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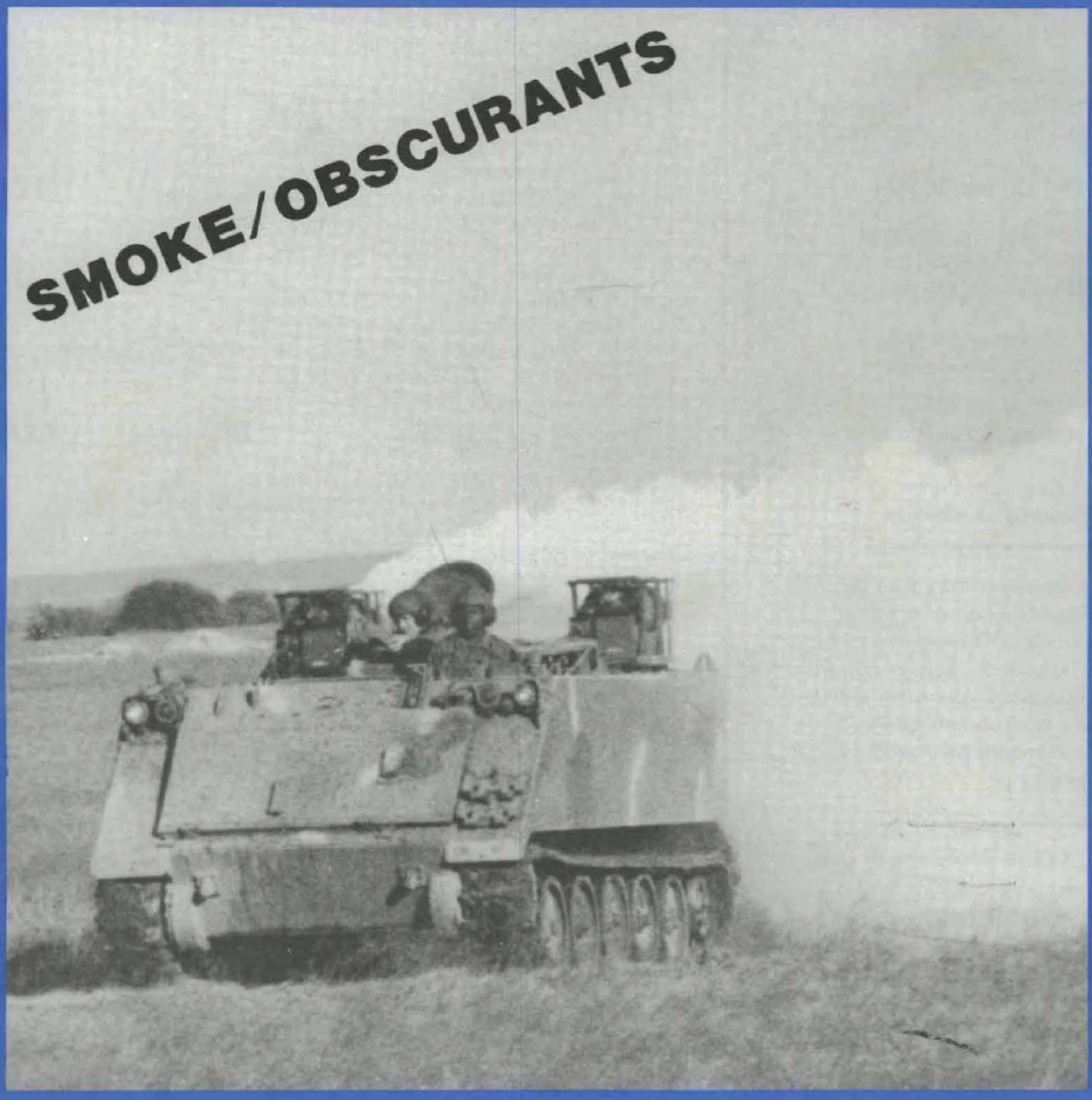
JANUARY-FEBRUARY 1988

SMOKE/OBSCURANTS



ARMY
Research
Development
Acquisition

RD&A

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PROFESSIONAL BULLETIN OF THE RDA COMMUNITY

This medium is approved for the official dissemination of material designed to keep individuals within the Army knowledgeable of current and emerging developments within their areas of expertise for the purpose of enhancing their professional development.

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FEATURES

DEPARTMENTS

ABOUT THE COVER

Shown on the front cover is the M1059 Smoke Generator Carrier, one of numerous materiel resources associated with the Army's smoke/obscurants program. The back cover is related to a presentation on streamlining and quality by a member of the industrial community.

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Smoke/Obscurants Technology

By COL Francis M. Durel

Introduction

In Tom Clancy's popular book, *"Red Storm Rising,"* SFC Terry MacKall, an M-1 Abrams Tank platoon leader, sat astride the Russian axis of advance into the Federal Republic of Germany. When massive Russian artillery enveloped his position with grey-white smoke that obscured the entire area, he flipped on his thermal-imaging sights and proceeded to kill the advancing enemy tanks with deadly accuracy. The enemy was unable to respond as the unpredictable winds blew the smoke back into the Russians' faces, effectively blinding them. "'Damned Smoke!' Sergetov swore."

Although a fictitious account of how a World War III battle may occur and be fought, Clancy's depiction is outdated. The "damned smoke" of the modern battlefield will bear little relationship to the traditional "smokes" that have wafted and waned across the ground where our combat forces have had to fight in the past. The "dirty" battlefield of the future will not be easily tidied up by the mere flick of a thermal-imaging switch.

New, specially-designed obscurants will render thermal imagers and other similar devices ineffective and the advantages we have gained through the use of sophisticated electro-optical systems will be lost.

PM Smoke Formed

To ensure that our capabilities to face enemy electro-optic and obscurant technology remain the most current, the Office of the Project Manager for Smoke/Obscurants was formed. Chartered in August 1976, PM Smoke spearheaded efforts to meet a pressing Army need to address critical deficiencies in battlefield operations that were uncovered during evaluations conducted on the use of smoke and obscurants in the 1973 Arab-Israeli conflict.

For years, the technical base and production capabilities for smoke/obscurant munitions had been allowed to languish and, as a result, an intensive effort was required to modernize.

During the past 11 years much has been accomplished and today the U.S. Army has a superb technical base devoted to the development of a broad spectrum of obscurant materiels and devices and has a wide array of munitions and generators for the soldier to use on the battlefield. In addition, an important capability has been developed that enables electro-optical system developers to evaluate their systems in a realistic battlefield environment.

Initially given broad responsibilities to re-energize the smoke/obscurants program and provide a single focus for all smoke materiel development and acquisition efforts, PM Smoke has evolved with the changing Army management structure and is now subordinate to the Program Executive Office, Chemical/Nuclear located at Aberdeen Proving Ground, MD. The current missions of the office are more narrowly defined and can be separated into two main areas: one, to manage the development and initial production of smoke and obscurant materiel; and secondly, to assist developers of electro-optic systems evaluate their devices in realistic battlefield environments.

The emphasis of the office is to field systems in a timely manner, utilizing the capabilities of the Army Materiel Command Research, Development and Engineering Centers, as well as other government agencies, to mature the technology and support the development efforts. The Chemical RDE Center

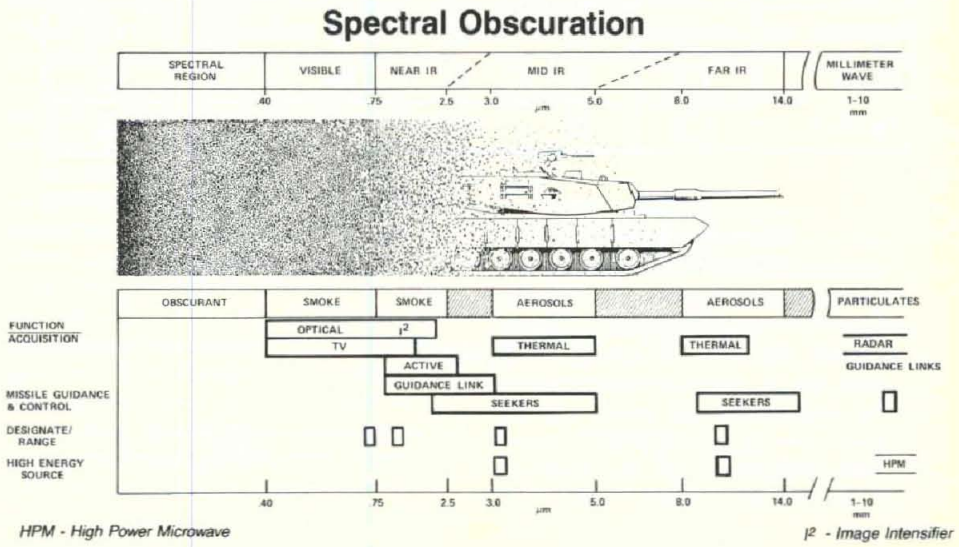

Figure 1.

Combat Vehicle Defensive Obscuration System (CVDOS)

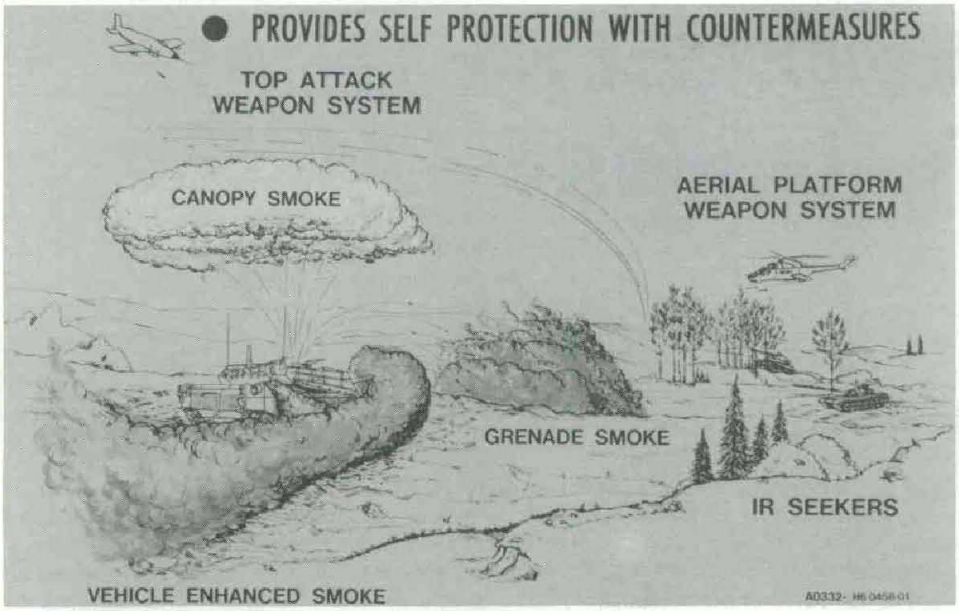

Figure 2.

SUSCEPTIBILITY OF SMART WEAPON SENSORS TO BATTLEFIELD SMOKE

SENSOR WAVELENGTH	CURRENT INVENTORY			DEVELOPMENTAL		ADVERSE WEATHER
	Oil Smoke	HC	WP	IR Smokes	MMW Chaff	Fog, Rain, Snow
	Generators Engine Exhaust	Pots Artillery	Projectiles Grenades	Generators Grenades	Generators Projectiles	
VISIBLE	●	●	●	●	○	●
NEAR IR	●	●	●	●	○	●
MID IR	○	○	⊛	●	○	⊛
FAR IR	○	○	⊛	●	○	⊛
MM-WAVE	○	○	○	○	●	⊛

Minimal Problem
Moderate Problem
Severe Problem

HC - Hexachlorethane
WP - White Phosphorous
MMW - Millimeterwave

Figure 3.

at Aberdeen Proving Ground and the Armaments RDE Center at Picatinny Arsenal are the principal organizations that PM Smoke relies upon for support.

Working in close concert with the user community, the project manager has responded to the current and future needs of the Army in the field. Modern technology has produced increasingly sophisticated threat sensors and guidance systems that operate in portions of the electromagnetic spectrum that are not affected by the traditional smokes produced by burning phosphorous or vaporizing fog oil. These new systems rely on electromagnetic energy propagation in the infrared and millimeter wave bands of the spectrum and are not defeated by obscurants effective only in the visible band (Figure 1).

A sound theoretical basis for the development of obscurants effective over certain bands of the spectrum has been developed and materials of specific size, shape, and conductive properties can be produced that will optimize attenuation of specific wave lengths of electromagnetic radiation.

Using a "tailoring" procedure, it is possible to produce true multispectral materials that are effective over several bands of the spectrum. When such materials are developed, total obscuration on the battlefield can be achieved and an important capability will be provided to our combat forces.

Grenades, Projectiles, and Generators

Since the formation of the Project Manager Office (PMO), an impressive array of smoke items has been type classified and placed in the field. A family of Smoke Grenade Launchers (SGL) mounted on various types of armored vehicles provides near-instantaneous screening for vehicle self protection.

The L8A1/A3 Red Phosphorous Smoke Grenade and the M76 Infrared Defeating Grenade can be fired from the SGL to provide visible through infrared obscuration. The M84A1 105mm and M116A1 155mm HC Smoke Projectiles underwent product improvement to provide enhanced ballistic and functional capabilities.

The M825 155 White Phosphorous Smoke Projectile provides a twofold improvement in screening capability over the M116 by employing new techniques of smoke agent dispersal over the target and is compatible with the extended ranges of the new howitzers.

An on-board smoke generating capability for armored vehicles, called

the Vehicle Engine Exhaust Smoke System, is now available and in use. The M3A4 Smoke Generator, a product improvement of the older M3A3 generator, is now in the hands of all active and reserve component smoke generator units.

Items currently in production, but not yet fielded to active forces include the M157 Smoke Generator Set, the M819 81mm Mortar Red Phosphorous Smoke Cartridge, and the M722 60mm White Phosphorous Smoke Cartridge. Of particular note is the M157 Smoke Generator Set that will be mounted on the M113A2 Armored Personnel Carrier and on the M998 High Mobility Multipurpose Wheeled Vehicle to provide smoke generator units the capability to make smoke while on the move.

Under current development are a new generation of large area screening systems and a Combat Vehicle Defensive Obscuration System (Figure 2). These programs will provide a multispectral obscuration capability for forward and rear forces and give armored vehicles a fully integrated, rapid reacting on-board system to provide all-around obscuration. Both of these systems will be type classified in the early 1990s and fielded shortly thereafter.

The PMO is also working with the Hydra-70 project team to provide an improved smoke warhead for the aerial delivered 75-inch rocket system. Projects in the early formative stages include a medium range multispectral projectile, a 40mm high velocity smoke grenade, directed energy neutralization systems, and a smoke dissipation system.

These projects respond to battlefield deficiencies that have been identified by the user which can only be filled by a materiel development program. All of the projects are following the Army streamlined acquisition process initiatives.

Aerosol Countermeasures

An important mission of the project manager is not related to the acquisition of smoke materiel, but rather related to the acquisition of systems which rely on electromagnetic energy propagation and are susceptible to aerosol countermeasures (Figure 3).

Early on, the Army recognized the need to thoroughly and effectively evaluate all new system developments in environments representative of actual combat conditions. The Countermeasures and Test Division executes the PM Smoke charter to provide that capability.

Bolstered by the newly-released AR 70-10 on test and evaluation requirements, PM Smoke supports accurate assessments of electro-optic systems in realistic battlefield environments that include smoke, rain, fog, dust, other obscurants and potential enemy countermeasures. This is accomplished during the periodic Smoke Weeks hosted by PM Smoke or during developmental and operational test evaluations sponsored by the system developer. Items that have benefited from this evaluation are the Copperhead, HELLFIRE, FAAD-LOS (H), and the XM21 Remote Chemical Agent Detector, to name but a few.

Serving as the focal point for smoke, obscurants, and their effects, PM Smoke hosts an important annual event, the Smoke/Obscurants Symposium. This three-day symposium has grown over the years to a major international conference on smoke technology. It is attended by over 400 individuals from industry, academia, allied nations, and other defense agencies.

The scope of the smoke symposium ranges from basic research on aerosol interactions with electromagnetic energy to operational considerations of employing new generation obscurants on the battlefield. The symposium has been a major factor in the success PM Smoke has had in serving as a focal point for the Army's obscuration program.

In assessing future directions for the program, it is clear that there are many opportunities available for improving Army capabilities to operate on the "dirty" battlefield. Inobtrusive measuring devices that characterize the obscurant environment must be developed so that effective force-on-force training exercises can be conducted. A MILES-like system that operates in a smoke environment needs to be made available to foster realism in training.

Training smoke systems that are both non-toxic to humans and environmentally safe need to be made available so that combat forces can realistically train in the operational employment of smoke. The technology base must begin to measure and define the effects of aerosols on directed energy weapons systems such as high energy lasers and particle beams. There are many knowledge gaps in this particular area that must be filled and, when filled, could provide high pay back for relatively little investment.

The U.S. Army Chemical Center and School has updated the doctrinal literature for smoke and obscurants operations. TRADOC Pamphlet 525-3 (Operations Concept for Smoke and Obscurant Employment and Countermeasure - May 1987), FM 3-50 (Deliberate Smoke Operations - July 1984) and Field Circular 3-50-1 (Smoke Operations - May 1987) are the publications of interest and provide the very latest doctrine.

Conclusion

The smoke materiel items that have been type classified and fielded and the new items under development, coupled with the current doctrine for employment, provide the Army with an effective combat multiplier.

Our combat forces, properly equipped with smoke items and countermeasure devices, knowledgeable in their application, and properly trained to operate in an obscured environment will have a distinct advantage on the "dirty" battlefield, while our potential adversaries will continue to stumble and mutter like Sergetov, "Damned Smoke"!

COL FRANCIS M. DUREL is the project manager for smoke/obscurants at Aberdeen Proving Ground, MD. He holds a bachelor's degree in chemistry from Spring Hill College, Mobile, AL, and a master's degree in the same discipline from the University of Alabama, Tuscaloosa, AL. He is also a graduate of the Command and General Staff College, the Armed Forces Staff College, and the U.S. Army War College.

From Industry. . .

The Streamlining-Quality Connection

By John P. Leslie

Editor's Note: The following remarks, which were originally presented last year at an acquisition streamlining conference in Washington, DC, have been edited to conform to Army RD&A Bulletin format. The author is manager of quality and reliability assurance services, audits and liaison, Defense Systems and Electronics Group, Texas Instruments Inc.

Introduction

In trying to get my thoughts together in preparation for this presentation I read back in my file through some of the many documents that have been written about streamlining, over the past several years. In reviewing this, I found that most often the benefits of streamlining were listed as reduced cost, shortened schedules, and improved quality.

If you go back to the DOD Directive 5000.43 itself you can read: "The purpose of acquisition streamlining is to promote acquisition strategies that will result in the most efficient utilization of resources to produce quality weapon systems and products."

