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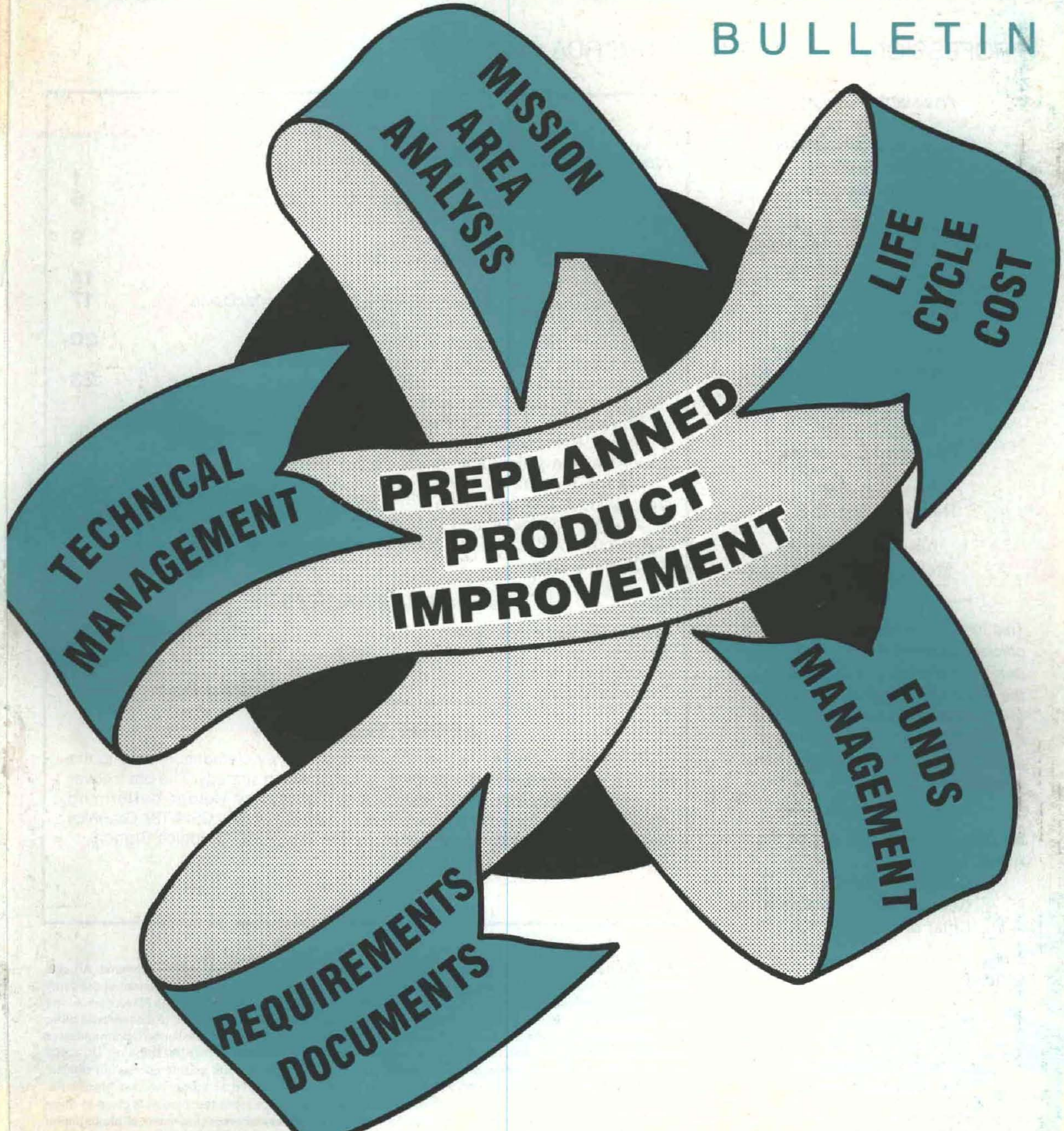
NOVEMBER - DECEMBER 1988



ARMY

Research Development Acquisition RD&A

PB 70-88-6

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PROFESSIONAL BULLETIN OF THE RDA COMMUNITY

FEATURES

DEPARTMENTS

ABOUT THE COVER

Displayed on the front cover are some of the key elements related to the Army's preplaned product improvement acquisition strategy. The back cover shows an Army Materials Technology Laboratory welder performing mechanized gas metal arc-welding on aluminum armor alloy, 2519-T87. Graphics support for the covers was provided by Joe Day, AMC Graphics Branch.

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UPDATE ON PREPLANNED PRODUCT IMPROVEMENT

By LTC Phillip E. Miller

Introduction

Within the Department of Defense, the decision environment for selecting and following through with the Preplanned Product Improvement (P3I) acquisition strategy is complicated by the unyielding views of both critics and supporters.

Many advocates of P3I view it as a necessary alternative to the development and acquisition of entirely new systems. Indeed the trends seem to indicate that the alternatives to the evolutionary strategy are unaffordable systems or insufficient numbers to answer the need.

As suppliers of the tools needed for the defense of our country, we are faced with increasing costs for research and development, lengthening acquisition intervals, increasing age of fielded weapons, constrained budgets, and various technological barriers. This fact alone should generate substantial interest in a strategy with great potential for overcoming these problems. Nevertheless, after years of trying to institutionalize this concept, we are no closer to implementation than we were when Secretary Carlucci issued the DOD implementation plan in 1981.

One of the primary causes of disagreement over the merits of evolutionary development has been the lack of specific data to indicate the cost effectiveness of incremental improvements and parallel development of deferred technology. Until we begin to apply the P3I strategy in earnest we will have to rely on bits and pieces of data to justify proceeding, and some risks will have to be taken.

American military research and development has historically been pragmatic, adaptive, flexible, and tenacious. This has resulted in tremendous advances through the development of new systems which incorporate the latest technology. But, it is also true that a great deal of our military technological advancement depends on recurrent increments of performance improvements, developed and applied to already-existing systems. This concept of product improvement has been extremely effective for many years.

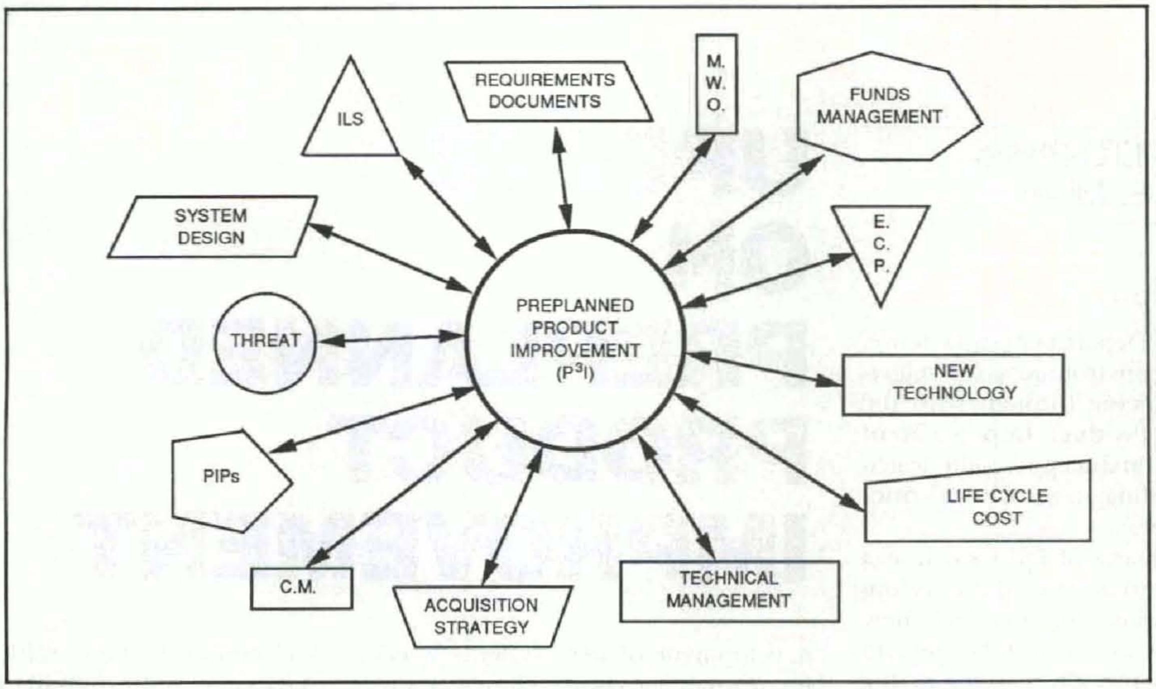
Nevertheless, these increments are increasingly difficult to achieve and even harder to fund when replacement systems are preferred over improved versions of fielded weapons. When product improvement is selected as the method for answering a materiel requirement, the data seems to indicate that there are cost benefits associated with the design of systems capable of evolving at rates more closely aligned with the changing demand for increased capability, an indication that P3I is cost effective.

Equal Capability

There are two basic concepts associated with the perception of equal capability on the battlefield. First, a qualitative edge can be obtained through high technology systems. This results in very expensive hardware, justified by the claim that fewer numbers are required to maintain the desired balance. Second, a quantitative balance can be achieved through low technology systems with improved reliability, supportability and maintainability factors.

The overall cost of these two approaches is basically the same. The major difference has been the risk associated with acquiring and maintaining the support necessary to fund the selected approach. Product improvements have in the past and will continue in the future to be applied to systems developed under both concepts (another reason for preplanning improvements). In the high technology systems, design constraints appear to be a primary contributor to early obsolescence and the cost of improvement. For low-technology, high-volume systems, the cost of retrofit has led to multiple configurations which increase the ownership costs and may be a contributor to early obsolescence. Systems developed under either of these concepts eventually reach a point where the cost to improve them is so great they are replaced or simply allowed to age.

Extending the useful life of a weapon system is extremely cost effective and while standard product improvements accomplish just that, recent research indicates that product improvements to major weapons systems are becoming increasingly costly and are subject to the same cost and schedule problems associated with new development. There is also an indication that basic system design constraints can make



the cost of improvement equal to or greater than new development.

Gone are the days of the B-52 where large amounts of excess capacity were designed into the system to accommodate unknowns (another reason for preplanning improvements). This suggests that flexible designs beyond those associated with basic good design rules offer potential for cost-effectively extending the useful life of systems.

Rapid changes in technology can affect both high technology, low volume, and low technology, high volume concepts. As an example, the introduction of high energy laser weapons to the battlefield could impact rifles as well as aircraft. This tends to support the notion that evolutionary designs can be useful in both concepts.

My research indicates that evolutionary designs should not be used unless specific performance improvement requirements can be identified and there are valid technological impediments to proceeding with a full-capability system.

There is no evidence to indicate that the use of P3I has reduced total improvement costs on a given system, in fact the reverse is true. Designing a system for future upgrades will increase the total cost of improvements to that system because upgrades that would ordinarily not be cost effective now are. Thus, P3I will increase the cost of a weapon system, both developmental (parallel development costs) and life cycle (it will be in the inventory longer). If this is true then why should we use it? The answer is found in the larger context of total materiel costs. As the costs for evolutionary development increase, the total cost of materiel will decrease. This will occur as a result of not having to replace systems as often.

While evolutionary development clearly offers the opportunity to reduce the total cost of materiel, in reality it is not used to any great extent. Within the Army, use of the P3I strategy is greatly limited. Generally, it is standard product improvement that is reported as being P3I and not evolutionary development. This, of course, sends the wrong message to management and as a result we conduct "business as usual" and materiel costs keep rising.

If the increasing cost trends for weapons systems continue, the long term ability of the country to fund the revolutionary development of replacements for major weapons seems questionable. To avoid this situation and the resulting obsolete equipment, I believe the Army must install firm institutionalized procedures to insure the use of P3I in the acquisition of all major weapons systems. This includes the necessity to accommodate the increased initial funding required to install growth provisions and to develop, in parallel, the deferred technology to incrementally upgrade weapons.

The reasons for not using the P3I strategy are painfully obvious yet difficult to overcome. Here are the major reasons:

- The strategy is not understood.
- Managing P3I is extremely difficult.
- The "system" is spring loaded against it.
- PMs don't control funds for parallel development.
- Requirement documents are not properly written.
- Capabilities are deferred for the wrong reasons.

The Strategy

Before proceeding to specific examples of P3I let's establish, in simple terms, what the strategy is. The P3I concept begins with a clear definition of the requirements and then "backing away" from specific requirements which pressure the state-of-the-art. This allows development of a basic system designed for incremental

- **Evolutionary development works! But, the system is spring-loaded in the opposite direction**
- **Industry can and will respond to P3I if prevailing deterrents (competition and profit) are alleviated**
- **P3I criteria must become mandatory contract and RFP requirements which flow from properly stated requirements documents**

improvement to achieve the original requirement and parallel development of the deferred requirements.

The less complex basic system is not less capable against the near term threat because it responds to a less technologically advanced enemy. By clearly establishing the specific requirements for growth, it is assumed that design engineers can configure the basic system to facilitate upgrade. The deferred capability is developed in parallel with the basic system and installed incrementally over time. As improvements are installed, provisions for the next upgrade can be made and new parallel development begun as follow-on requirements are established. While the concept of incremental upgrade is easy to understand, the specifics associated with accomplishing it are extremely complex and impact all areas of acquisition management. This has caused a great deal of resistance to the concept and has led to superficial implementation.

Two Sides

Should military weapons systems be designed with a P3I strategy or shouldn't they? There is evidence to support both sides of this question. A positive example is found in the Northrop F-5 aircraft. The F-5 Freedom Fighter was developed with corporate funds for sale to European and Asian air forces as well as the U.S. Air Force.

The Northrop Corp. did anticipate future modification activity. The F-5 basic design was the result of thorough market research which determined that different air forces would have different needs and therefore would want different combinations of engines and avionics. As a result, space was allocated in the airframe nose to provide growth capability for alternative armament radar and reconnaissance version equipment layouts. Also, engines were installed in a way that permitted substitution of different models with a minimum of airframe modification. This design concept allowed successful improvement of the system through a strategy of incrementalism. Preplanning room for growth and planning for incremental improvements facilitated the modification process and reduced R&D risks and uncertainties in the development of the F-5's avionics systems.

On the negative side, there is evidence that preplanning can increase the initial cost of a system and contribute to its early obsolescence when the concept is misapplied. In this case, the Navy F-14 development was the "victim" of a P3I strategy that was not carried to fruition in the needed time frame.

The designers of the F-14 aircraft were able to forecast improvements because all of the subsystems envisioned to be incorporated into the aircraft were under development when the design was approved. Thus, in the case of the F-14, parallel development was not controlled through the program office.

Technical difficulties on the airframe and the planned for improvements, along with a changing requirement led to a decision to postpone the purchase of the improved version. This resulted in the acquisition of an aircraft that was quickly outpaced by the threat and for nearly 10 years may have been less capable than the requirement indicated. There is also evidence to suggest that the F-14 P3I strategy was not properly supported or understood by high level decision makers. This can be seen in the upgrade effort of the AYK-14 onboard computer. This is the computer chosen by the Navy to control weapons, radar and navigation systems on the aircraft.

The original AYK-14 was developed in 1976, yet development of the improved version called the AYK-14P3I was not started until 1984. A properly structured P3I process would have established the AYK-14P3I computer capabilities as the actual requirement and produced the AYK-14 as the basic model. Parallel development of the specific improvements would have been undertaken in 1976 to provide the upgrade in the time frame it was needed. Thus, there is risk that the additional money invested in P3I designs may prove to be sunk cost if, for whatever reason, the planned for improvements are delayed or never made. In the case of the AYK-14P3I computer, we may be looking at standard product improvement as opposed to one which was preplanned and because of misunderstanding was reported as P3I.

When considering the development of a new weapon system versus the improvement of an existing system, the rate of technological advancement is a factor. Research indicates no significant difference in the rate of technological advances when comparing new development with product improvement. When comparing non-P3I designs with those designed for P3I, it is clear that the upgrade process can better accommodate the insertion of new technology in P3I systems. Improvement cost trends associated with P3I acquisition strategies indicate accelerated growth when compared with similar systems acquired under the more traditional process.

This is a strong indication that technological advancement is more easily achieved in systems designed for growth. If this is true, and I believe it is, P3I will extend the useful life of systems and reduce the need for the more costly route of system replacement.

The P3I concept appears to allow more productive use of increasingly scarce national defense dollars. Yet, there is a cost in that the strategy clearly will add additional management complexity to materiel acquisition programs. However, the potential reduction in total acquisition costs offer significant advantages both to the operational community and to the taxpayer.

Based on the data obtained through my research, I believe that military acquisition programs should use the evolutionary development concept of preplanned product improvement. Use of P3I will extend the useful life of military systems and reduce acquisition costs.

