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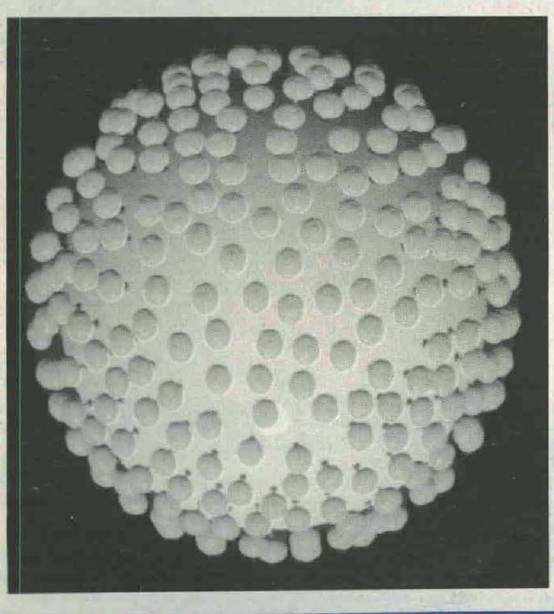
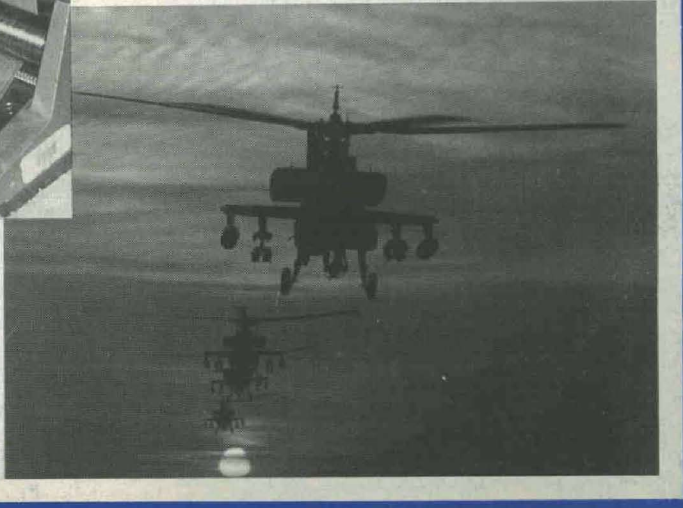
PB 70-91-4

ARMY RD&A BULLETIN

JULY - AUGUST 1991

50 Years OF ARMY R&D





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ARMY RD&A BULLETIN

Research Development Acquisition

Professional Bulletin of the RD&A Community

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COVER

A sampling of Army technology during the past 50 years is shown on the cover. Clockwise from the top: the Jupiter C rocket; ENIAC, the first digital computer; the Apache helicopter; expanding healthy skin for burn-patient treatment; and a computer model of HIV, the causative agent in AIDS.

ARMY RESEARCH AND DEVELOPMENT: 50 YEARS OF ACHIEVEMENT

By S. Paul Klein

The United States Army, like the Republic it serves, is constantly evolving to prepare for and meet the demands of today and the challenges of tomorrow.

Throughout its history, the Army has looked at the needs of the soldier, the requirements of combat, and the lessons of history as opportunities to improve every element of military service. Man or machine, man and machine: both couplings dictate change as the needs and realities of war and peace change.

In the early years as America expanded, needs developed slowly and were met by minor changes in uniforms, rations, weapons, and strategy. When the world began to expand rapidly, when our responsibilities began to reach beyond our borders, new demands were met with increasingly resourceful responses.

As America approached the middle of this century, we found ourselves in a role befitting the most successful and powerful nation of modern times. Suddenly thrust into our global role on Dec. 7, 1941, our ability to recover, to respond, and to win was immeasurably aided by the research and development capability already existing in both the Army and private industry.

That is the story told in a new booklet being distributed by the Office of the Deputy Assistant Secretary of the Army for Research and Technology: of problems large and small, often of daunting severity, many times of a simple but universal nature, met and solved by scientists and engineers in uniform and civilian clothes, working in industry, academia, and government.

We have chosen a 50 year span, beginning in 1940, because the accomplishments in that period include things that have changed the world forever and left us prepared to meet the future. It is also the period which marks the true beginning of organized, managed, and directed research and development in the Department of Defense. We have included, too, a look at the world of tomorrow as our soldiers will see it, confident that Army research and development will prepare and protect them.

A number of key areas, some resulting in major technological achievements, have been singled out based on their relevance to military needs, and their contributions to society as a whole. The first of these is nuclear energy.

A New World is Born: Nuclear Energy

Certainly, there has been no greater impact on the world than America's harnessing of the atom. Spurred by developing technology in Europe, military planners quickly realized the potential for weaponry in the hands of those who would first succeed in creating a nuclear chain reaction. Called the "Manhattan Project," under the Corps of Engineers, the work brought together scientists and engineers of international repute, directed by Army planners and visionaries.

The Manhattan Project produced an explosion — not only of the two atomic bombs, Fat Man and Little Boy — but also an explosion of knowledge that has since acted as a catalyst for the development of innovative fields such as nuclear medicine, lasers, fiber optics and X-ray imaging. Literally thousands of patents were issued to the government, and many new industrial processes were developed as a result of this work.

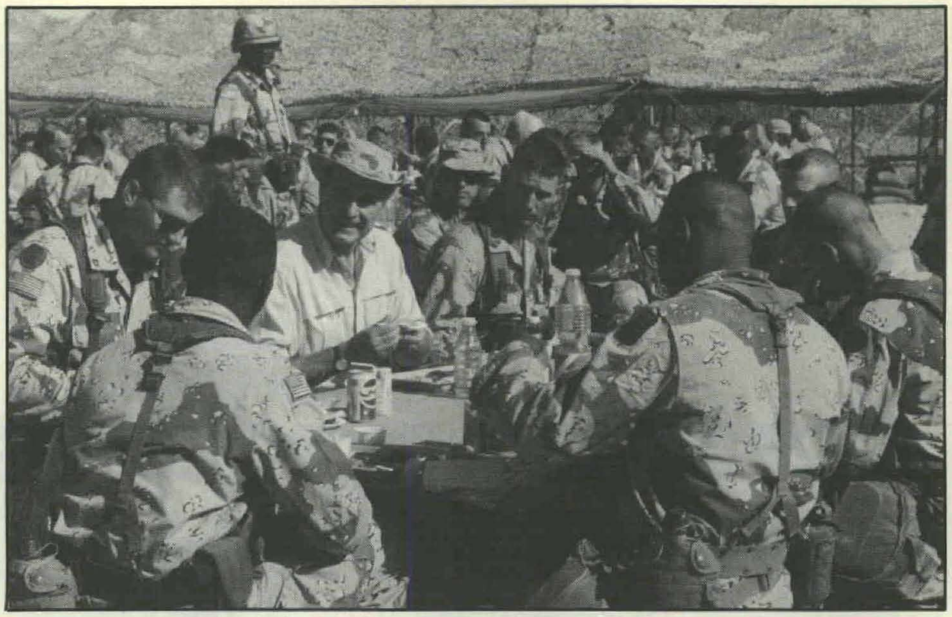
With the identification of new elements, and the ability to create additions to the periodic table, the outer limits of man's knowledge were significantly expanded. At the same time, the need became apparent for greater knowledge of man himself.

Arms and the Man: Personnel, Classification and Assignment

Today's battlefield, with its "star war" technology and advanced tracking and protection equipment, is really nothing more than an enhanced environment for the most important element of all — the soldier. Without soldiers, there is no Army and no defense. But soldiers aren't just men and women in uniform. They must be the right men and women, suited to the job to be done and trainable for future tasks to be accomplished. How does the Army find these men and women?

The selection process depends on a comprehensive set of characteristics in more than one category. Proficiency, temperament, and spatial and psychomotor dimensions can be measured and evaluated. Proficiency looks at elements specific to a particular job and elements common to all enlisted assignments. Temperament measures achievement, discipline, and stress tolerance.

ABLE, or assessment of background life experience, is the name given to the test for temperament dimensions. It can predict disciplinary problems, leadership ratings, and attrition far more effectively than previous tests. Object orientation, locations, shape, and eye-hand coordination are the spatial and psychomotor dimensions measured. At a time when the United States lags behind foreign competitors in many industries, a tool to aid in matching applicants to jobs could provide a needed boost to our national economy.



Thanksgiving for troops in the Persian Gulf meant not only a traditional turkey dinner but also a chance to meet the commander-in-chief.

Preparing for the Challenge: Vaccines, Drugs, Blood and Burn Treatment

Since the beginning of recorded history, more wars have been lost to disease than to enemy weapons. Vaccination to prevent disease and the development of drugs for treatment have played major roles in national defense. No period has been more impressive than the past 50 years.

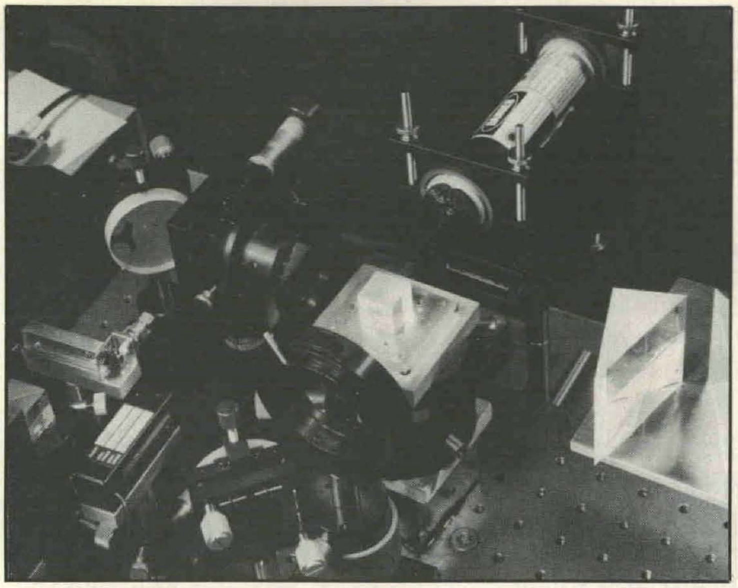
From the training camps to the combat zone, our soldiers have been the

TIM

1940	1950	1960
Proximity fuze	Iodine tablets for individual water purification First specific cure for typhoid fever First synthetic quartz BRL patented ENIAC, first digital computer First supersonic wind tunnel Atomic bomb fielded Helicopter first flown Engine for first American jet fighter Whole blood preservation	Global standard for time measurement Photolithographic process for printed circuit boarc First weather/communication satellite Solar cells for satellites Redstone rocket - Army first in space Turbine power for helicopter Dehydration/freeze drying of foods made practica Mouth-to-mouth resuscitation Image intensifier scope T1-6A1-4V titanium alloy for aircraft

beneficiaries of the advancing technology developed by Army medical researchers. Their work has meant fewer man days lost in basic training, and fewer soldiers sidelined in war time because of preventable sickness and disease. These same research programs have placed chemical protective measures within reach of every soldier, and today offer the potential of leading edge solutions to diseases like AIDS.

Two other areas of medical knowledge have their roots in Army research and development: blood transfusion technology, and the care and treatment of burns. Here again, Army researchers have led the way for more than 50 years. New frontiers, such as skin grown from a few cells scraped from unburned skin, and blood made entirely in the laboratory are two major projects underway today in Army medical research and development labs.



The helium neon laser, one of the first lasers invented, is used in an experiment for digital image processing.

An Army Travels on its Stomach: Food Technology

Soldiers have always complained about the food. Civil War soldiers subsisted on hardtack and salt pork. World War II soldiers depended on canned C rations. But today's combat soldiers can enjoy nutritious and tasty ready-to-eat meals in a pouch. Someday American favorites such as pizza and hamburgers may be possible in field conditions. It's amazing how a good meal can raise morale. Finding ways to make good food better has been one more of the benefits of Army research and development. And many of those new technologies, like dehydration and freeze drying, have found their way into kitchens and campsites all over the world. Of course, it probably won't stop the complaining, but that is something no research will cure!

Getting There and Back: Helicopters

With the modern soldier better prepared in every way to go to war, it is not surprising that a concomitant amount of research has gone into getting him there and back. Helicopters, as recently as 1939 still considered experimental, have over the last 50 years thrust their way to the front of the battleline. Army research developed turboshaft power, the control and the construction technology that has made the "chopper" the fearsome weapon and merciful deliverer it is today. From air assault to medivac, helicopters are as ubiquitous today as the Jeep was in World War II.

A Shield to Match the Sword: Ballistic Protection

A healthy soldier, properly matched to the task, well fed and well trained, delivered where and when needed, must also be protected. Research and development efforts to produce ever lighter armor, capable of providing personal protection or deflecting a

LINE

1970	1980	1990
Meningitis vaccine	Reverse osmosis water purification	AIDS diagnostic and staging schemes published for wide usage
Individual & vehicle ceramic armor	Frequency hopping radios	Skin decontamination kit
Inertial surveying for field artillery	Fiber optics applications: fly by-light, FOG-M & communications	Anticonvulsant therapy for soman nerve agent/nerve agent antidote
Freeze dried compressed foods	Lightweight, flexible body armor	Ballistic-laser protection spectacles/goggles
Fast fourier transform	Meals, ready to eat (MRE)	High precision missile terminal imaging
Sulfamylon, an antibacterial cream for treatment of burns	High burn rate solid rocket fuel technology	Mefloquine antimalarial drug
First starlight scope	First practical tilt rotor technology (XV-15)	All composite helicopter airframe
Laser rangefinder	Composite rotor system	Image processing
Rubella virus (German measles) isolated	Superlattice electronics	Personnel selection, classification & assignment for volunteer Army
Laser semiactive guidance invented	1st generation thermal imager	Wire strike protection system

missile from a battle tank, has not gone unrewarded. Army labs, using commercially available fibers like Kevlar, and transparent materials like polycarbonate, have given the soldier of today as much protection as knights of old had against the weapons of their time. Combinations, unique designs, creative use of existing materials have resulted in better, lighter helmets, body armor, eye protection, and safer tanks and personnel carriers, to give the soldier every possible advantage.

Accelerating Change: Digital Computers

For the man aiming an artillery round, knowing in advance what the trajectory of a particular load will be is a definite advantage. In 1942, the calculations necessary to build a ballistic firing table for a new weapon required a minimum of three days for each trajectory. The full table could take months. With the reduction of that time as a goal, the Army funded a group of experts to develop a machine that would perform the task in seconds instead of hours. ENIAC, the electronic numerical integrator and calculator, was the result. It took three years to produce, weighed 30 tons, was 80 feet long and filled a 30 by 50 foot room. Its 18,000 vacuum tubes were joined by half-a-million solder joints and connected to 70,000 resistors. It was the world's first digital computer. It could calculate a 60 second trajectory in 30 seconds; a job three technicians using manual calculators needed 20 hours to accomplish. Today, a pocket calculator has more capacity and greater speed than ENIAC, and is more easily programmable. That, too, has its roots in Army driven research and development.

Reducing Our World: Printed Circuits

When we refer to a technological explosion, we don't often mean it quite as literally as when we refer to the advent of the printed circuit, but that is just about what happened. The time was the beginning of World War Two, and the need was for a projectile that didn't need to strike a target to detonate. Army and civilian scientists collaborated to design and build the first proximity fuse: one that would sense the spatial relationship with a nearby object and then ignite the charge. In order to package the electronics required, engineers hit on the idea of making the small electrical circuits using photolithography, and the printed circuit was born. All of the microelectronics we take for granted today resulted from that creative application of existing technology.

Smaller and Smaller, Faster and Faster: Nanoelectronics

Still, there are newer, and smaller, worlds to conquer. Just as the technologies of computers and printed circuits combined with transistors to produce what is known as "microelectronics," so the newly emerging technology of nanoelectronics has taken those elements, as well as chip technology, integrated circuits and other advances to produce devices the size of a few atoms! So far, the Army holds seven patents in nanoelectronics, and that in itself is no small feat. This technology will bring us a giant step closer to instant data acquisition and processing: something the future battlefield may well demand.

Touching the Stars: Laser Applications

Precision is another demand we can expect in warfare. Precision which will allow placement of a missile with true surgical sharpness, or the placement of an individual soldier within a footfall of where he is supposed to be. Light amplification by stimulated emission of radiation, LASER, is another development driven by Army requirements, engineered through Army research, that is pointing toward that perfection. The laser rangefinder, for example, was the first lightweight, portable device of its kind, and provides accuracy to within a few feet over very long distances, and is now a common tool for civilian surveyors.

Army contributions to the development of lasers has reached into communications, medicine, strategic missile defense, and even education and entertainment. And there are more applications on the horizon.

Eyes Like a Cat: Night Vision Devices

To help see the horizon, and what lies between it and the viewer, has been

Administration of the Army Alpha test, circa 1917, took place in less than favorable conditions. It was the first written selection and classification test used for mass testing.

Recognized worldwide as innovators in ballistic protection, the U.S. Army advises the secret service regarding protection for the president of the United States.

the work of the Army's night vision researchers. Darkness can hide an enemy just as fog and smoke can cover a troop movement. But for a soldier aiming a weapon or guiding a vehicle, lack of vision brings confusion, error and delay. By amplifying available light as much as 20,000 times, special goggles allow objects to be seen clearly when, to the naked eye, the brightest light around is a partially obscured star. And what about when there is not even star light? Thermal imagers can capture the heat objects give off as infrared radiation and use the information to form images without reference to the visible spectrum. Like the military, civilian law enforcement agencies have been quick to adopt these devices, increasing further the value of the Army's patented technology.

Seeing the Unseen: Image Processing

Eventually, all of this technology begins to come together, as we approach the end of the 20th century. Printed circuits, computers, nanoelectronics, lasers, night vision devices and another Army inspired technology, image processing, are the very fabric of the future. Information gathered and transmitted to earth stations as electronic bits and pieces can be converted, by image processing, to not just recognizable pictures, but pictures of incredible clarity and extraordinary detail. Whether looking at the back side of a distant planet, or the "hidden" area of an enemy installation, this technology is already capable of seeing the unseen. It remains only to position devices capable of recording the images in exactly the right place to bring the information home. And there the Army has been in the vanguard for most of the last 40 years.

Looking and Listening: Application Satellites

When President Dwight D. Eisenhower used the first communications satellite to beam a New Year's message to the world, an Army rocket put it there. When the first rocket with a controlled flight path lifted off, it was guided by an Army designed inertial guidance system, truly a first for the world's burgeoning space program.

Today, rockets and satellites are a part of our everyday lives, giving us eyes in the sky with which to track and report weather, astronomical phenomena, and, more to the point, ground activity by military organizations virtually anywhere in the world.

Communications, observation, protection and retaliation have always been part of the military equation. Today they are accomplished with a great deal of help from Army research and development programs in technological areas not even begun 50 years ago.

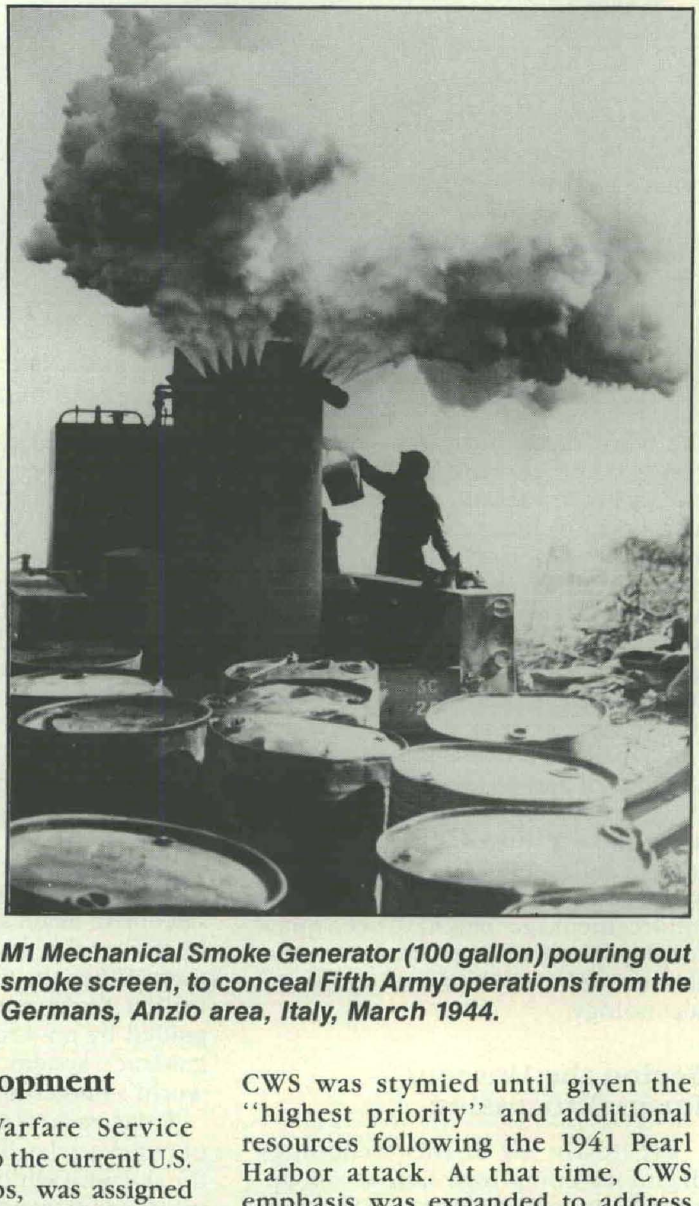
A New World Again: Research for the Soldier of the Future

Whatever the military needs of the future, there will also be scientists and engineers to provide them. What we must not allow to happen is for that capability to slip into disuse, to atrophy and be overtaken by others who don't have the needs and perspective of the Army interwoven with their immediate goals and objectives. For 50 years, Army research and development technology has led the nation in war and peace. It is a national resource known and respected in every branch and discipline of science and engineering — one we cannot afford to put aside. The future calls our name, and we must answer.

S. PAUL KLEIN is associate director for communications, Walter Reed Army Institute Research. He is a 1956 graduate of American University, where he majored in mass communications. He joined the WRAIR in 1965, after several years as a film writer in both government and industry.

LARGE AREA SMOKE TECHNOLOGY

By LTC John D. Gorrell



M1 Mechanical Smoke Generator (100 gallon) pouring out smoke screen, to conceal Fifth Army operations from the Germans, Anzio area, Italy, March 1944.

Background

Dating back to antiquity, combat commanders have envisioned smoke as a combat multiplier, capable of providing large area cover and concealment for troop movement and concentrations. However, smoke has also been acknowledged as a "two edged sword," and unless properly employed, "that damned smoke" may just as easily serve to hinder defensive operations or blunt offensive maneuver.

Historical Development

The Chemical Warfare Service (CWS), predecessor to the current U.S. Army Chemical Corps, was assigned primary responsibility for the technical aspects of large scale smoke screening shortly after its activation in 1918. Lacking sufficient personnel and monetary resources, the CWS concentrated its early smoke efforts on development of hardware. Unsuccessful in its initial attempts to develop effective smoke agents or means for dissemination, the CWS was stymied until given the "highest priority" and additional resources following the 1941 Pearl Harbor attack. At that time, CWS emphasis was expanded to address general doctrinal principals and techniques associated with smoke screening in addition to its equipment/hardware development activities.

While many pre-World War II theories on the doctrinal use of smoke had been developed, "combat experimentation" would serve U.S. forces as the primary method for developing its smoke doctrine and for identifying user equipment needs. By 1940 the CWS, in conjunction with the National Defense Research Committee (NDRC), had begun experimenting at Edgewood Arsenal, MD, with various burning and mechanical smoke generators to produce more efficient large smoke screens.

Initially conceived as a "passive defense" measure, commercially procured "smudge-pots," then designated as the M1 "stationary" oil burning generator, were adopted for U.S. use. M1s were employed within the U.S. Western Defense Command and along the Panama Canal and Sault Saint Marie locks to counter potential air threats to these large area strategic targets.

According to emerging doctrine being developed for newly activated chemical smoke generator companies, multiple M1s were positioned in two or more concentric circles around the "smoke target." While labor and equipment intensive, this tactic allowed the smoke company to respond rapidly to changes in wind direction and speed, and counter the inherent slow build up time associated with the generator's screening capability.