In November of 1986 Secretary Weinberger said, "Basically, this initiative frees program managers and contractors from those provisions of the 45,000 Military specifications, data requirements, management systems, and contract terms and conditions that do not contribute to the quality of the system being produced."

Actually both these statements seem pretty neutral with respect to quality — neither comes right out and says streamlining will "improve quality." They seem more to imply that streamlining will perhaps maintain quality at the status quo, not that any improvement is to be expected. So my challenge here is to provide some convincing arguments to support the proposition that streamlining improves quality — in other words to make the streamlining-quality connection.

In order to start at the beginning, if we are going to talk about improving quality we'd better get our terms of reference defined. Just what do we mean when we talk about "improved" quality? If we were talking about some other parameter, like range for example, improved range might refer to 75 miles instead of 60. Improved sensitivity might refer to 1.5 microvolts per db instead of two. Even improved reliability might refer to 2,000 hours mean time between failure (MTBF) instead of 1,000 hours. But improved quality — what does that mean, and how is it measured?

Defining Quality

Unfortunately, as we know, quality is something we can't measure very well. Unlike the parameters mentioned previously, "quality" remains today pretty much what it always has been — an extremely desirable characteristic, but one that is difficult to define, in spite of the fact that everyone thinks they know it when they see it. If you don't believe that, just consider how long DOD has been struggling with the idea of making quality a meaningful contract award criteria. The problem comes about because unlike range, sensitivity, or reliability, quality has no universally accepted unit of measure, and therefore it is difficult to talk about improving something we can't measure.

So you might ask, "How can I assert that streamlining improves quality?" Well let's take a closer look at what quality is, and is not. I think most of you would agree that quality has nothing to do with "goodness" or with terms like luxury or beauty.

Roughly half the world's quality experts support "conformance to requirements" as the proper definition of quality, and the other half support "fitness for use." Rather than choose up sides, I'm willing to compromise and propose the following working definition of quality: "Quality is conformance to a set of requirements which, if followed, will result in a product that is fit for its intended use."

Notice the use of the word "requirements" in this definition. Quality is conformance to requirements — but only if

EXPECTED STREAMLINING RESULTS

REDUCED COST

SHORTER SCHEDULES

IMPROVED QUALITY

TRADITIONAL CONTRACTING FOR QUALITY

IF 100 SPECS ARE REQUIRED TO DESCRIBE A QUALITY PRODUCT, THEN 200 SPECS MUST DESCRIBE A PRODUCT WITH TWICE THE QUALITY

those requirements are "correct." That is, that they correctly describe a product that will perform as required in use. I think you can begin to see the basis of the streamlining — quality connection, for what is streamlining focussed on? These very same requirements that form the definition of quality!

Requirements' Impact on Quality

If, as generally acknowledged, many of the requirements imposed in today's contracts, specs and standards are outdated, ambiguous, conflicting, or unnecessary, what is their impact on quality? One could argue that if quality is "conformance to requirements," then the more requirements one imposes via a contract the higher the quality will be. If 100 specs are required to describe a quality product, then 200 specs will get you a product with "twice as good" quality? Probably no one would support such an argument. Yet, someone must believe that in order to get a product that is "fit for use," it's necessary to impose either directly in a contract or through chain referencing, literally thousands of specs, each containing hundreds of individual requirements. And of course each and every one of those requirements must be met in each and every product.

Evolution of Requirements

The Air Force, in a briefing on their Mil Prime program, had a very good description of the process of evolution of these requirements as reflected in many of today's specs and standards. The process they described began when specific design solutions and lessons learned began to make their way into the requirements documents. If something worked in a given case, it was made a requirement. If something didn't work, it was prohibited forevermore.

These specific "how to" and "how not to" requirements served to effectively prevent the use of other possibly equal or more effective approaches or to prevent techniques from being used long after the technical problems that caused the original prohibition had been solved.

At the same time, these specs became so numerous and complex that through a combination of factors — lack of time to scrub each requirement or a feeling that "more is better," we progressed to the point we are at today where specs are imposed in blanket fashion. If we look closely, what we have today are procuring activities imposing requirements they haven't read, and contractors agreeing to meet requirements they have never seen — all in the name of quality!

Well maybe all this isn't too bad if it works — if it really results in a quality product. But one service, in analyzing problems they had with some recent systems, makes the statement that "the systems met all their specified requirements, yet still contained numerous quality problems." Apparently the specifications didn't describe requirements that would result in a product that was fit for use — therefore, under our working definition, a quality product was not possible under those conditions. If the requirements aren't correct, then even 100 percent conformance to requirements won't yield a "quality" product.

Then, is the answer to write new specs and add them to the list of requirements? According to the Air Force, such has been the practice in the past. But that practice is what has brought us to the present situation and as has been said, "those who do not learn from the past are bound to repeat it." Up to now I have been addressing the quality of specs and standards. Let's look at the flip side of this problem — the quantity of specs and standards imposed in today's contracts.

I have already alluded to the problem of guaranteeing compliance to the thousands of specs imposed via tiering and chain referencing in our contracts. But the problem with over specification of requirements goes far beyond the issue of compliance, although that is certainly important.

The problem gets back to the working definition of quality — "conformance to correct requirements." The basic element of the quality program at most contractors is the creation of a quality culture wherein everyone strives for conformance to correct requirements.

The engineer's role is viewed as primarily being concerned with the correctness of the requirements as reflected in design and process documentation that will result in a product fit for customer's intended use, and the manufacturing role as conformance to these requirements without exception. The employee, whether in manufacturing, design, or a support role, strives to achieve 100 percent conformance to the "right" requirements, and thereby to produce a "quality product." What happens to this quality culture if we don't employ streamlining? Stated simply, lack of streamlining can destroy a quality culture. This is the key to the streamlining-quality connection... lack of streamlining can destroy a quality culture.

Impact of Not Streamlining

Here are just a few of the ways how failure to streamline can impact quality. I'd like to discuss each of these briefly.

- Wasted Resources to Communicate and Verify Requirements. What I'm talking about is not just planning conducted by the Quality Assurance (QA) engineer, although this effort certainly is important. But QA engineers don't design or build the product. Any company that is serious about its quality culture must ensure that the people who do design and build the product are aware of each and every requirement. All sorts of systems and approaches have been developed and are used in an attempt to uncover all the requirements in a contract and communicate them to those who need to know. We all do our best and yet with thousands of requirements on each contract the task is tremendous.

In addition to communication, a rep-

utable contractor who wants to comply with the warranty provisions of his contract, will have more than a passing interest in verifying that these requirements are complied with as will the DOD Contract Administrative Service (CAS) activity. What this all amounts to is a tremendous effort (and cost) associated with this planning and verification — a cost that is wasted if many of these requirements are unnecessary, conflicting, or incorrect.

- Enforcing Bad Requirements Generates Disrespect for All Requirements. Just like the boy who cried wolf — if many contract requirements are not correct, our people will lose respect for all requirements in general — and this is not what we want. All MIL Specs and standards are not defective. There are many valid requirements and true "lessons learned" incorporated in these documents. But these trees tend to get lost in the forest and the result is that the requirements (and MIL Specs and standards in particular) as a group "don't get no respect" — and as a result the customer sometimes "don't get no quality."
- Ignoring Some Requirements Compromises QA Integrity. Anyone responsible for quality, and that means everyone who affects the product, not just those in the quality function — must make "100 percent conformance to requirements" his or her way of life. There is no place in a quality culture for individuals to pick and choose which requirements they will conform to and which they will ignore. And certainly there is no place in a quality organization for anyone who will ignore some specs and enforce others — it simply will not work over the long run and eventually compromises the integrity of anyone who attempts to do so. This same principle applies to activities such as the Defense Contract Administrative Service (DCAS) or the Air Force, Navy or Army Plant Representatives' Office Quality Assurance Representatives (QARs). It is a cop out for a procuring activity to expect the contractor or the government QAR to compensate for unstreamlined contract requirements by selectively enforcing some and ignoring others.
- "Generates Attitudes of Let QA Worry About the Specs." This is another attitude or culture problem that is extremely distasteful to the quality professional, and extremely damaging to a company's quality culture. When no one has time to read or understand all the specs, and many of them are known to be outdated or incorrect anyway, it is easy for an attitude to develop which in effect says that QA's job is to negotiate around, through or over such roadblocks if, and when, they surface.

If the problem is one of interpretation caused by an ambiguous or unclear spec, sometimes an agreement can be reached locally. However, if the spec is clear, even though it may appear to be unnecessary or technically incorrect, once it comes to light there is little that can be done other than to follow it, or process a minor waiver or Materiel Review Board (MRB) action — neither of which is an attractive or profitable mode of operation.

- Critical Requirements Get Overlooked. This may have the highest negative quality impact of all. Yet it is a subtle point. Simply stated, what this means is that with limited resources, and the extensive time taken up in pursuing all the actions discussed up to this point, it is easy to overlook the vital few requirements that are buried among the "trivial many" others that we have to deal with.

Ask any of your QA engineers how much time they spend resolving problems having to do with ambiguous or over applied specifications, versus how much time they spend actually assuring or improving the quality of the product itself. I suspect you'll be surprised. Some quality engineers tell me this number is around 50 percent.

What I have said so far can be summarized as follows. Quality is conformance to correct requirements. Streamlining can influence these requirements, therefore streamlining can influence quality. Failure to properly streamline requirements has a negative impact on a company's quality culture.

Cost of Quality

What I'd like to do now is address the impact on quality from a slightly different perspective — cost of quality. When requirements are imposed incorrectly or unnecessarily, the impact extends far beyond damage to the quality culture. In fact the impact is directly translatable to dollars, dollars spent by the QA engineer in trying to identify and research unnecessary or ambiguous requirements, and communicate them to design and manufacturing; dollars spent by those engineers in attempting to understand and incorporate them into their designs and processes; dollars spent by quality control or test in verifying compliance, by audit functions both internal and external to the company; and dollars spent in correcting or redefining processes that were performing satisfactorily but in violation of some detail buried in one of the requirements we're talking about.

We've heard a lot about the savings that can and have resulted on the programs where streamlining has been applied. I am confident that these reported savings are just a drop in the bucket compared with the potential if streamlining were to be applied across a broad spectrum of contracts and products. I have called this enormous wasted cost the "Hidden Requirements Factory" to suggest that this entire cost should be considered as cost of poor quality, and attacked with the same enthusiasm we currently find focused on MRB cost, return to supplier cost, cost of engineering change notices, and other elements of cost of quality.

So now, in addition to destroying a quality culture, and diverting attention from critical requirements we have added "increased quality costs" to the list of consequences of non-streamlining.

The final quality impact area I want to discuss has to do with the current atmosphere in which the DOD and the defense industry find ourselves. I know I don't have to go into the details — let it suffice to say that we now operate under intense scrutiny. And this scrutiny comes from a number of different agencies.

The one thing all of the reviewers, auditors and monitors have in common is a focus on requirements — these same requirements that we are hoping to streamline. And just as surely as quality means conformance to correct requirements, any audit (and I include contractor self audits, CAS audits, contractor operations reviews, system status reviews, government accounting office audits, etc.) is going to turn up examples of non-compliance to one or more of these thousands of requirements we've been discussing.

The less streamlining, the more requirements — the more requirements, the greater the chance of coming up short in an audit — and the more times you come up short in an audit — you get the picture.

So to recap one more time, failure to streamline has direct significant negative impact on a company's quality culture, hides critical requirements in a mass of unnecessary ones, drives up quality costs and provides fuel for negative audit reports.

Summary

There is no extra cost or effort needed to realize the benefits of quality

improvement through streamlining. Quality improvement will indeed come "free" if we can get on with streamlining — not just on a few demonstration programs, but across the board on all major DOD procurements. What it takes to push streamlining to fruition I am convinced, is to institutionalize the concept via meaningful language in the acquisition regulations.

We must stop talking about streamlining and make it a reality. As good an idea as streamlining is, and I believe it is one of the best, it will not happen if we continue at the present pace. The concept has been studied long enough, and someone has to push it through.

Who has the ball? I'm not entirely sure, but I believe that industry can certainly help and support. DOD has a critical responsibility and I urge the program managers, and the others who have seen what streamlining can do for the acquisition process and for the country, not to rest until streamlining is a way of life on each and every major procurement.

If we are successful, then the "streamlining-quality connection" will ensure an immediate, tangible and real payback in quality improvement and quality cost reduction!

New Special-Purpose Communications Van

By MAJ James E. Moffett

The problem most often encountered during relocation of a major operational headquarters is providing the tactical communications adequate to continue the mission. This problem is magnified when the headquarters is the largest forward deployed logistics command in the U.S. Army — the 21st Support Command (SUPCOM), U.S. Army, Europe.

The 21st SUPCOM has solved its problem through the use of a special purpose communications van. This capability, commonly referred to as "The Commo Van," was assembled as a non-developmental item (NDI). The commo van provides the 21st SUPCOM the capability to rapidly relocate with minimum-essential communications to continue its mission.

The NDI approach was chosen because of time and cost constraints allocated to fabricating the system. It proved successful. This approach is consistent with many ongoing DOD projects which utilize existing technology and equipment to satisfy new operational requirements.

The 21st SUPCOM teamed up with the 5th Signal Command to determine requirements and provide detailed electrical specifications and drawings. The final assembly and testing was performed by the 21st SUPCOM's Communications Maintenance Facility. Electromagnetic radiation/interference testing was performed by the 7th Medical Command.

System Description

The system consists of AM and FM radios, a semi-automatic tactical switchboard, electrical hookups for a portable worldwide military command and control system (WWMCCS), and the 21st SUPCOM-unique automated force tracking terminal. The commo van provides multiple communications in a small, mobile, and tactical package.

Assembled in a standard 2 1/2-ton truck shelter, the system can be transported rapidly, as required. It can also be transported via standard Air Force aircraft. Transport capability is important since the 21st SUPCOM operates in five European countries.

The tactical switching capability is provided by a 3082 semi-automatic switchboard. The switchboard terminates 50 common user tactical telephones, including eight commercial trunks. This capability is particularly useful with the U.S. communications grid network which is installed throughout selected European countries.

The commo van also transports the 21st SUPCOM automated force tracking terminal. Performed by the Burroughs B-25 computer, automated force tracking enhances a previously labor-intensive method of tracking deploying CONUS units. Both the WWMCCS and force tracking equipment can be removed from the van for operation or activated inside.

A long-range radio capability is provided via two AN/GRC-193A AM radios. Short-range radio capability is provided by two standard-inventory AN/VRC-46s.

The U.S. Army Equipment Authorization Agency is currently reviewing the communications requirement, with emphasis on its applicability to other theater Army area commands (TAACOM) having missions and responsibilities similar to those of the 21st SUPCOM.

Acquisition Strategy

Department of Defense directives require developers to review existing systems for upgrade, retrofit, and modernization prior to initiation of new programs. This approach to satisfying new operational requirements can literally save the developer millions in acquisition and life cycle costs. This approach was used for the 21st SUPCOM commo van.

Configured with all current-inventory equipment, the project fabrication time was greatly reduced. Project duration was 18 months. Likewise, project costs were minimized. NDI and system upgrade are the acquisition methods of the future.

Conclusion

The 21st SUPCOM's capability to relocate has been greatly improved through use of the commo van. It provides the U.S. Army's largest deployed logistics command with the capability to relocate rapidly and continue to operate with minimum-essential communications.

MAJ JAMES E. MOFFETT is currently a Training-With-Industry participant at the Boeing Aerospace Co. He developed the commo van while assigned to the 21st SUPCOM. He has an M.S. degree in acquisition management and is a graduate of the Army Command and General Staff College.

Military and Domestic Technology Transfer

By Dr. Karl Bastress

Introduction

According to the 1981 *Webster's Third New International Dictionary,* technology is defined as "The science of the application of knowledge to practical purposes." However, the term technology transfer conveys a variety of meanings and implications. In particular, there are both beneficial and harmful modes of technology transfer. Beneficial or "positive" modes of technology transfer support useful applications of knowledge while harmful or "negative" modes may have adverse impacts on national security or competitiveness in international commerce.

An important point to recognize is that both the positive and the negative modes of technology transfer are highly interrelated, and anyone engaged in one must be cognizant of the requirements and constraints imposed by the other.

Positive technology transfer can be categorized further as military and domestic. Military technology transfer activities support development of new and improved equipment for military operations and may include adaptation of technologies from non-military sources to military systems. Domestic technology transfer supports development of products for commercial markets and includes adaptation of military technologies to such products.

This article specifically addresses Army programs designed to promote both military and domestic technology transfer through dissemination of technical information and other interactions among developers and manufacturers of products for both markets.

Effective technology transfer will become increasingly important in military developments if research, development, test, and evaluation (RDTE) program funding is reduced. Also, technology transfer from defense and other government R&D programs to non-defense industries may enhance the ability of the country to compete in international commerce.

The Technology Transfer Act of 1986 and its predecessor, the Stevenson-Wydler Technology Innovation Act of 1980, direct that all government laboratories and research centers establish vigorous programs to identify military technologies having potential commercial applications and to transfer those technologies to the commercial sector. Consequently, both military and domestic technology transfer are elements of the missions of all Army R&D activities.

Technology Transfer Programs

To enhance Army technology transfer efforts, management of technical information programs and other programs involving technology transfer has been combined under the Technology Transfer Division of the U.S. Army Laboratory Command at Adelphi, MD. These programs are listed in Figure 1.

In addition to those Army programs listed in the table, the Technology Transfer Division also manages the Army Materiel Command (AMC) Unsolicited Proposal Program, the AMC Materials and Parts Availability Control Program, and LABCOM international cooperative R&D activities. With these programs combined into one organization, they benefit from interactions with each other and much duplication of effort is eliminated. Managers of these programs operate through a combined communication network with other Army commands where, in most cases, the same programs are combined under unified management.

Scientific and Technical Information Program

The Army Scientific and Technical Information Program (STIP) is a comprehensive technical information exchange program providing support for military technology transfer. STIP is actually a DOD program in which the Army participates along with other ser-

ARMY PROGRAMS SUPPORTING MILITARY AND DOMESTIC TECHNOLOGY TRANSFER

PROGRAM	IMPLEMENTING REGULATION
SCIENTIFIC AND TECHNICAL INFORMATION PROGRAM	AR 70-45
INDEPENDENT RESEARCH AND DEVELOPMENT TECHNICAL EVALUATION PROGRAM	AR 70-74
SMALL BUSINESS INNOVATION RESEARCH PROGRAM	
INFORMATION FOR INDUSTRY PROGRAM	AR 70-35
DOMESTIC TECHNOLOGY TRANSFER PROGRAM	AR 70-57

Figure 1.