While there is general agreement that the concept of P3I is valid, there is confusion within the acquisition community over the details of implementation. There is limited service specific guidance and no accepted method of implementing a P3I strategy. The concept of P3I has become little more than a "buzzword" lost in the obscurity of weapon system acquisition.

There are indications that P3I has been only partially used employing a short term strategy directed only at the initial upgrade. There are other indications that growth provisions are being added to already difficult near term development efforts when they should be used to offset reduced requirements.

In Army acquisition, the program manager is generally provided only limited control of funds required to support development of deferred technology. Along with the lack of funds control is the inability of the budgeting process to accommodate the funding levels necessary for specific programs to enjoy the level of effort required to insure incremental development and application of deferred upgrades.

The original vigor exhibited by high level Army decision makers toward implementation of the P3I concept has all but disappeared. P3I projects are no longer reported or made visible in the budget process.

Those responsible for materiel change at HQ, Army Materiel Command can no longer determine the amount of P3I acquisition and thus are unable to provide management an indication of its use or effectiveness.

Conclusion

Insuring the use of P3I as an integral part of Army acquisition programs must start with clear, precise guidance. P3I is complex and not well understood. Use of P3I can not simply be legislated or directed. Acquisition managers and decision makers throughout the Army must be convinced that the P3I strategy is both viable and acceptable. To accomplish this they must fully understand the concept. Therefore, a program to provide the necessary training and resources should be initiated without delay.

Without action by management, implementation of the P3I strategy will be delayed and faces the strong potential of being misapplied.

Misapplication will cause serious problems for legitimate attempts to implement the P3I strategy and perhaps prevent evolutionary development from taking hold as a viable alternative. This could eventually affect national security through inefficient use of limited defense dollars.

The P3I strategy will work if properly applied. This requires a thorough understanding of everyone involved with its application. As a first step, I strongly recommend that the Army initiate the action necessary to develop and publish a comprehensive guide of step by step instructions for the funding and management of evolutionary development programs. Until this is done and people are educated, the Army has little chance of implementing the P3I strategy.

LTC PHIL MILLER, the developer of Army P3I policy, is the director of the Technical Management Department, Defense Systems Management College, Fort Belvoir VA. He holds a B.S. degree in aeronautical engineering, an M.S. degree in contract and acquisition management, and a Ph.D. in business administration. A highly decorated combat veteran, LTC Miller was a Medal of Honor nominee and is a certified Army acquisition manager with more than 22 years of active service.

MTL EVALUATES A NEW ALUMINUM ARMOR ALLOY

By Chuck Paone

Sacrificing one strength to gain the advantages of another has never been a very appealing option, especially when such a sacrifice could prove particularly costly, as in the design of military vehicles and equipment. The cost of giving up a positive feature in such cases must of course be measured in more than dollars; it must be measured in terms of effectiveness, reliability and ultimately in terms of the ability to protect the lives of American soldiers.

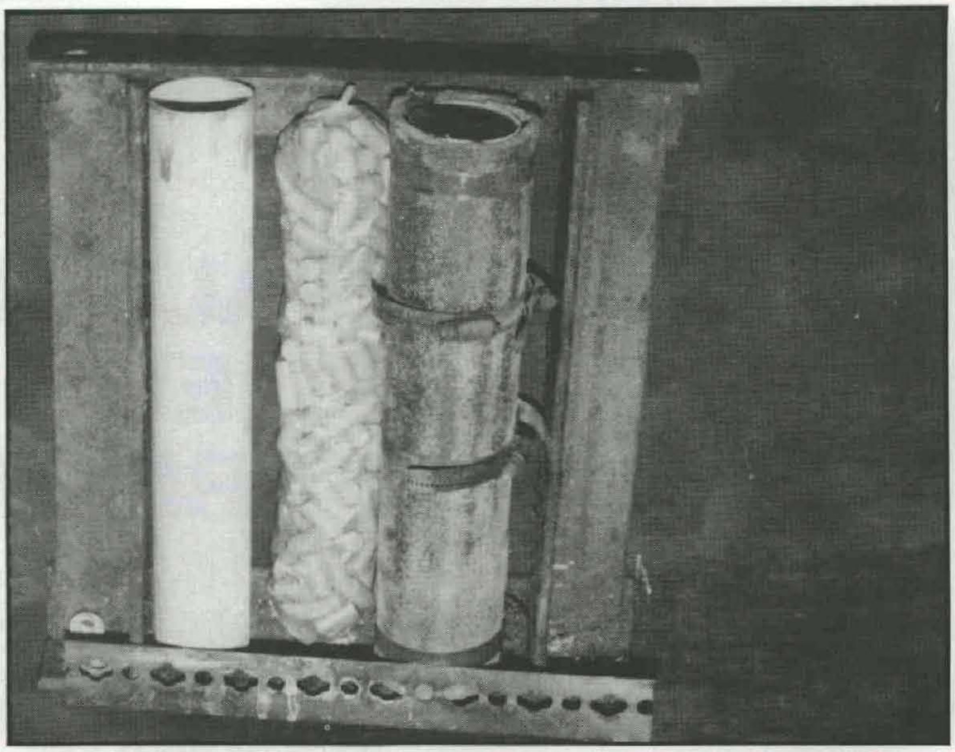
Development of a new aluminum alloy armor may soon save military program managers from one such dilemma. For the past several years, engineers at the U.S. Army Materials Technology Laboratory (MTL), Watertown, MA, have been evaluating this new alloy and have found it to have great potential. Aluminum alloy 2519-T87, developed by ALCOA, Inc., combines the positive characteristics of the alloys predominantly used in lightweight armored vehicles. Aluminum alloy 7039-T64 possesses excellent strength and ballistic properties, but is very susceptible to stress corrosion cracking, a near fatal flaw whereby an alloy can fail by cracking under constant stress while in service. The other alloy widely used on lightweight vehicles, including the Bradley Fighting Vehicle (BFV), is designated 5083-H131. 5083 is basically resistant to stress corrosion cracking and is very weldable, but it's strength and ballistic characteristics fall short of those possessed by 7039.

The stress corrosion problem with 7039 renders it unsafe for most armored vehicle applications, because extreme environments, such as saltwater, will intensify and expedite the cracking. Thus, engineers and program managers have been forced to make a rather odious choice. Using 5083 on the vehicles, to avoid stress corrosion cracking, means making the armor 25 percent heavier in order to provide the same ballistic protection. In order to keep the weight the same, ballistic protection has to be sacrificed on the order of 25 percent.

Enter this new 2519 alloy. As determined by extensive MTL testing, it provides the same strength and ballistic properties of 7039, while also being resistant to stress corrosion cracking. Obviously, this new alloy could potentially provide a much better option for military program managers.

Hopes for rapid application of this promising alloy were set back recently when butt-weld shock loading tests proved disappointing, but other joining processes for alloy 2519 are now being considered, and the MTL engineers remain optimistic about its eventual application.

According to Dr. Alan Goldman, the MTL engineer currently coordinating the lab's effort to exploit this new material, MTL actively sought this alloy when they first recognized the need. In 1982, MTL and the Army, faced with the problem described above, decided to search for a new alloy. Three major U.S. aluminum companies, ALCOA, Reynolds and ALCAN, submitted candidate alloys at that time. The alloys were evaluated by MTL engineers under the auspices of a joint program involving MTL, the Marine Corps Development and Education Command and the U.S. Army Tank-Automotive Command (TACOM). "This is a perfect example of working with the private sector," Goldman said.



Before Detonation
The "donor" propellant, which is to be ignited, is surrounded by the unprotected "witness" sleeve (left) and the protected sleeve.

The candidates were tested for strength, ballistic properties, corrosion resistance, weldability and several other factors, over a period of two years. They were tested in relation to each other and to alloys in use, and in 1984, 2519 was selected as the most promising prospect.

The 2519 development process dates back to 1979, according to Romeo Pascasio of ALCOA's Applications Engineering Division. FMC, manufacturer of the Bradley, came to ALCOA looking for an alloy with the strength and ballistics of 7039, which would not be susceptible to stress corrosion cracking. "That's what initially prompted our development program," said Pascasio.

So ALCOA began working to develop a high-strength alloy that would meet those criteria. Another popular alloy, 2219-T851, was known to be quite weldable and resistant to stress corrosion cracking. "2219 has rarely been used in armor applications, however," Pascasio said, "because it does not approach the ballistic properties of 7039."

Aluminum alloys from a given alloy series — determined by the main elements that are alloyed with the aluminum, such as silicon in 4XXX-series alloys and magnesium in 5XXX-series alloys — share similar characteristics. "Highest strength can generally be achieved with 7XXX-series (zinc/magnesium) alloys," according to Pascasio. 5XXX-series are generally not as strong. "2XXX-series (copper), "Pascasio said, "if alloyed properly, can be stronger than 5XXX-series and can approach 7XXX-series strength."

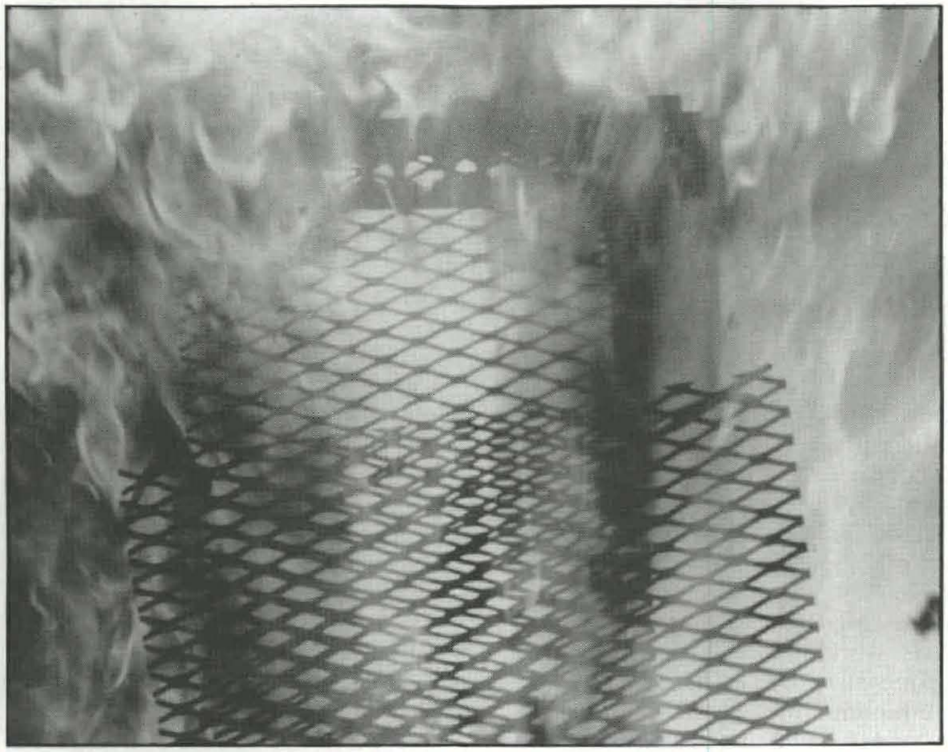
From this base of knowledge and awareness of 2219's positive qualities, ALCOA set their course. "Basically, we took 2219 and started tweaking the chemical content and method of manufacture," Pascasio said. The result was eventual development of the superior 2519 alloy.

The other attempts at developing a suitable alloy, according to Eugenio DeLuca, the MTL engineer who coordinated the lab's examination of the candidate alloys as well as the advanced testing of 2519, involved trying to remove the stress corrosion problem from 7039 and improving the strength of 5083. Neither ultimately proved successful.

After selecting 2519 as the most promising candidate in 1984, MTL formally began to pursue more extensive alloy characterization under the direction of TACOM's Mobile Protected Gun Program (MPG). From 1984 to 1986, MTL put the alloy through much more advanced testing, developing an across-the-board data base. "We looked at everything critical for its application on combat vehicles," said DeLuca. MTL engineers investigated the alloy's chemistry, engineering mechanical properties, fatigue life and ballistic properties, among other things, in great detail.

Through special testing designed to produce accelerated time lapse, MTL engineers tested the new material for any potential stress corrosion cracking problem. That testing proved conclusively that 2519 would not fail due to stress corrosion in salt water environments. The same tests conducted on 5083 showed that the in-use alloy could become susceptible to stress corrosion cracking over an extended time, even though it had previously been considered stress-corrosion resistant.

DeLuca says MTL quickly recognized the positive potential of 2519 and attempted to expedite the exploitation process. "MTL grabbed the opportunity and ran," he said, indicating that the lab jumped at the chance



· *Left,* ***During Detonation.*** Ignition of the donor propellant and subsequent ignition (cook-off) of the propellant in the unprotected sleeve during the test.

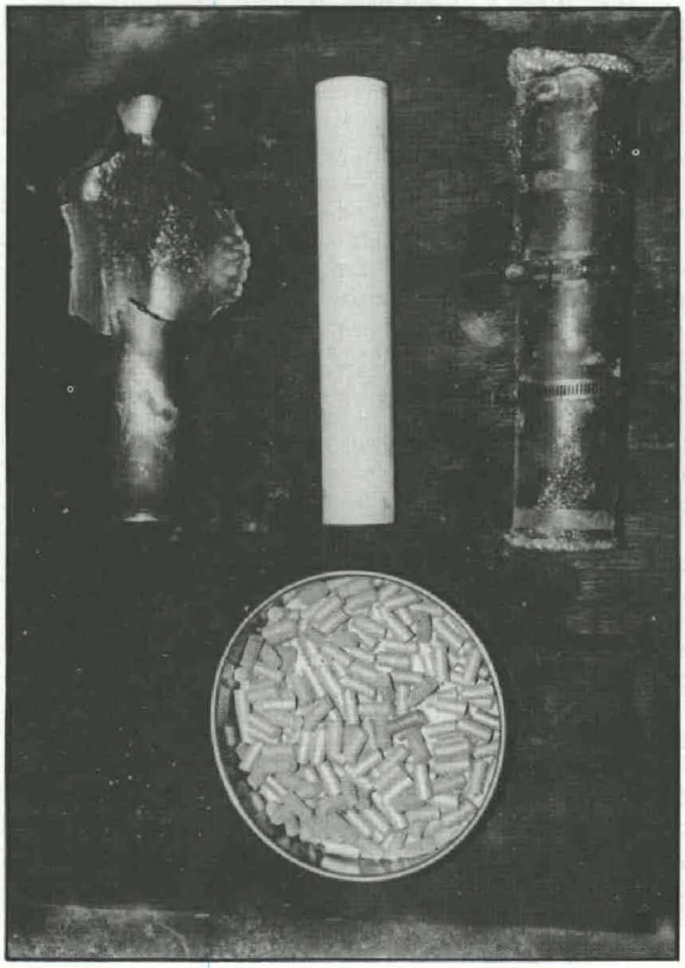
· *Below,* ***After Detonation.*** On the left, the unprotected sleeve, after the test, is shown ruptured. Next to it, lies the unscathed protected sleeve and the intact intumescent material. Beneath, the unburned propellant from the protected sleeve is displayed.

to "harness good private industry technology" for Army needs. Once the lab's testing efforts had demonstrated that this alloy would most likely be usable on military systems, MTL's Engineering Standardization Branch issued a military specification for it. At that point, the material became a valid entity for eventual military acquisition.

"MTL played a big part in getting this alloy off the ground, by recognizing the capabilities of the alloy through their testing and by expanding the data base," said Pascasio. "If we didn't get MTL's backing, we may have never got this thing going."

With most positive characteristics already proven, weldability became the crucial factor in determining the usefulness of the alloy, and the MTL took the lead in this area as well. Although weldability data was included in the extensive two-year study of the material, MTL engineers determined that a larger, more comprehensive study was needed.

That testing proved that 2519 was weldable to itself and to 5083, important because many parts made of 5083 would conceivably remain on vehicles even if 2519 eventually replaces it in most armor applications. "It at least



Obviously, this new alloy could potentially provide a much better option for military program managers.

allows us to preserve that option," says Goldman. According to an MTL Welding Laboratory summary report on the 2519 study, "It has been shown through this study that 2519 is indeed superior to the more commonly used alloys."

According to MTL welding engineer Dan Nowak, 2519's weldability is very good. When welding it to 5083, he noted, some precautions have to be taken, but it has worked well.

Ballistic shock testing of the 2519 weldments was one of the few remaining hurdles for the alloy. Weldments of full-size ballistic test plates recently underwent ballistic shock loading at Aberdeen Proving Ground, MD. This entailed shooting 75mm, five-pound proof rounds directly at the welds at a velocity (V50) that causes 50 percent of the plates to fail by cracking. Failure is constituted by the total of the cracks on a particular weld adding up to 12 inches or more.

