ARMY R,D&A

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BALLISTIC
MISSILE
DEFENSE

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ABOUT THE COVER:

The front cover photograph, which is related to a feature story on the Army's contribution to the Strategic Defense Initiative, shows a flight experiment in the Radar Homing Intercept Technology program at White Sands Missile Range, NM. The flight vehicle is steered by more than 100 small solid-state rocket motors arrayed around its forebody. Shown on the back cover is an artist's concept symbolizing a major new initiative to tighten the link between Army R&D laboratories and operational forces. Cover designed by Patricia Warren, HQ AMC Graphics Section.

FEATURES

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The Army's Contribution to SDI

By Edward Vaughn and Jerry Berg

Many people were surprised—doubly surprised in fact—in June 1984, when a dummy intercontinental ballistic missile (ICBM) warhead was destroyed over the Pacific. First, they were surprised to find that President Reagan's vision of non-nuclear defenses that might someday render strategic nuclear missiles obsolete already has some demonstrable basis in reality. Second, many were also surprised to discover that the feat was accomplished by the U.S. Army.

There may be additional surprises for outside observers, because the remainder of the 1980s promises still more exciting accomplishments for those within the Ballistic Missile Defense (BMD) Organization—the Army's only activity in the field of strategic weapons technology. After a year of transition and program realignment, a new chapter has begun in the BMD program's history.

In the next few years, several key projects initiated during the transition will be producing major contributions to the Strategic Defense Initiative (SDI), the Department of Defense research program directed by LTG James A. Abrahamson, USAF.

How does the Army BMD program fit into the Strategic Defense Initiative? This article attempts to answer that question.

Most coverage of the SDI in the popular press, referring to it as the "Star Wars Program," has encouraged two erroneous ideas: that the program came into being overnight, without precedent or lineage; and that the program envisions space as its exclusive base and theater of operations.

In reality, the SDI has a rich ancestry. Essentially all the SDI technologies were already being pursued by the Army, Air Force, Navy and other DOD agencies and federal departments well before SDI's 1983 "birth." Moreover, the Army's efforts in ground-based BMD, under way since 1955, provide some of the SDI's primary foundations. Highlights of those three decades include:

- The Nike Zeus system achieved what was probably the world's first intercept of an ICBM in 1962, but was not deployed because the Soviet threat was becoming more sophisticated even then.
- The Nike-X project achieved breakthroughs in electronically-steered, multiple-function radars; high speed, high capacity data processing; and high acceleration interceptor missiles which were needed to cope with the increasing threat. (Nike-X components selected in 1967 for deployment as the Sentinel system to defend the nation's urban/industrial areas were reoriented in 1969 to "safeguard" U.S. Minuteman ICBMs.)
- The Army's successes in the Safeguard development program are credited with bringing the Soviets to the SALT I bargaining table.
- The single-site Safeguard system—after becoming operational on schedule and within cost in North Dakota in 1975—was inactivated by Congress in 1976. (The system could not provide sufficient defense of Minuteman within the constraints of the 1972 SALT I Anti-Ballistic Missile (ABM) Treaty).
- The post-Safeguard Low Altitude Defense and Sentry technologies were considered by both the Carter and Reagan administrations as options for defending MX/Peacekeeper.

As these achievements suggest, emphasis in the Army BMD program for years was on technologies for nuclear engagement of targets in the late midcourse and terminal phases of ICBM flight, principally the latter. The main reason was that, from March 1969 to March 1983, national policy envisioned the primary mission for BMD as defense of U.S. ICBMs or other hardened targets.

During that same period, however, the BMD program was also analyzing systems to intercept ICBMs in all phases of their flight. This included boost and postboost as well as midcourse and terminal. The program was also pioneering work on infrared sensors, miniaturized data processing, and directed energy weapons technologies, all of which appear to be promising for use in the components of a multi-layered non-nuclear defense to defend soft targets (such as cities) as well as hard targets.

From this experience and technology base, current Army BMD projects incorporate missile, sensor, data processing and guidance advances that have been evolving and matur-

This model is a preliminary concept of how a commercial jet will be modified in the Airborne Optical Adjunct (AOA) project. The upper fuselage will house two sophisticated optical sensors. Experimental flights of the AOA will examine how airborne optical sensors can be used to augment ground-based BMD radars.

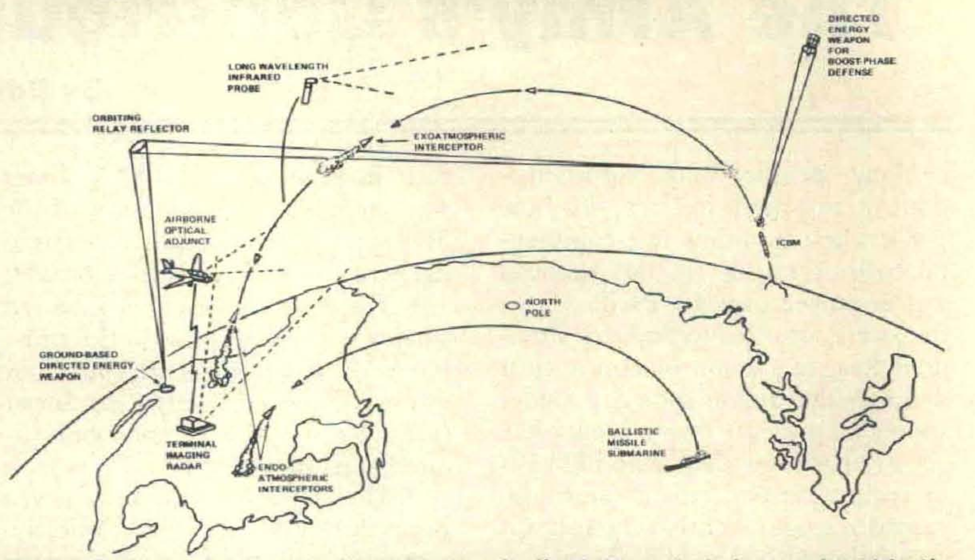
ing over the last 25 to 30 years, and particularly during the last decade.

A major breakthrough came on June 10, 1984, when the Homing Overlay Experiment demonstrated—apparently for the first time by any nation—the capability for non-nuclear, direct impact, physical intercept and destruction of an ICBM re-entry vehicle above the atmosphere.

This brief history goes far in explaining why the Army has been called on to carry out significant responsibilities in all five technology areas of the SDI. It also suggests why roughly 40 percent of the SDI's $1.4 billion budget for 1985 is devoted to Army efforts.

In each technology area, the effort consists of, first, developing discrete technologies—the fundamental prerequisites for system components or subsystems—and second, conducting experiments and demonstrations. The Army's specific responsibilities in each area are described below. Like all previous efforts, the work described below is being conducted in strict compliance with the ABM Treaty. Ultimately, the plan is to bring the elements together for an integrated-technology demonstration.

BMD BALLISTIC MISSILE DEFENSE



A broad range of concepts for ballistic missile defense is being explored in the Army's BMD program, as suggested in this conceptual drawing. Included are ground-based and space-based elements. Some of the devices shown are near-term possibilities, while others would require long-term technology advances.

Surveillance, Acquisition, Tracking and Kill Assessment

In addition to the four areas named in its title, this effort includes another vital function—discrimination, the capability to separate real ICBM warheads from decoys and debris. In conjunction with the development of hardware for technology demonstrations, a number of technologies may be pursued, such as new radar-imaging techniques, new optical-imaging techniques using lasers, and high-data-rate processing. Developing the means for imaging objects in space is particularly important in the effort to advance discrimination capabilities.

Functional technology demonstrations for which the Army is responsible include:

• The Airborne Optical Adjunct Project. This experimental project will examine the use of airborne infrared sensors to augment ground-based radars for the detection and tracking of ICBMs, and hand over of targets to the radars. The $289.4 million prime contract for a five-year Airborne Optical Adjunct technology demonstration program was awarded in July 1984. The effort is currently in the definition phase.

• Terminal Imaging Radar Development Project. The primary objective is, first, to develop and demonstrate capabilities for high-altitude track and discrimination using a ground-based, X-band, phased-array radar. Plans are to award multiple contracts before the end of 1985 for development of preliminary Terminal Imaging Radar specifications and design. The six-month contracts would include an option for a second-phase effort to develop a sufficiently detailed design to permit procurement of long-lead-time items and to develop proposals for the fabrication and functional technology demonstration of the Terminal Imaging Radar. Later, the radar would be augmented by the Airborne Optical Adjunct in a functional Terminal Imaging Radar demonstration.

Another project under study is a Long Wave Infrared (LWIR) Probe. The concept calls for launching one or more rockets carrying long wave infrared sensors from the ground. Once above the atmosphere, the sensors would provide data on an approaching attack. Data from the probe would be correlated to provide high-accuracy pointing information for the defense and to predict which targets are under attack.

Directed Energy Weapons

The directed energy weapons area includes some of the most potentially revolutionary approaches to defend against ballistic missiles. Four basic concepts are being pursued: spaced-based lasers, ground-based lasers, space-based particle beams, and nuclear driven directed energy weapons. This area of research appears to hold the greatest opportunities for breakthroughs in terms of boost-phase and post-boost-phase intercept.

The BMD program has, since the late 1970s, included participation in managing work at Department of Energy laboratories on a short wavelength free-electron laser and a neutral particle beam device.

A ground-based free-electron laser may be a candidate for a boost-phase kill system whose beam would be directed against targets by bouncing it off large relay mirrors based in space. By contrast, the neutral particle beam device would be based entirely in space, to achieve the same result.

Projects such as these have firmly captured the imagination of the news media and public and resulted in the widespread substitution of the term "Stars Wars" for "Strategic Defense Initiative."

Both of these intriguing devices are still in the laboratory, but the goal is to bring all the beam device concepts to an equivalent level of maturity in time for decisions regarding strategic defense which SDI is designed to support.

Kinetic Energy Weapons

In its flight on June 10, 1984, the Army's Homing Overlay Experiment showed the potential of employing infrared-homing technology and missile on-board data processing for a "hit-to-kill" approach, at altitudes above the atmosphere, to defend against ballistic missiles. This is the principle of kinetic energy weapons, which are at the heart of the Army's responsibilities in the SDI. Areas being explored include non-nuclear interceptor missiles and projectiles that would be fired by hypervelocity gun systems.

Major programs for development and demonstration of technology for both endoatmospheric and exoatmospheric interceptors that are under way or planned are:

• The Small Radar Homing Intercept Technology Program is investigating new missile control techniques, using a highly maneuverable, homing, non-nuclear flight vehicle. A series of flight experiments is yielding data on the accuracy achievable within the atmosphere with such a vehicle.

• The High Endoatmospheric Defense Interceptor Project has conducted a competitive concept definition for a non-nuclear interceptor which would operate in the upper reaches of the atmosphere in conjunction with the ground-based Terminal Imaging Radar. Such a system would be capable of defending soft as well as hard targets. Concept definition studies were performed in 1984 by four major aerospace firms. The results have been received and are being evaluated. The best concept, or a combination of features from two or more, will be used as the basis for a functional technology demonstration of a high endoatmospheric defense interceptor. Selection of a contractor for the interceptor technology demonstration will be by an unrestricted competitive procurement planned for this year.

• The Exoatmospheric Re-entry-Vehicle Intercepter Subsystem (ERIS) Project will develop the technology for a ground-launched non-nuclear interceptor that would intercept ballistic missile re-entry vehicles above the atmosphere during the mid-course portion of their flight. It is expected that knowledge gained in the Homing Overlay Experiment will be directly beneficial to the ERIS effort. So, it will probably be multi-stage, lightweight, and employ an optical sensor for homing on its target. Four concept definition studies have been conducted by major aerospace companies to define exoatmospheric interceptor concepts. The best features of the four concepts will be combined into a single design specification. That specification will be the basis for an unrestricted competitive acquisition during 1985 for the ERIS functional technology demonstration.

A Functional Organization

Aggressively pursuing the broad range of research and technology projects just outlined would be an overwhelming assignment, if it were a case of "starting from scratch." But, as indicated earlier, the BMD program's past achievements have laid a solid foundation on which the Army can proceed to build with its contributions to the SDI. The existence of a smoothly functioning organization is another form of "headstart."

The BMD Organization, with 772 civilian and 154 authorized military personnel, is headed by the Army's BMD program manager, headquartered in Cummings Research Park in Huntsville, AL. As current Program Manager MG Eugene Fox puts it, "I actually have two bosses. I report to the Office of the Chief of Staff of the Army. However, I get most of my money from the director of the SDI Organization."

The majority of BMD Organization personnel are also located in Huntsville, where program activity has been centered since its beginning.

MG Fox is assisted by Deputy BMD Program Manager BG William J. Fiorentino. BG Fiorentino is located at the BMD Program Office in the Washington, DC area.

The two principal field operating agencies of the BMD Organization, both in Huntsville, are the BMD Systems Command and the BMD Advanced Technology Center, both of which are engaged in SDI projects. The Advanced Technology Center develops technology for future BMD systems and improvements in current capabilities. When the technology has reached sufficient maturity, it is transferred to the BMD Systems Command, where it is integrated into candidate BMD system concepts and validated through laboratory and field testing.

Most BMD field testing is conducted at Kwajalein Missile Range in the Marshall Islands, a national range operated by the BMD Systems Command for the Department of Defense. Located 4,000 kilometers southwest of Hawaii, the range also supports developmental and operational testing of Air Force ICBMs. Collecting terminal trajectory data on ICBMs launched 7,900 kilometers from California benefits the BMD program as well as the Air Force.

Systems Analyses, Battle Management, and C^3

While the tasks are as formidable as the title sounds, the goal in this area is simply stated: provide positive control of the operations of a complex, multi-layered defense system—certainty that the system can be employed when it is needed and that is safe when not needed. The Army's responsibilities are to:

• Perform systems analyses to provide overall technology guidance in the areas of weapons, sensors, battle management, command, control, and communications (C^3) and supporting technologies required to engage ballistic missiles late in the midcourse (exoatmospheric) and during the terminal (endoatmospheric) phases of their flight.

• Develop high-performance processors and software, and responsive, highly reliable communications networks. These are essential to achieving a highly responsive, ultrareliable, survivable, enduring and cost-effective battle management/C^3 system.

Technology evaluation and demonstration in this area will depend largely upon simulation. Therefore, development of effective modeling and simulation tools is also a high priority. Impressive advances in data processing capabilities will be required to realize the goal so simply stated above.

The Air Force bears similar responsibilities for the boost and early midcourse defense phases. General Abrahamson's SDI Organization will coordinate the efforts to assure that the systems mesh.

Support Programs

Providing the necessary supporting systems and technologies for strategic defense includes four primary projects:

• Predicting the minimum energy required to kill an opponent's systems.

• Establishing the ability of a deployed BMD system to survive attack and continue to function effectively.

• Developing multimegawatt power systems.

• Improving space logistics capabilities.

It is in the first two of these areas, that is lethality and survivability, that the Army's support programs responsibilities are concentrated.

The SDI's emphasis on non-nuclear defense has intensified a similar emphasis that was already present in the Army's programs. As a result, a prime focus for Army responsibilities in this area is expanding the data base on the lethality of non-nuclear defensive weapons against nuclear offensive weapons.

Survivability in all its endless aspects is obviously a constant concern anytime military technologies are being investigated: What effects can the threat enforce against this sensor, that interceptor, and their associated data processing, battle management, and C^3 systems? What active or passive countermeasures are possible? Even if each of the elements is survivable, can the system as a whole survive?

The Army is also interested in investigating unusual forms of power generation because of the requirements for both continuous-maintenance power and high-peak powers in most systems.

Integrated Technology Demonstration

Following functional demonstrations of the individual technology projects, the Army plans an integrated technology demonstration at Kwajalein Missile Range. This integrated demonstration is expected to underscore the maturity of the capabilities developed by the Army. Conceivably, it could provide decision makers with options for evolutionary defensive developments and deployments—that is, a step-by-step approach to realizing the full benefits of an effective defense against nuclear ballistic missiles.

Secretary of Defense Caspar W. Weinberger observed in a recent speech that "Our Strategic Defense Initiative truly is a bold program to examine a broad range of advanced technologies to see if they can provide the United States and its Allies with greater security and stability in the years ahead by rendering ballistic missiles obsolete." The Army's BMD program has a crucial part to play in that undertaking and has taken up the challenge by building a coherent program. That challenge and that response are what make the prospects exciting in the coming years for the BMD program.

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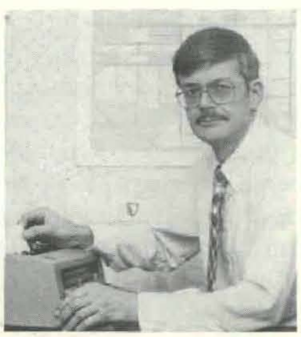

MANPRINT: The Leverage for Excellence

By COL Warner D. Stanley III

Over the last several months considerable publicity has been given to a new initiative—MANPRINT (Manpower and Personnel Integration). The last issue of *Army RD&A Magazine* had a fine article concerning MANPRINT (COL John Tragesser, January-February 1985, pages 4-6) which provided a good overview of the program. I would like to expand on some points of that article which we R&D developers need to appreciate.

No, the use of "we" is not a typographical error; the deputy chief of staff for personnel (DCSPER) is deeply involved in the RDA process. He is charged with managing the Army's human factors, manpower, personnel, and training R&D program. Furthermore, he ultimately has to man all those systems produced by the RDA process. Consequently, R&D issues are a vital aspect of his duties.

As COL Tragesser's article pointed out, MANPRINT is intended to impose human factors, manpower, personnel, and training considerations across the entire materiel acquisition process. He went on to point out why the inclusion of these MANPRINT considerations is so important.

The simple fact is we can no longer afford to ignore MANPRINT considerations. While this may appear to be an extreme position, I advance it for three reasons, each discussed below.

People Are a Vital Part of Systems

The whole materiel development and acquisition process, fundamentally, is directed at fielding weapons systems. In all but the very smallest number of cases, the "hardware" part of the system requires people to operate, maintain or repair it—thus making the hardware into a system. Now this really isn't a trivial observation; people make the bent metal, coded software, or other hardware into systems. Nevertheless, all too frequently those who are normally very rigorous in the definition of the hardware elements of a system, appear to ignore the human contribution (or limitation) to the functioning of the total system.

This observation places no blame on anyone, it is merely a statement of fact. There are numerous reasons why this failure to adequately address human considerations occurred in many (but not all) systems development efforts; each of us could develop our own list of reasons. However, the key point is that, as a practical matter, it probably made little difference—until fairly recently—that human considerations were largely overlooked. Sure, it created some problems during fielding—but with a few exceptions, our Army has generally managed to absorb and accommodate earlier failure to adequately consider human issues throughout the development process.

Why can't this continue, and what's the need for MANPRINT and its current emphasis? What has changed is technology. Until a few years ago, the vast majority of the developed hardware was generally operable, maintainable, or repairable by soldiers of average ability. There were exceptions, but by and large these exceptions were identified and special measures were taken, such as expensive retrofits or extended training.

With the microprocessor revolution (and other advances in technology) however, it has become relatively easy to develop hardware that surpasses the abilities of soldiers to operate, maintain, or repair it. Now that doesn't mean high technology has to overwhelm today's soldiers. Numerous systems have been developed that accommodate average abilities. However, this accommodation has been achieved by paying special attention to human abilities and limitations throughout the development and acquisition process or by being very lucky in the development process.

In the world of high technology and complex hardware, if MANPRINT considerations aren't addressed, we are likely to develop equipment that outstrips the abilities of our soldiers. This recurring concern about soldiers with average mental abilities is central to the problem and is discussed further in a later section.

It may be useful to look at the development process without MANPRINT, as seen through the eyes of the personnel system. In a greatly abbreviated summary a Mission Area Analysis deficiency is recognized and a requirement established for an item of equipment. The relevant and emergent technologies to solve this problem are surveyed and selected, generally with an emphasis upon using technological advancement as a prime means to meet the identified need, and a prototype or demonstrator is developed.

Once the hardware is substantially in hand, we turn to the human side. Given the performance characteristics of the equipment, what levels of human performance (operating and repairing) are required to attain established levels of systems performance? We then begin to consider how much of what kind of training is needed to reach the required levels and how many of our soldiers can qualify for the training.