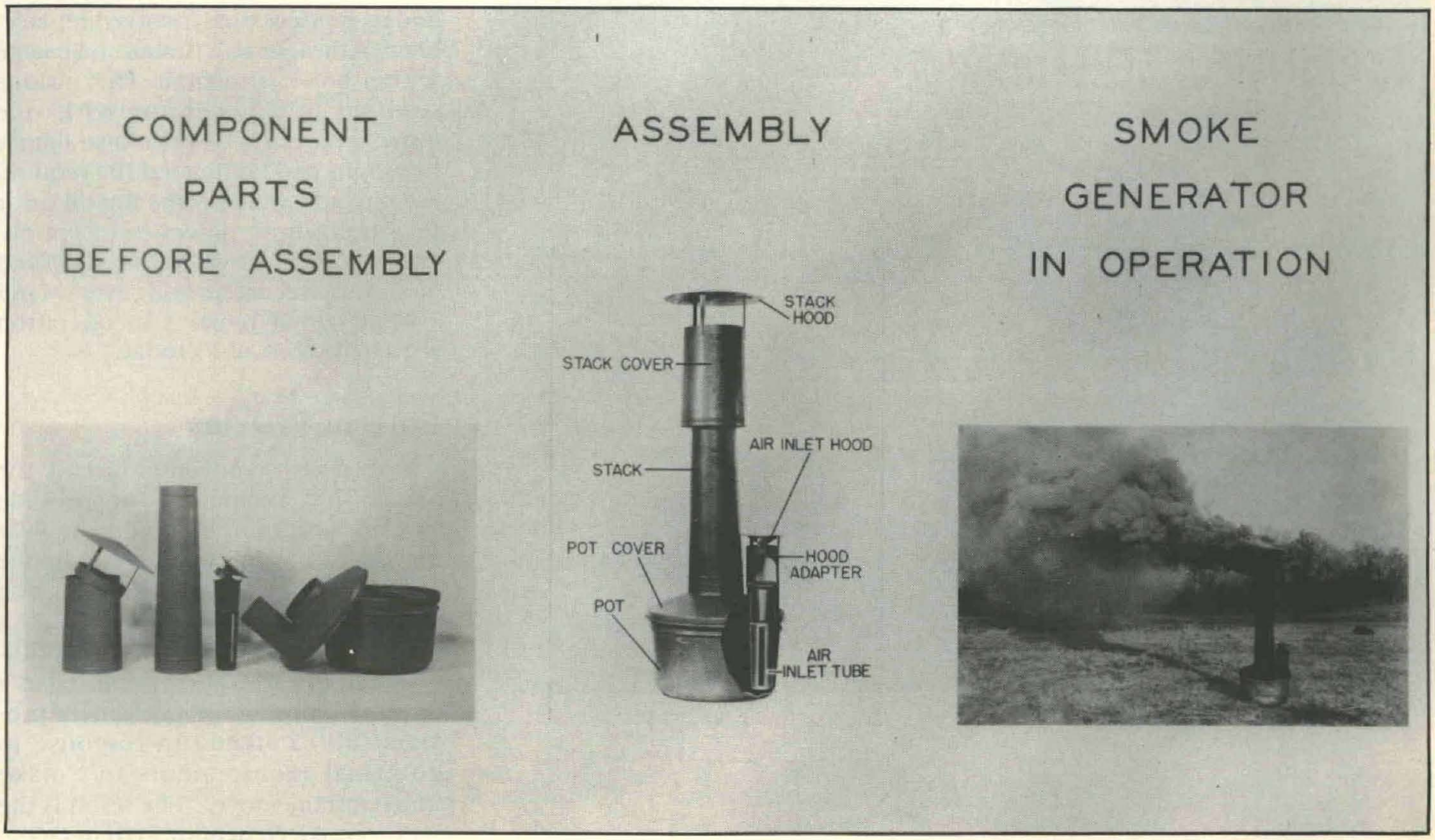
Early World War II experimentation by U.S. forces to define large area smoke doctrine led to basic conclusions that smoke used at dusk, dawn or during night tended to confuse attacking enemy aircraft while smoke used during daylight tended to accentuate location of friendly operational areas, resulting in the smoke points becoming easy targets. Concerns over whether large area smoke would serve as a help in concealing rear area and port operations from enemy attack or be a hindrance to the air and artillery defense of the facilities surfaced repeatedly during combat operations throughout the Mediterranean and European Theatres of Operation.

Responding to these concerns, the CWS rapidly developed techniques to reduce smoke coverage, making light smoke hazes over these large area facilities. This tactic caused enemy aircraft target acquisition to be severely degraded while ground defenses were able to conduct their missions with little interference. Combat commanders soon realized that smoke could "complement, not compete" with their combat operations.

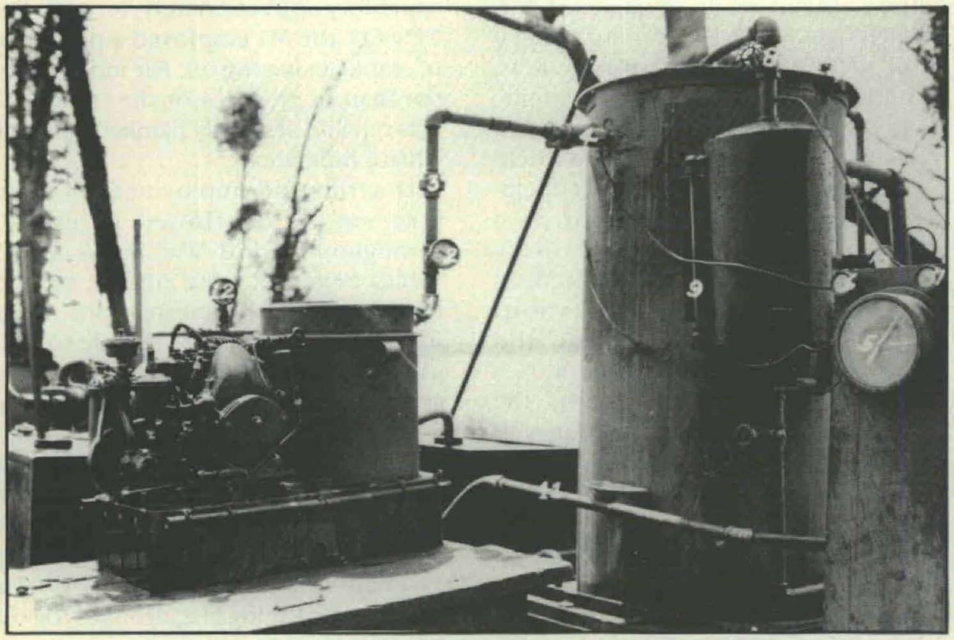
In September 1942, the M1 "mechanical" smoke generator, a behemoth at 3,000 pounds, was fielded to smoke units, providing the U.S. with its first effective, large area smoke generation capability. Affectionately termed the "ESSO," the M1 employed a new type of smoke using fog oil. Far more effective than its predecessor, the "new" M1 was capable of rapidly blanketing a four square mile area.

Doctrine for employment of large area smoke continued to evolve throughout World War II. As Allied forces began moving inland, smoke took on new, front-line missions. Need for a lightweight, more mobile smoke generator became imperative. Immediately preceding D-Day, the M2 generator was fielded to U.S. chemical smoke and decontamination units. Weighing only 172 pounds, the M2 was capable of making smoke within one minute of start up and drew fog oil from an external source (usually a 55-gallon drum), consuming 50 gallons of fog oil per hour of operation.

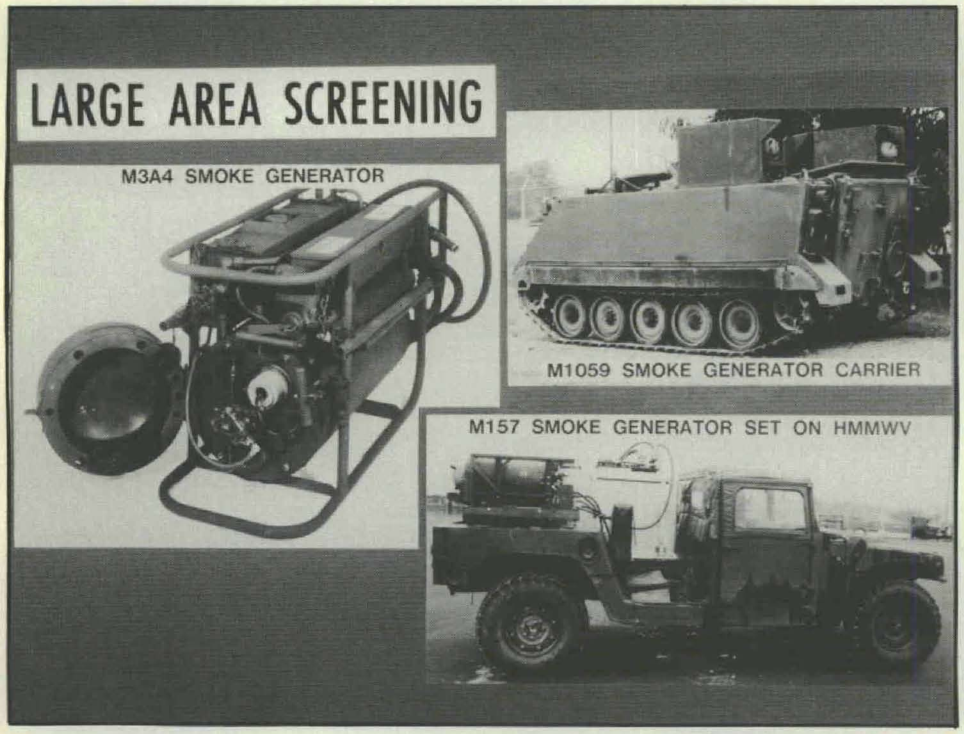
Augmented by smoke pots and mortars, the M2 provided a highly mobile, man portable smoke platform which



Generator, oil smoke, M1 (stationary).



M2 connected to the condenser on the test stand.



saw extensive use during WWII bridging and river crossing operations and in screening main supply routes. Doctrinal lessons derived from river and port operations pointed out the need to develop procedures for "localized" command and control of smoke generation and a continuing requirement to plan for smoke points surrounding (360 degrees) the smoke target area in response to changes in the prevailing winds.

Not limited to the Mediterranean and European Theatres of Operation, M2 smoke generators and A-20 aircraft equipped with M10 smoke tanks were used extensively in the Pacific Theatre to screen beachheads, port facilities and airborne operations.

In response to user requirements, smoke system development has progressively stepped toward lighter weight systems having more reliability, fewer moving parts, and fewer types of liquids. The M3 (series) smoke generators, first fielded during the Korean conflict in 1952, are indicative of this "systematic, evolutionary" approach to improve existing smoke system technologies to meet documented battlefield deficiencies.

The key difference between the M3 and its predecessors involved replacement of the internal combustion engine with a pulse jet engine. This change resulted in a generator with one moving part. The M3 was also lighter in weight and eliminated the requirement to add water to the fog oil prior to vaporization. Since its inception, the basic M3 design has seen several modifications, culminating in the M3A4 system which remains in operation with many U.S. units today.

Current Systems

Doctrinal requirements call for developing a capability to provide smoke in support of highly mobile forces and coincidentally enhance smoke system survivability by reducing susceptibility to being targeted as a point source. The most recent modification to the M3 system occurred as a result of a product improvement program (PIP) initiated in response to doctrinal requirements to "make smoke on the move." The result is the M157 Smoke Generator System (SGS), type classified in 1985.

The wheeled version of the M157 employs two M54 (M3 generators modified for a mobile smoke capability) smoke generators mounted on an M1037 High Mobility Multipurpose Wheeled Vehicle (HMMWV). The system includes an 80-gallon fog oil tank, the M284 mount, and is capable of making one hour of continuous visual smoke.

The tracked variant, the M1059, consists of two M54 generators with a 120 gallon fog oil tank mounted in a modified M-113 APC and is able to produce visual smoke up to one and a half hours. Fielding of the M1059 (276 systems) was completed in August 1990. To date, 227 M157s have been fielded. Additional fieldings for USAREUR are scheduled in Fiscal Year 1992. A proven winner, as demonstrated during Operations Desert Shield and Storm, the M157/M1059 SGS has the reliability, mobility and maneuverability to support the force in low, mid or high intensity conflict.

Future Systems

The XM56 Large Area Smoke System (LASS) is currently in 6.4 engineering development. This system will replace the M157 and M3A4 systems. Modular in design, the XM56 will provide a visual through far infrared (IR) screening capability. Unlike the M3 (series)/M157 generators, the LASS will rely on a turbine generator to disseminate singly or simultaneously, up to one hour of fog oil and a half hour IR obscurant without refueling.

The XM56 will be mounted on the M1097 HMMWV and is expected to be type classified in the third quarter of FY94. A preplanned product improvement (P3I) program is planned to add a modular, millimeter wave (MMW) obscurant screening capability.

The Large Area Mobile Projected Smoke System (LAMPSS) development program will incorporate enhanced XM56 technologies to provide one to two hours of large area screening in the visual through MMW electromagnetic spectrum. LAMPSS will also provide a first ever, integral smoke projection capability, designed to augment existing mortar and artillery smoke capabilities.

LAMPSS will be capable of producing two to four projected, visual smoke screens between 500-6000m. LAMPSS will also include a multi-spectral (IR/MMW) obscurant projection capability when available. Currently in 6.3 engineering development, LAMPSS is planned for type classification in 2002.

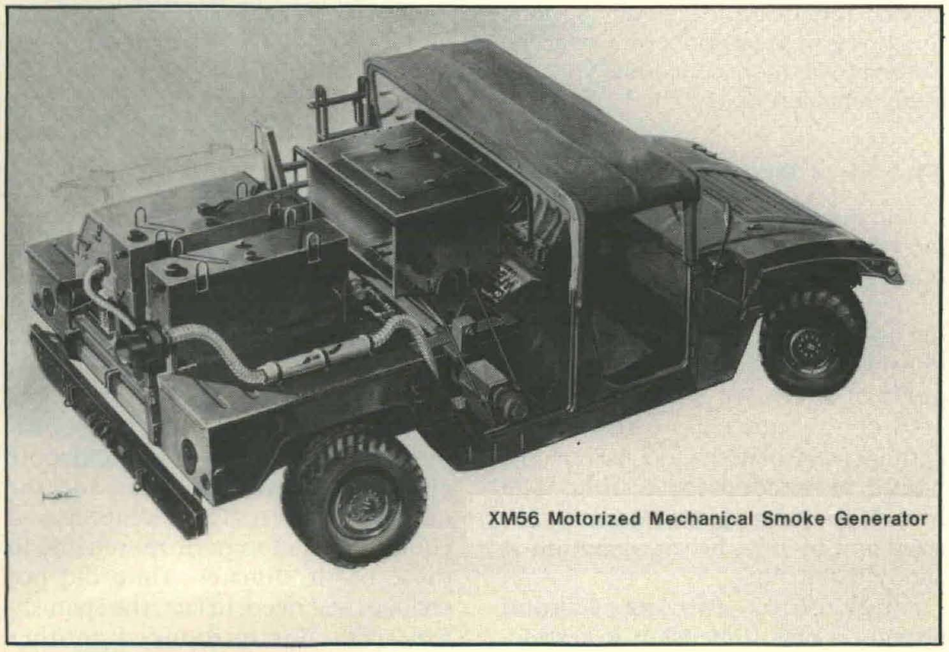
Conclusion

First generation large area smoke generators severely lacked in their combat mobility and agility to respond to changing battlefield and meteorological conditions. They were inefficient, manpower intensive, and imposed a significant logistical burden to the combat commander. Since developers were unable to achieve the illusionary battlefield potential envisioned from the use of smoke, they placed little emphasis on advancing smoke doctrine or material development between WWI and WWII. As a result, smoke doctrine and interrelated hardware development severely lagged the advances in military doctrine.

Historically, smoke system development has centered around improving operation of the large area systems first conceived in WWI — making them smaller, more efficient, and reducing their logistics burden. Even recent improvements in efficiency, survivability and mobility have done little to technologically advance the art of making smoke. Fog oil remains the standard for producing "visible" smoke. Thus, these systems remain severely limited in their capability to counter the rapidly expanding threat posed by readily available sensors and smart weapons which operate in the IR to MMW ranges of the electro-optical spectrum.

Future smoke systems will need to provide the commander with highly mobile/deployable capabilities to counter sensors operating in the visual through MMW regions of the electro-optical spectrum. In addition, they must be even more survivable and supportable to operate on the non-linear battlefield. Dependency of smoke operations on meteorological conditions must be reduced by capabilities to project, control and sustain smoke/obscurant screens, hazes or blankets over large areas. While future airland operations pose increased threat and greater lethality, the XM56 and LAMPSS smoke/obscurant systems now being developed can fully meet these challenges of the future battlefield.

"That damned smoke. . ." is finally advancing toward achieving its full potential as the highly effective combat multiplier so long envisioned.


XM56 Motorized Mechanical Smoke Generator

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THE HISTORY OF DESERT TESTING

By Wahner E. Brooks

Introduction

Army equipment that was deployed in the Arabian desert represented a long legacy of desert testing. Though this legacy dates back to the frontier period, today's testing methods are as new as satellite imagery. Our soldiers have acquired the benefits of this legacy in the Abrams, the Bradley, the M109 155mm Howitzer, and a host of other vehicles, weapons, and munitions.

Up to and after the Civil War, test methods were simple and fundamental. New designs for weapons were demonstrated before a board of officers representing the user arm and involved technical services. Criteria were relative performance, maintainability, ruggedness and, in peacetime, relative cost. Promising candidates were often procured in limited quantities and issued to troops for use in the field.

While this approach sufficed up to the Spanish-American War, two events occurred which had a major effect on the evolution of American test methodology. Technology introduced a major threat to the United States and politics demanded major troop deployments in extreme environments.

The technological threat should not have caught the United States by surprise. During the Civil War, technology played a major role in how the war was fought. However, at war's end the Union possessed a huge inventory of modern weapons and warships which were obsolescent before demobilization was complete. European observers made detailed reports to their governments, and German and British armament manufacturers met the demand with longer ranging, larger caliber, breech-loading guns mounted on well armored steamships. Our potential enemies could threaten us with weapon systems clearly superior to ours.

To a country which had based its defense on a relatively economical coastal fortification system, the new threat was of great concern. Congress, however, was more concerned with the huge debts left by the Civil War.

The First Proving Ground

The thousands of cannon left from the war still worked, why develop new ones? A compromise was reached; the United States would upgrade its existing inventory by an extensive product improvement program. Because the performance and safety limits of artillery would be pushed to the extreme, an isolated, large barren area would be needed for testing. The Army's first proving ground was authorized and in 1874 began operation at Sandy Hook, NJ.

Sandy Hook Proving Ground brought a new dimension to testing. The latest scientific apparatus was adapted to provide precise measurements of ballistic parameters. Cannon could be tested beyond their limits in the safe, controlled environment of the proving ground. New munition designs, mixed composition propellants, and mechanical fuzes could be evaluated singly and in combination. While the environments available were those of the Jersey shore, they varied adequately to demonstrate their effects.

Extreme Climates

The latter was considered important, because the U.S. Army was beginning to operate under some extreme climatic conditions. Prior to the Civil War, such exposures were limited to small detachments, usually acting as escort units or exploring parties. Special equipment was procured from local markets. If special equipment was not available, the Army restricted itself to more benign climates. If this was not possible, then loss rates to exposure were high.

After the Civil War, the units on the frontier were larger and were permanently garrisoned in the extreme climates of Alaska Territory and the desert Southwest. Their weapons and equipment had to perform reliably in these harsh climates. Time did not change their need, in fact, the Spanish-American War introduced another environment in Cuba, the Philippines, and Panama — the tropic environment.

Even with the availability of the proving ground, most equipment was still tested by troop trials. Sample lots were now issued not only to troops in the temperate areas, but also, carefully and intentionally, to units in the arctic, the desert, and the tropics.

Villa's raid on Columbus, with Pershing's subsequent expedition into Northern Mexico, gave the Army a chance to test three new weapons: the machine gun, the airplane, and the motor car. And the enemy included the hot desert by day and the bitterly cold desert by night. Lessons learned about desert operations though, were largely forgotten since the Army was immediately thrust into World War I.

Aberdeen Proving Ground

As the United States entered the war, Sandy Hook Proving Ground was closed, and its equipment moved to a new proving ground opened along the Chesapeake at Aberdeen, MD. As the war ended, Aberdeen was testing not only guns and ammunition, but trucks and tanks. And the new courses incorporated the environments of Western Europe (the Belgian block roads, trenches, and mud courses). Although American troops fought in Siberia before and after the armistice, most fought in the Western Front. The conditions of the Western Front predominated in American military thinking, even though troops garrisoned Panama and the Philippines, as well as Alaska and the U.S.-Mexican Border.

After the First World War, the United States found itself with large inventories of weapons and vehicles. The Army shrank, and development funds were limited. Product improvement again became the major effort. Trials by the widespread garrisons became a mainstay of testing.

Typical of the test effort outside of Aberdeen Proving Ground was the 1919 and 1920 Transcontinental Motor Convoys. Besides the effort to support the Good Roads movement, the convoys served a variety of purposes including testing motor vehicles. The 1920 convoy left the nation's capitol for San Francisco following the southern route. Passing through New Mexico and Southern Arizona, lessons about desert operations were relearned and added to.

As Germany rearmed and began enlarging its empire during the 1930s, the Army once again faced the probability of becoming involved in a European War. As lend-lease began, American equipment was sought by the British to support Commonwealth operations in North Africa and the Middle East. American observers passed home the deficiencies of equipment used in the desert.

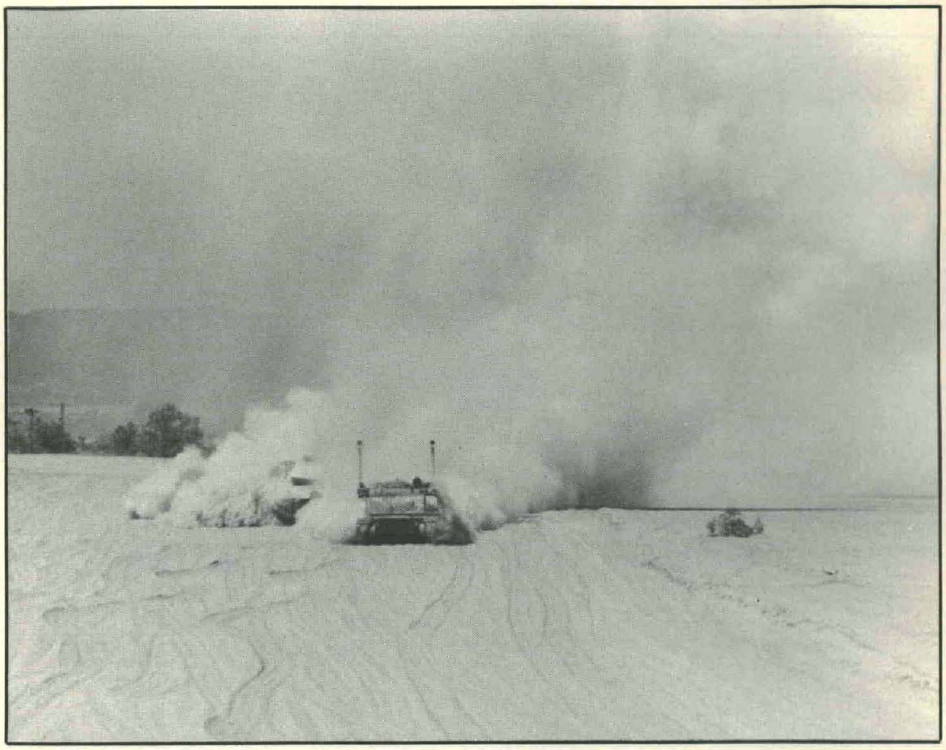
After Pearl Harbor, General George S. Patton started a vast training area in the Southwest desert. The emphasis was on training in Corps and Army maneuvers, but the desert operations proved the vulnerability of men and equipment to the harsh climate and topography. The lessons were not digested in time and the U.S. Army soon was involved in Northwest Africa. Operations quickly moved onto other environments, but this time the Army did not forget.

Yuma

In 1948, the Ordnance Corps conducted Operation Desert Furnace, testing all its tanks, vehicles, and weapons in the desert north of Yuma, AZ. As a result of these tests, the Ordnance Corps as well as the other technical services sent test teams to the newly established Yuma Test Station to determine improvements needed to allow materiel to survive in the hot desert.

The ordnance team was composed of volunteers from Aberdeen Proving Ground. In addition to Aberdeen Proving Ground's philosophy and equipment, they brought the bible of ordnance testing, the *Ordnance Proof Manual*. The manual was a collection of detailed, standard test procedures which had started at Sandy Hook as the *Manual for Proofing of Cannon.* Over the years, the procedures were expanded to cover all items of ordnance materiel as well as various specialized range instruments and facilities.

Thus, it was only natural that desert testing would be based on the common test procedures developed in temperate Aberdeen. Of course, some of the procedures had to be modified. Vehicle cooling, vapor lock handling, sand mobility, and filter adequacy were examples of the desert procedures. And these procedures were supported by new, desert-unique facilities such as the Dust Course, Vapor Lock Course, and Rock



An M113 Armored Personnel Carrier with two attached upright poles to hold signal lights creates dust for an M1 Abrams Main Battle Tank following on Yuma Proving Ground's challenging dust course.

Ledge Courses, as well as the Desert Cross-Country Course and the Desert Hill Course.

By the early 1960s, Yuma Test Station's composition began changing. The various teams had sufficient work to support year around activities. The labs, shops, and offices built to support desert testing, coupled with the fine winter climate and the extensive ranges and airspace, began attracting other development testing that could not be done by the Eastern proving grounds. With the elimination of the technical service structure in 1963, the various teams were permanently assigned to what was now YPG (U.S. Army Yuma Proving Ground).

Desert testing assumed a smaller portion of the overall workload, but ordnance testing still dominated. And the *Ordnance Proof Manual* was still the bible. Trials had largely disappeared, being replaced by service tests. Because of the technology involved, service tests often took on the semblance of proving ground, or engineering tests — instrumented, controlled exposures conducted by highly trained officers and men.