So far, as noted, these results have not been encouraging. Corner joints of approximately 90 degrees passed the shock loading when a on-impacted plate backed the impacted plate, but the more severe test on flat butt joints caused the welds to fail at fairly low velocities. Explained Nowak: "The failures were due to the poor ductility of 2519 weldments; they just wouldn't give as much as the 5083 weldments."

All the butt joints were welded with the Gas Metal Arc Welding (GMAW) process, which is widely used in fabricating Army vehicles. After witnessing the tests, Nowak noted that: "These results don't help the program, but although they do indicate that additional welding studies are required, they don't devastate it either." He was alluding to two things. First, flat butt joints are not prevalent on Army vehicle designs, because of their inherently poor ballistic properties. Secondly, GMAW is not the only way to weld 2519.

The MTL Weld Lab is already working on other methods of welding 2519, which will likely have a better chance of passing the ballistic shock loading tests. Work on three different welding processes for joining the 2519 aluminum armor is now underway.

Nowak stated that because of 2519's good properties it should also lend itself well to aeronautical use, where shock performance is not relevant. He added that Army helicopters are among the aeronautical equipment that potentially stands to gain from incorporation of this alloy.

According to Goldman, if weld shock loading failure can be corrected, 2519 will eventually replace both 7039 and 5083 for most major aluminum armor applications, although 5083 will probably continue to be used in some areas. Application, he says, will probably come with the next generation of lightweight armored vehicles, in the early '90s. He doubts that it will ever be placed on the current BFV, because the filler wire needed to weld 2519 is different from the one required for 5083 and that could cause delays when vehicles are brought in for repair.

Again, assuming the shock test failure can be corrected, Goldman sees few remaining impediments to application. "I'm definitely optimistic about it," he said. Now that most testing is complete, he is looking ahead to prototype development. "Fabrication is the last major test," he said.

Several Army materiel manufacturers, including FMC, are planning 2519 fabrication efforts. One is developing a chassis for an artillery vehicle, such as those currently contemplated for the Army's Armored Family of Vehicles (AFV). FMC is scheduled to develop a 2519 turret similar to that on the BFV. Goldman anticipates completion of these projects within 12 to 18 months. "When these things are completed," he said, "we'll shoot at them too," to see how well the alloy holds up against live fire when fabricated.

Goldman remains hopeful that this alloy will be incorporated into the next generation of light and medium weight armored vehicles, either dramatically reducing weight or increasing ballistic performance.

DeLuca stresses that, although MTL vastly expanded the existing data base and formally endorsed the alloy, many organizations are jointly responsible for the improvements expected to come about as a result of development and exploration of this new material. "Credit must be shared among ALCOA, the other aluminum companies that participated, the vehicle manufacturers, TACOM, the Marine Corps and MTL," he said.

MTL is the Army's lead laboratory for research and development of advanced materials and is part of the U.S. Army Laboratory Command in Adelphi, MD, a major subordinate command of the Army Materiel Command in Alexandria, VA.

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THE VERY HIGH SPEED INTEGRATED CIRCUIT PROGRAM

By COL W.H. Freestone

Introduction

In the late 1970s both the Congress of the United States and the secretary of defense were briefed by the Defense Intelligence Agency (DIA) concerning erosion of the technology lead the United States had previously enjoyed in electronics over the Soviet Union. The report highlighted the fact that the Soviet Union was succeeding at inserting U.S. commercial integrated circuit designs into certain of their weapon systems faster than the U.S. defense industry was able to achieve insertion of those same products into U.S. weapon systems. Concern over this erosion of our technical lead led to the creation of the Very High Speed Integrated Circuit (VHSIC) program.

It is the policy of the U.S. Department of Defense to use technology to overcome numerical superiority on the battlefield. The secretary of defense has initiated several programs aimed at giving U.S. weapon systems a war winning advantage. During 1980 and 1981, the Defense Science Board identified key technologies that would make a significant difference to U.S. weapon system performance (Fig 1). VHSIC was identified as having the highest priority for development and application among several initiatives.

With a belief that the electronic integrated circuit is the basic building block for all Department of Defense weapon systems, since removal of electronic components from our systems would leave empty boxes, the secretary of defense sought to capitalize on the strength of the U.S. semiconductor industry and develop a program designed solely for military system needs.

In formulating the concept for the VHSIC program, it was determined that military system needs were not being addressed by the commercial semiconductor industry. In the early 60s, the military was one of the first users of the then newly created integrated circuit. The first noteworthy insertion then was into the Minuteman Missile. The range and accuracy of the missile were improved by addition of a small processor and associated software program, rather than requiring a costly redesign of the guidance package.

In those early days, the Defense Department purchased approximately 75 percent of what the commercial semiconductor industry produced. The DOD, as the prime customer, was able

TECHNOLOGIES THAT COULD MAKE A BIG DIFFERENCE

1. VERY HIGH SPEED INTEGRATED CIRCUITS
2. STEALTH
3. ADVANCED SOFTWARE/ ALGORITHM DEVELOPMENT
4. * MICROPROCESSOR-BASED PERSONAL LEARNING AIDS
5. * FAIL-SOFT/FAULT-TOLERANT ELECTRONICS
6. RAPID SOLIDIFICATION TECHNOLOGY
7. * MACHINE INTELLIGENCE
8. * SUPER COMPUTERS
9. ADVANCED COMPOSITES
10. HIGH-DENSITY MONOLOTH FOCAL PLANE ARRAYS
11. * RADIATION-HARDENED ADVANCED ELECTRONICS
12. SPACE NUCLEAR POWER
13. HIGH POWER MICROWAVE GENERATORS
14. LARGE SPACE STRUCTURES
15. OPTOELECTRONICS
16. SPACE-BASED RADAR
17. SHORT-WAVELENGTH LASERS

*VHSIC DEPENDENT

Figure 1.

	CURRENT	VHSIC
Number of Boards	44	24
Number of Board types	21	8
Power (Watts)	120	70
Lines of Code	150,000	90,000
MTBF		24 times better
MTTR		reduced by one half

Table 1. AN/ALQ-131 Results

to influence what the fledgling integrated circuit industry produced. However, the commercial world rapidly took over as prime customer, until in the early 80s, DOD was purchasing only five to seven percent of what the industry was producing.

DOD, therefore, was no longer in a position to influence the semi-conductor producers. The commercial world demanded data processors, microprocessors, and memory devices. The military's needs were in a different world of high speed signal processing, military qualification, radiation hardening and built-in-test.

In addition, and of great significance, was the fact that the transistor was getting smaller. More performance could be packed into a smaller space. End products could be produced that were smaller, lighter, more reliable, and easier to maintain. The military community, which could benefit greatly from these improvements, was being left out.

One of the principle goals of the VHSIC program was to overcome the delay time being experienced by the defense acquisition community in keeping pace with the rapidly changing world of integrated circuits. The hands-off policy of DOD during the 1970s contributed to systems being fielded that were obsolete upon delivery.

In some cases, changes were taking place so rapidly in the commercial semi-conductor world that diminishing manufacturing source notices were being issued at the same time that new systems were being delivered (eg. F-16 aircraft/Westinghouse). The VHSIC program sought to take a great leap forward in order to overcome this problem.

In attacking the problem, the under secretary of defense for research and engineering (USDRE) developed a comprehensive strategy to insure that the VHSIC integrated circuits produced by various semi-conductor manufacturers would be an integral part of the defense semi-conductor industry. In addition, the Congress insisted that the technology to manufacture these new devices would be available throughout the U.S. industrial community. The new devices would be protected from foreign use by the International Traffic in Arms Regulation.

The strategy for the program included provisions for innovation in the manufacturing process, yield enhancement efforts to reduce the cost of individual devices, and an integrated design automated system. It should be noted that VHSIC products are intended for use in NATO weapon systems on a case by case basis.

The VHSIC program was defined in four phases, with phase one setting the ambitious goal for the development of military specific families of integrated circuits with 1.25 micron feature size to meet processing speeds and radiation hardness for tactical requirements. Phase two was aimed at producing integrated circuits at .5 micron feature size. In addition, a built-in-test (BIT) capability was specified leading to a two-level maintenance capability.

Parallel Development

Rather than waiting until the VHSIC program had produced sufficient product yield before attempting to insert the new technology into systems in 1984, the USDRE established a parallel development effort with the military services.

Each service was asked to offer up candidate systems that would help to illustrate enhancements in various categories. The Office of the Secretary of Defense entered into joint development, with the three military services sharing the cost of each insertion effort.

VHSIC Demonstration Program

In December 1985, a formal demonstration of VHSIC technology insertion into an actual weapon system showed for the first time that VHSIC integrated circuits could make dramatic improvements in weapon system development. The first system to be demonstrated was the AN/ALQ-131 Electronic Warfare Pod. The results of that demonstration are shown in Table 1.

The great success of this first demonstration prompted the newly appointed Under Secretary Of Defense For Acquisition Richard Godwin to formalize the demonstration of VHSIC technology insertion efforts in order to teach system developers both in industry and the government both the benefits and process for VHSIC technology insertion. What follows are highlights of other VHSIC technology insertion demonstrations:

AN/UYS-1 Advanced Signal Processor

This demonstration was located at the Navy side of Andrews Air Base. A P-3 ORION submarine hunting aircraft was flown there to demonstrate that VHSIC integrated circuits were actually being used in another frontline system. In addition, the demonstration sought to show how easy it is to convert an existing system from conventional to

VHSIC electronics. In just 30 minutes, a sailor was able to change from the current input signal conditioner to a VHSIC version of the same element. This simple change, which did not require any modifications to the basic AN/UYS-1 system, doubled its sonobuoy monitoring capability. Later, software changes quadrupled the basic systems ability to listen to sonobuoy transmissions.

The significance of this particular demonstration is the fact that an "in use" military systems basic combat power was increased by a factor of four, without necessitating the creation of a new system in order to achieve that level of performance. Thus, the current aircraft and associated electronics package life may be extended in terms of the current mission of the ORION.

Enhanced Position Location Reporting System (EPLRS)

The challenge that ground commanders have in keeping track of personnel, particularly during night operations, can be very difficult. The Position Locating Reporting System (planned for use with the Marine Corps) and the Enhanced (VHSIC) version of this system (planned for use with the U.S. Army), holds the promise of greatly facilitating that aspect of a ground commander's job.

The PLRS system is a manpack portable radio system that transmits individual positions to a base station which looks similar to an air traffic control position. A unit commander with a map overlay on the screen, can pinpoint individuals in his unit silently, and in real time. Since PLRS is a ground tactical system that relies on radio transmissions, it is susceptible to jamming.

The Army found that conventional electronics could not provide the operating speeds necessary to reduce the impact that enemy jamming would have on PLRS. The Army decided to step up to VHSIC. The Marine Corps is currently considering moving up to the Enhanced PLRS also.

Not only do the enhanced operating speeds of VHSIC integrated circuits provide the Army with a much greater anti-jam capability, but if two of the PLRS modules are built with VHSIC components and the full buy of approximately 20,000 sets are purchased, dramatic results are possible. For example, by using VHSIC, there is an expected acquisition cost savings of $112 million and an additional life cycle cost savings of $100 million. Enhanced PLRS modules planning to use VHSIC components are the signal message processor and the key generator.

The expected savings mentioned above are to due to less labor required to assemble these modules, fewer parts, plus the increased reliability of the VHSIC components.

AN/SRN-1 Vector Product Calculator

The Vector Product Calculator is part of a Naval shipboard system that

ITEM	VHSIC		CONVENTIONAL	
Integrated Circuits (ICs)	VHSIC ICs 44 @ $500 x 1.5	$33,000	24 @ $ 50 4 @ $200 12 @ $100 455 @ $ 10	$ 1,200 $ 800 $ 1,200 $ 4,500 $ 7,750 x 1.5 $11,625
Boards	1 @ $5,000	$ 5,000	6 @ $1,000	$ 6,000
Test & Handling	1 @ $8,000	$ 8,000	6 @ $2,000	$12,000
TOTAL:		$46,000 x 1		$29,625 x 3
Material Cost for Equivalent Throughput		$46,000		$88,875

The Vector Product Calculator VHSIC Assembly replaces 6x3 = 18 conventional integrated circuit boards with one (1) VHSIC board.

The Single VHSIC board provides an easy Fault-Isolation-Test (FIT) capability not available with the conventional board.

Table 2. Vector Product Calculator

	FORMER	VHSIC
Integrated circuit reduction	102	1
Total components	224	60
Built-In-Test	NO	YES
MTBF (Hours)	40	5000
Costs (dollars)	24,000	2,000

NOTE: This system is currently being test flown in an F-111

Table 3.

monitors a network of antennas. The front end of the system contains the vector product calculator. A VHSIC upgrade of this part of the system produced the results shown in Table 2.

M1-A1 Main Battle Tank

Employing two M1-A1 Tanks at the Chrysler (automobile) proving ground near Detroit MI, one as a moving target and the second as a targeting system, the Army demonstrated an automated lock-on capability for distant evasive targets. At present, a tank gunner must acquire a target and then hold the sighting crosshairs on the target until engagement. This demonstration showed how VHSIC integrated circuits provided great assistance to the gunner by freeing him from the task of maintaining constant manual contact with the target.

Coupled to an enhanced VHSIC fire control computer, the M1-A1 will be able to engage multiple targets at extended ranges. As part of the demonstration, a helicopter was flown in the sighting range of the tank. The automated sight lock-on capability of this experimental VHSIC-based system permitted the main gun of the tank to track the moving helicopter at an extended range opening the way for special ammunition being developed by the Army to be used against air targets.

Logistics Retrofit Engineering (Product Improvement)

During 1987, the Sacramento Air Logistics Depot was asked to upgrade an existing digital circuit board that was experiencing logistical support problems. The logistics engineering community selected one board from the F-111 aircraft for the experiment. The results of that upgrade are shown in Table 3.

VHSIC Phase II

The demonstrations discussed above and the retrofit engineering examples described were accomplished with products developed through phase one of the VHSIC program. The second main thrust of the VHSIC effort is contained in Phase II.

Phase II products will have capabilities considerably beyond Phase I. Dramatic increases in computation speeds will provide advanced capabilities such as digital maps, three dimensional terrain depiction (in vehicles/aircraft) to permit embedded training within a system and autonomous operations by individual systems. The second phase of the VHSIC program will be an integral part of the Strategic Defense Initiative.

Hardware Description Language

In order to overcome the problem of weapon systems being outpaced by the relentless movement of advances in microelectronics, the VHSIC program included a concept methodology to permit program managers to stay abreast of those changes without sacrificing their program schedules. The program that was created as an integral part of the VHSIC effort is called the Integrated Design Automation System (IDAS). This part of the VHSIC program is based on the latest developments in computer aided design.

Using a newly created software program identified as the VHSIC Hardware Description Language (VHDL), this revolutionary approach permits program managers to capture the electronic design of the system they are developing at a given point in time. Once the electronic design has been developed, VHDL permits the system developer to prototype either a new system or product improve an existing system using current electronic technology (digital).

When the time comes to produce the system in quantity, the IDAS system, using VHDL, will take the initial digital electronic design and translate it into the latest electronic geometries available at the time the system is purchased in quantity.

IDAS and VHDL permits acquisition managers at all levels to overcome the problem of continued purchase of the same design. This reinventing the wheel process is presently quite costly. If equipment currently in service becomes obsolete, a new or replacement item may require DOD to purchase the same design for a system performing the same task.

The VHDL language provides program managers, item managers and logisticians a new and efficient way to stay abreast of evolutionary changes in digital electronics. The potential savings in DOD system acquisition costs and the flexibility that VHDL affords system developers is great. To further facilitate this process for system developers, the Institute for Electrical and Electronic Engineers (IEEE), has adopted VHDL as an industry standard. As of March 1987, VHDL is IEEE standard #1076. A data item description is being written which may be included in all DOD contracts as desired by individual program managers.

The Technology Issue

The principle issue facing the VHSIC program is the implementation of the strategy. That is, the use of VHSIC integrated circuits in weapon systems. Technology implementation is a traditional program manager task. The majority of program managers are concerned with buying the minimum system that will satisfy the requirement. Contractors select and apply the technology to be used in a given system by establishing the configuration and design of a system.

Program managers are influenced by their perception of risk. Since their primary task is to deliver on time and within cost the system they are steward for, anything that is perceived to be a risk with respect to cost schedule, performance, and supportability, may be rejected. However, as may be seen in the VHSIC demonstrations that have been conducted to date, plus other insertions that are being considered, advanced (VHSIC) technology can reduce system acquisition risks in the following areas:

Acquisition Cost Risk Factors
(Risk Reduced):
- Fewer number of components, devices, boards, etc.
- Total cost of individual parts less costly
- Assembly and manufacturing costs reduced
- Verification and testing costs reduced

Schedule Risk Factors (Risk Reduced):
- Reduced design complexity and constraints (by advanced technology)
- Improved experience and qualification of the design team through greater technology experience
- Better simulation and prototyping capabilities through advanced CAD tools

Performance Risk Factors
(Risk Reduced):
- Less risk in design complexity and constraints
- Better computational throughout performance and system speed
- Improved availability of design standards (data bases, instruction set architecture's etc.)