DEFENSE TECHNICAL INFORMATION CENTER DATA BASES

RESEARCH AND DEVELOPMENT PROGRAM PLANNING DATA BASE

RESEARCH AND TECHNOLOGY WORK UNIT INFORMATION SYSTEM

TECHNICAL REPORTS DATA BASE

INDEPENDENT RESEARCH AND DEVELOPMENT DATA BASE

Figure 2.

vices and DOD agencies. The primary function of the program is to acquire and disseminate information on DOD R&D efforts in three categories: work planned, work in progress, and work completed. This function is supported by a collection of data bases maintained by the Defense Technical Information Center (DTIC) listed in Figure 2.

Information on R&D projects in the planning stages is essential to DOD program managers seeking to combine or coordinate efforts in particular subject areas. Joint laboratory programs planned in advance reduce duplication of effort and provide greater output. R&D planning information is also of particular interest to the defense industry as guidance in planning independent research and development (IR&D) programs. IR&D projects planned in coordination with future DOD projects result in effective utilization of industrial R&D funding.

R&D planning information is maintained in the DTIC R&D Program Planning Data Base. This data base is accessible by DOD laboratories and by defense contractors and it is the responsibility of STIP program managers to assure that the data base contains current R&D planning information.

Similarly, information on R&D work in progress is necessary to minimize duplication of effort among defense research activities and to facilitate coordination of projects with related objectives. The DTIC Research and Technology Work Unit Information System data base contains information on R&D projects currently underway either in-house at DOD laboratories or under contract by industry or universities.

Project information is submitted to the data base in summary form (DD Form 1498) and is accessible through an on-line computer system or in the form of printed output. Unfortunately, universal submission of project information to this data base has not been achieved and, as a result, complete information on current work is not available. Improving Army inputs to and utilization of this data base is a top priority goal of the STIP.

Information on R&D work completed is contained in a third DTIC data base, the Technical Reports Data Base. Upon completion of any DOD-sponsored R&D project, a copy of the final report, including a summary (DD Form 1473), is to be submitted to DTIC. Summary information on the project is accessible by on-line computer and either a summary or a full copy of the report can be obtained in various hard-copy formats. This data base constitutes an enormous reservoir of technical information generated primarily by DOD programs and every Army project manager must make use of this resource.

A STIP mission is to assure that Army-sponsored R&D reports are submitted and that the data base is accessible by all Army scientists and engineers. Other STIP functions include support and utilization of DOD Information Analysis Centers and sponsorship of and participation in scientific and technical meetings. STIP managers also remain cognizant of national security and export control regulations pertaining to technical information dissemination to assure that STIP functions are performed in accordance with these guidelines.

Independent R&D Technical Evaluation Program

The Army, in conjunction with the Navy and Air Force, performs technical evaluations of IR&D programs conducted by major defense contractors. (See *Army RD&A Magazine* May-June, 1986, Pages 9-12.) The primary purpose of these evaluations is to provide a basis for negotiating IR&D cost recovery agreements with these contractors. To facilitate the evaluation, each contractor distributes a detailed technical plan on its IR&D program annually to DOD laboratories.

A summary of each IR&D project is also submitted to DTIC and entered in the IR&D Data Base which is accessible only by DOD employees. The technical information contained in the data base and the contractor reports support the transfer of militarily relevant technology from industry to Army acquisition programs.

Small Business Innovation Research Program

The Army Small Business Innovation Research (SBIR) Program is a Congressionally-mandated program to promote transfer of innovations from U.S. small businesses to federal R&D programs. A portion of the Army RDTE budget is set aside each year to fund technology development contracts with small businesses.

In FY 1987, $37 million in R&D contracts were issued by Army laboratories and RDE centers under the SBIR Program and information on these SBIR contracts is contained in the DTIC Work Unit Information System and Technical Reports Data Bases. This program has created a clear avenue for military technology transfer from the small business community.

Information for Industry Program

The Army Information for Industry (IFI) Program has been established to provide technical and advanced R&D planning information to current and potential defense contractors. The purpose of the program is to increase the effectiveness of contractors in meeting

the materiel and service requirements of the Army by providing information necessary to support IR&D and bid and proposal efforts. To accomplish this purpose, the IFI Program sponsors Technical Industrial Liaison Offices at Army laboratories and centers, promotes advanced planning briefings for industry (APBIs), certifies companies for access to controlled information through the Army Potential Contractor Program, and promotes the use of R&D unfunded studies to assist potential contractors in developing capabilities in new areas of technology.

Domestic Technology Transfer Program

The Army Domestic Technology Transfer (DTT) Program promotes transfer of Army-developed technologies to industry for domestic applications in accordance with requirements of the Stevenson-Wydler Technology Innovation Act of 1980 and the Federal Technology Transfer Act of 1986.

Federal laboratories have established Offices of Research and Technology Applications to identify technologies with potential for domestic use and to actively promote applications of those technologies in the private sector. The latter act provides additional mechanisms for domestic technology transfer such as authority to enter into cooperative R&D agreements with industrial and academic research organizations. The Army DTT Program is managed for LABCOM by the Harry Diamond Laboratories and will be the subject of a future article in this bulletin.

Making Technology Transfer Work

To promote technology transfer in Army RDTE programs, the LABCOM Technology Transfer Division is working toward two objectives: to make technical information readily accessible to all Army scientists and engineers, and to establish a monitoring mechanism to determine how well technology transfer is actually working.

Access to technical information is improving rapidly as electronic communication systems are installed at Army R&D organizations. In particular, routine access to the DTIC data bases will allow laboratory and RD&E center personnel to perform searches easily for information on other programs related to their own. When electronic access to data bases becomes routine, inputs to the data bases will improve, rendering the system more useful to everyone.

Monitoring technology transfer activities is necessary to determine whether the programs are actually working and if the Army is taking full advantage of available technology resources. On the other hand, it is possible to overly burden the R&D process by imposing excessive reporting requirements which draw upon staff resources.

The primary approach being taken to monitor military technology transfer is to require evidence of utilization of external sources of technology in regular program planning and status reports. This approach allows an R&D program manager to demonstrate technology transfer impacts on the program without the requirement for a separate reporting mechanism and should provide a measure of technology transfer effectiveness. On the other hand, monitoring domestic technology transfer activities requires an independent reporting process.

Impacts of Technology Transfer

The principal impact of technology transfer is adaptation of new innovations in one field to applications in others. Such transfers result in more rapid progress in military materiel development than would occur if the development process were entirely dependent upon military R&D programs as sources of innovation. Similarly, federal R&D programs represent a vast source of innovations with possible applications in domestic products. Recent legislation and implementing programs are providing the incentives and mechanisms for transfer to domestic markets to occur.

Economic benefits of technology transfer are evident in several categories of Army materiel. Systems such as utility vehicles and communications equipment draw heavily on technologies developed for non-military applications. The Army conserves RDTE resources by utilizing these technologies and allowing resources saved to be directed toward requirements which are uniquely military.

Conclusion

Army technology transfer programs are designed to increase further the benefits of innovation and economy in both military and domestic applications. These benefits will be substantial if the entire Army RDTE community supports the programs.

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Evaluating the Effectiveness of Antiarmor Weapons

By Douglas Longshore and Jeffery L. Grady

Introduction

The effectiveness of modern antiarmor weapons in battle depends on a large, interrelated set of conditions, many of which are difficult to measure and predict. As these conditions become more complex, so does the task of evaluation.

How can decision makers know which conditions are most critical to performance? How can they sift through the competing claims and voluminous data? How can they transform material obtained from scattered sources with vested interests into a balanced, overall view of a weapon's likely effectiveness in battle?

We propose a simple framework for summarizing and interpreting information on antiarmor weapon effectiveness. While technical experts may find the framework useful, it is designed mainly for managers, reviewers, and others whose work is not technical but who nevertheless participate in decisions regarding the pace of development and the selection of weapon alternatives. Use of the framework can improve the quality of those decisions by:

- focusing evaluators' attention on degraded performance, that is, on the many conditions that can reduce a weapon's actual effectiveness in battle;
- requiring proponents to explain how a weapon's technical capabilities will contribute to its actual effectiveness; and
- highlighting the need for comprehensive and comparable data for any and all weapons being evaluated.

The Framework

Our framework covers five weapon effectiveness factors: accuracy, lethality, rate of fire, sustainability of fire, and vulnerability.

To guide the prediction of performance under battlefield conditions, we need to consider as well three degradation factors that can weaken the effectiveness of antiarmor weapons: the mission environment (visibility conditions and terrain in which a weapon will be employed), countermeasures (enemy efforts to toughen materiel, conceal movement, or jam our communications), and human factors (the gunner's ability to handle a weapon, especially under the stress of combat.

Guided by this framework, evaluators would first estimate the likely performance of a weapon under benign conditions — a lab or test range, for example. The next step is to consider whether and how each degradation factor can influence a weapon's performance on each effectiveness factor. In some cases, test data will be solid enough to support a clear answer. In other cases, the data may be minimal and the answer will remain tentative, based perhaps on expert judgement or prior experience with similar weapons.

Accuracy

Under benign conditions, accuracy is a function of a weapon's technical characteristics, the size of the target, and range.

What about the weapon's performance when conditions are not benign? Elements in the mission environment — wind, obscurants, and terrain — can severely degrade a weapon's accuracy. First, they make it more difficult to guide weapons to a target. Smoke and trees, for example, can interfere with the tracking device. Second, they make it more difficult to find targets in the first place — a problem for unguided as well as guided weapons.

Countermeasures include camouflage, decoys, evasive target movement, and counterfire. Notably, counterfire can degrade accuracy without actually hitting the gunner; it is only necessary to disrupt his aim.

Human factors can also degrade accuracy. These include a gunner's weapon-handling skills such as the ability to assemble the weapon quickly and to aim it accurately, and more general attributes of gunners such as their ability to handle stress and the quality of their training.

In short, elements that interfere with target detection can degrade the accuracy of unguided weapons. Elements that interfere both with target detection and with the ability to track targets can degrade the accuracy of guided weapons.

Lethality

Lethality — the likelihood of damaging or disabling a target — depends not just on penetrating the outer armor but also on doing further damage once inside. It is a function of various technical characteristics of the warhead such as its size, composition (liner shape and materials, for example), and type (chemical energy or kinetic energy).

One countermeasure, reactive armor, reduces penetration by exploding outward when hit, disrupting the formation of a chemical-energy jet. A future possibility is active armor, in which a sensor on the target detects oncoming rounds and triggers the release of debris or charges that impede their progress. There are, in addition, countermeasures designed to reduce interior damage, including spall liners and screens, fire suppression systems, and insensitive fuels and munitions.

Rate of Fire

The number of rounds a gunner can fire per minute, or rate of fire, is a function of the time that it takes to find a target, aim, and fire, and (for guided weapons) to track the round until impact. If the launcher is reusable, we must also consider the time that it takes to reload it.

Under battle conditions, human factors such as combat stress or inadequate training can slow the rate of fire. Even when gunners can fire repeatedly without having to move, the rate of fire is likely to be much lower than the rate that is technically feasible.

Sustainability of Fire

Sustainability of fire is the number of rounds that a unit can carry into the field and fire. Under benign conditions, the "carry weight" and deployment level determine sustainability of fire.

First, consider the carry weight; the lighter the weapon is, the more rounds a unit can carry. Evaluators need to take into account the weight of all components to be carried, not just the weight of a launcher and a single round. Additional components can include the day and night sights, battery, coolant, platform (bipod or tripod, for example), cleaning equipment, and storage containers. There is, of course, an advantage to weapons with reusable pieces.

Also relevant is the level at which the weapons are deployed — individual soldier, squad, or battalion, for example. Larger units can carry more weight by assigning it to specialized subunits.

Under combat conditions, suppressive counterfire can reduce sustainability. An enemy need not achieve direct hits; if gunners must keep their heads down or move after firing, they may not be able to sustain fire.

Vulnerability

Vulnerability depends on technical features of the weapon or platform, plus the likelihood of attrition — the chance that either gunner or weapon will be disabled during battle. Relevant technical features include the extent of gunner exposure and the weapon's range and firing signature.

The key degradation factor for vulnerability is counterfire — in this case not disruptive or suppressive counterfire, but disabling counterfire.

Problems in Evaluation

Contractors and DOD sources routinely provide the data just described, but the task of data evaluation falls on managers and reviewers who are not technical experts. In many cases, the meaning and importance of one or another bit of data remain obscure. In some cases, the data can actually be misleading.

First, a weapon's technical features by themselves do not indicate its likely effectiveness in battle. Will a 10 percent reduction in backblast significantly reduce a weapon's vulnerability to counterfire? How much will another 200 millimeters of armor penetration add to a weapon's lethality against its intended targets?

Second, data that describe performance under benign conditions are often misleading because combat conditions can severely degrade performance. How easily will gunners be able to find and hit targets when the battlefield is blanketed in fog or smoke? How much will reactive armor degrade a weapon's lethality.

In most cases, evaluators do not have access to projections of degraded performance under the full range of likely combat conditions. When DOD considers these conditions, the focus is usually on forces, not on each weapon in isolation. But force-on-force outcomes do not indicate the extent to which the conditions simulated in the model degrade the performance of individual weapons. Even when a model produces loss-exchange ratios per weapons, those ratios can vary widely depending on the scenario (terrain, tactics, synergistic effects of other weapons, and so on).

DOD does estimate degraded effectiveness for some weapons in isolation, using field tests and simulations, but the comparability across weapons is limited. Tests have not included the same degrading elements or varied the elements in the same way.

A third problem for evaluators is that estimates of lethality are difficult even under benign conditions. As noted above, the likelihood of disabling a target depends not just on penetration but also on interior damage.

At present, it is not possible to simulate adequately the effects of blast, fire, and shock behind the armor or that predict the paths of spall fragments and the resulting damage to components. Moreover, warhead penetration capabilities have, until recently, been expressed in millimeters of solid steel (called rolled homogeneous armor, or RHA). But developments in armor technology have now complicated matters.

Composite armor and interior tank liners present penetration problems not directly comparable to those presented by solid steel, and the degree of protection they afford depends heavily on the depth and materials of each composite layer, as well as on characteristics of the attacking warhead. Hence, it is difficult to generalize beyond a particular pairing of armor and warhead.

Value of the Framework

How can our framework improve the quality of weapon evaluations? Its usefulness lies, we believe, in structuring the review of data around a manageable number of factors, each of which clearly and directly contributes to effectiveness.

First, our framework identifies in a generic way the battlefield conditions that can degrade effectiveness and signals for evaluators the sort of information they will need in order to estimate a weapon's likely performance under those conditions.

Furthermore, proponents of a new weapon often support its acquisition on the basis of impressive technical characteristics — time of flight, weight, or range, for example — leaving to evaluators the task of determining how much difference those characteristics will actually make for effectiveness. Use of the framework requires that proponents "speak to" each relevant set of effectiveness and degradation factors, so that evaluators can link a weapon's technical capabilities directly and systematically to its likely performance in battle.

A third advantage of the framework is that it enables evaluators to judge more easily the trade-offs among weapon alternatives. It highlights the need for performance data that are comparable across weapons, covering the same set of degradation sources and test conditions. Moreover, it underscores the fact that effectiveness is relative. Performance degradation, even when severe, should not bear unduly on an evaluator's judgement, since all weapons to a greater or lesser degree are subject to degradation.

Evaluators may wish to expand the framework to include cost, risk, force

effectiveness, or reliability, when such factors are of special concern. But we recommend keeping the framework as simple as possible and making explicit the relevance of such factors to the weapon's ultimate effectiveness in battle.

DOUGLAS LONGSHORE and JEFFERY L. GRADY are staff members with the Program Evaluation and Methodology Division of the U.S. General Accounting Office. The opinions expressed here do not represent official GAO policy.

Acquisition Streamlining Awards Presented

The first "Army Honor Roll" awards for acquisition streamlining excellence were presented late last year to seven Army organizations and three individuals. Robert O. Black, Army advocate for acquisition streamlining, hosted the ceremonies at HQ, U.S. Army Materiel Command.

Assistant Secretary of the Army for Research, Development, and Acquisition Dr. J. R. Sculley presented the awards in recognition of 1986 achievements in reducing the time and cost of systems acquisition through application of streamlining principles while maintaining performance and quality requirements.

Nominations for the award were received from the Army network of acquisition streamlining advocates and approved by the Under Secretary of the Army. Recipients and their achievements are:

- *The U.S. Army Information Systems Command* was recognized for emphasizing the use of nondevelopmental items to meet requirements and for the development of a process called Adaptive Acquisition Strategy. This strategy encourages industry to place developmental money in those areas which will specifically satisfy future government needs.
- *The U.S. Army Test and Evaluation Command* received the award for its strong role in challenging unrealistic system technical requirements; ensuring that test programs are the minimum essential to provide required data for evaluation; and for establishing a process which achieved significant cost avoidance by eliminating duplication in test facilities.
- *The Office of the Deputy Chief of Staff for Combat Developments, HQ, U.S. Army Training and Doctrine and Command* was cited for development and implementation of policies and procedures which streamline the requirements development process, and for management initiatives to ensure early and continuous management involvement throughout each materiel acquisition program.
- *The U.S. Army Command and Control System Program Office, U.S. Army Communications-Electronics Command (CECOM)* was commended for emphasizing a nondevelopmental item approach which places heavy emphasis on the use of commercial specifications/components for rapid procurement of state-of-the-art technology and for fielding of integrated sets of battlefield automated nodal control systems, component systems, and communications systems. Their acquisition strategy includes a "proof of principle" phase involving all bidders' proposals and "hands on" testing with troops.
- *The Mobile Subscriber Equipment Project Office, CECOM,* received the award for emphasizing a total system nondevelopmental item approach for procurement of the total Army requirement for communications at Division and Corps. This includes communications equipment, trucks, installation kits, spares, repair parts, training, logistics, and fielding support. Additionally, all items that could not be totally justified and/or every requirement that could be eliminated to simplify solicitation and award documents were stricken. This resulted in over 50 percent of the draft solicitation being eliminated prior to release for industry review.
- *The Unmanned Aerial Vehicle Project Office, U.S. Army Missile Command (MICOM)* was recognized for emphasizing a nondevelopmental item acquisition strategy, and for successful tailoring of the final solicitation. In addition to eliminating all tiering, the project office reduced the volume of data items, standards, and military specifications by 50 percent. This was achieved by eliminating all unnecessary and counterproductive requirements.
- *The M119 Howitzer Program Management Organization, U.S. Army Armament Munitions and Chemical Command (AMCCOM)* was cited for using a nondevelopmental item approach, and for limiting testing to only fill "data gaps" between user requirements and test data from the United Kingdom. This allowed the program to proceed from Milestone I to production in just 19 months.
- *Ben Jackson Risse, chief, Systems Analysis and Evaluation Office, MICOM,* received the award for developing a method for weapon system management that provides for more efficient use of command resources. He was also commended for establishing the Systems Analysis and Evaluation Office as the MICOM focal point for program acquisition strategy assistance to PMs.
- *David M. English and John A. Scavnicky, XM43 Protective Mask System, Chemical RDE Center, AMCCOM,* were recognized for significant streamlining achievements related to development of the XM43 Protective Mask. Through the use of an innovative streamlined acquisition strategy, they succeeded in achieving outstanding technical and operational NBC performance for the Advanced Attack Helicopter. As a result of their efforts, the protective mask was type classified in only 49 months, which is exceptional in comparison to the normal 8-12 year development cycle.