I suspect that in this greatly simplified example, the suboptimization is apparent. In the process as described, the whole issue of interactive effects and trade-offs between the hardware and the skills, limitations, and abilities of people is omitted.

Consequently, the entire realm of potential economies in personnel and training is overlooked and unavailable for rigorous analysis. Consider an example in which we elect to push the "state-of-the-art" to improve hardware performance. However, in our example the only way to make these hardware choices perform at the desired (objective) systems performance level is to make a substantial human capital investment. This investment may take the form of requiring higher skill levels for soldiers or additional training. Over the life cycle of the system, these human demands are likely to be terribly expensive for the Army. Indeed, at times these human requirements have been unattainable at any reasonable cost—and that leads to my second category of concerns.

People Resources Are Constrained

We intellectually appreciate and accept that human resources, like all others, are constrained—however, at times, the results of our actions point in a contrary direction. Consider the fact that virtually every new weapon system proposed for development promises to "save people" as one of the reasons why the Army needs to develop and acquire it. My hunch is that this promise is seldom, if ever, realized once the system is fielded and operational.

To better appreciate the above point, it is necessary to understand what the term "save people" usually means and how such savings can be illusionary or can even add to costs. As commonly used, "saving people" tends to apply to operators only (at times it has included first line maintainers). It is also important to recognize that this term usually focuses on the raw number of people, and not on the grade, or skill, or training of that person.

As the first level of analysis, consider how this number of spaces being saved can be misleading. Take a hypothetical system that reduces the number of operators required but which requires additional logistical support. These added costs frequently have come in the form of added consumables (e.g., petroleum, oil, and lubricants), or more frequent or more difficult repairs, etc. Since each of these place added demands on the Army they are appropriately attributable to that system. Hence, the observation of "saving people," is usually illusionary if total systems effects are fully accounted for even on this most basic or "personnel spaces" level of analysis.

At a second level of analysis, people savings can easily be illusionary when grade, skill, and training are considered. Each of these can, in fact, impose hidden personnel costs. Grade and skills costs are easily overlooked but may be substantial. Consider the case in which a new system requires an E7 operator vice an E4 in the system being replaced. Since E7s are "grown" through the force and not assessed directly, the increased personnel costs are obvious. The E7 really represents several E4s, E5s and E6s.

Similarly, take the example of replacing four E3/E4 repairers with a single E6, armed with some special test equipment and a considerably enriched job. That could be a very prudent decision—but it is erroneous to think automatically that we've saved three people. One must consider the full range of impacts on the Army of such systems decisions. In this example, it may be an eminently healthy decision given that the Military Occupational Specialty/Career Management Field is of sufficient size to absorb the changes. Alternatively, it may be disastrous by effectively abolishing all of the lower graded authorizations through which the desired E6s would have been "grown."

Training is also capable of imposing hidden personnel costs. The most evident case occurs when a new system demands new school courses or lengthens existing courses. However, training is more than what happens "in the schoolhouse." It includes training in units to sustain proficiency, or special simulators, refresher training, etc. Each of these have people costs which are not immediately obvious, ranging from the instructors themselves, to the "frictional costs" of having to have more people to offset the time spent in school.

One might think that these many potential complications complete the list of people considerations. However, there is one more and ultimately the one of most concern. Over the last few years as the Army has introduced more and more high tech equipment into the force, there has been a parallel ramp-up of soldier quality (as expressed by the Armed Services Vocational Aptitude Battery test categories) required for the force. To date, the level of soldier quality required has largely been obtained through the Army's recruiting and retention programs. What we in the development and acquisition community must be mindful of, however, is that we do not inadvertently build equipment for an Army that has aggregate soldier quality demands that are not realistically attainable.

This is a difficult challenge where the current emphasis on MANPRINT is particularly applicable. As noted, there is compelling evidence that high-tech systems do not necessarily demand brighter people to operate, maintain, or repair them. Appropriate design in many cases can yield very sophisticated items fully workable by soldiers of average mental ability. However, such cases are the result of deliberate effort or fantastic luck. Failure to pay heed to these people-quality demands is likely to yield high-tech systems requiring a level of soldier quality too costly to obtain for operating, maintaining, or repairing.

MANPRINT is intended to provide the necessary discipline to ensure that the development and acquisition process addresses this quality issue and preclude the inadvertent inattention to soldier quality, training, or other MANPRINT considerations.

It must be emphasized that this effort is not solely oriented upon driving down the requirement for soldier quality. Far from it! Nevertheless, we must appreciate that the stock of high quality soldiers available to the Army now and in the out-years is a fairly fixed quantity. Consequently, those systems in which we "invest" these higher quality personnel ought to be the result of deliberate choice, to meet specific considerations—and

NOT because a development effort gave only superficial attention to MANPRINT considerations, forcing up the investment of human capital to make the system work. Such outcomes are wrong for the Army and progressively become more likely as we venture into more complex, high-tech systems.

Another aspect of this concern becomes especially acute upon mobilization. We need always to be mindful of the fact that the distribution of quality we have attracted into the current active component may not be obtainable for the total force in war time—nor with return of the draft. So where's the problem? Simply stated, if we have developed a system requiring soldiers of a given level of quality (e.g., Test Category I-IIIa), and then fail to man the system with such soldiers, the shortfall reflects itself as diminished system performance. It is as though we squandered our investment. This must be avoided! It matters not whether the shortfall is the result of mobilization or recruiting. We will have fielded a system that will not perform as expected in combat and ultimately that is something all of us have the obligation to preclude.

MANPRINT—The Leverage for Excellence

Given the above, the MANPRINT program offers exciting prospects for the Army. We are on the threshhold of fantastic new machines—machines that can, if properly designed, unload a wide variety of tasks, both thinking (cognitive) and manual from soldiers; machines that can monitor subsystems and report failures or anticipated failures. Such devices offer the prospect of giving us whole new ranges of capabilities. Best of all, they are becoming dramatically less expensive and hence reasonable to apply to developing systems. The prospects range from embedded training to job performance aids to a host of more exotic applications.

Unfortunately, there is a dark side to this utopian view. The omnipresent danger is that we will apply these smart machines without careful application of the MANPRINT process. Failure to apply the full range of manpower, personnel, training, and human factors considerations, plus systems safety and health hazard assessments, can lead to adding these fancy new devices without understanding what they are trying to fix and why. Such an unfortunate outcome could only be seen as "gold-plating," a needless waste of resources.

But what does MANPRINT in action look like? What's being done? Let's take some examples. In the light helicopter (LHX) program, the attempt to do the mission with a single pilot demands that certain activities must be automated to mentally unburden the pilot. The MANPRINT process helps identify those functions to be automated.

In a fighting vehicle system, the MANPRINT process may identify that gunnery skills are the most perishable and require frequent sustainment training. Further analysis may lead to the conclusion that embedding training (microprocessor) in the system is the least expensive solution. In another system, it may be determined, via the MANPRINT process, that embedded sensors and diagnostics will reduce the requirement for organizational mechanics and boost reliability. The list of potential applications is limited only by your imagination . . . and in every case is oriented on one objective—improving the overall systems performance by mining the soldier-machine interface like it's a gold mine—because it is!

Unfortunately, we are not yet able to do some of the above things. Simply stated, the tools, procedures, and data bases to fully address such key human issues as cognitive loading are rather rudimentary. The human side of the RDA team is working hard to solve these problems but it will take time. Nevertheless, we cannot wait until we have the perfect solutions—that day will never come. We need to get on with the issue now and start the MANPRINT process, learning and developing as we go.

We have to ask our hardware brethren in this joint systems development and acquisition process to be patient with us "softer" scientists for a while. We're doing our best to become full partners. Meanwhile, we ask you to keep in mind our joint obligation to use the current state-of-the-art to field the finest possible systems for our Army. Without people and their special capabilities and their limitations, hardware is not a total system; we need each other to truly attain an Army of Excellence.

Ultimately, we should point to the day when we can approach the human side of systems much as we presently do the hardware side today. Consider the example of convening a special study group to assess emerging technologies seeking a hardware breakthrough, for a replacement weapons system. We really should be able to do the same thing on the human side.

Visualize a future special study group to assess emerging technologies to improve systems effectiveness by focusing those technologies to improve human performance—or solve a persistent MANPRINT problem, unsolved in an earlier development effort. We are all familiar with the saying, "People Are Our Most Important Resource." Some of us have probably uttered it. MANPRINT offers the prospect of moving beyond the rhetoric and into action. We need to get on with it—with a vengeance. Utopia is not here—yet!

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Nondevelopment Item Acquisition

By Jim Sheldon

Nondevelopment item acquisition (NDI) is a concept whose time has come. NDI is not new, so why the sudden interest in it now? Because today we're encountering fast moving, complex technologies whose half-lives are getting shorter all the time. Technology can take quantum leaps in sophistication yearly. Under these conditions, our traditional heel-to-toe, business-as-usual approaches to weapon system acquisition in most cases no longer serve us well. They result in long, costly development programs which may deliver expensive, obsolete equipment. We can't afford that and our soldiers shouldn't have to look down their sights at a technologically superior threat.

What's the answer? We must completely re-think the way we approach satisfying materiel requirements and drastically shorten the acquisition process. NDI, although not revolutionary, is an essential element in the Army Materiel Command's (AMC) new approach to acquisition.

We have used NDI successfully for years in certain commodity areas such as mobile electric generators and construction equipment. Now we must broaden our horizons and consider NDI as an alternative to almost all our needs.

There are, and probably always will be, some weapon systems that must be developed from scratch due to their specialized military nature and threat-driven technology demands. But we must open our minds, discard assumptions and at least seriously consider NDI before we take on other more expensive and time consuming solutions.

In fact, current Army acquisition policy requires at least one NDI alternative as part of each Milestone I acquisition strategy proposal. That means we must demonstrate, on a cost benefit basis, why NDI can't fulfill the requirement before we commit to a new development start.

NDI's advantages are obvious: lower R&D costs and fielding state-of-the-art technology while it is still state-of-the-art. However, these advantages don't make NDI acquisition easier to manage. There is no one right way to conduct NDI acquisition. There are as many different approaches to NDI as there are for development programs. There's policy galore that governs the acquisition process, including a whole array of 70-series Army Regulations (AR) and AMC policy documents.

AR 70-1 is the capstone regulation and AMC-TRADOC Pam 70-7 addresses NDI in particular. But Army regulations and policy documents can't predict and advise on every conceivable acquisition situation. Thus, "tailoring" is the name of the game. When planning a program, if you have a good idea, and you can't find it in a regulation, use it anyway. Conversely, if a regulation requires something dumb in your situation, don't do it. All that's required is to identify these innovations in your acquisition strategy proposal and elevate it to the appropriate decision authority.

With this attitude towards Army acquisition regulations, you might ask, "Are there any unbreakable rules at all?" I like to refer to the ultimate regulation, "AR 70-0: Common Sense in Acquisition Management." You can't get a copy through your publication center but it ought to be in every acquisition manager's mental library. What does "AR 70-0" say about NDI?

First, it must do the job we paid for—meet the requirement.

Second, we must be able to operate, maintain, supply and repair the item in the military operational environment—NDI goes to war!

Third, the Army must be able to procure and maintain the item over it's life cycle—We must live within our means.

If we follow these three basic precepts when planning and executing NDI acquisition, we should be on the right track. This is especially important since AMC is expanding the use of NDI beyond its traditional domains. This expansion presents a number of challenges to the acquisition community:

CHALLENGE: Realistic Requirements

Army requirements tend to be idealized. That's why we have problems going for an NDI solution. We hardly ever find a match with the Army Training and Doctrine Command's (TRADOC) "wish list."

There's nothing necessarily wrong with an idealized requirement at the very beginning of the requirements process. The initial requirement, the Operational and Organizational Plan, should be a broad expression of the user's perception of an Army need or deficiency. It's the next step that's critical.

The user must recognize that we can't always afford those idealized requirements. This recognition can best be achieved by TRADOC's intimate involvement in the Market Investigation (formerly called the Market Survey). Heretofore, the Market Investigation has been an AMC tool to determine what's available to meet the requirement. That, unfortunately, is too narrow a view of the Market Investigation.

AMC must bring TRADOC into the process to promote a dialogue that makes all acquisition players aware of real world constraints, leading to acquisition strategies that embrace the art of the possible, and not technology for technology sake. This may entail reassessing operational requirements or relaxing specifications. Given current cost and time constraints, the choice is often not between two levels of performance, but rather, a modest, yet adequate, performance level *now* versus a high performance level *never*.

Exactly how are we bringing about this dialogue? First, we're now staffing draft requirements documents with industry. This serves two purposes—it alerts industry to the Army's wants and needs early on, and gives them an opportunity to inject both realism (what's available now) and innovative concepts into the requirements generation process.

Second, TRADOC is a major player in the all-important Market Investigation. They prepare an independent evaluation plan to guide the Market Investigation and an independent evaluation report that sums up the results. This participation provides a major impact as TRADOC converts the Operational and Organizational Plan into the next level requirements document, usually a required operational capability or a letter requirement.

Third, we've established senior level review boards at each major subordinate command and the Materiel Acquisition Review Board at HQ, AMC to conduct technical reviews of all requirements documents with senior TRADOC participation. These boards afford a forum for TRADOC and AMC to get together one-on-one and negotiate trade-offs between requirements and technical "facts of life."

What are some of these trade-offs? We must examine the practice of designing to the "worst case" scenario for all our equipment. This approach is necessary for front-line combat materiel but may not make sense for materiel used in rear echelons or stateside. Let's take climatic hardening as an example. Do we need to harden the entire Army inventory of equipment to withstand an arctic climate when only 10 percent of the equipment is ever used there? Why not harden the 10 percent that's supposed to endure the environment or provide supplemental environmental protection in the form of kits or shelters. We have now reduced the problem to proper equipment distribution. That's one example of simple questions we must ask ourselves. Just because "we've always done it that way" doesn't mean we'll continue to do so. We must challenge the so-called conventional wisdom and see if it really makes sense.

CHALLENGE: Defeating the "Not Invented Here" Syndrome

Changing attitudes or prejudices is a most difficult undertaking, and not something easily accomplished by publication of policy. But it's absolutely essential that AMC act as an honest broker, bringing TRADOC and industry together to arrive at the best match and fit—hardware to requirements—even though all needs

NDI: The Concept Behind the Definition

Why does NDI need a definition?—its name is self-explanatory . . . an item acquired requiring no development on the Army's part. But that definition is too limited and simplistic, and misses the essential spirit of NDI philosophy—i.e., "Take maximum advantage of what's already out there." Preferred NDI is right off-the-shelf or out of a catalog (commercial products, other service materiel or foreign military equipment). However if we can't meet the absolute minimum essential requirements off-the-shelf (and I mean *minimum*, not just nice-to-have), then we should consider modifying off-the-shelf items or integrating proven components rather than resorting to development strategies. The degree of modification or integration can be considered as points on an acquisition spectrum.

If classic off-the-shelf is one end of the spectrum, the other end is a modification or integration program that may be indistinguishable from a development program. The goal of the acquisition manager is to select the optimal point on the spectrum to minimize acquisition costs and time.

might not be fulfilled. The classic remedy for prejudice is education. In the case of NDI, there are two facets to that education:

The first remedy is getting the word out on new NDI policy. The February 1984 revision of AR 70-1 set the stage. This policy is reiterated and expanded in DARCOM-TRADOC Pam 70-2, *Materiel Acquisition Handbook.* The recently published AMC-TRADOC Pam 70-7, *NDI Acquisition Handbook* (November 1984) complements AR 70-1 and the *Materiel Acquisition Handbook,* and provides further insights and details on conducting NDI programs. These documents serve notice of NDI's expanded role and set the policy and procedural foundation for developing and executing NDI acquisition strategies.

Second, ensure that TRADOC and AMC major subordinate commands and laboratories are open to and aware of technological innovations from any and all sources. We're directing that labs become experts in the technology market place. They will become market place data bases to be tapped by subordinate commands, other labs and TRADOC. Thus, labs will provide the foundations for Market Investigations, so that each one won't have to start from scratch.

CHALLENGE: NDI Must "Go to War"

NDI must function within the Army's operational and logistic systems, just as all other items do. This is a challenge because the very speed of NDI acquisition may outstrip the Army's standard integrated logistic support process. It does us no good to deliver an item that can't be operated or maintained through lack of training or tools, or can't be repaired due to lack of spare parts. Compounding this situation are availability problems. We select NDI to take advantage of current technology—but the technology train never stops.

We run a risk of vendors discontinuing or significantly upgrading items with enhancements we don't need. We either end up with an "orphan" system or we keep buying the "new, improved" models, resulting in a proliferation of makes and models. Therefore, supportability is integral to NDI acquisition strategy, just as it is for developmental systems, but we don't have to do it the same way. Innovative and tailored support strategies are encouraged for all systems, so that the Army's supportability needs are met.

- We can use interim or permanent contractor support to provide initial training, manuals, maintenance, spares, and even operators in some instances. We have done that successfully in the past, in both peacetime and wartime environments.

- We can make increased use of the throwaway logistic concept, either with line-replaceable units or complete systems. This works well in electronics and is not necessarily more expensive. It can also make the difference between fielding a system immediately or waiting several years for the Army support base to be set up.

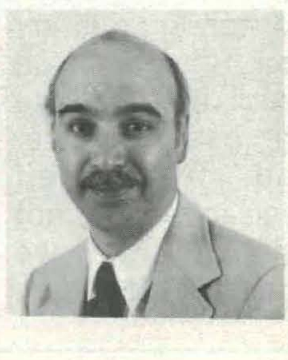
- If we cannot be assured of availability of spares/components over the intended Army life cycle, we may choose to execute a "life of type" buy—a one time procurement of all spares/components necessary to support the system's intended usage life.

- A key integrated logistic support element is Manpower and Personnel Integration (MANPRINT). NDI limits MANPRINT options because we're starting with a defined end product or component. Because of this limit, early Market Investigation activities must focus on identifying MANPRINT issues and developing accommodations or "workarounds."

MANPRINT activities predict system demands on future personnel inventory and determine whether there are unsupported requirements (quantity, mental category, task loading, training burden). Where there are shortfalls, trade-offs determinations are necessary.

NDI's expanded use has raised a lot of questions, and we don't have all the answers yet. HQ, AMC is currently conducting an NDI Functional Process Assessment to develop guidance and lessons learned on how to extract the maximum advantage from NDI acquisition strategy. The emphasis will be on how to procure and deploy NDI smoothly. The Functional Process Assessment is also looking at how best to conduct Market Investigations. The results will be incorporated in a revision of the *NDI Acquisition Handbook.* Also planned is an NDI seminar or workshop in mid-1985 to spread the new policy directly to workers at the major subordinate command level.

Whatever the outcome of the assessment, we don't intend to publish all-encompassing, bureaucratic, rigid policy that stifles imaginative approaches. Only "AR 70-0" (common sense) reigns supreme and can't be waived. We expect the acquisition community to treat this policy as a reference and starting point to experiment, modify and create unique and innovative approaches to NDI.



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A Perspective on

Spare Parts Review Initiatives

By John P. Thomas Jr.

Everyone in the acquisition community should be concerned about the reports of flagrant abuses in the pricing of spare parts. The Army's share of the Department of Defense's spare parts budget for FY84 was over \$6 billion, and based on what some Department of Defense critics have inferred, one would think that a large portion of that budget is being squandered on overpriced spare parts.

The media has devoted substantial space and time to reporting on prices paid on selected items in the inventory and comparing prices to similar items at the corner hardware store. While much of this attention has been placed on items purchased by our sister services, it is important that the Army's views and perspective be presented. Over a year has passed since the initial barrage of adverse publicity. During the past year the Army and the other services have indeed made significant progress in addressing the root causes of apparent overpricing. We are proud of this progress.

The two-fold purpose of this article is to put the spare parts pricing issue in perspective and to outline the Army initiatives to reform the way we buy spare parts. Specifically, this article will address the first phase of the Army's Spare Parts Review Initiatives, commonly known as SPRINT.