Meanwhile, the policy of basing desert testing on tests conducted at Aberdeen Proving Ground was begin ning to be questioned. The purpose of desert testing is to determine the capability of the test item to survive and perform in the severe desert environment. But often the result of such tests was to only determine the degree of degradation of desert operations from temperate operations.

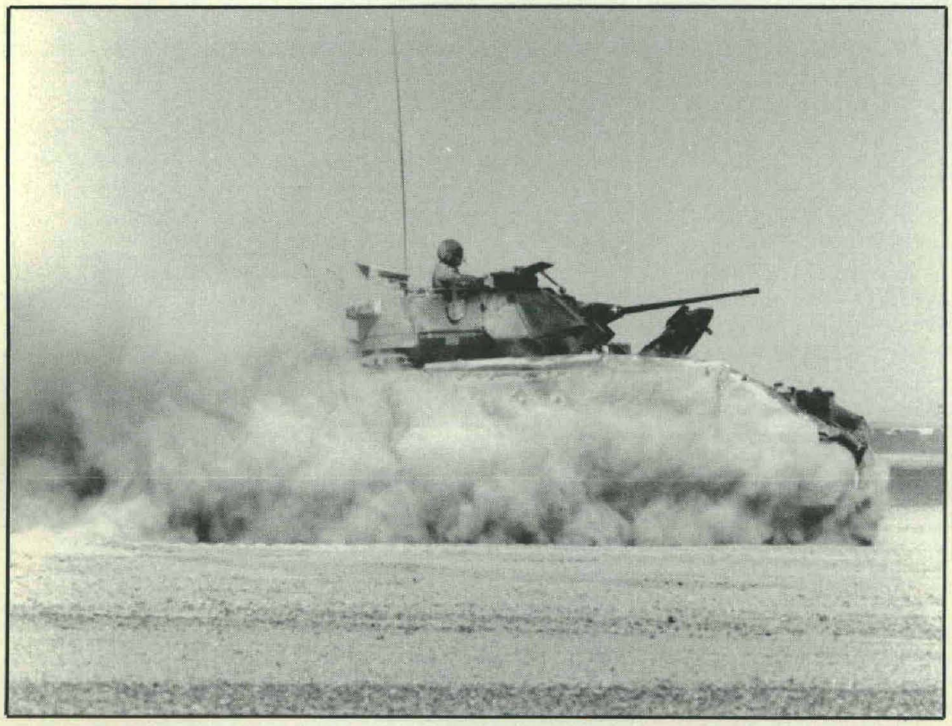
Environmental engineers at Yuma stepped back and looked at the issues as a systems problem. They began developing a stockpile-to-target scenario, and identifying appropriate test criteria.

ENTAC

The first application was crude by today's standards, but at the time was considered a major improvement in environmental testing. The ENTAC, a French developed, wire-guided antitank missile, was scheduled for a desert engineering service test in the summer of 1964. The test plan was revised to include two types of field storage, a 100-mile mounted cross-country transportation test several deployment cycles, and operation on the dust course. Although the ENTAC failed the tests, the procedure stood up to a rigorous challenge, and was found realistic and valid.

The procedure was adapted to other weapons and munitions, ranging from the TOW antitank missile system to foxhole digging aids. While significant information short-falls were identified, the resulting test designs were still, with the exception of vehicles, considered superior to the prior designs.

In the meantime, the young Test and Evaluation Command decided to expand the old Ordnance Corps' *Ordnance Proof Manual* to cover all the materiel that had come under its cognizance as a result of the Army reorganization. The new procedures were to be called MTPs (for Materiel Test Procedures). Under this program, YPG was directed to prepare a new series of procedures covering desert environment testing.



Bradley Fighting Vehicle testing at Yuma Proving Ground began in April, 1982. Since then, over 36,000 miles of use have been put on the vehicle at the proving ground.

Defining Desert

The first task in developing the procedures was defining "desert." Most requirement documents of the time specified hot- dry or intermediate hot-dry climates categorized in AR 705-15 (superseded by AR 70-38). These regulations were based on MIL-STD-210, which present extreme climatic conditions based on poorly stated sources and risk levels. The various members of the tri-service working group who wrote MS 210 who were contacted were very disturbed by the use of standard as a source of test criteria. So was Dr. William Brierly who prepared the draft of AR 705-15. Based on their advice and concerns, these documents were not used after the geographic areas concerned were identified.

The second task was developing a schedule for the transport phase. There were no such schedules for deserts. *The Ordnance Proof Manual* had schedules for highway, secondary road, trail, and cross-country based on European and American road maps, but it was hard to find such a map on North Africa or the Middle East. Consequently, a mammoth manual spread sheet was started, using histories of warfare in North Africa and the Middle East, as one source. Officers previously assigned on military assistance programs was another source.

Actual road data were fed into the model along with probabilities of tactical and logistic use. The summation of the maps showed a range of 40 to 80 percent of cross-country operation depending on the desert region. Studied clearly, desert surface

An AH-64 Apache fires over Yuma Proving Ground's Cibola Firing Range — The Department of Defense's most highly instrumented aircraft armament test range.

conditions would provide a major input to specifying the equipment transport phase.

Earlier Studies

Fortunately for the study team, there was a large body of data on desert terrain. The most important portion was an extensive study performed by the Corps of Engineers' Waterways Experiment Station at Vicksburg, MS. During the 1950s, Dr. R. Kolb and J. R. Van Lopik developed a procedure for determining the analogy of different desert areas by comparing a complex array of geomorphic and vegetative factors. The object of the study was to locate test areas in Yuma analogous to North Africa and other world deserts for testing of a logistic support "Overland Train." Although the procedures had shortcomings, mainly in scaling errors, they provided a good start on the problem.

Matching the probability-of-use maps with the waterways data produced distribution of terrain types, for different desert areas. An agreement with Natick Labs, and later, the Engineer Topographic Center, led to a jointly funded geomorphic study of YPG by H. Frank Barnett and a team of geologists during the 1970s. As a result, the entire proving ground was mapped to a high resolution, avoiding many of the scaling problems in the initial study. YPG's Middle East course, incorporating this data, was laid out in 1984, providing a mobility course that matched the terrain occurrences in a band from the Upper Sudan, across the Sinai and Arabia Peninsula to the Tigris-Euphrates Valley. The course was validated by military and geographic experts from the United States, Israel, and Iran.

The third task was updating the exposure schedules. What was expected to be the easiest, turned out to be the least successful. The classic exposure of 30, 45, and 60 days without specification of climatic levels was intuitively suspect. But, in spite of the availability of thousands of weather records, there was not enough available for the foreign areas having real extremes to prepare probability and risk analyses. Reliable map records tend to be kept in inhabited areas which often meant coastal towns.

In the 1950s, William Robinson and Arthur Dodd of the Quartermaster R&E Natick Labs prepared climatic analogies to assist in the location of a desert test center. Natick Labs also published several studies of temperatures occurring in boxcars and ammunition storage facilities in desert areas.

Howard Schaeffer at the Navy's Weapon Test Center, China Lake, CA., independently began developing a stockpile-to-target scenario. Schaeffer's scenario was for Navy aircraft external stores with emphasis on storage conditions. As part of his project, he integrated data from all three services. This effort permitted the YPG scenario to begin at the port of debarkation.

The most vulnerable storage exposure in desert operations is that occurring at the forward supply point. The degree of vulnerability is dependent on the nature of the test item, overpacks, and type of shelter. Consequently, a separate exposure schedule was published for each category of equipment using a combination of probable duration and aggregate thermal transfer.

New test methods are described in a series of test operations procedures published between 1968 and 1972. These test operations procedures are currently being reviewed and updated. Information gained during the last two decades is being incorporated as well, including the results of studies in payloading effects, route-selection, and driver learning curves. Additional effort is planned to answer other questions raised since the procedures were first published.

Conclusions

Departure from the "degradation" approach to testing was a major advance in environmental testing. The application of "stockpile-to-target" criteria to desert environmental test methodology has resulted in greatly improved tests. Today's testing accurately determines the capability of equipment to operate and survive in the hostile desert. It is this testing that provides military personnel with supreme confidence in the quality of the equipment currently deployed in the Southwest Asia.

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U.S.-CANADA LARGE CALIBER AMMUNITION EXCHANGE PROGRAM

By Dr. Jerome Rubin and Edward K. Ernstrom

Introduction

In the event field artillery units of the United States become involved in a high, mid or low intensity conflict along with an allied nation or nations, the artillery units must be ready to exchange or receive another country's ammunition and fire confidently in support of whatever action is taking place. Such was the opening paragraph of the Dec. 18, 1990 report of Maine Army National Guard CPT Fred E. Umphrey in describing the firing of U.S. and Canadian exchanged ammunition at Gagetown, Canada.

Field Artillery CPT Umphrey was reiterating what General Eisenhower and Field Marshall Montgomery had concluded some 40-plus years ago and thereby set in motion an attitude among the English speaking nations to work together in the area of materiel development much as they had fought together effectively in the recently concluded European battlefield. This gentlemen's agreement soon developed into a basic standardization concept between the Armies of the United States, Britain and Canada.

By 1964, after Australia joined the group this had matured into a Basic Standardization Agreement establishing the American/British/Canadian/Australian (ABCA) Armies Standardization Program. New Zealand became an observer in 1965. The prime purpose of the ABCA can be stated in a single word — interoperability i.e., develop fighting forces that can operate on common principles, similar doctrine, and with equipment that is interoperable.

On the other side of the world, the North Atlantic Treaty Organization (NATO) had established the Military Agency for Standardization (MAS) in 1951, its purpose being to facilitate operational, procedural and materiel standardization among NATO forces. From its early beginnings in the late 1940s, NATO recognized the critical nature of the interoperability factor in fielding an effective multinational force. Allied nations must be able to resupply, refuel, and rearm in a common fashion.

Maintaining allied interoperability was a rather easy matter in the early decades after the Second World War. Interoperability was a natural outcome since most nations had little or no surviving defense industry and essentially all their equipment came from American stocks either through grants, loans or foreign military sales. Hence, Germany used the same 8-inch howitzer and 155mm howitzer that Italy used, that Denmark used, that the U.S. used, etc.

Slowly the situation began to change. National modifications (Germany's M109G, Italy's M109L) were being made to U.S. weapons. U.S. technical data packages were being used by foreign producers but engineering changes, quality control, and malfunction history were unknown, leading to questions as to the actual interchangeability of the ammunition. And true national weapons began to appear — the Trilateral FH70 155mm howitzer, 120mm rifled and smooth bore mortars, 120mm rifled and smooth bore tank cannon, and a plethora of small arms. Clearly, materiel interoperability was in jeopardy.

Interoperability Today

If nations would not develop armaments to common requirements and follow that with common specifications, the only recourse would be to determine the degree of interoperability of common calibers after the fact. Such is the basis for much of the work being done in the area of interoperability today. Nations determine if a common caliber among them can be safely fired in each other's weapon. The initial criteria addressed in determining interchangeability of specific ammunition items are form, fit and function. This is followed by what may be considered one of the most important parts of the determination — that of safety, as evidenced by a review of:

- Modifications to original technical data packages
- Production quality control (including NATO and reciprocal quality assurance agreements)
- Histories of total rounds fired and malfunctions
- Maintenance engineering of the inventory

In developing and concluding bilateral agreements between the U.S. and other nations, specific fuzes, projectiles, propellant charges, primers and weapon combinations are identified. No substitutions are permitted without a thorough review of the proposed replacement.

The U.S. Army has been active in formal international peacetime large caliber ammunition exchanges, including artillery, since the 1970s. The program was initiated at the request of General George Blanchard, formerly commander-in-chief, U.S. Army Europe and Seventh Army and was later adopted by NATO. It was recognized that the ability of allied forces to exchange ammunition in combat results in a true battlefield multiplier effect, not the least of which is reduced logistics burden and resupply times.

Exchange Agreements

The bilateral large caliber ammunition exchange agreements are administered in

AMMUNITION AND HOWITZERS USED IN TEST FIRINGS

	CANADA		U.S.	
WEAPON:	M109A3 SP HOWITZER		M198 TOWED HOWITZER	
FIRING TABLE				
MANUAL:	FT 155-AM-2		FT 155-AM-2	
COMPUTER:	MILIPAC		BATTERY COMPUTER SYSTEM	
GUN CONTROL:	GUN ALIGNMENT AND CONTROL SYSTEM		N/A	
PROJECTILE	M107 HE	U.S. MADE	M107 HE	CANADA MADE
PROPELLANT	M4A2 ZONE 7	U.S. MADE	M4A2 ZONE 7	CANADA MADE
FUZE	M739	U.S. MADE	M739	CANADA MADE
PRIMER	M82	U.S. MADE	M82	CANADA MADE

U.S. M198 firing from Maine Army National Guard's gun position.

Canadian M109A3 and gun crew (Ed Ernstrom of ARDEC on right) load U.S. ammunition at W Battery, Canadian Field Artillery School's gun position.

Members of the U.S. gun crew (with Canadian soldier) install Canadian fuze on Canadian projectile.

the U.S. by the U.S. Army Armament Research, Development and Engineering Center (ARDEC). Located in northern New Jersey and commanded by BG William R. Holmes, the ARDEC is the lead Army organization responsible for the conventional land forces rationalization, standardization and interoperability (RSI) programs. The center also provides the U.S. principal representative and head of the U.S. delegation to the NATO Land Forces Ammunition Working Party and U.S. Army principal representatives to several NATO panels within the NATO Army Armaments Group and cadre groups under the Conference of National Armaments Directors. Representation is also provided to the NATO Air Armament Working Party and to several ABCA Quadripartite Working Groups.

Objectives

The program for the exchange of large caliber ammunition has several key objectives:

- Enhancing operational readiness of U.S. and allied forces
- Developing troop familiarity with allied ammunition
- Promoting troop confidence in the performance of allied ammunition
- Evaluating existing peacetime and wartime exchange agreements for concurrency, and for determining need for changes or improvements
- Developing new bilateral agreements where appropriate

To date, the U.S. has now entered into some 48 bilateral agreements with 13 nations for the exchange of large caliber ammunition during training exercises. These agreements cover 81mm and 4.2-inch mortars; 105mm, 155mm, and 203mm howitzers; and 105mm tank ammunition. Since the latest publication of the agreements in 1984, no actual firings of exchanged ammunition have taken place. It was a only a paper document on interoperability — until November 1990 in Gagetown, New Brunswick, Canada, that is.

Much behind the scenes coordination had to be attended to before the firings at Gagetown could become a reality. Not the least of which was the decision to turn the paper document on ammunition interoperability into a true operational one involving combined forces. In 1989, the decision was made within ARDEC to do three things related to these interoperability agreements:

- Update all agreements on a 5-year cycle
- Develop an annex to cover procedures for the exchange of the ammunition
- Conduct live firings of exchanged ammunition

ARDEC began developing the exercise annex to the bilateral agreements early in 1990. One of the first tasks was to locate a U.S. land forces unit that could support the program as part of its regular training. The State of Maine Army National Guard expressed enthusiasm for the effort and the 1st Battalion of the 152nd Field Artillery was designated to participate. In August, Canada's Force Mobile Command (Army Headquarters) approved the Field Artillery School at Canadian Forces Base (CFB) Gagetown in the Province of New Brunswick to be the Canadian participant.

Exchange Firings

On Nov. 28, 1990, land forces of the U.S. Maine National Guard arrived at the Canadian Combat Training Center in Gagetown, New Brunswick to begin their joint training exercise to include the exchange firings. This exchange was the first test of the recently developed new exercise annex to the U.S and Canada bilateral artillery ammunition exchange agreement and the first formal exchange of artillery ammunition in a live fire peacetime exercise.

The original 1978 bilateral agreement contracted between the U.S. and Canada provided for the exchange of 155mm M107 high explosive rounds, the M3, M3A1, M4A1 and M4A2 propellant charges, the M557, M564 and M514A1 fuzes, and the M82 primer, to be fired in the Canadian M109A1 and the U.S. M109A1/A2/A3 howitzers. In 1989, the agreement was updated to reflect weapon changes, ammunition additions and deletions to the inventories and changes to the malfunction histories. Although no changes were made to the projectile or propelling charge categories, the VT M514A1 fuze was deleted from Canada and the PD M739 was added to both U.S. and Canada. The MK2A4 primer was added for the M114A2 howitzer. On the weapons side, the M109 and M109A1 were deleted and the M114A2 and M198 towed howitzers were added.

The close proximity of the Canadian post to the 152nd Field Artillery made the coordination and conduct of the exercise relatively easy. The exercise started for the 152nd with a motor march to CFB Gagetown approximately 130 miles away. When the group arrived, introductions were made between the participants of both countries and an in-briefing was given by CPT R. L. Spencer of the Canadian Field Artillery School. From the outset, it was clear that cannoneers talk a similar language wherever they are and stories began to be exchanged readily. Many Canadian soldiers had not seen an M198 before and were eager to learn about its range, sighting system, ammunition and capabilities. In response therefore, the U.S. invited Canadians to augment each of the U.S. gun crews during the firings.

Classroom Instruction

The first phase of the exercise was devoted to classroom instruction. Briefings were provided to familiarize all with the weapons, ammunition, and fire control equipment being used. Canada discussed their M109A3 self-propelled howitzer, the type and source of ammunition, and the fire control system to be used. The U.S. did the same for its M198 howitzer. Operational details and safety procedures followed in great detail. In addition, the units involved were tasked to identify any exchange problems associated with the exercise procedures, equipment or ammunition.

As Canada was host for the exercise, its data were used by the U.S. to lay their equipment. Each nation provided its own command post and a Canadian liaison was stationed at the U.S. site. The plan called for both nations to fire eight rounds in each of the two national howitzers supplied. This would be a total of 16 rounds fired from the other nation's ammunition inventory. The ammunition and howitzers used in the firings are shown in the accompanying chart.

Important to note here is that even though the 155mm ammunition of Canada is very similar to that of the United States, there is a confidence factor involved with the actual exchange of the ammunition. By conducting the exchange during a live fire exercise, the practical experience necessary was assured and the measures of safety and familiarization can be properly noted and integrated officially into the exercise.

As mentioned earlier, the artillery ammunition of Canada is very similar to that of the United States in that manufacturing standards of Canadian ammunition are based on American standards. However, packaging procedures for both sides are unique. The Canadian propellant packaging consists of a fiberglass ribbed canister with two charges and primers for the M4A2 propellant as opposed to our metal canister containing only one charge. The Canadian packaging combines both the propellant and primers while the U.S. issues primers separately.

The morning of the firings was perfect for the exchange, no wind, milder than normal temperature for this time of the year, and a slightly overcast sky. The anxious crews moved at daybreak to their field positions with enthusiasm and anticipation.

The different techniques of laying the howitzers between the two units proved to be a learning experience for both sides. The Canadian artillery uses azimuth bearings as opposed to the United States system using deflections. Calls for fire from the Canadian observers required some on-the-spot training for the Fire Direction Center.

As host nation, the Canadians fired first. The impact area was approximately 10,000 meters from the firing point at Zone 7. The Americans fired next and their initial round landed within 200 meters of the target. All subsequent rounds (for a total of 16 by each nation), fired alternately by U.S. and Canada, were right on target. To complete the exercise, a final two rounds of U.S. ammunition were fired by the U.S.

Muzzle Velocities

Muzzle velocities were determined by the Canadians using their recently purchased Fairey Mark 3 Muzzle Velocity Indicator, while the U.S. forces used the older M90 Chronograph Velocimeter. No appreciable differences were noted between the two systems.

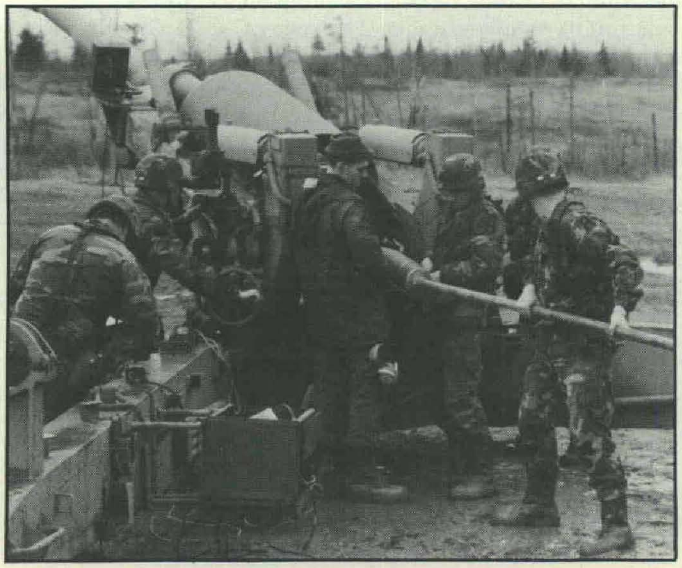
At an after-action meeting, future exchanges were discussed for different shell and fuze combinations and the possibility of a longer exercise and incorporation of logistical handling techniques. All felt more detailed discussions in this area would help in the event actual exchanges would have to be accomplished in wartime conditions.

The 1st Battalion 152nd Field Artillery and the Canadian Field Artillery School at CFB Gagetown, have enjoyed a more than 20-year relationship that helped make this exercise smooth and profitable. This exchange not only assisted the study, but increased the comradery and friendship the American and Canadian Forces have experienced for so many years. As the 152nd drove away from CFB Gagetown, the artillerymen did so looking forward to future exchanges and even greater working relationships.

Other Exchanges

Exchanges with other allied countries are already in the planning stages. Plans include mortar ammunition exchanges with Canada and large caliber ammunition exchanges with Norway. U.S. units being considered for participation in Norway are elements of the Marine Corps and the U.S. component of the recently organized NATO Composite Force. This would consist of battalion units from the U.S., Germany, Canada, and Norway and is designed for the quick reinforcement of Norway should the need arise.

Exchange exercises like this will also do much to ease the burden of ammunition resupply. For the U.S. artillery to be able to confidently use ammunition of other countries as well as offer ammunition from its own stocks to other nations, these exchanges and the developed annex will be the key. The knowledge that ammunition can be exchanged within the NATO community and fired from the national artillery weapon using the national fire control adds a dimension to the soldier heretofore unknown. This reassurance is a most valuable one for all commanders.



U.S. gun crew (with Canadian soldier) load Canadian high explosive projectile into chamber of U.S. M198.

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DEPLOYING THE VOICE OF THE CUSTOMER WITH TOTAL QUALITY DESIGN

Insuring the Voice of the Soldier is Heard Throughout the RD&A Process

By MAJ Timothy C. Lindsay

Introduction

In recent years, the Army materiel acquisition community has focused on improving the acquisition process by applying Total Quality Management (TQM) principles to the RD&A mission. Thomas R. Stuelpnagel highlighted the 14 elements of this philosophy in his article published in the January-February 1990 issue of *Army RD&A Bulletin* (p.25). Dr. Richard A. Stimson discussed the application of TQM to the DOD acquisition process in his article published in the September-October 1989 issue of *Army RD&A Bulletin* (p.38). Stimson underscores the need to insure the customer is heard throughout the early stages of concept evaluation and selection. As he aptly states, "The specification becomes the critical link to inform the contractor of what the true DOD requirements truly are." The method by which customer wants are translated to engineering specification could spell the difference between a product's success or failure. Simply stated, TQM is the philosophy of "Doing the right thing, right the first time, on time, all the time; always satisfying the customer."

It is doubtful that anyone will argue with this philosophy given the success of Japanese industry, for whom it is religion, and of U.S. companies who have adopted it with success, such as Ford in their Quality Function Deployment program. The QFD program translates the customer's voice to product and process design and engineering. Xerox Corporation and GM in their Saturn Division have also adopted the TQM philosophy. The message is that when survival of the firm is at stake, the existing culture is ripe for change. Yet, despite the justifiable excitement surrounding the promises of TQM, there have been few proposals about the mechanisms for employing it in the DOD acquisition process to improve tech base responsiveness to the customer. One such mechanism, called **Total Quality Design (TQD),** was developed under an Army Research Office/University Research Initiative (ARO/URI) at the University of Delaware, Center for Composite Materials. It is a tool for employing TQM in the concurrent design and engineering of products, processes and organizations. As a tool for tech transition, it can be used to deploy the customer's voice in tech base programming and for developing technology pull. The motivation to improve tech base responsiveness to the product development process is well known and quite clear:

• Resources are Committed Very Early in Concept Evaluation

• Early Decisions are Critical to Establishing Life Cycle Costs (LCC)

• New Materials and Processing Technologies for Advanced Materials, Advanced Electronics, etc., demand a Concurrent Engineering Approach to R&D to Optimize Their Performance

• Focused Tech Base Programs are Crucial in a Resource-Starved RD&A Environment

As shown in Figure 1, decisions made very early in the development process lock in the majority of the life cycle costs. This is sometimes referred to as the 80/20 rule, since 80 percent of the life cycle costs are locked in after only 20 percent of the development time. For this reason, it seems prudent to involve the tech base with the customer — the Training and Doctrine Command (TRADCOC), very early in the process to insure that requirements are reasonable and rational with respect to emerging technologies and to provide tech base planners with a focus for their research programs. Although these functions occur through the Technical Working Groups (TWG) and Joint Working Groups (JWG), TQD suggests a more immediate and dynamic mechanism to connect requirements generation with the tech base more frequently and integrate it with key materiel development players. Under TQM the materiel developer (MSC's, PM's and industry) become partners with the tech base, all focusing on the customer.

