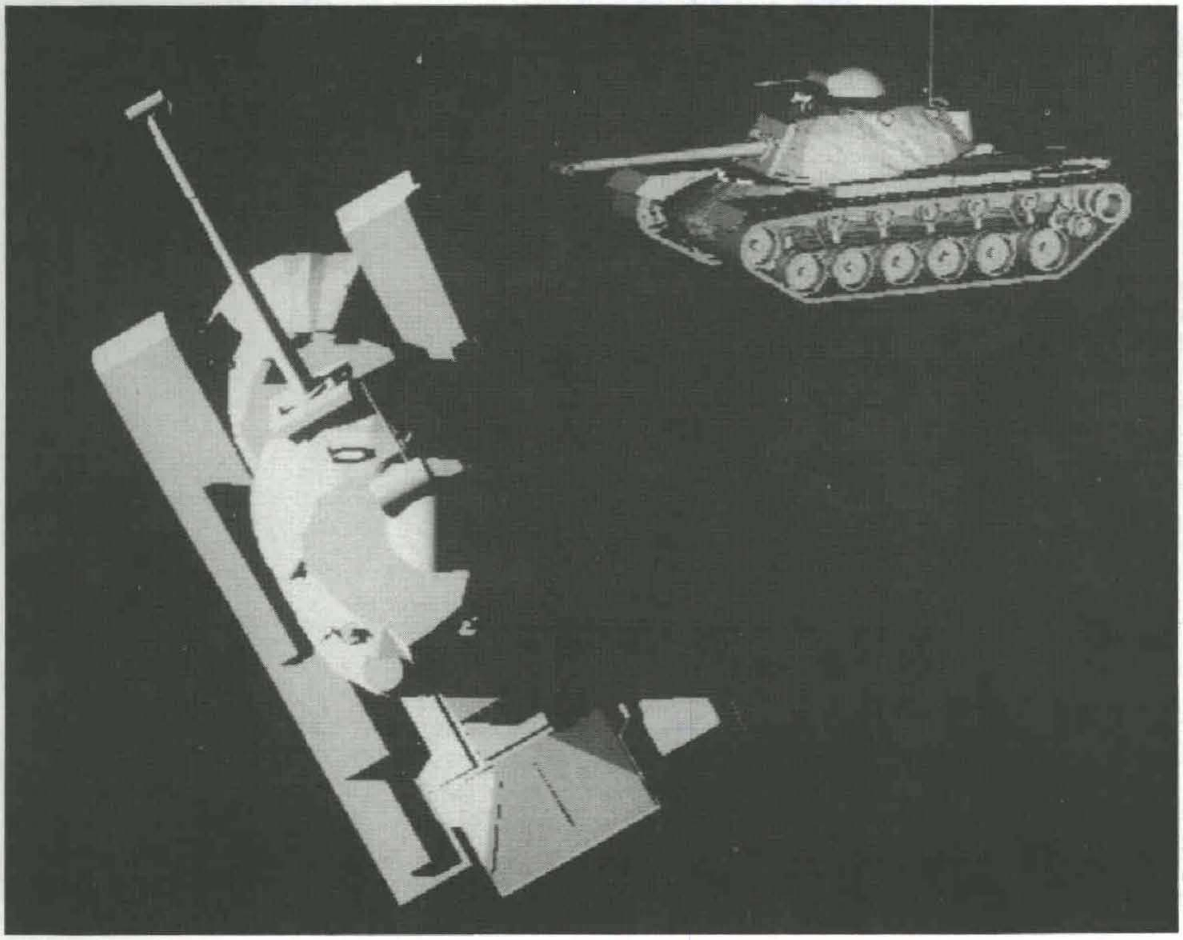

Figure 5. *High-resolution SAR images of an M48 tank. In both images, cross range is plotted against range. On the left, the vertical/vertical (vv) polarization components are shown; on the right, the vertical/horizontal (vh).*

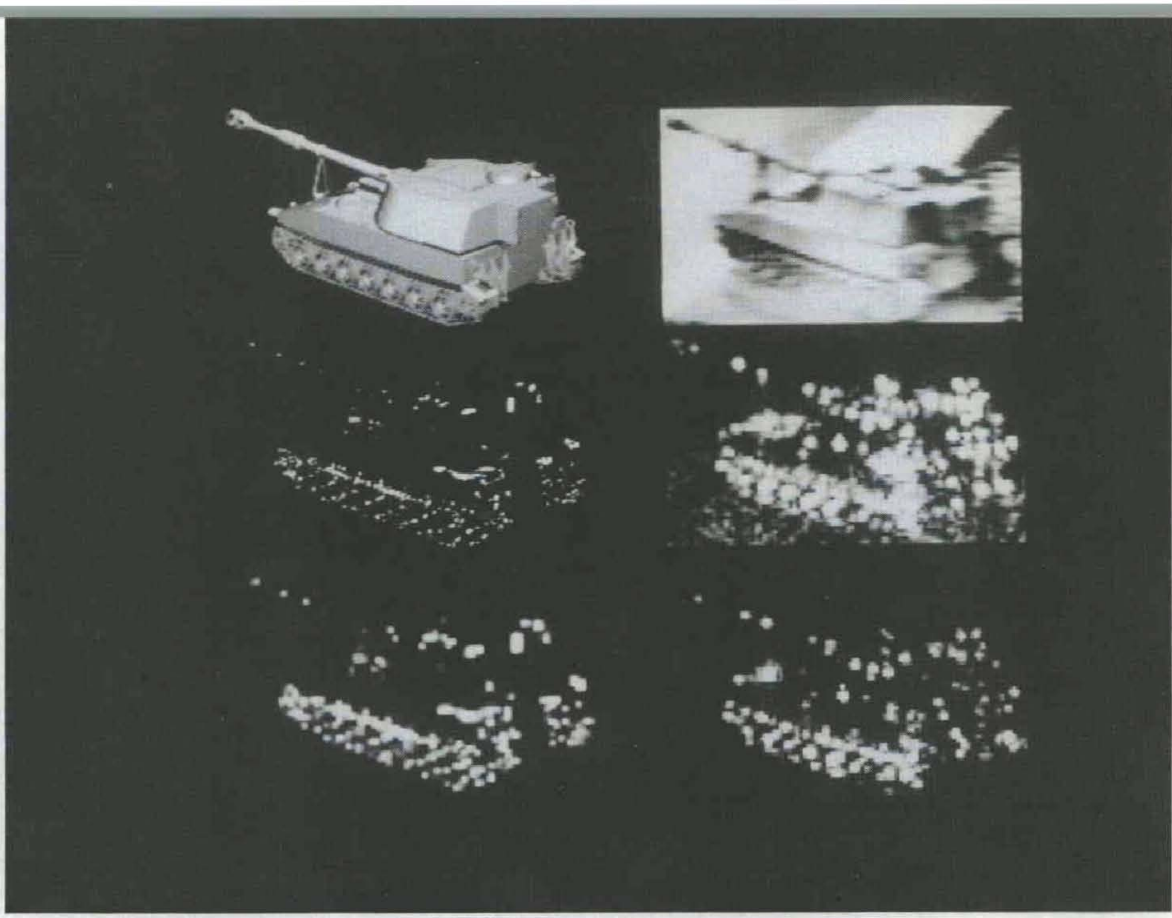

Figure 6. *Comparison of 94 Gh radar data with simulation for M109 self-propelled howitzer. Right-hand images are field-derived; left-hand are simulations.*

Finally, predicting the performance of high-frequency radars can be particularly challenging because of the geometric detail required as frequency increases. A tool which is finding increasing utility is illustrated in Figure 6. The objective is to characterize radar scattering at 94 Ghz to support smart munition as well as armored-fighting vehicle design.

In the upper right portion of Figure 6, a U.S. M109 self-propelled howitzer is shown from the left rear. This is an optical image of the actual vehicle. The middle right image is a plot derived from a 94 Ghz scanning radar (6-inch target resolution) set in a co-polarized mode. The cross-polarized mode is shown in the bottom right. To simulate this process, a target description of an M109 was built to a high-level of detail including high-resolution tracks and suspension system. This target was viewed from the same orientation as the actual optical image (upper right) and is shown in the upper left corner.

Using the lighting model described above, the target was given the properties of a purely specular (mirror-like) object. A single light source at the view position was used. The middle-left image shows the results. A glint image, highly suggestive of the right middle and lower images, is also shown. The middle left image was low-pass filtered to achieve an even greater similarity with the field data shown on the right.

Summary

This has been a brief review of some state-of-the-art techniques for predicting military signatures. The general methods share an approach used for many other kinds of high-resolution calculations in item-level analyses. The procedure is based on the construction of computer files representing three-dimensional geometry and related material properties. These files are then linked to a particular application code based on the required signature, viewing angle, and other physical attributes.

In the final article of this series, a summary will be presented of other item-level predictive tools of importance to weapons designers and system analysts.

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A NEW CONCEPT FOR INDUSTRY-TO-INDUSTRY BASED INTERNATIONAL COOPERATION

By Bryant R. Dunetz

Cooperation with our allies is a critical element of our defense strategy. The recent Congressional mandate — the Nunn Amendment — has resulted in increasing numbers of international cooperative R&D programs. These programs are carried out under various approaches. The traditional approach is based on government-to-government agreements, management, and direction. This article proposes an alternative approach — characterized principally by industry-to-industry cooperation in a highly competitive environment.

Disadvantages of the government approach result from the complexities of establishing prior work-sharing arrangements, cost-sharing arrangements, and management through an international body, consisting of government personnel or a mix of government and industry personnel.

The principal aim of the "industry-to-industry based concept" is to align the process of international collaborative development and production with national acquisition procedures. It builds on industry cooperation at the component/subsystem level to develop and ultimately provide to the government the best equipment available.

A further objective is to have the international management aspects of development and production become almost transparent to our program executive officers and project managers and to have them deal solely with national prime contractors and the rules of acquisition as they know them and as they are promulgated in the U.S. Department of Defense.

Discussions at the government level (see Figure 1) should lead to harmonized requirements and sets of standards and technology, which are exchanged under specific "Technology Sharing Agreements." It is envisioned that under this approach, Technology Sharing Agreements will be the precursor to full-scale industry-to-industry cooperation. For industry, the roles are divided into three main phases with emphasis on the need for industry-to-industry cooperation in the requirements formulation phase of a program. This is the phase during which the national program requirements and acquisition strategies are formulated.

Two key elements required to accomplish this type of cooperation are a clear set of international standards and battlefield requirements as agreed to with allied and friendly nations, and well-formulated, long-standing relationships and business arrangements among the technology-oriented product producers and system prime contractors throughout the world.

International cooperation in the commercial sector has been underway for many years through numerous cross-licensing agreements and joint ventures, particularly in aircraft. More recently, as evidenced at several major international defense exhibitions, cooperation is rapidly taking hold in the defense sector as well. Numerous examples of U.S. and foreign firm mergers and acquisitions can be identified as well as the formation of international teams to bid on specific programs of the military services. The question then is how can this be further cultivated to encompass a larger number of key industries related to defense.