Support Cost Risk Factors
(Risk Greatly Reduced):
- Improved reliability, maintainability and testability

Conclusion

The design and support of DOD electronic systems has not changed very much, from the end of the second world war. We still build individual boxes which are connected by cables. In some cases there is a sufficient number of those boxes in a given system that supportability becomes a very difficult task. VHSIC technology products offer DOD a unique opportunity to enhance both existing and planned systems design and function by several orders of magnitude through miniaturization and integration. It is up to everyone involved in the defense acquisition process to consider the insertion of VHSIC level products in DOD system development.

COL W.H. FREESTONE is director of technology insertion in the Office of the Under Secretary of Defense for Acquisition (Research and Advanced Technology). He is also a guest lecturer on technology at the Defense Systems Management College, is a member of the materiel acquisition management program, and is currently serving as military staff assistant to an Army Science Board on technology insertion.

CONTROLLING THE ARMY'S DEMAND FOR TERRAIN DATA

By Celine M. Childs

A decade ago, the Army's requirement for Digital Terrain Data (DTD) was relatively small and requirements were satisfied through unique solutions. Today, dozens of systems need DTD support, and it is no longer economically feasible to meet requirements on a one-to-one basis. For example, a 1984 Army study identified more than 70 weapon, analysis, and command, control and communications system requirements for DTD. The study also predicted that more than half of these systems would be operational by FY90.

GEN Maxwell R. Thurman, then the vice chief of staff, Army, expressed concern about the Army's appetite for DTD. He emphasized a need for controlling and coordinating DTD requirements to ensure they were not overstated. As a result, several Army regulations were revised to include a U.S. Army Corps of Engineers' (USACE) responsibility for reviewing all DTD requirements. The responsibility was delegated to the U.S. Army Engineer Topographic Laboratories (USAETL), which formed a new, technical operating element to support USACE in this endeavor.

This new organization, called the Concepts and Analysis Division (CAD), was formed at USAETL in October 1986. CAD has since been serving as the Army's center of technical expertise for all military applications of DTD. In this role, CAD has been involved in many activities: providing analytical support and technical advice to dozens of Army materiel and combat developers; conducting technical liaison with the Defense Mapping Agency (DMA), other DOD agencies, Army and private industry to maintain a complete awareness of emerging requirements and state-of-the-art means to meet these requirements; serving as the Army's technical focal point for defining, distributing and evaluating prototype DTD products to ensure centralized control of requirements; reviewing, processing and validating all new requests for DTD support by Army users; and performing technical reviews of program management documentation in support of the materiel-acquisition process.

A number of factors are influencing the demand for DTD support. First, DMA is undergoing an extensive modernization program. When completed, the program will give DMA an all-digital production capability, putting them in a position to respond to the services with a variety of digital products.

Second, computing capabilities are escalating. A personal computer's (PC) power exceeds that of earlier mainframes, yet a PC is much more compact and a fraction of the cost. As a result, PCs are becoming more attractive to military users. A large number of users want digital data, and for the first time ever the Army has the ability to process it.

The third factor is enemy threat. We must be prepared to commit relatively small forces to various locations quickly and with short notice. Management of these forces will be decentralized, giving commanders more responsibility. They will need information fast because they will have less time to prepare. Thus, a detailed knowledge of the terrain will be even more important than it is now. An ample amount of DTD will be needed to support this scenario.

Benefits to the User

With DTD, users will be able to do their jobs faster and more accurately. They will be able to integrate terrain information more easily with other information available in digital form; such as weather, and enemy and friendly situations. DTD will allow commanders to rehearse battle plans in minute detail and will ultimately improve their effectiveness and efficiency in fulfilling missions.

Products of the Future

DMA produces many types of DTD. Digital Terrain Elevation Data (DTED) and Digital Feature Analysis Data (DFAD) are the most readily available and widely used by DMA customers. As a source of elevation information, DTED Level I fulfills many Army needs.

As a source of information on natural and man-made features, DFAD satisfies very few Army needs. After an extensive survey of existing and emerging DTD requirements, Army formally stated, to DMA, a requirement for a new digital product. This request resulted in a prototype product called Tactical Terrain Data (TTD).

TTD consists of an elevation matrix, information currently found on three, hard-copy DMA products, plus a few enhancements. The elevation matrix, DTED Level II, contains more data points than DTED Level I, thereby permitting subsequent modeling of microrelief by users. The feature data are similar to that currently portrayed on the 1:50,000-scale, hard-copy Tactical Terrain Analysis Data Base (TTADB) with additional information on vertical obstacles and urban areas, as well as an intensified transportation description. The feature data also will contain selected information from the 1:50,000-scale topographic line map and combat chart. Another important aspect of TTD will be the built-in provision for users to add additional feature information in the field. This "value-added" concept is a new capability of DTD products.

For the past two-and-one-half years, the services have been negotiating with DMA on the content and format of TTD. Since its formation, CAD has provided the technical expertise to support these negotiations. At present, the services are awaiting delivery of a prototype TTD cell from DMA. CAD will manage the Army's evaluation of this prototype TTD cell from DMA. Evaluation results will be provided to DMA to ensure that the end product is sufficiently responsive to user requirements.

CAD also has represented the Army in discussions with DMA to provide, before TTD is available in volume, an Interim Terrain Data (ITD) product to adequately and quickly service Army's near-term tactical and analysis community requirements for digital terrain data sets.

DMA's recent decision to support the Digital Topographic Support System with a volume of ITD required for operational deployment has been underscored by their commitment in developing a product specification for ITD. This specification was delivered to the Army in August 1988. DMA plans to deliver a prototype data set by the end of this calendar year.

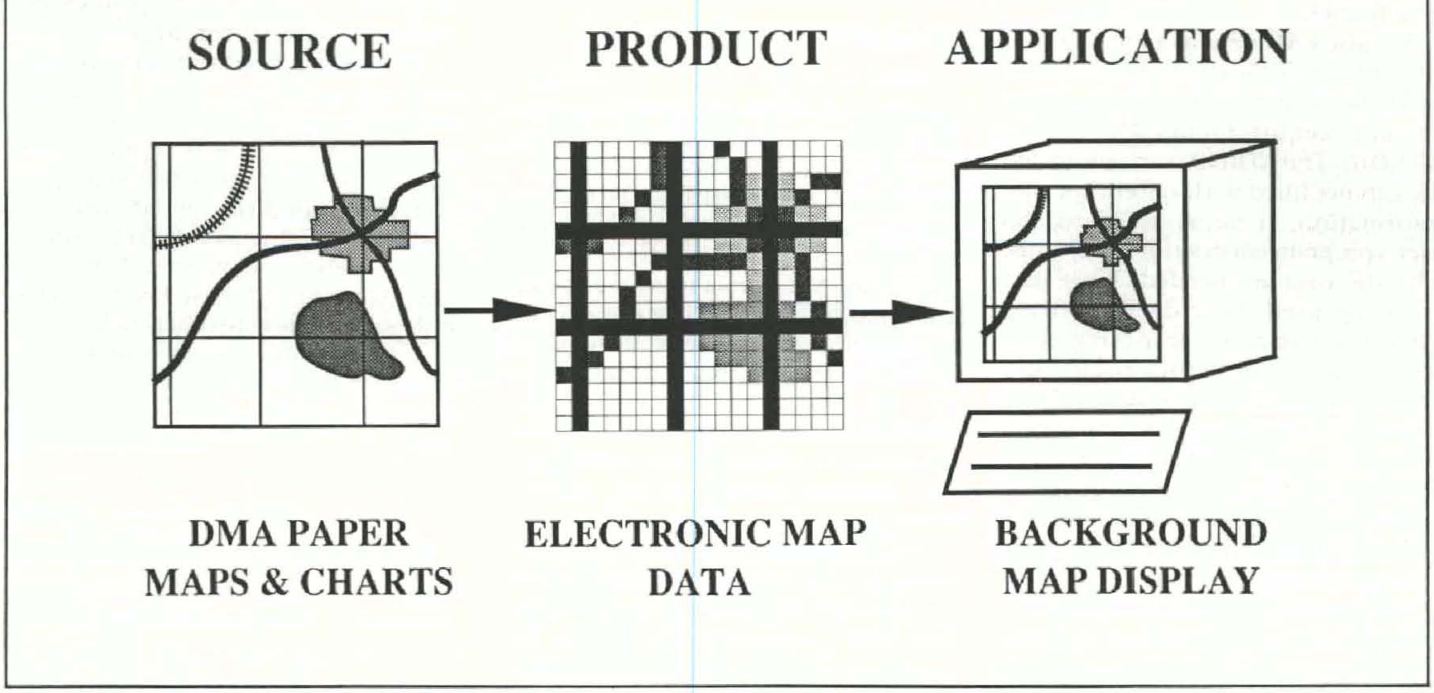
IDT will consist of digitized TTADBs and Planning Terrain Analysis Data Bases together with DTED Level I. The information content of ITD will be a subset of TTD. As conceptualized bythe Army, ITD must be easily usable, cost effective, coproducible and adaptable to either existing or near-term, fieldable tactical and non-tactical systems and programs.

Achievements

CAD's success story began shortly after its establishment. CAD was tasked to update the previously mentioned 1984 Army-wide study. Because it had to accomplish this in a short amount of time with few people, it opted to research only the tactical systems that would be fielded by FY93. CAD identified 15 systems with digital requirements. These systems are expected to be operational before TTD will be available in volume from DMA. CAD has been involved in a continuing effort to find near-term solutions for these systems.

CAD's investigations, revealing that the vast majority of these systems had a definite need to display a hard-copy map on a computer screen, led to the Electronic Map Display (EMD) initiative. CAD consolidated the EMD requirement in order to define it in minimum essential terms for DMA. In turn, the standard product being developed by DMA satisfies some, but not all aspects of the requirement. CAD will most likely be involved in determining the next step for the Army. If so, CAD could possibly develop a prototype to satisfy the requirements, evaluate the prototype and recommend future courses of action.

Another achievement has been CAD's interaction with more than 40 program managers (PM) and combat developers-providing both technical advice and support. In some cases,



Electronic Map Data are created by scanning paper maps and charts. The end result is a background map, displayed on a computer, that is identical to the original paper map.

these interactions serve primarily to provide information to users regarding existing and emerging digital products. In other cases, a more detailed analysis is necessary.

For example, CAD recently completed a study of Army DTD requirements for the Office of the PM, Mobile Subscriber Equipment (MSE). CAD's goal was to determine if the standard products requested for the MSE system were necessary for a particular application. CAD concluded that in rough to very rough terrain, more DTED resolution than planned by the system was required to obtain reliable line-of-sight (LOS) predictions. Additionally, it found that the use of DFAD standardized heights to model vegetation does not support reliable LOS predictions.

CAD also worked with the PM, Operations Tactical Data Systems (OPTADS), who is responsible for the development of the Maneuver Control System (MCS). MCS requires an EMD capability and will be fielded in FY89. CAD has been searching for a means to get a DMA product in usable form for them.

In addition to supporting PMs, CAD has processed more than 100 requests for DTD. These were mainly requests from users needing DTED Level I for specific areas within limited time frames.

Because CAD obtains a great deal of information through interacting with DTD users, it developed the Army Terrain Requirements Data Base (ATRDB). The ATRDB is an automated file cabinet filled with system-specific information. It contains details on user's programs such as funding status, why the data are needed, what data are being used, how data are being used and if data are satisfying their requirements or being used only because nothing else is available. With the ATRDB, CAD can easily maintain and update this program data, and can readily share it with Headquarters, Department of the Army and DMA. The data base eventually will show what data are available for specific areas.

CAD's accomplishments extend to its current evaluations of a number of prototypes which are being planned or produced by DMA, such as the Operational Navigation Chart (ONC) and the ARC-Digitized Raster Graphics (A-DRG).

The DMA-produced ONC is a 1:1,000,000-scale paper product which supports high-speed radar navigation requirements at medium to high altitudes as well as other applications requiring only small-scale map information. Presently, DMA is planning the production of a new digital product called the Digital Chart of the World (DCW). The DCW will consist of an integrated set of digital files holding all the information currently found on 270 ONCs. CAD is now working with DMA to further define the actual data-base content and will coordinate the Army's evaluation of the DCW prototype.

The A-DRG prototype was developed by DMA specifically to support the Marine AV-8B Harrier aircraft, however it also will be used within the Army as a background map. USAETL engineers have been demonstrating the ability to display the overview image and full-resolution A-DRG data. The MCS, All-Source Analysis System, Special Operations Aircraft and Joint Surveillance Target Attack Radar System have all experimented with the engineering prototype. Each of these systems plans to integrate their mission-specific information with the map data. Production of A-DRG data will begin in the second quarter of FY89.

Plans for the Future

Although DMA will be a fully operational digital production facility in five years, it still will be unable to satisfy all customer needs. With technologically advanced tools, customers will require more and more data. Consequently, there always will be a gap between customer needs and digital information available. For this reason, control and management of requests for additional information are critical. The "nice-to-haves" must be separated from the essential requests. CAD must continue to identify areas where data and software standards can save the Army money.

CAD foresees a greater emphasis being placed on software standards in future years because software proliferation will most assuredly follow the evolution of DTD. CAD anticipates the necessity to build a library of standardized DTD software packages. This library could serve as a clearing house for users to obtain and share common software packages, alleviating the need, for example, to develop a product 20 times for 20 different users. Instead, all users interested in the same application could use the same software package to extract the data needed from a standard product. CAD would maintain and advertise the library to the Army-wide user community which could readily obtain a package or a point of contact for further information.

CAD does not yet have a current awareness of all evolving Army requirements. Subject to resource constraints, it will meet this challenge through attending tech-base R&D reviews and interacting with Army users, laboratory personnel and doctrine developers. Such contacts will keep CAD abreast of emerging systems and help in answering questions such as what systems could conceivably be in the field in a decade or so, and what their requirements will be for DTD support.

In summary, CAD was established to control and coordinate all emerging Army requirements for DTD. Its accomplishments since acquiring this responsibility have been widely recognized. It has formed and maintained contacts with PMs, combat developers and Army contractors, provided technical advice, researched tactical systems, completed studies on program needs and processed numerous requests for DTD.

CAD is eager to continue its work in these areas as well as to meet the challenges that lie ahead. In addition to a continuing technical support role, plans for the future include building the aforementioned library of software packages aimed at making DTD exploitation easier and more affordable. Attendance at tech base R&D reviews and interactions with others will enable CAD to continue to fulfill its role in serving as the Army's primary point of contact to combat and materiel developers, and other users for terrain data.

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DESIGN-FOR-DISCARD IN SYSTEMS ENGINEERING

By By Dan McDavid

Editor's Note: In the July-August 1987 issue of Army RD&A Bulletin, COL William V. Murry introduced the subject of design-for-discard. That article provides good background for this current one, which has been written to clarify the relationship between the engineering effort associated with DFD and other system engineering efforts.

Most of us, when we first began hearing of design-for-discard (DFD), wrote it off as another repackaging of tired old ideas. There is, however, a variety of ideas of what DFD "really" is. Each functional expert who handles a part of DFD has difficulty seeing beyond his own foxhole — because his function is extraordinarily complicated and is all-consuming by itself. Add in related and sometimes conflicting areas such as reliability engineering, manpower and personnel integration (MANPRINT), and producibility engineering, and the job of optimizing the design of equipment appears almost impossible.

This article examines several prevalent views of DFD, pointing out what is correct and what is misconception. It provides insight into what is missing in the overall effort, and how the solution applies to related systems engineering functions.

DFD is indeed a portion of the design influence which should be exerted by the logistician. But there are inherent problems if this is the meat of the DFD program. First of all, the way logisticians influence design in the Army is by up-front restrictions or constraints on the design and through design reviews.

Constraining the design to discardable components (or a high percentage of discardable components) might be an easy solution; but may be unrealistic in a new design and certainly can overrestrict competition in off-the-shelf systems. And influencing design through design reviews is inherently flawed as a method of accomplishing

DFD, since this involves trading off among a limited number of designs; and even if some recommended changes are accepted may not lead to substantial inclusion of DFD.

The job of the logistician within the DFD effort is manifold, including early definition of logistics constraints, influencing the design to lower the

The Logistician's View

DFD is only a portion of the up-front design influence required of the integrated logistic support program.

logistics burden, and performing repair-vs-discard and level-of-repair analyses. But the logistician does not have the entire job, or in most cases even the right perspective, to complete the DFD job.