The RD&A Process Today: Opportunities for Improvement

Despite recent initiatives, the DOD and U.S. industry efforts to transition technology from the tech base into new systems development, the DOD and U.S. industry suffer in comparison with the success achieved by the Japanese. The tenants of TQM mesh smoothly with Confucian-Buddhist philosophies of the Japanese, who enjoy close cooperation among industry, government and academia. In contrast, U.S. technology development has been adversarial and compartmentalized, with little concern for market needs. These destructive U.S. business practices influenced the style and philosophy of the Army's RD&A process and an adversarial procurement and contracting system has been codified. (Fortunately, the management approach of U.S. companies began to change in the late 1970s as Japan internationalized the production and marketing of popular consumer goods.)

While the ability of the U.S. tech base to push state-of-the-art technology in science and engineering has been justifiably lauded as world-class, our ability to effectively transition this knowledge to military and commercial applications has been less successful when compared with the industrial nations of the Pacific Rim, particularly Japan. Where does the breakdown in tech transition occur and what can be done to bridge this technology gap?

In his article titled the *Improved Product Development Process, Changing the Ten Cash Drains into Cash Flow,* Dr. Donald Clausing, the Bernard M. Gordon Adjunct Professor of Engineering at MIT, identifies as contributing to this breakdown, 10 cash drains in the product development process. Those which are most relevant to the tech base and tech transition are:

• **Tech push but where's the pull?** *Translation*: "Good" technology is generated within the tech base, but there is not a strong advocate pulling it into product development. *Solution*: Involve the customer early in the process as a member of the technology development team. Do it at the lowest practical organizational level. Develop less restrictive funding and teaming approaches which will unshackle the tech base.

• **Where is the voice of the customer?** *Translation*: Frequently, the customer is not truly involved in the R&D process until the product is well into development or close to fielding. By this time, life cycle costs have long since been established. *Solution*: Establish and resource real R&D marketing centers within the corporate labs. Use TQD to translate customer's qualitative needs into quantitative engineering characteristics.

• **"Give me my targets and let me do my thing."** *Translation*: We are not used to working in teams to solve technical and scientific problems. In the academic tradition, people have been trained to work isolated from each other. This often results in inefficiency and loss of contact with the customer. *Solution:* Establish interdisciplinary teams at lowest operational levels for solving customer problems. Marketing, engineering, design, manufacturing and customer team members are required. Reward teams. Eliminate

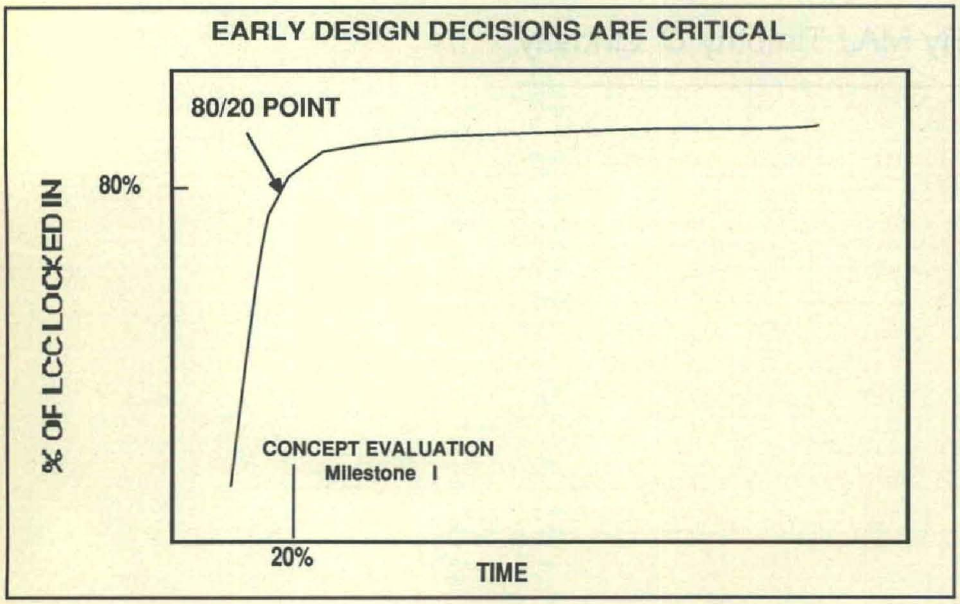


Figure 1.
The tech base is crucial to controlling system costs because most of the Life Cycle Costs are determined at a time when the tech base should be most active in the process.

individual awards. Promote cooperation, eliminate competition.

• **"We've always done it that way."** (a variation of the "not-invented-here" syndrome) *Translation:* Innovation and creativity are stifled rather than encouraged, making "leap ahead" technology difficult to achieve. *Solution:* Remove stigma for research "failure." Reward creative tangible solutions to real problems. Skew programs to high payoff, low risk efforts.

All told, the 10 cash drains make up 40 percent of the cost of a product to society. Of these, the focus on tech push strikes at the heart of the technology transition challenge. Nevertheless, all must be seriously addressed to make the RD&A system efficacious.

Figure 2 depicts barriers to effective product development which slow the process, increase system and life cycle costs, cause misinterpretation of requirements, obscure accountability, and decrease the quality of the end product. Each activity is shown completing an action, such as writing a technical report, and then throwing its results over the wall to the next. In this system there is little incentive to establish teams for the development of technology to meet the customer's needs or for cooperation among activities. In fact, there are often disincentives or statutory restrictions against doing so! The brick and mortar, if you will, that make up these barriers are listed below:

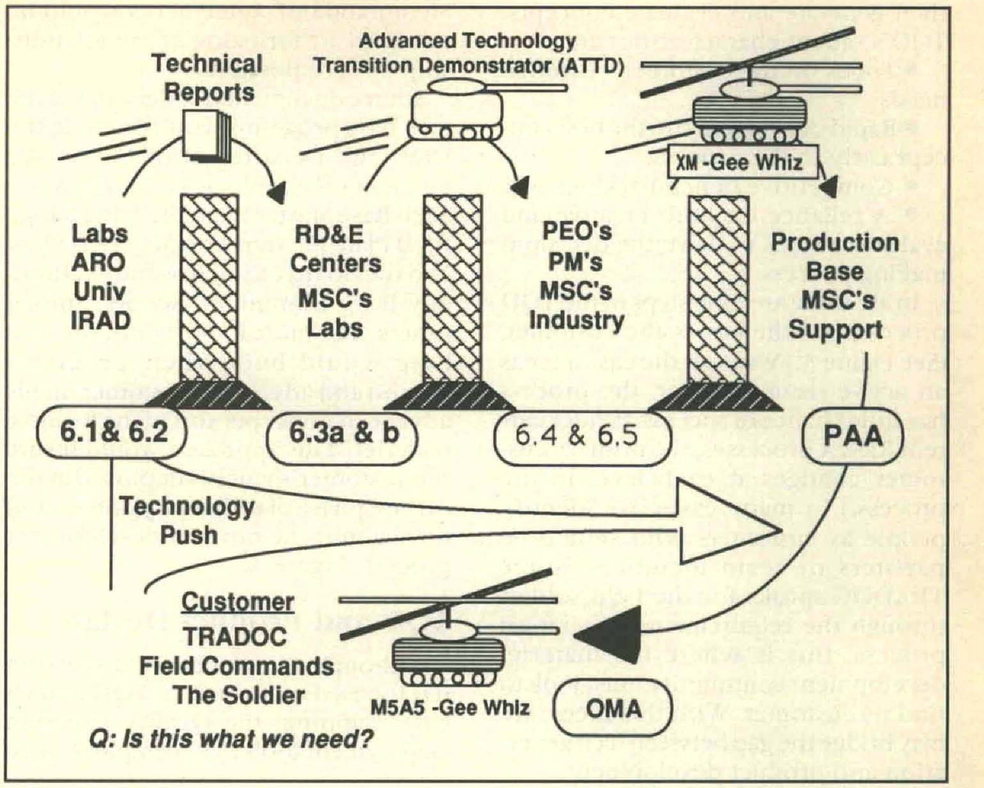


Figure 2.
The current RD&A process thwarts effective customer involvement and frustrates team building by erecting barriers.

• **Organizational/institutional** - Highly hierarchical bureaucracies — typical of government and large industry — tend to value compartmentalization, power hoarding, and self-preservation over team building, power sharing, and cooperation — typical of customer-focused organizations.

• **Regulatory, Procurement and Contracting** - Money coloring and restrictive contracting practices, which emphasize short term price over long term cost, frustrate managerial prerogatives for problem avoidance and the cultivation of real cooperation between government, industry and academia.

• **Cultural and Psychological** - Incentives for change must be intense before people will alter their approach to a problem or process. Success and failure are defined by short term adherence to arbitrary cost, schedule and performance goals, rather than long term system performance and support costs, i.e., customer satisfaction.

• **Historical** - We tend to do that with which we are comfortable and which has worked in the past, even if poorly. Innovation is avoided as too risky.

• **Technological** - Despite improvements in communications and travel, the ability to establish highly integrated product development teams of experts over time and distance is a challenge, as is the psychological and economic lag in assimilating technology. The development of computer- aided design, engineering and machining systems is essential for the ultimate success of truly concurrent design practices for complex products.

Our R&D system has, in the past, relied on tech push to generate new technology for battlefield systems. In times of plentiful resources, this has been shown to be a somewhat effective method of generating technology; however, it is almost always inefficient. Funds are frequently applied to programs for which, at best, only a moderate need exists. Funding may be established according to staffing levels rather than actual programmatic needs, while the academic curiosity of investigators often justifies projects. These factors cause difficulty in establishing and supporting systematic and coherent long range tech base programs.

Fortunately, all of these problems are resolvable in the long term. TQD is a useful tool for attacking them today.

TQD and the RD&A Process

As noted, TQD can be used to improve the transition of technology to the product development process by focusing on the customer's needs early in the process, i.e., during requirements generation. It uses Quality Function Deployment tools such as the House of Quality (HOQ) developed by Dr. John R. Hauser, a professor at the MIT's Sloan School of Business, and Dr. Clausing (discussed earlier), and a concept selection process devised by Dr. Stuart Pugh at Loughborough University of Technology, Great Britian. These tools identify the primary customer and his needs, translating these to the engineering characteristics (called *Quality Metrics* in TQD) required of the design or process and then generate and evaluate concepts. TQD's salient characteristics are:

- Focus on the customer's **intense** needs;
- Rapid convergence to the best concept early in the process;
- Competitive benchmarking; and
- A reliance on both creative and evaluative steps to drive the decision-making process.

In all, there are nine steps in the TQD process, but the key is the customer. (See Figure 3.) Without the customer as an active team member, the process has little chance of success. (Under current RD&A processes, the primary customer changes at each level in the process.) In many cases, we identify people as customers who should be partners or team members. Since TRADOC speaks for the field soldier through the requirements generation process, this is where the materiel development community must look to find its customer. With this focus, we may bridge the gap between tech generation and product development.

Using TQD in tech base planning and programming would help the Army's R&D community identify and translate the customer's needs (the "What") into scientific and engineering problems (the "How"). This, in turn, would be used to develop a cogent, coherent, and cohesive R&D program which supports these needs, despite the source of funding. This program would be bottoms-up, needs-driven and include the materiel developer (MSC's and PM's), industry and academia in the tech base loop. Implicit in the success of such an approach is alignment of needs determination and program development with the cycle of the Programming, Planning, Budgeting and Execution System. Ideally, the Army labs and RD&E Centers would reorganize with interdisciplinary teams to develop the 6.2 research and non-systems specific technologies (6.3a), while being supported by critical 6.1 research for fundamental understanding of scientific issues and the Mantech program for processing science and technology to assure producibility. These programs would be integrated into transition plans for system specific advanced development (6.3b, 6.4 and 6.5), production (PAA) and support (OMA). Responsible agencies would be identified (including primary customers); estimated timelines, schedules and resources would be planned and Memoranda of Agreements would be executed to formalize these relationships where possible.

Source documents for developing the tech base programs would include the DOD and Department of Commerce Emerging Technologies Lists, the Army Tech Base Master Plan, the Long Range R&D Plan, Mission Area Materiels Plan, and the Board of Science and Technology R&D Committee Report, among others. But, more importantly, the tech base would build their programs around and advise the customer on his advanced concepts and plans for new materiel. This approach would insure the customer's voice is deployed at the earliest phase of tech base planning and throughout the product development process, Figure 4.

TQD and Product Design

Although the preceding discussion has focused on the use of TQD in tech base planning, the Quality Function Deployment tools that it employs, such as the House of Quality (HOQ), were initially developed to assist in the early stages of product design. For example, Dr. Dick J. Wilkins at the Center for Composite Materials, University of Delaware, and Dr. John H. Henshaw at University of Tulsa, have used TQD to assist the U.S. Army Chemical Research, Development and Engineering Center in the concept generation and evaluation of composite materials replacement parts for a new Aircrew Protective Mask and for DS2 decontaminate containers. Lightweight, low cost, producibility, deterioration resistance and toughness were critical design parameters. A number of other product designs have been developed and evaluated by University of Delaware students using TQD tools, including a folding composite bicycle and a composite hip prosthesis.

TQD and Process Design

Working with the U.S. Army Missile Command, Wilkins and Henshaw also

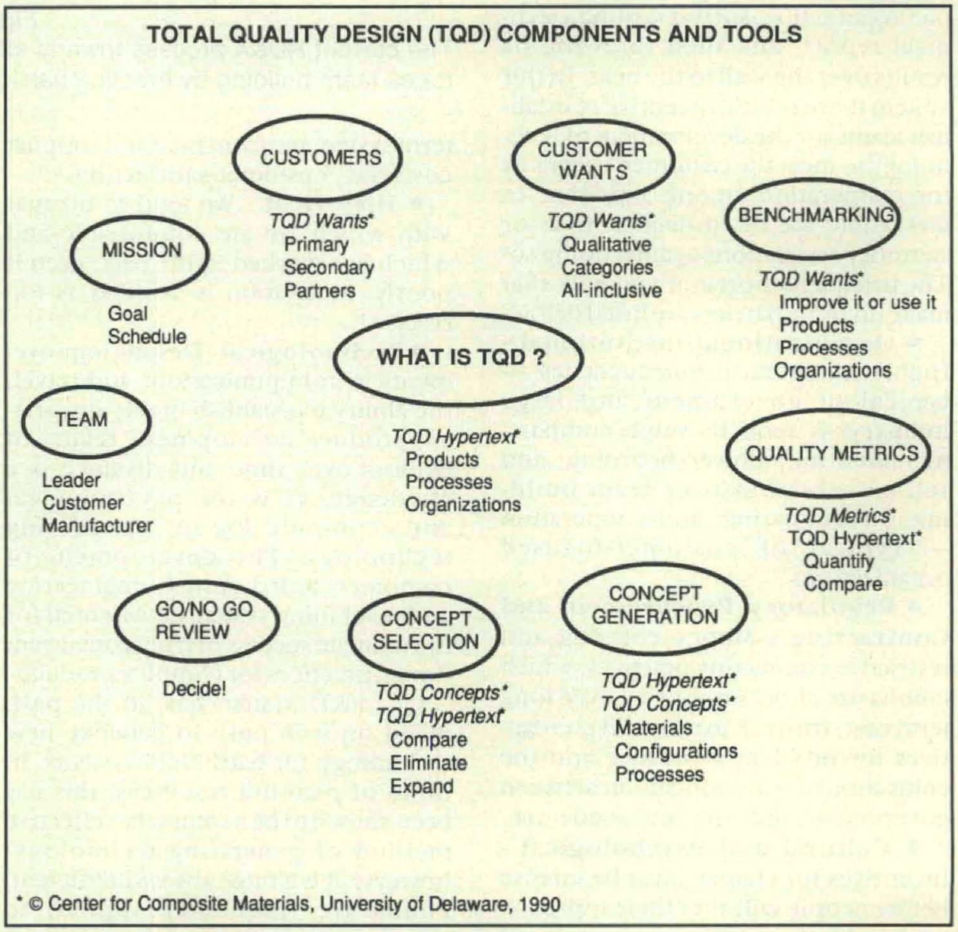


Figure 3.
The nine components of TQD and the TQD Automated Tools developed at the University of Delaware. TQD focuses on the customer and his needs.

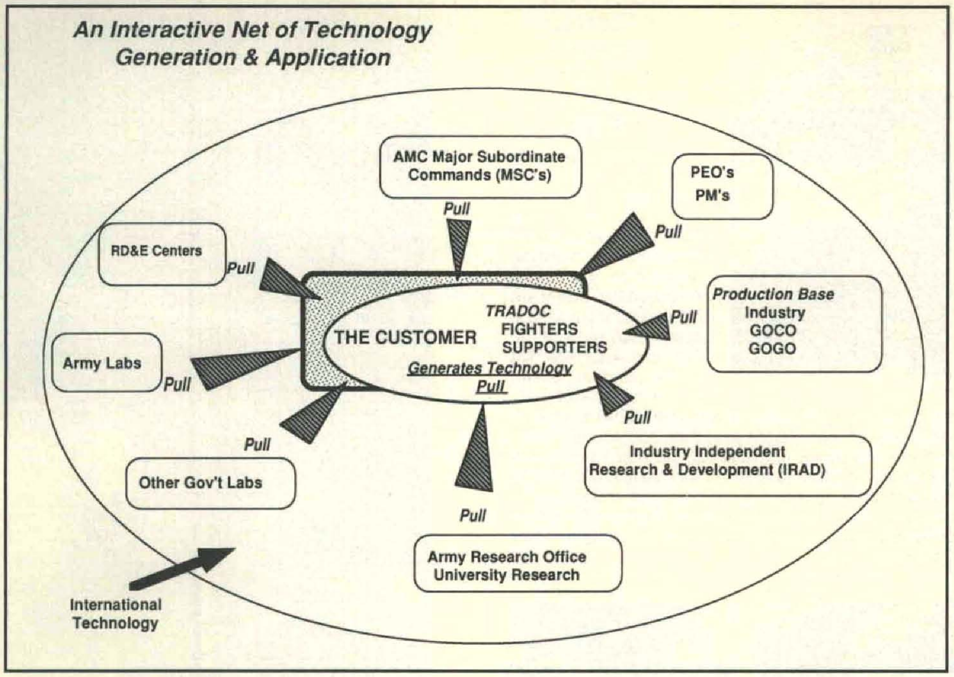


Figure 4.
An improved customer-focused RD&A process based on TQM principles. The customer is a team member in the RD&A system and is included in the technology generation stage. A cooperative and interactive network of tech base activities is necessary to develop the technology required to meet the customer's needs.

used TQD principles to develop a "Composite Manufacturing Heuristics Guide," a software program for the selection of composite materials and manufacturing process based on selected design criteria, such as shape, size, and operating environment. A TQD user's guide and a composite materials database benchmarking guide have also been delivered under this contract.

Finally, the author has used TQD in the development of a methodology for designing composite structures for low-velocity impact damage as well as a model for improving the tech base planning, integration and tech transition functions at the U.S. Army Materials Technology Laboratory, some notions of which have been presented here.

In each of the examples above, a specific customer was identified and was actively involved as a team member in the development of the product or process. Continuous customer involvement throughout the design process dramatically improves the chances of a successful effort.

Conclusions

The R&D tech base no longer has the luxury to espouse a corporate philosophy of "research for research sake." Clearly, the realities of the knowledge and technology explosion, global economic competition, high cost of money, and shrinking federal budgets demand shorter product life cycles.

To achieve shorter development cycles will require increased funding early in the life cycle and fundamental cultural and organizational changes in our R&D system. This will focus on the customer's needs and involve him in the process. Corporate America has begun to recognize the need for this change; this should signal the Army to do likewise. Successful R&D efforts of the past, such as the Army's Manhattan Project and NASA's Apollo project to put a man on the moon, are proof that focused, customer-oriented research is possible. It does not mean, as some may fear, the loss of flexibility to decide on a research strategy based on sound scientific and engineering principles. Rather, it suggests that tech pull, based on customer needs, will drive the R&D train rather than tech push. Scientific and engineering initiative and innovation are not only maintained but are likely fueled, rejuvenated and focused by the opportunity to help solve real problems and meet real needs.

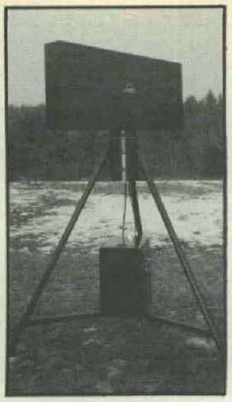
While the ability to introduce the TQM philosophy and implement TQD in the acquisition process may be hindered by those factors noted previously, these problems may be overcome with properly motivated and trained personnel. Government, industry and academia all have a critical role in making this happen over the long term. Stimson notes that developing a "critical mass" of people who support this approach is crucial to generating action. Certainly, true and long lasting success will require a commitment to the *Kaizen* philosophy of continuous improvement and of fundamental cultural and organizational change within the Army.

Nevertheless, short term benefits may accrue by applying TQM philosophy and TQD techniques within the existing framework of the RD&A system. With the establishment of the PEO system, and the Army Acquisition Corps some of the barriers to improving technology transition have been addressed. Additionally, many activities in the Army tech base are developing innovative teaming approaches to improve their responsiveness to the soldier; however, many challenges remain, offering opportunities for the innovative and the bold. With TQM as a frame of reference and TQD in one's "toolbox" one thing is certain: The voice of our most important customer — **the soldier** — will be deployed in the RD&A process.

MAJ TIM LINDSAY is a materials technology manager for lightweight structures at the U.S. Army Materials Technology Laboratory, Watertown, MA. He is a member of the Army Acquisition Corps and a Distinguished Graduate of the Materiel Acquisition Management (MAM) Course. He holds a B.A. degree in natural sciences from St. John's University, and an M.S. degree in materials science (composite materials) from the University of Delaware.

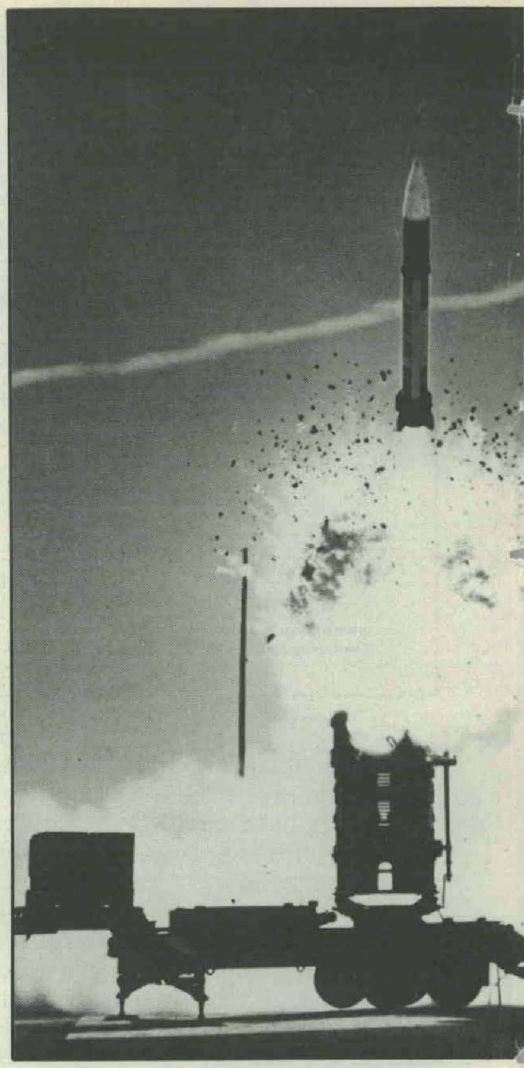
PROGRAM EXECUTIVE OFFICER– AIR DEFENSE

A Continuing Series to Introduce Our Readers to the Army PEO Structure



LIGHT AND SPECIAL DIVISION INTERIM SENSOR (LSDIS)

The LSDIS is needed to provide U.S. Army light and special divisions and contingency corps ADA battalions with an interim early warning sensor to alert and directionally orient air defense gunners. The system will replace the Forward Area Alerting Radar pending fielding of the lightweight variant of the Ground Based Sensor. The LSDIS is a stand-alone system, lightweight (less than 350 pounds), man portable, low power (28 volts DC), air droppable, capable of detecting fixed and rotary winged aircraft out to 15 kilometers during both day and night operations and under all weather/visibility conditions. The LSDIS is a non-developmental program. Initial fielding is scheduled for September 1992.



AVENGER

The AVENGER system, formerly referred to as Line-of-Sight Rear or Pedestal Mounted STINGER, mounts eight reprogrammable STINGER missiles on a HMMWV. AVENGER is designed to counter, in a daylight or night environment, both fixed and rotary-wing aircraft attacking targets in the division rear or passing through to attack deeper targets. The computerized fire-control system integrates a Forward Locking Infra Red device, laser range finder, and missile seeker display, and can be operated by a gunner from inside the turret or remotely relocated up to 50 meters from the HMMWV. AVENGER supported allied forces in Saudi Arabia. Currently in full scale production, AVENGER was initially fielded in April 1989.