Nominations for the 1987 Army Honor Roll for Acquisition Streamlining Excellence will be requested in early 1988.

A New Approach to Materiel Change

By Jim O'Brien

Introduction

The procedures used by the Army to review and approve changes to materiel will be revised prior to FY89. This article presents a brief overview of the revised management and decision structure that will be the basis of the new procedures for handling materiel change.

Impetus for this restructuring goes all the way back to 1984, when GEN Wickham, then chief of staff of the Army, asked GEN Thompson, then the Army Materiel Command (AMC) commanding general, to work with the Training and Doctrine Command (TRADOC) in developing an integrated approach to managing modifications to Army equipment. This request had its genesis in the perceived obstacles, omissions and inconsistencies inherent in the traditional management, control and execution procedures for materiel change.

While numerous earlier studies had examined the problems with the current management systems, and proposed remedies, it was apparent that these solutions addressed only some of the symptoms of the basic problem. Without resolving the underlying lack of management focus, which is the root cause of much of the dissatisfaction with current methods, these solutions were only so many "band aid" fixes.

Direction for the materiel change management (MCM) restructuring effort then, was to obtain agreement on the basic problem parameters and to propose a new approach to managing materiel changes which focused on the overall Army requirements. In addition, this new approach was to be integrated into the traditional program management and budgeting tools.

A Joint Effort

Development of the new approach to materiel change management was a joint AMC, TRADOC and HQDA effort. Oversight and direction were provided by the AMC Acquisition Management Improvement Committee, chaired by Robert O. Black, the AMC principal assistant deputy for research, development and acquisition.

Review and analysis of the perceived problems with materiel changes led to identification of the following shortcomings with current procedures:

- insensitivity to differences in type of change or magnitude;
- illogical separation of production and retrofit decisions; and
- failure to promote efficient block changes.

It soon became apparent that the common genesis for these shortcomings was that the Engineering Change Proposal (ECP) and Product Improvement Proposal (PIP) procedures were mutually inconsistent. Further, the perspective of the senior Army leadership was that this inconsistency actually impeded planning, control and execution at appropriate management levels.

The inherent management conflict is illustrated by comparing the diagrams in Figures 1 and 2. These simplified schematics illustrate the path currently followed for review and approval of a proposed change to equipment. Figure 1 shows the process typically followed for a "production line" change, while Figure 2 is representative of what is required for a change which involves retrofit to fielded equipment.

While there is historical justification for how these processes have evolved over time, the key issue here is that we have lost sight of what we were trying to accomplish, and now face a fundamental inconsistency:

- The ECP process is basically under control of the PM, and is normally very responsive (both in terms of approval

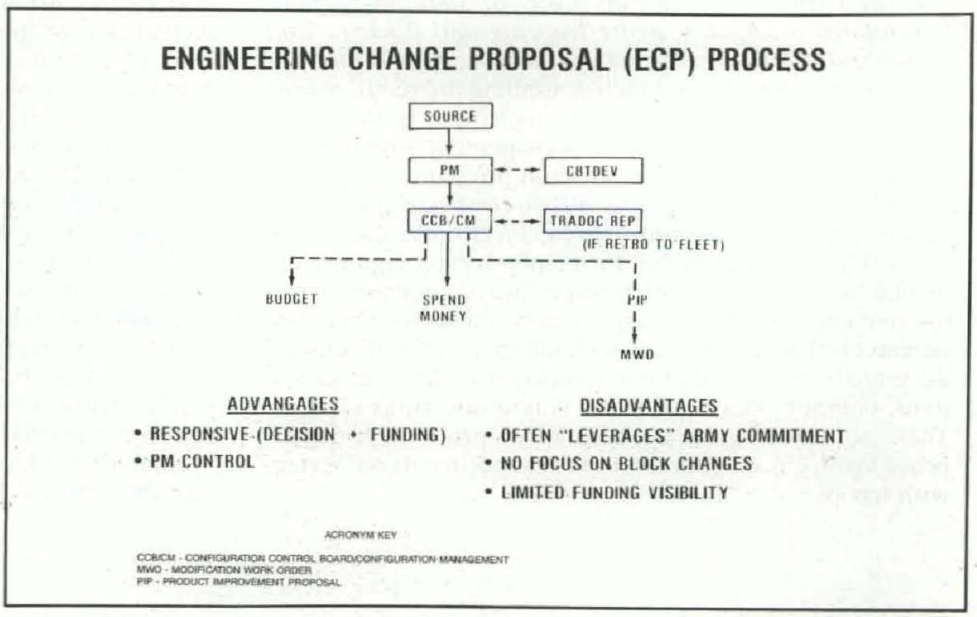

Figure 1.

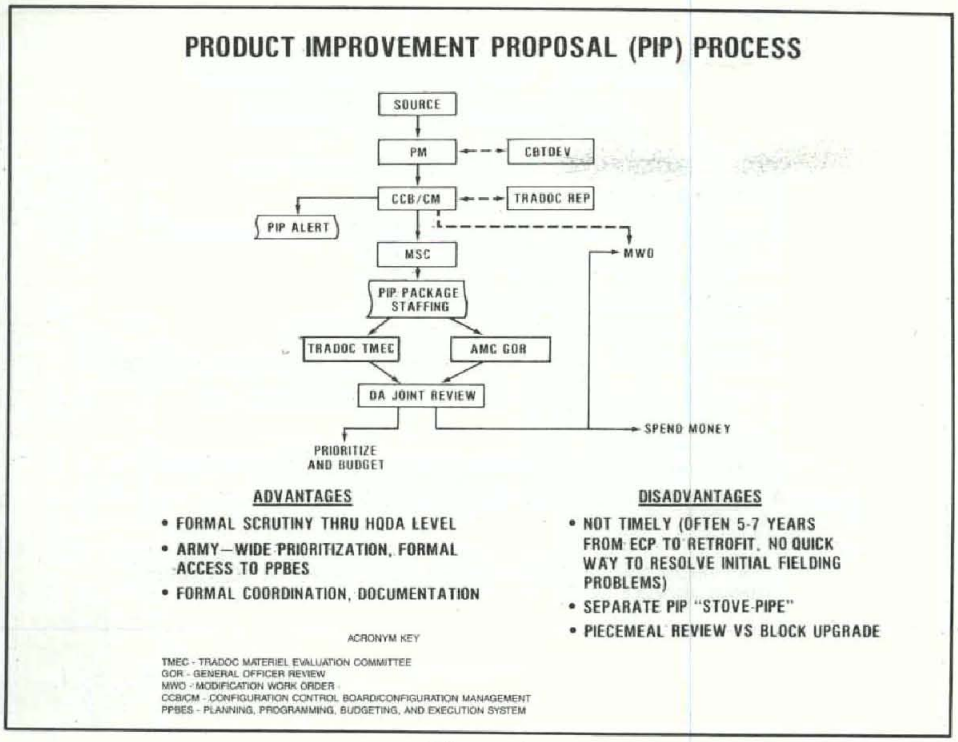

Figure 2.

and funding) but provides little DA level visibility and control.

- The PIP process provides excellent visibility and control (both approval and funding) but allows little flexibility and often imposes an undesirable delay in execution.

Further, as already noted, neither process, with minor exception, adjusts its level of review and approval to accommodate differences in nature or magnitude of the change effort being proposed, and any single change may have to go through both review and approval procedures independently.

The Objective

The objective of this new effort then, was to re-examine the entire Army decision structure for materiel changes, and to develop an approach which:

- integrates materiel change decisions with traditional management and funding mechanisms;
- insures *appropriate* higher level visibility and control;
- allows for flexibility and responsiveness needed to operate on a day-to-day basis; and
- vests control and authority at the lowest appropriate level.

The scheme developed to accomplish these objectives is illustrated in Figure 3. As shown, the process distinguishes between those change efforts which can be planned for in advance and those which are basically unanticipated. In the former case, the emphasis is on developing a plan which lays out the long-range goals and objectives for the system and using existing planning, approval, funding and management review methods applied to block changes.

In the latter case — the unanticipated requirements — what is required is an expedited decision process distributing decision authority and control to three different levels, with determination of the appropriate level based on criteria related to the nature and magnitude of the change.

The specific criteria for each review and approval level must still be finalized, but the subject areas for the threshold criteria are listed in Figure 4.

The intent of this restructuring is to stratify the authority and control responsibility for change so that those issues which should normally be within the purview of the PM are handled at that level and those issues which are of wider Army concern (whether as a result of overall funding level, or because of user impact for example) are automatically forced up through the system to be addressed at succeeding higher levels. As an illustration, Figure 5 shows the distribution of major system ECPs and PIPs that would have occurred if the FY86 actions had been reviewed under the materiel change management approach (this stratification uses only a dollar level discriminator, the actual process will involve more than just a dollar level threshold).

The key point to note is that very few decisions are made at the program executive officer/major subordinate command and Army acquisition executive levels, but that these few decisions

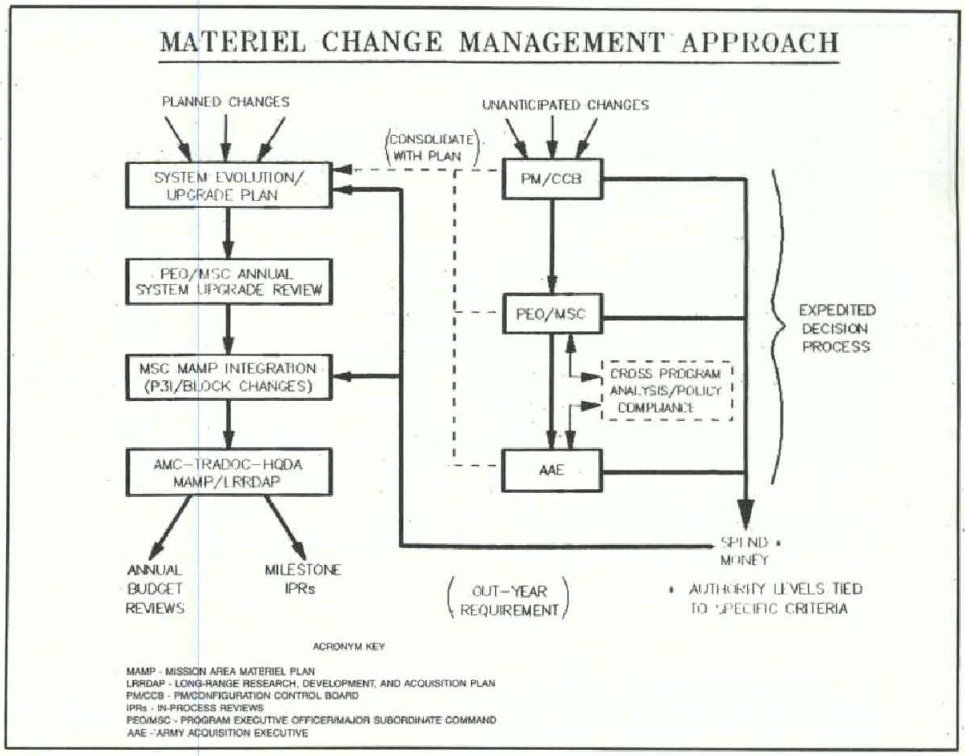

Figure 3.

are those that have by far the greatest overall impact (in this case in terms of total cost).

It is beyond the scope of this introductory article to go into all of the detail that is implicit in the materiel change management approach to reviewing and approving materiel changes. That will be left to follow-on interim guidance and revised Army regulations.

Implementation of materiel change management is assigned to the Office of the Assistant Secretary of the Army (Research, Development and Acquisition) and is being supported by both HQ AMC and HQ TRADOC. Current plans are for interim guidance to be issued approximately in the mid-FY88 time frame, with full implementation (including finalized regulation revisions and issuance of a clarifying handbook) in effect for FY89.

MATERIEL CHANGE MANAGEMENT APPROACH REQUIREMENTS

SPECIFIC MATERIEL CHANGE DECISION CONSIDERATIONS:

- **BLOCK APPLICATION INTEGRATION**
- **TOTAL CHANGE COST (ENGR, PROD, RETRO, O&S IMPACT)**
- **FUNDING AVAILABILITY/SOURCE/IMPACT**
- **RETROFIT/DUAL CONFIGURATION IMPACT**
- **BUDGETING/MILESTONE REVIEW REQUIREMENTS**
- **SYSTEM BLOCK UPGRADE INTEGRATION, MWO PLAN AND STATUS**
- **TRADOC CONCURRENCE ON FUND SOURCE/IMPACT, ROC REQUIREMENT/REVISION***
- **PRIORITIZATION INTEGRATED WITH MAMP/LRRDAP PROCESS**
- **CONGRESSIONAL NOTIFICATION/APPROVAL ELEMENTS**

*** IF NO TRADOC REP, HQ TRADOC COORDINATION AND CONCURRENCE/POSITION FORMAL AGENDA ITEM**

Figure 4.

Summary

In summary, let me say that, under the materiel change management concept, the application of the criteria based on the concerns identified in Figure 4 will lead us to: identify the total change costs and priority up-front, encourage the use of block mods to minimize the turmoil caused by separate change applications, consolidate the production and retrofit decisions, and vest the authority to act at the appropriate level.

All who have been involved in the development of the new concept hope that its implementation will be characterized by appropriate visibility and control balanced by appropriate flexibility and responsiveness.

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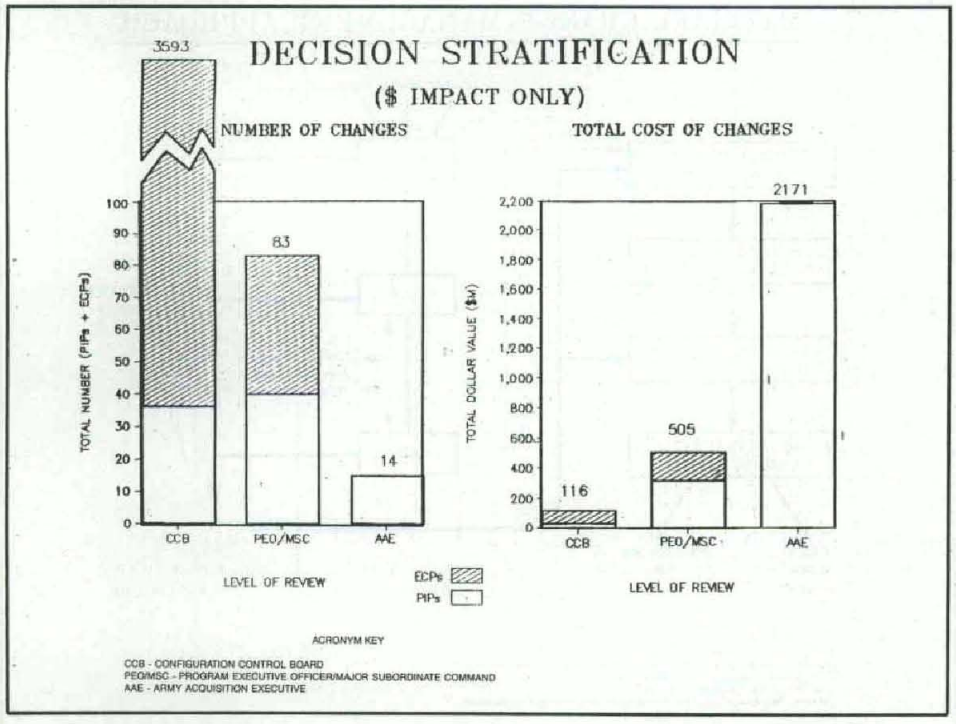

Figure 5.

Expert Systems in Army Aviation Maintenance

By Deane G. Reis and Bruce E. Thompson

Introduction

Faced with an adversary who possesses a substantially larger number of conventional forces, the U.S. Army has adopted the strategy of using advanced technology as a "force multiplier."

While "high-tech" integrated weapons and avionics systems enhance the operator's capability to fight, inadequate condition monitoring and diagnostic systems combined with a lack of skilled maintenance personnel can make them a maintenance nightmare. These potential shortcomings could result in unnecessary removals of good equipment, repetitive maintenance tasks, uncertain system condition and a general increase in support costs. Accordingly, senior Army managers have identified improved diagnostic/fault isolation as a major initiative for the technology base program.

This article addresses the application of artificial intelligence (AI) in the form of diagnostic expert systems which appear most promising in solving diagnostic/fault isolation problems. No attempt will be made here to discuss the science of AI per se, but rather focus on the application of the technology as a diagnostic tool. Specifically, this article addresses the current problems to be solved, why expert systems may be a key technology in their solution and a brief description and status of the Army Aviation Systems Command's (AVSCOM) programs in exploring the potential benefit of expert systems.

Problems

Fault location diagnostics in particular is a maintenance task that is greatly affected by system complexity. Increased system complexity generally makes the fault location task more difficult, particularly when the basic skill level and capability of the maintenance personnel do not improve at the same time as the system performance.

Figure 1 depicts the corrective maintenance man-hours per flight hour (MMH/FH) for both unit and intermediate maintenance levels for various current and proposed aircraft. As noted, MMH/FH increases as the level of complexity of the aircraft increases.

Increased system complexity also results in the need for more specialized knowledge to understand system functions and perform troubleshooting tasks. Acquiring this knowledge requires specialized training, which often leads to the creation of additional maintenance skill categories and increased personnel requirements.

Figure 2 depicts the growth in special skill categories required to maintain the increasingly complex advanced helicopter. One major goal of the LHX-type aircraft is to reduce MMH/FH and special skill category requirements.

The time required to develop the special skills and the continued proliferation of skill categories may result in a shortage of skilled maintenance personnel. The "expert knowledge" which characterizes these skill categories is a prime candidate for an expert system application. With the core of specialized knowledge resident in the expert system, the number of skill categories required to maintain the aircraft can be reduced as well as the time required for maintenance personnel to become "fully operational."

Current diagnostic concepts such as tech manuals (TMs), automatic test

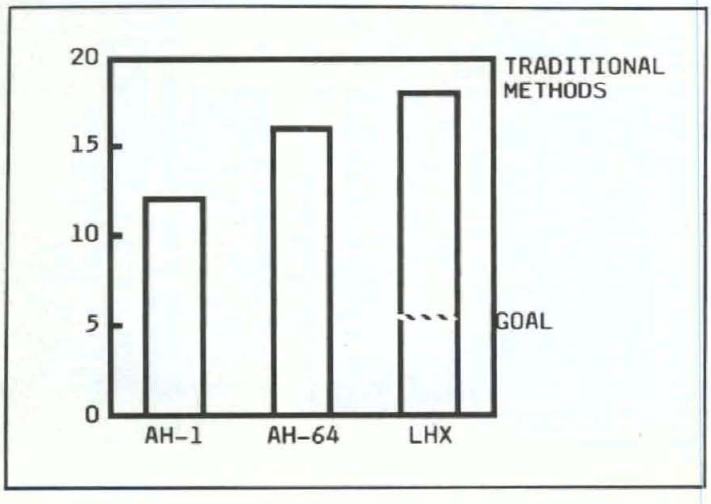

Figure 1. MMH/FH vs. Complexity.