Integrated logistics support (ILS) tends to be a review function, integrating work that has largely been completed. ILS is a major consideration when trading off alternative designs, but has limited influence when the designs are actually being created. Since the slant of these trade-offs tends to be toward fitting the new weapon system into the existing support structure, they would rarely lead directly to designs which were purposely created to entirely eliminate repair actions. Instead they lead to the lowest cost option which meets the operational requirements and mission availability for the system. If a designed-for-discard option is not offered, it is extremely unlikely that one would be created as a result of an ILS review.

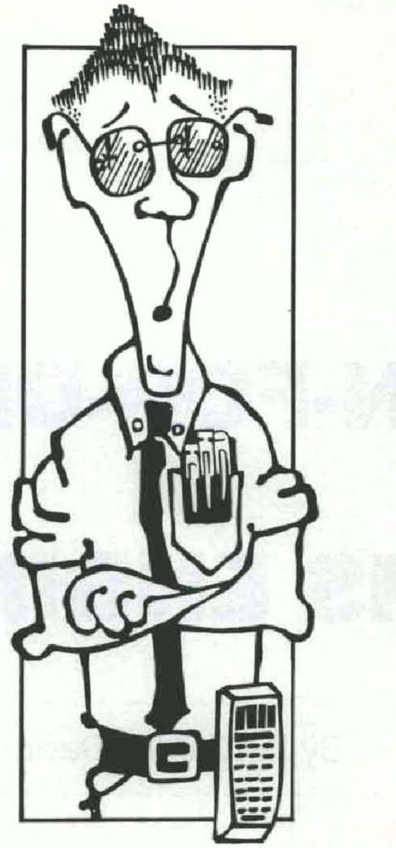
The Reliability Engineer's View

DFD is in direct conflict with the goals of reliability engineering. If components are cheap enough to discard, then we haven't invested enough to achieve the reliability we require.

DFD, just like reliability, cannot be pursued in a vacuum. Higher reliability may actually enhance design-for-discard, because the frequency of repair is low enough to justify eliminating the organic capability to maintain the highly reliable components.

The key to properly trading off reliability and discardability is to consider the true total life cycle cost, in dollars and manpower, of the components that are being designed, and not to assume a fixed cost for the overhead involved in maintaining a repair capability. Many techniques used in designing for discard do not detract at all from the reliability of a system, because cheapness is not the only criteria for discardability.

The best way to illustrate the interrelationship of DFD and reliability engineering is by example. Most of



today's major components of communications equipment are extremely reliable (mean-time-between-failures in the hundreds or thousands of hours) and relatively inexpensive (in the hundreds or thousands of dollars). Some are expected essentially not to fail at all during the life of an individual item; and even with the high density of fielded items one would only expect a very few failed items over the course of a year. Under these circumstances, economics dictate that a repair capability not be developed, and that failed items be disposed of without the expense of packing, handling, storage or transportation by the government. So in this case, high reliability actually causes the decision to discard rather than prohibiting it.

The Maintainability Engineer's View

Maintainability engineering will automatically lead to the optimum number of discardable components.

Classical maintainability engineering leads to the least expensive solution to system failures which maintains the required operational availability. This is done within an assumed set of constraints, usually including a limited number of maintenance options and assuming certain overhead and "pipeline" costs to be fixed. This solution is usually driven by the need to lower the amount of downtime, which in turn tends to drive repair actions to the lowest allowable maintenance level, because the transportation time associated with repair at higher levels is usually by far the largest component of downtime. DFD can be compatible with this design approach; but decisions can be different when the option of not repairing is given its proper value in terms of life cycle cost and operational readiness, rather than the only consideration being the downtime.

The Test Designer's View

Complete and reliable diagnostics, designed in, will lead to a high confidence in failure diagnosis, then economics will dictate whether to discard the component. Deciding ahead of time to discard a component prevents testability from being built in.

Testability is an important consideration in designing for discard; but it also must be viewed as it interacts with other design disciplines, and cannot be seen as only a positive contributor. Testability adds to the cost of a component, and it introduces failure modes which would not otherwise be there. The additional cost and unreliability may be the only things forcing repair of a component. Diagnostics must reliably identify failures to the level of discard, but must not be designed into a system wholesale without regard to the impact on other design factors.

The Producibility Engineer's View:

Producibility engineering will yield the lowest cost item, allowing the discard or repair decision to be purely an economic one for each component.

Producibility is extremely important, since a design is no good if it cannot be manufactured economically. But, as with all system engineering disciplines, producibility must be traded off with other considerations; and full accounting must be made for all life cycle costs, not just the cost of manufacturing. A DFD approach would most likely be a positive contribution to producibility, since features which allow repair often complicate the manufacture of an item.

The Technologist's View:

DFD has nothing to do with me. Research will produce the best new technology to develop. The designers will turn it into weapon systems and the logistics people can figure out the best way to maintain it.

Technology can go in all sorts of directions. In some technological areas, such as electronics, the discard of highly complex components at failure is the way the state-of-the-art has naturally gone. In other technologies, the road to discard-at-failure is not so direct.

Habits, prejudices of designers, traditional manufacturing techniques, and other built-in roadblocks keep some promising new technologies from being developed which might otherwise result in higher level components being discardable at failure.

The commercial automotive industry has been only lately adopting designs which use more plastic and composite components which are not repairable but are extremely reliable. There is of course considerable consumer resistance to engine components which cannot be repaired, but economics have clearly dictated that this is the way the design had to go. Military automotive acquisitions have been even slower to follow this trend, because it goes against the grain to not repair automobile components at breakdown.

Technology which is principally military, such as missile technology, is perhaps even harder to move in the direction of discard because there is nothing in the commercial sector with which to compare the methods of maintaining missile systems and the associated costs. This resistance to DFD is easily overcome, however, when the life cycle advantages of this approach to design are made clear.

The automotive industry has been won over by the reduction in warranty costs to the companies and by the lower skill levels necessary at the dealer level to do test, remove and replace actions rather than actual repairs. In electronics, even the consumer has become a DFD fan because of the tremendous decrease in cost of most electronic devices at the same time as reliability was increasing.

Technologies which raise the level of discard should be pushed into development; and one very good place to approach this is through the logistics research and development program. The lower life cycle costs which can be achieved by development of technology conducive to DFD will be strong justification for pursuing those technologies ahead of others.

Conclusions

If everyone seems to be involved in DFD, who is making all the tradeoffs among the various interests and who has the knowledge and authority to cut one program in favor of another? Unfortunately, the answer varies; and often decisions are made with incomplete knowledge and when proper tradeoffs have not been made.

The overall tradeoffs and the knowledge of what is affected by favoring one design factor over another should rest with the systems engineer or a systems engineering team. Decision authority might rest with the design engineer, the systems engineer, or project manager, depending on whether the decision is strictly technical, interdisciplinary, or programmatic.

Regardless of who is making the decision, it must be made with full knowledge of the overall impact on the system — which can only be gained by a systems approach to the design. DFD is completely intertwined with all aspects of system design and support. It depends on a complete systems engineering approach; because the end objective is not just components that can be discarded, it is low total life cycle cost with the least total support burden on the Army. This objective cannot be achieved unless all the interrelated systems engineering functions are considered together and a system is designed to optimally combine the various possibilities.

So who does DFD? Everyone involved in the design does it, but only a truly integrated systems engineering effort gets it done correctly.

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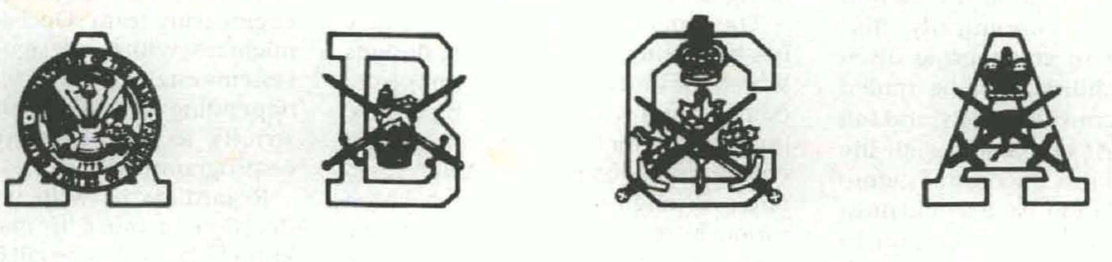

THE AMERICAN, BRITISH, CANADIAN AND AUSTRALIAN STANDARDIZATION PROGRAM

By Terry L. Thompson

Introduction

The American, British, Canadian and Australian (ABCA) Program has been in existence and productive for over 20 years and is one of our oldest programs aimed at achieving interoperability of combined forces.

The primary objectives of the ABCA Program are to ensure that there will be no materiel or technical obstacles to full cooperation among the four Armies and to obtain the greatest possible economy in the use of combined resources and effort. To fully understand the ABCA Program it is necessary to review its history and look at its existing structure.

History

The ABCA Program evolved from the close cooperation between these four nations during World War II. After the war, General Eisenhower and Field Marshal Montgomery decided that this close cooperation should continue and discussions began on how to achieve this goal through standardization of equipment and procedures.

By 1947, a "Plan to Effect Standardization" was initiated between the Armies of the U.S., UK and CA — The ABC Armies. This plan was replaced by a "Basic Standardization Concept" in 1950 and then by a "Basic Standardization Agreement" in 1954. Australia joined in 1963, and the ABCA Program was formally established.

In 1964, the four nations signed the current "Basic Standardization Agreement (BSA 1964)." Although not a signatory to the agreement, New Zealand became associated with the ABCA Program through Australia in 1965.

Organizational Structure

The structure of the ABCA Program is shown in Figure 1. Senior direction to the program is provided by an international conference, known as TEAL. The delegations from each Army are headed by their respective vice chief of staff or equivalent.

The International Management Board responsible for everyday supervision of ABCA matters is the Washington Standardization Officers (WSO) on duty in Washington, DC. The U.S. WSO is from Headquarters, Department of the Army, Deputy Chief of Staff for Operations (DCSOPS) while the others are military attaches from their respective embassies.

The permanent staff for the WSO is provided by all four countries and is located at the Primary Standardization Office (PSO) which is located in Falls Church, VA.

Detailed work leading to standardization and interoperability is undertaken by 19 Quadripartite Working Groups (QWGs), each specializing in a specific functional area. The QWG is a forum for exchange of information. A listing of the QWGs is shown in Figure 2. From this sharing of views and the preparation of ABCA concept papers, a process is set in motion which should eventually lead to the production of Quadripartite Standardization Agreements (QSTAG).

Each ABCA country has an office to coordinate the ABCA Army Standardization Program for its Army. The National Standardization Office (NSO) for the United States is located at Headquarters U.S. Army Materiel Command in the Office for International Cooperative Programs, International Standardization and Staff Talks Division. The most critical duty of the U.S. NSO is to coordinate U.S. and U.S. Army positions on the proposal, ratification, implementation and evaluation of all ABCA standardization agreements.

Each ABCA Army maintains standardization representatives with the other armies to facilitate the exchange of information. This arrangement is one of the principal values of the program to the nations, since it opens formal and informal channels of communication.

Program Benefits

Each participating Army benefits in different ways by being a member of the ABCA program. The following are considered to be the major benefits to all participants:

- Exchange of information and ideas;
- Adopting common requirements;
- Agreeing to materiel and non-materiel standardization agreements; and
- Opportunity to borrow equipment from other armies for its own test and evaluation, providing the loan is in the interest of standardization.

Current Emphasis

The ABCA Program compliments but does not duplicate the work and standardization of NATO. NATO is an international headquarters with operational plans while ABCA has standardization agreements but no war plans. The benefits of a common language, shared heritage and less formal association permit greater flexibility in the working of the ABCA program. This is apparent in the current aim of the program. It has been directed to an examination of mid and low intensity conflict in a deliberate attempt to complement, rather than duplicate, the high intensity warfare contemplated by NATO planners.

Summary

In times of increasingly austere defense budgets, the ABCA Program provides an opportunity to share the resources of the ABCA partners. Through the free exchange of information, each Army has access to R&D programs which it would find difficult or impossible to fund. Only the Armies can decide to what extent they want to use the program to economize

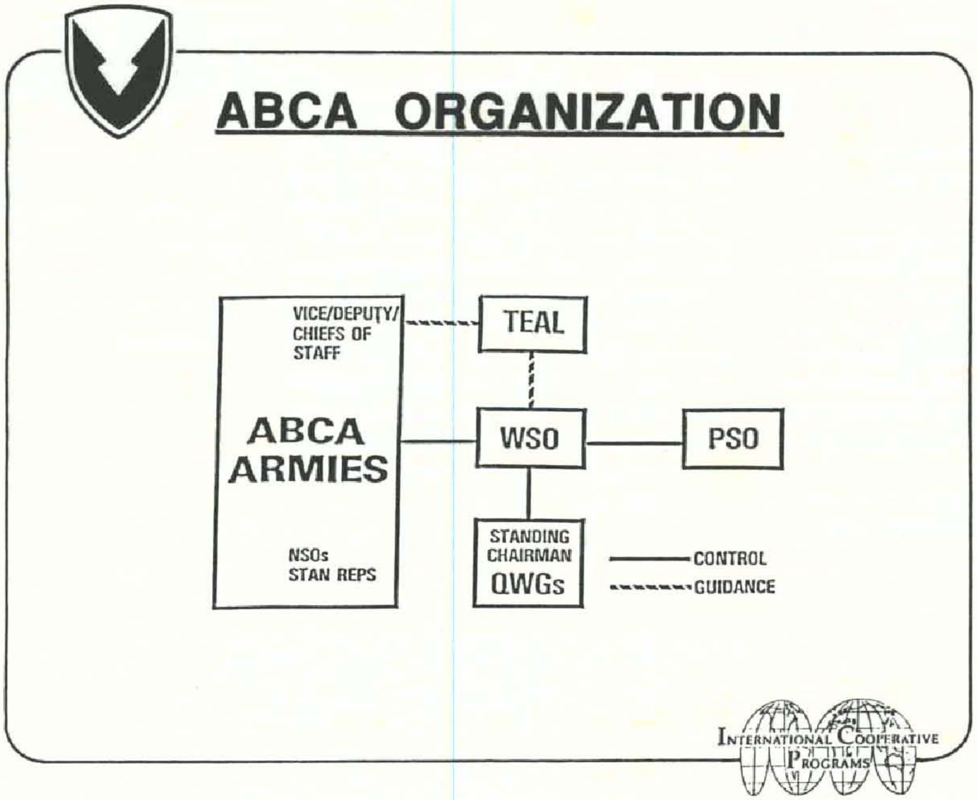

Figure 1.

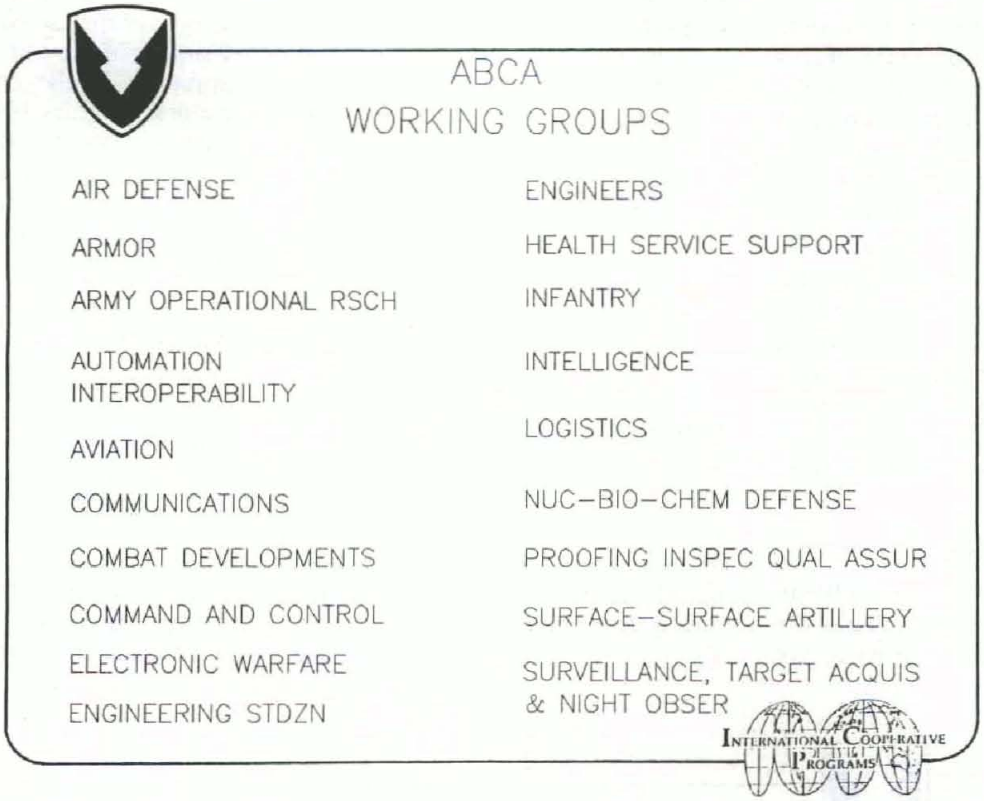

Figure 2.

in their R&D programs, and to acquire equipment which they need but cannot afford to develop.