Perspectives

The volume of spare and repair parts needed to support our modern Army is impressive. With over 341,000 stock numbered items managed by the Army Materiel Command, 206,000 of which are routinely purchased, there is a probability that errors will occur. The addition of over 400 new weapon and equipment systems to the Army's inventory will cause the total number of items managed to grow even further.

While computerization of certain aspects of the spares acquisition process has partially tempered the impact of increased inventories, personnel resources have not kept pace with the recent increases in complexity and price volatility of spare parts. Although the budget for spares has almost tripled between FY80 and FY84, the number of personnel dedicated to the acquisition of spare parts in AMC, the largest buyer of spares for the Army, has increased by only 15 percent.

The resource impacts of the introduction of new systems, such as the M1 Tank, Bradley Fighting Vehicle, Advanced Attack Helicopter, and the Multiple Launch Rocket System, cannot be overlooked. A top priority of the Army during the 1980s has been force modernization. A prime concern, however, is that the efficient management of spare parts must receive its share of attention.

Potential for Overpricing

The question remains "is the Army paying a fair price for spare parts?" Several studies and audits have been conducted during the past year to address the question of overpricing. One important study was commissioned by AMC to examine the problem. A comprehensive task force report, published in early December 1983, did identify several specific instances of overpricing but did not find rampant overpricing of spare parts. The report made 64 recommendations for improvement in the way the Army buys spare parts, ranging from annual buys, reviewing prices contained in the Army Master Data File, and increasing emphasis on competition by "breakout" of items from prime manufactures. The Spare Parts Review Initiatives (SPRINT) implementation plan incorporates these recommendations.

What is Overpricing?

Determining the degree of overpricing is not a simple matter. As pointed out by an audit completed by the Army Audit Agency on May 11, 1984 on a sample of over 17,000 parts valued at \$29.4 million, "in cases where the price is higher than the commercial price, the prudent man will agree that the price paid is excessive." The audit points out, however, that "determining exactly how much the part is overpriced is difficult and often impossible, because estimates are subjective and vary from one expert to another."

Some believe that any item not bought competitively has the potential for being overpriced. This view is supported by examples of savings resulting from items purchased competitively and is shared by the Army Audit Agency in their comprehensive audit of spare parts completed in May of 1984. AMC strongly supports competition as the key to insuring that overpricing does not occur.

While competition does not absolutely guarantee the lowest possible price, use of the forces of the market place is often the most cost effective method of controlling price. In this regard, the Army track record is good and getting better. During FY82, over 45 percent of the dollars spent on spare parts were competed. During FY84 that percentage increased to 51 percent of the dollars spent on spare parts.

Can 100 percent of all the items in the inventory be purchased competitively? Theoretically yes, but practically no. This is for a variety of reasons, from the limited production capacity of manufacturers to the limited quantities of specialty items being purchased.

Is the Army attempting to increase the percentages of competition on the spares it buys? Yes. One example of this effort is the implementation of *Defense Acquisition Regulation Supplement Number Six* as a part of the overall Spare Parts Review Initiatives. SPRINT initiative number three is directed to this program.

Competition Advocate Program

To further emphasize cost control through competition, the Army has appointed advocates for competition at the general officer level at each of the buying commands. Each of these advocates is vested with the responsibility for maximizing competition, not only in spare parts but in all major system buys. Legislation passed in FY84 places extensive requirements on the services to expand reviews and to take positive actions to create the environment for expanded competition. A recently published "white paper" on competition addresses the role competition advocates will play in complying with this legislation.

Reform Initiatives

On Aug. 29, 1983 the secretary of defense published a memorandum outlining 25 initiatives designed to reduce the probability of spare parts overpricing. These initiatives covered the entire spectrum of spare parts acquisition, from a directive to immediately apply additional resources to automating data repositories.

In response to these initiatives, AMC Headquarters directed that each major subordinate command develop a plan to comply with the secretary of defense's directives. A uniform implementation plan was compiled from the subordinate command plans and published on Nov. 29, 1983.

The Army's plan is right on target according to a report to Congress on spare parts procurement completed by The Office of Federal Procurement Policy in May 1984. The report, which surveyed all the services spare parts practices, stated that the Army program is, "comprehensive and responsive to the OSD initiatives and congressional concerns."

SPRINT Design

Early in the design of the SPRINT program it became evident that meaningful and substantive changes to the system of acquiring and pricing spare parts was necessary and this reform emphasized four fundamental categories.

Discipline, the first category, is well applied to the conventional missions of the Army and is most frequently thought of as a prerequisite for combat. However, the principle of discipline can be applied equally in the management of logistics. The orderly and disciplined application of sound acquisition principles, developed over years of evolution, frequently offers more than seemingly dramatic and revolutionary changes to the system.

For example, over the past five years the Army expanded the use of "Unpriced Contractual Instruments." This method of contracting allows the contractor to either start production of an item without a firm price, or the contractor supplied the part with the understanding that the price would be determined in the future. While this practice allowed more timely delivery and resembled a cost type contract, the Army Audit Agency found that this practice contributes to the potential for overpricing because contractors have little incentive to control costs. The Army Audit Agency sampled orders with 47 of the larger Army contractors and found that the major portion of these orders were unpriced and that the system for arriving at a final price lacked discipline.

Starting in November 1983, the Army essentially halted the practice of issuing unpriced contractual instruments. While it has not been proven that all items purchased on unpriced instruments are overpriced, increased discipline in the pricing of items will serve to reduce the potential for overpricing. The balance of unpriced instruments on hand within AMC has been reduced by 64 percent through the initiation of stricter controls over the use of unpriced instruments, and their use is continuing to be reduced.

Other examples include the application of discipline to the management of the DOD Parts Control Program and efforts to increase competition through the Army's breakout program. Finally, the Army's position concerning disciplinary actions against any individual found negligent in the management of spare parts is clear. Negligence will not be tolerated. The net effect of the Army's efforts to increase discipline is better and more professional management.

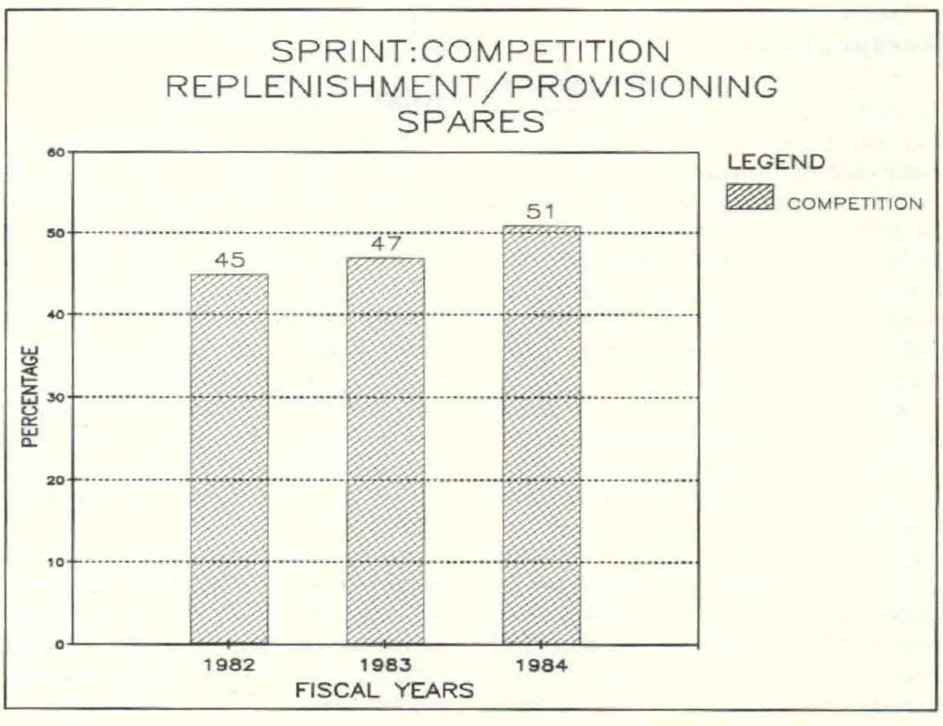
The second category, people, deals with motivating, organizing and involving people in the resolution of cases of suspected overpricing. From the Army's extensive employee awareness program to the SPRINT awards program, the emphasis is on people oriented solutions. All employees are encouraged to report suspected cases of overpricing through various "hot lines." An aggressive awards program is ongoing to reward employees who make significant contributions to the effective management of spare parts. The focal point for these people initiatives at each command is the Spare Parts Manager's Office.

The third category, training, is directly related to the SPRINT category of people. A fundamental redirection of resources to emphasize the effective management of spare parts acquisition has been accomplished within the Army. Over 25,000 manhours of additional local training on spares has been accomplished since the initiation of SPRINT.

Additionally, a formal spare parts management course has been developed by the Army Logistics Management Center for presentation on site during the next two years. This 40-hour course fills the need for a comprehensive and intense examination of the techniques and procedures for effective management of the spare parts acquisition. Nearly 5,000 people are expected to attend this course.

The final category is common sense. A common sense approach consistent with good management principles was used in the development of the Spare Parts Review Initiatives. To the casual observer, many of the initiatives, both directed by the OSD and initiated by the Army, make good sense. For example, expanded use of already proven techniques under value engineering is a sensible way to reduce the cost of an item when other alternatives prove fruitless. Saving money by buying directly from the actual manufacturer or opening items to competition are common sense approaches to utilizing the forces of the market place to control costs.

Other sensible approaches to acquiring spare parts, such as purchasing in larger quantity when proven cost effective, integrating the purchase of spare parts with the production of the end



item, and functional changes such as reducing the number of procurement work directives, are being employed. These actions are having a positive effect. For example, $2.5 million in savings are expected to be realized by reductions in the number of work directives for FY85. Finally, if reasonable long-range changes to the spare parts acquisition process are to be realized, a price in resources must be paid.

Spare Parts Review Initiatives

The plan categorizes the 25 secretary of defense initiatives into eight general Spare Parts Review Initiatives. Each initiative has specific objectives and actions to address the basic goals associated with that initiative. Seven spare parts managers at the major subordinate buying commands are vested with the responsibilities of local implementation of the plan and, at Headquarters AMC, the manager for spare parts is responsible for monitoring the overall plan.

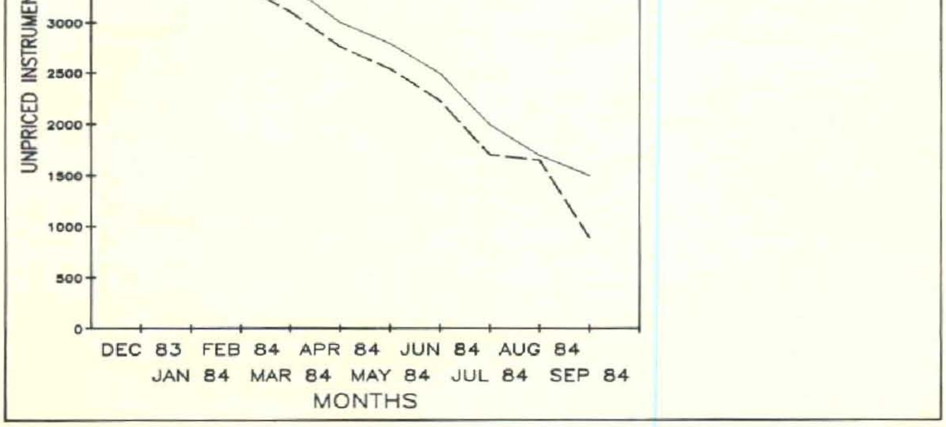
SPRINT One: Give Spare Parts the Necessary Attention. Most initiatives are specific in nature, however the first is general. It focuses resources and attention to all aspects of spare parts management. The general statement, "Give Spare Parts the Necessary Attention" includes action to redirect resources to the acquisition of spare parts until additional resources could be obtained.

The Army was authorized a significant number of additional personnel in FY84 for the implementation of the spare parts initiatives. Recognizing that the lead time for hiring of new personnel could take many months, immediate redirection of personnel from other acquisition related functions within AMC began in November 1983. This redirection of personnel peaked in March of 1984. Over 90 percent of these new personnel have been hired as of Oct. 25, 1984. It should be noted that AMC is paying close attention to the effective management of these resources and anticipates that improvements in productivity and expansion of automatic data processing systems will reduce the need for additional personnel.

The first initiative also includes a massive effort to revise personnel evaluation factors to reflect spare parts responsibilities. Managers and other key personnel involved in the spares mission are being held directly accountable for their performance as it relates to spare parts.

Scores of other actions directed to the review of spare parts acquisition practices and regulations are being taken to search for improvements.

SPRINT Two: Insure That Prices Paid Are Fair and Reasonable. The second initiative is directed at the heart of the spare parts issue. It calls for actions to insure that the prices paid for spares are fair and reasonable. Contracting officers have long been required to certify that prices are fair and reasonable. However, with the increased attention given to spares, additional controls have been directed. Price increases above a commodity-related percentage threshold require special justification. All annual price increases above 25 percent are approved by the head of the contracting activity. Included in this initiative is the incorporation of a systematic process of identifying cases where overpricing may be present, and then resolving those pricing discrepancies. Pricing reviews have been conducted on many selected items to determine price reasonableness.



SPRINT Three: Implement DAR Supplement No. Six *"Breakout."* Supplement Number Six to the Defense Acquisition Regulation (Now DOD Supplement to the Federal Acquisition Regulation) made substantial revisions to a long-standing program designed to increase competition on spare parts. The Army has established three goals designed to identify candidates for competition and to breakout items from the prime contractor, either to open competition or by purchase directly from the actual manufacturer.

The first goal of this program is to screen all items in the inventory that do not have acquisition method codes and assign a code signaling to the contracting officer that the item should either be bought from prime manufacturer, actual manufacturer or competed. During the next three years, more than 75,000 items will be screened.

The second goal is to code 50 percent of new items coming into the inventory so they can be purchased from other than the prime contractor. Parts normally coded with this objective are of stable design with stable delivery schedules and where purchase from the actual manufacturer is proven to have the potential for cost savings. This front-end coding system will help insure that attention is directed to competition during the introduction of items into the inventory.

The last goal relates to the overall increase in the number of items coded for competition. To date, 38.4 percent of the active items in the inventory are coded for full competition. The goal is to have 50 percent of all items coded competitive by the end of FY86. While sustained progress in this area cannot be guaranteed, the increased competition created by these efforts has the potential of saving the Army $170 million annually by FY89.

Spare Parts Review Initiative number three also extends the use of this tool by encouraging breakout as a factor in source selection. An example of this can be found in the Light Helicopter Experimental (LHX) Engine Program. The Request for Proposal for the 10,000 helicopter engines to be bought over the next 10 years as a part of the LHX Program will request specific plans for breakout of the majority, if not all, engine spare parts.

Other provisions helping to create the environment for extensive breakout of spare parts include granting limited rights to technical data to the government after 72 months and identification of specific goals for competition of spare parts early in the development cycle. The LHX will be a model aviation program, if not a model Army program because of its high visibility and innovative approaches to increasing competition.

SPRINT Four: Eliminate Disincentives on Industry to Breakout. The fourth Spare Parts Review Initiative again deals with efforts to increase competition by creating positive incentives for the contractor to breakout items. A special OSD task group has published a "model concept" to provide incentives for contractors to increase competition. This model concept provides financial rewards to contractors to compensate for the additional efforts involved in creating the environment for effective breakout of spare parts.

Since breakout of an item in most instances means the potential loss of revenue for the prime contractor because the Army buys directly from the actual manufacturer or opens the item to competition, there is naturally a reluctance on the part of the prime to cooperate in the breakout effort. Financial incentives, such as sharing in savings and royalty payments, may serve to reduce disincentives and to gain contractor participation. AMC is testing this concept on several systems to determine how effective these incentives can be.

SPRINT Five: Optimize the Use of Standard Military Parts. Recognizing the potential for savings through standardization, the secretary of defense made the application of the DOD Parts Control Program mandatory in his Memorandum of Aug. 29, 1983. SPRINT five emphasizes the use of standard military parts to reduce costs by eliminating duplication of effort in developing parts already in the supply system. The Army is meeting that challenge with all contracts that are suitable for parts control containing the appropriate clause.

SPRINT Six: Use Value Engineering to Investigate Prices. The sixth initiative encourages use of value engineering to reduce costs on items where other efforts may have proved ineffective. Value engineering is a well established program within the Army and has provided $20.9 million in hard savings during FY84. These techniques are being employed in the initiatives to bring down the cost of an item by basic re-evaluation of the functions being performed by the part. Where a less expensive way to achieve that function can be achieved, value engineering changes are affected.

SPRINT Seven: Acquire Restriction-Free Reprocurement Data. Initiative seven relates to the attainment of data usable for reprocurement of items in open competition. Army experience on this issue has been mixed. On June 22, 1984 an OSD study group concluded that data rights is not the greatest impediment to competition of spare parts. Research showed that only a small number of items in the inventory contain restrictive legends that would prevent the Army from procuring the item competitively. However, a significant number of technical data packages appear to be deficient because unusable technical data were provided by the contractor and these data were not updated properly. A program has been instituted within AMC to include provisions for warranty of data to insure that they are suitable. The quality of technical data is physically enhanced by SPRINT eight.

SPRINT Eight: Automate Data Repositories. Based on the premise that datum is a resource to be managed effectively, modern techniques for digitizing drawings and storing these drawings on laser disks are scheduled for introduction at the major subordinate commands. Seven sophisticated digital storage and retrieval engineering data systems will be completely installed by FY89. The Army Missile Command will have the first digital data system operational in FY86. These systems will represent a major leap forward in the management of data.

AMC is pursuing a number of other automation initiatives which will have long-range effects on spare parts acquisition. An example of this is the Army Communications-Electronics Command's Automated System of Procurement project which is designed to significantly reduce or eliminate the manual processing of procurement documents and will allow significant cost savings and increased control of procurements.

Summary

In retrospect, the problems with spare parts acquisition are not new. A review since World War II reveals numerous problems with the acquisition of spare parts. What is different in the current initiative is the level of support, backed up with additional resources to institutionalize reform in the way the Army buys spare parts.

Only a representative sample of the total Army efforts in spare parts has been discussed in this article. Literally hundreds of actions designed to modify and improve the acquisition of spare parts are ongoing in the Army Materiel Command. The independent reviews by the Army Audit Agency, the Office of Federal Procurement Policy, and other agencies have lauded the SPRINT program. Most importantly, positive results are starting to be reported.

AMC reported a savings of $211 million from breakout, value engineering, voluntary refunds from contractors and reduction in procurement work directives against $31 million in costs during FY84 as a result of the Spare Parts Review Initiatives. As reported to Congress, this positive picture of progress is an indication of the success of these initiatives.

Building on the success of phase one of the Spare Parts Review Initiatives, AMC is implementing an expanded program of reform directed to giving more attention to setting the stage for price reasonableness early in the acquisition process and to increasing competition. Completed actions have been closed out and new goals and objectives set for FY85. This evolutionary process of reform is expected to further enhance readiness by maximizing the quantities and quality of materiel the Army purchases with the dollars budgeted by Congress. The potential long-range benefits are substantial and will save tax dollars.

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Software Development Planning

By CPT Steven Frith

For every action there must be an equal and opposite reaction. That observation is as true in project management as it is in physics. The past decade has seen a revolutionary shift in the balance of Command, Control, Communications and Intelligence (C^3I) and weapon system development from an emphasis on hardware to an emphasis on software.

Software, rather than hardware, in many C^3I and weapon systems is now the cost and schedule driver. Black box systems, in many cases, are being replaced by what are essentially general purpose computers and sophisticated software systems. The challenge of software development is a very different one from that of hardware and it calls for an innovative response on the part the materiel acquisition community.

Problems with software development are found throughout the defense organization. Symptoms of these problems are slippages of weapon system schedules, system failures, system inflexibility and soaring costs. Software development now represents the major development risk for command and control systems and it is a problem that is increasing. The Electronics Industries Association predicts that by 1990 there will be over 250,000 embedded computers in DOD's inventory and that 85 percent of the DOD budget for computer related items will be for software.