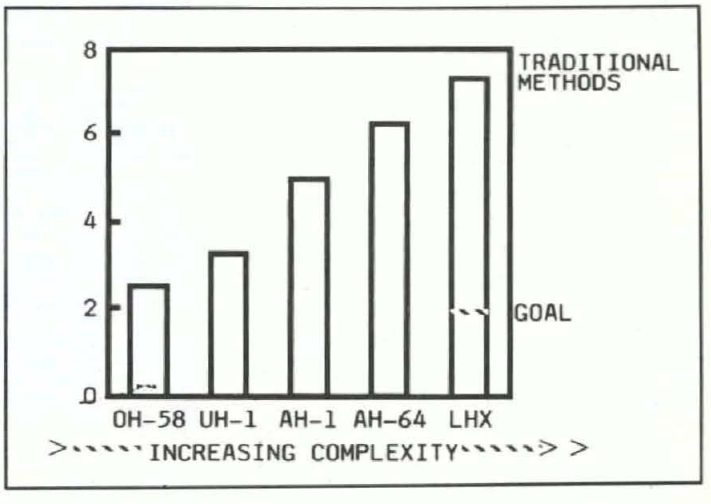

Figure 2. Skill Categories vs. Complexity

equipment (ATE) and built-in-test (BIT), fall short of their goals. TMs are voluminous and awkward and their test procedures lengthy. ATE can be complex, unreliable, inflexible and difficult to use. BIT is subject to a high false alarm rate and can be misinterpreted. The systems themselves add to the problem, being subject to intermittent failures and anomalous behavior which shows up as a false alarm or "could not duplicate."

Regardless of the diagnostic approach selected, one of the major dangers is that in actual practice, if the TMs are unworkable, they will be ignored. If ATE is too awkward, complex and unreliable, it will lead to its misuse and erroneous results.

Even BIT indications may be misinterpreted when fault codes must be interpreted and referenced in a manual. When no systematic approach to fault isolation is employed, remove-and-replace becomes the standard troubleshooting process. This may even evolve into the "shotgun" approach, where all the possible failed components are replaced.

An expert system for maintenance must be designed to provide major advantages over all of the manual and automatic diagnostic approaches described above and reduce the amount of ground support equipment now required. In cases where accurate BIT and fault sensors are not provided, an expert system can offer an effective complement to existing approaches, especially where interface faults exist or where analysis of fault data is required.

Objectives

Our objective is to demonstrate the potential benefits of artificial intelligence techniques, specifically expert systems, to fault isolate Army aviation systems. To ensure a most robust appraisal, three concepts were selected which represent a wide spectrum of aviation systems, ranging from all-electric to electro-optical to electro-hydromechanical.

The concepts selected also took three entirely different approaches: one a purely heuristic rule-based system, one a heuristic rule structure executing a connectivity model, and finally a probabilistic data base assisted by an "expert" rule base.

The performance of the expert systems will be assessed based on the success rate in isolating faults, the number of tests required per session, the total test time per session and the number of test flights/ground run ups required. The effect of the system on no-fault removals and user response to the system will also be examined.

AI Tutorial

Knowledge based or expert systems provide several advantages over the fault isolation procedures presented in tech manuals or simple computerized binary fault trees. In expert systems, "rules-of-thumb" or heuristics, gathered from diagnostic experts are encoded in the form of IF-THEN rules. These heuristics can drastically reduce the amount of testing required for fault isolation, allowing a novice to approach the expert's level of performance. Knowledge from various experts can be combined and compared for optimum gain.

In an expert system, the information peculiar to the problem is contained in a set of rules or knowledge base. A separate software module, called an interference engine, operates on this set of rules. This separation makes the expert system easy to modify and maintain as more knowledge is gained or if the weapons system itself is modified.

The rules contained in the knowledge base can represent more complex decisions than the simple yes-no fault trees of the technical manuals. Observable symptoms, environmental factors and past history can be used to direct testing and to minimize the time spent in troubleshooting.

The amount of time to make a test and the failure rates of the items should be considered during testing. Expert systems can deal with unknowns and make a diagnosis using incomplete information. This allows much more flexible test strategies to be used.

Being interactive, expert systems can provide explanations of its diagnostic reasoning to the user, providing a level of on-the-job training.

CH-47D Chinook

Boeing Vertol Co., assisted by Boeing Computer Services, is developing a prototype expert system to fault isolate the flight control system of the CH-47D "Chinook" helicopter. Mechanical, hydraulic, electrical and electronic components comprise this highly complex system, which is further complicated by the interaction of its large tandem rotors. And to make the task more challenging, many of the faults in the flight control system are subjective observations of the crew rather than objective ones: "No, it had more of a shuffle than a shimmy, and only at a Hover"!? This expert system consists entirely of heuristic "rules-of-thumb" gathered from domain experts.

Starting with three Boeing flight test engineers, the rule structure was assembled. More rules were added by other Boeing experts (design engineers and field representatives), and Army maintenance instructors, test pilots and technicians. Although almost 2,000 production rules made up the system, they

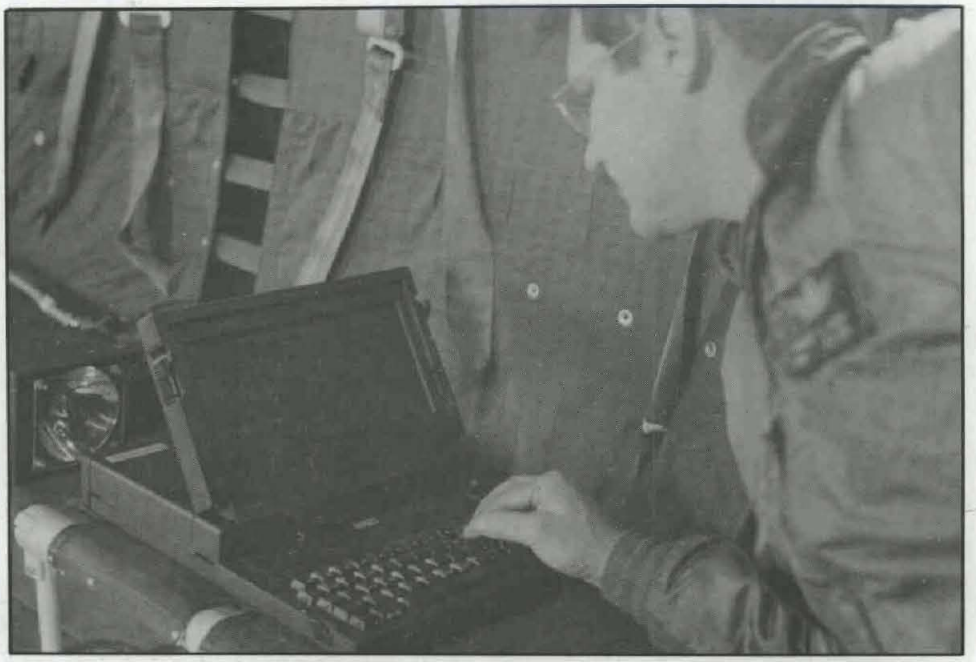

Figure 3. Portable Computer in Use on CH-47D.

Figure 4. Hughes AI Ferret in Operation.

had been "compressed" into under 200 rule-matrices.

The system was developed on a Digital Equipment Corp. (DEC) Microvax II computer using the "C" version of the S.1 development tool, or "expert shell." Boeing also added "technology demonstrators" in the form of a laser-disc player to demonstrate available visual aids and a talk unit to demonstrate computer voice synthesis. The prototype system has undergone a 60-day field demonstration and evaluation and has been exhibited at numerous CH-47D units and at related meetings.

Based on their experience during the field demo, Boeing is currently evaluating available portable (lap-top) computers to determine which hardware will make the best host for a fully portable version of the expert system. The portable version will be field tested in late 1988. Following a successful field demo, the program can be rapidly scaled-up to include all CH-47D units within six months. Figure 3 shows the portable computer in use on the CH-47D.

AH-1S Cobra/Tow

Hughes Aircraft Co. has developed an AI based fault isolation system for the M65 Tube-launched Optically-tracked Wire-guided (TOW) missile system. The TOW was an appropriate demonstration system due to the high system complexity, availability of technical information, availability of field experts and potential benefit to the Army.

The TOW system has BIT, but it is inaccurate in determining which line replaceable unit is at fault. A test set is required to troubleshoot the TOW which is operated manually and requires complex switching to run the various tests used for fault isolation. Current TM fault isolation procedures are long and involved, making diagnosis prone to error.

The authoring system/shell developed by Hughes has been dubbed "AI Ferret." This system combines the rules of an expert system with a connectivity or dependency model. This combination eliminates many of the problems inherent to the individual approached. AI Ferret uses a hybrid inference engine that allows the expert system and the connectivity model to interact.

System capabilities include troubleshooting, phase maintenance procedures and a quick system checkout. The user is provided with a block diagram of the system and an indication of the present status of each line replaceable unit i.e. known good, known bad or unknown. Procedures for troubleshooting, illustrations and check lists are provided to step the technician thru the procedure. In the event no test set is available, the system can still troubleshoot the TOW. It is more accurate and faster with the test set but very capable without it. Figure 4 shows the Hughes AI Ferret in operation.

AI Ferret runs on a Xerox 1109 computer and is written in INTERLISP-D and LOOPS. Heuristics for the system were obtained from Army maintenance instructors and Hughes own engineers and field representatives. Currently, the system contains over 2,500 rules. Approximately 50 graphics were developed to aid the technician through the diagnostic.

The system has been demonstrated at an attack helicopter battalion over a six month period. Randomly occurring as well as inserted faults were used to test the system. Data collected have been fully analyzed as of this writing but the percentage of correct diagnoses was greater than 90 percent and test times were shorter than technical manual procedures. User acceptance was good and little training was required to use the system.

AH-64 Apache

McDonnell Douglas Helicopter Co. has developed a prototype expert system called the Intelligent Fault Locator (IFL) to fault isolate the following four subsystems on the AH-64A Apache: auxiliary power unit, fuel system, communications and navigation avionics, and flight control system.

The IFL features multiple knowledge bases and a simulation model. As with all new systems, expert knowledge of the AH-64 was initially very limited. However, experts were able to provide rules-of-thumb which pertain to general maintenance practices, such as troubleshooting electrical wiring problems, finding leaks, etc, to form a general knowledge base.

McDonnell Douglas next developed a probabilistic knowledge base using component reliability data. Given a system malfunction, the IFL could at least tell which component was most probably at fault, although the certainty may be quite low. As expert knowledge became available, heuristics were added as a system-specific knowledge base.

When the IFL is advised of a fault symptom, it first accesses this system-specific knowledge base. If this does not isolate to a single cause, the IFL accesses the probabilistic base to break the ambiguity. If the IFL is still unsuccessful in isolating the fault, it will access the general knowledge base. And finally, if the IFL is still unable to isolate the fault, it can actuate the simulation module.

The simulation module can simulate the failure of one or more components until it matches the symptoms given. Only the fuel system has a simulation module for this demonstration. The IFL has over 2,000 production rules.

McDonnell Douglas developed the IFL on a Texas Instruments (TI) Explorer computer using Lisp and a development tool package called OPS.5. In order to use the IFL at the aircraft, TI (under contract to McDonnell Douglas) modified an Army 4x4 field ambulance by installing a 6.5-kilo-

watt generator, an air conditioner, work spaces and the Explorer computer. The prototype system has been field demonstrated at operational units for 22 weeks and will continue for 10 weeks more. System accuracy to date is better than 75 percent.

Lessons Learned

Prototype diagnostic logic has been accurate but has been difficult to measure. This is due to the lack of sufficient test cases that can be compared to baseline systems.

Models must be flexible when aircraft configurations differ among the same type: not all aircraft of the same type have similar equipment installed; models should include diagnostics for any essential test equipment; experts often disagree and therefore knowledge base must be easy to update; and lab testing on mockups can never replace actual operational testing.

Validation of diagnostic logic is very difficult. Although faults can be inserted, true validation can only occur after a significant number of random faults occur in the day-to-day operation of the equipment.

Militarized host hardware is only just now emerging and is not yet standardized.

Software standardization and a system for configuration control may be an "Achilles" Heel' for implementation. Since the software can unusually be updated easily, a central location must be maintained to ensure that the fielded software packages are all the same and can run on all types of equipment.

The impact on current training doctrine may be dramatic. Questions regarding MOS consolidation and the degree to which the soldier should be trained to rely solely on these concepts versus conventional concepts must be addressed.

Conclusions

Testing to date has indicated that expert diagnostic systems have the potential to increase the speed and reduce the errors in fault isolation, but the testing is very time consuming. It will take much longer application periods to collect sufficient data to accurately quantify the benefits of expert diagnostic systems. It is clear, however, that expert diagnostic systems are but one example of emerging advanced technologies which have maintenance applications.

Integration of the expert diagnostic systems with the forthcoming fully-electronic maintenance publications and maintenance data collection systems, improved operator interfaces, the Army portable computer unit, the aircraft flight data recorder (or the data, at least) and specialized test equipment appears to be essential to realize the full potential of expert systems and the other emerging technologies.

Further application demonstrations of expert systems must include these technologies on a non-trivial basis so that the impact of these technologies on each other and on Army doctrine can be assessed.

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Contract Awarded for Agent Monitor

One of the largest single-production contracts in the Edgewood area of Aberdeen Proving Ground has been awarded for a chemical agent monitor (CAM) that will provide lightweight detection capability for soldiers in the field.

The $22.2 million contract was awarded to Allied-Signal Inc., Bendix Environmental Systems Division, under license from a United Kingdom firm, Graseby Dynamics (now Graseby Ionics), that developed the CAM in 1982.

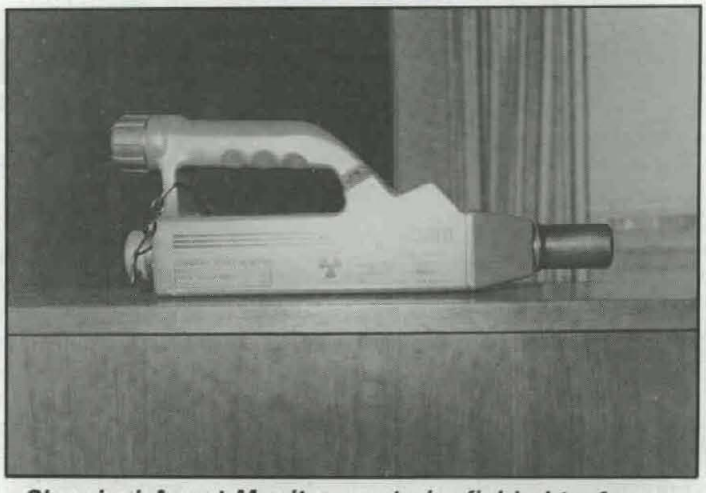
The contract for 3,739 CAMs was signed at the Procurement Directorate of the U.S. Army Armament, Munitions and Chemical Command (AMCCOM).

Participating in the ceremony was BG Peter D. Hidalgo, commander of the U.S. Army Chemical Research, Development and Engineering Center, which specializes in detection of and protection against chemical agents.

The CAM is a hand-held, soldier-operated device used to detect low levels of chemical agent by sensing molecular ions of specific mobilities, and uses timing and microprocessor techniques to reject interferences.

Among its components are a drift tube, signal processor, molecular sieve, membrane assembly, unit assembly and carrying case, which allows soldiers to carry the CAM with both hands free.

About the size and weight of a large flashlight, the monitor will be fielded to the U.S. Army in 1988. It will be produced at the Bendix plant in Towson, MD.



Chemical Agent Monitor . . . to be fielded to Army units in 1988.

The Army Research Office: Matching Basic Research to Army Relevance

By Dr. Robert W. Shaw

The Army Research Office (ARO) has several missions, but is best known for its support of basic scientific research performed in university, national, industrial, and contract research laboratories.

ARO uses scientific quality as a principal criterion in choosing which of many possible projects to fund and, in this respect, it resembles the National Science Foundation (NSF). But the NSF supports a very wide range of activities to provide the basic technology for the progress of society in general, while the ARO program focuses on technology to serve the needs of the soldier. This article will briefly describe how that focus is achieved.

Every year ARO publishes a guide book called the "Broad Agency Announcement." This book describes the research areas that ARO has decided to support. For example, the ARO Physics Division is not interested in supporting research on astrophysics or the theory of relativity — these are not likely to be relevant to the needs of the soldier. But that division does support considerable work on optical physics — highly relevant to target acquisition.

This focus on basic research for Army needs is maintained throughout the ARO contract program. Investigators are encouraged to read the Broad Area Announcement and to discuss prospective research with the ARO scientific staff before submitting a proposal for support.

ARO has about 40 scientific staff in its seven divisions of Chemistry and Biological Sciences, Electronics, Engineering, Geosciences, Mathematics, Materials Science, and Physics. All have earned the Ph.D and, consequently, have personal experience in basic research. In addition, they keep track of current Army technology needs by visiting Army labs and RD&E centers and by reviewing the Army Training and Doctrine Command (TRADOC) mission area deficiencies.

ARO also maintains close communication with the rest of the Army scientific community by having visiting lab associates from the labs and centers work at ARO for periods of six months to a year. The scientific staff is responsible for encouraging the submission of high quality proposals in research areas with implications for Army needs.

When a proposal arrives at ARO, the appropriate scientific staff person reviews it for scientific quality and Army relevance. If the proposal passes this first review, it is sent for peer review to scientists who are experts in the field of the proposal. The proposal is also sent to scientists in Army labs and centers who are most likely to use the results of the proposed research. For example, a proposal on semiconductor devices may be sent for review to scientists at the Electronics Technology and Devices Lab, Harry Diamond Laboratories, and the Center For Night Vision and Electro-optics; one on energetic materials may go to the Ballistic Research Laboratory, Missile Command, Armament RDE Center, and the Belvoir RDE Center. The Army scientists review the proposals for scientific quality and for potential relevance to their Army missions.

All these reviews — outside expert reviews for scientific quality and Army scientist reviews for scientific quality and relevance — are used in the ARO decision to decline or accept the proposal. Competition for research support is severe and ARO has many more proposals of high scientific quality and Army relevance than it can afford to support.

The Army Research Office provides funds for basic research workers outside the Army and it provides a link between them and Army scientists. ARO contractors write semiannual reports on their research progress. These reports are reviewed at ARO and copies are sent to interested research workers at Army labs and centers. Often, an Army lab scientist recognizes a special application for the basic research supported by ARO and arranges for the outside research scientists to work directly on that application with support from the Army lab or center.