The greatest challenge of this concept for government and industry is the establishment of an effective infrastructure. Figure 2 attempts to lay out the elements of an infrastructure and the process to achieve industry-to-industry cooperation.

With this suggested infrastructure, U.S. industries can pursue suitable arrangements with industries of other countries early in the acquisition cycle and more specifically in the requirements formulation phase. It must be recognized however, that many countries the U.S. deals with do not follow our procedures and industry-to-industry joint ventures may be seen differently. Therefore, if this concept meets with U.S. Government and industry acceptance, it would still have to be presented to our allies to determine the degree to which it can work in their countries as well. It may be possible to build on several existing organizations and procedures, e.g., advanced planning briefings for industry (international focus) might be the catalyst to advise our industries as to what directions they should be moving. Others are: how to do business seminars, cooperation among associations, participation in the NATO Industry Advisory Group; and access to the Conventional Armaments Planning System.

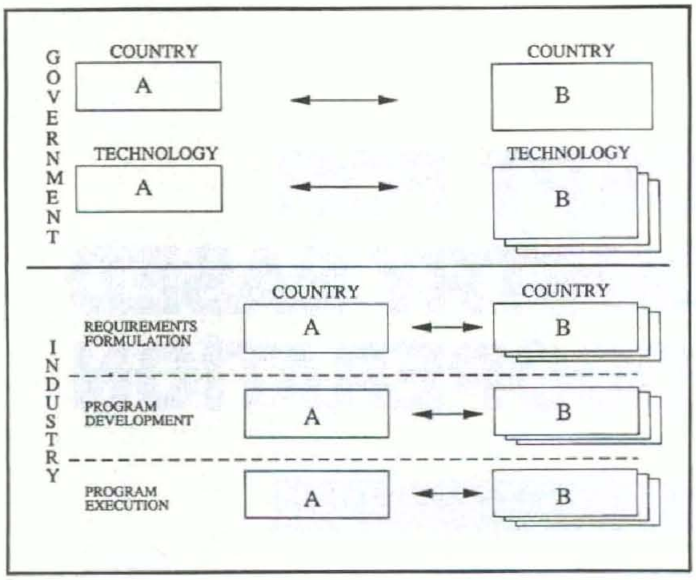

Figure 1.

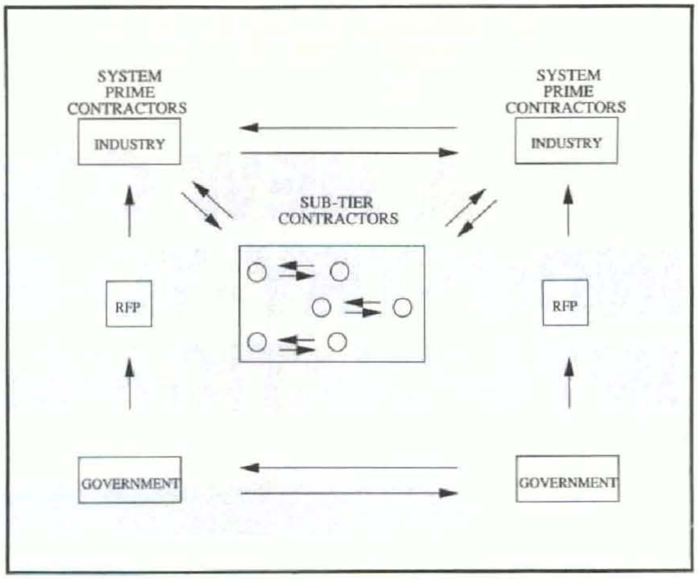

Figure 2.

New U.S. laws and government policy may also need to be established to enable this type of cooperation among U.S. and allied industries. On the government side, the difficulty will be in securing early commitments to comply with agreed to international standards and to initiate early technology sharing agreements to facilitate the transfer of emerging technologies to both governments.

The elements of this concept can provide a sound basis for international cooperation. At the sub-tier level of contractors, it suggests that cooperation is a continuum between technology companies and component/subsystem developers and producers. Also depicted are discussions between governments and their main system developers and producers. It suggests that when governments/military services agree on a requirement, one or both governments can issue a request for proposal to the main system developers and they in turn can tap directly into the pre-existing base of sub-tier collaboration and technology solutions at the component/subsystem level.

In regard to management, the governments will use their own rules for acquisition and therefore an international management team should not be required except for some elements of coordination. If the other partner is not prepared to invest at the front end of the program with its industry, the equipment solution or weapon system to be developed would be available at a later time in a co-assembly/licensed production configuration. Some countries may choose to obtain the national prestige of developing a part of a system while limiting the burden of the entire cost.

Early entry into the program would provide additional benefits in sharing of markets beyond the national requirements. Both nations would benefit from the a priori arrangements of industry on private investment and technology sharing agreements to avoid the duplication of expenditures for product development.

Benefit can also be derived from the components and subsystems development work that has been accomplished through the initiative of national industries. The ability to introduce systems into the force in roughly the same time period with similar capability, which meets all the international standards, would have great military advantage not only for modernization purposes, but in the areas of cooperative logistics and interoperability as well.

This concept places a great deal of emphasis on international cooperation at the component/subsystem level. Three major system areas of the Army undergoing modernization are aircraft, combat vehicles, and missiles. These are examples where industry may choose to pursue cooperation.

While it can be observed that this concept attempts to deal with an oversimplified model of industry-to-industry based international cooperation, it is presented as only the first step. It must now be subjected to a critical review based on the realities of experience and the environment within which it must operate.

The subject of this article and related areas of international cooperation were reviewed in a conference sponsored by AMC on "Improving U.S. Industrial Role in International Armaments Cooperation," in November 1988. The report of that conference and recommendations from industry, published in January 1989, is available upon request to the Logistics Management Institute, 4875 Eisenhower, Ave., suite 101, Alexandria, VA 22304-4833.

The environment as we know it today is characterized by a growing national movement toward protectionist measures for our defense industry, initiatives to increase the competitiveness of our industry at home and abroad, and by mandates from Congress for greater alliance burdensharing and cooperation. The open question then is whether there is a best approach to this situation and if so, how U.S. industry and government might work together to achieve this end.

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By David Whiteree

TECHNOLOGY 'TRANSFIX'

International cooperation encourages the free flow of technology between friends and allies of the U.S. while protecting the reasonable military and commercial concerns of all.

The institutions set up by governments to control the flow of technology for political, economic and commercial reasons were adequate in an earlier age when technological progress was slower. Now, a tremendous explosion of new technology has changed the equation dramatically.

According to the U.S. Department of Commerce, 90 percent of everything we know in the sciences has been generated over the last 30 years. It will double again in the next 15 years. Ninety percent of the scientists and engineers who have lived are still living and working today. Their numbers too will double. In another 10 years only a third of the world's scientists and engineers will be living in the United States.

It follows from this that no country has a monopoly on technology and that many of the developments are well beyond the capacity of any individual company, organization or country to exploit. International cooperation will therefore become increasingly essential and the efficient transfer of technology a vital feature of the process. The Department of Commerce, recognizing this, has improved the average licensing time for products going to the Free World from 60 days in 1985 to 14 days today.

Recognition of changing times is going on elsewhere. The British Government, recognizing the need to capitalise on research efforts by both government and industry which lie dormant through lack of exploitation, has supported a commercial organization to identify and market technology. It is a privately funded firm to improve access to emerging and growth technology available in the UK's R&D establishments. Challenges facing the organization include removing barriers to technology transfer, creating civil spinoffs, and expediting the flow of technology from government to industry. This seems to be a significant step in the right direction.

Electronic licensing now allows a request to be submitted directly from a personal computer in the office of a company, requesting the license. This is considerable and commendable progress which enabled Dr. Paul Freedenberg, the first under secretary for export administration in the Department of Commerce, speaking at ComDef'88, (a 20 nation international conference on Defense cooperation), to say, "The delay for licenses going to the Free World is really a thing of the past."

Historically, the transfer of any technology has been contentious. General Alain Cremieux, deputy director for research, development and engineering from the French Department of Defense, also speaking at ComDef'88 reminded the audience that "in the 19th century, transferring technology between Britain and France was punishable by death!" Relationships have progressed significantly and now there are "no rules about technology transfer towards the United States and no book to tell people how they should arrange technology transfer within the U.S. It is something which can be done case by case." General Cremieux went on to propose a balance sheet on which technology transfers going one way could be recorded against transfers going the other way. He believed this would help to allay U.S. concern that the benefits were one way in the wrong direction.

This concern is very real and the subject is debated world-wide. Warwick Beutler, broadcasting across Australia on March 28, 1989, reported "These days whenever Americans debate why the country has lost some of its competitive edge, it's inevitable that someone will answer, because we lost the technology. There are now dozens of examples, starting with the video cassette recorder, where basically American technology was adapted by someone else, marketed in a better way and earned fortunes for Japanese or Europeans, but not American corporations. In one area where the United States still has a very definite technological edge, weapons systems, it's perhaps natural that the U.S. is reluctant to share its knowledge, even

Despite a pervasive protectionist mentality, becoming increasingly out-dated in the short life technology existing now, there is widespread recognition of the importance of the need for a smoother transfer process.

with its friends, but that's become another irritant in Australia's relations with its ally."

The irony, of course, as in the publicized case of the FSX aircraft with Japan, is that there are compelling arguments in the U.S. for Australia and Japan to have a defense capability sustained and maintained domestically. The economic concern that selling this technology to Japan will allow the Japanese to enter the commercial aerospace industry in much the same way as they entered the motor car industry is genuine. Hoarding technology, however, seems less a certain remedy than the creation of a culture which adequately rewards the exploitation of home grown technology.

Despite a pervasive protectionist mentality, becoming increasingly outdated in the short life technology existing now, there is widespread recognition of the importance of the need for a smoother transfer process. There is also concern about the institutional inability to generate timely and acceptable responses to transfer applications in critical areas.

If an application is the least bit controversial or difficult, the historic response from a process that requires three departments, defense, state, and commerce, to produce an answer, is inevitably no. In government by and large, right decisions go unrewarded and wrong decisions carry career implications. The emphasis is always on "play it safe." In such an environment, companies are finding it difficult, if not impossible, to prepare timely bid packages where international technology transfer is an issue.

Foreign companies cannot even easily attain access to the preliminary briefings which are an essential prerequisite to competing for business. This bureaucratic inertia has produced a condition which I call "Technology Transfix" — information not moving rapidly enough to be used effectively in a proper timescale.

There are, fortunately, some guidelines to a better way. Captain Hans Brink, the defense cooperation attache in the Netherlands Embassy in Washington, recently described the F-16 program as the most successful international program yet achieved and described the system for technology transfer clearances as a model for future use. In this case, the F-16 Project Office is the focal point for all export of technical data or hardware.

Everett Greinke, former deputy under secretary in the Department of Defense for International Programs and Technology, said "We need some new policies on technology transfer. We are not going to achieve effective and long-lasting armaments cooperation if technology transfer policy, focussed basically on west to east transfers, not west to west, is not changed. Maybe we have to bring up a new policy for west to west technology transfer."