The ABCA Program provides the ideal vehicle for achieving these economies through the use of combined resources and effort. The ultimate goal is the earliest possible adoption of standardized materiel and procedures. When this is not possible, lesser degrees of physical and functional interoperability are attempted.

In his State of the Union message in 1958, President Eisenhower summed up the importance of standardization programs in these words, which are still valid today: "It is wasteful in the extreme for friendly allies to consume talent and money in solving problems that their friends have already solved — all because of artificial barriers to sharing. And we cannot afford to cut ourselves off from the brilliant talents and minds of scientists in friendly countries. The task ahead will be hard enough without handcuffs of our own making."

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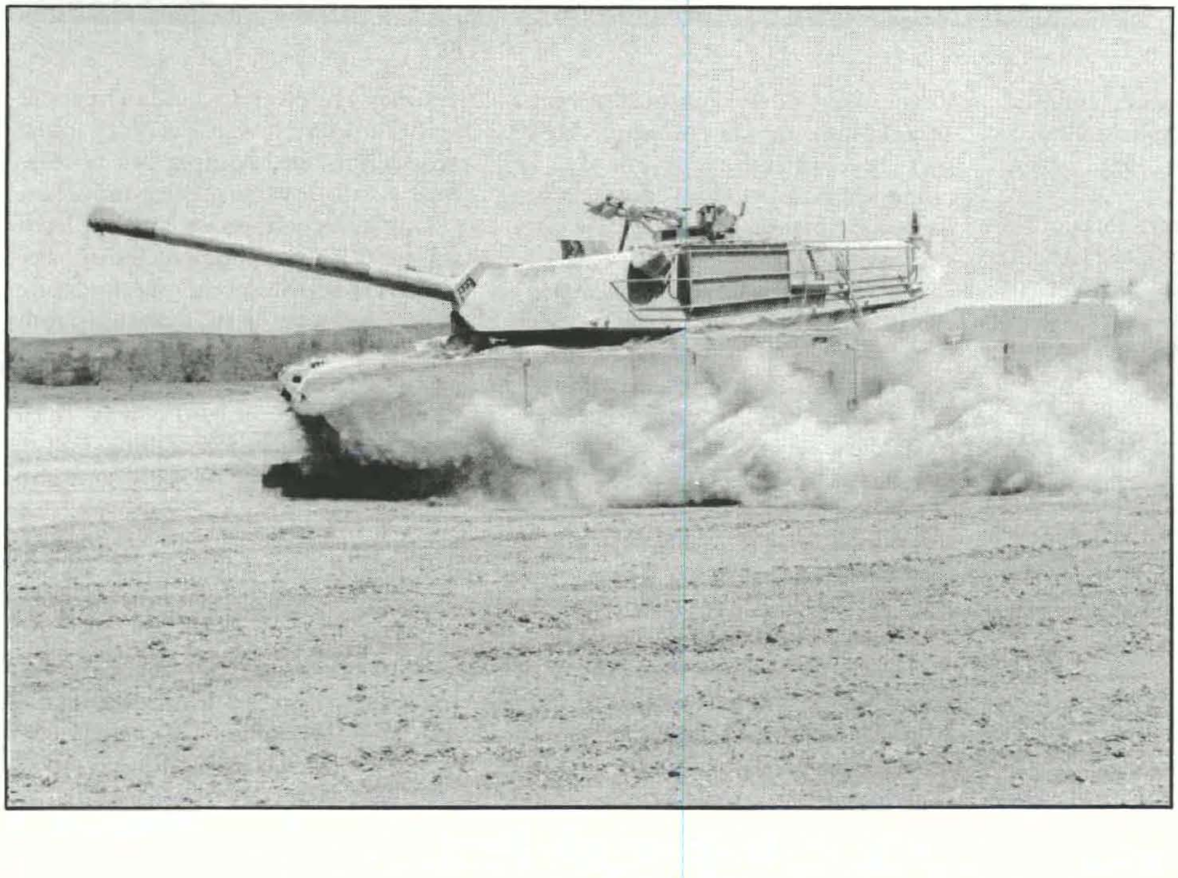
YUMA PROVING GROUND'S AUTOMOTIVE TEST MISSION

By By Fran Northon

In 1943, as war raged in Europe and the Pacific, the Army established a test station on the lower Colorado River in southwestern Arizona. Known as the Yuma Test Station, the small facility tested boats and pontoon bridges under controlled river conditions. Dams and flood control measures had tamed the "wild Colorado" from a river "two miles wide and a foot deep" into a channeled water course ideally suited to the Army's river testing needs.

At Yuma Test Station, technicians and engineers from various Army elements, such as the Ordnance Test Activity, and Transportation Corps, as well as Corps of Engineers Desert Test Activity, used the facility.

In 1962, the Army testing command was reorganized under the Test and Evaluation Command, headquartered at Aberdeen Proving Ground, MD. Yuma Test Station became a proving ground and many of the missions of the individual activities were consolidated. Since 1962, testing of Army tanks and trucks has been done by Yuma Proving Ground's Automotive Division. Today, after consolidation of YPG's Automotive Division and



M-1 Abrams during earlier testing on YPG's dust course. The course is made up of 18-inches of talcum powder-like silt and sand, and is used to evaluate the vehicle's ability to withstand extreme dust conditions and its effect upon intake systems.

YPG's hilly cross-country course was constructed using test equipment. The course is used to determine a vehicle's ability to withstand rugged road conditions, and other factors.

Mobility Engineering Branch, tank and vehicle testing is the responsibility of YPG's Tank-Automotive Engineering Branch.

YPG's automotive test mission is similar to other YPG missions: To plan, conduct and report test findings of Army materiel. This has always been our mission in tank-automotive, but we've also tested general application equipment, such as engine generator sets, fuel pumping stations, welders, and chemical/biological equipment.

One of the most interesting aspects of being involved with the testing side of materiel development is that we, as testers, often see many knew developments years before they are issued. Some items we test, however, never see production.

As technology leaps ahead, the development time frame continues to be shortened. In the 1950s and 60s, it would often take 10 years to design, develop and produce a truck, for example. That length of time is no longer acceptable. The need to get a vehicle into the system as quickly as possible, and the current use of commercial designs and contracts, has caused a major shift in testing over the years.

During the early 1960s testing included many engineering design tests. Now, most military vehicles are adaptations of commercial vehicles, and seldom is testing done to develop a vehicle. One exception, of course, is battle tanks.

Tanks continue to evolve, or are developed through contracts, and are tested in competition. The winner receives the production contract. Our principal customer has been, and is, the Tank-Automotive Command in Warren, MI. Until the mid 60s, TACOM engineers designed military vehicles from the ground up. Currently, TACOM is involved in preparing specifications for vehicle contract, as well as designing some minor vehicles.

Today at YPG, tests tend to be more in the line of technical feasibility, initial production, and comparison testing. But, we still do a few special study tests.

One such test recently completed was on a Heavy Equipment Transporter (tank carrier) for a computer modeling exercise. Here, actual results from special vehicle handling tests were compared to computer generated results. The computer was then adjusted to match the real thing. Future designs for that size and configuration of vehicle can now be evaluated for handling performance by computers, without actually spending the money to build the vehicle.

Diesel and turbine engineers have eliminated the need for fuel vapor handling and octane requirements testing. Gasoline engines are no longer used in the military.

There is also a trend to reduce grades of oil in the field. The 15W/40 grade is replacing 10, 30 and 50 weight oil.

Human factors engineering is also becoming more important than in past years. Tests now being done routinely were not even considered in earlier years. Older vehicles had no power steering or automatic transmissions. They were noisy and rough riding. Arms like a gorilla and a macho attitude were needed to maneuver these dinosaurs. Now, soldiers have most of the amenities in the new vehicles that can be found in the family Buick. Equipment must be designed for use by a broad range of soldiers, both male and female.

There's still a ways to go before military vehicles become as comfortable as the family car. Not many military vehicles have air conditioning and the radios are hardly wrap-around high-fidelity FM stereos. We still have a goal of increased reliability and maintainability, but every day we're moving closer to the goal line.

Some tests are exciting. Some are tedious. But all of them are important. Determining which rubber compound out of a dozen types incorporated on 320 individual track pads of an M60 tank is boring. Weigh a pad, run the test courses, and weigh the pads again. Track shoes are expensive, about $90 each. And each tank uses 160 shoes. Replacement pads cost about $30 and can make a tank track like new again. Even a dull, unexciting test can bring about changes and improvements that save American taxpayers millions of dollars.

As in any test program, there are some winners and some losers. Failures in design do occur. And that's also part of the job, to identify problem areas. One such vehicle we tested some years ago was a swimming two-and-a-half ton truck. It was an ungainly looking cargo vehicle that was a cross between a track-layer and a wheeled truck. Large, balloon-like tires were connected to a rather flimsy track. On a hard surface, the truck's sponsons would roll on the tires as the track pulled them around. In soft soil, sand, or water the wheels acted like paddles. The concept was willing but the design and hardware were weak. Not many people have heard of this "Marginal Terrain Vehicle." Marginal was meant to be an adjective for the terrain. It quickly became an adjective for the vehicle.

One of the advantages of engineering testing is that occasionally you can actually use the equipment to get some unrelated work done. YPG's hilly cross-country course was built with mostly test equipment. Arrangements were made with the customer/design proponent to construct the courses while testing the equipment. Exceptionally rocky areas of the course were prepared using test rock drilling equipment before dynamiting. After blasting the hill side, test D7E Caterpillars were used to bulldoze the course into a rough profile.

Gravel was hauled by two-and-one-half ton dump trucks undergoing transmission tests. It must have looked strange to passers-by to see these dump trucks loading gravel and hauling it over eight miles of paved and gravel roads to dump it only a few hundred feet from where they started. This cooperation allowed the YPG Tank-Automotive Branch to meet equipment test requirements of 80 percent of time full-load hauling. Test road graders put the final contour on the course.

Like most test installations, YPG has seen some strange and curious things. In the 1860s cargo hauling was done by mule. In the 1960s YPG tested an Army and Marine Corps cargo hauler propelled by a "20-mule-power" air-cooled cylinder engine. It could be driven from a hard little seat, or after flipping the steering wheel around, from the ground when the terrain was too rough to ride.

Occasionally, some real wonders appear. Some have even been funny. For example, take the case of the bullet proof jeep tires. Filled with foam rubber, the idea was that when the tire was shot out or punctured, the jeep could be driven without much of a problem. This idea may have solved one theoretical problem, but foam 130 pound jeep tires have a tendency to radically change a jeep's handling. They acted like gyroscopes attached to the jeep's four corners.

Since our earliest days as a proving ground, Yuma has provided test support for many non-Army agencies. We supported the National Aeronautics and Space Agency (NASA) tests of its Lunar Rovers. Our test results were instrumental in the design of the actual rover that landed on the moon in 1968.

More recently, we supported mobility tests of the U.S. Air Force Minuteman missile transporter/firing platform known as a Hardened Mobile Launcher.

We've also completed testing for a number of allied governments, including Canada, Germany, Great Britain, and Israel. Testing has included desert environment testing of British Chieftain Tanks, German Leopard II Tanks, and drone aircraft for Canada.

The U.S. Marine Corps has always been among YPG's best customers. We've been involved in Marine Corps projects since the early 1960s and we're still closely involved with new projects.

What does the future hold for automotive work a YPG? Certain environment tests can be done nowhere else. As encroachment continues and population densities grow at eastern test facilities, more tank firing work will move westward to take advantage of the wide open spaces and low population density. Since automotive testing goes hand-in-hand with firing, more automotive performance testing is expected to move west as well.

In the future, it's likely the majority of tests will include initial production, and comparison production tests. Product improvement tests will also most likely continue. More emphasis will be focused on reliability, maintainability, logistical supportability, and human factors, with a corresponding decrease in developmental and mobility test projects.

Whatever the future holds, YPG will continue to help provide the best possible equipment for America's fighting forces.

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THE ARMY AND B/ IN BI

By Dr. Robert W. Shaw,
Dr. Reginald P. Seiders and Dr. Shirley R. Tove

This discussion of biotechnology outlines current industrial applications, explains why the Army is involved, and describes some of that current involvement. First, however, we will define the term "Biotechnology." Any use of living systems (farming, fishing, timber) involves us with biology; but biotechnology does not include these standard sorts of activities. "Biotechnology" refers to the use of cells or cell components in a controlled manner to achieve a technically useful goal.

The term, "controlled manner" is important. For centuries, people have used simple biological systems (e.g., yeasts in brewing and baking, bacteria for yoghurt); but they had almost no understanding of how the process worked and they were not able to alter the behavior of the biological systems they were using. The modern revolution in genetics, molecular biology, and biochemistry enables us to begin to understand these processes and to engineer changes in the cells. In this sense, the "new biotechnology" enables us to control and direct these operations. In the following we will loosely refer to the organisms employed (yeasts, bacteria, or molds) as cells, microbes or bugs.

Industrial Biotechnology

Presently, there are several broad areas of industrial biotechnology. We will describe several of them to indicate the kinds of activities involved.

Microbial Biomass: As we mentioned above, people have used microbes since ancient times to transform or produce food. The first industrial production of microbes (in this case, yeasts) was by Germany during World War I. By the 1970s, many companies around the world had started production; the principal use is to supplement livestock feeds and make up the protein shortage that exists in many countries. In this case, we use the bug simply to regenerate itself — it is the product. Obviously, for such an application we need to find a microbe that multiplies rapidly, has high protein content and good nutritional value, will not cause disease in plants or animals, and does not produce toxic compounds. It will be advantageous if the microbe itself is able to use different food sources to multiply; an ideally cooperative microbe will use waste materials.

Following these criteria, research workers discarded algae for microbial biomass because of the possibly toxic pigments they contain. Bacteria have very high growth rates, but they are relatively difficult to recover from the nutrient broth in which they grow. Fungi are not suitable: many produce toxins and their growth rate is low. Yeasts have a high growth rate, are relatively easily recovered, and are used in most biomass projects.

Food sources currently used for the microbes include molasses, whey (a cheese byproduct), and some other waste products of food industries. A very advanced plant in Finland uses waste material from wood pulp mills and produces 10,000 tons of protein product per year.

Chemical Production: Besides reproducing themselves, microbes transform part of their food into materials that are waste products to them but may be useful to us. Presently, there are industrial biotechnology processes to produce simple chemicals (e.g., alcohols, organic acids, amino acids) and complex chemicals (e.g., antibiotics). The alcohols can be used as automotive fuels; the organic acids have many uses — in foods, metal cleaning, in plastics; and the amino acids are used in animal feed and drugs.

The simple chemicals can also be made without microbes using straightforward industrial methods and the choice to use biotechnology would be based on relative costs of the methods. Some of the complex molecules, however, would be prohibitively expensive to make ourselves and so we let the bugs do it for us. Hundreds of tons of penicillins and related antibiotics are made every year in huge deep tank fermenters ranging up to 300 cubic meters in volume. This is a profitable business and every manufacturer uses a different (proprietary) process. This example shows the interplay between chemical engineering and microbiology and the severe constraints and requirements imposed on these industrial processes: only a slight change in the bugs' environment can change the product. This means that large volumes of material must be handled under reproducible, highly controlled clean conditions.

Digestion: The primary goal is not to create a desirable product but to get rid of an undesirable one — a toxic waste, for example. Various applications have been made to industrial, agricultural, and domestic wastes; the example is given above of the plant in Finland. Development has been hindered mainly by engineering difficulties — the lack of mechanically reliable digesters. A secondary goal is the production of some useful material; for example, the digestion of animal wastes into methane that can be used

ASIC RESEARCH
OTECHNOLOGY

"Why go to all the trouble of synthesizing a molecule, if you can get a bug to do it for you?"

— anonymous

as fuel. These systems generally need a mixture of types of microbes to break down the complex waste materials and transform it.

Cell Cultures: Both animal and plant cells can be used as media (as single cell factories) in which to produce materials that would not ordinarily be there. For example, viruses can be grown in cells and used to produce vaccines — 100 million doses of human viral vaccines (polio, mumps, measles, rabies) are produced each year. Beyond this, we can use genetic engineering to develop cell products such as insulin, human growth hormone, blood clot dissolving enzyme, etc., in cells that would not normally produce them. Most of the new biotechnology companies are using cell cultures.