Software development is the cost and work driver on many DOD projects. Both contractor and project management staffs, however, often address software development from a hardware management perspective. Software is unique in many respects, particularly in that the end result is a "slippery intangible" hidden inside a read only memory or random access memory somewhere. The invisible nature of software tends to foster a loose management environment in which, as stated in an article by Joseph McCarthy in the May-June 1984 issue of *Program Manager Magazine,* the coding process is 90 percent complete for half the total coding time and the debugging process is 99 percent complete most of the time.

The critical role of software development as the cost and schedule driver calls for an innovative management approach by both the contractor and the DOD project manager staff. The foundation for success in software development is the encouragement of informal interaction between the contractor and the project management staff during the critical requirement definition and planning stages. Software projects that have failed in the past were often characterized by poor requirements definition, limited informal interaction between the user and the contractor, and poorly developed software configuration plans.

The contractor must clearly understand not only the system specifications but also the environment the system will be operating in and even the philosophy and doctrine that is driving the system requirements. Careful analysis and planning during the requirements definition stage will pay off during the implementation by reducing the amount of rework and change required.

I want to discuss the foundation elements upon which successful software development plans must be built. My object is to share some of the information and experiences gained during my training with industry assignment at Litton Data Systems. Litton Data Systems has over 25 years of successful experience in C^3I systems development arena. The record includes the development and production of the Army's TACFIRE and AN/TSQ 73 systems, the Navy's E2C, DD963, and LHA ship electronic system, and the Marine Corps' and Air Forces's TAOC-85/MCE air defense tactical control system.

This article is the result of interviews and discussions with Litton's employees concerning the "how to" of successful software development and the role of the DOD project manager in the development process.

The elements of a successful software development program are:

- Well defined requirements.
- Realistic scheduling and funding.
- Integration of systems and software test planning from the inception.
- Detailed work task planning as part of an integrated top down system.
- Creative informal communication between the contractor and the military project manager staff.

Hardware development normally calls for project management involvement down to work break down structure level two or three. Successful software development, on the other hand, demands at least informal involvement by the project management (PM) staff at a much lower level. The contractor should also utilize a project or matrix approach for the design and development tasks.

The PM staff should work hand-in-hand with the contractor during the company's requirement and specification analysis. The informal channels of communication should be active in dealing with confusion and questions over specifications and requirements.

Use of informal memos, phone calls and meetings should be maximized because of their efficiency and timeliness. Formal correspondence should be used primarily to document direction or agreements already thoroughly discussed in informal working and telephone sessions.

The contractor and the PM staff work together closely to ensure that the software development plan is driven by the contract requirements and specifications. The plan should definitize requirements at the lowest possible level without getting involved in the actual design process. A "plan-a-little/build-a-little" approach should be avoided.

Each type of input should be completely defined (including format and content), the processing completely defined and the exact content, format, and time sequencing of the output provided. Effectively organizing the software development plan will go a long way toward minimizing the possibility of misunderstanding between the user and the contractor.

Software development programs are notorious for radical shifts in percent complete because of rework and the use of ambiguous task milestones. Litton has dealt with this problem successfully through the use of rigorous work task schedules. The PM should interact with the contractor to ensure that the work task organization is realistic and manageable. The contractor should delineate tasks and subtasks at the lowest effective level for the type of work. Each task scheduled, as a rule, shouldn't exceed 200 manhours and five weeks in duration.

The objective of rational task scheduling is to ensure that tasks are manageable in size and length. The contractor must also have an effective system for measuring work progress against schedule for each task. The procedures for measuring progress within each task must be clearly understood and agreed upon by both the contractor and the PM staff.

Milestone systems that give a percent complete figure based on the passage of time are simple to use and effective for non-critical tasks. Critical software development tasks should employ a milestone system that provides an accurate assessment of percent complete for the task.

Task and subtask delineation at the lowest practical level and implementation of an effective actual percent complete milestone system for critical tasks are essential for software management control.

The way a contractor manages systems and software testing can often determine whether a program will be on time and on cost or wildly over. Testing is a significant cost driver that will often represent 30 or 40 percent of the total software development budget. Emphasis on test planning and design early in the development process is essential in funding and correcting program errors before a system is fielded. Some sources maintain that identifying and correcting a program error in the field can cost 10 times as much as the price of correcting it during development (see Bolino and McCracken "Software Test and Evaluation in DOD," *Signal Magazine*, July 1984). The successful software developer involves his test personnel in the planning process from the very beginning.

System and software testers must be involved in the planning process early on and there should be "cross-fertilization" between designers and testers through transfers between sections.

The test process should begin with the design of the hardware. A test oriented hardware design can reduce the complexity and time required for test procedures. Test oriented engineers can also direct the design toward a more maintenance and "test friendly" configuration.

Software development, more than any other kind, requires a close linkage between development and operational testing. The PM staff should encourage operational testers to get involved, early on in the development process. They must stay involved, identify issues, and establish criteria. This approach will minimize time delays during operational testing and aid in providing a total picture of software suitability.

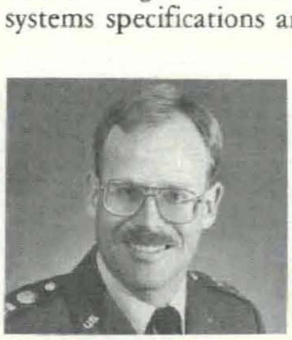
Early involvement by operational testers will give them an awareness of systems specifications and an appreciation of test tools used in development. Bolino and McCracken also point out in their article that smarter operational testing begins at contractor facilities where experienced user personnel can assess set up and test down times, government furnished equipment interfaces, documentation, and instrumental adequacy.

Systems and software test planning can not be end loaded in the development process. Testing programs must be incremental in nature and driven by the "build-a-little/test-a-little" philosophy.

Software development is often the cost and schedule driver in DOD weapon and C^3I systems. The tremendous growth in the demand for software and its intangible nature call for an innovative and aggressive management response on the part of the DOD acquisition community.

The PM staff must be actively involved in the planning and requirements definition stage to ensure that the contractor fully understands what is needed. Active involvement by the PM staff during the definition and planning phase will minimize the need for costly change requirements during the implementation stage.

The PM staff must develop informal channels of communication to encourage a clear understanding and innovative response on the part of the contactor. If we are to maintain our advantage in C^3I and weapon system technology we must be creative and innovative in our management response to software development. The keys to successful software management are well defined requirements, realisitic scheduling, a "plan before you jump" approach to task structure, integration of system and software test planning from the inception and, of course, close and informal interaction between the user and the contractor.



CPT STEVEN FRITH is a SC51 officer currently participating in the Research, Development and Acquisition Management Training with Industry Program. He began one year of training with Litton Data Systems in Van Nuys, CA, in August 1984.

Maximizing Creativity and Innovation

By RADM Rowland G. Freeman III (USN Ret.)

The following speech by RADM Rowland G. Freeman III (USN Ret.) was presented at the 14th U.S. Army Science Conference at the U.S. Military Academy, West Point, NY. Published here in an edited format, the speech reflects the theme of the Army Science Conference—"A Future of Excellence Through Innovation and Creativity." RADM Freeman is vice president for strategic planning and energy systems ventures, McDonnell Douglas Corp.

A great many people have expressed grave concern that the United States is far behind technologically, that foreign technology, both West and East, is equal to or surpasses ours, and that we have been "resting on our oars." I disagree. I think we still have the capability to retain our leadership in the world of technology.

Our major problem in the past few years has been that we have been preoccupied with what seems to be overburdening political problems. We have lost our technology momentum. We remain a society characterized by innovation and creativity, but we have allowed the relatively peaceful domestic environment which this country has enjoyed for several decades to distract us from the creativity and innovation that have made us a great industrial nation. I'm convinced, however, that the ability is still there. Our current challenge is basically to create an environment that will nurture those qualities of creativity and innovation.

I would like to discuss four problems that I see in our technological environment, problems which hinder our ability to maximize creativity and innovation.

The first problem is that we have not really articulated a national technological strategy, nor have we even allocated resources according to any kind of strategy. Our planning in this area has been totally inadequate, characterized by lack of focus, short-term orientation, uncoordinated priorities, and inadequate funding, especially in certain critical fields.

In answer to this criticism, many technologists will argue that you can't plan innovation, creativity, and technological discovery. I disagree! While planning certainly will not solve all our problems, having some kind of plan is better than having none. I say that because the process of preparing a plan requires the discipline of focusing on the critical elements, and that's an absolute requirement if we are ever going to prioritize our technological efforts.

There are a number of facts of life that should guide us in planning our technical stragtegies. Let me suggest a few of them.

- Every product is composed of a number of distinct and identifiable technologies and no matter how generic we consider our technologies to be, we are ultimately working on products.
- These technologies or products have widely different potential impacts on our competitive position.
- Technologies, like products and industries, have life cycles and stages of maturity.
- Competitors have different relative strengths in different technologies.
- Technology strategies should be driven by technological and business or mission conditions, rather than by purely management conditions.

Rather than delve into an analysis of those factors, let me instead summarize with a generalization. Our technical planning should have three distinct bases: financial planning, which of course everyone does to some extent; market-oriented planning, which is directed toward the external world and which not everyone does; and, most importantly, a technology base, which is essential, and which must be carefully thought out and integrated into a coherent whole.

Improving Our Educational System

My next concern, which is of equal importance, is our educational system. It seems to me that we have de-emphasized the requirements for math, finance, and language, and during their most formative years, our young people are not being urged into the hard skills of engineering and science.

I don't want to argue about whether or not there is a shortage of engineers, but it is apparent to everyone that there are shortages even now in certain technical areas.

Furthermore, we are beginning to see the retirement of a large body of scientific and engineering professionals who entered the system during and immediately after World War II. That leadership has been largely responsible for the scientific and engineering innovation and creativity that distinguished our country for the past three decades.

We are doing too little to replace those who are retiring. We are failing to provide adequate opportunities for those who are interested in pursuing an education in engineering or science, and I mean at all levels . . . secondary, college and graduate.

We also are not providing assistance for those technical students who would like to join the faculty in science or engineering rather than leaving for industry. The result of these failures is that fewer technical degrees are being awarded and fewer technical graduates are going into teaching.

The cry of the engineering and scientific communities has always been for more R&D dollars. I believe that today their most self-enlightened course would be to allocate a share of those dollars for scientific and engineering education.

Without building a capability to replace those outstanding people who are leaving the system, all our efforts to increase the nation's creativity and innovativeness will be futile. Some recent figures I have seen indicate that some 2,000 teaching vacancies remain unfilled in our academic institutions. Now that's bad enough, but let me cite a few other data that I find equally alarming:

- Fewer than one-fifth of the states require more than one year of science in grades 9-12. As a result, according to a survey conducted in the late 1970s, 45 percent of the high school graduates had studied only one year of biology, 17 percent had studied a year of general science, 16 percent had had a year of chemistry, and only nine percent had had a year of physics. Don't you find that worrisome?
- There are only 10,000 physics teachers for 16,000 school districts. What do the rest of them do? Call in the football coach?
- Over 70 percent of elementary school science teachers do not feel well qualified to teach science. (I'd guess their pupils agree with them, too.)
- Only 75 percent of our youth graduate from high school. By contrast, 90 percent in Japan and 98 percent in Russia graduate. And by the same token, only six percent of our college students graduate in engineering and 30 percent in science, versus 20 percent and 65 percent respectively in Japan.

The conclusion I draw from these numbers is that we are facing potential shortages of technically trained people, both in quality and in quantity. Furthermore, we are graduating large numbers of students who have little or no knowledge of science and engineering and of their importance to our future and our culture. The consequences are not pleasant to contemplate.

For one thing, this ignorance of technology could very well act as a serious deterrent to the investment and growth that are essential to an environment that can nurture innovation and creativity. That in turn could lead to a situation in which our economic position, relative to other nations, declines . . . along with our standard of living, and we might well have to relinquish our position as the leader of the western alliance.

The steps to correct these problems in our educational system are numerous, of course. The most obvious one is the correction of curricular requirements at every level and the upgrading of course content. But to me the most important step is a significant investment at local, state, federal, and institutional levels to correct the current problems in teacher training. This, coupled with a modernization of the curriculum itself, would go a long way toward refining engineering and scientific education in this country.

Integrating Engineering and Other Disciplines

The third problem that I see is our failure to integrate engineering properly with manufacturing and product support—and that doesn't even consider the place of the scientific laboratory in the scheme of things. It is almost as though these technologies operated in different worlds. In many cases, our motto seems to be Design First and Look at the Support Problem Later; or perhaps: We'll Design It, You Produce It.

Today, only lip service is given to the subject of R&D in the field of logistics and product support, and I don't have a ready solution, other than to point to the need. Similarly, the United States is certainly not in the forefront of factory automation and robotics, but I can point with some pride to the actions of the corporation for which I work.

We are investing heavily in plant modernization and have recently approved a $700 million program for the upgrading of our facilities for producing military aircraft. Similar plans are being made for the commercial aircraft side of the house. The sooner other corporations follow suit, the more likely we will be to maintain at least parity if not leadership among our friends and foes.

The same lack of integration exists in the scientific world as well. For example, the tremendous assests we find in industrial and federal laboratory systems are seldom related closely enough to their principal customers within the operating environments.

It is significant that a recent report on the federal laboratory system drove hard at two recommendations: A closer relationship with industry and a closer relationship with the academic community. Unfortunately, the feverish competition for jobs and dollars has tended to stand in the way of the closer collaboration that would create the environment needed for more creativity and innovation.

One of the best examples of what industry can do is the innovative lab created by Westinghouse. Engineers there are periodically assigned to a laboratory whose principal function is to develop new technology in all areas of Westinghouse production.

Tom Murrin of Westinghouse makes a very strong point of the need for this renewal process, and I certainly would agree with him about that. In fact, I suggest that any organization—academic, industrial, or governmental—could benefit by following this example and periodically rotating its technical people from the production side of the business to the innovative side.

Our nation grew industrially because the early entrepreneurs understood how to integrate the skills involved in development and production. If it is to continue growing, we must learn again how to convert technology to high-quality manufacturing production that is economical and supportable.

Integrating Our Laboratories

The fourth problem I want to discuss is our failure to integrate our academic, industrial, and government laboratories. I have been fortunate in being associated with all three of these vital systems, and I know at first hand some of the reasons—or excuses—that are given for the lack of cooperation between them. I find these reasons insignificant and think that they should not be allowed to stand in the way of achieving a creative environment in this country.

Any program formulated to help correct this problem should emphasize exchange programs involving industry, the DOD's R&D system, other federal laboratories, and our universities. There is no better way, in my experience, to foster understanding of another person's problems than to spend some time working in the other person's environment.

Concluding Remarks

I could spend a great deal more time talking about the problems I see in our current technology environment. For example, I worry about the problem of user orientation in the scientific and engineering community, by which I mean the almost total refusal of the designers to consider the needs of the customer, and the reluctance of the educators to consider the needs of the future employers of the students, and so on. There are many other examples.

I worry also about a federal bureaucracy that for all practical purposes is ignorant of science and technology and yet controls a major chunk of all R&D funds.

I worry about the publish-or-perish syndrome in academia, a syndrome that creates problems ranging from the premature publication of incomplete results to the constant publication of trivia.

I think all of the problems I have discussed are real. I know they are serious. But I'm convinced that with proper attention and effort, they are soluble. We are in the prime position to take some appropriate remedial action. I hope I have convinced you of the need to do so.

Tightening the Link With the Operational Forces

By Bruce M. Fonoroff

"Since the major task of DOD Laboratories is to enhance the capability of our military forces, greater communication between the DOD's operating forces and its laboratories would benefit both parties."—Report of the White House Science Council Federal Laboratory Review Panel (The Packard Report), May 1983.

For the Army Materiel Command (AMC) laboratories and research, development and engineering centers "staying close to the customer" means supporting the combat soldier where he lives and works—at the major Army commands, or MACOMs, located throughout the world. A major new initiative, called the AMC Scientific Assistance Program (ASAP), will provide senior scientific advisors to the MACOM commanders and mid-level scientists and engineers to selected logistics assistance offices worldwide. The purpose of this program is to increase the coupling between the laboratories/centers and the operational forces.

Numerous high-level studies, including an independent review of DOD laboratories by former Assistant Secretary of the Air Force Robert J. Hermann, and the report to the president of the Federal Laboratory Review Panel, chaired by former Deputy Secretary of Defense David Packard, identified coupling between the laboratories and the operational forces as an important area in need of improvement. The Hermann Report in particular pointed out the following benefits of tightening the link between scientist and soldier:

- Improving the laboratories' awareness and understanding of the operational concepts which their scientific and engineering efforts are supporting;
- Illuminating reliability, maintainability and supportability issues for both the laboratories and the commands they ultimately support;
- Providing an improved channel for laboratory and command cooperation in fielding product improvements; and
- Providing an improved mechanism for the evolutionary application of technology.

Figure 1 shows the principal scientific assistance program objectives. The first is to support the field commander with competent technical advice and quick reaction solutions to technical problems. The second is to improve communications between laboratory and operational personnel—primarily by assisting the field commander in articulating requirements in a way that is meaningful to the scientific and technical community, but also by providing feedback to the laboratories' tech base programs to ensure that the work that is undertaken is relevant to operational needs.

The third objective is to use the program to provide operational experience to senior technologists as part of their career development. As the science advisors rotate through their two-year tours at the major commands, AMC will begin to accumulate a cadre of key individuals who not only have technical training and experience, but operational experience as well. In the future, a scientific assistance program assignment will undoubtedly become an important qualification for the selection of senior laboratory managers and directors.

The Program

The program has three main elements: the senior science advisors from the labs/centers at selected major commands, mid-level scientists and engineers from the labs/centers to augment AMC logistics assistance offices, and a sum of R&D money reserved at AMC HQs for quick reaction projects in response to major Army command requests.

The science advisor (GS-15 level) will serve as the principal staff advisor to the commander on science and technology matters, making recommendations regarding both short- and long-term technical initiatives

ASAP OBJECTIVES

- SUPPORT THE FIELD COMMANDER
  - WITH COMPETENT TECHNICAL ADVICE
  - QUICK REACTION SOLUTIONS TO TECHNICAL PROBLEMS
- IMPROVE COMMUNICATIONS
  - ASSIST IN ARTICULATING REQUIREMENTS
  - PROVIDE FEEDBACK TO THE TECH BASE PROGRAM
- PROVIDE OPERATIONAL EXPERIENCE
  - KEY ASSIGNMENT FOR SENIOR TECHNOLOGISTS
  - TRAINING GROUND FOR FUTURE LAB DIRECTORS

Figure 1.

for improving the effectiveness of the command. He will coordinate specific lab/center efforts in response to command requests.

Scientists and engineers (normally at the GS-13 and 14 level) assigned to the logistics assistance offices will bring a new perspective to the analysis of day-to-day readiness problems associated with fielded materiel. Whereas the logistician and field maintenance technican may view a given problem in terms of the availability and distribution of spare parts or quick fixes to design deficiencies, the technologist is more likely to think in terms of designing the problem out of the system by fundamental changes in materials, system design or even conceptual approach.

The science advisors and scientists and engineers in logistics assistance offices will work closely together as they seek opportunities for the technical community to contribute to improving the effectiveness of our operational forces.

The 50 logistics assistance offices employ over 1,200 civilian and military personnel who provide peacetime and wartime assistance to field commanders in all facets of logistics, including supply, maintenance, and supplemental training. They also provide logistics intelligence to the wholesale community (i.e. the Army depots and arsenals), which is critical to resolving readiness problems and sustaining a favorable readiness posture. The logistics offices are highly regarded by field commanders for the support they provide to the operational forces.

THE ASAP QUICK REACTION NETWORK

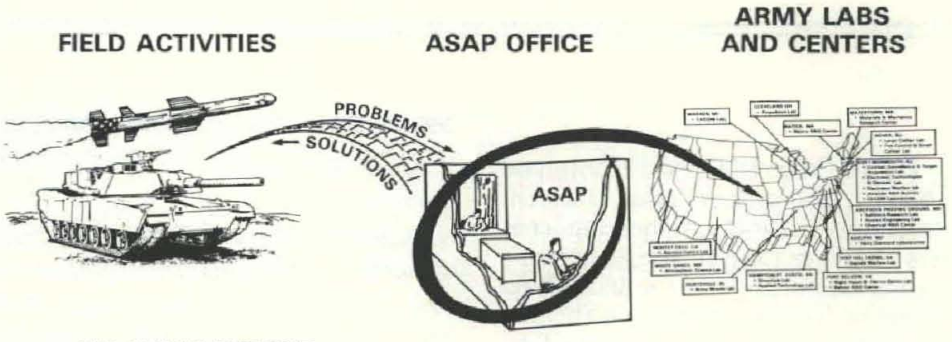


Figure 2.