That this need is urgent is not questioned. We are simply not producing the equipment we need to defend ourselves at an affordable price. We have 11 firms and seven different countries working independently on anti-tank weapons and, as General John Galvin, supreme allied commander, Europe, said recently, "We have a posture that cannot hold the Warsaw Pact for more than two weeks and a force that is still outnumbered by 32,000 tanks, 22,000 artillery pieces and 1,800 tactical aircraft.

"We have always relied on our technological supremacy and we do not seem to have found a way to transfer this technology efficiently between the allies." The recent Soviet gesture of a unilateral withdrawal of armor from forward positions in Europe, while welcome, does not substantially reduce the threat.

Dr. Robert Costello, under secretary of defense for acquisition, stated unequivocally that "We, in the Department of Defense, recognize several facts. No nation has a monopoly on technology. Technology has a short half life and must be used." Speaking at the same conference, his counterpart at the Department of Commerce, Dr. Bruce Merrifield, said "The life cycle in new technology has collapsed; it is three to five years now for electronics and rarely more than five to 10 years in most other industries. Collaborative efforts to continuously generate these new things and to manufacture them are critical. The entrepreneurial culture is burgeoning all over the world and is generating 700,000 new small businesses every year in this country. This is where 90 percent of our 17.5 million new jobs have been formed since 1980. This entrepreneurial revolution is re-structuring the U.S. economy."

A further recommendation was to establish foreign availability as a major criterion for technical evaluations during export license reviews for munitions list items.

This clear recognition of the prime importance to the United States of technology sharing brings into focus the need to determine how this can be done without detriment to political, commercial and military interests. Certainly a procedure designed to control west to east transfer is not adequate to the technology sharing amongst America and its allies that is clearly necessary today.

Norman Augustine, chairman and chief executive officer of Martin Marietta, in his capacity as chairman of the Defense Policy Advisory Committee on Trade (DPACT), discussed in a Nov. 21, 1988 report to the secretary of defense and the U.S. Trade representative that "the technology transfer process does not provide adequate differentiation among allied and friendly countries, neutral and developing countries and Eastern bloc countries. The primary mechanism used by DOD for determining technology exportable to any country is the military critical technologies list. This was drafted initially as a list of technologies which should be restricted from east/west trade."

The DPACT report went on to recommend that the DOD Program Office managing a specific Memorandum of Understanding (MOU) program should be given the sole authority for determining whether or not an export license request meets the conditions agreed to in the MOU. The recommendation was also to develop a policy for export controls for west/west trade, followed by the preparation of a west/west Military Critical Technologies List (MCTL) that contains only the limited number of technologies which are unique to the United States and of truly critical significance.

The third suggestion was to provide additional resources to the State Department Office of Munitions Control to reduce licensing delays, streamline the International Traffic in Arms Regulations to remove items from the munitions list that do not need to be controlled, develop alternate methods for administering the export licensing process and resolving interagency disputes, and use all U.S. Government resources established for export controls.

A further recommendation was to establish foreign availability as a major criterion for technical evaluations during export license reviews for munitions list items. They also recognized the need to negotiate to strengthen the Coordinating Committee for Multilateral Export Controls (COCOM) and develop a U.S. export control policy and system of implementation more consistent with multilateral controls established through COCOM.

At the same time, they needed to review the east/west MCTL with the intent to reduce the list to today's sensitive technologies. This should provide a mechanism that allows allied and friendly nations that comply with COCOM controls to re-export U.S. technology to other countries within COCOM. This would then mean they could explore options to liberalize the re-export of U.S. products from COCOM countries to non-COCOM countries.

In summary, a situation exists where the leaders of the Free World recognize a technology explosion and understand there is no monopoly of technology in any one country. They know defense of the West depends on technological superiority, particularly with an imbalance in conventional forces, and also recognize the outdated problems in transferring this technology — "Technology Transfix."

These problems persist, despite the recent improvements in the processing of licenses. The DPACT, a 35 member committee of senior industrialists, established to advise the executive on the concerns of U.S. industry, has produced a series of recommendations addressing this problem and there is little doubt that if the recommendations were implemented the situation would be greatly improved. The key, therefore, lies in the implementing organization. This should be set up immediately and headed at a level sufficient to command attention between the competing departments of State and the different countries.

This streamlined executive must reflect the views of the three departments concerned. In order to be effective, they will need some measure of independence and perhaps should report directly to the president. The organization should have a simple aim — to facilitate the free flow of technology between friends and allies of the United States while protecting the reasonable military and commercial concerns of all.

DAVID WHITEREE has been employed as a British Government official with over 15 years experience in defense equipment transfers. In 1985, he conceived and founded ComDef, a defense exhibition and symposia for the 19 countries with reciprocal defense procurement agreements with the United States. He is the chairman of IDEEA, Inc. the organizer of ComDef and chief executive officer of ComDef '89, which is scheduled to take place Oct. 11-13 in Washington, DC.

NEW TRAINING MINE ACHIEVES INDISPUTABLE REALISM

By Harry N. ("Hap") Hambric

The Scenario

Envision, if you will, a group of youngsters playing army. Carrying their toy weapons, they advance on each other, scurrying from tree to tree.

"Bang! Bang! I got you."

"No, you didn't."

"Yes, I did."

Sound familiar? You bet it does. Usually, size won the argument.

Now envision a company team of real soldiers advancing toward an objective during a unit training exercise.

"Boom! Boom! Boom! Rata ta ta ta . . .!"

The flash and sounds of enemy weapons takes the team by surprise. Immediately the squeal of alarms and rotating beacons designate those vehicles and soldiers hit by fire. The game is the same as played by the youngsters, but the outcome is different. There is no doubt who was hit, and therefore no need for argument.

Let's carry the scenario further. The advancing unit quickly recovers from its initial surprise and takes to cover as it continues its advance. The scouts several hundred meters ahead of the main body report a minefield in their path. Rapidly organizing the unit into breaching, support and assault teams, the company team commander orders the force to advance and breach the minefield.

As the breaching team approaches the obstacle, they see the long line of engineer tape, or blue training mines. Quickly the team begins simulated breach activities, and in a matter of minutes the commander declares the existence of one or more breached lanes and starts to order the breach team across to secure the far side of the obstacle.

"Hey! Wait a minute, bub!" a voice shouts.

The commander turns to see who had the nerve to address him in such a manner. He sees another captain with the white arm band of umpire walking toward him.

"You haven't breached this minefield."

"Oh, yes we have. . .we did this and that and such and such. . . ."

"Wrong fella! I've watched the entire operation, and your people didn't do. . .this and that."

"The heck you say!" the other counters. "We most certainly did. Now get out of the way before you get your butt run over by a tank!"

"You aren't going anywhere until you finish breaching the minefield."

A booming voice behind them shouts, "What's happening up here? Captain, why aren't your tanks moving?"

The task force commander has arrived on the scene. The argument starts all over again, and ends just as it did with the youngsters.

"Young man, you are interfering with my unit's valuable training time. I say the minefield is breached; now let's get back to maneuver. Get those tanks rolling."

Size — in this case rank — has won again. The tanks are soon crossing the minefield, routing the defenders, and declaring victory.

Some time later, the task force commander's boss may call him in and "jack him up" for violating the minefield play. Nine times out of 10 the task force (battalion) commander's response will go something like this:

"Sir, we don't get many opportunities to train at task force strength. I felt it was critical that we spend that time in maneuver. I can train mine-clearing procedures and tactics during small-unit training. Besides, my company commander had the engineers with him. I'm not sure he couldn't have breached it anyway."

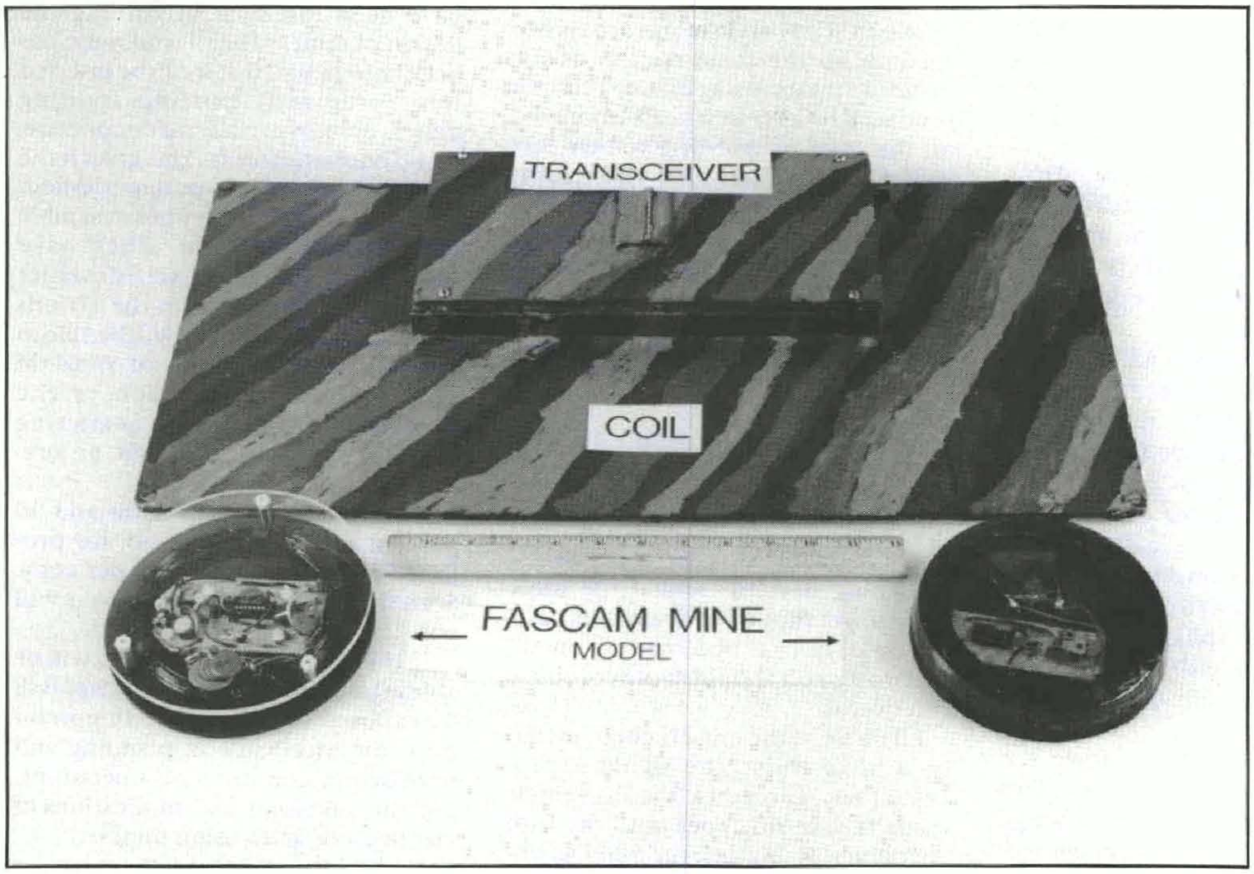
The brigade commander smiles and shrugs his shoulders.