PEO-AD

BG Robert A. Drolet holds a B.A. degree from Boston College and an M.S. degree from Shippensburg University in Pennsylvania. His military education includes completion of the Basic and Advanced Officer courses at the Air Defense Artillery School, the U.S. Army Command and General Staff College, the U.S. Army War College, and the Defense Systems Management College. Among his most notable assignments are: project manager, STINGER and Pedestal Mounted STINGER, U.S. Army Missile Command, Redstone Arsenal, AL; chief, Missiles and Air Defense Division, Office of the Deputy Chief of Staff for RD&A, Washington, DC; air defense team chief and force integration staff officer, Firepower Division, Office of the Deputy Chief of Staff for Operations, Washington, DC; and battalion commander, 3d Battalion (HAWK), 68th Air Defense Artillery, Homestead Air Force Base, FL and Fort Bragg, NC.

BG Robert A. Drolet

BG Drolet's management philosophy is to decentralize management via delegation of full line authority to project managers (PMs) with vertical coordination responsibility assigned to the PM. The Program Executive Officer — Air Defense (PEO-AD) is responsible for coordination efforts between PMs, other PEOs and vertical coordination with Headquarters, Department of Army.

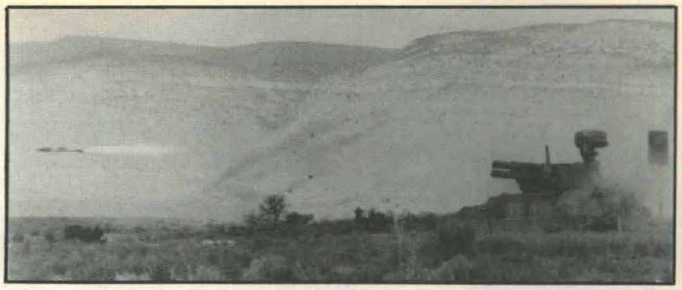
Missions and Organization

The PEO-AD reports to the Army Acquisition Executive relative to technical, cost, and schedule aspects for assigned programs and supervises assigned project and product managers. BG Drolet provides the planning, guidance, direction, control and support necessary to field systems within cost, schedule, and performance baselines. The PEO-AD has an authorized technical staff of 32, comprised of military and civilians who provide expertise in business management, contracting, cost analysis, engineering and logistics.

One of the major areas under the PEO-AD umbrella, Forward Area Air Defense System (FAADS), is an integrated system of systems consisting of five components which operate in the forward area of the battlefield to counter an increasingly complex air threat. These components are: Combined Arms Initiative (CAI); Line of Sight Forward-Heavy (LOS F-H); Non-Line of Sight (NLOS); Line-of-Sight Rear (LOS-R) [AVENGER]; and Command, Control, Communications and Intelligence (C^3I). The C^3I consists of a command and control component that integrates,

PHASED ARRAY TRACKING TO INTERCEPT OF TARGET (PATRIOT)

Patriot is an advanced, high-to-medium altitude, surface-to-air missile system that serves as the Army's centerpiece of theater air defense for the 1990s and beyond. The combat element of the system is the fire unit which consists of a multifunction radar set, an engagement control station, a power plant, requisite communications, and eight launchers. A five-year Patriot production contract was awarded in 1987. In response to the growing tactical missile threat being allocated to Air Defense, Patriot Anti-Tactical Missile (ATM) capability was initially fielded in 1989. A future enhancement and improvement currently being addressed for the active tactical missile defense is the multi-mode sensor. Patriot is deployed with U.S. forces and through foreign military sales to other countries, including Germany, Netherlands, Japan and Italy. In fact, Patriot recently won high marks for its outstanding service with allied forces in Operation Desert Storm.



LINE-OF-SIGHT FORWARD-HEAVY (LOS F-H)

LOS F-H will use the Air Defense Anti-Tank System (ADATS TM) which integrates a missile system, communications equipment, and detection, identification and tracking and tracking sensors on an armored tracked vehicle (XM 1069, a derivation of the M3A2 Bradley). The system will use radar and optics to detect, acquire and identify targets within its field of view. The system will operate autonomously or using FAAD C3I in day or night, in obscurants, in adverse weather and in battlefield environments where electronic and physical countermeasures are prevalent. The system is in the operational assessment phase with the current milestone schedule calling for initial fielding in mid-1996.

STINGER-REPROGRAMMABLE MICRO-PROCESSOR (STINGER-RMP)

The STINGER is a shoulder-fired weapon system that provides effective, short-range air defense capabilities against low-level fixed and rotary-wing aircraft attack. STINGER is currently being dual-produced by the European STINGER Consortium (Germany, Greece, Netherlands, and Turkey) in STINGER-RMP (less reprogrammable module) configuration. Switzerland is also co-producing STINGER-RMP (less reprogrammable module). STINGER was deployed in support of allied forces in Saudi Arabia. RMP entered development in 1984, production in 1985, and was initially fielded in November 1989.

processes and distributes aerial target information gathered from ground based and masked target sensors, identification friend or foe (IFF), positive hostile identification (PHID) and noncooperative target recognition (NCTR) devices. The PEO-AD has full line authority for STINGER, Patriot, Light and Special Division Interim Sensor (LSDIS), and two of the five FAADS components (LOS F-H and AVENGER) plus one of the C^{3}I components (Ground Based Sensors (GBS)), as well as responsibility for the integration of the developed C^{3}I with the other FAAD components.

The NLOS fiber optic guided missile system will provide day and night and adverse weather air defense protection to the maneuver force against masked, standoff rotary-wing craft. In addition, the NLOS system will provide precise anti-armor fire capability against the most severe threat armor well beyond the maximum range of tank main guns or direct fire anti-tank missiles. The NLOS system will utilize an on-board passive sensor to provide autonomous target acquisition. NLOS is currently in the Advanced Development Process and is currently under the operational control of the U.S. Army Missile Command at Redstone Arsenal, AL.

GBS provides detection and tracking of fixed and rotary wing aircraft to cue AVENGER fire units, protect friendly aircraft from fratricide, and provide targeting information to other FAAD weapons. GBS data is provided through FAAD C^{2}I or directly to fire units. GBS consists of a radar based sensor with IFF and NCTR identification devices, prime mover/power and communications, an operator's remote control unit and FAAD C^{2}I interfaces. GBS is in the source selection phase with fielding scheduled for FY 95.

RD&A efforts of the PEO-AD on AVENGER, the STINGER-Reprogrammable Micro-Processor, and specifically the Patriot, significantly aided defensive efforts of allied forces in the recent Persian Gulf War.

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Commanding General MICOM

MG William S. Chen

MG William S. Chen holds a bachelor's degree in engineering mathematics and a master's degree in aeronautical and astronautical engineering from the University of Michigan, and a master's degree in business administration from Auburn University. His military education includes the Air Command and Staff College, the Defense Systems Management College, and the Industrial College of the Armed Forces. Among MG Chen's most notable assignments are: project manager, Division Air Defense Gun, Picatinny Arsenal, NJ; project manager, Chaparral Missile System, U.S. Army Missile Command, Redstone Arsenal, AL; chief, Munitions Division, Office of the Deputy Chief of Staff for Research, Development, and Acquisition, HQ, Department of the Army, Washington, DC; operations research analyst on missile and air defense programs in the Program Analysis and Evaluation Directorate, Office of the Chief of Staff, HQ, Department of the Army, Washington, DC; and commander, 1st Battalion, School Brigade, U.S. Army Ordnance and Chemical Center and School, Aberdeen Proving Ground, MD.

MISSIONS AND ORGANIZATION

Headquartered at Redstone Arsenal, AL, the U.S. Army Missile Command (MICOM) is a major subordinate command of the U.S. Army Materiel Command. MICOM's 7,000 soldiers and civilians support more than a dozen collocated project managers and are responsible for research, development, acquisition and worldwide support of Army missiles, rockets and related programs, including foreign missile sales.

MICOM's primary missions are: to exercise integrated systems acquisition and commodity management of missile and rocket systems and other assigned materiel, including research, development, procurement, logistical support and security assistance services; to conduct basic and applied research and engineering and advanced development in related technologies; and to exercise command, control and supervision of assigned activities and installations.

Army facilities on Redstone's 38,000-plus acres comprise a total investment of more than $800 million. MICOM's annual budget averages more than $7 billion.

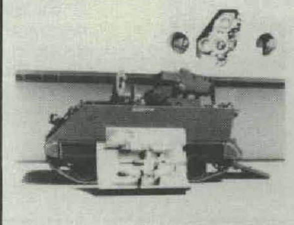
MICOM COMMAND GROUP

Commanding General	MG William S. Chen DSN 746-2101 Comm.	Redstone Arsenal, AL (205)876-2101
Deputy Commanding General	BG Larry R. Capps DSN 746-2122 Comm.	Redtone Arsenal, AL (205)876-2122

U.S. ARMY M

JEEP

COBRA



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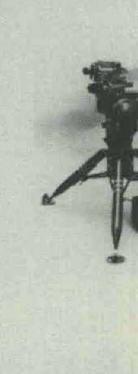
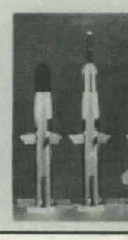


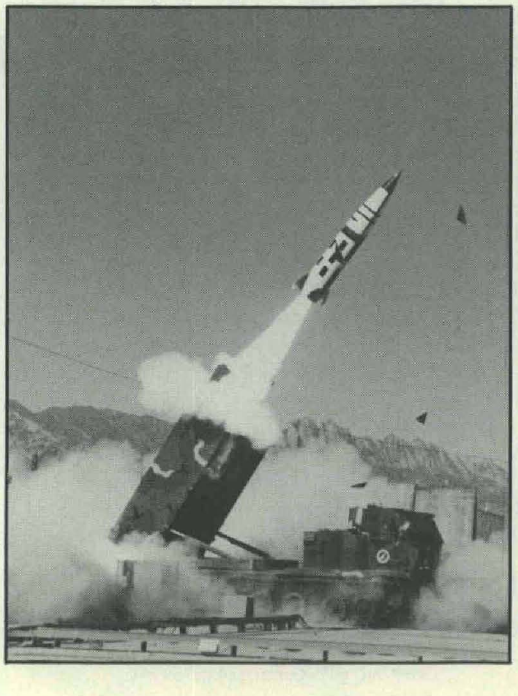


TOW WEAPON SYSTEM

(Shown above) TOW is a crew-portable, vehicle-mounted, heavy anti-armor weapon system consisting of a launcher and missiles to defeat armored targets and other battlefield fortifications. The system will operate in all weather conditions in which the gunner can see a target throughout the missile flight by using either a day or night sight. TOW is used on the high mobility multipurpose wheeled vehicle, the M151 jeep, the armored personnel carrier, the Bradley Fighting Vehicle, Cobra helicopters, and the U.S. Marine Corps light armored vehicle.

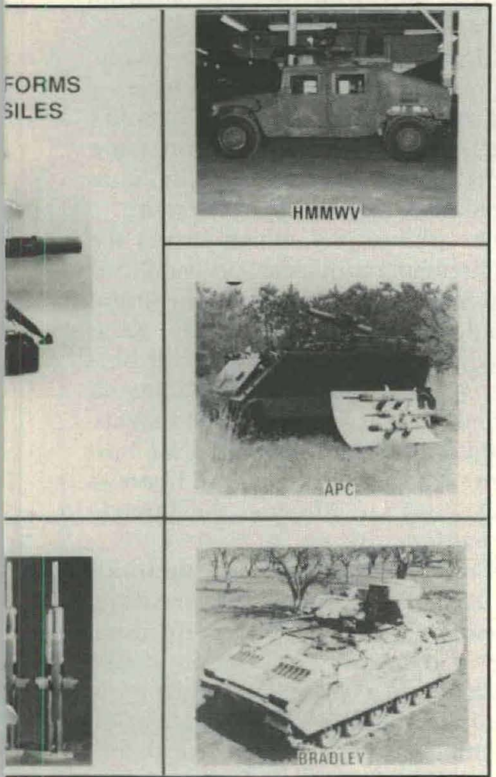
ARMY TACTICAL MISSILE SYSTEM (ATACMS)

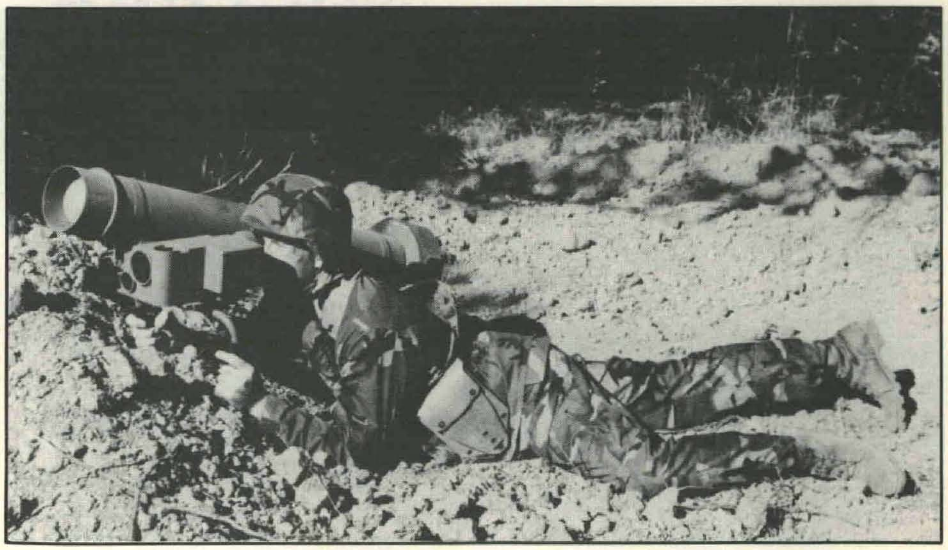
ATACMS Block I is an inertially guided missile with a range of more than 100 kilometers which is fielded with Multiple Launch Rocket System units and fired from the same launcher. ATACMS will destroy tactical missile launchers; suppress air defense; attack command, control and communication sites; and disrupt logistics. ATACMS Block II, a follow-on warhead, is a candidate system to fill the requirement to destroy enemy armored combat vehicles at long ranges.



MISSILE COMMAND

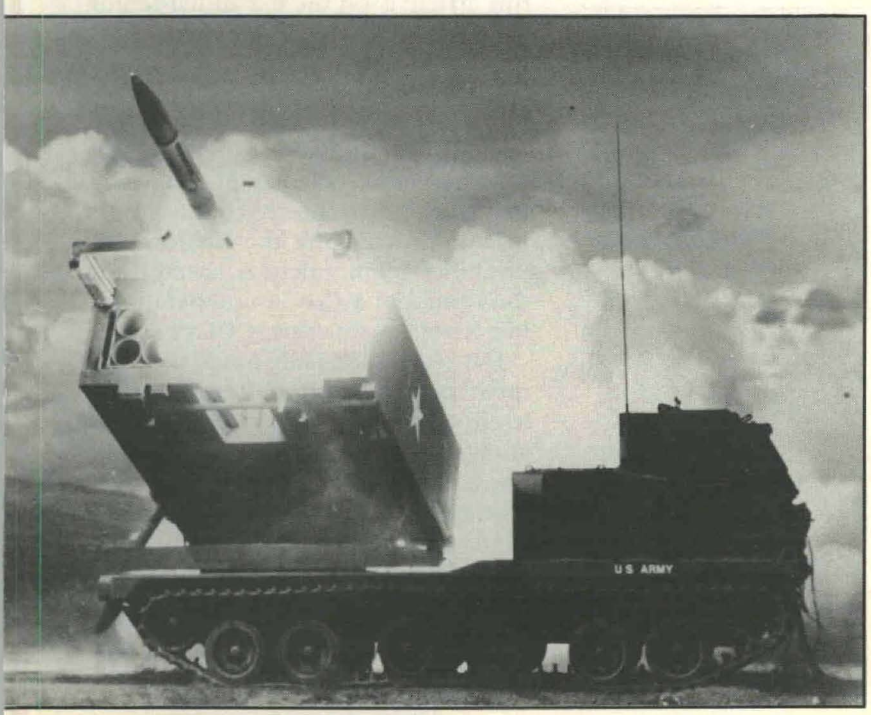
A Continuing Series to Familiarize Our Readers with Key Army RD&A Organizations and Leaders





ADVANCED ANTITANK WEAPON SYSTEM MEDIUM (AAWS-M)

AAWS-M is designed to be carried by one man, but lethal against tanks with both conventional and reactive armor. Slated for use by the Army and Marine Corps, the AAWS-M system consists of a command and launch unit which can be used alone for surveillance but must be used to fire the missile. The unit has a day/night sight, and will engage targets during adverse weather conditions. The missile is sealed in a disposable launch container.



MULTIPLE LAUNCH ROCKET SYSTEM (MLRS)

MLRS is an unguided artillery rocket mounted on a tracked vehicle. Each launch vehicle carries 12 rockets. The MLRS Rocket warhead contains 644 high explosive grenades for anti-personnel and light vehicle engagement. Alternative warheads in development include the Sense and Destroy Armor warhead and the Terminal Guided Submunition.

NUCLEAR HARDENING OF ARMY SYSTEMS

Giving Field Commanders Greater Confidence in Their Ability to Fight and Win on the Battlefield

By MAJ James C. O'Shaughnessy

The purpose of the Army's nuclear survivability program is to ensure that mission essential systems can survive initial nuclear weapons effects (INWE) environments at levels which correspond to a soldier's or crew's inherent vulnerabilities to those effects.

INWE of interest are those which occur within the first minute of a detonation and include air blast, initial nuclear radiation, thermal radiation and electromagnetic pulse (EMP).

Survivability considerations involving residual radiation effects (such as neutron induced gamma activity (NIGA), fallout and rainout) are addressed in the Army's NBC contamination survivability program.

The philosophy which drives the requirement for nuclear survivability is that mission essential equipment should survive exposure to INWE as long as there are enough soldiers surviving to operate that equipment. For nuclear survivability requirements, soldier survival normally implies short term survival on the order of hours — long enough to influence the immediate battle.

While there are several methods available to achieve nuclear survivability (such as providing for timely resupply of damaged equipment, taking advantage of a system's redundancy on the battlefield or using mitigation techniques (such as the use of tie downs to mitigate blast effects)), the focus of this article is on the use of hardening as a means of achieving nuclear survivability.

The combat developer has responsibility for establishing nuclear survivability requirements and for stating how the requirement will be met. A decision to pursue hardening as a means of achieving the nuclear survivability requirement is based upon the results of a Cost and Operational Effectiveness Analysis (COEA).

Hardening is usually found to be the most cost effective alternative for high value, low density systems such as combat vehicles. When hardening is required, the nuclear hardening criteria are established by the U.S. Army Nuclear and Chemical Agency (USANCA).

USANCA utilizes the methodology of Annex A, Allied Engineering Publication-4 (STANAG 4145) (and its Quadripartite equivalent, QSTAG- 244) to develop nuclear hardening criteria. The methodology considers the man-machine relationship and crew survivability requirement for a system as well as its proposed location on the battlefield.

The principal objective in applying the hardening criteria in the design and production of systems is to make undetected, untargeted systems survive the collateral effects of detonations on adjacent targets rather than making a targeted system survive a nuclear attack. Therefore, the hardening criteria are normally balanced to the soldier or crew's inherent vulnerabilities to INWE and take into account the fact that for different weapon yields, the INWE of interest have varying ranges to effect.

USANCA relies upon the combat developer to identify the man-machine relationship for a developmental system. The man-machine relationships (as related to the INWE free field environment) of interest are: man and equipment exposed; man protected, equipment exposed; equipment protected, man exposed; and, man and equipment protected.

The correspondence between a particular man-machine relationship and casualty production is established by the Personnel Risk and Casualty Criteria. INWE casualty mechanisms include:

- **Blast:** solid impact of translated prone personnel, foxhole collapse, severe lung damage to foxhole occupants, moderate II damage to vehicles, and vehicle overturn (on back);
- **Thermal:** second degree burns under chemical protective overgarment; and
- **Initial Nuclear Radiation:** immediate transient incapacitation (ITI).

For nuclear survivability requirements, soldier survival normally implies short term survival on the order of hours — long enough to influence the immediate battle.

In addition to identifying the man-machine interface for a system, the combat developer must state a crew survivability requirement. For example, if a four man crew is required for operation of a combat vehicle, but under emergency circumstances a two man crew will suffice in completing the immediate mission, the crew survivability requirement would be 50 percent. Given this figure, INWE effects levels which correspond to 50 percent injury production can be determined.

Finally, a system's proposed location on the battlefield will provide a basis for assigning a threat yield spectrum which identifies the threat's capability to engage a particular area of the battlefield with nuclear weapons of various yields. For example, a forward deployed system would be exposed to low yield weapons since it is unlikely that high yield weapons would be used due to the risk presented to an aggressor's own troops.

Conversely, low yield weapons are less of a threat further to the rear where high value targets would be engaged by delivery systems capable of delivering larger warheads.

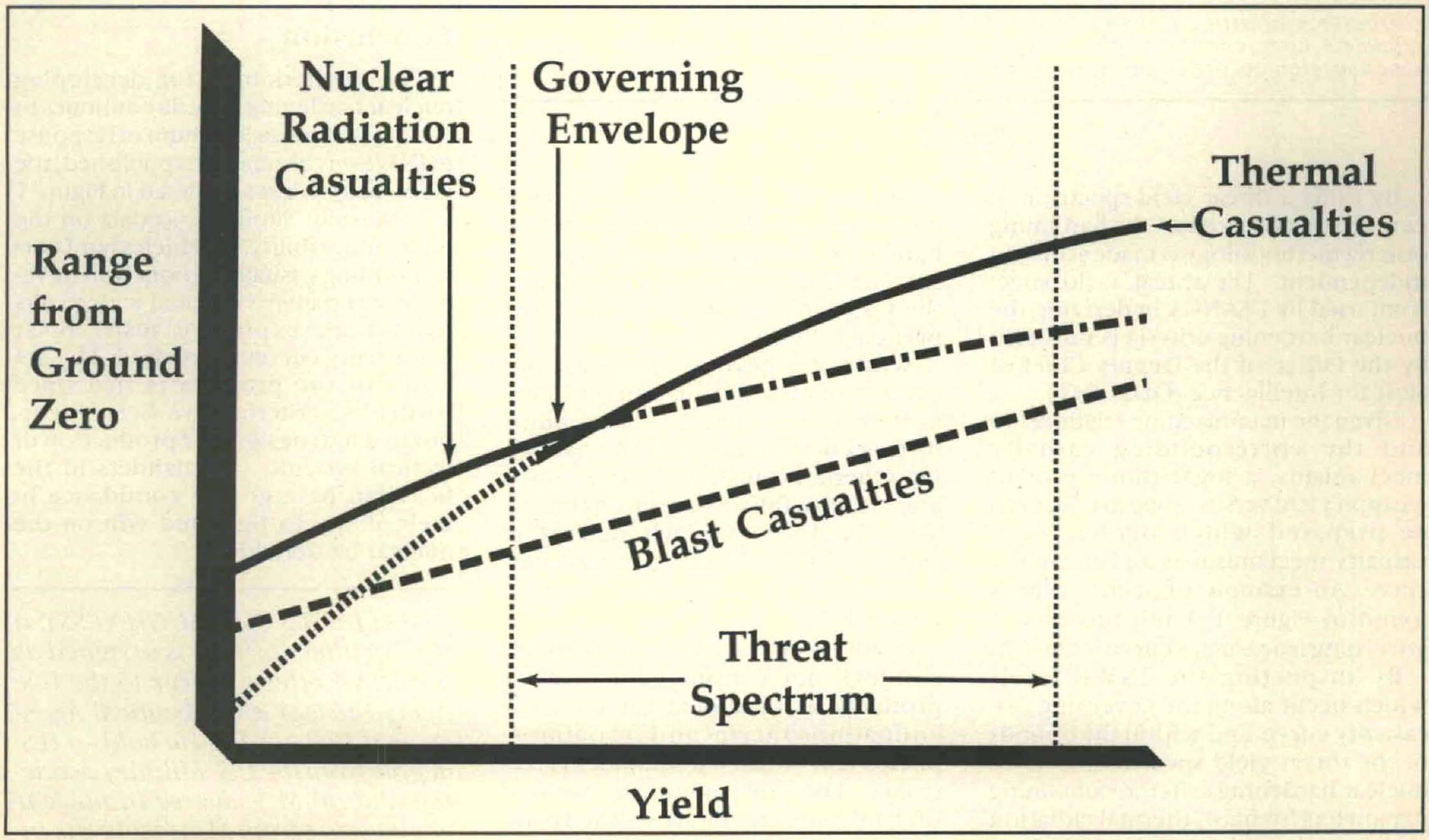


Figure 1.