The program will be managed by a program director in AMC HQs. As shown in figure 2, the director will provide an important bridge between the program's overseas personnel and designated points-of-contact in each AMC laboratory and research, development and engineering center. He will insure that each request for support is given thorough and immediate attention, and that all of the appropriate resources of the labs and centers are brought to bear on the identified problem. He will also be responsible for coordinating any major request with managers of related programs in order to avoid duplication and disruption of on-going efforts.

The scientific assistance program is not intended to be a "back door" for the development of materiel but, rather, a mechanism for demonstrating technical feasibility on a quick reaction basis. Long-term solutions must be picked up by the conventional development and acquisition process.

Background

For over a year, AMC has been studying ways to improve the effectiveness of its labs and centers. One

Engineers Join Soldiers in Field Exercises

The Army Materiel Command has instituted another program which allows AMC managers, scientists, and design engineers to get first-hand knowledge of the field environment in which soldiers and their equipment function. The program, called Design Engineers Field Experience With Soldiers, consists of a two-to-four-week period in which participants live with soldiers during the simulated combat environment of a field training exercise. They work with the same type of equipment they are employed to design or improve upon in their regular jobs.

Working side-by-side with soldiers and performing the same duties as squad, tank, or gun crew members, they are subjected to all the stresses experienced by soldiers in the field.

All participants are volunteers. They are screened by an Army combat arms officer, must pass a thorough physical examination, and must take and pass the Army Physical Readiness Test. Both men and women may volunteer for the program. Upon completion of the screening process, the participants are prepared for their visit to an active Army organization in the continental United States. This intimate field experience gives the volunteers an excellent chance to use and observe the type of equipment on which they work.

Originally developed by the Armament Research and Development Center of the Armament, Munitions and Chemical Command, the program has recently been expanded AMC-wide. To date, over 40 engineers, managers, and scientists have completed trips to the field, working with equipment ranging from M16 rifles, to chemical decontamination systems, to 8-inch self-propelled howitzers. The response from the Army units involved and from the participants themselves has been universal enthusiasm and acceptance.

of the initiatives undertaken was aimed at increasing the relevance of laboratory work to operational problems. In February 1984, LTG Robert L. Moore, AMC deputy commanding general for research, development and acquisition, formed a task force to ". . . seek ways to improve the process by which the DARCOM laboratories serve the needs of their ultimate users, the operational forces in the field."

The task force, chaired by William Marroletti, deputy PM for training devices, assessed the formal and informal mechanisms for coupling operational needs to the laboratories' programs. They concluded that while several such mechansims existed, the laboratories were largely isolated from real world operational problems and that the best advantage was not being taken of highly skilled laboratory personnel who could recognize and solve problems when they occurred.

The task force's primary recommendation to establish science advisors at Army major commands is modeled after a similar Navy program called the Navy Science Assistance Program. The Navy program has been operating successfully for almost 15 years and, in fact, has its roots in a program shared by the Army. In the late 60s and early 70s the Vietnam Laboratory Assistance Program focused the expertise of the DOD labs and centers directly on operational problems faced during the Vietnam War. After the war the Army discontinued their program but the Navy rechartered and continued theirs.

The Navy program has become an integrated part of the process by which the chief of naval material provides technological support to naval operational forces afloat and ashore.

Status

To date, five Army commands have agreed to participate in the scientific assistance program. They are the U.S. Army Europe; Eighth U.S. Army (Korea); U.S. Army Western Command, HI; U.S. Army Forces Command, Fort McPherson, GA; and U.S. Southern Command (Panama). The scientific assistance program is an outreach program initiated by the AMC Commander GEN Richard H. Thompson, and as such, science advisors will be assigned only at the specific written request of a major field commander.

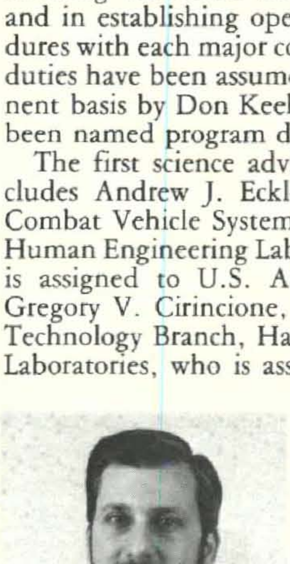
Science advisors (SA) and laboratory representatives assigned to logistics assistance offices (LAO) shown with LTG Robert L. Moore are (front row l. to r.) Mike Kelly, Night Vision and Electro-Optics Lab, (LAO, SOUTHCOM); Donald W. Keehan, Belvoir R&D Center, (program director); William Hagler, Roland Project Office, (LAO, WESTCOM); Charles MacCrone, Army Missile Command, (unassigned); Charles Cundiff, Office of Missile Electronic Warfare, (LAO, EUSA); (back row, l. to r.) Dr. Henrich Egghart, Belvoir R&D Center, (LAO, USAREUR); Thomas Brower, Electronics R&D Command, (LAO, USAREUR); Dr. James Chevalier, Tank-Automotive Command, (SA, WESTCOM); Andrew Eckles, Human Engineering Lab, (SA, USAREUR); Greg Cirincione, Harry Diamond Lab, (SA, EUSA); Arlie Keister, Avionics R&D Activity, (LAO, EUSA). Not shown is Kevin Kirby, Night Vision and Electro-Optics Lab, (LAO, FORSCOM).

Implementation of the scientific assistance program concept has been managed by John McCarthy, special assistant to the director, Army Materiel Systems Analysis Activity, who was also a member of the original Marroletti Task Force. McCarthy has literally travelled around the world briefing the program concept to the MACOM commanders on behalf of the AMC commander. In addition, he was instrumental in recruiting and selecting the initial science advisors and in establishing operating procedures with each major command. His duties have been assumed on permanent basis by Don Keehan, who has been named program director.

The first science advisor team includes Andrew J. Eckles III, chief, Combat Vehicle System, U.S. Army Human Engineering Laboratory, who is assigned to U.S. Army Europe; Gregory V. Cirincione, chief, Radar Technology Branch, Harry Diamond Laboratories, who is assigned to the Eighth U.S. Army, Korea; and James L. Chevalier, chief, Armor and Components Function, Tank-Automotive Systems Laboratory, who is assigned to the U.S. Army Western Command. These science advisors have been in place at their respective assignments since January 1985.

An orientation for the science advisors and the logistics assistance office scientists and engineers was held at AMC HQs during the week of Dec. 17, 1984. Because these individuals will represent the entire laboratory/center system and not just the organization from which they came, they were briefed on a wide range of research, development and acquisition programs that may be relevant to their overseas assignments.

In addition, LTG Moore addressed the group (see photo) and expressed his belief that the scientific assistance program is an important step in providing the operational forces with the most technologically advanced and effective materiel in the world.



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Geophysical Methods for Military Ground Water Detection

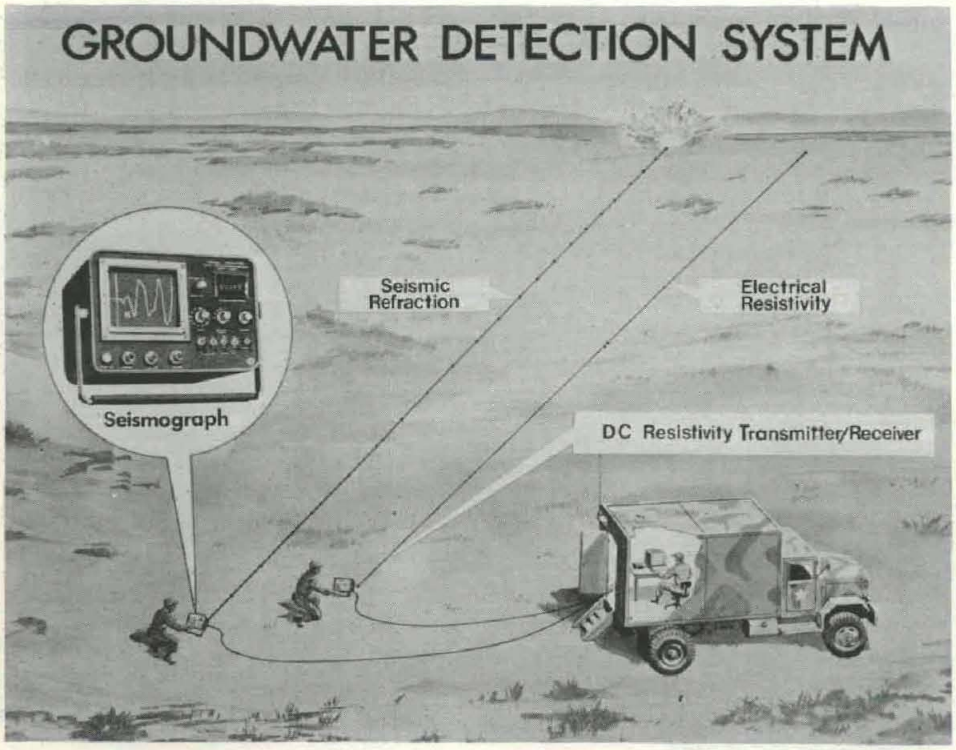
By CPT Robert J. Thompson

The need for ground water becomes increasingly important in arid regions where surface water sources are non-existent, inadequate, or grossly contaminated (i.e. with NBC contaminants). Recent emphasis on desert operations has prompted the Army to initiate efforts to develop an integrated ground water detection system consisting of: ground water statistical mapping overlays, remote data collection techniques (i.e. satellite imaging devices), and surface deployed ground water detection instrumentation.

The mapping overlays and the remote data collection techniques will be used to identify areas which potentially contain ground water. The surface deployed ground water detection instrumentation will identify the exact location within a potential area where the highest probability of drilling into an adequate water source exits. Thus, time and resources consumed in drilling dry or low-volume wells can be saved and more adequate water sources developed quicker.

The ground water detection system will permit locating water resources closer to using units, thereby significantly reducing requirements for long line bulk haul of water or large-scale water conduit systems.

In 1981, a Defense Science Board Water Support Task Force concluded that technology shortfalls exist in surface techniques for the detection of ground water. These shortfalls in technology were also recognized in a Draft Letter of Agreement for a Subsurface Water Detector, written by the U.S. Army Engineer School in 1981. In recognition of the ground water detection technology shortfalls, a Ground Water Detection Workshop was held in January 1982.



The conclusions of the Geophysics Working Group at the workshop were: there are two currently "fieldable" geophysical methods, electrical resistivity and seismic refraction, that are applicable to the ground water detection problems and may offer a near-term solution to the detection technology shortfall; and there are several state-of-the-art and emerging geophysical techniques that may have potential in the far term for application to the ground water detection problem.

Conceptually, the location of ground water by geophysical methods should be straightforward. The presence of ground water in rock and soil significantly changes both their electrical and seismic properties. However, the change of physical properties when the rock and soil are buried in the subsurfaces proves to be non-unique. Changes in other rock and soil properties may trigger the same geophysical anomaly as going from a dry to a saturated rock or soil. Hence, there is ambiguity in the interpretation of the existence of ground water.

The principal methods for ground water detection are electrical and seismic. These are most applicable because water significantly alters the measured physical properties.

The seismic refraction method consists of measuring the travel times of compressional waves generated by an impulsive energy source to points at various distances along the surfaces of the ground. The energy is detected, amplified, and recorded so that its time of arrival at each point can be determined. The raw data consists of travel times and distances. This timedistance information is then processed to obtain an interpretation in the form of velocities of wave propagation and structure of the subsurface strata. All measurements are made at the surface of the ground, and the subsurface structure is inferred from interpretation methods based on the laws of waves propagation.

The physical principle involved in detection of the water table by seismic methods is that the compression-wave velocity of saturated sediments is considerably greater than the same sediments in dry or only partially saturated conditions.

Surface electrical resistivity surveying is based on the principle that the distribution of electrical potential in the ground around a current-carrying electrode depends on the electrical resistivities and distribution of the surrounding soils and rocks.

Most soils and rocks conduct current primarily electrolytically, i.e. through interstitial pore fluid. Thus, porosity, water content, and dissolved electrolytes in the water are the controlling factors in determining resistivity rather than the soil or rock type. A major exception to this generalization is clay, which can conduct current both electrolytically and electronically. The usual practice in the field is to apply an electrical current between two electrodes implanted in the ground and to measure the difference of potential between two additional electrodes that do not carry current.

Electrical resistivity and seismic refraction methods are complementary in the sense that they respond to or detect different physical properties of geologic materials. In cases where both methods detect the water table, one method serves to confirm the results of the other method or to resolve ambiguities.

During 1982 to 1983, a joint testing investigation was conducted by the Colorado School of Mines and the Waterways Experiment Station, under the direction of the Mobility Equipment R&D Command (now Belvoir R&D Center). The purpose of this investigation was to assess the feasibility of using electrical resistivity and seismic refraction for military ground water detection application.

Two field sites were selected, each representing a common ground water occurrence. White Sands Missile Range (WSMR), NM, was the site for an alluvial aquifer with an unconfined water table. Fort Carson, CO, was the site for a confined (artesian) rock aquifer. Five locations were selected at WSMR with water table depths ranging from approximately 60 to 450 feet and water varying from fresh to brackish. For the location selected at Fort Carson, the depth to the top of the aquifer was approximately 270 feet and the thickness was approximately 100 feet. An assessment of the integrated methodologies used for the field testing revealed the following:

- Complementary seismic refraction and electrical resistivity surveys can generally be used successfully for ground water detection when the water table occurs in consolidated sediments and can generally not be used successfully for detection of ground water in confined rock aquifers.
- The most significant factors affecting the probability of detecting ground water are complexity and previous knowledge of existing geological conditions, skill of operator/interpretor, depth of aquifer, and thickness of aquifer.
- Rugged, reliable seismic refraction and electrical resistivity equipment is commercially available which would require very little adaptation for military ground water detection application.
- Interpretation of the field data is often a complex process requiring an individual with significant background and training in the survey techniques.

The last finding of the 1982-1983 study concerning the interpretation of the field data is crucial. The interpretation of geophysical survey data requires expertise in geophysics and several branches of geology that is not normally available in field units. In recognition of this issue, the Office, Chief of Engineers sponsored a Subsurface Water Detection Symposium in June 1984. One of the objectives of the symposium was to determine the potential effectiveness of a Department of Army water detection team and to make recommendations for a potential organizational structure. A position paper and proceedings of the symposium are currently being prepared and will soon be forwarded to the chief of engineers and commandant, U.S. Army Engineer School for action.

In summary, ground water becomes an increasingly important resource in hot/arid environments and also in NBC contaminated environments. The ability to accurately locate ground water remains a continuing challenge as the geophysical techniques used are highly complex.

The ability to have experienced professionals conduct ground water explorations will reduce the number of dry holes, but will not eliminate them. However, any geophysical technique that will significantly reduce the resources expended in the development of a productive water well should be exploited to ensure that water does not become a mission limiting factor.

CPT ROBERT J. THOMPSON, a graduate of Drexel University, was an environmental engineer in the Belvoir Research and Development Center's Logistics Support Laboratory when he wrote this article. A recipient of the Army's Expert Field Medical Badge, he is now attending the Medical Services Officer Advanced Course at Fort Sam Houston, TX.

Trends in Armor Materials Development

By MAJ Bruce W. Cotterman and Dr. Robert D. French

To many people, the word armor brings to mind a picture of some sort of ground combat vehicle, typically a tank. Others know that nearly every system has some component that is said to be armored; that is, given improved ballistic resistance. The array of such systems in the Army is vast, extending from certain items of protective clothing for the individual soldier through bunkers, housing, storage containers and tactical vehicles to combat weapons and vehicles of many types.

The trend in development of nearly all weapon systems is toward lighter-weight equipment. Armor on these systems is no exception to the trend in spite of increasing levels of threats. Although a certain amount of weight reduction can be gained through modern techniques of engineering design, eventually the materials in use must be lighter themselves.

Overseeing the development of these materials, introducing them to armor concepts through materials design analysis, and paving the way for development of the necessary materials industrial base are responsibilities of the Army Materials and Mechanics Research Center. To provide general awareness of armor material developments throughout the AMC community, it is helpful to review where some of the development stands today.

Metals

Technical developments in metals are concentrating on alloy development and improved processing techniques. Future challenges will arise in the areas of overcoming energy restrictions, critical materials shortages, increasing costs, and a potential shortage of available capacity for producing armor steels in the 1990s. Compounding these problems will be the increasing demand for better performance to improve combat vehicle survivability, both on the ground and in the air.

Armor steels are not ordinary steels and are becoming more sophisticated as the demands for performance on the battlefield increase. Since the Army is not a large buyer of steel in the U.S. market, it is not safe to presume the there will always be a domestic source of the materials needed at the lowest price.

Ongoing metallic armor programs include development of high strength steels for combined hardness and fracture toughness (see figure 1.) The objective is to develop structural tank armor with higher strength for improved ballistic properties and with higher fracture toughness for structural integrity.

Processing procedures from melting practices, through cutting and joining to the fabrication of the finished product, are being investigated to improve the shatter resistance of structural steel armor at temperatures at least as low as −40F.

High hardness steels are made in the United States today, but maintaining control of flatness and waviness on thinner plates requires special handling that increases costs and reduces the number of readily available suppliers. Part of the planned process development program is directed at overcoming this problem.

An ultrahigh strength steel, AF 1410 (14 Co, 10 Ni, 2 Cr), has also been investigated and characterized as a possible model for combat vehicle armor properties. This nickel-modified steel was originally developed as a substitute for titanium in selected aircraft components. Its cost and critical element content preclude its use for tonnage quantity applications in combat vehicles. However, except for its plate shattering transition temperature, this alloy has a remarkable combination of strength and toughness useful for baseline comparison purposes.

- Ultrahigh Strength Steels for Combined Strength
- Development of Armor Plate With Improved Shattering Resistance
- Thick Dual Hard Armor Steel
- Textured Steel for Armor Applications
- Improved Joining Processes For High Strength Steel Armor
- Processing and Alloy Studies for Improved High Strength Aluminum Armor

Figure 1. Ongoing Metals Program

One new class of alloys being investigated for possible application to combat vehicles is an ultrahigh carbon steel family. Work to date has demonstrated superplastic characteristics due to a very fine grain structure. The very high carbon content (one percent to two percent) means that these steels can be heat treated to high hardness levels. Their superplastic characteristics permit them to be easily rolled and even roll bonded to themselves or other steels and then selectively heat treated.

Another significant ongoing program is the development of specially processed textured steels. Through proper thermomechanical processing of steel armor, crystallographic preferred orientation can be controlled and utilized to provide useful improvements in ballistic and critical mechanical properties.

Development of joining processes for high strength steels has emerged as a high priority effort for ground vehicles. Significant progress has been made toward producing crack-free weldments with good ballistic properties. Concurrently, welding procedures for the production and field repair of advanced armors are also being prepared.

The use of aluminum armor on Army ground vehicles is rather extensive for reasons which include ballistic properties, light weight, ease of manufacture and low cost. Despite these advantages, there exists an urgent need for improved corrosion characteristics and better ballistic performance. Another ongoing program is addressing both deficiencies. Subtasks include developing an understanding of the effect of alloy chemistry and controlled deformation mechanisms on strengthening and stress corrosion.

Ceramics

Lightweight ceramic armor was investigated and developed in the early 1960s. Its principal use has been in personnel armor although some has found its way into helicopters where added weight means a strong cost penalty. Application of ceramic armor technology to ground combat vehicles at that time was considered, but abandoned for reasons which included high material cost, along with a lack of structural and multiple-hit integrity. Because of escalating protection requirements on current and future combat vehicles against medium and heavy threats, ceramic armor has once again emerged as a prime candidate for vehicle armor systems.

Development programs include investigating, characterizing, and applying lightweight ceramics for special armor requirements (see figure 2). Methods to achieve multiple-hit capability with ceramic armor are being intensively studied and tested.