"I know what you mean. I've been there myself. Besides, I don't know why the chief of staff got so fired up. That umpire must be one of his fair-haired boys."

Sound like something you've heard before? You bet, and we all know there is no use to take anyone's side. Both sides have valid arguments.

The Situation

The lack of realistic mine-effects play is detrimental to force-on-force training and prevents realistic mine-warfare training. Its absence during training allows soldiers and units to "play the mine game according to

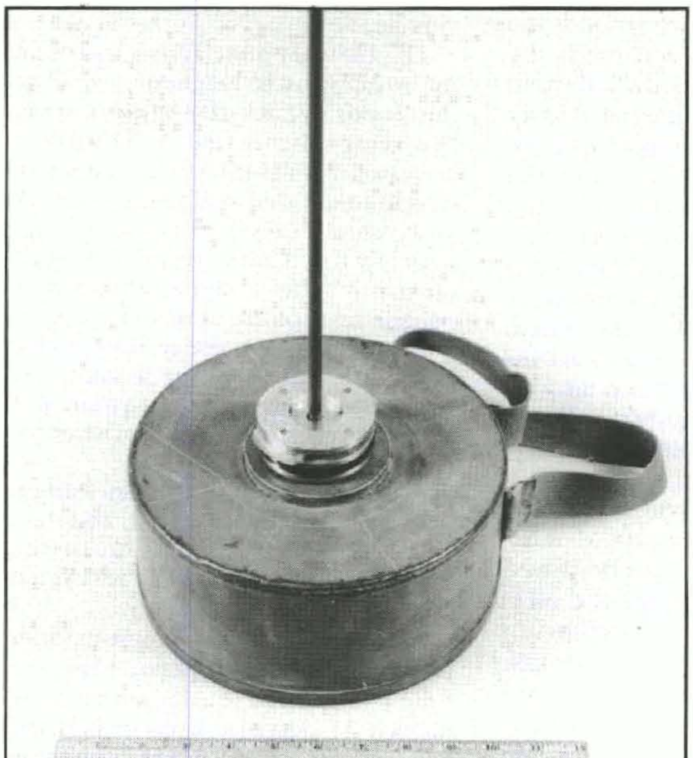


their own rules," and the result is a total disregard and misunderstanding of how mines will impact on the tactics, techniques and procedures of installing or breaching minefields during real combat operations.

The Army has long been aware of the training discrepancies resulting from the inadequate realism of mine warfare during force-on-force maneuver. Considerable time, effort and money have been obligated to develop an inexpensive, realistic training system. Until recently, all attempts to develop such a training capability failed to satisfy the requirement.

The Solution

In September 1988, engineers at the U.S. Army Belvoir Research, Development and Engineering Center were asked by the commandant, U.S. Army Engineer School, to solve the training-mine problem. The RD&E Center's Advanced Systems Concepts Office received the task, and in less than four months demonstrated two separate prototype casualty-assessing training-mine systems.



• ***Above,** this second prototype simulates the Family of Scatterable Mines.*
• ***Left,** tilt rod training simulator, installed in M-21 Training Mine.*

One prototype, simulating a standard placed mine, provided the capability for tilt rod and pressure fuzing, and the other prototype simulated the attack of the Family of Scatterable Mines (FASCAM) anti-tank mine.

The "tilt rod mine" is activated by a vehicle encountering the tilt rod. If the vehicle roles over the mine to signal a catastrophic kill (k-kill) or mobility kill (m-kill), a sequence of events is triggered.

The tilt rod transmits an electronic signal to a small receiver box on the vehicle. Immediately, the receiver ignites a smoke grenade (visual cue), and activates a horn or Hoffman device, depending on the vehicle. A Hoffman device is a flash-bang producer that sits on the barrel of a tank. It fires a large blank round to create a realistic explosion and flash. Vehicles without either a Hoffman device or horn would only have the smoke-grenade cue.

The receiver box then stores the signal it received for two seconds. This allows the vehicle to move far enough to allow the wheels/tracks to encounter the pressure plate, which is connected to the base of the tilt rod on top of the training mine. If after two seconds the pressure plate is not activated, the receiver box sends a coded k-kill signal to the MILES (Multiple Integrated Laser Engagement System Equipment) computer. (In the future, this will be the Simulated Area Weapons Effects-Radio Frequency system, or SAWE-RF.) The MILES/SAWE-RF system integrates the mine kill into the computer processor inside the vehicle. This is the system that activates the beacons and alarms indicating a vehicle has been hit.

If the vehicle wheels/tracks engage the pressure plate, the mine sends a new (m-kill) signal to replace the k-kill signal. The fact that a wheel or track is over the mine at the time of "detonation" indicates the m-kill of destroyed mobility. Failure to engage the pressure plate indicates the explosion has hit the belly of the tank for a k-kill.

The m-kill signal overrides the k-kill signal and is sent to the MILES/SAWE-RF system. By distinguishing between m- and k-kills, total battle realism can be achieved, processed and evaluated during post-exercise after-action reviews.

Comparable Realism

The FASCAM-style mines are able to accomplish the same realism as the "placed" mines. Using induced current produced by a "search head" mounted on the front or rear of a vehicle, the FASCAM Mine is activated, and returns a signal to the search head. The search head is able to determine if the "hit" was under the vehicle's belly, or a track/wheel.

The same visible and audio cues, as well as signal to the MILES/SAWE-RF associated with the tilt rod mine, are available on the FASCAM system. Total realism is available in both systems. Breaching-action realism is accomplished on the tilt rod mine by using a tilt switch to turn the mine off if it's pushed on its side by mechanical breaching devices. And if the mine were to get flipped back onto its base, it would, in fact, become "rearmed" and may go off should another vehicle run over it.

Likewise, if the mine is encountered by a mine roller, the signal is processed but ignored by the on-vehicle casualty-assessing cues until the fifth encounter. At this time the roller is considered destroyed and further mine encounters will "damage" the pusher vehicle.

The FASCAM mine allows use of an on-board vehicle magnetic signature duplicator (VEMASID) by "notifying the search head that VEMASID is activated." VEMASID is a system in development that will allow the tank and vehicle crews to counter magnetically fuzed mines by projecting an electro-magnetic signal ahead of a vehicle to explode mines in its path. During a training exercise, the damage cues are ignored, but a signal is transmitted to the crew that a mine was encountered, so that appropriate warnings can be given.

Both types of training mines allow only one encounter (signal), and then shut off. At the conclusion of the exercise, both types can be recovered and reused.

The tilt rod mine has a built-in timer to turn on its transmitter at a specific time to allow the (buried) mine to be located. The signal will stay on until the battery loses power, or until the mine is found, and the battery is disconnected. Research is under way to determine the best option to locate the FASCAM mines.

Efforts to provide training realism have been foremost in guiding the design of mines. The tilt rod mine has been designed so that it can be inserted into (prepared) existing training mines, or into specially made concrete, wood or plastic forms. This gives it the ability to portray any type mine desired.

The FASCAM-type mines resemble the anti-tank version. They have delayed arming and self-destruct features to coincide with the actions of the actual mine. They will be able to withstand the G-Forces of FASCAM mine-laying systems such as the Ground Emplaced Mine Scattering System (GEMSS) and FLIPPER, an auxiliary GEMSS dispenser.

Both mine types will withstand 90 percent of encounters and are projected to cost less than $40 per copy. Search heads and vehicle receivers will cost less than $200.

In the near future, U.S. forces will be able to train as they will fight. They will be exposed to the equally important need for excellence in planning and conducting countermine operations, and the time/logistical implications of creating obstacles using mines.

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THE USE OF COMPOSITES IN ANTENNA DESIGN

By COL Gordon W. Arbogast
and MAJ Steven K. Matthew

Introduction

A dichotomy currently exists between electronic and mechanical miniaturization of communications systems components. One important communication component that illustrates this is the antenna mast. All services need compatible, highly mobile, and survivable mast systems.

The Army now has over 20 mast systems for ground based and vehicular mounted antennas. While the antenna and sensor payloads have increased in weight and volume, the available space in Army vehicles has decreased. The mobility and the fluidity of the modern battlefield requires rapid set-up and breakdown of communications, electronic warfare, and sensing/detection sites.

The purpose of this article is to discuss new approaches in building antenna mast components using advanced composite materials and changes in design.

Depending on the height requirements, a heavy mast system may weigh from 170 to 16,000 pounds. A light mast system may range from seven to 100 pounds. Of these antenna masts, most are wire guyed for stability and require a minimum of 15 minutes to erect. Often, an hour may be needed to erect an antenna, particularly if it is in unfavorable terrain.

The traditional materials that have been used for mast systems are aluminum and steel, with some limited application of fiberglass. What is needed is to increase mobility, ease of use, and survivability in a tactical environment. In order to do this, a stronger, as well as lighter, stiffer, and ballistically survivable material is needed. This is why modern composites combined with innovative design are required to meet the needs of the Army for state-of-the-art antenna masts. When considering the needs of all services, economy of manufacturing could be achieved in the production of superior mast systems.

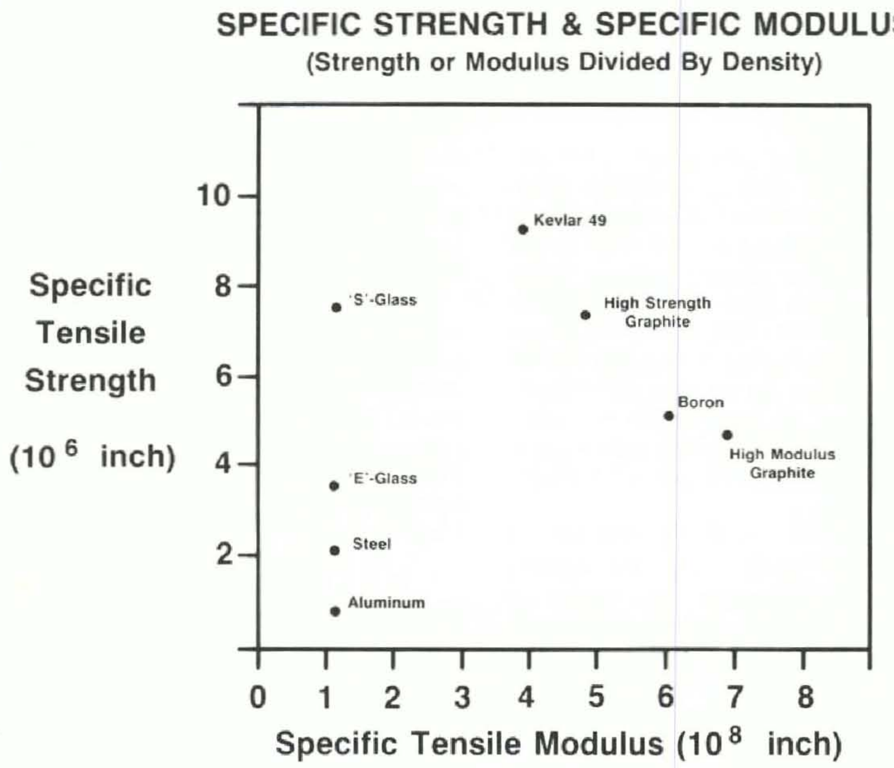

Figure 1

Composites: The Material of Choice

Composites have been called the material of the future. However, composites have been in use since the days of Moses. The Egyptians made bricks using clay as the binder (matrix) and straw as the reinforcing material (fibers). The matrix is the material that holds the fibers together in a fixed alignment. For high strength applications, thermosetting resins such as epoxy have become very popular.