Genetic Engineering: This refers to our ability to give cells the ability to carry out new functions. The cell carries out all its activities based on the "blueprints" contained in its genetic material, the molecules of DNA. We can break a DNA molecule, remove the piece of DNA (gene) that provides the blueprint for some desired material (e.g. insulin) and put that gene into a different kind of cell that has other good properties (e.g., rapid growth). This is direct control of cell operation — the most remarkable aspect of the new biotechnology.

Biotechnology In The Army

The examples described above indicate a part of current biotechnology research and development activities outside the Army and the DOD. With all this activity, one might assume that Army needs will be met by the civilian sector and that the Army need not be directly involved. This is not so. First, the Army has responsibilities for problems unlike any other organization, inside or outside the DOD. It is, for example, the lead service for chemical and biological defense and for energetic materials; and there is little or no activity in the civilian sector (apart from that funded directly by the Army and DOD) to deal with these and other special military problems.

Second, as described in the examples above, each biotechnology system must be tailored to its own specific problem. The bugs are demanding — they require a specific food source and will produce specific products. Change the conditions and, at best, they will change their products. At worst, they will die. Of course, the Army can be and is guided by advances in the civilian sector; but we cannot depend on others to solve our specific problems. In fact, the Army is already making significant progress on some of these problems using biotechnology.

U.S. federal agencies are currently investing almost $3 billion on biotechnology research and development. Most of that comes from the National Institutes of Health and most of the total investment, including that from the Army, is in human health care products. The remainder of this article discusses some of the less obvious applications of biotechnology for the Army. These applications include microbial synthesis of silk or rubber, lubricants, adhesives, and improved detection and decontamination of toxic agents and wastes.

Materials: The goal is to lighten the soldier's load by devising super-strong, super-light fabrics to be made into uniforms, packs, tents, flak jackets, parachutes, etc. Nature has provided us with a good candidate material — silk — which we want to adapt to our particular need. Silk is a protein: a string of building blocks called amino acids. These different amino acids vary in size and other characteristics and the order of these building blocks in the protein string gives each protein its special properties . This connection between the order of the building blocks and the properties is called a "structure-function" relationship and understanding these relationships for biological molecules like proteins is a crucial part of biotechnology.

Research workers at Natick Research, Development and Engineering Center are now studying the structure of silk protein. They are cooperating with the Army's Biotechnology Center at Cornell University. The general understanding of structure-function relationships is a principal part of the program at Cornell. Once the silk protein structure is determined, we hope to use our understanding of structure and function to determine changes in the order of protein building blocks to improve the properties we want. In the cell, the structure of proteins manufactured by the cell is determined by the genes. As discussed above in the section on "Genetic Engineering," we can alter genes and, in this case, we hope to use our knowledge about genes (the cell's blueprints) to alter the gene for silk production. This gene can then be returned to a microbial cell for production of new, "improved" silk.

Chemical Defense: Basic research workers at the Chemical Research, Development and Engineering Center and their collaborators using biotechnology are focusing on decontamination and on detection of chemicals and agents of biological origin (ABOs) such as toxins. Enzymes that can decompose nerve agents have been discovered in several different microbes and methods have been developed to grow these microbes, extract the appropriate gene, and insert it into another microbe species where the desired enzyme is then produced in higher yield than it was in the original microbe. The status of biotechnology in enzymatic decontamination was well covered in an article by W.E. White in

The Army Chemical Journal (Vol. 2, Pages 30-33, 1986). Although progress has clearly been made in this area, it will be a number of years before enzyme decontaminants can be fielded because enzymes to degrade other types of agents such as ABOs and vesicating chemicals like lewisite and mustard have yet to be developed.

In the detection area, biotechnology research is closely related to the development of human health care products mentioned earlier. This close association should, and does, lead to spinoffs from medical research that facilitate progress in the detection area. The proliferation of monoclonal antibody-based medical diagnostic kits has benefitted Army researchers by showing them how best to handle and use antibodies which they are studying for detection of chemicals and toxins.

Because antibodies are usually specific for one particular chemical, a wide array of antibodies would be needed to detect all the possible chemicals that might impede the effectiveness of the soldier. Furthermore, we would need to know the identity of all the possible chemical agents before they are used so that we could develop appropriate antibodies to them for use in our detection system. Clearly, this is an unwieldy approach, and luckily there is a better alternative under investigation by a team that includes the Chemical RDE Center (CRDEC), the University of Texas and Johns Hopkins Applied Physics Laboratory.

In contrast to the exquisite specificity of antibodies, other large macromolecules called receptors which exist in the human body, are much more general in their response to chemicals to which they are exposed. In the body, receptors normally respond to drugs, hormones, and other regulatory chemicals such as neurotransmitters (the chemicals that regulate information flow in nerves). A special panel of university and industry experts convened by CRDEC has concluded that as few as 12 different receptors would be able to detect any type of chemical that is physiologically active. That is, anything that could affect the body and thereby interfere with the soldiers' performance would be detectable. The detector envisioned here is an array of microsensors, each of which is coated with one of the 12 required receptors. The pattern of response would aid in the identification and quantification of the offending chemical.

A working detector array is still a long way off; indeed, a report in 1984 by the National Academy of Sciences projects that biosensors will not be in common use until the next century. Nevertheless, significant progress in basic research has been made recently. During tests conducted at the University of Texas at San Antonio (the University of Texas is a contractor participating in CRDEC's receptor program) the key receptor protein was isolated and purified for the first time. This protein was then used as part of an experimental detector. When this system was exposed to rattlesnake toxin, it produced a signal, while addition of non-toxic substances had no effect. This critical experiment proved that toxin detection using receptors can work. A detailed description of this work is available in a recent CRDEC report (Mojave Toxin: A Selective Calcium Ion Channel Antagonist; J. Valdes, V. Wolff, D. Menking, R. Thompson and J. Chambers; CRDEC-TR-88120, July 1988).

In another collaborative effort, CRDEC's scientists and engineers have embarked on a joint experimental program with the U. S. Army Medical Research Institute of Infectious Diseases and the National Institutes of Health. Highly purified preparations of a nerve gas receptor have recently been attached to optical glass fibers that can function as part of a detector. Preliminary data indicate that the chemical responses of the attached receptor are not changed from those in its natural environment.

While the above two examples of receptor research show promise, many obstacles remain. The opportunities for receptors are expected to increase as the mechanisms for chemical agents' physiological activity is more clearly understood.

Summary

Without exaggeration, we can say that the new biotechnology has brought about revolutionary changes in our control of biological processes. But the accomplishments of biotechnology have been hard won: they have required skilled, dedicated workers (biologists, chemists, engineers, and others); and modern (and expensive) equipment. These accomplishments have also required the patience and foresight required for long-term support of research and development, just as continued new developments will require that patience and foresight. Like all new developments, the tools of biotechnology may be appropriate for some problems but not for others and, because of the complex nature of biotechnology, it is important to plan carefully and well in advance.

The Army is practicing the new biotechnology in its labs and centers and is cooperating and collaborating with outside workers in several difficult but promising programs. The new biotechnology is well suited to these programs which are themselves strongly goal oriented — specific methods and products are sought — and, in the Army, the underlying goal is to serve the specific needs of the soldier.

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LASER MAY PLAY IMPORTANT VEHICLE PARTS PRODUCTION ROLE

By George Taylor III

The U.S. Army Tank-Automotive Command's (TACOM) RDE Center is evaluating a laser machine tool which, according to its developer, can balance critical, high-speed turbine engine components much faster and more accurately than is possible with the traditional hand-grinding method.

Phase one of the program was done for TACOM by Textron Lycoming (formerly Avco Lycoming), the firm that manufactures the AGT-1500 turbine engine for the M1-series tank.

The project is part of TACOM's Manufacturing Methods and Technology (MM&T) program. The purpose of the MM&T program is to improve the quality of military equipment and reduce its production costs by using state-of-the-art technology to develop improved manufacturing methods.

In the standard balancing procedure, a part is first mounted on a balancing machine, which then rotates the part rapidly. The machine determines the spinning part's degree of imbalance by electronically measuring the vibration present. If balancing is required, a display shows the operator the extent of the imbalance and its precise location on the part.

The operator then removes the part from the machine and attempts to manually grind the excess metal causing the imbalance from the designated area. Then it's back to the machine to check the balance, and if more grinding is called for, he repeats the process until proper balance is achieved.

"With this procedure, it takes anywhere from an hour to sometimes more than a day to do one part — depending on the operator's skill," said RDE Center engineer John Herbert, technical point of contact for the advanced laser machining balancing project.

"But the laser can remove the typical amount of imbalance usually present in a part in about 15 minutes, and it can do it with greater accuracy."

The new concept uses a computer-controlled laser that is integrated into an existing balancing machine's electronic circuitry. This allows the machine to continually feed data about a part's state of balance into the laser computer during the balancing operation.

To balance a part, the operator simply mounts the item on the machine as he would in the conventional procedure and initiates the machining process through the laser computer keyboard. The rest is automatic.

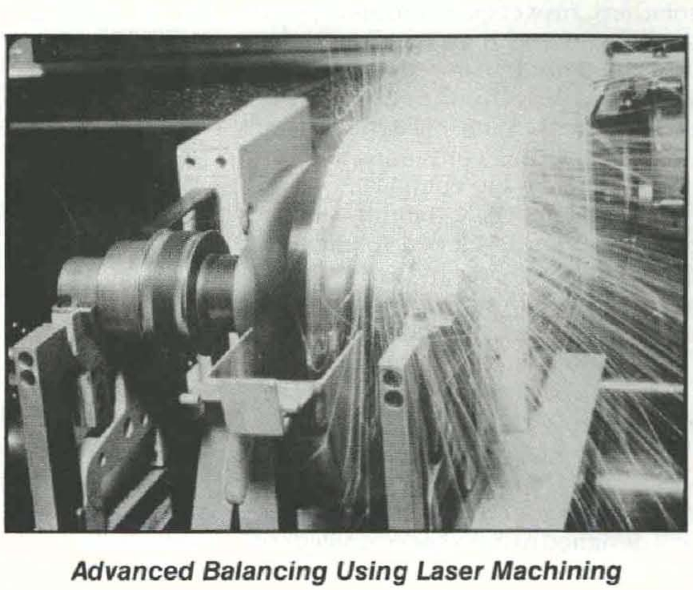
As the part spins, the computer analyzes the balance machine's electronic data to determine if an imbalance exists and pinpoints its location. The computer then generates a signal that switches the laser beam on precisely when the area of the imbalance is in perfect alignment with the beam during each revolution. Each laser pulse removes a minute quantity of metal, and the process continues until the imbalance has been machined away.

TACOM awarded Textron Lycoming a Phase I contract to begin development of the laser system in September 1985, after the firm submitted an unsolicited technical proposal. That agreement called for Textron Lycoming to outfit an existing balancing machine with laser hardware and balance AGT-1500 turbine impellers.

Efforts are under way to award a Phase II contract that will be funded jointly by TACOM and the Aviation Systems Command. The second phase will extend the laser concept to the other rotating components of the AGT-1500, as well as some used in the T53 and T55 turbine engines that power helicopters.

When asked if the laser balancing system has a money-saving potential, Herbert said: "Yes. Savings from using the system are estimated to be $45,000 per part per year. The return on investment will increase dramatically and considerable cost savings and quality improvements will be achieved when this system is fully implemented in the production of the AGT-1500, T53 and T55 engines."

GEORGE TAYLOR III is a technical writer-editor for the Army Tank-Automotive Command. He holds a bachelor's degree in journalism and a master's degree in communications from Michigan State University.



Advanced Balancing Using Laser Machining

THE MALOS-QDX SIMULATION

By John M. Deponai III and Dr. James E. Snellen

Army captains learn brigade level tactics in the Officer Advanced Course of their respective branch school. Specific skills, techniques, tactics, and doctrines are taught in blocks of instruction and then a capstone map exercise is conducted to integrate what has been learned by exposing the students to situations they would face in combat. A realistic wartime scenario is defined and students are tasked to develop plans for movement to contact, meeting engagements, hasty attacks, etc.

Students analyze the missions in light of what they have learned, study 1:50,000 scale maps, and develop plans, complete with map overlays and orders. Instructors critique the various solutions, answer questions and update the situation with an approved solution. Students then develop courses of action and plans for the next phase of the scenario. Such classroom map exercises are time consuming and can take several days to complete.

The MALOS-QDX training simulation has been developed to augment tactical map exercises and to provide an automated environment for exercising maneuver tactics. MALOS is the name of the umbrella system on which the "Quick Decision Exercise" (QDX) simulation is installed.

While several micro-computer based wargames are now available on the commercial market, only MALOS-QDX was designed to meet specific needs of military instructors to teach maneuver tactics. MALOS-QDX provides instructors with a complete environment for developing a library of war game scenarios designed to support specific teaching points. A MALOS-QDX scenario runs in solitaire mode and requires only 15 to 30 minutes to complete. A carefully designed family of scenarios can provide students with an opportunity to integrate tactics skills by applying them in a series of simulated situations. A student can run each scenario many times trying different solutions and comparing outcomes. Because the result of each combat engagement is computed quantitatively, the relative success of each solution is obvious. Scenario runs can be recorded and the instructor can "step through" the scenario and provide an individual or a whole class with a qualitative assessment of the actions executed during a particular game.

How The Game Is Played

Using fire and maneuver options, a user maneuvers a blue force across a computer-based game map toward a prescribed tactical objective and responds to red force counter-moves as the situation develops.

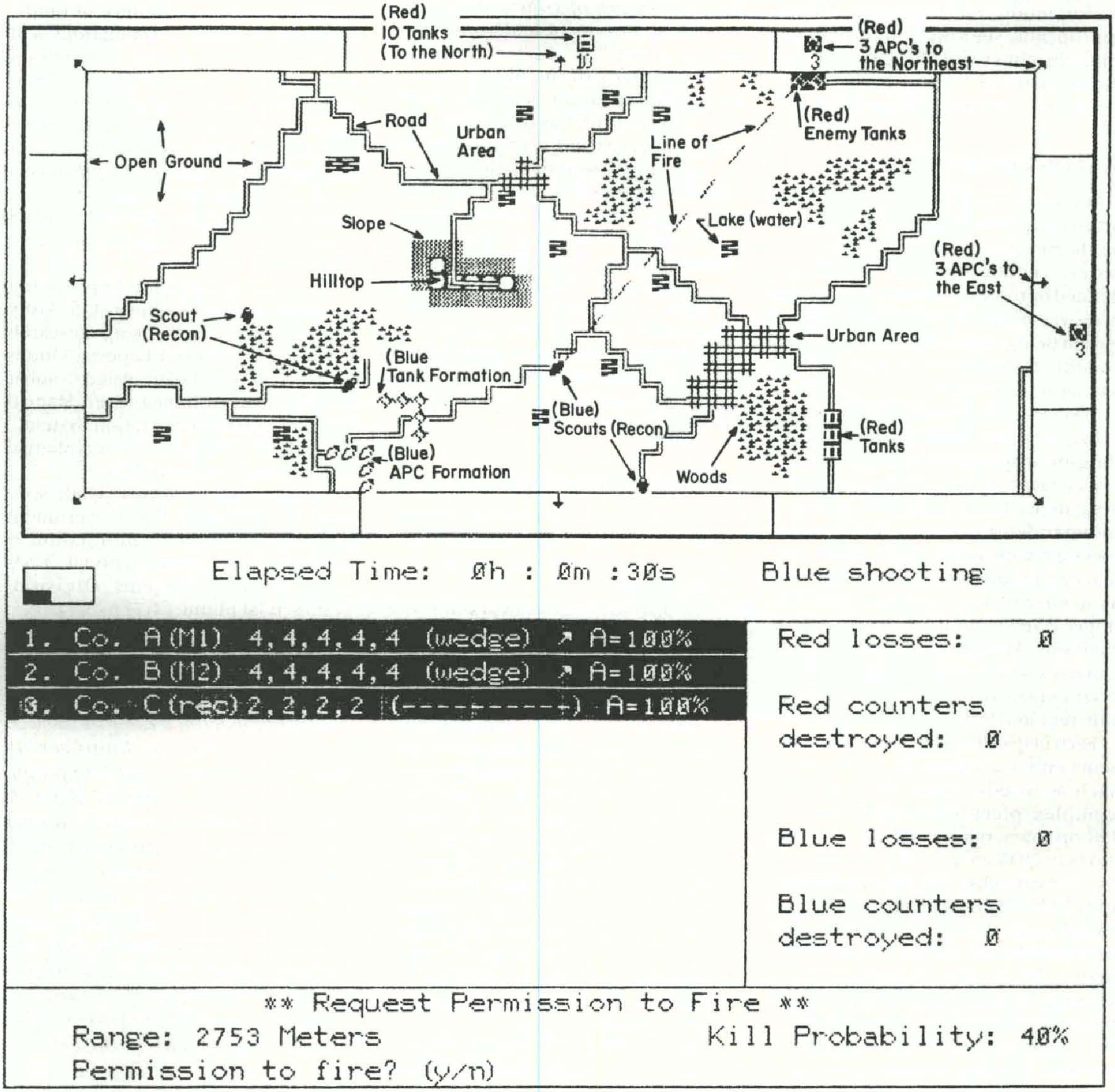
Direct killing fires, direct suppressive fires, and indirect fires can be executed. A moving barrage complete with smoke can even be simulated. MALOS-QDX uses automatic rules of engagement, but the user can impose fire discipline on designated blue force units. Units subject to fire discipline continue to move and acquire targets automatically, but do not engage the target automatically. Instead, the system plots a broken line as shown in the figure to indicate the proposed engagement on the screen, indicates the range and kill probability, and requests permission to fire.