Air Blast:

Peak Overpressure (psi)

Overpressure Duration (sec)

Overpressure Impulse (psi-sec)

Peak Dynamic Pressure (psi)

Dynamic Pressure Positive Duration (sec)

Dynamic Pressure Impulse (psi-sec)

Arrival Time (sec)

Thermal Radiation:

Total Thermal Energy (cal/cm2)

Maximum Irradiance (cal/cm2-sec)

Time to Maximum Irradiance (sec)

Initial Nuclear Radiation:

Tissue Absorption*:

Total Dose (rad(tissue))

Maximum Gamma Contribution (rad(tissue))

Maximum Neutron Contribution (rad(tissue))

Silicon Absorption/Displacement Damage*:

Maximum Combined Neutron/Gamma Ionizing Dose (rad(silicon))

Maximum Neutron Fluence (1MeV equivalent damage in Silicon) (neutron/cm2)

Peak Gamma Dose Rate (rad(silicon)/sec)

**Silicon dose is provided for the engineer's use in overcoming Transient Radiation Effects in Electronics (TREE) problems in silicon based electronics. The neutron and gamma components of the total tissue dose are provided for conversion to other dose responses as required.*

Figure 2

By using a threat yield spectrum in lieu of particular yields, the hardening criteria methodology is made scenario independent. The threat yield spectrum used by USANCA in deriving the nuclear hardening criteria is validated by the Office of the Deputy Chief of Staff for Intelligence (ODSCINT).

Given the man-machine relationship and the corresponding casualty mechanisms, a logarithmic plot of weapon yield versus range to effect can be prepared which depicts each casualty mechanism as an isocasualty curve. An example of such a plot is found in Figure 1. From this plot, a governing isocasualty curve is chosen.

By inspecting the INWE levels which occur along the governing isocasualty curve, and within the bounds of the threat yield spectrum, a set of nuclear hardening criteria, containing parameters for blast, thermal radiation and initial nuclear radiation, may be derived.

The use of a governing isocasualty curve ensures that a system will be hardened at a level where the crew survivability requirement is met and the system is not left vulnerable to any particular INWE.

While the governing isocasualty curve provides information on INWE as they relate to human survivability, materiel developers need the hardening criteria expressed in terms which are meaningful to design engineers. Therefore, the INWE environments are expressed as nuclear hardening criteria according to the format shown in Figure 2.

In addition, the EMP environment, although not considered a casualty producer, is described for both the endoatmospheric and exoatmospheric EMP threats to equipment electronics. The EMP parameters specified for hardening criteria are selected components of the electric (E) and magnetic (H) fields and the air conductivity.

While a nuclear survivability requirement may be met by a method other than hardening, the alternative choices of timely resupply and redundancy are inappropriate for systems which have electrical components which are vulnerable to the theater-wide effects of exoatmospheric (or high altitude) EMP (HEMP). Therefore, a requirement for HEMP only hardening is often imposed on systems that may not otherwise require hardening against all INWE.

In the case of armored combat vehicles, there is an interesting adjunct to nuclear survivability requirements. At the lower end of the yield spectrum, an armored vehicle is less vulnerable to blast effects than its crew is to the associated radiation environment.

Through the use of radiation shielding, the area of crew vulnerability to the radiation environment may be reduced to a level where blast and radiation casualty mechanisms are coincident.

Although the nuclear survivability program does not address radiation shielding as a requirement, there are operational benefits which may accrue from incorporating shielding into the development of armored vehicles in concert with nuclear survivability requirements.

Conclusion

The methodology for developing nuclear hardening criteria continues to evolve. As new data on human response to INWE environments is published, the isocasualty curves depicted in Figure 1 are adjusted. Similarly, as data on the blast vulnerability of vehicles (and corresponding casualty production in vehicle occupants) is updated with results from high explosive tests, blast isocasualty curves are revised. The net result of the program is that once hardening criteria have been incorporated into design and production of tactical systems, commanders in the field can have greater confidence in their ability to fight and win on the nuclear battlefield.

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Economic Analysis. . .

A NECESSITY FOR RESOURCE ALLOCATION DECISIONS

By Richard Scott

Introduction

Although this article concerns the application of economic analyses (EAs) within the Department of the Army, most individuals probably apply the same concepts discussed here in their daily life. People do not normally make a significant purchase such as an automobile, furniture or major appliance without first comparing various alternatives. In doing this comparison, people employ the basics of EAs, answering such questions as what is the initial acquisition cost, what is the annual operations and maintenance cost, or what do the available options add to the cost?

Questions concerning potential benefits which will be enjoyed as a result of the investment are also basic to most people when contemplating a major investment of personal funds. The time it takes to perform the analysis which precedes these major investments is extremely valuable in either saving a few dollars or providing a sense of satisfaction at having spent money wisely.

EAs are a critical aspect of the materiel acquisition process. The development and acquisition of Automated Information Systems require the preparation and approval of an EA for systems at major command, HQDA or OSD approval level. Additionally, all facility acquisition (or lease), equipment procurements, value engineering proposals and productivity improvement proposals require the preparation of an EA. In the weapon system acquisition area, there are special EAs — Cost and Operational Effectiveness Analysis (COEA) and Cost/Training Effectiveness Analysis (CTEA) — which are an integral part of the acquisition process. In fact, all who have responsibility for investing Army funds are required by AR 11-18, The Cost and Economic Analysis Program, to perform an EA.

Unfortunately, there are a large number of instances when an EA is not performed for Army resource investments; thus dollars may not be saved nor are resources being invested wisely. A recent Army Audit Agency study identified 135 different instances at activity or installation level in which the Army had not properly applied an EA. In general, the study noted the failure to conduct an EA, the issuing of a waiver of EAs where the situation did not warrant such a waiver, and the application of improper EA methodology.

Components

The formal definition of an EA is the systematic evaluation of alternative solutions to a specific mission requirement in terms of comparative costs and benefits. As a minimum, each EA must contain the following components:

- **Establishment and definition of desired goal or objective.** A statement of the mission-related objective of the action being considered where the objective is some fixed standard of accomplishment. The more precisely the objectives can be defined, the greater the likelihood that the analysis will be of benefit to the needs of the decision maker.

By relating the objective to the current mission of the organization, criteria for judging each suggested alternative can be established; i.e., what is the primary benefit being sought? For example, 100 persons must be trained to perform an error-free overhaul of an aircraft engine after 80 or less platform hours of instruction. This establishes three criteria: 100 persons must be trained, their training must be completed in 80 hours or less, and they must be able to execute perfectly what they have learned.

- **Identification of alternatives.** Once the objective has been defined, all feasible alternative methods for accomplishing the objective can be developed. This includes the current way of doing business, also called the status quo. Optimal allocation of resources is largely dependent on the consideration of suitable alternatives. Clearly, the final decision can be no better than the alternatives available to the decision maker.

- **Specification of assumptions and constraints.** Assumptions are statements made to support and reasonably limit the scope of the study, and to make it consistent with the current operating environment. Assumptions should not be confused with facts, and there must not be an attempt to ease the workload by utilizing assumptions when, with research, factual information and data could be presented.

Unreasonable, unrealistic or undue constraints can result in limiting the number of alternatives considered. This seriously slants the analysis and forces omission of feasible solutions. On the other hand, minimizing the attention given to assumptions and constraints can lead to recommending unrealistic courses of action. All underlying assumptions must be explicitly stated, logically consistent, relevant to the question at hand, and defensible. Generally, constraints are imposed from outside, while assumptions are formed by those doing the EA.

- **Listing of costs (inputs) for each feasible alternative.** Cost considerations must enter every decision relating to the allocation of resources. The cost concept used in a particular situation depends upon the decision to be made. The analyst must determine what resources (such as personnel, equipment, and facilities, including existing assets) are required for each alternative.

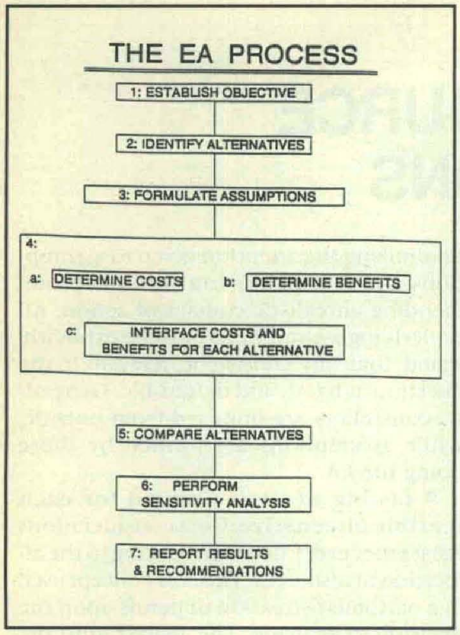
The acceptance of the entire EA is predicated on the credibility of the cost estimates. Therefore, care must be taken to document data sources, provide the derivation of all costs, and maintain a clear audit trail in the EA.

- **Listing of benefits (outputs) for each feasible alternative.** Mission related benefits of the alternatives must be identified and analyzed. Benefits should be expressed in terms of a quantified common denominator; e.g., dollars, and they should be expressed quantitatively whenever possible, number of items inspected, etc.

If quantification is not possible, the benefit can be non-tangible; e.g., improved morale, improved safety, etc. Benefits are indicators of the degree to which a manager will accomplish the mission and, therefore, should be in terms which are meaningful to the decision maker. Benefits should be documented with the same effort and integrity as the cost estimates.

- **Comparison of costs and benefits and ranking of each feasible alternative.** This is the essence of the EA process that provides the necessary tool for decision making. After the costs and benefits of each feasible alternative are quantified, you can analyze the alternatives side by side, evaluate ratios/factors/results, compare the benefits, rank the alternatives, and select the preferred alternative.

- **Uncertainty or sensitivity analysis.** A sensitivity analysis is basically a "what-if" exercise. It tests whether the conclusion of the EA will change if some variable, such as a cost, benefit, or other assumed variable value changes. Sensitivity analyses should always be performed when the results of the EA do not clearly favor any one



alternative or when there is a great deal of uncertainty about a cost, benefit, or other assumption in the EA. By performing a sensitivity analysis, the analyst assures the decision maker that uncertainties in the EA have been tested and the results documented.

• **Prepare conclusions and recommendations.** The final step of the EA process is to summarize the results and make conclusive statements about the comparisons. Conclusions should describe the relative effectiveness of the competing alternatives by explaining how well the alternatives satisfy the desired goal or objective within the scope of the assumptions and constraints.

The conclusions should also demonstrate clearly the type of cost/benefit relationships that exist between alternatives, how the alternatives were ranked, and how the criteria established in the objective statement were met. Following a clear statement of the conclusions, the EA document should contain a firm recommendation regarding the preferred alternative. The diagram above shows the entire EA process.

EAs are generally required for all new or on-going programs forwarded to higher headquarters for approval. Programs or activities justified on the basis of military necessity are not exempt from the requirement for an EA. We recommend that all programs and activities, whether or not they go to higher headquarters, have an EA performed. This ensures that all appropriate alternatives are evaluated in the decision making process.

EAs should be prepared at the Army activity having program or project proponency. Documentation supporting the results of the analysis must include the methodology, rationale, and computations used to estimate the costs and benefits. This documentation must permit independent reviewers to follow the formulation of the conclusion with data sources specifically identified.

EAs must be validated by a cost analysis organization at the MACOM level prior to submission to HQDA. The EA validation process should be accomplished concurrently with the development of the estimate in order to preclude delaying the decision process until the EA is validated. That is, the organization doing the validation should be involved as the analysis progresses, rather than seeing the EA only after it has been completed. The policy for validation of EAs which do not come to HQDA is left to the discretion of the MACOM.

Exceptions

The only exceptions to the requirement for preparation of EAs are:

• When it can be shown that the minimum level of effort required to do the analysis would not be worth the benefits to be gained from such an analysis.

• When DOD instructions or directives waive the requirement for an EA.

• When proposed actions are specifically directed by statute, regulation, or a directive of higher authority that precludes choice or trade-off among alternatives.

Training

One can see from the previous discussion that almost all projects and programs within the Army will require an EA. Even though it's prescribed by regulation, it makes sense, with resources becoming increasingly constrained, that EAs must be performed. The dilemma of this situation is that most resource managers do not have adequate staff or their staff isn't trained to perform an EA.

Obviously, there are no simple solutions for the lack of staff. This is another case where managers are going to be required to prioritize workloads to get an EA accomplished at the expense of lower priority work. For the staff with a lack of training, there are solutions.

The Army Management Engineering College (AMEC) in Rock Island, IL provides several opportunities for EA training at different levels. The point of contact at AMEC for course content and schedules can be reached at DSN 793-0465 or commercial (309) 782-0465.

Additionally, over the past several years, a number of organizations have developed internal EA training programs. The course material developed for those training opportunities will provide, at the least, the basics for the conduct of an EA. Cost analysis organizations at most Army Materiel Command subordinate commands have developed and conducted internal EA training.

There is an additional dilemma which is sure to surface in the conduct of an EA. After the EA is finalized and approved, the preferred alternative may be unaffordable in terms of the organization's available resources. Again, there is no obvious solution. However, the program with the well defined, well documented EA is sure to compete much better for those resources which are available than the project or program that has no EA.

The U.S. Army Cost and Economic Analysis Center (USACEAC) is the proponent for the Cost and Economic Analysis Program. USACEAC, located in the Washington DC area, is prepared to provide guidance in the preparation of an EA. Questions can be directed to (703) 756-0217, DSN 289-0217.

A goal of USACEAC is to establish a number of centers of excellence for various EA types. The Office of the Chief of Engineers, for example, would be the focal point for guidance in all construction type EAs, while other organizations would be designated to provide guidance in value engineering, productivity improvements, and all other types of EAs. Once the centers are established, the locations of the points of contact will be publicized.

USACEAC recently updated it's Letter of Instruction (LOI) for Performing an EA and Costing Requirements for Automated Information Systems (AIS). Copies are available on request. Additionally, a new DA Pamphlet 11-2, *Guide for Economic Analysis* is scheduled for publication by the end of FY 91.

Conclusion

The purpose of this article is to improve the application of economic analyses throughout the Army, to raise management awareness of the process and to advertise available training opportunities. It is imperative that the EA process within the Army be incorporated as an integral part of resource allocation decisions.

The improvement of the Army EA program has the complete support and backing of the assistant secretary of the Army for financial management and the comptroller of the Army. We can not afford to make decisions to spend dollars without the benefit of an appropriate EA to substantiate those decisions. To ignore economic analyses in decision making just doesn't make good management sense.

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THE 'RAPID' WAY TO SOFTWARE DEVELOPMENT

Reducing Costs of Software Development and Maintenance By Revising Ada Products

By Russell Roberts

In this era of increasing software development and maintenance costs, Reusable Ada Products for Information Systems Development, better known as RAPID, is providing the key to reducing these costs within the Army.

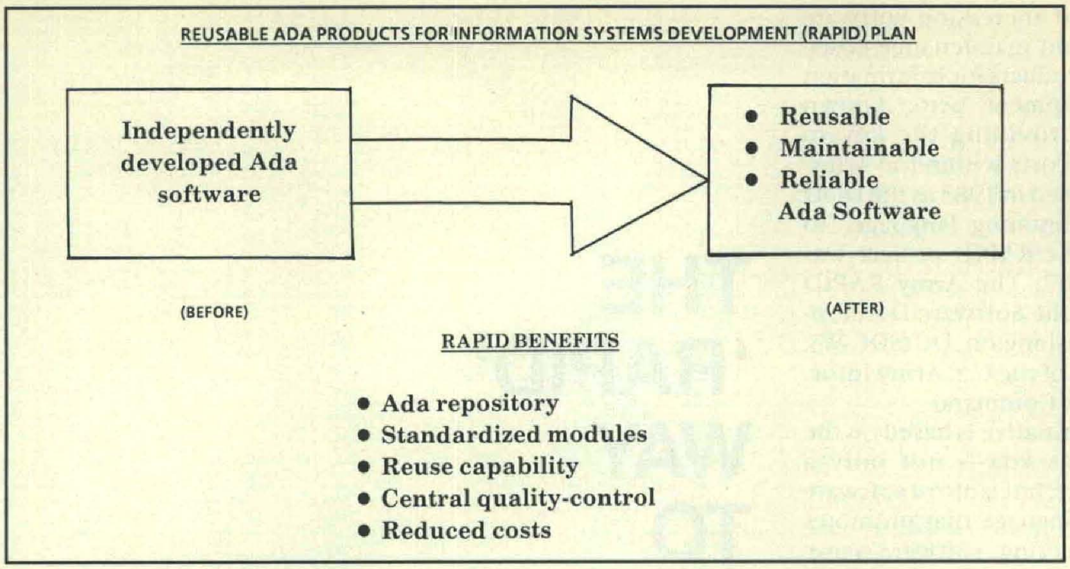
Ada was adopted in 1983 as the DOD standard programming language. To support Ada, the RAPID project was initiated in 1987. The Army RAPID effort is led by the Software Development Center, Washington, DC (SDC-W), a subcommand of the U.S. Army Information Systems Command.

The RAPID initiative is based on the realization that Ada is not only a coding language, but is also a software development language that promotes software engineering, software reuse, and reduced development costs. With this in mind, the RAPID Center library system incorporates reusable Ada products and is being developed as a "user friendly" support tool to facilitate the storage, classification, cataloging, retrieval, and selection of reusable Ada software packages.

Major objectives of the RAPID project are to promote the "reuse" of Ada software components and to reduce the cost of systems development and maintenance. Figure 1 presents these objectives in a "before and after" scenario which shows the change from an environment where Ada is developed independently, to an environment that reuses Ada software.

The heart of the RAPID Center is the RAPID Center library. This automated facility is an operational, interactive library system which operates on a Digital MicroVAX or larger computer. The RAPID Center library is used for the identification, analysis, and retrieval of Ada reusable software components. When fully populated, it will contain at least several thousand Ada reusable software components. At present, the library contains 871 components. It's at the RAPID Center where the reusable software components are evaluated, categorized, and stored in the library for easy access by software developers.

To retrieve components from the library, the user identifies the requirements of the component needed through the use of descriptors. The library system uses the descriptors, called "facets," to search the data base for candidate reusable software components, and to provide the selections to the user. When a user has identified



a satisfactory component, the library provides the requestor the reusable software component, including source code, its requirements, and design criteria. By providing this service, the RAPID Center saves the user development time and resources.

Key to the success of the RAPID project is its experienced staff. They provide the expertise to operate the RAPID Center and to interface with its users.

The RAPID project is being implemented in three phases. Phase I, completed in 1989, consisted of developing the software for the RAPID Center library system and identifying the policies and procedures necessary to run the center. Phase II, currently underway, is an 18 month pilot RAPID Center operation intended to test the RAPID concept, to resolve technical, management, and legal issues regarding reuse, and to provide RAPID functionality to the four other USAISC software development centers. Phase III includes plans to expand the RAPID Center services throughout the Army and DOD.

The initial RAPID pilot tests covered only management information systems such as financial and logistical. Because the policies, procedures, and guidelines developed in support of Ada reuse are generic and evolutionary, they can be applied to any system that uses Ada.

While the RAPID project has already experienced preliminary successes in its pilot tests, cost savings through Ada reuse have a proven track record. A 1988 Air Force report entitled *The Ada Evaluation Project on the Reuse of Ada Software Modules*, indicated that a six to eighth month effort to create Ada code was completed in three weeks through Ada reuse.

According to the RAPID Center, the Marines are developing systems that are composed of 70-80 percent reused components. The remaining 20-30 percent is new Ada code development. These "reused" components have been successfully incorporated across several application domains, including logistics, training, finance, and nuclear regulatory systems.

As for the Army, the RAPID technology is being applied to the development of the Standard Army Information Systems such as the Standard Finance System and the Standard Installation/Division Personnel System-3. In addition, the RAPID project is also involved in the development of command and control systems to include the Army Worldwide Military Command and Control System Information System and the Army Tactical Command and Control System.

Industry experts are reporting gains in productivity with the limited number of reusable components and corresponding documentation available. Industry has estimated that the amount of components expected to be reused on projects is 40 percent over a complete system. In terms of dollars, the cost savings obtained through Ada reuse are significant. A 1986 Institute for Defense Analysis study indicated the cumulative cost reduction over 10 years on DOD expenditures would be about $7.35 billion. With the proliferation of Ada throughout DOD over the last four years, today's potential cost reduction savings are much higher.

Although in its infancy, the RAPID project has an impressive list of customers that include the Air Force Computer System Division, NASA's Space Station Freedom effort, DOD's Joint Integrated Avionics Working Group, and DOD's Software Technology for Adaptable, Reliable Systems National Repository. The high visibility that has been achieved by the RAPID project can only enhance its reputation as the Army's leader in promoting software cost savings.

The RAPID project is a self-perpetuating entity. As more SDCs use the RAPID Center and provide additional reusable software components to its library, the larger it will become. This will provide for even greater customer satisfaction. In these times of increasing software costs, Ada reuse offers a sure way to reduce software development and maintenance costs. This is truly the "RAPID" way to software development.

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TESTING OF THE M109 SERIES HOWITZER

A Case Study

By COL Robin L. Elder

Introduction

A review of the testing of the M109 series howitzer during its extended life cycle provides a look at the development and growth of a successful Army weapon system over its 30-plus years of service. It also provides a look at the changes that occurred in the Army's test and evaluation policies and organizations during that same period. This review provides some insights about the effectiveness of those testing policies.

Evolution of Testing

In 1956, when testing of the first prototype of the M109 howitzer began, virtually all testing of field artillery materiel was conducted by or under the supervision of the Field Artillery Board. The board president reported to the commanding general of the Continental Army Command and was tasked as follows: "You will conduct user tests on those items of equipment designated as your responsibility by the provisions of reference lh as directed from time to time by this Headquarters. Your examination and test of these items will be from the viewpoint of their suitability for use by average troops under combat conditions and will take into consideration the necessity for ruggedness, simplicity, and ease of maintenance insofar as these are compatible with the state of the relevant art and the approved military characteristics."

The board's evaluation relied on the experience, expertise, and military judgement of the assigned officers with provisions for minority reports from any officer assigned. The board was included from the earliest design phase, including review of engineer drawings, through the final fielding of materiel.

In a 1962 reorganization of the Army, the Field Artillery Board was assigned to the Army Materiel Command's Test and Evaluation Command. This change did not alter the mission of the board and service testing of the M109 was continued. This testing was characterized by a test-fix-test process in which the correction of deficiencies, validated by the board, appeared to be the final criteria for acceptance by the Army.

In 1972, the Department of Defense was directed to establish independent operational test and evaluation organizations within each of the services. The Army Operational Test and Evaluation Agency (OTEA) was created and assigned the mission of evaluation of operational testing. Creation of OTEA was in response to the findings of a 1970 Presidential Blue Ribbon Defense Panel which determined the need for an evaluation of testing independent from the materiel developer.

In 1974, the Army Materiel Acquisition Review Committee recommended that test boards be transferred to the Training and Doctrine (TRADOC) Command for operational testing and force development testing and experimentation. The mission of the boards evolved from service to operational testing, distinct and separate from engineering or development testing.

The classification of testing as developmental or technical testing (DT/TT) and user or operational testing (OT) is a current part of the lexicon of the test and evaluation community.

Technical testing, which is characterized by scientific approaches under controlled conditions, determines if the technical development objectives of the acquisition process have been fulfilled. Operational testing is that testing conducted with typical user operators and crews under realistic combat conditions to determine if the system meets the user's requirements.

In 1988, the test boards were again reorganized, this time under the command of the Test and Experimentation Command (TEXCOM), a new subordinate command of TRADOC. This reorganization was immediately followed by the directive from the Defense Management Review that reorganized the entire test and evaluation community. The test boards were consolidated with TEXCOM and OTEA to create the Operational Test and Evaluation Command.

Evolution of the M109

The need for a self-propelled howitzer to support the armored force dates back to 1950 when the requirement was established in the *Army Equipment Development Guide.* In June 1952, the Qualitative Materiel Requirement was approved by the Department of the Army. The first prototype (T196) was completed in 1956. At that time, the Army changed the requirement from a calibre 156mm to the current 155mm. It was also revising its policy to require a multifuel engine in all systems. Since the T196 was propelled by a gasoline engine, this required a major design change to a T196E1.

Testing of the new howitzer was terminated in August 1960 due to a number of design problems, including a problem with the power rammer. The power-rammer problem would plague the system for years to come. Testing resumed on the redesigned howitzer in July 1961.

The T196E1 was type classified Standard A as the M109 howitzer on July 25, 1963. It underwent what was known as Type II Confirmatory Test through January 1964. A program to develop a propellant (M119) to achieve a range of 18,000 meters was initiated in 1963 and was undergoing testing concurrent with but separate from the weapon testing.

Extensive testing of the M119 propellant over a five-year period resulted in excessive blast and overpressure problems for both the personnel and the howitzer and eventually led to a requirement for a new cannon tube (M185).

Concerns about the combat readiness and the ruggedness of the design of the M109 howitzer were raised by commanders in Vietnam in the mid-60s. These concerns resulted in a

Product Improvement Testing M109/M109E1

Preparation of Ammunition During IOTE M109A3E2

37-item product improvement program (PIP) begun in 1966 and a test in that same year. A subsequent product improvement test was conducted in January 1968 which evaluated 36 additional items.

The product improved M109, with M185 cannon, was redesignated the M109E1, retested in 1970, and type classified as the M109A1. The howitzer was not changed again until 1977 when a product improvement package of 19 items was tested and resulted in the type classification of two models — the M109A2 and A3. The A2 was a production model howitzer with product improvements incorporated in the design, the A3 was a depot rebuilt howitzer. The two models were identical except for minor details.