Modern composites first became available in the late 1930s with the development of fiberglass by Owens-Corning. Today, fiberglass accounts for approximately 90 percent of the fiber reinforced-plastics produced.

In the early 1960s, the Air Force began to use boron fibers in their fighter aircraft. Since that time, other advanced fibers such as carbon/graphite fibers and polymer fibers (e.g., Kevlar) have been developed with remarkable increases in stiffness, strength, and other properties. For example, graphite fibers can have tensile strengths of 600,000 pounds per square inch (psi) with an elastic modulus of 120 million pounds per square inch (msi). A high strength steel typically has a strength of 200,000 psi with an elastic modulus of 30 msi.

Due to graphite's low density, the specific strength and specific modulus for a graphite composite with an epoxy resin matrix is 7-million inches and 500-million inches, respectively. In contrast, as shown in Figure 1, steel and aluminum have much lower specific strength and modulus than advanced fiber reinforcements.

Stiffness, the property which provides stability to the mast, is five times greater for graphite than steel or aluminum. An aluminum mast which requires guy wires for stability could be replaced with a graphite mast, thus eliminating the guy wires. This would dramatically reduce erection and breakdown time.

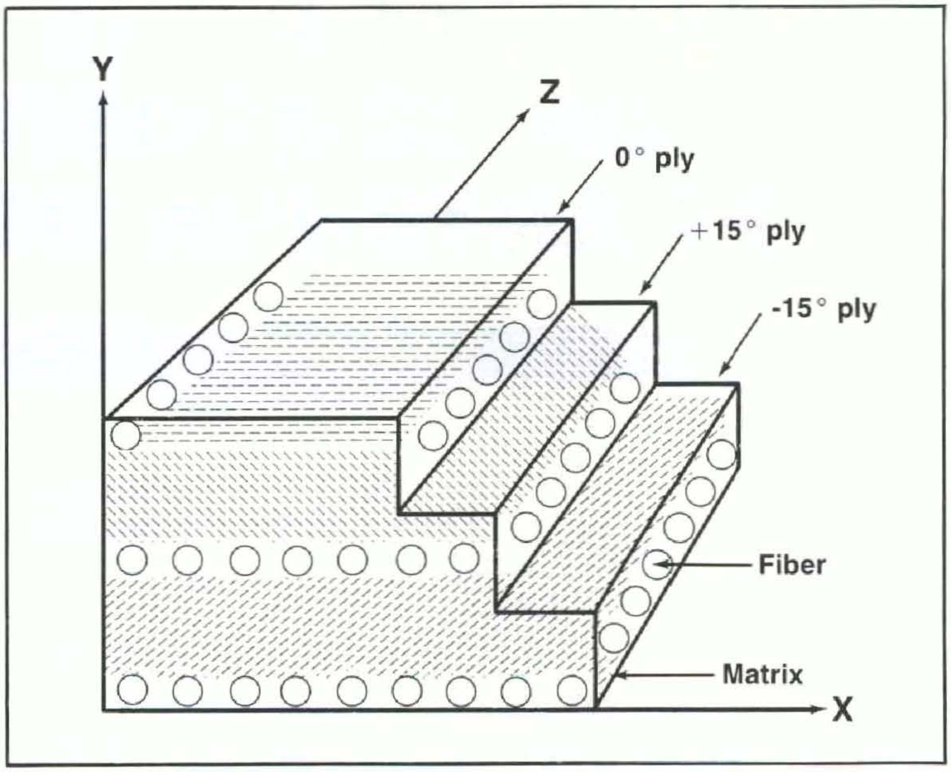

Figure 2

Durability and Survivability

In addition to graphite composite's high strength and stiffness, such a composite generally has better fatigue properties (up to three times the fatigue life of aluminum) and excellent vibrational damping characteristics. Therefore, the masts made from graphite composites will have excellent durability in the varying wind conditions of a field environment. Furthermore, the thermal expansion coefficient can range from negative to virtually any value desired by controlling the layering of the fibers and matrix.

Corrosion is not a problem with polymer matrix composites. However, moisture can degrade the composite's strength and stiffness properties. Depending on the environment, a special coating or sealant may be required.

The greatest advantage of composites is the damage tolerance capability. If a metal bar is damaged from a fragment or projectile, the hole or the damaged area creates a high stress concentration zone. This often leads to failure. With composites, the fibers and the matrix of the composites work to redistribute such stress and reduce the stress concentrations. This increases the damage tolerance capability, which results in greater ballistic survivability.

Additionally, ballistic damage in composites tends to fray the impact area, rather than petal (e.g., similar to a flower opening) as experienced with metals. This is an extremely important factor in the design of telescoping antenna masts, which are the majority of Army quick erecting masts systems.

The petalling effect of metals jams the sliding components of the mast and prevents further operation. This is contrasted to frayed composite fibers which would shear off and allow continuous operation of the telescoping components. Additionally, rough handling often causes dents or bends in the metal components. Such damage hinders and prevents antenna section erection. Composites are more impact resistant and do not deform to the same extent as metals.

Lastly, field repair kits can be produced to allow repairs at the unit and support level. This is a feature currently not possible with metal masts.

In cold weather operation, icing will often occur on the antenna mast. Ice adheres to metals and this interferes with both set-up and tear-down operations. While icing still occurs with composite masts, ice is easily shed from such a mast allowing continuous operation even in adverse weather conditions.

Design Approach

Metals are generally isotropic, that is they behave similarly along any axis (i.e., strength and modulus are the same in any direction). Composites do not behave like metals. Hence, they are anisotropic. The strength of composites varies with the fiber direction.

TABLE 1
Comparison of Graphite Composite Design With Aluminum Design

Laminate Structure:	DESIGN 1 $[0_2/15_1/-15_1]_S$	DESIGN 2 $[0_2/20_1/-20_1]_S$	DESIGN 3 $[0_2/45_1/-45_1]_S$	ALUMINUM 6061T6
Strength (1000 psi)				
Longitudinal	198.5	169.5	82.0	40.0
Shear	18.4	22.8	34.7	30.0
Modulus ($\times 10^6$ psi)				
Longitudinal	24.0	22.3	10.1	10.1
Shear	1.8	2.2	3.9	3.9
Maximum Load				
Bending (kip)	4.1	3.5	1.7	0.4
Torque (kip-in)	89.7	112.6	202.3	85.7

TABLE 2
Aluminum and Composite Mast Data

Aluminum 6061T6		Graphite Composite	
Thickness	= 0.25 inches	* Thickness	= 0.236
inches			
Diameter		Diameter	
External	= 4.00 inches	External	= 4.00 inches
Internal	= 3.75	Internal	= 3.764
Length	= 12 feet	Length	= 12 feet
Weight	= 21.4 pounds	Weight	= 11.99
pounds			
Moment of Inertia	= 6.28 (inches)^4	Moment of Inertia	= 5.94 (inches)^4

Symmetrical laminate repeated six times.

Therefore, the proper design and fabrication of composites are essential to its performance. The fibers must be oriented in the direction of the loads. This means that the designer must determine the loads as accurately as possible.

Generally, composites are layers of fibers combined with a matrix. The combination of fibers, matrix, ply angles, and weave patterns are virtually limitless. Due to the numerous possibilities of composite design, many engineers tend to shy away from composites or only approach them in a piecemeal, rather than with a systems perspective.

Depending on the application, numerous mechanical tests may be required to certify a composite. Also, the testing of composites is not as well established or standardized as the testing of metals. For example, due to redundancy, certification testing of a composite coupon for aircraft use can cost up to $250,000. The engineer should not be discouraged by these disadvantages. Sufficient data on the various combinations of fibers and matrix exists so that additional research and development should not be necessary for most antenna mast applications.

Designing with composites is not as difficult as it may initially appear. A typical mechanical engineer knows how to design with aluminum or steel. Although there are numerous grades of aluminum and steel, this is not a difficult problem. A good engineer is able to research the different grades and select the best alternative.

The procedures are generally the same for composites. The engineer principally evaluates the alternatives between fiberglass for low cost, polymer fibers for strength and impact resistance, and graphite/carbon fibers for high strength and stiffness. The problem is determining the properties based on the selected matrix, fiber fraction, and fiber direction. Here again, the task is not as laborious as it may seem. Computer programs are available which allow engineers to optimize the ply thickness, fiber fraction, moisture content, and fiber direction. For example, the computations found in Table 1 were generated by a spreadsheet program called MIC-MAC, by Think Composites, Dayton, OH.

The principal antenna mast design considerations are compressive strength, elastic buckling, torsional strength, and elastic modulus. The sail effect of the antenna can result in a large bending moment. Due to the additional load of the antenna and the mast weight, compressive stresses are greater than tensile stresses. Furthermore, it is important to note that composite's tensile and compressive strengths are not necessarily equal. Generally, a composite's compressive strengths are lower than their tensile strengths.

Torsional strength must also be considered. Depending on the antenna design, the winds could cause sufficient torque to twist the antenna and decrease its operational effectiveness. Elastic buckling and elastic modulus are directly related. By increasing the elastic modulus, resistance to buckling can be enhanced.

With these design features in mind, it is possible to demonstrate the distinct advantages of composites over metals. Consider the aluminum and graphite epoxy composite mast sections shown in Table 2. For comparison purposes, the mast dimensions were kept nearly the same.

Table 1 compares the characteristics of three different composite designs with an example of a standard aluminum mast. The notation and terminology of laminates are shown in Figure 2.

Comparing the modulus and load bearing capabilities of the aluminum mast and the composite masts: the graphite composite's bending strength was higher by a factor of nine; the modulus was doubled; and the weight was decreased by 50 percent. Further weight savings could be achieved by designing for the actual load requirements.

Table 1 clearly demonstrates that the engineer has the flexibility to tailor the composite structure to meet specific load and stiffness requirements. As the angle of the fiber plies are changed, the elastic modulus, bending load, and torsional load bearing capabilities change with the ply angles. For maximum bending strength, the ply angles should approach zero. However, to maximize the torsional strength, the ply should approach 45 degrees.

Costs

Composites are considerably more expensive than steel or aluminum. Typically, steel and aluminum costs $.50 and $1.00 per pound, respectively. Graphite fibers can range from $15 to $100 per pound depending on the strength and modulus requirements. However, it is inappropriate to compare the cost of the materials alone. In general, a simple filament winding process is less costly than a metal extrusion process. Additionally, the improved survivability and durability of the composite should dramatically reduce the total life cycle costs.