Perhaps the most important ceramic armor technical objective is a reduction in the cost of ceramic armor materials without significantly sacrificing ballistic properties. Some very promising ceramic armor candidates for combat vehicle application are emerging. Processing studies are being intensively pursued to make these candidates more attractive in terms of reduced cost. As a part of this effort, several different sintering techniques are being explored. Sintering is a processing technique amenable to mass production with potentially lower costs.

Another parallel cost reduction study focuses on the development of techniques to make low cost starting powders. Together, these processing studies promise to make ceramic armor cost competitive with other armor systems being developed against future battlefield threats.

Ongoing

- Characterization of Ceramic Armor for Protection Against Medium and Heavy Threats

Planned

- Development of Low Cost High Performance Ceramic Armors

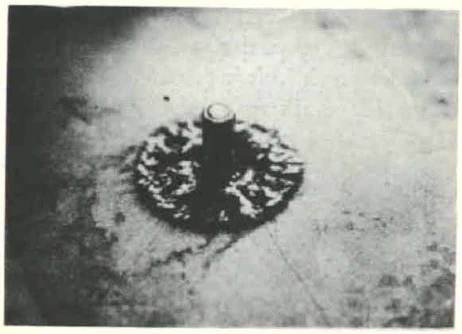


Figure 2. Ceramic Armor

Organic Materials

The use of organic materials for combat vehicle structures and components is being considered with increasing interest. Composite materials have already demonstrated a useful capability for blast hardening of combat vehicle roadwheels and track shoes. In addition, lightweight composite armor systems which include organic-base materials such as glass reinforced plastic are being evaluated for application to ground vehicle structural components.

A scale-up project is underway with industry to demonstrate the feasibility of a composite structure with integrated armor for the turret of an infantry fighting vehicle. Reduced weight and cost, and im-

Ongoing

- Engineered Composite Materials for Blast Resistant Suspension Components
- Lightweight Composites for Vehicle Hull Sections
- Spall Supression Liners

Liners

- Environmental Performance

Figure 3. Organic Composites

proved ballistic performance are the goals (see figure 3).

Kevlar and glass reinforced plastic type materials have been demonstrated to be most effective for spall suppression liners within critical combat vehicle areas. Liners which will decrease and/or absorb backspall and provide enhanced radiological protection have been developed.

Organic materials development emphasis will shift in the near future to the determination of long-term properties. Development and optimization of composite roadwheel and track shoe components will continue under TACOM direction.

Performance of all structural components will be determined in environments such as the natural climate variations and exposure to fuels, hydraulic liquids and other contaminants.

Composite/Hybrid Structures

Composite/hybrid structures are replacing monolithic metals in many applications, including armor (see figure 4). General reasons include weight and cost reduction and improved multithreat ballistic capability. Lightweight steel-aluminum Kevlar composite armor, for example, has been optimized for kenetic energy and fragment operation. A system of this type is used on the current M-9 Armored Combat Earthmover design. Other systems of different designs have been produced for the Ground Launch Cruise Missile System, Improved TOW Vehicle, M110 Self-propelled Howitzer, and a crash survivable seat for helicopter pilots.

Planned work in this area will intensify. Evaluations integrating composite armor systems with structure will be conducted. In addition, other composite armor concepts are being designed for special area protection requirements for high energy antitank, anti-personnel and self-forging fragment threats.

Threats

The classes of armor materials covered here are not all-inclusive of even the passive armors, but it should be clear that development is active on a broad front. Moreover, the story does not end with a new material, for that material must be integrated into a system concept. This is a responsibility of the weapon system developers within the AMC major subordinate commands.

Well before a material or material array concept is ready for release, advanced concept system developers are tracking progress. When the handoff to systems materials engineers is made, then AMMRC moves into its service support role, working with Army developers and contractors to solve any unexpected materials related problems during the systems integration process. Armor materials development activity is not only broad but also has considerable depth, from basic research through applications.

An overview of this nature is necessarily a broad-brush treatment. Further details or questions concerning possible applications of armor materials technology should be directed to the Army Materials and Mechanics Research Center.

Advantages	Ongoing and Planned
• Lightweight	• Composite Design Configuration
• Low Cost	• Integrating Armor to Structures
• Multithreat Protection	• Special Area Protection
	• Medium Threat Appliques

Figure 4. Composite / Hybrid Armor

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AMC Establishes DCS Intelligence Office

By LTC John L. Cook

For those of you who pay close attention to the Headquarters Army Materiel Command's organizational chart, you may have noticed a new box squeezed in between the Deputy Chief of Staff for Development, Engineering and Acquisition, and the Deputy Chief of Staff for International Programs. It's a small box as boxes on this chart go and you may have overlooked it. Or, if you noticed at all, you may have mentally dismissed it as another attempt to build an empire in a forest of empires. Well, let me tell you about this little box—Office of the Deputy Chief of Staff for Intelligence (DCSI). You will learn how it's going to do some amazing things for all of us in the materiel development world.

The Office of the DCSI was established on Sept. 1, 1984 as part of AMC Commander GEN Richard Thompson's reorganization of AMC Headquarters. However, the need to provide the developer first rate intelligence support has always existed. The overall mission of the new office is straight forward—"to formulate and direct the execution of intelligence and security policies required to support and protect the Army Materiel Command's research, development, acquisition and readiness programs." The bottom line is that the office will provide whatever intelligence support AMC needs.

First, in the area of security, the Office of the Deputy Chief of Staff for Intelligence will provide a full array of services designed to protect our sensitive technology. This will be done by:

- Preparing AMC policy on counterintelligence and operational security.
- Identifying, validating and managing Special Access Programs.
- Managing information, personnel, signal, industrial and automatic data processing security.
- Directing preparation of security classification guides. As technology has grown, so has concern over managing the transfer of technology. To meet the command's needs in this critical area, the new office will manage AMC's International Technology Transfer Control program by:
- Coordinating with AMC subordinate elements, TRADOC, DA, DOD, international authorities, and industry for early identification of critical technologies.
- Provide notification of critical technologies to proper agencies, thus insuring proper protection.
- Preparing AMC policy and guidance on all aspects of technology transfer.

These services are critical to the developer and need to be provided by the AMC staff in a coherent, coordinated manner. In addition, they must be aggressively managed in order for us to keep faith with the outlying provinces. If the intelligence office accomplished only the objectives already mentioned, then the expenditure of resources would be well rewarded. But it would not be enough. We need to address the command's number one priority—shortening the acquisition cycle. GEN Thompson has made it clear that a four-year development cycle can and will be achieved. In order to get there, all staff elements must make a contribution to this end. I hope you're thinking along these lines because you will want to pay particular attention to what comes next.

The creation of an Office of the Deputy Chief of Staff for Intelligence at AMC Headquarters represents a revolutionary change in the way we've always done business. For the first time, the development world and the intelligence world are joining forces across a wide spectrum. This means we can no longer think of intelligence as an end in itself. Rather, it is a means to an end. Intelligence will be used as a tool, stripped of its mystique and "green-door" syndrome, to provide whatever information is necessary to shorten the acquisition cycle. If someone else in the world has an idea or a proven technology that can be used to shortcut our own development efforts, then we'll use it. This can lead to the identification and application of alternative designs, manufacturing technology, and production engineering.

Foreign materiel exploitation will be a major mission of the new office, and it will be managed aggressively to achieve this end. Why? The answer is because we can no longer afford the luxury of starting every program or project from zero. The development world has been criticized in the past for allowing the "not invented here" syndrome to cloud our vision. As a result, we have not injected foreign technology into our acquisition cycles to the maximum extent. This criticism will continue until we do better.

Time saved during development represents resources saved for other critical systems. To achieve this goal, AMC must be viewed as the Army's major consumer of technical intelligence. During the concept formulation stage of every program, careful consideration must be given to foreign technology. It must be given the same priority as other critical issues such as reliability and supportability to determine if foreign technology can be applied.

Another area where the new office can play a time-saving role involves threat assessment. "Threat" must be considered on two levels. First, we must consider why we're fielding the system. If it is to counter some new enemy capability, then this capability is the threat. Second, we must determine the degree of vulnerability the system will be exposed to on the battlefield. This degree of vulnerability, or risk, is also the threat.

In short, the system must be both survivable and effective. This is impossible without an accurate threat assessment. Currently, the materiel developer is forced to go on a hunting expedition to find the information he needs to prepare the threat annex to his requirement. This is a time consuming and, frequently, frustrating exercise. To improve threat support, the new office will serve as focal point for threat assessment and validation within AMC. This service will cut time from the development cycle and free the developer to pursue other tasks.

To accomplish all this, the intelligence office will have approximately 40 employees at the headquarters, divided into various technical areas of responsibility. In addition, the office was recently tasked with direct supervision of the U.S. Army Intelligence Materiel Activity, located at Fort Meade, MD.

There are other duties and responsibilities that must be satisfied by the new intelligence office and, no doubt, new ones will come as time passes. I've only touched on the critical ones. Can all this be done? Yes. Will it be easy? Not really. It will require both the intelligence and development communities to undergo a massive philosophical change and then come to the conclusion that we all need each other to execute the mission that has been laid out. There's a horse for everybody to ride—all we have to do is stay in the saddle.

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Evolution of M60 Tank Series Continues

In 1959, the first of the M60 series of main battle tanks entered the Army inventory. Today, testing of this proven weapon system still continues at the Combat Systems Test Activity (CSTA), Aberdeen Proving Ground, MD.

The tank that is being put through its paces, the M60A3 TTS (Tank Thermal Sight), is almost a completely new design from the M60 that made its rounds in 1959. One of the earlier versions has already found an honored place among the other war relics preserved at the Army's Ordnance Museum.

Further product improvements in the M60 series are still planned. This reliable system will probably remain with the Army's armored forces for another 20 years, according to Edward H. Roberts, chief of CSTA's Automotive Division.

The need for the M60 became apparent in 1956 when intelligence reports showed the Soviet Union was developing a well-armored, powerfully armed new tank, the T54. In response to this threat, the Army sought a new tank to replace the M48 series it was currently using.

An experimental T95 tank demonstrated to the Army the effectiveness of a new British-designed tank gun, the L7 105mm rifled cannon. Tests showed that, if the breech were redesigned, the weapon could be fitted into the M48 turret. The redesign was accomplished and the gun was adopted by the Army as the M68 105mm gun.

The next step to counter the T54 was to enhance the armor on the American tanks. A complete redesign of the M48 hull was undertaken using a new, flat rolled-plate glacis. The M48 tank commander's cupola also was redesigned with the old M1 cupola being replaced by the larger M19 version that is still in use today.

Since the M60 was to replace both the M48 medium tank and the M103 heavy tank, the term heavy and medium tank was dropped by the Army in favor of a new nomenclature, main battle tank. The final improvement inaugurated in the M60 involved replacement of the M48 tank's stereoscopic range finder, adopting in its place a coincidence range finder which was easier to use and more effective in actual service.

A major drawback in the M60 design lay in the turret which was essentially the same as on the M48 tank. The larger M68 gun used larger shells and, consequently, ammunition storage in the turret was restricted. A major redesign of the turret produced one which was better shaped, more thickly armored and capable of storing a larger load of ammunition. As production of the new M60 variant began in the early 1960s, the model was renamed the M60A1.

The new M60 chassis aroused the interest of the Army Corps of Engineers and, within a few years of the initial introduction of the M60 tank into the inventory, two major engineer vehicles were in production based on the M60. The first was a version of the Armored Vehicle Launched Bridge, a scissors-type bridge which had already been proven using the M48 chassis.

The second vehicle was the M728 engineer vehicle which saw the M68 main gun replaced with a short-barreled 165mm demolition howitzer, a bulldozer blade installed in the front of the vehicle, and a heavy duty A-frame jib boom installed on the turret to enable the vehicle to function as a crane.

While the M60 and M60A1 tanks never saw combat in Vietnam, both engineer versions were active in that conflict. An M728 once demolished a North Vietnamese tank with a single shot.

In 1964, the Army decided to experiment again with the M60 tank to determine whether the new 152mm Shillelagh missile/gun system could be mounted on the vehicle. Tests at Aberdeen and elsewhere in the Test and Evaluation Command (TECOM) were successful and the M60A2 soon entered the Army inventory. The M60A2 variant remained in service until 1980.

The fighting in Vietnam held down Army funds for armor development throughout most of the late 1960s, but in 1971 a modification program was begun for the M60A1 to keep it current with recent technological developments. The first of these modifications resulted in a top-loading air filter for the tank engine, and an add-on stabilization (AOS) system for the 105mm M68 gun.

This had been a dream of American armor crewmen since 1942 when the first gyro stabilizing system was attempted, unsuccessfully, on the M4 Sherman tank. The M60A1 AOS worked well and allowed the M60A1 to fire accurately on the move. This enhanced the M60's survivability since a moving target is harder to hit than a stationary one.

The AOS phase of modification was followed by a second, tagged "reliability improvement of selected equipment," which saw the AVDS 1790-2D engine and improved electrical harness installed in the M60A1. In 1977, the final M60A1 modification was completed, consisting of a deep-water fording kit and passive night sights. The infrared system on the vehicle was removed.

1978 saw the next stage of M60 series modifications begin. Modifications were so extensive that the M60A1 was redesignated the M60A3. A ruby laser range finder, a solid-state analog ballistic computer, an M240 coaxial machine gun, and a thermal sleeve for the gun barrel to prevent heat warpage were incorporated into the tank.

The next year, 1979, saw the latest version of the M60A3 enter production, the M60A3TTS. This variant saw the passive night sight replaced by an improved system which amplifies the night sight image by sensing incident infrared emissions from the area outside the tank. This system allows the tank to fire when there is no ambient light, on a literally pitch-black night. A wind drift sensor on the M60A3 also has been added to enhance firing accuracy of the main gun, a new track design has been adopted, and smoke grenade launches have been added to the turret side.

Today, the M60A3 is still in production, despite the fact that it was originally planned to terminate M60 series production in April 1981.

There are three types of tests by CSTA on the M60A3. First, tests are run on randomly selected sample production M60A3s to ensure the manufacturer, General Dynamics Tank Systems Division, is meeting contractural specifications.

The second type of testing deals with those rebuilt M60A3s and M60A1s which have been upgraded to M60A3 TTS standards at Anniston Army Depot, AL. The rebuilt vehicles undergo the same grueling tests as the new tanks—the automotive systems are checked, the guns are fired, the laser range finder is checked out, and so forth. A full climate test is also done on one vehicle each year.

The third, and last, type of testing on the M60A3 involves evaluating new systems being considered for adoption to enhance the tanks's operation and extend its service life.

"We're into an 18-month test of an M60A3 enhancement program right now," says Art Cummings, M60 series test director, CSTA, "in which we're evaluating the potential of a hydropneumatic suspension system for the tank.

"We also are looking at replacing the ruby laser range finder with a carbon dioxide laser system. Other areas we're examining involve enhancing the basic armor package, changes in the main gun system, installing a digital computer to replace the tank's analog computer system, and a new transmission system," Cummings said.

From The Field ...

Copperhead Achieves New Milestone

The M712 155mm Guided Projectile (Copperhead) program has reached another milestone. Following on the heels of its deployment to U.S. based units and introduction to service schools in this country, Copperhead has begun to be fielded in Europe.

In addition to receiving the laser-guided projectiles, our troops will be given total Copperhead logistics support. This includes training rounds, extractors, repair parts, and technical manuals. In addition, the laser designator that is part of the Copperhead system will get similar logistics support.

Deployment of the Copperhead system to Europe is the culmination of a great deal of materiel fielding planning involving the Office of the Project Manager for Cannon Artillery Weapons Systems, the U.S. Army Armament Research and Development Center, the U.S. Army Missile Command, and the gaining command—U.S. Army Europe.

Meanwhile, Cannon Artillery Weapons Systems officials have expressed elation over the results of testing of the last four production lots of Copperhead projectiles at White Sands Missile Range, NM. Every round fired scored a hit.

Earlier, Copperhead had hit the target for a success rate of more than 80 percent during operational tests conducted at Fort Riley, KS, under realistic European-type battlefield weather conditions. The adverse weather included rain and wind gusting up to 50 miles per hour.

Officials noted that Congress is processing an increase in Copperhead procurement funds for Fiscal Year 1985. The Army had originally requested $103 million. That figure has been increased by approximately $30 million by four Congressional committees. The U.S. Marine Corps was allocated an additional $12 million for Copperhead procurement. It should be noted that the Army's FY84 procurement figure was $73 million.

Copperhead is a modified 155mm artillery projectile that is equipped with a laser-seeker and control fins. In flight, the seeker senses reflected laser energy from a target designated by a laser-equipped forward observer and controls the trajectory to automatically home in on the target—whether moving or stationary.

BRL Reports on Low-Vulnerability Ammunition

Research to develop low-vulnerability ammunition for U.S. Army tanks, under way at the Ballistic Research Laboratory (BRL) since 1973, is close to putting the first generation of these materials into the field for use by tank crews.

According to Dr. Joseph J. Rocchio, low-vulnerability ammunition project manager, the study began following the October 1973 Yom Kippur War in the Middile East. Post battle analysis showed the majority of tanks which were destroyed in the fighting were destroyed by the explosion of ammunition carried inside the tank.

The principal effect of anti-armor weapons was to penetrate the tank's armor and produce a cloud of hot metal shards. These then hit ammunition in the tank, penetrated the shell casings and triggered catastrophic explosions.

In December 1973, Harry Reeves of BRL's Vunerability Division asked the Interior Ballistics Division if it would be possible to develop a propellant which would perform as well as the M30 propellent contained in the tank shells, but which would be less likely to explode if penetrated by hot metal fragments generated by a "hit" on the tank by an armor-penetrating weapon.

If the tank's on-board ammunition could be rendered safer from these hot fragments, damage from a hit by an anti-armor weapon could be repaired quickly, and the tank could be returned to action. BRL research showed the most vulnerable portion of the tank's on- board ammunition was the propellant in the shell casing. "The casing of a shaped charge warhead," says Rocchio, "is much thicker than the cartridge case and is far less likely to be penetrated by hot fragments generated by a hit from an anti-armor weapon. Also, since the warhead is much smaller than the cartridge case, it presents less of a target for the fragments to hit."

BRL researchers began by examining work done during the Vietnam era in developing caseless ammunition for Army rifles.

Rocchio said, "during development of this caseless ammunition, it was determined they could be easily ignited by a stray heat source such as a hot cigarette or a match." This led to further work to develop a propellant that had a high ignition temperature but which was self-extinguishing at normal atmospheric pressures.

"Essentially, we were looking for a propellant that would burn under pressure—such as in the breech of a gun—but would not burn outside the weapon," Rocchio said.

Because of technical problems, the goals of this earlier research were not fully achieved, but it did offer a starting point for BRL research into low-vulnerability ammunition. Many problems inherent in developing the caseless rifle ammunition could be avoided when the techniques were applied to tank cannon ammunition.

What was initially devised was named low-vulnerability ammunition—X1A. This was a mixture of HMX, a high explosive, which was finely ground and dispersed in an inert polymer binder. This proved that lower vulnerability could be achieved while maintaining ballistic performance. For a commander on the battlefield, this means between one-third and one-half of the tanks he could expect to lose could instead be repaired and returned to action.

"Our research at BRL has progressed a long way from the initial X1A formulation," Rocchio said, "and we have gained a clearer insight into the physics and chemistry that affect ammunition vulnerability and its ballistic performance."

The low-vulnerability ammunition program is now a joint Army-Navy effort involving several laboratories. Work is now under way to put an advanced first generation formulation into the field for 105mm tank gun ammunition.

"We're at the beginning of the end of this study," according to Rocchio, "and work should be completed by September of this year. If the Army decides to adopt low-vulnerability ammunition as a replacement for M30 as the propellant for tank cannon ammunition, tank crewmen in the second half of this decade should find themselves using a far safer, but equally reliable and effective, ammunition."

Tank commanders, instead of losing multi-million dollar weapons systems and trained crewmen as a result of internal explosion of on-board ammunition, should be able to recover and repair upwards of 50 percent more vehicles with a corresponding decrease in the casualty rate among crews.