The ARO research program benefits the Army in other ways. Scientists supported by ARO frequently visit Army labs and centers for seminars and technical discussions and these outside scientists play prominent roles in workshops where recommendations for Army related research are formulated.

Because of their exposure to Army research and their basic research expertise, these scientists are often invited to review the research programs at Army labs and centers. Graduate students, working on a basic research thesis supported by ARO, often take postdoctoral or permanent positions at Army labs or centers or at ARO.

As stated at the beginning of this article, the two principal criteria for ARO support are high scientific quality and Army relevance. Investigators in the ARO basic research program have won many awards and wide recognition. Among these awards are the Nobel Prizes — the most prestigious honors in science.

In the last 20 years ARO has provided support for work leading to seven Nobel prizes: Charles Townes for the maser and laser, Leo Esaki for electron tunneling in superconductors, Herbert Brown for structures of boron and phosphorus compounds, Nicholas Bloembergen for solid state lasers, William Lipscomb for structure and bonding of borane compounds, Arthur Schawlow for solid state lasers, and John Bardeen for the theory of superconductivity. With continued support of basic research of high quality and high Army relevance, we can expect that these prizes will not be the last.

ROBERT W. SHAW is chief, Chemical Diagnostics and Surface Science Branch, Chemical and Biological Sciences Division, U.S. Army Research Office.

Reliability Centered Maintenance

By James A. Eastwood

Introduction

Reliability centered maintenance (RCM) has received considerable attention in the Army logistics community since its initial introduction in the mid 1970s. It was introduced as the logical discipline for modifying scheduled maintenance programs that would reduce resource requirements and retain or improve the achieved reliability of the equipment.

The program has recently matured from one of just reducing existing scheduled maintenance tasks to one of impacting design, developing scheduled maintenance tasks and intervals, and, through age exploration, provide maintenance tasks, adjustments, and product improvements.

Background

The airline industry, in the late 1960s, was very concerned with the resource requirements of maintaining the wide body aircraft about to enter service. The Air Transport Association organized a study group and under Federal Aviation Agency guidance, established a new concept of scheduled maintenance determinations based on reliability, criticality of failure, time required to correct failure, and the ability to detect impending failure. The result was a procedure and decision logic that dramatically reduced scheduled maintenance costs while maintaining or improving overall achieved reliability and safety.

The Department of Defense (DOD) initiated a program to incorporate these principles into its aircraft program and eventually for all equipment in the DOD inventory. The Army had several programs that covered portions of the overall concept but they were fragmented at best. It was recognized early that the RCM philosophy was a structured approach to the application of maintenance engineering concepts to not only existing equipment and procedures but to the design process. It quickly became an element of logistic support analysis (LSA).

Objectives

Overall objectives of the RCM programs are to:

- establish design priorities which facilitate scheduled maintenance;
- plan scheduled maintenance tasks that will preserve or restore safety and reliability to acceptable levels where equipment/system deterioration can or has occurred;
- provide for design improvements of these items whose inherent reliability and/or ability to restore the inherent reliability proves inadequate; and
- accomplish the above at minimum total costs including maintenance costs and costs/impacts associated with failures.

Program Description

The Army RCM Program can be broken down into four major areas: scheduled maintenance checks and services, depot maintenance overhaul procedures, determination of depot maintenance candidates, and sustaining engineering. The first two elements are concerned with the development of scheduled maintenance procedures at the field and depot level and the interface with the other LSA elements.

During equipment design, decisions on physical characteristics of materials, configurations, and redundancy can dramatically change scheduled maintenance requirements. A complex trade-off analysis to determine the optimum configuration should not only interface with the LSA elements but the total item design including operational parameters.

A detailed procedure and logic has been developed to be used with the LSA program described in MIL-STD-1388-1A, Logistic Support Analysis, and the MIL-STD-1388-2A, DOD Requirements for Logistic Support Analysis Record. This procedure is documented in AMC-P 750-2, Guide to Reliability Centered Maintenance.

The Navy and Air Force have developed RCM procedures for use on aircraft that generally follow the same logic. The Army's procedure has been developed to allow for different equipment types, state-of- the-art status, and reliability requirements. The end result is a scheduled maintenance program including procedures and interval determination that provides an optimum balance between resource requirements and achieved reliability.

The third element, determination of depot maintenance candidates, addresses the need to return major items to depots for overhaul. Not many years ago the concept of depot overhaul was to return major items to a depot for complete reconditioning on a hard-time or fixed interval basis. Based on equipment type, this could be flying hours, mileage, hours, rounds fired, or another similar measure of usage.

Due to the complexity of most major items, components do not have the same time between overhaul wear out rates. The need to return the major item to the depot for overhaul depended not only on the overhaul reliability of the item but also on the level of repair and extent of repair authorized for the various components. This concept forced time between overhaul interval setting to be based on the anticipated overhaul requirement of the weakest items and therefore caused the major items to return to the depot more frequently than necessary. The cost of depot maintenance includes the actual overhaul process and the pipeline of end items to keep units equipped.

Under RCM analysis, a process of equipment evaluation has been established to provide for periodic inspections and evaluations to determine when depot overhaul is required to achieve reliability requirements within support cost parameters. Evaluation cri-

teria developed during the LSA process enhances the overall support and can influence design reliability to minimize these support costs.

In his poem titled "The Deacon's Masterpiece" written in 1858, Oliver Wendell Holmes described an ideal design for depot maintenance:

Have you heard of the wonderful one-hoss shay,
That was built in such a logical way
It ran a hundred years to a day?
It went to pieces all at once,-
All at once, and nothing first
Just as bubbles do when they burst.

Designing all components to fail at the same predicted time would be an ideal situation and was obviously thought of over 100 years ago. With RCM design influence we may be able to approach this concept as other design related technologies are improved. In the meantime we optimize the design and support within our capabilities.

The fourth element, sustaining engineering, addresses the area of age exploration. There are design and support areas where, because of uncertainty, an intensive scheduled maintenance program is required until the equipment is aged and real world experience is available. This information and experience can then be used to set an optimum scheduled maintenance program. Tracking components and end items and obtaining detailed usage information is necessary.

Initiatives in areas of serial number tracking and data recording devices will enhance ability to perform further RCM analysis and scheduled maintenance adjustments. The Air Force has been extremely successful in optimizing scheduled maintenance early in the fielding of new equipment through intensive data collection on critical components and the fleet leader concept.

As the Army moves toward more complex and multi-functional equipment, new concepts and techniques will be required to provide needed information. The philosophy and application of RCM will still follow the basic logic flow analysis.

An RCM logic diagram is contained in AMC-P 750-2. Detailed explanations of each block on the diagram, the analysis process, and interrelationship of elements are contained in that pamphlet. The logic is designed to lead the analyst to effective scheduled maintenance requirements and actions or identify redesign requirements.

Determination of the most effective actions and intervals are shown through techniques also described in the pamphlet.

Summary

The RCM program encompasses and interfaces with many other disciplines and programs. It is in fact nothing more than a logical attempt to assume maintenance engineering efforts include scheduled maintenance considerations during the design process. As other disciplines and techniques such as reliability and prediction life cycle cost estimates, level of repair analysis and design for discard improve, RCM will also improve.

The interrelationship of the individual elements in the LSA process is very strong and the consideration of these elements during design is of paramount importance if we are going to provide equipment that can be supported and stay effective in the field. RCM is one important element of that total effort.

JAMES A. EASTWOOD is chief, Policy and Procedures Section, Maintenance Doctrine Branch, Army Materiel Readiness Support Activity, Lexington, KY. He holds a B.S. degree in aeronautical engineering from Purdue University.

CECOM Tests Automatic Target Recognizer

The Army reports a significant advance in its development of a new generation of night vision equipment with the completion of tests on an automatic target recognizer.

Test director John Farr of the Army Communications-Electronics Command (CECOM) Center for Night Vision and Electro-Optics, Fort Belvoir, VA, said the successful tests produced 14 sets of videotapes of collected imagery. "The data will be used in the development of night vision equipment designed to reduce the pilot's workload and the time it takes to find a target," Farr said.

Tests were conducted with a sensor package mounted on the nose of a helicopter. A video screen inside the aircraft displayed target objects and the heat they emanated. The imagery was recorded on high-resolution videotape.

The objective was to collect continuous 875-line imagery of different types of military targets. Four target types were used — tank, armored personnel carrier, truck and high mobility, multi-wheeled vehicle. More than 70 low-altitude runs were made over two weeks at CECOM's Central Oregon Test and Evaluation Facility.

Using the collected data, engineers will "teach" the automatic target recognizer to detect and classify targets from sensor output. As technology develops, the target recognizer will be able to discriminate among friendly and hostile vehicles and aircraft, prioritize targets and direct fire toward the highest threat target.

Eventually the automatic target recognizer will be mounted on remotely piloted vehicles. With the ability to differentiate between live and spurious enemy warheads, the automatic target recognizer will help drivers of tanks and other land vehicles navigate and lock in on targets.

The imagery collection effort involved the use of a unique night vision system employing a Type 1 utility helicopter with a target acquisition designator system.

An Army UH-1 helicopter was fitted with a nose-mounted support for two high-resolution imaging sensors. The tapes have two audio tracks, one carrying verbal instructions, the other continuous range information from the primary target to the target areas.

The Oregon National Guard provided eight target vehicles and drivers for the tests. Two M60A3 tanks, two M113 armored personnel carriers, two M35 2½-ton trucks and two of the Army's new high mobility, multi-wheeled vehicles were split between the two target areas a little over six miles apart.

Program Managers and TRACE

By COL Gordon W. Arbogast

Introduction

In a recent major study on the "Total Risk Assessing Cost Estimate" (TRACE), 40 major Army projects participated in addressing the question: Has TRACE reduced Army R&D cost overruns and development time? It was shown using mathematical modeling techniques that TRACE was having little effect on reducing cost overruns, but was significant in reducing schedule slippage.

Other variables were identified that were significant in their effect on controlling cost overruns. These included the degree of technological risk, amount of contractor buy-in, as well as the education and experience of the key personnel in the program office. Assisting TRACE in reducing schedule slippage were technological risk and education, as well as testing and the length of R&D contracts.

These study results are significant and have important management implications concerning the future use of R&D risk assessment. The Army has re-emphasized the value of TRACE to the field. Although TRACE is being more selectively employed by program managers, it is clear that risk assessment techniques are here to stay.

Program Manager Involvement

In collecting the data for this study, there was major involvement with the Army's principal program management offices. Data requirements were varied and very demanding. Detailed data on annual cost overruns were required from the middle 1970s to the present. The two best-known documents that contained this type of data are the Selected Acquisition Reports (SARs) and the Cost and Schedule Control Systems Criteria (C/SCSC) reports. However, SARs are not required on every major Army system. Congress mandates that certain systems should be included in the SAR reports for designated periods of time. In addition, not every major Army system employs C/SCSC. For these reasons, as well as security, it was decided to seek primary data directly from the program offices.

In securing this data, an Army R&D acquisition questionnaire was employed. Army program offices were asked to provide historical data on their respective programs from 1976. Included were data from both TRACE and non-TRACE programs. It was also decided to concurrently measure the attitudes of program managers toward TRACE and other related programs. TRACE included both TRACE for R&D (TRACE-R) and TRACE for procurement (TRACE-P). The questions on attitudes constituted Part II to the basic questionnaire that was sent to all program managers.

It is important to note the outstanding cooperation and support from the top levels of the Army in securing the information requested by the questionnaire. The deputy under secretary of the Army for operations research and his staff emphasized the importance of this research to the Army staff and requested support. The assistant deputy for science and technology at the U.S. Army Materiel Command also provided major support by endorsing the questionnaire to the field. This was done via personalized letters to the commanding generals of each major subordinate command. Direct distribution of the questionnaire with a signed cover letter was also made to each major program manager in the Army.

In order to increase the number and quality of returns, follow-up methods were employed. Virtually all program offices were visited in person at least once. Direct channels of communications were established with program managers and key program office personnel. These proved very useful in securing a realistic data set.

Since most of the historical information in the program offices resided with the civilians, most follow-up requests for additional data and clarifications were conducted with the civilian deputy of the program or the head of the program management division. This direct communication proved to be invaluable in terms of the quality of the study. Countless hours were spent clarifying program office responses and ensuring that the data provided were consistent with the information required.

Measuring PM Attitudes

In Part II to the basic questionnaire, program managers attitudes about TRACE and related programs were measured. These attitudes were measured using Likert agree-disagree scales to provide the data on which to conduct statistical analysis. Respondents were asked to respond to a statement with regard to their specific program and the overall viewpoint that existed collectively within their program office. Included for evaluation were such statements as "TRACE-R reduces cost overruns" and "TRACE-P will aid in controlling schedule slip."

The Department of Defense Acquisition Improvement Program had also included a number of other R&D programs and initiatives to reduce cost overruns and aid in controlling schedule slip. These were also included in similar statements to form a basis for comparison with the statements that focused on TRACE. These programs included the Carlucci initiative to encourage contractor capital invest-

ment and Budget-to- Most-likely Cost. Lastly, questions were asked concerning the effectiveness of the Probabilistic Network Model. This is probably the most sophisticated networking model in which to implement TRACE. Several program offices had adopted its use.

In responding to these questions, PMs used the following convention: (1) Strongly Disagree; (2) Disagree; (3) Uncertain; (4) Agree; and (5) Strongly Agree. Program managers would circle the one response that most accurately fit their view on the statement.

TRACE Attitude Results

The average response for all of these questions tended to be around three. In virtually all questions, program managers exhausted the full range of responses from one (strongly disagree) to five (strongly agree). Standard deviations generally clustered around a value of one.

Paired t tests were conducted to measure the statistical differences between the responses for the various programs. For example, a test was conducted to measure if there was a difference in attitude between the perceived effectiveness of TRACE-R and contractor capital investment with regard to reducing cost overruns. There was not a statistical difference between the response for these two programs. The only difference in attitude that existed was between TRACE-R and Budget-to-Most-Likely Cost with regard to the effectiveness in reducing cost overruns.

In order to ensure that the non-TRACE programs were not unduly influencing this data, similar tests were conducted using only data from the TRACE programs. Summary statistics for the data from the 18 TRACE programs were computed, as well as the paired t test results for those programs. The results are almost identical.

Analysis of TRACE Attitude Results

Concerning TRACE attitudes, the following anticipated results were contrasted with the actual results from the program management offices:

- It was anticipated that program managers would agree that TRACE-R is effective in reducing cost overruns. This turned out not to be the case. Program managers tended to be uncertain that TRACE-R is effective, although the standard deviation of this response was larger than any of the 10 responses. It was seen that the average response tended slightly toward the direction of disagreeing.

While many PMs did agree, a like number disagreed. The implication was that PMs tend to be sharply divided on the worth of TRACE-R in controlling cost overruns. It was anticipated that program managers would agree that TRACE-R is effective in controlling slippage. On average, PMs tended to again be uncertain. This time the averages were slightly in the direction of agreement. However, again a large standard deviation was seen to exist. This again indicates a significant split in the way in which PMs view the effectiveness of TRACE-R in controlling schedule slippage.

- It was anticipated that program managers would be uncertain as to the effectiveness of encouraging contractor capital investment in reducing cost-overruns and schedule slippage. On the average, the PMs were again uncertain. The standard deviations were significantly less than what they had been for TRACE-R, indicating that true uncertainty existed in the minds of the PMs on the utility of contractor capital investment.
- Concerning Budget-to-Most-Likely-Cost, it was anticipated that PMs would agree that it is effective in reducing cost overruns, while disagreeing that it is effective in controlling schedule slippages. The data suggests that the PMs tended to view this initiative in the most positive light. PMs tend to agree that Budget-to-Most-Likely Cost is having an effect on both cost overruns and schedule slippages, although it is more pronounced in the case of cost overruns.
- It was anticipated that program managers would agree that TRACE-P is effective in reducing cost overruns and be uncertain about its effect on schedule slippages. On average, PMs tended to be uncertain on both questions. However, the variances were relatively high, indicating again a split in opinion by the various program managers.
- Concerning the Program Networking Model, it was anticipated that PMs would agree that the probabilistic networking approach was best for implementing TRACE, but would disagree that it should be made mandatory. This appeared to be confirmed in the statistics.

The last key issue addressed was the relative effectiveness of the various initiatives in the DOD Acquisition Improvement Program. These could not be measured directly, but were analyzed indirectly using the attitude responses from the questionnaire and subsequent paired t tests on this data.

The results indicate that PMs are perceiving Budget-to-Most- Likely-Cost to be more effective in controlling cost overruns. All other tests indicate that program managers do not perceive any other clear difference between the effectiveness of TRACE-R, TRACE-P, Budget- to-Most-Likely-Cost and contractor capital investment with regard to controlling cost overruns and schedule slippages.

Conclusions

Program managers are sharply divided on the issue as to whether or not TRACE-R is reducing cost overruns. More disagree that TRACE-R is effective than agree. They are also sharply divided on whether or not TRACE-R is controlling schedule slippages. Slightly more agree than disagree that TRACE-R is effective.

In addition, PMs are uncertain as to the effectiveness of contractor capital investment in controlling cost overruns, and schedule slippages.

Program managers tend to moderately agree that Budget-to-Most-Likely Cost is effective in controlling cost overruns, and tend to slightly agree that Budget-to-Most-Likely Cost is effective in controlling cost overruns.

PMs also tend to be divided on whether or not TRACE-P is reducing cost overruns. Slightly more disagreed than agreed that TRACE-P is effective. They also tend to be evenly divided as to whether or not TRACE-P is reducing schedule slips.

Finally, program managers tend to agree that a probabilistic networking approach is the best method for implementing TRACE-R, but tended to disagree that it should be mandatory.

It is obvious that TRACE is not being perceived across the board as a strong program. This is true despite the fact that several program managers who have employed TRACE appear to be totally convinced that TRACE is a vital Army program that has contributed significantly to their program's success.

As a result of this research, the former deputy chief of staff for research, development and acquisition and AMC headquarters sent messages to the field reemphasizing the importance of TRACE

and requesting that program managers support the TRACE concept. The manner in which current and future program managers provide such support will dictate in large measure the future success of risk management in the Army.

COL GORDON W. ARBOGAST is currently a permanent associate professor and acting head of the Department of Engineering at the U.S. Military Academy, West Point, NY. He has a master's degree in both electrical engineering and industrial management from the Georgia Institute of Technology. His Ph.D. is in industrial management from Clemson University.

PLRS Meets Soldiers Needs

"It's a magnificent system," COL Stanley M. Clough said of the Position Location Reporting System (PLRS) that was fielded to the Marine Corps late last year. The system provides tactical forces with three-dimensional positioning information, navigation assistance and coordination of fire or air support.

"Synchronized radio transmissions in a network of users controlled by a master station is the basis of the PLRS," said Clough, project manager, who reports to the program executive officer, communications systems.