Summary

In conclusion, composites offer an attractive alternative for conventional antenna mast design. In addition to the advantages of high strength and stiffness, composite antenna masts would significantly shorten erection and breakdown time. Fatigue life would be greatly extended, vibrations dampened, and corrosion would not be a problem. However, the greatest advantage of composite masts would be their damage tolerance capability. The design of composite antenna masts would be more involved but is certainly feasible given the state-of-the-art in composites.

At this time, cost is the only major disadvantage of using composites. The cost of composites is now being reduced. Thus, cost/benefit analysis should soon demonstrate that composites are an attractive alternative for the Army. For this reason, the Army's Communications-Electronics Command is actively pursuing the use of this technology in its future communications systems. Composites clearly are part of the wave of emerging technologies and are one of the top materials to consider in a variety of future Army applications.

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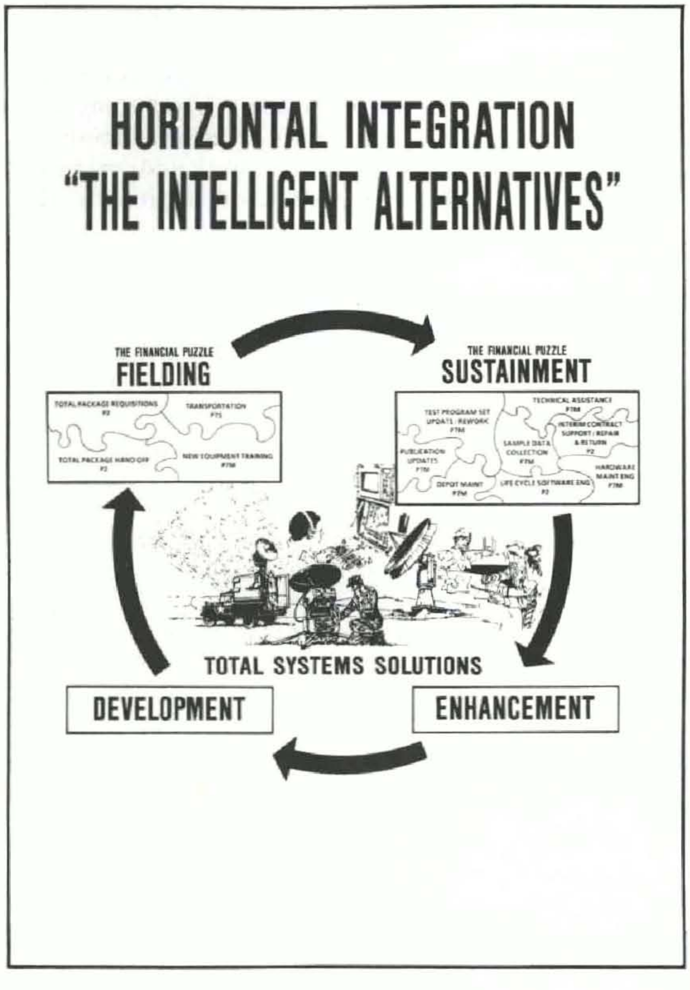

Systems Analysts...

TYING IT ALL TOGETHER AT CECOM

By Ray G. Thall

Introduction

When MG Billy M. Thomas took command of the U.S. Army Communications-Electronics Command (CECOM) at Fort Monmouth, NJ, he looked for a way to integrate the diverse functions performed by the large organizations at CECOM and to cross the appropriation "stovepipes" that funded those diverse functions and organizations.

MG Thomas' solution was to restructure the Systems Analysis Office, which reported directly to the Command Group, and to redirect its efforts toward integration of functions and resources that cut across different organizations.

Thomas' success using the Systems Analysis Office with their unique systems analysis skills has exceeded his expectations and should serve as an example for other major subordinate commanders who are faced with similar stovepipes in organizations, functions, and funding by appropriations.

CECOM'S Stovepipes

Although CECOM focuses on communications and electronics equipment to support the Army's weapons systems and battlefield communications network, its mission is split among diverse activities — research and development of new concepts and equipment, design and procurement of the equipment, fielding of the equipment, and finally, maintenance and support (sustainment) of the equipment once it has been fielded. In most cases, these functions are performed by different organizations at CECOM and financed by different appropriations. RDTE and procurement funds generally finance development and procurement of the equipment, while OMA funds finance fielding and operation and maintenance (sustainment) costs once the systems are deployed to the field.

These diverse functions are represented in the accompanying chart as a circular flow of activities to enhance and develop new systems that are then fielded and sustained in the field. The financial puzzle of activities related to the fielding and sustainment of those systems are summarized in that chart along with the appropriations involved: Total Package Fielding (P2), Transportation (P7S), Total Package Handoff (P2), New Equipment Training (P7M), Test Program Set Update/ Rework (P7M), Technical Assistance (P7M), Interim Contract Support/ Repair and Return (P2), Depot Maintenance (P7M), Publication Updates

(P7M), Life Cycle Software Support (P2), Maintenance Engineering Support (P7M), and Sample Data Collection (P7M).

Restructuring the Systems Analysis Office

Thomas looked around for an organizational structure that could tie it all together. He obviously needed a structure that was somewhat independent of the parochial interests of the organizations involved — he needed an independent "third-party," an honest broker that could give the commander an unbiased look at integration of activities and resources. He also needed an organization with experience in technical evaluation of weapon system development projects and experience in resource management and the DOD Planning, Programming, Budgeting, and Execution process.

Thomas found his solution in the Systems Analysis Office that already reported directly to the Command Group at CECOM. This Command Group perspective gave him the "independent, third-party" overview that he wanted. The systems analysts in the organization had experience in evaluating costs and benefits of individual weapon systems and management programs. Many of them had been heavily involved in the Mission Area Materiel Plan (MAMP) and the Long Range Research Development and Acquisition Plan (LRRDAP) processes — both of which had significant inputs to planning, programming, and budgeting for the RDTE and procurement appropriations.

The systems analysts had strong computer skills and computer facilities available to add the dimension of integrating programs and overseeing the OMA appropriation in this process. Thomas added some additional resource management talent by creating a Program Analysis Office staffed with program analysts that have broader resource management experience.

CECOM'S 'Talent Pool'

Historically, systems analysts and resource managers have had little interface. The systems analysts were tied up with technical mathematical problems of combat simulations, computer systems, computer programming, risk analysis, mathematical evaluations of acquisition alternatives, and cost benefit analysis of individual projects. The resource managers were tied up with the day-to-day operations of planning, programming, budgeting and executing resources.

Under Dick Caccamise, the director of CECOM's Systems Analysis Office, that has all changed. Now, the systems analysis community is getting involved in the bigger picture of resource management to ensure that CECOM's resources are integrated across appropriations, functions, projects, and weapons systems.

The systems analysts are working to ensure the balance needed for optimal utilization. Caccamise has done this by bringing together program

MG Billy M. Thomas emphasized critical components of resource horizontal integration to Dick Caccamise (right) and Bernie Price.

The challenge facing MSC commanders is to integrate programs, activities, and funding to ensure that appropriate support and funding crosses organizational and functional lines.

analysts, who are familiar with resource and program/budget issues, with systems analysts to focus on development, procurement, fielding and sustainment activities as well as the funding for those activities.

For example, Charles Plumeri, an experienced systems analyst has been looking at costs associated with tech data packages and other drivers that influence the decision to pursue a competitive procurement. Plumeri has been joined by Sam Fusaro, acting chief of the Program Analysis Group, to integrate the program horizontally and ensure that fielding and sustainment resources will be available to support the tech data packages being considered. "We've got a task force together to see what the missions are and how to focus on them. The MAMP/LRRDAP are at the heart of the effort, but Operations and Maintenance Army funding is there, too. We are now at the stage of defining the problem: Are we really doing the smart thing?"

Bernie Price, chief of the Systems Analysis Group, is working on a readiness optimization matrix at CECOM that, in a microcosm, the Department of the Army could apply on a grander scale. With the redirection of systems analysis into resource management, Price has expanded the model to relate weapon system support readiness drivers to functions and the Army Management System (AMS) codes involved. The optimization model is being redirected to include CECOM resources with Army readiness indicators.

Raoul Cordeaux, deputy director of the Plans and Operations Office, noted that, "We look at each assignment in terms of systems analysts and program analysts together, not as separate entities. This enables us to explore horizontal integration across the entire community."

The CECOM team is looking at how it can best support OMA requirements for new technology. Take the case of communications security (COMSEC). "We are interested in the long-term view of COMSEC, how CECOM should sustain it in the future, and where COMSEC is going in the next 20-30 years," Cordeaux said. Of particular interest is how CECOM may be called on to support COMSEC with different appropriations, organizations, and functions.

Other Major Subordinate Commands (MSCs)

The problem of stovepipe organizations, functions, and appropriation funding is not unique to CECOM. Most other MSCs within AMC have similar stovepipes in their organization resulting from the sheer size of the tasks and funds involved. The challenge facing MSC commanders is to integrate programs, activities, and funding to ensure that appropriate support and funding crosses organizational and functional lines.

Thomas' approach at CECOM has been well received by others. Mike Sandusky, deputy chief of staff for the Program Analysis and Evaluation Office at Headquarters, Army Materiel Command, is charged with integration and balance of resources at the headquarters level. He noted with approval CECOM's wise use of the strong analytical skills of the systems analysis community in the area of resource management. He believes that the entire AMC systems analysis community needs to rise above the macroview of resource management.

When LTG Jerry Max Bunyard, Army Materiel Command deputy commanding general for research, development, and acquisition, heard about Thomas' initiative to integrate and balance functions and resources with systems analysts, he commented that, "I would hope that all MSCs are doing this. If not, we are missing the boat."

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CAREER DEVELOPMENT UPDATE

THE DCAS RESIDENCY OFFICER-IN-CHARGE

By MAJ Charles S. Fulmore

I, like most officers, remember well that day I stood in front of a formation of soldiers and took command of my first company. Everyone had told me it would be the best job I would ever have in the Army. They were right! I have never had a job since that even came close. . .until now.

I have the good fortune of being the officer-in-charge of the Defense Contract Administration Services (DCAS) Residency in Colorado Springs, CO. Within DCAS, there are 11 residencies (with OICs). Four of those are designated as Army positions (one position is scheduled to become a Defense Contract Administrative Service Plant Representative Office (DCASPRO) 0-5 command designated position, this summer). So why is an OIC position almost as good as the "best job in the Army"?

Let me begin with the position itself. First and foremost, it is a 97B00 or acquisition management position. But, as you will see when I cover the residency's mission, as an OIC you have the opportunity to be involved with much more than just the contracts side of the house. DCAS is part of the Defense Logistics Agency and thus, the position is a joint assignment. Perhaps more important, the OICs are or soon will be designated as "joint service." Finally, and the most appealing to me, it is a line verses a staff job. You are definitely not an assistant. OICs are commanders in all but name.

The residencies fall into two basic categories; those with an area responsibility and those with a single contractor responsibility. The Colorado Springs Residency for example, is an area residency which covers approximately 12,000 square miles, over 40 different contractors, considerable product diversity, and well over 1.5 billion dollars in contracts.