SP4 Robert Wood, Battery B, 5th Battalion, 8th Field Artillery, wearing new Tactical Load Bearing Vest. The Large Field Pack's top flap pocket is removable and can be attached to the vest as a combat patrol pack.

Natick Develops New Load-Carrying Items

Today when a soldier goes out to the field he can look like a peddler displaying his wares. Ammo pouches, canteens, poncho, flashlight, knife and protective mask hang about his waist. An entrenching tool, sleeping bag and pad are strapped to a cumbersome rucksack which is strapped to his back. The sleeping bag and other assorted equipment bang against his body as he walks. With a weapon in his hand and extra ammo stashed . . . somewhere . . . he is outfitted to engage the enemy, right?

Well yes, but the U.S. Army Natick Research and Development Center thinks they have found a better way to carry the load. Last October, they recommended the Army Clothing and Equipment Board approve two new items: a Tactical Load Bearing Vest and a Large Field Pack.

The Tactical Load Bearing Vest was designed to be a more efficient method of carrying individual fighting equipment. Instead of having a lot of equipment around the waist, there are cargo pockets on the vest front which distribute the weight over the upper torso. There are also permanently attached grenade and ammo pouches on the vest which leave room on the belt for other equipment.

For comfort, the vest design incorporates laces and straps which allow adjustments in torso length and girth. It is made of nylon fabric in a woodland camouflage print and weighs 1.8 pounds empty.

The Large Field Pack is designed to allow the combat soldier to more efficiently carry his mission existence load under all environmental conditions. With an internal capacity of 7,500 cubic inches, the pack has side pockets with compression straps located on each side of the pack to carry long narrow objects.

Besides being roomier than the current rucksack, the Large Field Pack features a separate zippered compartment for the sleeping bag. The compartment allows easy access to the sleeping bag and protects it in bad weather.

As an added feature, the top flap pocket of the pack is removable and can be attached to the Tactical Load Bearing Vest as a combat patrol pack.

A unique suspension system allows the pack to be custom-fitted to most soldiers. A torso bar allows the pack to be adjusted for length and inner frame bars can be bent to match the contour of a soldier's back. Although it may sound as if the added features also add weight, the pack is a light system.

Innovative field tests were conducted last summer at the Yakima Firing Center in Yakima, WA, and at Camp Ethan Allen in Vermont during the winter of 1984. According to Natick officials, test reports indicate that both the pack and the vest have potential for military use.

The preceding article and accompanying photo were prepared by SP5 Lori Goodrow, a photojournalist assigned to HQ, XVIII Airborne Corps and Fort Bragg, NC.

Howitzer Improvement Program Continues

The Department of the Army has announced approval of the 155mm self-propelled Howitzer Improvement Program to be managed by the project manager for Cannon Artillery Weapon Systems and supported by researchers at the U.S. Army Armament R&D Center (ARDC), Dover, NJ. The decision to continue with the improvement of this weapon system marks a major turning point in artillery weapon system development.

Work on the 155mm howitzer improvement began in 1980 and has been the subject of an extraordinary effort. Initially, concepts to improve the 155mm howitzer as well as new and foreign system alternatives were explored. Later, full-scale mockups—representing various configurations of the self-propelled howitzer—were developed and displayed at the Pentagon and other sites around the country.

The program is now in full-scale engineering development. Significant improvements in the M109A5 self-propelled howitzer will be forthcoming as a result of this phase.

The Army will select a prime development contactor next year as part of its full scale engineering development effort. Concurrent in-house government development efforts will be carried out by the Armament R&D Center's Large Caliber Weapon Systems Laboratory and integrated by the prime contractor under the direction of the project manager.

Engineers Examine New Bridging Systems

Prototype foam flotation bridging/rafting systems developed by the U.S. Army Construction Engineering Research Laboratory (CERL) have been tested by the 15th Engineer Battalion at Fort Lewis, WA. Polyurethane foam river crossing equipment is lightweight, quick and easy to use, and relatively unsinkable—even when subjected to small-arms fire and shell fragments.

Researchers tested a three-man reconnaissance boat, a light tactical vehicle flotation system, and a foam footbridge in a rapid-flowing river. The reconnaissance boat consists of water-resistant canvas filled with polyurethane foam.

The light tactical vehicle flotation system consists of two foam-filled fabric cylinders and aluminum channel members for attaching the cylinders to a ¼-ton utility truck. Finally, the foam footbridge consists of 20-foot, foam-filled canvas sections linked together to form a walkway.

The reconnaissance boat and the vehicle floation system, capable of supporting 700 pounds and 4,400 pounds respectively, worked extremely well. Researchers are studying the effects of high current to improve the footbridge's performance. The footbridge will be improved and retested in spring 1985.

CERL is developing the MLC20 Rafting System which supports up to 40,000 pounds and can float heavy Army vehicles across rivers or serve as a bridge section. This system will be tested in summer 1985.

Awards...

5 Army Employees Get Presidential Rank Awards

Five Department of the Army Senior Executive Service (SES) employees are among 19 recipients of 1984 Presidential Rank Awards.

Career SES members whose performance is deemed exceptional for an extended period may be granted one of two presidential ranks of either "Distinguished Executive" or "Meritorious Executive." An individual may receive each award only once in any five-year period.

Each year, up to five percent of SES executives may receive the Meritorious Executive Rank, which includes a $10,000 award. The Distinguished Executive Rank, which carries a lump sum payment of $20,000, may be awarded annually to no more than one percent of SES members.

Army recipients of the 1984 Distinguished Executive Rank are: Richard B. Lewis II, director of Army research and technology, Office of the Deputy Chief of Staff for Research, Development and Acquisition, (ODCRDA); and Dale F. Kinney, deputy for command operations, Army Depot Systems Command.

Lewis was cited for his sustained and extraordinary accomplishments as former technical director of the Aviation R&D Command and in his present capacity as director of Army research and technology, ODCSRDA. His application of exceptional technical abilities, coupled with his innovation and vision has, according to his citation, provided the Army with aggressive programs for future rotorcraft.

As technical director of the Aviation R&D Command, Lewis was responsible for activities ranging from basic and applied research through engineering development and qualification to technical support of more than 8,000 fielded Army aircraft.

Kinney was recognized for his pioneering efforts in making the Depot Systems Command a model of high work force productivity. He was instrumental in establishing a productivity gain sharing program which saved an estimated 30 man-years.

Additionally, Kinney was credited for his efforts which resulted in the command's having the largest Quality Circle Program in the Army, and for establishing Centers of Technical Excellence which are intensely involved in early maintenance planning for the Army's newest weapons systems.

Army recipients of the Meritorious Executive Rank are: Theodore A. Pfeiffer, technical director of the U.S. Army Communications Electronics Command (CECOM); Dr. Edward J. Poziomek, chief, Research Division, Army Chemical R&D Center; and Dr. Harry M. West III, deputy director, Army Manpower Programs and Budget, Office of the Deputy Chief of Staff for Personnel, HQ DA.

Pfeiffer was chosen for Meritorious Executive Rank as a result of his superior professional talents and outstanding technical and managerial direction which resulted in early fielding of priority equipment, an evolving ability of the Army to deal with rapidly changing technologies, and the ability of CECOM to lead the way in applying new technology to the Army's command, control, communications and computer systems.

Dr. Poziomek is recognized for his far-reaching contributions to the nation's chemical/biological defense and chemical deterrence research programs. During the past five years, Dr. Poziomek implemented a broad multidisciplined extramural research program, established a number of programs which brought nationally renowned scientists to the Chemical R&D Center, and he instituted an annual Chemical Defense Research Conference. He also helped build and shape a strong in-house research force.

Dr. West is credited for his contributions to long-term improvement in economy and effectiveness of both the Army and the Navy in the fields of manpower mangement, weapons systems affordability, and specific manpower requirements in support of tactical effectiveness and operational readiness. Dr. West was singularly responsible for the comprehensive and articulate presentation to the DOD, Office of Management and Budget and to Congress of critical civilian Army manpower needs to enhance near-term readiness.

Secretary of the Army Honors 22 Personnel

Twenty-two Army civilian and military personnel were recently honored for their exceptional service to the nation at the annual Secretary of the Army Awards ceremony.

The awards were made in six categories: exceptional and distinguished civilian service, outstanding suggestions, outstanding achievement in equal employment opportunity, editor of the year and publications improvement. Five exceptional civilian service awards were for herosim.

Secretary of the Army John O. Marsh Jr. told the honorees, "We are engaged in a search for excellence in this country." He added, "We are a stronger nation today because of your contributions."

Decorated for exceptional civilian service were:

- Dr. William R. Beisel, deputy for science, U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Fredrick, MD, for developing measures to immunize soldiers against biological agents and infectious diseases.
- Harriet L. Hightower, supervisory budget officer, Office of the Deputy Chief of Staff for Research, Development and Acquisition, for effective management leading to improvements in the Army's research and development program at the Pentagon.
- Dr. Ingo W. May, supervisory chemist, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, for technical achievements in interior ballistics and propulsion systems which contributed to the development of liquid propellant gun technology.
- Alan M. Moss, technical director, U.S. Army Armament Research and Development Center, Dover, DE, for leading development of a new type of kinetic energy armor defeating cartridge and other specialized munitions.
- Benjamin E. DeCenzo, supervisory mechanical engineer and deputy commander, Lima Army Tank Plant, Lima, OH, for substantially increasing production of and improving quality control for the M1 Abrams tank.
- Lyman L. Ellis, supervisory communications specialist, U.S. Army Information Systems Command-Japan, Camp Zama, Japan, for achieving cost savings of $41,438,000 while managing and directing communications projects in Camp Zama, Japan.
- William C. Garner, supervisory civil engineer, Greers Ferry Resident Office, U.S. Army Engineer District, Little Rock, AR, for directing the Greers Ferry Project, a model clean-up campaign for parks, camping areas, beaches and nature trails.
- Robert J. Surkein, director of transportation and traffic management, U.S. Army Armament, Munitions and Chemical Command, Rock Island, IL, for developing procedures for shipment of ammunition to all military services which resulted

in cost avoidances totalling more than $63 million.

• Joseph D. Vincent, deputy director for materiel, 29th Area Support Group, 21st Support Group, 21st Support Command, Kaiserslautern, Federal Republic of Germany, for his efforts in preparing the European logistic community for changes associated with force modernization.

Five Army civilians were decorated for exceptional civilian service as a result of acts requiring great courage and voluntary risk of life. Fort Belvoir, VA, firefighters Robert E. Spence, Russell E. Dodge Jr. and Robert E. Missal were honored for risking their own lives to rescue three small children trapped in a burning house in 1983.

Janet Z. McCormack, a civil engineer with the U.S. Army Engineer District in Tulsa, OK, jumped into the swift currents of a creek and pulled a drowning worker to safety. Harry L. O'Connell III, with the U.S. Army Engineer District in Pittsburgh, PA, rescued an injured fisherman whose canoe had capsized. O'Connell swam 250 feet in the dark, calmed the man and assisted him in holding onto a ring buoy until help arrived.

A Distinguished Civilian Service Award was presented to Eugen Lenhardt, plant manager, Equipment Support Center, 29th Area Support Group, 21st Support Command, Kaiserslautern, Federal Republic of Germany, for his role in making cost saving modifications to refrigeration trailer vans and standard trailers in Europe.

Outstanding Suggestion Awards went to Anthony W. Stoll, supervisory electrical engineer, U.S. Army Engineer Topographic Laboratories (ETL), Fort Belvoir, VA, and to CPT George H. Wotton, electronics project engineer, U.S. Army Electronics Materiel Readiness Activity, Vint Hill Farms Station, Warrenton, VA.

Stoll saved the Army and taxpayers $1,327,000 in 1983 by recommending that ETL purchase spare parts for a military mapping system direct from the factory and through existing government contracts. CPT Wotton saved the Army $904,658 in first year savings for his suggestions to build test devices for experimental equipment in-house.

Awards for Oustanding Achievement in Equal Employment Opportunity went to three individuals. Troy E. Ellis, installation maintenance officer, Directorate of Industrial Operations, U.S. Army Infantry Center and Fort Benning, GA, increased opportunities for handicapped persons. Calvin W. Munroe, general supply officer, Anniston Army Depot, Anniston, AL, and Dr. Robert W. Whalen, Supervisory Engineer, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, both substantially increased opportunities for women and minorities in their commands.

Patricia S. Pond, writer-editor, U.S. Army Chemical and Military Police Centers and Fort McClellan, AL, was named Army Editor of the Year for her work on two critically needed field manuals on the AirLand Battle.

The Award for Publications Improvements went to Benjamin T. Gouse, logistics management specialist, U.S. Army Logistics Evaluation Agency, New Cumberland Army Depot, New Cumberland, PA, for reducing 57 cumbersome logistics regulations to nine handbooks.

Capsules...

Beretta Will Produce DOD's 9mm Gun

The Department of the Army, as executive agent for the Department of Defense, has announced the winner of its competition for a 9mm personal defense weapon. The Beretta U.S.A. Corp. of Accokeek, MD, has been selected to supply the new standard handgun to be used by the Army, Navy, Air Force, Marines, and Coast Guard. A five-year, multiyear, fixed-price contract for 315,930 weapons will be awarded to Beretta.

The Army decision was based on a thorough test and evaluation of eight candidate weapons from both American and foreign manufacturers. The Beretta was one of only two candidates to satisfactorily complete a rigorous test program designed to verify both performance and durability under both normal and adverse environmental conditions. It met or exceeded all mandatory requirements and was judged to have the lowest overall costs and provides potential further savings over the life of the weapon due to durability advantages.

The 9mm Beretta will be the first new military handgun since introduction of the .45 caliber pistol in 1911. The need for a new standard handgun was reflected in a 1978 House Appropriations Committee survey that showed a proliferation of handguns and ammunition among the services.

The adoption of a 9mm standard handgun and ammunition will provide compatibility with our NATO allies and result in savings and efficiencies due to its enhanced reliability, better performance, and lighter weight.

DOD Establishes Software Engineering Institute

Undersecretary of Defense for Research and Engineering Richard D. DeLauer has announced the selection of Carnegie-Mellon University, Pittsburgh, PA, to implement and operate the DOD Software Engineering Institute (SEI) which will serve as a federally funded, R&D center to support DOD in software engineering technology. The selection of the university is subject to the negotiation of a satisfactory definitive contract.

The mission of the SEI is to accelerate the transition of advanced software technology into practice for defense in areas such as intelligence surveillance, command, control and weapons systems. The SEI is intended to be a credible advocate for new technology, a visible standard of excellence for DOD software engineering practices, and a stimulus and guide to the entire defense software community.

Activities of the institute will focus on methods of technology transition and will exclude development of mission software for defense systems. In this area, DOD will continue to rely heavily on the private sector to satisfy its needs.

As a federally funded center, the SEI will be a national resource, free of proprietary, commercial, or profit interests with wide, unimpeded access to industry, academic and government data concerning software technology. Following the completion of negotiations with Carnegie Mellon, the institute will be established under a five-year contract.

Computer software essential to a mission has been growing rapidly in size, complexity and cost as defense systems become more sophisticated. A significant amount of new software technology exists, and continues to emerge at a rapid rate from the R&D community. Very little of this technology, however, is used in practice. The SEI is intended to eliminate this problem.

The institute plans to employ 250 people, mostly scientific and technical personnel. It will support all military services and DOD agencies, and will be administered by the Air Force Electronics Systems Division, Hanscom Air Force Base, MA.

Army Research Office Moves

The U.S. Army Research Office moved to a new and larger facility on Nov. 2, 1984. The new building, which is leased through the General Services Administration, is located approximately three miles from the previous site and is situated at the corner of Cornwallis Road and Old Raleigh Road adjacent to the Research Triangle Park, NC. The mailing address and telephone numbers will remain the same.

On Nov. 19 a ribbon cutting ceremony and luncheon officially opened the new facility. LTG Robert L. Moore, deputy commanding general (RDA), U.S. Army Materiel Command, presided over the ribbon cutting ceremony and Dr. Jay R. Sculley, assistant secretary of the Army (RDA), spoke at the luncheon.

Other guests included LTG Lewis C. Wagner Jr., deputy chief of staff for research, development and acquisition; Dr. Gordon Prather, deputy for science and technology, Office of the Assistant Secretary of the Army (RDA); Dr. Frank Verderame, assistant director of Army research and technology, Office of the Deputy Chief of Staff for Research, and Development and Acquisition; and Dr. Richard L. Haley, assistant deputy for science and technology, U.S. Army Materiel Command.

The director of the U.S. Army Research Office is Dr. Robert E. Weigle. The office, which is a field activity of the U.S. Army Materiel Command, is responsible for developing the AMC research program for mathematics and for the physical, engineering, atmospheric, terrestrial, and biological sciences according to Army-wide requirements.

AMC Publishes New Lubricants Regulation

There is good and bad news in a recent status report by Maurice LaPera of the Belvoir R&D Center on the Army's long-term efforts to improve management of packaged fluid, lubricant and grease products entering the military supply system.

The bad news is that a proliferation of proprietary products, now in excess of 25 percent, continues to plague logistical and supply personnel, impair readiness, and increase military costs.

The good news is that DARCOM/AMC Regulation 750-11 *Maintenance and Supplies—Use of Lubricants, Fluids and Associated Products,* can remedy this state of affairs. All that Army equipment managers, specification writers, and program managers have to do is to adhere to it.

The regulation establishes the Belvoir R&D Center as the AMC focal point on proper selection and utilization of the packaged products it governs. In this role, the center's Fuels and Lubricants Division provides the coordination and approval necessary to insure that lubricant orders and technical manuals contain only current standardized product specifications.

Guidance in the regulation explicitly prohibits random introduction of proprietary products. It curtails former procedures that have allowed contractors and developers to specify proprietary products.

The regulation requires compelling justification for use of non-standard products as opposed to those qualified in accordance with military/federal specifications or purchase descriptions. The regulation also imposes MIL-STD-836 (Lubrication of Military Equipment) on all designs, developments, and acquisitions, and insists that all procurement requests, solicitations and contracts have lube order/technical manual approval before first unit acceptance.

If DARCOM/AMC Reg 750-11 is followed, according to LePera, the next news on long-term management of packaged lubricants and fluids will be all good.

CERL Publishes Working Microcomputer Guide

The U.S. Army Construction Engineering Research Laboratory (CERL) recently published USA-CERL Technical Report P-146 (Revised) entitled *Microcomputer Selection Guide for Construction Field Offices, Updated Edition,* by Michael J. O'Connor, Timothy A. Kruppenbacher, and Glenn Colwell.

This guide is designed to help managers at U.S. Army Corps of Engineers construction field offices determine their needs for microcomputer support in their day-to-day operations, and select and procure appropriate systems. The information in this report supersedes that in the 1983 edition.

The guide begins with an introductory tutorial on microcomputers intended to provide managers with the necessary information to make decisions about microcomputers, followed by a review of software packages and examples of their use.

After a discussion of factors that influence the use of microcomputers in construction field offices, a step-by-step procedure is presented to assess the needs for automation at a specific office. Next, a method is described which will assist the field manager in determining the characteristics of an appropriately sized computer system to meet the needs of his field operation. Three general methods of procurement are described: competitive procurement using the federal supply schedule, competitive procurement using performance specification, and sole-source procurement.

The report can be purchased from the National Technical Information Service at 5285 Port Royal Road, Springfield, VA 22161, using accession number ADA146615. Additional information on the report can be obtained by contacting Michael J. O'Connor, CERL-FS, P.O. Box 4005, Champaign, IL 61820-1305. The commercial telephone number is 217-373-7267.

Blackhawk Helps to Save Soldier's Life

The speed of the Army's new UH-60 Blackhawk helicopter and the expertise of medics of 2-75th Range Battalion from Fort Lewis, WA, combined to save the life of a U. S. Army soldier in the Republic of Panama just before last Christmas.

The soldier, Zacarias Portillo Olivas, 20, of Alpino, TX, assigned to Company C, 1-187th Infantry, Fort Clayton, Panama, had been severely wounded in the groin during a training exercise at the Army's Jungle Operations Training Center, Fort Sherman, Panama.

The wound had torn the femoral arterial vein and the femoral artery and Olivas lay bleeding near death in the jungle 12 kilometers from the nearest medical aid station at Fort Sherman.