The M109 underwent what was intended to be its final product improvement in 1986. These improvements were named the Howitzer Extended Life Program (HELP). Twenty-five product improvements were evaluated during an operational test and a technical test. This "maxi-PIP" was then scaled down and resulted in the M109A3E2 Howitzer Improvement Program (HIP). A test was conducted in 1989, and the howitzer was type classified as the M109A6 (Paladin).

Discussion

A review of the M109 over its extended life reveals a classic example of evolutionary development of a proven system. No major breakthrough in technology has occurred that would have resulted in revolutionary changes to the system. Major PIPs were applied and tested in 1966, 1968, 1971, 1977, and 1985, culminating in the HIP in 1989.

Extensive testing was conducted and substantial test resources committed to testing the M109 howitzer. More than 185,000 rounds were fired, and the howitzer was driven over 72,000 miles during predominantly operational testing. (The distinction between DT/TT and OT did not occur until several years into the life cycle of the system. Test data in this article does not include all technical testing conducted after 1973.)

The volume of testing is impressive and causes a reviewer to ask many questions. Has this testing been cost effective? Has the testing improved with the many reorganizations of the test and evaluation community? Have we done too much testing? Has the Army made effective use of test results? These questions, among others, should be considered as we look at the testing of the M109.

RAM Requirements

The amount of testing of a military product is driven primarily by the number of rounds, miles, hours, etc., necessary to demonstrate statistical confidence that the product meets its reliability, availability, and maintainability (RAM) requirements.

RAM is often the main driver of test duration and resources. A review of selected M109 test results was compiled to determine if an historic evaluation would provide any useful generalizations in this critical area of testing. Two mission success parameters were selected for comparison, Mean Miles Between Failure (MMBF) and Mean Rounds Between Failure (MRBF) (see Figure 1).

In early testing of the M109 (prior to 1970), the number of miles and rounds required to demonstrate system RAM appears to have been a constant (4,000 miles/rounds per howitzer). RAM values were not computed. The comparison of results after 1970 is alarming. The results shown in Figure 1 indicate that the many product improvements of the M109 have resulted in a deterioration of the two RAM values listed by a full order of magnitude. Actually, this is not the case.

Because no attempt has been made to establish system performance baselines, little of value can be determined by comparing numbers in Figure 1. Likewise, the system operational mode summary mission profile (OMS/MP) has changed as the threat and requirements changed. It is clear, however, that each test in the life cycle of the M109 was treated as a discrete event.

Side-by-side comparisons of current and experimental models were the most common testing mode, but the potential to base-line and track system improvements has not been realized as a result of the change in conditions and treatments during each test. The matter is further complicated by improvements in the ability to replicate the threat and to create realistic combat conditions since the first test of the M109. However, there is no data available indicating that these improvements in operational testing have resulted in a better howitzer in the field.

The RAM area was then examined from a different approach. Test reports were reviewed to determine if there were trends in failures or failure modes. This analysis revealed some common failures that have occurred in testing of the M109. The most common failures occurred in the following systems: cooling system, power rammer, breech mechanism, and headlights.

Component redesign apparently remedied three of the four areas prior to the most recent testing of the system. Breech mechanism failures were again noted during the HIP initial operational test and evaluation (IOTE).

Sample Data Collection

In this sense, testing has been an accurate predictor of system performance in the field as shown by a comparison of the failure modes reported during operational testing to similar data from the extensive 9-year sample data collection program conducted by U.S. Army Armament Munitions and Chemical Command. This would seem to indicate that hardware failures detected during operational testing are true indicators of design weaknesses.

The sample data collection program drew from organizational units deployed worldwide. It is safe to say that unit training under the most strenuous conditions rarely satisfies the OMS/MP and therefore, could not be compared to test derived RAM data.

The M109 program illustrates another problem related to the OMS/MP, that is the dichotomy between the requirement to conduct system testing under simulated combat conditions and the inability to train to that level due to constrained resources.

In order to satisfy the HIP OMS/MP, for example, it was necessary to achieve rates of fire and movement far beyond that conducted by any artillery unit since before the conception of the M109, if ever. The HIP howitzer section fired more rounds in one month of testing than is allotted to a section for 10 years of training. This can lead to system failures that are attributable to testing in a unique environment and not to the system under test.

Although RAM is the key to the length and duration of testing, it is by no means the only potential area for improvement. Tests are designed to provide the necessary data to answer issues of concern to decision makers. The history of M109 testing indicates that some issues seem to be very resilient. The requirement for spades on the M109 howitzer has been an issue addressed in four separate tests; the results in each case were similar.

The accuracy and precision of firing were not affected by the use of spades except in soft soil conditions, mud, or sand. This type of redundant testing may be a result of an inadequate literature search but more commonly is due to a perception by the decision maker that conditions have changed. This is a simplified example in that the decision maker for the spade test was the proponent. In the case of a major IOTE the tester must satisfy the proponent, the independent evaluator, the DOT&E, the Defense Acquisition Board, and Congress.

It would be very difficult to accurately assess the true impact of organizational changes in the test and evaluation community on the M109 program. Due to the significant changes to all aspects of materiel acquisition by the DOD over the past 30 years, it is impossible to assess causality.

M109 RAM DATA

SOURCE	YEAR	MODEL	VALUE MMBF	VALUE MRBF
USATACOM RAM ASSESSMENT		M109	1662	3788
SERVICE TEST M109E1	1970	M109E1	1927	9982
ARMCOM SYSTEM ASSESSMENT	1976	M109	620	1100
		M109A1	420	1330
PRODUCTION IMPROVEMENT TEST-HELP	1986	M109A2	390	1850
		M109A3	390	1505
		M109E4	141	554
OT II M109E4	1986	M109E4	121	757
IOTE HIP (M109A6)	1989	M109A3	-	296
		M109A6	-	320

Figure 1.

Conclusion

The testing required to initially type classify the M109 was certainly much less than that required for the product improvement to the HIP. The first test consumed 10,725 rounds for both engineering and service tests, and the HIP consumed 25,872 rounds in operational testing alone.

The HIP IOTE was a test of the entire artillery system from observer to howitzer. It was a side-by-side test against a realistic threat.

The M109 test was primarily a hardware test of the howitzer. The scrutiny of a system by all levels of decision makers, to include the U.S. Congress, is certainly much greater today than 30 years ago. None of these changes assure us of a better howitzer. There is little doubt, however, that the Paladin has been adequately tested to date and, when it clears the final hurdle of follow-on test and evaluation, will have demonstrated the pedigree to represent the M109 family in the field.

COL ROBIN L. ELDER is director of the TEXCOM Fire Support Test Directorate. He was commissioned through the Reserve Officers' Training Corps Program. He holds an M.S. degree in management science from Rennselear Polytechnic Institute.

AMERICA'S FIVE ARMED SERVICES

By Norman R. Augustine

Our country's stunning victory in the Persian Gulf is a tribute to all five branches of America's armed services. The Army, Air Force, Navy and Marines are the four branches that immediately come to mind. The fifth branch, though we don't often think of it as such, is the U.S. defense industry. We need all five to maintain our defense preparedness.

Without the Navy, we never would have been able to get most of our forces to the battlefield. Without the Air Force, we never would have been able to gain total mastery of the skies and pound the Iraqi ground forces from above. Without the Army and Marines, we never would have been able to deliver the knockout punch in the ground war. And, without the defense industry, we never would have had the high technology capability that acted as a true force multiplier against Iraq's numerical and home-court advantages.

Before the Gulf War started, the combat-area ground forces of Iraq were larger than those of the U.S. Army and U.S. Marines combined. Conventional tactics say that a well-prepared defending force can stalemate an attacker three times its size. Superior American technology helped make that principle itself stale.

Technology has worked that way throughout history. The stirrup, for example, simple by today's standards, was an enormous breakthrough. For the first time a knight on horseback could secure his feet and thereby control a lance with great precision.

The wonders of the stirrup were minor when compared to the power the longbow gave English archers against the French in the Battle of Crecy in 1346. The longbow became outdated by the invention of gunpowder and, eventually, the rifle. The rifle's dominance was in turn blunted by the power of the machine gun. This technologically-superior weapon gave the Germans victory in the Battle of the Somme during the First World War. The British, using outdated infantry tactics, advanced battalion after battalion against entrenched German machine guns and promptly lost some 10,000 of their finest troops.

The machine gun produced a stand-still among well-entrenched forces until the invention of the tank, which could overwhelm fixed positions. Germany's highly-mobile tank armies at the beginning of the Second World War swiftly overwhelmed the heavily-fortified Maginot line.

During the Second World War it took some five tons of air munitions or three tons of artillery to destroy a single tactical target. The same ratio held true during Korea and Viet nam. Over 850 sorties and 250 tons of conventional bombs failed to destroy a single span of the Thanh Hoa bridge in Vietnam during the early years of the war. But a single laser-guided bomb in use near the war's end destroyed the bridge in just one attack without the loss of aircraft or crew member.

Each new military advance eventually finds its match in a countermeasure. We can be sure that the technologies that proved so decisive in the Persian Gulf — lasers, infrared detectors, space surveillance, precision-guided missiles, night vision, stealth — will all generate countermeasures.

That's why we must continually improve our military capability. If we don't, we'll find ourselves in the position of the French at the Battle of Crecy or the British on the Somme. Indeed, most of the technology used in the Gulf War was of 1970s vintage — paling in comparison with what is being pursued in American laboratories now. Smart weapons of today will soon give way to brilliant weapons of tomorrow.

President Eisenhower, in a generally-forgotten passage of his oft-quoted speech about the military-industrial complex, said that "we can no longer risk emergency improvisation of national defense; we have been compelled to create a permanent armaments industry of vast proportions."

The systems we saw at work in the Gulf demonstrated exactly what he must have meant. They were funded and built over a 20-year period. It takes an average of eight years to develop a new weapon system and another five-to-10 years to acquire it in significant quantities. In the case of the Patriot missile, it took a quarter of a century to get the system that was used so successfully for the first time in the Gulf. Yet when the war began, we barely had Patriot at all to counter the Scud attacks. The Army and industry's efforts to deliver the system before January 16th gave new meaning to just-in-time manufacturing.

In addition to taking time to develop, technology also takes money. But it's money well spent. It has saved the lives of countless numbers of our armed forces and the people they defend. The choice is simple: either we spend money on technology before a war starts, or we pay the price after it begins. In the latter case, we pay in a much more precious currency — that of the blood of our men and women in uniform.

The invasion of Kuwait presented us with a true "come-as-you-are" war. Fortunately, America was prepared. Our troops were well led, well trained, and well equipped. Contrast that with the experience of our soldiers at the outset of the Second World War when they had to train with broomsticks for rifles and old automobiles with the word "tank" painted on their sides.

FROM INDUSTRY

It is the responsibility of the fifth armed service — the defense industry — to develop technologies that endow the other four armed services with superior fighting power. But the defense industry cannot do this without support from our political leaders and the public and, indeed, for its sister services.

During the development of virtually every major weapon system embodying any reasonable advance in the state-of-the-art, there comes a time, no matter how ably the program is managed, when seemingly overwhelming problems are encountered. In such cases, it invariably becomes easier — and far more popular — to cancel the program, and start over with a new system which would — as we delude ourselves — have no problems. We came within millimeters of doing this on the Patriot which was nearly cancelled not once but several times. The same is true of the Cruise missile, the M-1 tank, the Bradley Fighting Vehicle, the Blackhawk, Apache helicopter, Tomahawk, and AWACS.

Everyone of these systems proved itself invaluable in the Gulf. Yet, at one time or another, cancelling these programs and starting over would have been more popular with the media, the public, the Congress, the president, and sometimes even with parts of the military services themselves. Fortunately, different counsel prevailed. That is not to say that once in a while there is a system that truly is a failure and has no realistic chance of success. Such projects certainly should be cancelled. But in the *overwhelming* majority of cases, the correct answer is to work through the problems. In short, "tough it out" — just as an Army does in any type of combat.

To fail to exhibit this perseverance merely guarantees that we will have ill-equipped armed forces backed with a long trail of half-completed R&D projects. We *narrowly* avoided this in the Persian Gulf War.

NORMAN R. AUGUSTINE, a former undersecretary of the Army, is chairman and chief executive officer of Martin Marietta Corp. and coauthor with Kenneth Adelman of The Defense Revolution.

LETTERS

Dear Sir:

I was on active duty in MICOM for five years and have been working as a Systems Engineering and Technical Assistance Contractor (SETAC) for 6 years. During the latter period, I've personally subscribed to RDA Bulletin to keep up with the state-of-the-art.

It is very difficult, down in the pits, to keep up with organizational and personality changes so that I may better advise my customer.

Please consider publishing in RDA Bulletin a top level listing of the HQ AMC structure, titles, names, and phone numbers. This should help the acquisition community identify the key players in support of their particular system. It would also serve to provide HQ AMC additional visibility in this day of the Program Executive Officer.

Respectfully,
Paul A. Hays

Army RD&A Bulletin Responds: Thank you for your letter. Since space limitations preclude us from publishing the information you requested, we have asked the HQ, AMC Public Affairs Office to provide you whatever material they have available to meet your requirements. In addition, *Army RD&A Bulletin* is currently featuring a series of articles highlighting the Army's PEO structure and AMC's major subordinate commands. We hope this information is helpful.

Dear Sir:

I am writing with regards to [the] article in the September-October [1990] Bulletin regarding the Journal of Defense Research (page 41). Your article indicated that the JDR is the only refereed journal for classified papers at the secret level. This is not correct.

The Defense Nuclear Agency publishes the **JOURNAL OF RADIATION EFFECTS, RESEARCH AND ENGINEERING** (JRE) with articles up to the level of Secret, Restricted Data. This is a refereed journal published to provide a permanent record of the excellent scientific research in the area of nuclear weapons related radiation effects precluded from publication in the open literature. In addition to classified articles, the JRE provides a media for the considerable volume of unclassified but limited distribution papers such as those falling under the International Traffic in Arms Regulations. As with the JDR, distribution is to approximately 1,200 members of the DOD and DOD contractors with appropriate need to know.

The JRE is published at least twice each year with one issue documenting the Proceedings of the annual Hardened Electronics and Radiation Technology (HEART) Conference. Other issues may focus on specific technical areas or represent an assembly of contributed papers.

The JRE is assembled by the Defense Nuclear Information Analysis Center operated by the Kaman Sciences Corporation for the Defense Nuclear Agency. For additional information contact DASIAC at: DOD Nuclear Information Analysis Center, 2560 Huntington Avenue, Suite 500, Alexandria, VA, 22303.

William A. Alfonte Jr.
Managing Editor
Journal of Radiation Effects

Army RD&A Bulletin Responds:

Thank you for providing this information. We encourage feedback, such as your letter, from our readers.

Locations for RD&A Officers

In the "Career Development Update" of the November-December 1990 issue of the *Army RD&A Bulletin*, we published a listing of assignment locations for RD&A officers. The locations focused on positions in the Functional Areas (FA) 51, research development and acquisition, and FA 52, nuclear weapons research. Those locations having AAC Critical Positions (4Z) were also listed. This article focuses on assignment locations of positions in FA 53, acquisition developmental or related systems automation acquisition assignments; FA 97, contracting and industrial management, and branch combination 15C35, aviation and intelligence. Please note that these locations do not reflect grades or numbers of authorizations at the locations. Further note that source documentation is under constant change, particularly during this period of downsizing the Army. In the event your organization is not listed, please notify the Army Acquisition Corps Proponent Office at DSN 284-9575 or Commercial (703)274-9575. We will identify your organization in a subsequent issue of the *Army RD&A Bulletin*.

ALABAMA

Redstone Arsenal:
HQ, U.S. Army Missile Command (FA 97)
Anniston Army Depot:
U.S. Army Depot Anniston (FA 97)
Fort Rucker:
U.S. Army Aviation Center (15C35)

ALASKA

Fort Wainwright:
6th Combat Aviation Brigade (15C35)

ARKANSAS

Little Rock:
Joint Readiness TN (FA 97)

ARIZONA

Fort Huachuca:
U.S. Army Info Sys Engr Cmd (FA 53)
U.S. Army Information Systems Command (FA 97)
U.S. Army Intelligence School (FA 53)
Mesa:
Rep Plant McDonnel Douglas (FA 97)

CALIFORNIA

Fort Irwin:
U.S. Army National Training Center (FA 97)
Elsegundo:
DCMR Los Angeles (FA 97)
Alameda:
U.S. Army Element Defense Subregion (FA 97)
Livermore:
U.S. Army Research Associate Group (FA 97)
Sacramento Army Depot:
U.S. Army Depot Sacramento (FA 97)

COLORADO

Fort Carson:
U.S. Army Garrison (FA 97)

FLORIDA

Orlando:
Office, PM Training Devices (FA 97)
MacDill AFB:
U.S. Army Element U.S. Central Command (FA 97)
U.S. Army Element, U.S. So Cmd (FA 97)

GEORGIA

Fort Gillem:
U.S. Army Information Systems Dev Center (FA 53)
Atlanta:
U.S. Army IRMICS (FA 53)
DCMR — Atlanta (FA 97)
Fort McPherson:
HQ, U.S. Army Forces Command (FA 97) (FA 53)
U.S. Army Forces Command Info Mgt Center (FA 53)
Fort Stewart:
24th CBAA (15C35)
Fort Gordon:
U.S. Army Signal Center (FA 53)

HAWAII

Camp Smith:
U.S. Army Elm Intell Center — Pacific (FA 53)
Fort Shafter:
HHC Spt Gp A (FA 97)
U.S. Army Support Command Hawaii (FA 97)
Schofield Barracks:
25th Infantry Division Aviation Brigade Light (15C35)

ILLINOIS

Chicago:
U.S. Army Reserve Full Time Support (FA 97)
DCMR — Chicago (FA 97)
Fort Sheridan:
HQ, Fourth U.S. Army (FA 53)
U.S. Defense Manpower Data Center (FA 53)
Scott AFB:
U.S. Army Element U.S. TC Command (FA 53) (FA 97)
USA Def Coml Comm (FA 97)
Rock Island Arsenal:
U.S. Army Rock Island (FA 97)
U.S. Army Armament Munitions Command (FA 97)
Office of PM 9mm Pistol Program (PEO Armaments) (FA 97)

INDIANA

Fort Benjamin Harrison:
U.S. Army Information SYSTEMS Dev Ctr (FA 53)
U.S. Army Soldier Support Center (FA 53)

KANSAS

Fort Leavenworth:
U.S. Army Information Systems Command (FA 53)
U.S. Army Combined Arms Center (FA 97)
U.S. Army Combined Arms Development Activity (FA 53)
TRADOC Analysis Center (FA 53)

KENTUCKY

Fort Campbell:
390th Contract Supv (FA 97)
101st Support Group (FA 97)
HHC 101st Airborne Division (Air Assault) (15C35)
TF 160 (15C35)
Fort Knox:
U.S. Army Armor School (FA 53)

LOUISIANA

New Orleans:
U.S. Army Reserve Full Time Support (FA 97)

MARYLAND

Fort Meade:

U.S. Army INSCOM MI Bn CI Tech	(FA 53)
HQ, First U.S. Army	(FA 97)
U.S. Army Garrison Fort Meade	(FA 97)
U.S. Army Foreign CI Activity	(15C35)
Fort Ritchie:	
HHC Augmentation Command	(FA 97)
Aberdeen Proving Ground:	
U.S. Army Ordnance Center & School	(FA 97)
PM, ITTS	(FA 97)
Harry Diamond Labs	(FA 97)

MASSACHUSETTS

Boston:	
DCMR Boston	(FA 97)

MICHIGAN

Warren:	
HQ, U.S. Army Tank-Automotive Command	(FA 97)
Detroit:	
Tank Plant Detroit	(FA 97)

MISSOURI

St. Louis:	
U.S. Army Reserve Personnel Center	(FA 53)
HQ, U.S. Army Aviation Systems Command	(FA 97)
HQ, U.S. Army Troop Support Command	(FA 97)
Office of PEO Aviation	(FA 97)

NEW JERSEY

Fort Monmouth:	
Joint Tactical C3	(FA 97)
HQ, U.S. Army Comm & El Command	(FA 97) (FA 53)
U.S. Army Communications & Electronics Center	(FA 53)
PEO Cmd & Ctrl	(FA 53)
U.S. Army Electronic Technical Devices	(FA 97)
Office of PM Common Sensor (PEO IEW)	(15C35)
Office of PM MSE (PEO Comm Sys)	(FA 97)
Office of PM AAS (PEO STAMIS)	(FA 97)
Picatinny Arsenal:	
U.S. Army Munition Production Base	(FA 97)

NEW YORK

West Point:	
HQ, U.S. Military Academy — Staff & Faculty	(FA 97) (FA 53)
New York:	
DCMR — New York	(FA 97)
Watervleit:	
U.S. Army Watervleit Arsenal	(FA 97)

OHIO

Dayton:	
Defense Electronic Supply Center	(FA 97)
Columbus:	
Defense Construction Supply Center	(FA 97)
Cleveland:	
U.S. Army Element, DCMR Cleveland	(FA 97)
Lima:	
Tank Plant, Lima	(FA 97)

NORTH CAROLINA

Fort Bragg:	
1st Corps Support Command	(FA 97)
0140th Transportation CNTC	(FA 97)
2nd Materiel Management Center	(FA 97)

PENNSYLVANIA

Carlisle Barracks:	
U.S. Army War College	(FA 53)
U.S. Army Information Systems Command	(FA 53)
Philadelphia:	
Defense Personnel Support Center	(FA 97)
Defense Industrial Supply Center	(FA 97)
DCMAO — Philadelphia	(FA 97)
Plant Rep Boeing H	(FA 97)
Letterkenny:	
U.S. Army Depot Letterkenny	(FA 97)
Tobyhanna Army Depot:	
U.S. Army Depot Tobyhanna	(FA 97)

TEXAS

Fort Bliss:	
U.S. Army Air Defense Artillery School	(FA 53)
Fort Hood:	
TEXCOM	(FA 53)
13th Corps Support Command	(FA 97)
U.S. Army Garrison Fort Hood	(FA 97)
4th Materiel Management COSCOM	(FA 97)
Dallas:	
DCMR — Dallas	(FA 97)
Army — Air Force Exchange	(FA 97)
Red River:	
U.S. Army Depot Red River	(FA 97)
Fort Worth:	
Plant Rep Office BHT	(FA 97)

VIRGINIA

Fort Belvoir:	
U.S. Army Information Systems Software Command	(FA 53)
U.S. Army Reserve Technical Group 310	(FA 97)
U.S. Army Element, Def Sys Mgt College	(FA 97)
U.S. Army Fort Belvoir	(FA 97)
Office of PM TAADS-R (USAFISA)	(FA 53)
Pentagon:	
Office of the Chief	(FA 97)
Director, Information Systems — DISC4	(FA 53)
U.S. Army Element OJCS	(FA 53)
U.S. Army Element OSD	(FA 97)
Defense Mobilization Planning System	(FA 97) (FA 53)
Defense Security Agency	(FA 97)
Deputy Chief of Staff, Opns & Plans	(15C35)
U.S. Army Joint Data Systems Support	(FA 53)
U.S. Army Joint Systems Control	(FA 97) (FA 53)
U.S. Army Directed Military Overstrength	(FA 97) (FA 53)
Office of the Asst Sec Army (RDA)	(FA 97) (FA 53)
Office of the Admin Asst to Sec Army	(FA 53)
Department of the Army IG	(FA 97) (FA 53)
U.S. Army Defense Systems Mgt Act	(FA 97)
Management Systems Support Activity	(FA 53)
U.S. Army Programs Office Info Sys Activity	(FA 53)
National Guard Bureau	(FA 97)
U.S. Army Equipment Evaluation Activity	(FA 97)
Exercise Support Activity	(FA 97)
Office, SDBU	(FA 97)
U.S. Army Congressional Detachment	(FA 97)
U.S. Army Comm Act Agency	(FA 97)
ACS Intelligence	(15C35)
Fort Lee:	
Information Systems Development Center	(FA 53)
U.S. Army Quartermaster School	(FA 97)
U.S. Army Logistics Management College	(FA 97) (FA 53)
Fort Monroe:	
HQ, U.S. Army Training & Doctrine Command	(FA 97)
U.S. Army Info Sys Cmd — TRADOC	(FA 53)
U.S. Army Info Sys Cmd-Fort Monroe	(FA 97)
Combined Field Operations — TRADOC	(FA 53) (FA 97)
Falls Church:	
U.S. Army Systems Development Center — Washington	(FA 53)
U.S. Army National Guard Op Act Ctr	(FA 97)