The mission for both types of residencies is essentially the same: provide contract administration for those contracts delegated for administration and/or quality assurance surveillance for the company at which the residency is located or for those businesses located within the residency's geographical area of responsibility. The excitement really begins when one breaks the mission down a bit further. For a more detailed discussion of the residency mission, see the article "Dog Collars to Delta Rockets" in the March-April 1989 issue of *Army RD&A Bulletin*.

The buying activities that a residency can support range from all of the Armed Services and their various buying commands, agencies within DLA, NASA, NSA, and DCA. As an OIC, you have the opportunity to interface with numerous program managers and their staffs. Your responsibilities include establishing and maintaining working relationships with the top-level management of the companies with which the residency has business. These folks are not the captains, majors, or even lieutenant colonels of industry. They are the colonels and generals! It is a whole new experience to sit across the table from a senior vice president of a major company and assume the role of his/her business equal. They do not teach you that in CAS3 or CGSC!

The job can offer some visibility. Given the nature of defense contracting, occasionally the press has an interest in the process. As the senior DOD contracting official in the area, you may be the one they will come to for comments on an array of related topics. Additionally, you may have an opportunity to interact with certain government watchdog agencies. And finally, once in awhile, Congressional members may make inquires into certain aspects of your operation. These inquiries can be a bit more complicated than responding to Johnny's mother's concern that you and your company leadership kept Johnny in the field too long.

Of course the real gem associated with an OIC's job is that you are in a leadership position; in charge of people. A residency organizational structure can vary in size from 50-150 personnel. The grade structure ranges from GS-04 to GM-13, with a diversity of occupational specialties.

In some cases, you may have the chance to directly supervise industrial engineers, contracting specialists, property administrators, and several other occupational groups. While I have all the respect in the world for civil servants, and DCAS

DCAS (Continued)

residency civil servants in particular, being "in charge" of a substantial civilian workforce will yield every leadership challenge you faced as a company commander and a few more.

In terms of experience, the OIC position is an excellent training ground for DCASPRO, Defense Contract Administrative Service Management Area (DCASMA), or even Army Plant Representative Office (ARPRO) commands. The area residencies are essentially mini-DCASMAs and the plant residencies are mini-DCASPROs. There are some residencies as large in terms of personnel and/or value of contracts administered as some DCASPROs.

The officer-in-charge position offers a unique opportunity for officers at the 0-4 and 0-5 level in the acquisition management field. From a technical development standpoint, the residencies are truly the place to learn at where the "rubber meets the road" in the procurement process.

There is no other job out there that I know of that will give you more exposure to the entire field of DOD procurement. If you thought that being a company commander was the best job you have had in the Army, you will most certainly enjoy the leadership challenges of a DCAS officer-in-charge position.

MAJ CHARLES S. FULMORE is officer-in-charge, Colorado Springs Residency. He has a B.S. in political science from Utah State University.

MATERIEL ACQUISITION MANAGEMENT SURVEY

Results from the MAM officer occupational survey are in and preliminary analysis of the data is underway. In the next several issues of the bulletin, we will provide you feedback on the survey results. Overall, the return rate was very good; 1,042 officers responded (290 CPTs, 340 MAJs, 286 LTCs, 126 COLs).

One significant problem that was identified in the survey was attendance at the MAM Course. Most officers are not attending the MAM Course prior to their first MAM assignment; only 44 percent of all CPTs and 30 percent of all MAJs responding to the survey ever attended the course. The MAM Course is the basic qualifying school for all officers entering FA 51 and the MAM program. While quotas are becoming tight for select classes, both quotas and funding are generally available. GEN Wagner, commander, U.S. Army Materiel Command (AMC), recently reaffirmed the importance of the MAM Course for all officers in or on their way to their first MAM assignment. Major subordinate commands within AMC have been encouraged to send officers to the course TDY-and-return if the officers were unable to attend enroute to their first assignment.

Following are some MAM officer demographics derived from the survey.

Command:

AMC — 44%
TRADOC — 16%
HQDA — 13%
DOD — 6%
SDC — 5%
ISC — 3%
Other — 13%

Location: CONUS 93%; OCONUS 7%

Officers who are "6T" serving in 6T positions:

CPT — 104 (36%)
MAJ — 187 (55%)
LTC — 197 (67%)
COL — 87 (69%)

70 percent of MAM officers have an advanced degree or higher:

Management — 507 (49%)
Engineering — 214 (21%)
Science — 142 (14%)
Other — 166 (16%)

Most MAM officers are satisfied or extremely satisfied with their jobs:

Extremely satisfied — 29%
Satisfied — 50%
Neither (neutral) — 8%
Dissatisfied — 9%
Extremely dissatisfied — 4%

Sex of the survey sample:

Male — 98%
Female — 2%

MAM Survey (Continued)

Officer Retirement Plans:

Definitely plan to separate before eligible — 1%
Undecided, probably seperate before eligible — 3%
Undecided, probably serve until eligible — 12%
Definitely plan to retire as soon as eligible — 13%
Undecided, probably serve after eligible — 35%
Definitely plan to serve after eligible — 36%

Length of time assigned to present duty station:

less than 3 months — 7%
3-6 months — 18%
7-11 months — 11%
1-3 years — 60%
4-6 years — 4%

Branch Breakout:

IN — 7%	MI — 3%
AR — 8%	AG — 1%
FA — 8%	FI — 1%
AD — 9%	CM — 5%
AV — 15%	TC — 2%
EN — 5%	OD — 19%
SC — 10%	QM — 6%
MP — 1%	

Functional Area Breakout:

41 — 1%	51 — 57%
45 — 1%	52 — 2%
46 — .2%	53 — 4%
48 — .3%	54 — 2%
49 — 5%	97 — 25%
50 — .5%	99 — 2%

Knowledge of certification requirements:

Yes — 73%
No — 27%

Number of acquisition assignments:

1 — 42%
2 — 30%
3 — 14%
4 — 8%
5 or more — 6%

Total years of experience in acquisition:

less than 1 year — 10%
1 to 3 — 30%
3 to 5 — 26%
5 to 7 — 16%
7 or more — 18%

PROJECT MANAGER BOARDS

The following statistics from the three previous 0-6 Project Manager Boards are provided for your information:

FY	Number Selected	0-5 Command	Product Manager	Both	Neither Cmd nor PM
88	25	19	1	2	3
89	39	17	1	6	15
90	26	14	2	7	3

ASAP TRAINING

Under the leadership of Robert O. Black, the Army streamlining advocate, a course of instruction on the Army Streamlined Acquisition Program (ASAP) is being developed. As a part of the development effort, a series of pilot courses are being presented. The pilot courses are open, on a space available basis, to both Army and industry personnel involved in the acquisition of Army materiel. Key to success of the development effort are comments from students. Individuals who have participated in previous pilot courses have provided useful feedback that is being incorporated into the course curriculum.

The ASAP course consists of an executive overview for senior level management and 3½ days of "hands on" instruction for working level personnel that covers the Army's three front approach to streamlining: requirements, acquisition strategies, and business practices through in depth instruction of streamlining principles as they relate to each of the three fronts. The instruction is reinforced by "hands-on" case studies which require the students to apply knowledge gained in the classroom to actual programs.

Additional information about the course content, presentation dates, and locations may be obtained from Ivory Fisher, AMCDE-AQP, 703-274-5100, or AUTOVON 284-5100.

HMMWVs Complete Accelerated Corrosion Test

The Army's HMMWV (High-Mobility Multipurpose Wheeled Vehicle) has successfully completed a one-year accelerated corrosion test conducted by the Ohio-based Transportation Research Center (TRC) for the U.S. Army Tank-Automotive Command.

The aim of the test, the first of its kind ever conducted on Army vehicles, was to evaluate corrosion-prevention technology currently used in the Army's tactical fleet. The project was part of a larger TACOM-managed, long-term program to improve protection against premature rusting of tactical vehicles.

An accelerated corrosion test attempts to simulate a vehicle's normal service life in a relatively short time period by subjecting the vehicle to a controlled, highly corrosive environment. Accelerated testing does not totally reflect the actual corrosion which occurs during a vehicle's normal life, because certain corrosion mechanisms are not uniformly stepped up in a condensed time frame. But the results of such testing can be helpful in identifying potential corrosion problem areas and are routinely used by automobile manufacturers to predict how well a vehicle's design and materials will resist corrosion.

The one year TRC test was intended to simulate corrosive environments which a vehicle may be subjected to during a 15-year field service life. It consisted of subjecting each of two HMMWVs to a total of 300 18-hour test cycles on a round-the-clock basis.

Each cycle included 13 hours in a humidity chamber at a temperature of 100 degrees Fahrenheit and 95 percent humidity; a four-hour driving routine consisting of operation on cross-country terrain, gravel, mud and paved roads, as well as in salt-water spray; and a one-hour period for vehicle inspection, maintenance and, when necessary, repairs.

The test had two objectives: to evaluate the vehicle's corrosion protection and to obtain life-cycle corrosion cost data.

"The test," said Irving Warshawsky, in charge of corrosion testing in the Design and Manufacturing Technology Directorate of TACOM's RDE Center, "showed that, in general, the HMMWV's anticorrosive properties are good. But it also revealed that small improvements can be made which would result in a significant reduction in life-cycle costs.

"Areas where cost savings may be made," he continued, "include improving the corrosion protection of the HMMWV hood latch, which corroded prematurely in the test, and making the air-cleaner inlet grill more corrosion-resistant."

Joseph Jaczkowski, a HMMWV systems project engineer in the Program Executive Office, Combat Support, said efforts are now underway to assess the report and the items it identifies. This will determine if improvements are feasible and whether or not the costs associated with making the improvements would make them economically practical. He noted that some of the items identified have already been modified, independent of TRC's findings.

In light of the success of the HMMWV accelerated corrosion test, Warshawsky was asked about the prospects of such a test becoming standard Army practice. "A decision on that is still up in the air, but we think it would be good if the Army would adopt this type of testing," said Warshawsky.

"It does have value," he asserted. "This is especially true if it is done while a vehicle is still in the developmental phase, because you can see what the mistakes are before you go into production. Even if the cost savings per vehicle would amount to only $20, by correcting a mistake early, if you produce 50,000 vehicles, that's a million dollars saved — more than three times the cost of running the HMMWV corrosion test." Warshawsky said there are currently no plans to run accelerated corrosion tests on other Army vehicles.

The preceding article was written by George Taylor, a technical writer-editor for the Army Tank-Automotive Command.

DOD Streamlines Procurement of Microcircuits

The Department of Defense (DOD) and the Semiconductor Industry Association have announced a new strategy for military microcircuit manufacturing and procurement that is expected to save DOD more than $800 million annually while accelerating introduction of new technology into defense systems.

The strategy, the result of more than two years of industry and government negotiations, encourages manufacturers to become globally competitive by increasing efficiency at onshore facilities. Under the program, called Generic Qualification for Microcircuits, as manufacturers' production processes are certified and qualified, they will be listed on the Qualified Manufacturers List (QML). All products of those technology methods will be generically qualified products.

By streamlining the certification and qualification process at the manufacturer level, industry will be able to bring new technologies to market faster, improve quality and reliability, reduce costs, and extend U.S. leadership in application of state-of-the-art microelectronics in defense systems.