A ranger medic, E5 Clarence Mayo, of Mt. Ary, NC, began treating Olivas by applying pressure bandages to the wound, inserting intravenous feeds of ringers lactate in both arms and then tightly bandaging Olivas' legs and lower torso with 6 inch elastic bandages to force blood up to the chest where it was most needed. For additional pressure, he applied inflatable splints.

At the same time, a call for medical evacuation by helicopter was relayed to a UH-60 Blackhawk helicopter of the 193d Infantry Brigade (Panama) which was on a Medevac training mission in the same general area.

The Blackhawk was fully equipped for Medevac operations except that it lacked a stokes litter. A stokes litter is a piece of equipment hung over the side of a helicopter and used for rescue operations. In 25 minutes, the Blackhawk crossed the 50-mile wide Isthmus of Panama, picked up the litter and was back at the pickup site.

It would have taken one of the Brigade's UH-1H Huey Medevac helicopters that long just to cross from one side of the Isthmus to the other.

Plucked from the jungle, Olivas was attended to in the air by the Blackhawk's medic, SP4 Roberto Rojas, of Santiago, Dominican Republic, until landing in a few minutes at the Troop Medical Clinic at Fort Sherman.

There, the ranger battalion's physician's assistant, CW2 Stephen Brick, of Yuma, AZ, determined that Olivas was unconscious and had no discernible pulse. Brick had the patient off-loaded from the Blackhawk for additional emergency treatment on the ground outside the blade wash.

"I established another I.V., reinitiated one of Mayo's I.V.'s, tightened up the tourniquet and put on a G-suit (for additional pressure on the lower limbs)," said Brick. When Olivas showed signs of suffering pain, he was reloaded onto the Blackhawk, with Brick accompanying him.

Pilot CW2 Jerry Moseley, of Dallas, GA, Copilot CW3 Jerry Bishop, of Jonesboro, AR, and Crew Chief E5 Todd Glidewell, of Sayre, PA, didn't waste any time. Flying at maximum speed, the aircraft crossed the Isthmus to Gorgas Army Hospital in just 12 minutes.

Nevertheless, by the time Olivas reached the emergency room, his body had consumed 11 liters of ringers lactate and his hemoglobin count was down to two, close to death, instead of a normal count of between 14 and 15. In other words, he had one seventh of the blood of a normal male.

But Olivas was not out of the woods yet. In the emergency room his heart stopped and it took a minute of cardiopulmonary resuscitation to get it beating again.

Two days later he was rated as 'seriously ill, but stable.' The following day, the Thursday before Christmas Day, he was air evacuated to Walter Reed Army Hospital in Washington, D.C. Olivas is described by medical personnel at Walter Reed as being in stable condition and "doing fine."

WSMR Pioneer Group Reunion

The White Sands Pioneer Group is looking for former civil service, military, or contractor employees of White Sands Missile Range who are interested in receiving their newsletter and details of the first ever reunion, in July 1985, of range, missile and space pioneers. Information may be obtained by writing the White Sands Pioneer Group, P.O. Box 1945-85, White Sands Missile Range, NM 88002.

Conferences & Symposia . . .

New System Tracks Generator Performance

Engineers at the Belvoir R&D Center's Tactical Energy Systems Laboratory have developed a computerized system to measure and record generator set performance. The Passive Power Measurement Method microprocessor can fit into a container about the size of a shoe box which is enclosed within the generator set, running on its battery system. In operation, it continuously records the kilowatt load on the generator set.

This information is stored in a matrix that records variation in the load under different operating conditions. When the test is completed, which may involve weeks, months, or even years, the device is plugged into a portable computer which provides a printout of cumulative time at load.

One advantage of this system is that it allows engineers to determine if a generator is too powerful for the requirements of the system it is supporting. It will, therefore, enable system developers to use smaller, more efficient generators or to use power available from generators on-hand instead of adding new ones.

Outgrowths of this technology could also lead to the development of units that can record other system data over extended periods of time.

These units, designed by DataMyte Corp. of Minnetonka, MN, are currently in use at White Sands Missile Range, NM, and Fort Bliss, TX. They will soon be used to test the Hawk and other missile systems and in various medical, communication and other tactical systems that require mobile electric power.

CERL Hosts Corrosion Workshop

Ion plating and laser surface alloying are just two of many promising plasma-based coating technologies which may be used soon to protect metallic and non-metallic components against corrosion and erosion. This was the consensus of attendees of an Army-initiated interagency workshop on Plasma-Based Surfaced Engineering Technologies, held last December at the U.S. Army Construction Engineering Research Laboratory (CERL) in Champaign, IL.

The objective of the workshop was to review and assess the status of plasma-based surface engineering technologies for structural, optical, and electrical applications. The plasma-based surface engineering technologies discussed at the workshop included ion plating, ion implantation and ion beam mixing, sputter deposition, molecular beam epitaxy, plasma polymerization, and laser surface alloying.

The attendees examined the feasibility of the plasma-based processing technologies for meeting future Department of Defense surface engineering requirements for reproducibility, reliability and cost effectiveness. Each technology was assessed and classified according to its readiness for use in the field.

The technologies that were thought to be most developed were sputter deposition, ion plating, laser surface alloying, and ion implantation. The technologies thought to be the least developed were molecular beam epitaxy, and plasma based chemical vapor deposition and plasma vapor deposition.

Some of the specific DOD applications of these technologies discussed at the workshop include: reduction of gun tube erosion, lubrication of gas turbine engine bearings, improved corrosion resistant coatings for compressor blades of gas turbine engines, hermetic coatings for optical fibers and devices, barrier layers for semi-conductor devices, fabrication of high purity semi-conducting layers, corrosion resistant coatings for high strength structural steels for aircraft components, and corrosion resistant electrically conductive coatings for gaskets and interfaces for use in electromagnetic interference and electromagnetic pulse protection.

Attendees were also briefed on the initial results of CERLS's ion-plating research. CERL recently acquired an ion-plating facility for conducting research on new coatings for electromagnetic interference and electromagnetic pulse shielding gaskets and ceramic anodes for protecting metal structures from corrosion.

The workshop was attended by 35 people from all three military services, NASA, the Department of Energy, and the University of Illinois. The workshop was co-sponsored by CERL, the Army Material and Mechanics Research Center, and the University of Illinois. Proceedings of the workshop will be published in FY 1985.

Personnel Actions...

Dr. Statler Named Director of AGARD

Dr. Statler

The National Delegates Board of AGARD has announced that Dr. Irving C. Statler has been elected the director for a three-year term starting July 1, 1985. Dr. Statler will be stationed at AGARD Headquarters, Paris, France.

AGARD is the Advisory Group for Aerospace Research and Development for the North Atlantic Treaty Organization (NATO). The selection was made at the semiannual meeting of the National Delegates at Oslo, Norway. The AGARD appointment marks the first time that a civilian director has been selected from the U.S. Army and the first time that the director comes to the post with a background in military helicopters.

Dr. Statler is the director of the Aeromechanics Laboratory of the Army Research and Technology Laboratories-AVSCOM, NASA Ames Research Center, Moffett Field, CA.

AGARD was organized in 1951 to bring together the leading personalities of the NATO-member nations in the fields of science and technology relating to aerospace in order to recommend effective ways for the member nations to use their R&D capabilities for the common benefit of the NATO community and to provide scientific and technical advice and assistance to NATO's North Atlantic Military Committee. AGARD provides for the exchange of scientific and technical information among the NATO-member nations in order to improve cooperation in aerospace R&D and to increase the scientific and technical potential of the member nations.

The National Delegates Board is the highest authority within AGARD. Its members are leaders in the field of aerospace R&D who are appointed by and represent the governments of the NATO-member nations. The first chairman of the board was Dr. Theodore von Karman who served from February 1952 until his death on May 7, 1963.

The staff of AGARD is headed by a director, appointed for a period of three years by the North Atlantic Military Committee on the advice of the National Delegates Board. The director acts as the executive officer of the board. He supervises and directs the AGARD staff and is responsible for planning and conducting the activities of AGARD, carrying out the decisions of the National Delegates Board, and approving the release of reports and studies prepared in the name of AGARD.

Dr. Statler previously served AGARD from 1972 through 1983 as the U.S. Army's representative on the Flight Mechanics Panel, which is one of nine scientific and technical panels of AGARD. He served as the chairman of the panel during 1975 to 1976, and was the panel coordinator for the United States during 1978 through 1983.

Dr. Statler joined the U.S. Army Research and Technology Laboratories in November 1970, and in November 1972 assumed his current position as director of the Aeromechanics Laboratory. Prior to joining the Research and Technology Laboratories, Dr. Statler served for 24 years with the Cornell Aeronautical Laboratory (currently called Calspan) in Buffalo, NY. He plans to return to the Army Research and Technology Laboratories upon completion of the three-year AGARD assignment.

Seiders Chosen for Executive Training

Barbara Seiders has been selected as the 54th trainee to participate in the technical executive development training program at the U.S. Army Chemical Research and Development Center (CRDC), Aberdeen Proving Ground, MD.

Seiders, a research chemist in the Physics Division of CRDC's Research Directorate, has begun a six-month specialized training program that will assign her to the Office of CRDC's Commanding General for the first three months, and then to the Office of the Deputy Chief of Staff for Research, Development and Acquisition at the Pentagon. This program, established in 1971, is designed to give practical experience in staff work relating to managerial decisions.

Seiders began her federal career in September 1981 as a Science, Engineering, and Diplomacy Fellow in Nuclear Technology and Safeguards at the State Department in Washington, DC. Following her one-year fellowship, she joined the CRDC staff as a research chemist in the Chemometrics/Biometric Modeling Branch.

Seiders was awarded a bachelor's degree in chemistry from Dartmouth College in Hanover, NH. Duke University, Durham, NC, awarded her a doctoral degree in theoretical quantum chemistry.

Seiders was selected as An Outstanding Young Woman for 1981 and as a 1979 Association of Women in Science Scholar. Her professional affiliations include the American Chemical Society, the American Association of Women in Sciences, and Sigma Xi, the international, honorary scientific association.

Reassignments and Promotions

Dr. Robert Smith, former director, Aero-Mechanical Engineering Laboratory, U.S. Army Natick R&D Center, Natick, MA, was named the center's associate technical director, engineering and acquisition.

Edward Levell, was elevated to a Senior Executive Service ranking and appointed director of the Individual Protection Laboratory (IPL), U.S. Army Natick R&D Center, Natick, MA.

Levell had been serving in a dual capacity as acting technical director, engineering and acquisition, and acting director, IPL.

Maurice Gionfriddo is the new director, Aero-Mechanical Engineering Laboratory, U.S. Army Natick R&D Center, Natick, MA. Gionfriddo had been chief of the Airdrop Systems Division.

Dr. James J. Savage is the new deputy director for research at the U.S. Army Chemical Research and Development Center, Aberdeen Proving Ground, MD. Savage was previously assigned as chief of the Obscuration Sciences Branch in the Center's Research Directorate.

Robert F. Giordano has been named director of the Electronic Warfare Laboratory at Fort Monmouth, NJ. Giordano had been the laboratory's deputy director of systems.

Dr. Richard Chait was recently appointed to the position of director, Metals and Ceramics Laboratory, U.S. Army Materials and Mechanics Research Center (AMMRC), Watertown, MA. Chait was serving as acting associate director for AMMRC before assuming his present responsibilities.

COL William S. Chen has been appointed project manager, SGT York Air Defense Gun System. He replaced BG Charles C. Adsit, who had been in the post since 1979. Adsit has been named assistant director for Policy and Plans, Defense Logistics Agency, Cameron Station, VA. Chen's previous assignment was project manager, CHAPARRAL/FARR, U.S. Army Missile Command, Redstone Arsenal, AL.

Cooperative Efforts Advance International Engine Oil Testing

The requirement for international automotive engine oil testing procedures has been a goal within the military for many years because of involvement within the NATO alliance and other multinational organizations. Here, standardization, interchangeability, and interoperability of equipment and the required lubricants are the end products of a system in which the common denominator has been to demonstrate equivalent requirements and performance.

Unfortunately, with automotive lubricants, there has been considerable difficulty. This is primarily because of the absence of established international testing procedures, the multiplicity of different engines existing within the NATO ground fleet, and their associated lubricant testing procedures and requirements.

Even with this difficulty, some elements of standardization have been successful during the past years. Following the development of Military Specification MIL-L-2104C (Lubricating Oil, Internal- Combustion Engine, Tactical Service) in 1970, the need for product interchangeability and minimum acceptable performance requirements for oils used within the NATO forces led to the initiation of a cooperative engine oil program.

The program, conducted under NATO's Military Agency in Standardization, involved the testing of different heavy duty diesel (MIL-L-2104D) level products by individual nations using their respective engine qualification acceptance procedures. From this cooperative program, the development of a "Guide Specification" evolved, which represented the minimum acceptance requirements for those engine oils formulated to the desired performance level. During this test program, a U.S. industry reference oil was used to demonstrate this performance level. Based upon this cooperative effort, MIL-L-2104D oils have since been successfully interchanged with equivalent products from France, Germany, and the United Kingdom under NATO Code Numbers 0-237, 0-238, 0-239.

As with a coin, there are two sides to this story. More recently, a second cooperative program was initiated within NATO to develop a guide specification for a multigrade heavy duty diesel SAE 15W-40 oil. This program evolved from a need to identify a reference oil for use in standardizing engine qualification and certification test procedures used by different NATO countries and a need to fully recognize multigrade oils for use in combat and tactical engine systems.

Again, the effort has involved the testing of representative multigrade oils in different engine procedures used by NATO countries. Problems have surfaced, however, in the identification of an oil which provides the minimum level of acceptance for all nations as the proposed reference oil. For example, a product being supplied by one country does not meet the U.S. requirements as defined by the Caterpillar 1G2 and the Detroit Diesel 6V53-T qualification engine acceptance testing procedures, both of which are specified in MIL-L-2104D.

The above examples serve to highlight the need for understanding the interrelationships of different engine testing procedures. It is not the intent to presume that one nation's procedures and specification requirements are to dominate. The important factor is that an understanding of different test methodologies can lead to the establishment of an equivalent performance "language" system whereby product specifications are directly comparable. The availability of such a system is currently non-existent.

The advantages of international engine testing procedures are obvious, not only to the military, but also to producers and user organizations within the different countries.

Assuming that international testing procedures lead to the development of "common denominator-type" engine performance requirements, the interchangeability and widespread acceptability of different products formulated against national standards would significantly increase. This would produce significant benefits to both industry users as well as the military, since procurement costs would decrease with an attendant increase in the interoperability of equipment.

Further, as national product specifications are upgraded due to engine design changes, the subsequent incorporation of these new requiremetns would not create major interchangeability problems because of the concurrent development of engine test procedure interrelationships. One additional benefit that may not be fully apparent would be the indirect impact of lubricant quality on engine design.

The development of reference oils in conjunction with the international testing procedures would cause the lubricant to be considered as a component of the total engine system. Needed changes in engine design would therefore occur before, and not after, the fact.

The preceding article was authored by Maurice E. LePera, chief, Fuels and Lubricants Division, U.S. Army Belvoir R&D Center.

Army Presents Annual Laboratory Awards

Department of the Army awards for Laboratory of the Year, Most Improved Laboratory, and for Excellence were presented recently in recognition of outstanding scienticfic, technical, and managerial achievements during 1984.

Walter Reed Army Institute of Research (WRAIR), the largest of the medical R&D laboratories operated by the U.S. Army Medical R&D Command, is the 1984 Army Laboratory of the Year. The U.S. Army Medical Research Institute of Chemical Defense, also a laboratory of the U.S. Army Medical R&D Command, was selected as Most Improved Laboratory.

Assistant Secretary of the Army for Research, Development and Acquisition Dr. Jay R. Sculley presented the Laboratory of the Year Award during ceremonies at WRAIR. The Most Improved Laboratory Award was presented at the Medical Research Institute of Chemical Defense by Amoretta Hoeber, principal deputy ASA (RDA).

Other awards for Excellence went to the U.S. Army Missile Laboratory, the U.S. Army Medical Research Institute for Infectious Diseases, the U.S. Army Electronics Technology and Devices Laboratory, the U.S. Army Engineer Topographic Laboratory and the U.S. Army Ballistic Research Laboratory.

Initiated in 1974, the annual laboratory awards program is authorized under provisions of Army Regulation 672-305. Winners of the Laboratory of the Year and Most Improved Laboratory Awards are selected by a special awards evaluation committee appointed by Dr. Sculley.

Members of this year's evaluation committee were: Dr. James G. Prather, deputy for science and technology, Office of the ASA (RDA); John Entzminger, director, Tactical Technology Office, Defense Advanced Research Projects Agency; Dr. Bernard H. Paiewonsky, Office of the Deputy Assistant Secretary of the Air Force (Research, Development, and Logistics); James E. Spates, assistant director of Army research for laboratory management, Office of the Deputy Chief of Staff for Research, Development, and Acquisition, HQ, Department of the Army; Dr. Leo Young, director, research and laboratory management, Office of the Under Secretary of Defense for Research and Engineering; and Dr. Louis Schmidt, chief scientist, Office of Naval Research.

Laboratory of the Year

Selection of WRAIR as Laboratory of the Year was based on a number of key accomplishments, including a collaborative effort between National Institutes of Health and WRAIR scientists which represents an advancement in military medical research of great potential importance. As a result of this effort, it has been possible to clone and sequence the gene encoding of a specific protein in the malaria parasite, Plasmodium falsciparum. This protein, CS (or Circumsporozoite), elicits a protective immune response in animals and man. WRAIR scientists demonstrated that the CS gene is identical in 18 different strains of parasites, thus opening the way for a vaccine not complicated by antigenic variation.

A more diffuse, but nevertheless important, group of studies by WRAIR confirmed that social support is essential in coping with or reducing mental and physical effects of stress. By social support is meant interactions among individuals leading to confidence by those involved that they are esteemed and valued, and belong to a network of communication and mutual obligation.

ASA (RDA) Dr. Jay R. Sculley presents Army Laboratory of the Year Award plaque to WRAIR Commander COL Franklin H. Top Jr., MC. Deputy Commander of the U.S. Army Medical R&D Command BG Frank A. Ramsey is shown at right.

Another achievement was the engineering of an oral vaccine to protect against enteric bacterial diseases (dysentery). This work won the Army Science Conference first place Paul A. Siple Award for its investigators.

Other WRAIR accomplishments were related to Army readiness. For example, research evaluating the effects of the New Manning System on soldier and military family morale and cohesion have played a major role in establishing value of a unit-oriented personnel system. WRAIR assistance to other commands in preparing for OCONUS deployment has also taken the form of medical guidance and information as well as development of preventive measures to be employed while overseas.

Four WRAIR divisions also collaborated with the Ballistic Research Laboratory in examining the relative biological hazards of the interiors of the M2/3 Bradley Fighting Vehicle and M113 Armored Personnel Carrier when penetrated by High Explosive Anti-Tank rounds. Results of this study should help prevent delays in fielding of the M2/3.

Most Improved Laboratory

The U.S. Army Medical Research Institute of Chemical Defense (USAMRICD)—as the recipient of the Most Improved Labortory Award—is the lead laboratory for the nation's research on medical defense against chemical warfare agents. This research is directed towards the prevention and treatment of chemical injuries, with emphasis on pretreatment and antidote development, soldier/patient decontamination, and medical management of chemical casualties.

The focus of improved R&D management concepts of the Medical Research Institute of Chemical Defense involved the following:

- A greatly expanded extramural research contract program.
- Program involvement of other U.S. Army Medical R&D Command laboratories having critical science skills.
- Reorganization of the USAMRICD's structure in order to sharpen its emphasis on mission requirements rather than technical background.
- Improved research efficiency through innovative management of task areas, upgrading of laboratory instrumentation, a comprehensive biomedical data base, and an internal Chemical Surety/Safety Program.
- Among the specific research accomplishments of the Medical Research Institute of Chemical Defense was development of a unique and innovative drug screening program which identified the first totally new class of antidotes in more than 20 years. Other achievements included development of a new class of pretreatment compounds which are effective with or without subsequent therapy, development of a series of new non-toxic skin decontaminants, and development of a variety of non-animal models which help reduce the need for animals in medical research.

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