Clough got the opportunity to see firsthand just how the system worked while stationed at Fort Lewis, WA, as 9th Signal Battalion commander, 9th Infantry Division, in the early 80s.

"My predecessor came out to Fort Lewis and asked our unit to really use this system and make it work," Clough said.

He had visions of long periods training with the new equipment and not being able to work it, but was told training could be done in a couple of days. "We were given about eight hours of individual training and instruction with the PLRS — and to our surprise we worked it very successfully in the field. The system was deployed with real soldiers when I was there and the soldiers just loved it — the leaders loved it.

The individual carrying the PLRS radio has the capability of asking the system where another PLRS equipped unit is and the system can provide the answer. The system can be asked by the user for directions to a particular user, and the PLRS will give the directions — even if the desired unit moves — that is why this system is nifty, said Clough.

PLRS provides valuable information to both a user and a commander. Users can receive position or location, zone avoidance alerts, and bearing and range to their present locations.

PLRS enables a commander to control his forces as they move rapidly around the battlefield, and it helps the soldier because his superiors always know his exact position via the master station.

The master station, or shelter, houses three computers, a display console and communication equipment. The master station automatically receives positions of individuals in the field, and can quickly coordinate battle points. The master station can also report on the accuracy of data it receives and controls the automatic relay system. Once a user's signal starts to fade, the control station will query the system for a stronger path and then tell the user's radio to switch to that stronger path.

A tank or rifle platoon can quickly locate other friendly units and receive an alert when crossing a dangerous boundary such as that of a minefield. An artillery battery can find a forward observer and position its firing battery. PLRS is a secure system with a low probability of intercept and high resistance to being jammed by unfriendly forces.

A soldier working at the master computer station plotting PLRS users in the field.

"PLRS is a well-engineered system, and it is being fielded as a result of hard work by a lot of good people — it's a joint venture by the Army and the Marine Corps," stated Clough.

The system the Marine Corps received consists of manpack units, test equipment and master stations. The manpack unit, weighing about 23 pounds, includes a very specialized radio called a basic user unit, a hand-held readout device, battery and antenna. Master stations include a radio, and a computer suite, and are self-contained except for prime power. These stations are designed for rapid deployment by air.

"The Marine Corps is primarily looking at the PLRS for quick location for someone in the field. The Army wants to use a modified version to send messages as well as location," Clough states.

While the Marines have been issued PLRS, Army units will not field their enhanced system until 1990. The Army realized that a radio that could transmit a position or a location back to a master station could also carry brief messages. The data carrying capability is now being developed.

ILS Management With the Work Breakdown Structure

By Ewell E. Eubanks

Editor's Note: This is the second installment of a two-part article. The first one appears in the November-December 1987 issue of *Army RD&A Bulletin*.

Background

The purpose of this article is to inform interested Department of Defense (DOD) and industry integrated logistic support managers (ILSM) about some basic concepts and general requirements associated with managing an ILS program utilizing a contractor's approved Performance Measurement System (PMS) and a Work Breakdown Structure (WBS). As discussed in the last article, published in the November-December 1987 issue of *Army RD&A Bulletin*, the WBS defines and organizes the work to be performed, and the resources to perform the work.

Under an approved PMS, the contractor's system provides for a clear definition of the overall contractual effort. Integration of the functional and organizational WBS is required in order to provide for assignment of responsibility for identified work tasks. Additionally, integration of the planning, scheduling, budgeting, work authorization, and cost accumulating subsystems is a key element in an effective control system and timely identification of actual cost and performance against a planned and controlled baseline.

Under this criteria concept, all authorized work is planned, scheduled, budgeted, and authorized within the contractor's system. The establishment of the performance measurement baseline is the key requirement of organization, planning and budgeting.

Costs of completed work must be accumulated from the bottom up, as directly as possible, without need for allocations in summation. To enhance effective organization, planning, budgeting, and accounting, the Contract WBS is very important to the effectiveness of performance measurement, and considerable care should be exercised in its development.

Contract Line Items, especially the logistic effort, should be included as separate WBS elements, and the WBS should be aligned with the Statement of Work (SOW) to the maximum extent possible. These actions will simplify the problems associated with future defining, reporting, and replanning of work.

After work (contract effort) is defined, planned, scheduled, budgeted and accounted for, comparisons of actual versus planned performance are required by this group of criteria elements. Thresholds for variance analyses are established by the government and required at the cost account, and reported on Format 5 of the Cost Performance Report (CPR) to avoid excess effort which would otherwise result from analyzing single variances. It is particularly important that variances be examined in terms of increments or aggregations of work which are large enough to produce significant information to the ILSM. Analyzing individual work package variances, for example, would not be necessary and would not be cost effective.

Inherently, the government has a right to access vendor data. Contractor incorporation of changes authorized by the government and due to internal replanning are dealt with in a formal manner. The ILSM should pay particular attention and place emphasis on the need to retain a meaningful performance measurement baseline for the logistic effort.

Other efforts the ILSM should look at include reconciliation of Estimated Costs at Completion with funds requirement reports and provisions for access to data for system evaluation, Logistic Status Reviews, Logistic Support Analysis Reviews, and other status and program reviews at the work package level.

Identifying Work Packages

As the contract effort is progressively defined through the extension of the WBS, the work breaks into different types of effort. Much is discrete in nature and when completed reflects a finite end result in the form of a completed product, analysis, record, or part of hardware. The beginning and ending of the discrete task is relatively easy to define and can be formally scheduled in terms of physical accomplishment as well as calendar dates. The Logistic Support Analysis (LSA) would be a discrete measurable work package effort.

In addition to work packages, considerable activity exists which is more general or supportive in nature, called Level-of-Effort (LOE). Program management is an example of the type of activity normally treated as LOE. Since LOE does not lend itself to discrete measurement of accomplishment, it must be limited in amount and segregated from the measurable effort, at least until one discrete evaluation of the measurable logistic effort has occurred. Only effort (logistic) which cannot be discretely packaged or apportioned to work packages may be LOE.

Apportioned effort (quality assurance, management, testing), sometimes factored effort, may be discrete in nature, but its accomplishment is directly in relation to the performance of other work (i.e., inspection, testing, etc.). Most inspection and test functions are apportioned effort. Most logistic efforts are not apportioned effort or LOE, but discrete.

Apportioned effort may be included in the work package to which it is related, or be work packaged independently with assigned budgets based on a proportion of the budget applicable to the discrete effort to which it pertains. This application is preferred where separate performance measurement of an

organization element (like QA, quality control or test) is desired.

Hence, if the ILSM wants to determine if the LSA effort will impact design, its work packages and schedules must be reviewed. In the review it should be determined that this logistic effort is a discrete and measurable effort, that it is performed early enough to influence the design and that the analyses are in fact provided as input to the design effort.

Subsystem Integration

The ILSM must ensure that the contractor's PMS provides for proper subsystem integration of the logistic effort. This is the only way to assure that the "I" has been incorporated into the ILS effort.

Besides the WBS and organizational structure, contractors have formal subsystems for scheduling, budgeting, accounting (for), authorizing work and collecting costs. Because a change in one of these areas impacts on one or more of the others, it is important that these subsystems be integrated with each other. Automatic integration usually exists at one or more points in the contractors system. For example, the contract itself normally identifies the logistic effort to be performed, the organization responsible, the negotiated cost and schedules, and the authority to proceed. In most vendors systems, these same elements also exist at the lowest level. In other words, a job assignment (work package) should describe the task to be performed, identify the organization or individual responsible, authorize the expenditure of resources, and identify budget and schedule constraints.

Under scheduling, one should be able to track the output of this work package and verify it as input into another work package, and that package to another and so on, until it is a completed product. This is what is meant by integration of subsystems as it is referred to in this context.

As mentioned previously, the integration of the organizational structure and WBS frequently results in a key intersection or management control point (typically Level 3 of the WBS). This point is often selected for establishment of the cost control account or "Cost Account (CA)." The integration of the subsystem described above should always exist at the cost account level since performance is normally managed at this level based on information obtained from the work packages, which make up this cost account. In addition, the CA may be the lowest level in the system where actual costs are collected for performance measurement purposes.

For logistics surveillance purposes, the cost account is the level at which the ILSM should conduct logistic reviews and the level at which the ILSM should ascertain the actual cost of the logistic effort.

Key Management Control Point

The requirements for systems integration, reportable data and costs collection, assignment and management responsibility and (CPR, work package, CA) variance analysis require a tightly knit and highly structured internal control system. Its effectiveness in operation depends to a great extent on the discipline employed within the individual subsystems.

One element of the system stands out as the most significant from a management point of view. The cost account is the main action point for planning and control of contractual logistic effort. Virtually all aspects of the system come together at the cost account including budgets, schedules, work assignments, cost collection, progress (or lack of progress) assessment, problems identification and corrective actions. Day-to-day management is accomplished at the cost account level. Most management actions taken at higher levels are on an exception basis in an effort to solve the significant problems.

For these reasons, the WBS and functional levels selected for establishment of cost accounts should be carefully considered by the contractor and reviewed by the ILSM at the outset of a new contract. This will ensure that the work will be properly defined into manageable units and that functional responsibilities are clearly and reasonably established. The quality and amount of visibility available to a ILSM during the performance of the contract and the logistic effort will be directly related to the level and make-up of the cost accounts.

Accounting

The accounting effort is primarily required so a contractor can accumulate all direct costs in cost accounts and summarize them, as directly as possible, to the contract level. Cost accumulation, by logistic WBS element, or by organizational element is facilitated by the WBS organizational structure integration which exists at the cost account level.

Contractor's accounting systems are subject to continual scrutiny by the Defense Contract Audit Agency, and public law requirements. Therefore, an ILSM can place reliance in this specific area for accurate and timely logistic cost and performance data. Very simple reconciliations can be made to verify the summary level reports. For example, the Contract Funding Status Report can be reconciled with the Estimate to Complete and Cost at Completion, Estimated Costs at Completion reported on the CPR, and Cost Information Report — all useful tools for the ILSM.

Reportable Data

As with the collection of actual cost, summarization of all data elements is possible by WBS element and organizational unit(s). This capability permits the ILSM to evaluate progress in terms of both contract performance and organizational performance. There should be no need for a separate contract performance assessment to be made at levels above the cost account since the WBS and organizational structure facilitate the summarization of data for successively higher levels of management.

For the ILSM use, the DOD CPR is designed to accommodate this information at the summary level, usually at Level 3 of the WBS (but may be extended to a level below) and at the total contract level for major functional areas. The CPR is a direct output of the contractor's internal data reporting mechanism, resulting in a format that is useful for both contractor and government ILSM.

Since data elements and associated variances can be progressively summarized by WBS and organizational element, traceability of data is inherent in this system approach to management. Although many variances will be "washed out" in the accumulation of both favorable and unfavorable variances during summarization, significant variances will appear at summary levels. It is a relatively simple matter to trace these variances to their source through either the WBS or the organizational structure.

In most cases, problems causing significant variances are already known to the ILSM through other formal or informal reporting systems and corrective actions may already be taken. But the CPR accurately depicts the cost impact of the problem within the logistic area. This information may be difficult to ascertain otherwise.

Occasionally, the CPR will identify a cost problem previously unknown to top level managers, but this is the exception rather than the rule. However, in this day and time of a tightly budgeted program, large numbers of small unfavorable logistic variances may be adding up to major cost or supportability problems. This could significantly impact the ILS effort and support issues. In such situations, this disciplined, formally structured management system approach to ILS management is required to show the true cost and performance status on a systematic, routine basis.

EWELL EUBANKS is a senior action officer in the Policy and Procedures Section, ILS Branch, Readiness Division of the Army Materiel Command's Materiel Readiness Support Activity. He holds a B.A. in industrial technology and business administration and co-chairs the SPG-ILS Work Group for Multiservice ILS Management and Acquisition.

MTL Employees Receive Patents

Blazing new paths along scientific frontiers is one important aspect of engineering. Removing impediments that hamper the functioning of equipment is another. The common denominator is efficiency: finding more effective ways of doing what needs to be done.

The two most recent patents received by engineers at the U.S. Army Materials Technology Laboratory (MTL) in Watertown, MA, can be classified and divided along the preceding lines — then brought together again by the need for efficiency.

MTL engineer Paul Cavallaro responded to a direct and immediate problem when he designed the connector for which he was recently awarded a patent.

Dr. Donald Messier, a researcher in MTL's Ceramic Research Division, was conducting leading-edge, experimental materials research when he, with the aid of other MTL researchers, developed a process for making nitrogen-enriched glass fibers.

One of the Army's major goals is "lightening the force." This is an efficiency-based program that is designed to provide our soldiers with lighter equipment and defense systems, which will increase manageability while retaining or increasing strength and effectiveness. The two new patents evolved from this effort and thus are a part of MTL's overall commitment to this Army goal.

While a student working in MTL's Mechanics and Structural Integrity Laboratory, Cavallaro became involved in the Tent, Extendable, Modular Personnel tent-frame project. This project basically sought to replace the traditional aluminum tubing, that the tent frame was comprised of, with a lighter composite material.

MTL first constructed the composite tent frame in 1980, the goal being, according to Cavallaro, "to develop a lightweight frame that wouldn't cost very much, but would be equally strong."

A major problem MTL engineers encountered was that pressure applied to the tent's connecting rods often caused the joints to bend. "Joints are always the big problem with composites," said Cavallaro.

According to Cavallaro, his design "prevents joint damage and facilitates ease of assembly." His connector is free to turn, rotate and bend, as well as to be pulled or pushed on. Through all this, the lock remains secure, and none of the bending tension is transferred to the joint. His device is also far less susceptible to damage, which earlier connectors often suffered due to the force of heavy weights, such as snow.

It is very difficult, in fact, for environmental factors to negatively affect this connector because it is virtually impossible for dirt and ice to enter the locking mechanism, which revolves around two tiny cylindrical pins.

While Cavallaro's invention helped perfect a new, lightweight composite product, Messier's may not see life in an actual piece of equipment or weapon system for some years. Equally important but often unappreciated, this type of basic materials research is the real backbone behind the effort to lighten the force.

The Army recognized the importance, however. In 1985, Messier and former MTL researcher Eileen DeGuire were awarded an Army R&D Achievement Award in recognition of the development of the process for which a patent has now been awarded.

Glasses containing nitrogen were first developed in the mid-1970s and were found to possess increased hardness, stiffness and strength, as well as being far more resistant to corrosion. "There were really very few options left for changing glass," Messier said. "Just about everything else had been tried."

Although it had been known for years that nitrogen-enriched glasses held several advantages over traditional oxygen-based glasses, Messier was the first to demonstrate that such glasses could be made into fibers that would retain all of those benefits. Such fibers are then used as reinforcements in composites, which will eventually enter into various end-user applications.

All of the potential applications of Messier's oxy-nitride glass fibers are not yet known. Messier said that there is a possibility that these fibers could be used in aircraft and missile radomes, which are the protective shields for sensitive radar equipment. Whether in radomes or some other piece of equipment, though, Messier believes the first applications of this strong, ceramic material will be military.

He admits that the fibers weren't very good at first. Also, at the time the patent application was first filed, only short strands of the fiber could be produced. Messier, with the aid of MTL technician Ron Rich and Rob Gleisner, an engineer from Geo-Centers Inc., has continually improved the process and is now able to produce continuous strands of the fiber, which is flexible and nearly as fine as human hair.

A couple of major companies have already expressed an interest in developing the technology, which, if marketed commercially, would require licensing the patent, with royalties to be paid to both MTL and the scientists who developed the process. Messier cited the possibility of a joint venture between MTL and private industry as another potential option for developing the process.

The preceding article was written by Chuck Paone, a public affairs specialist at the U.S. Army Materials Technology Laboratory.

Career Development Update . . .

From the FA 51 Proponent Office. . .

Student Research Topics

In response to requests for FA 51 student research topics, MAJ Harvey Jones at the Army Materials Technology Laboratory (MTL) has provided descriptions of MTL's research interests. Students desiring copies of this information for use in developing thesis topics, or who have further questions, should contact the FA 51 Proponent Office.

Ideally, we would like to be able to provide a consolidated listing of topics from many different sources, so we still need more input. Organizations with research and development, test and evaluation related interests in the engineering, sciences, business, or social sciences could benefit by utilizing FA 51 students currently working on master's and doctorate degrees to research topics of interest. The FA 51 Proponent Office may be reached at AV 284-8537/38 or commercial (202) 274-8537/38. The address is HQ, AMC, ATTN: AMCDE-O (CPT Forsyth/Ms. Green), 5001 Eisenhower, Ave., Alexandria, VA 22333- 0001.

Training With Industry

The FA 51 Proponent Office is currently in the process of matching utilization positions with defense industries for use in the 1988/89 Research and Development (R&D) Training with Industry (TWI) Program. Officers interested in applying for the Training with Industry Program should have their completed DA Form 1618-R application (Detail as Student Office In a Civilian Educational Institution on Training With Industry Program) completed and sent to their Branch Professional Development Officer.

The R&D TWI Program is designed to train a nucleus of officers in high level managerial techniques, industrial procedures, and practices not available through military or civilian schools. Officers get real life, hands-on training in program management as accomplished in major defense industries. During their year with industry, officers encounter successes and problems in management of major defense systems. Officers immediately utilize their training through utilization in R&D/T&E positions in Program Management Offices and other acquisition related organizations. Contact the FA 51 Proponent Office for further information on the R&D TWI Program.

Defense Systems Management College Courses

The following is a partial listing of Defense Systems Management College courses offered during FY88. Those courses with an "R" after the course number indicate regional offerings at the stated locations. For information about courses call the Registrar's Office on AV 354-1078 or commercial (703) 664-1078.