The key features of the QML program include the following:

- Manufacturing decisions, such as major and minor process changes, rest solely with the technology review board, which resides within the manufacturer.
- Government determines by a management audit whether the company has a stable controlled process including integration of design, fabrication, and assembly of microcircuits.
- A certified line may produce a variety of qualified integrated circuits with only one audit. Systems manufacturers will not be required to re-audit a QML facility as long as the method remains under control.
- The manufacturer will have flexibility to become more globally competitive through a program of continuing improvement in his own process.

Microcircuits (Continued)

• The market will be concentrated among the high quality manufacturers thereby increasing their loading of qualified lines and further improving quality and reliability while lowering cost.

• The program is being institutionalized in the semiconductor industry. First sites nearing completion are at General Electric and AT&T. The second part of the program, which now includes Intel, Harris, GE Solid State, Texas Instruments, National, VLSI Technology, and IBM, was started in October 1988 and will be completed by 1990. Several QML lines are expected to be producing QML parts by mid-1989.

• A plan is being developed for manufacturers to transition Qualified Parts List products to the QML program.

• The program will serve as a model for non-military customers who want the highest quality at the lowest price. It will facilitate future transition to a national standard for manufacturing of integrated circuits.

Ultimately, the use of generic qualification and QML listings are expected to be employed in other product areas based on the model developed for microcircuits.

Besson Memorial Award Cites Procurement Excellence

The Frank S. Besson Memorial Award for Procurement Excellence, sponsored by the American Defense Preparedness Association (ADPA), has been presented to three Army Materiel Command (AMC) contracting and acquisition careerists for improving the acquisition process during the period Oct. 1, 1987 through Sept. 30, 1988. Named in honor of AMC's first commanding general, the award was presented during a special ceremony at the Atlanta XV Army/Industry conference in Atlanta, GA.

Comprised of a plaque and a $500 check, the Besson Award recognizes one individual in each of three categories — civilian, military, and career intern. The purpose is to cite individual achievements for innovative acquisition planning, procurement policy improvement, reduction in contracting lead time, increasing competition, achievements in spare parts breakout, and exceptional procurement production management methods.

This year's awards were presented by AMC Commander GEN Louis C. Wagner and ADPA President LTG Lawrence F. Skibbie (USA Ret.). Recipients and their achievements are:

Charles A. Comaty, a contracting officer, with the U.S. Army Armament, Munitions and Chemical Command, was cited for his outstanding and innovative acquisition planning. His efforts led to a significant reduction in contracting lead time for the Nuclear, Biological, Chemical Reconnaissance System Program and the U.S. Army Chemical Research, Development and Engineering Center mission support contracts. The success of these contracts served as an example for other AMC subordinate commands to adopt similar contracting procedures for mission support.

MAJ Kevin R. Knotts demonstrated outstanding leadership as chief of the U.S. Army Tank-Automotive Command's Trailer Section in the Logistics Vehicle Systems Division, Directorate for Procurement and Production. He applied a variety of innovative contracting and management initiatives to correct a backlog of late deliveries and non-performance. He forged a team concept, both within the government and with industry, that has resulted in timely contract deliveries and expanded participation by responsible small business and small disadvantaged firms.

Tyrus M. Dorman, contracting and acquisition intern at the U.S. Army Missile Command, was recognized for his exceptional performance, sound business judgement and procurement proficiency. As a member of the ad hoc committee responsible for developing the overall strategy competing the command's Installation Support Services Program, he prepared solicitations ana other documents during the source selection process for maintenance of automatic data processing equipment. His expertise in acquisition planning resulted in a quality and cost effective contract.

Jain Chosen as Federal Engineer of the Year

Dr. Ravi K. Jain, an employee at the U.S. Army Corps of Engineers Construction Engineering Research Laboratory (CERL), Champaign, IL, has received the Federal Engineer of the Year Award for 1989. This is the first time ever that a U.S. Army engineer has received this honor.

The award is sponsored by the National Society of Professional Engineers and has been presented annually for the past 10 years to recognize contributions of engineers employed by the federal government. It is comprised of a plaque and an honorary citation. Dr. Jain was chosen from among more than 30 other nominees from all federal agencies employing a substantial number of engineers.

Dr. Jain is an internationally recognized engineer with over 25 years of experience and a distinguished record of accomplishments in engineering R&D management. He was specifically cited for developing innovative design procedures, laboratory and university R&D efforts, and for research management.

MICOM Scientist Receives WISE Award

Dr. Ann E. Stanley of the U.S. Army Missile Command's Research, Development and Engineering Center, Redstone Arsenal, AL, has received the 1988 Women in Science and Engineering (WISE) award for Scientific Achievement. She was presented the award by Dr. Janice L. Lucas, WISE national chairperson, during a luncheon earlier this year at the WISE Eighth National Training Conference in Rosslyn, VA. Assistant Secretary of the Army for Research, Development and Acquisition Dr. J.R Sculley also presented her with a Certificate of Achievement at the Pentagon.

MICOM (Continued)

In addition, Dr. Stanley also received, during a ceremony at HQ, Army Materiel Command (AMC), the AMC Certificate of Recognition from AMC Deputy Commanding General for RD&A LTG Jerry Max Bunyard.

The WISE award is presented annually in recognition of a special scientific or technical contribution by a woman scientist or engineer in the federal service and to promote the entry of young women and/or the advancement of women in science and engineering. The award consists of a plaque and an honorary citation.

Dr. Stanley was honored for her work as a pioneering investigator in the use of lasers to induce precise and controlled chemical reactions. She demonstrated the capability of laser radiation to deactivate certain lethal chemical agents. She is currently involved in making ultrapure materials for varied applications. The industrial state-of-the-art is such that current materials limit system performance and are the leading cause of inadequate production rates. In addition, Dr. Stanley has shown how these techniques can be applied to certain environmental pollution problems.

AMC Names Engineer of the Year

Dr. Jay S. Lilley, a research aerospace engineer in the Propulsion Directorate, U.S. Army Missile Command, has been named the U. S. Army Materiel Command Engineer of The Year for 1989. He competed with engineers from throughout the command for the AMC award.

As the AMC Engineer of the Year, Lilley also competed with nominees from 38 government agencies for the Federal Engineer of the Year Award, sponsored by National Society of Professional Engineers. He was one of the top 10 contenders for this award.

Dr. Lilley's achievements include significant contributions in the fields of solid rocket interior ballistics, nozzle analysis and design, and airbreathing propulsion. He has published a number of significant papers on side-exhausting nozzles. His work in this area is so new that it is considered on the "cutting edge" of technology.

Dr. Lilley has been awarded patents for outstanding work in his technical field. In addition, he designed and developed a solid fuel ramjet direct connect test facility and a personal computer-based data/acquisition/control system.

CONFERENCES

Operations Research Symposium Planned

The 28th U.S. Army Operations Research Symposium (AORS XXVIII) will be held Oct. 11-12, 1989 at Fort Lee, VA. About 400 government and industry leaders are expected to participate in the event.

The theme of this year's symposium is *Maximizing Army Effectiveness.* Reports of new work will be presented followed by discussions on how it meets the needs of future analytical challenges.

Attendance will be limited to invited observers and participants. Papers are being solicited which address the theme of the symposium. Selected papers and presentations will be published in the proceedings.

The U.S. Army Operational Test and Evaluation Agency (OTEA), commanded by MG Jerome B. Hilmes, is responsible for the overall planning and conduct of AORS XXVIII. For the 16th consecutive year, the U.S. Army Logistics Center, the U.S. Army Quartermaster Center and Fort Lee, and the U.S. Army Logistics Management College will serve as co-hosts.

Inquiries pertaining to the symposium should be directed to: Commander, U.S. Army Operational Test and Evaluation Agency, ATTN: CSTE-ZT, Park Center IV, 4501 Ford Ave., Alexandria, VA 22302-1458. Telephone inquiries should be directed to LTC Neal Jensen, AV 289-2367 or commercial (202) 756-2367.

Changes to Publication Distribution System

After Sept. 30, 1989, all unit and agency requests for *Army RD&A Bulletin* which are ordered through the Army Publications Distribution Center in Baltimore must be submitted on DA Form 12-99-R (DA Form 12 Series Subscription Change Sheet). If your unit's publication requirements have not been validated and reported by Sept. 30, your publications accounts may be terminated. To prevent a lapse in receiving *Army RD&A Bulletin*, be sure to inform your local printing and publications control officer of the number of copies that you require.

For *Army RD&A Bulletin*, "Form number" is 12-05, and "Block number" is 0035. Send completed 12-9 forms to: Army Publications Distribution Center — Baltimore, (ASQZ-BDC), 2800 Eastern Blvd., Baltimore, MD 21220-2896.

Should you need further assistance, contact Dave Johnson, at (202) 325-6232, or AV 225-6232.

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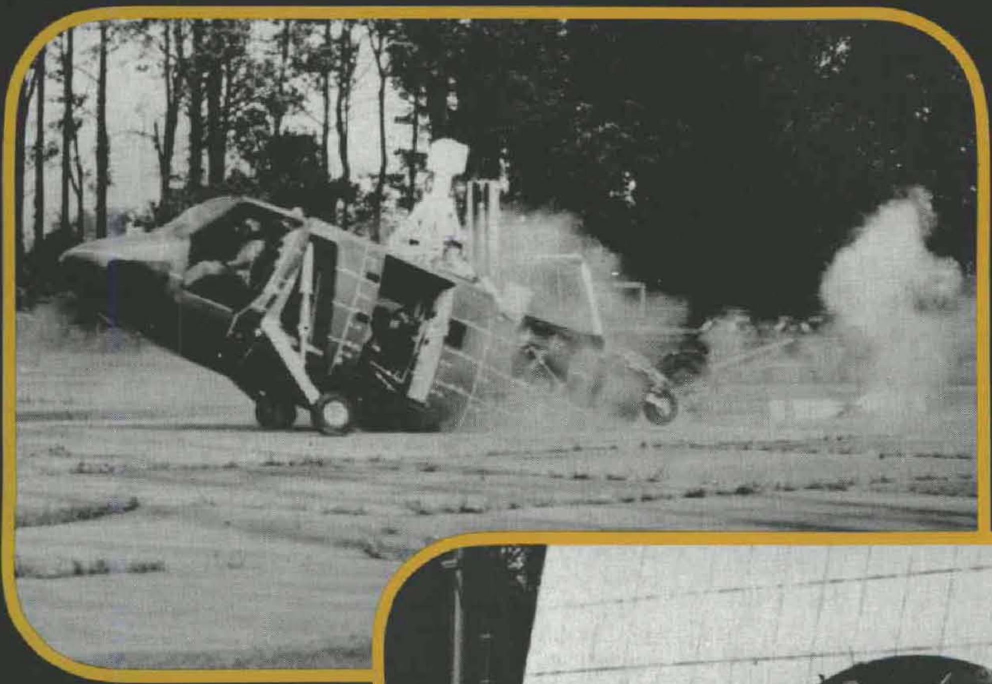

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