U.S. Army Op Test & Eval Cmd	(15C35) (FA 97)
Alexandria:	
Personnel Information Systems Center	(FA 53)
U.S. Army Element, Joint Test	(FA 97)
U.S. Total Army Personnel Command	(FA 97) (FA 53)
U.S. Army Space Program	(FA 97) (FA 53)
HQ, U.S. Army Materiel Command	(FA 97) (FA 53)
U.S. Army Materiel Command IG Activity	(FA 97)
U.S. Army Community and Family Spt Activity	(FA 97)
Activities & Special Projects	(FA 97)
PM, IPS	(FA 97)
Cameron Station:	
Defense Logistics Agency ADP/T Contract	(FA 97)
Defense Logistics Agency	(FA 97) (FA 53)
Defense Logistics Agency Systems Mgt Office	(FA 53)
Defense Fuel Supply Center	(FA 97)
Vint Hill Farms Station:	
U.S. Army Garrison	(FA 97)
Arlington:	
Command Systems Integration Office	(FA 97) (FA 53)
U.S. Army Strategic Defense Command	(FA 97)
Baileys Crossroads:	
U.S. Army Element Joint Test Center	(FA 53)
Military Traffic Command NT Cmd Field Ops	(FA 97) (FA 53)
Richmond:	
Defense General Supply Center — Richmond Depot	(FA 97)
Fort McNair:	
U.S. Army Element National Def University	(FA 97) (FA 53)
Fort Eustis:	
U.S. Army Transportation School	(FA 53)
U.S. Army Training Support Center	(FA 97)
7th Group -160th Det	(FA 97)

WASHINGTON DC

White House Communications Agency	(FA 53)
Defense Communications Agency CC Engineer Center	(FA 53)
U.S. Army Strategic Defense Initiative	(FA 97) (FA 53)
U.S. Army Intelligence Agency	(FA 53)
U.S. Army Management Staff College	(FA 97) (FA 53)
U.S. Army Contract Support Agency	(FA 97)
USACAMA	(FA 97)
DCA CC Engr Center	(FA 97)
U.S. Army Elm HQ DCA	(FA 97)
Office of PM DMS	(FA 97)

WASHINGTON

Fort Lewis:	
593d Support Group	(FA 97)
355th Contract Supv	(FA 97)

OVERSEAS LOCATIONS

BELGIUM

Brussels:	
NATO International Military STE	(FA 53)
Chevres:	
80th Area Support Group	(FA 97)
SHAPE:	
U.S. Army Element — SHAPE	(FA 53) (FA 97)

UNITED KINGDOM

Burtonwood:	
47th Support Group Area	(FA 97)

NETHERLANDS

Brunsum:	
HQ, Allied Forces Central Europe	(FA 53)

GERMANY

Munich:	
MI Brigade	(FA 53)
Augsburg:	
204th Signal Intelligence Unit	(FA 53)
Mannheim:	
SC HHD Aug	(FA 53)
Karlsruhe:	
SC HHD Aug — Plans Branch	(FA 53)
Schwetzingen:	
AG U Augmentation Team A	(FA 53)
25th Data Processing Unit	(FA 53)
First Personnel Command	(FA 53)
Worms:	
SC HHD Aug	(FA 53)
USAISEC-Europe	(FA 53)
Heidelberg:	
U.S. Command & Control Support Activity USAR	(FA 53)
U.S. Army Intelligence Center — Europe	(FA 53)
USAREUR & 7th Army (OCINC)	(FA 97)
Field Activity Element USAR	(FA 97)
U.S. Army Contracting Command — Europe	(FA 97)
Zweibrucken:	
U.S. Army Element Def Subs R	(FA 97)
200th Materiel Management	(FA 97)
Kaiserslautern:	
LG HHC TAACOM	(FA 97)
HHD 21st TAACOM	(FA 97)
9th TAACOM	(FA 97)
29th Area Support Group	(FA 97)
Nellingen:	
2nd Corps Support Command	(FA 97)
800th Materiel Management (COSCOM)	(FA 97)
Weisbaden:	
3d Corps Support Command	(FA 97)
19th Maintenance Management	(FA 97)
Bad Kreuznach:	
53d Area Support Group	(FA 97)
Vaihingen:	
U.S. Army Element EUCOM — DSC	(FA 53)
U.S. Army Element EUCOM Special Security	(FA 97)
Stuttgart:	
6th Area Support Group	(FA 97)
Rheinberg:	
54th Area Support Group	(FA 97)
Bremerhaven:	
543d Area Support Group	(FA 97)

HOLLAND

Rotterdam:	
Military Traffic & Management Command — Europe	(FA 97)
28th Contract Supv	(FA 97)
70th Contract Supv	(FA 97)

ITALY

Vicenza:	
5th TAACOM	(FA 97)
22nd Area Support Group	(FA 97)
Leghorn Barracks:	
201st TAACOM	(FA 97)
8th Area Support Group	(FA 97)
Naples:	
HQ, Allied Forces South	(FA 53)

KOREA

Yongson:	
U.S. Army Intelligence Support Detachment	(FA 53)
U.S. Army Information Systems Activity	(FA 53)
U.S. Army Element JUSMAG — Korea	(FA 97)
23rd Area Support Group	(FA 97)

HHC Logistics Area Support	(FA 97)
Camp Casey:	
HHC 2nd Infantry Division	(15C35)
Camp Henry:	
19th Support Command	(FA 97)
6th Materiel Management Support Command	(FA 97)
20th Area Support Group	(FA 97)
Camp Market:	
DESCOM Spt Act FE	(FA 97)
Hialea Compound:	
34th Area Support Group	(FA 97)

PANAMA

Corozal:	
93rd Mat Mgt Tank and Automotive Command	(FA 97)
41st Area Support Group	(FA 97)
Fort Clayton:	
U.S. Army Garrison — Panama	(FA 97)
HQ, U.S. Army South USAR	(FA 97)
Fort Kobbe:	
128th Brigade	(15C35)
Quarry Heights:	
U.S. Army Element U.S. SOUTHCOM	(FA 53)

SAUDI ARABIA

Riyadh:	
300th (WATGAA)	(FA 97)

TURKEY

Izmir:	
U.S. Army Element Allied Forces So East Europe	(FA 97)

Critical Acquisition Position Locations

In response to numerous inquiries from our readers, the following list of locations of critical acquisition positions is provided. The number of authorized civilian and military positions are listed separately:

Military Positions (Skill Identifier 4Z)

Activity	Location	Functional Area	No. Positions
HQ CECOM	Fort Monmouth, NJ	(FA 53,97)	3
HQ TROSCOM	St. Louis, MO	(FA 51,97)	5
HQ AMC	Alexandria, VA	(FA 51,53,97)	11
HQ MICOM	Redstone Arsenal, AL	(FA 51,97)	5
HQ TECOM	Aberdeen PG, MD	(FA 51)	1
USA ISMA	Fort Monmouth, NJ	(FA 51)	5
USACSA	Fort Monmouth, NJ	(FA 51)	5
HQ AVSCOM	St. Louis, MO	(FA 51)	9
DCSOPS	Pentagon	(Br 15C35)	2
ASARDA	Pentagon	(FA 51,53,97)	67
PM UAVJPO	Crystal City, VA	(FA 51)	1
OCLL	Pentagon	(FA 51,97)	2
USALMC	Fort Lee, VA	(FA 51)	1
TMDE SG	Fort Monmouth, NJ	(FA 51)	3
USAISEC	Fort Huachuca, AZ	(FA 51)	1
HQ LABCOM	Adelphi, MD	(FA 51)	2
PEO IEW	Vint Hill Farms, VA /Fort Monmouth, NJ	(FA 51, 15C35)	15
PEO AVN	St. Louis, MO	(FA 51,97)	28
PEO CCS	Fort Monmouth, NJ	(FA 51,53)	28
PEO ARMTS	Picatinny Arsenal, NJ	(FA 51,97)	6
PEO CBTSPT	Warren, MI	(FA 51)	6
PEO FIRE SPT	Redstone Arsenal, AL	(FA 51)	24
PEO COMM	Fort Monmouth, NJ	(FA 51,97)	13
PEO AIR DEF	Redstone Arsenal, AL	(FA 51)	15
PEO ASM	Warren, MI	(FA 51,97)	34
PM STAMIS	Fort Belvoir, VA	(FA 53,97)	16
PM LHX	St. Louis, MO	(FA 53)	4
PM JTFP	Mclean, VA	(FA 51)	1
PM UAV	Washington, DC	(FA 51)	4
AAESA	Alexandria, VA	(FA 51,53)	3
PM TNG DEV	Orlando, FL	(FA 51)	5
USA SPACE PROG	Mclean, VA	(FA 51,97)	4
PM NUC MUN	Picatinny Arsenal, NJ	(FA 51)	4
RSCH ASSOC	Warrenton, VA	(FA 97)	1
DSMC	Fort Belvoir, VA	(FA 51,97)	20
OPTEC	Alexandria, VA	(FA 51,97)	11
HQ TRADOC	Fort Monroe, VA	(FA 97)	1
PM ITTS	Aberdeen PG, MD	(FA 51)	1
CE CENTER	Fort Monmouth, NJ	(FA 51)	1
HQ TACOM	Warren, MI	(FA 51,97)	4
ARDEC	Picatinny Ar, NJ	(FA 51)	1
CRDEC	Aberdeen PG, MD	(FA 51)	3
AMCCOM	Rock Island, IL	(FA 51)	5
DCSO	Washington, DC	(FA 53)	1
USAFISA	Fort Belvoir, VA	(FA 53)	1
MTMC FO	Fort Belvoir, VA	(FA 53)	3
CNTSPTAG	Washington, DC	(FA 97)	5
USA SDC	Arlington, VA	(FA 51)	29
		TOTAL	**420**

Civilian Positions (Skill Identifier DC)

Activity	Location	Career Program	No. Positions
VHFS	Warrenton, VA	13 & 14	8
HDL	Adelphi, MD	16	3
USA CRREL	Hanover, NH	23	1
NRDEC	Redstone Arsenal, AL	16	9
SPACE SYS	Fort Monmouth, NJ	16	7
EN TOPO LAB	Fort Belvoir, VA	23	1
BRDEC	Fort Belvoir, VA	13 & 16	16
HQ TROSCOM	St. Louis, MO	13,14,16,17	45
HQ AMC	Alexandria, VA	11,14,16	53
HQ MICOM	Redstone Arsenal, AL	11,13,14,16,17	117
TECOM	Aberdeen PG, MD	14,16	5
USACOE	Washington DC	—	1
USAISMA	Fort Monmouth, NJ	14,16,17,25	16
IBEA	Rock Island, IL	16	4
AUG USACSA	Fort Monmouth, NJ	17	11
AVSCOM	St. Louis, MO	11,13,14,16,17	60
ASARDA	Pentagon	11,14,16,17	53
ETDL	Fort Monmouth, NJ	16	1
AVRDA	Fort Monmouth, NJ	16	1
TMDE SG	Fort Monmouth, NJ	14,16,17	16
ISSAA	Alexandria, VA	14	14
ISEC	Fort Belvoir, VA	17	4
ENG AUTO SPT ACT	Washington DC	23	1
VLAMO	Aberdeen PG, MD	16	1
HQ LABCOM	Alexandria, VA	14	1
VAL	White Sands, NM	16	3
PEO IEW	Vint Hill Farms, VA	11,13,16,17	65
PEO AVN	St. Louis, MO	11,13,14,15,16,17	71
PEO CCS	Fort Monmouth, NJ	11,13,16,17,23	85
PEO ARMTS	Picatinny Arsenal, NJ	11,14,16,17	60
PEO CBT SPT	Warren, MI	11,14,16,17	15
PEO FIRE SPT	Redstone Arsenal, AL	11,13,14,16,17	51
PEO COMM	Fort Monmouth, NJ	11,13,14,16,17,25	99
PEO AIR DEF	Redstone Arsenal, AL	14,16,17	29

CAREER DEVELOPMENT UPDATE

Activity	Location	Career Program	No. Positions
PEO ASM	Warren, MI	11,13,14,16,17,24	29
PEO STAMIS	Fort Belvoir, VA	11,13,14,16,17,23,25	67
PM LHX	St. Louis, MO	11,13,14,16,17	19
PM JTFP	McLean, VA	11,14,16,17,23	20
PM UAV	Washington, DC	16,17	6
AAESA	Alexandria, VA	17	3
AATD	Fort Eustis, VA	14,16	2
INFO TECH LAB	Vicksburg, VA	23	1
PM TRADE	Orlando, FL	11,16,17	16
PM NUC MUN	Picatinny Arsenal, NJ	11,16	10
FOA-CONTSPTAG	Washington, DC	14	4
HQ DESCOM	Chambersburg, PA	11,14	2
BRL	Aberdeen PG, MD	16	5
HEL	Aberdeen PG, MD	16	1
PM ITTS	Aberdeen PG, MD	11,16	9
CE CTR	Fort Monmouth, NJ	16,17	29
HQ TACOM	Warren, MI	13,14,16,17	71
TACOM	Warren, MI	16	28
HQ CECOM	Fort Monmouth, NJ	13,14,15,16	79
PM LAV	Warren, MI	11,14,16,17	5
STO	Adelphi, MD /Fort Meade, MD /Fort Belvoir, VA	16	4
ARDEC	Picatinny Arsenal, NJ	16	104
CRDEC	Aberdeen PG, MD	16	12
HQ AMCCOM	Rock Island, IL	11,13,14,16	77
ISC	Fort Huachuca, AZ	14	3
DISC4	Pentagon	14,23,25	15
MTMC	Fort Belvoir, VA	23,24	3
CNTSPTAG	Washington, DC	14	25
USA SDC	Arlington, VA /Huntsville, AL /White Sands, NM	11,15,16	31
7th SIG CMD	Fort Ritchie, MD	14	2
		TOTAL	**1,609**

Training with Industry (TWI)

Army officers selected for participation in the Training with Industry Program for Academic Year 1991-1992 are listed by Functional Area as follows:

FUNCTIONAL AREA 51

Name	Industry
MAJ Robert P. Birmingham	McDonnel Douglas Astronautics Company
MAJ Edward E. Gozdur	LTV Aerospace and Defense Company
MAJ William R. Johnson, Jr.	Martin Marietta
MAJ Jackie Roper	McDonnell Douglas Technologies
MAJ Billy H. Welch	Litton Data Systems
MAJ Mark C. Wiley	Aliant Tech Systems
CPT William M. Gavora	Sikorsky Aircraft
CPT Elester Jackson	EG&G Mound Applied Technology
CPT John M. Spiller	Westinghouse Elect. Systems Group
CPT Gregory J. Ulsh	Hughes Aircraft Co.
CPT Charles W. Wayne	Allison Transmission

FUNCTIONAL AREA 97

MAJ James C. Lloyd	LTV Aerospace and Defense Company
MAJ Roy A. Nyquist	General Electric Gov. Electronics
MAJ John E. Rouse	General Electric Gov. Services
MAJ Bryon J. Young	DPRO Raytheon
CPT David R. Baker	General Dynamics
CPT Donald B. Bennett, Jr.	Olin Corporation
CPT Kenneth C. Braddock	DPRO FMC
CPT Martin Bushey	Hughes Aircraft Los Angeles
CPT Peggy R. Carson	McDonnell Douglas
CPT Ming G. Chin	Boeing Aerospace Co.
CPT Raymond R. Derosa	DPRO Honeywell
CPT Patti D. Daye	Bell Helicopter Textron
CPT Etzel O. Ferguson	Hercules Engine
CPT Silven C. Gantt	Hercules Corporation
CPT Susan K. Grubb	Hughes Aircraft
CPT Jeffrey L. Gwilliam	Rockwell International
CPT Craig L. Hutzell	Textron Lycoming
CPT Howard T. McCord	Oshkosh Truck Corporation
CPT M. Brooke Myers	Sikorsky Aircraft
CPT James A. Nelson	Raytheon Corporation
CPT Rickey C. Nelson	Motorola
CPT Marilyn A. Ray	DPRO Textron Lycoming
CPT Roosevelt Robinson, Jr.	Martin Marietta
CPT Dennis Stalker	DynCorp
CPT Patrick J. Virgilio	Allison Transmission Company

Civilians in the Army Acquisition Corps

The Assistant Secretary of the Army (research, development and acquisition) (ASA[RDA]) formally accessed the first civilian members (510) into the Army Acquisition Corps. Those individuals received a letter from Honorable Stephen K. Conver, ASA(RDA), underscoring his commitment to acquisition professionals within the Army. Members will be afforded the opportunity to participate in professional development enhancements that will be both personally and professionally rewarding. Those enhancements include fully-funded advanced education programs, senior management training and attendance at the Program Management Course. Army Acquisition Corps members will form the elite cadre of the Army's acquisition work force.

Army Names PM of the Year Recipients

Two project managers and a product manager are recipients of the Army's PM of the Year Award. Alan D. Sherer, project manager of the U.S. Army Strategic Defense Command's (SDC) High Endoatmospheric Defense Intercepter Project in Huntsville, AL, is the first civilian to receive the award since it was initiated in 1977. COL Martin J. Michlik was cited for his work as project manager of the Night Vision Electro-Optics Program at Fort Belvoir, VA. LTC Gary J. Hagan — the first product manager to ever receive this award — was recognized for achievements as product manager of SDC's Hypervelocity Launcher. Stephen K. Conver, assistant secretary of the Army for research, development and acquisition, presented the awards.

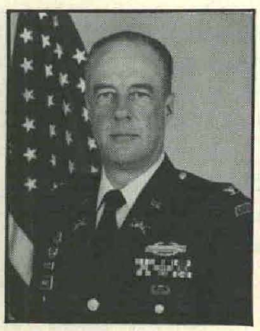
The purpose of the award is to recognize outstanding performance based on the success and overall management of an Army program. Criteria for selection are resource management, management techniques and innovation, program complexity, personal qualities, meeting or exceeding program objectives and total quality management.

The citation on Sherer's award stated: "Mr. Sherer's personal dedication and executive skill guided the HEDI project to the first successful flight test of a strategic defense interceptor capable of intercepting ballistic missile warheads within the atmosphere. This event was a critical milestone in the nation's strategic defense program and served to demonstrate the feasibility of endoatmospheric defenses as an element of the overall strategic defense system."

COL Michlik's citation stated, "Through his initiative, technical competence, excellent judgment and astute managerial ability, Colonel Michlik managed and coordinated the activities of a complex night vision program while maintaining established performance, schedule, and cost goals."

LTC Hagan's citation stated, "Because of the tremendous advances in miniaturization and launch hardening, hypervelocity launch of guided projectiles from advanced electric guns has the potential to revolutionize not only ballistic missile defense but also air defense and long range fire support systems. Component miniaturization and launch hardening are essential to making available smaller, less costly, and more capable kill vehicles with hit-to-kill target intercept capability."

Alan D. Sherer, PM HEDI



COL Martin J. Michlik PM Night Vision Electro-Optics

LTC Gary J. Hagan Product Manager Hypervelocity Launcher

Army Cites Achievements of R&D Organizations

The U.S. Army Missile Research, Development and Engineering Center, Redstone Arsenal, AL, is one of four Army R&D organizations recently recognized for outstanding achievements during FY 1989. Assistant Secretary of the Army for Research, Development and Acquisition Stephen K. Conver made the announcement. The Missile RD&E Center was named Army R&D Organization of the Year for accomplishments related to advanced kinetic energy missiles and sensor systems. Recipients of R&D Excellence Awards are:

- The Army Cold Regions Research and Engineering Laboratory, Hanover, NH, for advanced techniques in cold regions survivability, mobility and operations.
- The Army Armament Research, Development and Engineering Center, Picatinny Arsenal, NJ, for work related to advanced total spectrum armaments for the battlefield of the 1990s and 2000s.
- The Army Aeromedical Research Laboratory, Fort Rucker, AL, for advanced research and development on health hazards of Army aviation, vehicles, and airborne operations.

These awards are presented each year to top research and development organizations whose achievements during the preceding year are considered the best within the Army R&D community. Selection criteria include each organization's technical accomplishments, management initiatives, and personnel and resource management efforts.

Command, Control and the Common Defense

By LTC C. Kenneth Allard
Yale University Press, 1990

Reviewed by W. J. Holland Jr., retired Navy rear admiral, president of the AFCEA Educational Foundation and a member of the AFCEA Northern Virginia Chapter.

Command and control difficulties primarily are social perils rather than technological problems, according to COL Allard in Command, Control and the Common Defense. The colonel provides a readable blend of history and commentary about U.S. command and control organization, procedure and technology heretofore absent. His bibliography is prodigious and alone is worth the price of the book as a reference.

Central to his thesis is "... that the problems of modern command and control did not spring full-blown from the minds of technocrats and that they cannot be understood properly in isolation from the human institutions — government and military — that actually do the commanding and controlling."

Describing how the methodology and organization of the services arose from constitutional direction, geography, mission and experience, COL Allard explains the strain between centralized management and decentralized execution and how and why it differs in each of the services. He shows how the U.S. Army approaches command and control from the top down in theater specific networks, while the U.S. Navy always works from the bottom up, emphasizing global applications.

The history of how inter-service command relationships progressed, from independent actions through mutual cooperation to unity of command, sets the background for COL Allard's insights on various impediments imposed for political reasons. Describing the early 1990s, he observes that "...'civilian control' was simply a code word for the interests of the affected constituencies, their elected representatives and their bureaucratic allies."

No discernable decrease has occurred in the numbers or in the intensity of interest by players in the past 50 years. In fact, more actors are involved now than ever before, and none is anxious to leave the stage. At the same time, technical capabilities have exploded.

Illustrating the crux of current problems, COL Allard states, "The tight integration offered by emerging command and control technologies...often runs afoul of existing command structures and theories of warfare those structures embody.... The organizational preference leading to centralization had also created a highly efficient electronic system that not only mirrored these preferences [to exercise direct [control] but magnified them."

Decision makers at high levels often have acted without thinking or even without knowing, but systems now exist that allow that action to be transmitted directly to operators without the cushioning effects of an intervening time delay or levels of authority. The natural disaster lurking in such situations is clear.

While not a technical dissertation, the book describes the problems in two approaches to joint command, control and communications systems; the joint interoperability of tactical command and control systems (JINTACCS) and the joint tactical information distribution system (JTIDS). Those intimately involved with these two programs will not be entirely satisfied with COL Allard's technical descriptions, but he is close enough for a general work, and his conclusions are not changed — even if he has overlooked such things as the Navy's doubts about time coordination in JTIDS' time division multiple access construct.

Writing "While to the Navy, JTIDS represented the next generation of digital data revolution of which the service was an active proponent...," COL Allard shows how Air Force institutional concerns, such as preference for single seat fighters and voice communications, concern about growing complexity in the cockpit of single seat fighters and commitment to centralized command and control of air war from the ground all worked to magnify the technical problems and decrease the resources available to their solution.

COL Allard suggests great promise with his statement that "Nowhere is this great potential [of information-age technologies] greater than in the ability of command and control systems to link remote and dissimilar things, such as armies, airplanes and ships."

While he has no magic prescription or grand elixir, he does have advice and counsel well worth heeding. It is not counsel that can be obtained simply by reading this or other reviews but encompasses the lesson he teaches through the entire book.

"The answer lies neither in a blind reliance on high technology nor in a Luddite rejection of new methods, but in the making of wise technological choices and tough organizational decisions," COL Allard writes.

This book does not make anyone an instant expert. But, anyone who wants to be more than a dilettante in command and control must understand what COL Allard describes and documents in this marvelous volume.

The preceding book review is reprinted with permission from SIGNAL Magazine, the official journal of the Armed Forces Communications and Electronics Association, copyright 1990.

SUBMISSIONS TO THE ARMY RD&A BULLETIN

ARTICLES: *Army RD&A Bulletin* is continuously seeking articles of interest to the RD&A community. Articles for future publication may be mailed to the address below. Questions concerning submissions should be directed to the editorial staff at the phone number listed below.

LETTERS TO THE EDITOR: The editorial staff welcomes readers' comments on any articles published in the bulletin, or other topics of interest to members of the RD&A community. Letters to the editor should be limited to two typed, double-spaced pages, and should include your name, address, and commercial and DSN phone numbers. If you wish to write anonymously, please let us know, but enclose this information regardless, so that we can contact you, if necessary. Correspondence should be submitted to the address below.

BOOK REVIEWS: If you have read a book which you feel may be of special interest to the RD&A community, please contact us. The editorial staff welcomes your literary recommendations. Book reviews should be no longer than two double-spaced typed pages. In addition, please note the complete title of the book, the author's name, and your name, address, and commercial and DSN phone numbers. Submit book reviews to the address below.

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PURPOSE: To instruct members of the RD&A community relative to RD&A processes, procedures, techniques and management philosophy and to disseminate other information pertinent to the professional development of the RD&A community.

SUBJECT MATTER: Subjects of articles may include, but may not be necessarily limited to, policy guidance, program accomplishments, state-of-the-art technology/systems developments, career management information, and management philosophy/techniques. Acronyms should be kept to an absolute minimum and when used, must be written out and explained.

LENGTH OF ARTICLES: Articles should be approximately 1,500 to 1,800 words in length. This equates to 8-9 double-spaced typed pages, using a 20-line page.

PHOTOS: Include any photographs or illustrations which complement the article. Black and white or color are acceptable. We cannot promise to use all photos or illustrations and they are normally not returned unless requested.

BIOGRAPHICAL SKETCH: Include a short biographical sketch of the author/s. This should include the author's educational background and current position.

CLEARANCE: All articles must be cleared by the author's security/OPSEC office and public affairs office prior to submission. The cover letter accompanying the article must state that these clearances have been obtained and that the article has command approval for open publication.

Authors should include their address and office phone number (DSN/autovon and commercial) when articles are submitted.

In addition to printed copy, authors should submit articles on a 5 1/4-inch floppy disk in ASCII format.

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