Basics Of Defense Acquisition

COURSE NO.	BEGINS	ENDS	LOCATION
88-3R	Feb 29	Apr 8	Huntsville
88-4	Apr 25	Jun 3	
88-5R	May 31	Jul 8	Boston
88-6	Aug 8	Sep 16	
88-7R	Sep 19	Oct 28	Los Angeles

Contract Finance For Program Managers

88-3	Jan 25	Jan 29	
88-4R	Jun 6	Jun 10	St. Louis
88-5R	Jun 27	Jul 1	Huntsville
88-6	Aug 15	Aug 19	

Contract Management For Program Managers

88-3R	Feb 22	Feb 26	Los Angeles
88-4R	Apr 11	Apr 15	St Louis
88-5	Jun 6	Jun 10	
88-6R	Jul 25	Jul 29	Boston
88-7R	Sep 12	Sep 16	Huntsville

Contractor Performance Measurement

88-5R	Feb 8	Feb 12	Huntsville
88-6	Feb 29	Mar 4	
88-7R	Mar 14	Mar 18	St. Louis
88-8R	Mar 28	Apr 1	Boston
88-9R	May 16	May 20	Los Angeles
88-10	Jun 6	Jun 10	
88-11R	Jun 13	Jun 17	Huntsville
88-12R	Jun 27	Jul 1	St. Louis
88-13	Jul 11	Jul 15	
88-14R	Sep 12	Sep 16	Los Angeles
88-15	Sep 19	Sep 23	

Defense Manufacturing Management

88-3	Apr 4	Apr 8
88-4	Jul 18	Jul 22

Executive Management

88-2	Aug 8	Aug 26

Executive Refresher

88-2	Mar 14	Mar 25
88-3	Jun 6	Jun 17

Fundamentals Of Systems Acquisition Management

88-2R	Feb 1	Feb 5	Huntsville
88-3	Feb 22	Feb 26	
88-4R	Feb 29	Mar 4	Los Angeles
88-5R	Apr 25	Apr 29	St. Louis
88-6	May 9	May 13	
88-7R	May 23	May 27	Boston
88-8R	Jun 13	Jun 17	St. Louis
88-9R	Aug 22	Aug 26	Huntsville
88-10	Sep 12	Sep 16	
88-11R	Sep 19	Sep 23	Boston

Management Of Acquisition Logistics

88-3R	Jan 25	Jan 29	St. Louis
88-4	Mar 14	Mar 18	
88-5R	Apr 25	Apr 29	Boston
88-6R	May 23	May 27	Los Angeles
88-7	Jun 27	Jul 1	
88-8R	Jul 11	Jul 15	Huntsville

Management Of Software Acquisition

88-2	Mar 7	Mar 11
88-3	Jun 13	Jun 17
88-4	Sep 12	Sep 16

Multinational Program Management

88-3	Feb 22	Mar 4	
88-4R	Apr 18	Apr 22	Huntsville
88-5	May 16	May 20	
88-6R	Jul 18	Jul 22	London
88-7	Aug 15	Aug 26	

Program Management

88-1	Feb 22	May 27
88-2	Jun 6	Sep 9
88-3	Sep 19	Dec 23

Program Managers Briefing

88-5R	Mar 7	Mar 11	Boston
88-6	Mar 21	Mar 25	
88-7R	Mar 28	Apr 1	Los Angeles
88-8R	May 16	May 20	Huntsville
88-9R	Jun 27	Jul 1	Los Angeles
88-10R	Jul 11	Jul 15	St. Louis
88-11R	Sep 26	Sep 30	St. Louis

Systems Acquisition Funds Management

88-3R	Feb 22	Feb 26	St. Louis
88-4R	Mar 21	Mar 25	Crystal City
88-5	Apr 11	Apr 15	
88-6R	Jun 6	Jun 10	Los Angeles
88-7	Jul 25	Jul 29	
88-8R	Sep 12	Sep 16	Boston

Systems Acquisition Management For General/Flag Officers

88-2	Apr 25	Apr 29
88-3	Sep 12	Sep 16

Systems Engineering Management

PILOT	Jul 25	Jul 29

Technical Managers Advanced Workshop

88-2	Jun 6	Jun 10

Test And Evaluation Management

88-2R	Feb 29	Mar 4	St. Louis
88-3R	Mar 21	Mar 25	Los Angeles
88-4R	Apr 11	Apr 15	Huntsville
88-5R	May 2	May 6	Boston
88-6R	Jun 20	Jun 24	Los Angeles
88-7R	Aug 8	Aug 12	Huntsville
88-8R	Aug 29	Sep 2	St. Louis
88-9R	Sep 26	Sep 30	Boston

Materiel Acquisition Management

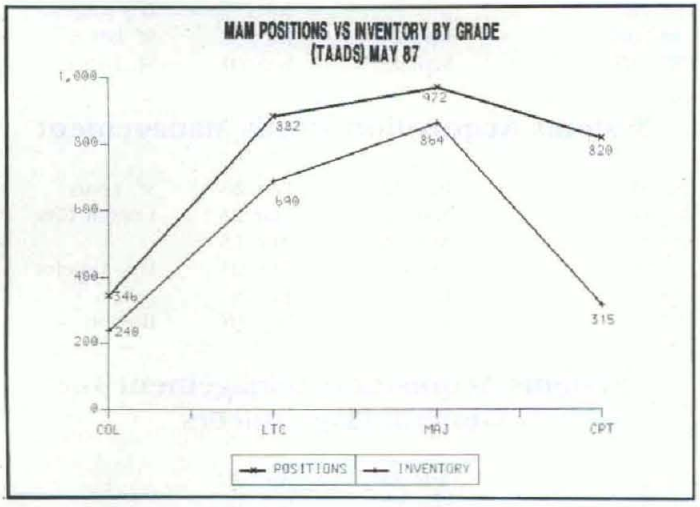
The Materiel Acquisition Management (MAM) Program was begun in 1983 to insure the Army produced superior, better qualified officers to perform and manage the materiel acquisition process through a deliberate blending of education, training, and developmental assignments.

The MAM Program can result in a single career path which will allow officers to serve most of their career in acquisition management, after having been branch qualified.

MAM is open to all commissioned officers in the Officer Personnel Management System. Officers requesting entry into the program must possess or obtain an acquisition specialty, and have at least six years remaining in service. Detailed requirements are outlined in DA PAM 600-3, Chapter 101.

Currently, the Army has over 3,000 MAM positions. To date, over 2,000 officers have been accepted into the MAM Program. Because acquisition management is a demanding and selfless calling, it is necessary to reward outstanding performers consistent with other career paths. Certification provides recognition that officers are professionals and demonstrate the potential to assume greater levels of responsibility associated with selection as a product/program manager.

In November 1986, the certification board selected 86 officers as certified materiel acquisition managers. Recent promotion trends, and the civilian education levels of MAM officers indicate that the MAM program attracts and retains quality officers.



PROMOTION TRENDS (FIRST TIME CONSIDERED)

COLONEL	6T	ARMY AVERAGE
1987	**49.6**	**45.0**
1986	71.1	51.3
1985	61.7	53.4
1984	71.4	48.9
1983	60.9	44.6

COL-BG	
FY 85	8
FY 86	3
FY 87	7

LTC	6T	ARMY AVERAGE
1987	81.4	69.5
1986	NO	BOARD
1985	94.8	76.4
1984	91.3	70.9
1983	86.4	71.7

8 OF 25 (32%) COL
7 OF 95 (7.4%) LTC
EARLY PROMOTIONS (LAST BD) WERE MAM

Contracting Career Programs Transferred

On Oct. 1, 1987 MG Harry G. Karegeannes, Army director for contracting in the Office of the Assistant Secretary of the Army for Research, Development and Acquisition, assumed proponency responsibility for the Contracting and Industrial Management Officer (FA 97) and civilian (GS-1100 Series) Contracting and Acquisition career programs.

Headquarters, U.S. Army Materiel Command, which formerly had proponent responsibility, will retain the Training With Industry and Defense Contract Audit Agency training programs until further notice.

The FA 97 program has approximately 1,641 Army officers between the grades of 0-3 and 0-6. The GS-1100 Series has approximately 9,757 civilians.

The contracting career program is an integrated set of functions which promote the professional health of the procurement work force. Major responsibilities of the proponent include professional development, training requirements, educational programs, career counseling and guidance, and public relations. In addition, the proponent provides coordination with the Total Army Personnel Agency (formerly CIVPERCEN and MILPERCEN) on career program qualifications and standards and makes policy recommendations to the Office of the Deputy Chief of Staff for Personnel on the structure and distribution of the FA 97 inventory.

One of the initial objectives of the new proponency office is to form an FA 97 Army Proponency Policy Coordination Board, comprised of senior major command FA 97 personnel, which will meet periodically to provide field input. The Department of the Army point of contact is COL A. Greenhouse, (703) 756-2782 or AV 289-2782.

Executive's Corner . . .

Operations Research Career Program Developments

By Marie B. Acton

Introduction

In May 1985, the Operations Research (OR) Career Program was established as a subprogram to the Engineers and Scientists, Non- construction (E&S, N-C) career field with the deputy for management and analysis, U.S. Army Materiel Command, as the functional proponent.

We have made considerable progress in developing the program as the result of a two part Master Training Plan. The first part — a Master Intern Training Plan (MITP) — applies to interns, while the second part — the Training and Development Plan (TDP) — is designed for intermediate through executive careerists.

Intern Training Plan

The Master Intern Training Plan was approved and published in December 1986 and provides standardized Army-wide guidance for the training and development of all operations research analyst interns in the E&S (N-C) Career Program.

The intern plan also provides a list of prescribed formal training required for each phase of the intern program. Operations Research Systems Analysis Military Applications Course I (ORSA MAC I) is the cornerstone of classroom training.

As a recruitment incentive, accelerated promotion is authorized for interns entering at either the GS-05 or GS-07 level. It is a one- time exception to the time in grade requirement which allows the GS-05 or 07 entry level intern to be promoted to the next higher grade at the end of six months with satisfactory performance.

Training and Development Plan

Unlike most other career ladders which focus exclusively on management as the only option for career progression, the TDP for intermediate through executive careerists contains a dual track career progression for those wishing to concentrate on technical expertise as well as the generalist who wants to become a manager.

Army-wide staffing of the TDP has been completed with publication by the U.S. Total Army Personnel Agency (formerly the Civilian Personnel Center and Military Personnel Center) expected by the time this article is published.

Army ORSA Fellowship

In addition to developmental options spelled out by the Master Training Plan, the Army ORSA Fellowship Program represents an outstanding opportunity for individual career development. Begun in 1985 as a test, the fellowship consists of four 6-month developmental assignments designed to provide participants with exposure to Army decision makers as well as experience with new OR methodologies and techniques.

The FY 87 fellowships are with the Office of the Deputy Under Secretary of the Army (Operations Research); HQ U.S. Army Training and Doctrine Command; HQ Department of the Army Program Analysis and Evaluation Directorate; and the Office of the Deputy Chief of Staff for Operations and Plans. An announcement for the FY 88 program is expected in the January 1988 timeframe.

Expansion of ORSA MAC I and II

Prior to FY 87, civilians were only allowed to attend the 13-week ORSA MAC I, taught by the Army Logistics

OR Career Program Information

The following points of contact can provide Operations Research Career Program information. All are located at HQ, Army Materiel Command.

Army OR Fellowships:
Mike Okin (AMCPE-CC-T) AUTOVON 284-8518 or commercial (202) 274-8518.

ORSA Net:
MAJ Dennis Sexton (AMCDMA-MA) AUTOVON 284-9099 or commercial (202) 274-9099.

AMCADS:
Ruth Shannon (AMCPE-CC) AUTOVON 284-8508 or commercial (202) 274-8508.

Management Center, Fort Lee, VA, on a space available basis. The primary focus of the course was on the training of military officers prior to their assignment as Functional Area 49s (skill code identifying operations research systems analysis).

Beginning in FY 87, the ORSA MAC I course was expanded to include a minimum of six reserved spaces per class for civilians, with priority given to operations research interns who are required to complete the course as part of the formal training prescribed by the Master Intern Training Plan.

The response to the expansion of ORSA MAC I has been outstanding with both interns and some intermediate (grade 11 and 12) careerists filling the allotted spaces. Due to this high level of interest in formal training, a minimum of 10 civilian spaces per class has been set aside for grade 12-14 careerists in ORSA MAC II, also taught by the Army Logistics Management Center. This is a 2-week course designed to provide a refresher in OR techniques and methodologies to higher grade analysts.

Communications

A key to the success of the career program is good communications with the operations research careerists. We have no institutionalized means of reaching each individual careerist since current population data bases do not track mailing addresses for civilians. We hope to overcome this by encouraging each ORA to register in the AMC Announcement Distribution System (AMCADS). This is an Army-wide job announcement distribution system which mails job announcements to those who have registered for a particular career program and geographic location.

For Series 1515s in the E&S (N-C) Career Program, it is mandatory that all Grade 12 and above job vacancies be announced through AMCADS as an additional recruitment source.

OR careerists who have registered in AMCADS will also receive periodic career program updates, surveys, and other items of interest. The career program update is provided approximately three times per year. The latest issue (April 1987) was distributed using the AMCADS mailing address system. We have also established an Army-wide network of career program points of contact and an electronic message/bulletin board, ORSA Net, which are designed to provide career program information to careerists.

Future Actions

Although much has been accomplished during the past 30 months, there are many challenges awaiting us in achieving Army analytical excellence. The participation of the individual careerist is the key to past and future achievements. Some future actions are as follows:

- proposed Army sponsored federal-wide study of Series 1515 classification standards;
- a mentor network of senior level OR careerists;
- publication of a guide to military familiarization for civilian careerists (greening); and
- further work in identifying the status of operations research positions (TDA review).

MARIE B. ACTON is deputy for management and analysis, HQ, U.S. Army Materiel Command. In May 1985, she was appointed as the Army functional proponent for the Operations Research subprogram to the Engineers and Scientists, Non-construction Career Program.

Senior Acquisition Manager's Course

During the period Oct. 19-23, 1987, the Defense Systems Management College (DSMC) hosted the first executive workshop in acquisition management at the request of GEN Louis C. Wagner Jr, commanding general, U.S. Army Materiel Command (AMC) and General Maxwell R. Thurman, commanding general, U.S. Army Training and Doctrine Command (TRADOC). The Senior Acquisition Manager's (SAM) Course was a great success due largely to the composition of the student body and the quality of the speakers and panel members made up of senior representatives from DA, AMC, TRADOC, and the private sector. Students were able to get a candid insight into the relationships between the Army, industry, and Congress from frank discussions between representatives of each group.

As a result of these discussions, several important issues were raised that will be addressed by action plans developed by AMC and TRADOC. These plans will be developed in concert with issues of mutual concern. A brief synopsis of these issues follows.

- The Army must establish an attractive, viable career field for combat and materiel developers.

- Both AMC and TRADOC (and other developmental commands) must define the word acquisition and the associated responsibilities. A common term of reference is required.

- The Army has yet to provide the acquisition community labor force with adequate funding for the number, grade, and skills of personnel required.

- The acquisition policy/doctrine which guides the U.S. Army requires updating to coincide with the new acquisition process. Also, there is no definitive set of instructions or policy which guides and integrates the efforts of the combat and materiel developers.

- Organizational and Operational plans, Required Operational Capability documents and Cost Operational Effective Analyses are written at too low a level in TRADOC schools. They are written by subject matter experts, generally captains and majors, without sufficient front end guidance from commandants. Commandants must become personally involved in their preparation and must work each throughout a system's development.

- There must be only one user, and hence, only one requirement for the Army. We send confusing signals to industry, and industry plays various users and developers against each other to the detriment of all concerned.

- The industry-Army team suffers from a perceived lack of full support from the Army. This is seen in changing requirements and instability in funding profiles.

- In defining requirements, we frequently use military standards and specifications drawn from manuals without fully checking their applicability or consequence of use.

- Linkages between the combat and materiel developer must be clear.

- The SAM course should be modified to include Congressional staffers on panels and other improvements to the material used during the course.

- Attendees at the course are central to its success. Those commands who participate in the acquisition process must send senior personnel to the course.

As a result of this course and the open interchange of ideas that took place, it is clear that guidance, parameters, and standards must be established by senior leaders and they must use these in supporting acquisition efforts continuously.

It is also clear that DA and OSD must be supportive from the outset with ideas, guidance, issues, and concerns from senior levels within DOD and DA being surfaced during the early stages of requirements determination and development.

The Army must put more resources of all kinds (manpower, money, and time) in the earliest phases of development and a well structured testing plan must also be in place from the beginning, and followed. In short, a central lesson learned was that for an acquisition to be successful, front end planning and execution is just as important, if not more so, than production and fielding and action plans must reflect this fact.

It is hoped that future Senior Acquisition Manager's Courses will continue to provide a forum for the type of open exchanges that took place during this initial session and lead to further improvements in the Army acquisition process.

From the Field . . .

TACOM/NSF Help Establish Research Center

The Tank-Automotive Command (TACOM) has joined with the National Science Foundation (NSF) to establish the NSF-TACOM Industry/University Cooperative Research Center for Simulation and Design Optimization. The center, proposed by the University of Iowa, will be part of the University's College of Engineering in Iowa City.

Objectives are to develop an inter-disciplinary software system to advance selected technologies and to exploit commercial software and computer graphics. Twenty leading industrial firms and five other government agencies have joined as charter members. Another 10 to 20 participants are needed before the program can become fully operational.

There is a $40,000 annual membership fee for a 3-year period in order to participate as a member of the research center. Membership provides a seat on the advisory board and enables members to use all simulation and design optimization software and research results. This initiative with NSF is TACOM's commitment to exploit supercomputer technology and commence a new way of doing military vehicle research and development.

Conferences & Symposia . . .

MICOM Co-hosts Shock and Vibration Symposium

Key issues related to shock and vibration technology were addressed late last year during the 58th Shock and Vibration Symposium held in Huntsville, AL.

Co-hosted by the National Aeronautics and Space Administration's George C. Marshall Space Flight Center and the U.S. Army Missile Command, the three-day symposium was attended by nearly 400 engineers and scientists from numerous Department of Defense and other U.S. government agencies, and from industry and academia. The conference theme was "New Horizons in Dynamics."

Dr. James C. Blair, deputy director of the Structures and Dynamics Laboratory at the Marshall Space Flight Center provided the keynote address on the "Challenges in Structures and Dynamics."

Other formal presentations included "Challenges in Large Scale Space Structures," "The Impact of Air Force Advanced Systems Concepts on Structural Dynamics Technology," "Vibration and Shock Problems in Kinetic Energy Weapons Development," and "A Commanding Officer's Perspective of Ship Shock Trials."

Specific topics addressed during 12 technical sessions of the symposium included mechanical shock, dynamic analysis, dynamic testing, space shuttle vibration, isolation and damping, analytical methods, ship shock and ground shock.

Smoke/Obscurants Symposium Announced

Smoke/Obscurants Symposium XII will be held at the Kossiakoff Conference and Education Center at Johns Hopkins University, Laurel, MD, on April 19-21, 1988.

Sponsored by the program manager for smoke/obscurants, the 12th annual symposium will be devoted to the theme "Obscurants on the Modern Battlefield." The symposium brings together materiel developers, combat developers, and end users of smoke and electro-magnetic systems to discuss new concepts, developments, and interactive assessments of system performance in realistic battlefield environments.

Topics considered for discussion at this year's meeting are: Smoke Materials, Smoke Effects on Electro-Optical Systems, Natural Obscurants, Operational Uses of Smokes/Obscurants, and Effects of Smokes/Obscurants on Health or the Environment.

Members of the Department of Defense, industry, academia, and personnel from allied nations are invited to attend. For more information, contact COL Francis M. Durel, Project Manager, Smoke/Obscurants, Aberdeen Proving Ground, MD 21005-5001, Autovon: 298- 2804 or commercial (301) 278-2804.

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- *Interview With GEN Louis C. Wagner, Jr.*
- *Dispelling the Myths of Test and Evaluation*
- *High Temperature Superconductors*
- *Concept Based Requirement System*
- *Computerized Monitoring of Subsistence Quality*
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