Combat is resolved using a modified probability to hit times probability to kill given a hit. Each weapon system can have a primary and a secondary weapon. The primary weapon is limited to a basic load.

When a friendly unit is fired on, the user is given a chance to change the movement orders, but the new orders must be issued in a limited amount of time set by the scenario designer. Otherwise, the system continues the game based on the original orders. This adds realism . . . and pressure.

Movement control options include changing the movement rates, moving individual units or formations of units, defining the axis of advance to be followed, and specifying the formation to be used for each leg of a movement plan.

There are also options to plot blue and/or red fire "tracers" to show who


(Red)
10 Tanks
(To the North)
(Red)
3 APC's to
the Northeast
Road
Urban
Area
Line of
Fire
(Red)
Enemy Tanks
Open Ground
Slope
Lake (water)
Hilltop
(Red)
3 APC's to
the East
Scout
(Recon)
(Blue
Tank Formation
Urban Area
(Blue)
Scouts (Recon)
(Red)
Tanks
(Blue)
APC Formation
Woods
Elapsed Time: 0h : 0m :30s
Blue shooting
1. Co. A (M1) 4,4,4,4,4 (wedge) A=100%
2. Co. B (M2) 4,4,4,4,4 (wedge) A=100%
3. Co. C (rec) 2,2,2,2 (------+-----+) A=100%
Red losses: 0
Red counters
destroyed: 0
Blue losses: 0
Blue counters
destroyed: 0
** Request Permission to Fire **
Range: 2753 Meters
Kill Probability: 40%
Permission to fire? (y/n)

is firing at whom, and to run the simulation in hidden movement mode. In this mode, red units not within appropriate sighting range of blue units are either not displayed or are shown with an "X"; otherwise the appropriate unit symbols are displayed.

MALOS-QDX Design

MALOS is a time-stepped simulation. An elemental time increment depends on the map scale and the speed of the fastest vehicle, both of which are defined by the scenario designer. Speed of movement is dependent on the type terrain being traversed, on the combat conditions, on the type vehicle, and on formation constraints.

MALOS-QDX provides for two levels of organization. Each icon displayed on the game map represents a basic maneuver element of one to nine weapons systems. Each icon can be maneuvered independently or can be grouped together with up to four other basic maneuver elements and be maneuvered as an integral upper echelon unit. Ten upper echelon units can be played on each side. An upper level echelon unit can represent a company, a platoon, or even a squad, depending on the resolution required by the scenario designer.

Each map cell in a MALOS map represents either a simple piece of terrain such as woods, slope, or town, or a complex piece of terrain, such as hilltop-town, road-woods. A complete MALOS-QDX map is an array of 150 by 75 map cells. The screen displays only 55 by 25 cells of the total map at a time, but the viewing window is easily moved to display any part of the overall map. The relative position of the viewing window with respect to the total map is shown in a diagram under the viewing window. Surrounding the terrain display window are eight peripheral panels that list the numbers and types of red and blue units that are deployed in each sector of the map not visible on the screen.

Unique graphics identify four kinds of combat units — tank, armored personnel carrier, antitank guided missile launcher, and reconnaissance. There are eight variations for each symbol to show which direction weapons are oriented. MALOS-QDX considers relative orientation of combatants when executing movement and computing effects of fire.

Various parts of the display screen provide information as to how much simulated time has elapsed, and whether the system is waiting for input, moving units, updating status, sighting who is visible to whom, targeting who is going to fire at whom, executing artillery fires, resolving combat, or signaling game completion.

A status box in the lower right part of the screen displays, at various times, cumulative combat losses for both sides, detailed results of each round of fires, status of artillery fires, formations being used, and status of the current order of battle.

Scenario Generation System

The Scenario Generation System consists of three major sub-systems: a map editor, a scenario editor and the access system.

The map editor gives instructors the capability to create and store a library of maps for incorporation into a family of MALOS scenarios.

An instructor uses the scenario editor to create new scenarios, edit Red/Blue orders of battle and initial deployments, specify Red team movement patterns and define conditions that cause their activation. The scenario editor is used to define the map scale, the speed of the fastest unit, rates of fire, kill probabilities for all combinations of weapon system on weapon system, numerous kill probability modification parameters, visibility parameters, artillery parameters, weapons characteristics, formations, battle drills, and a host of other parameters.

The access system provides the systems administrator with the power to control who has access to the various capabilities of the system and to what degree.

MALOS-QDX is currently installed on the Fort Belvoir and Fort Leavenworth PLATOtm systems as an option under lesson "MALOS." PLATO™ is a proprietary mainframe based training system marketed by Control Data Corp.

Future Developments

Subject to the availability of funds, the MALOS family of simulations will be converted to run on the Army's Electronic Information Delivery System(EIDS). Converting MALOS-QDX to run on a micro-computer will permit the use of color to display terrain attributes. This will greatly enhance a user's ability to interpret a game map. Another big advantage is that EIDS computers will be readily available throughout the Army.

Two users manuals are being prepared for publication as U.S. Army Construction Engineering Research Laboratory Technical Reports. One is "The MALOS-QDX Simulated Combat Environment, Volume I: Users Manual For the Scenario Generation System." The other is "Volume II: Users Manual For Running Scenarios."

Distribution of MALOS-QDX software is limited to U.S. Government agencies. Additional information is available from John Deponai, USA-CERL Facility Systems Division, commercial phone (217) 373-7271.

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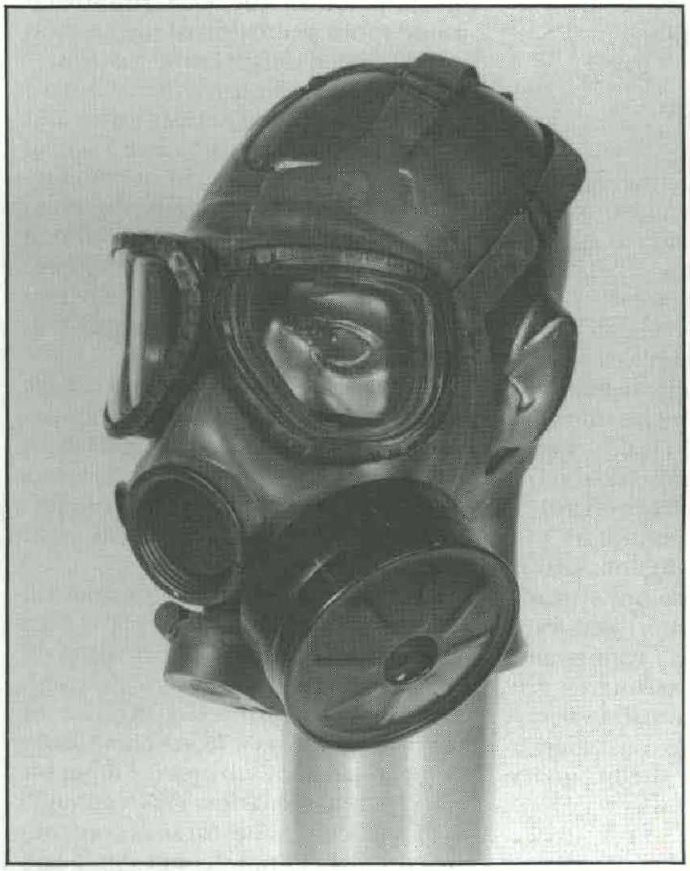
DR. JAMES E. SNELLEN is a research programmer at the Microcomputer Systems Laboratory of the University of Illinois at Urbana. He developed MALOS-QDX under contract with USA-CERL. He has a master's degree from California State College at Long Beach and a doctorate from the University of California at Davis.



TOXICOLOGY IN CHEMICAL AND MATERIEL DEVELOPMENT

By Dr. Harry Salem

M40 mask with C2 cannister containing Whetlerite carbon impregnated with chromium, copper and silver.

Introduction

Toxicology and tanks! What does one have to do with the other? Toxicology is a biological science that determines the effect of chemicals and materiel on experimental animals, while tanks are armored vehicles used in warfare. Yet, these two forces are brought together by toxicology's mission at the Chemical Research, Development and Engineering Center (CRDEC) at Aberdeen Proving Ground, MD.

Toxicology is an essential and integral part of the "developers" program prior to fielding an item. It provides the experimental animal data necessary to predict any potential adverse effect on the soldier following intentional and unintentional exposures of known and new potential chemical warfare agents while in or out of uniform, individual and/or collective protection, as well as in a fighting vehicle.

In addition, experimental animal data, environmental fate and effects data on soils, plants and earthworms, as well as on aquatic organisms are provided for incorporation into environmental assessments and environmental impact statements. These are required as was recently demonstrated prior to approval for construction of the Binary Munitions Production Plant at the Pine Bluff Arsenal, AR.

Toxicology Division

Toxicology, one of the five divisions within the Research Directorate at CRDEC has as its mission the development of a toxicological/pharmacological data base on chemicals and materiel of military interest in animal and alternatives to animal models. Additionally, their impact on the aquatic and terrestrial environment is also determined. These mission requirements are funded by 6.1 programs in basic research and 6.2 development programs.

Although toxicology classically is defined as the study of poisons, in current usage it is considered the study of safety of chemicals and related materiels. This concept is embraced by CRDEC as part of research, development, testing and evaluation (RDTE).

Toxicology research and testing is routinely conducted in mammalian animal species specifically bred for these purposes, and maintained under environmentally controlled conditions in accordance with regulatory guidelines. In addition to mammalian species, aquatic, avian, and insect species as well as microorganisms are also used.

In toxicological studies, the effect of chemicals and material are evaluated for skin and eye irritation and adverse effects on living organisms in terms of lethality, mutagenicity, reproduction, teratology, neurotoxicity, immunotoxicology, metabolism and carcinogenicity.

Efficacy studies are also conducted so that a safety ratio can be calculated. These effects are determined following many different routes of exposure in varied animal species so that reliable predictions can be made as to what might be expected in man. This is what is termed "human estimates."

These studies are extended to aquatic organisms and ecological systems as well as terrestrial including plants and earthworms to study environmental fate and effects. Data from these studies are used to predict the impact on the environment.

All of the above studies are conducted within the three branches that make up CRDEC's Toxicology Division. These three branches, Environmental Sciences, Biosciences, and Veterinary Services work in concert under a matrix management system to accomplish our mission. Studies that are conducted are consistent with good laboratory practices and are under the scrutiny of a dynamic quality assurance unit.

Toxicology Division activities of planning, designing, executing and evaluating programs and studies are peer reviewed by a Life Science Committee comprised of recognized scientists from other government agencies, industry and academia. This committee meets at least twice a year with scientists at CRDEC. Their input is invaluable in ensuring that studies are conducted and evaluated according to the latest state-of-the-art.

Historical

The inhalation facility boasts an illustrious history dating back to the World War II era when it was among the most prominent inhalation centers in the world. It was here where Dr. S. Silver developed many of the principles of inhalation toxicology.

Mouth to mouth resuscitation was also developed in these laboratories for the treatment of nerve gas poisoning. For this same condition, funding and oversight was provided to investigators, at the University of Pennsylvania, who developed techniques for the measurement of pulmonary mechanics. These techniques have become standard procedures for diagnosing disturbances of respiratory function.

The funding and oversight were extended to scientists at the University of California in San Francisco to investigate pulmonary surfactant. This was determined to be a phospholipid responsible for maintaining alveolar stability and thus preventing collapse of the lung. Its role in the etiology and therapy of hyaline membrane disease and respiratory distress syndrome was elucidated by these studies.

Classical and Unique Capabilities

In addition to conducting classical toxicology such as short and long term studies in a variety of animal species by many different routes of administration, special studies are also performed. These include metabolism, mechanism of action, neurotoxicology, reproduction, teratology behavioral studies (performance and learning) as well as pathology and clinical pathology. Special expertise also exists and is applied in penetration studies through skin, clothing and filters.

Unique capabilities in inhalation toxicology include nose-only, head-only and whole body short and long term exposures to gases, vapors and particulates. Human estimates are determined from exposure to a variety of species such as mice, rats, guinea pigs, ferrets, rabbits, sheep, goats and swine.

Unique capabilities in inhalation toxicology include nose-only, head-only and whole body short and long term exposures to gases, vapors and particulates.

In addition, the biochemistry and immunology of bronchioalveolar lavage fluid are conducted in some studies as are physiological measurements of pulmonary mechanics.

Ecotoxicology studies include the use of daphnia and fish as well as a community of aquatic organisms in a Standardized Aquatic Microcosm. This system was developed by Taub at the University of Washington and is used as an ecosystem level essay. In this system a variety of aquatic organisms including macro and micro invertebrates, and algae are observed as is their interactions following application of test article. During the last three years, our Ecological Toxicology Group has participated in the FDA supported round robin evaluation of the method using copper sulfate as the toxicant.

Brass and graphite particulates have also been evaluated in this system and currently the effects of a riot control agent are being examined in conjunction with degradative organisms. When used together with more traditional acute and chronic assays, the Standardized Aquatic Microcosm is a useful methodology for environmental risk assessment.

The Environmental Fate and Effects Group conducts research on the toxicity and persistence of chemicals in terrestrial systems. Research projects include the use of intact soil columns to measure the fate and transport of chemicals in soils.

Standardized phytotoxicity and soil organism toxicity studies are also conducted to generate information on the chemicals of concern. Research efforts have addressed the use of leachate bioassays from chemically contaminated soils to provide input for site clean-up scenarios. This technique is of particular value for soils contaminated with multiple compounds and when combined with statistical analysis will generate toxicity gradients. These gradients can allow decision makers to base their clean-up scenarios on toxicity values rather than chemical concentrations in soils.

Although we have an extensive capability in most areas of toxicology and are involved in many programs, in this article we will only highlight some of the accomplishments for the 6.2 technical area on Chemical/Biological (CB) Threat Agent Chemistry and Effects. The purpose of this key area under CRDEC's matrix management program is to identify and evaluate present and future CB threat agents so that defensive materials and procedures can be developed. Thus, the toxicological evaluation of potential threat agents is perhaps the most important step in this process.

From the basic toxicological data, the seriousness of the threat is determined and estimates of battlefield hazard are derived. In addition to annually programmed tasks, unscheduled requirements involving toxicological evaluation often arise. These studies are typically carried out under this technical area.

The examples cited here will document the role of toxicology, a life science in the Army Armament, Munitions and Chemical Command. As will be demonstrated, the role of toxicology in AMC research and development is a critical and necessary one for the fielding of safe items for the soldier and providing them with the decisive edge.

This program also permits the flexibility of quick responses to unexpected situations where data are required in a short time frame and is unfunded. The objective of the life science part of this program is to study the toxicological properties and hazards posing a potential threat to the U.S. chemical defense posture and to advance the requisite technology for this.

In this context, bio/chemical threat agents are screened for toxicity and human estimates are developed. Also, new applications of inhalation toxicology methodology to evaluate protective equipment defeating materiel and new potential threat agents are developed. This test methodology as well as data have been provided to the United Kingdom, Canada, the U.S. Navy and the U.S. Army Medical Research Institute of Chemical Defense.

Alternatives to Animal Testing

Animal experiments in research and testing are necessary in an attempt to predict human responses, as well as to meet criteria established by the government's agencies.

All of the Toxicology branches adhere to good laboratory practices, and are involved in our active alternative to the animal program and work in concert to support the division. Many laboratories around the world have also instituted programs in alternatives to animal testing, and we at CRDEC have taken a leading role in these programs for the development and validation of some of these alternatives.

In spite of the proliferation of the proposed alternative tests, few have been adequately validated. Those that have been validated (mutagenicity, drosophila, microcosm) and are now acceptable to the regulatory agencies are included in the regulatory requirements in the testing guidelines developed by the FDA and EPA.

The Alternatives to Animal Testing is an on-going program that has been in place for a considerable time and subscribes to the premise that animal testing cannot be eliminated. However, alternative test methods and approaches can be developed that will eliminate unnecessary animal testing, reduce the number of animals tested, and prioritize compounds which require animal testing. In this program, computer models, cell systems, and animals lower on the evolutionary scale are utilized.

Of the many approaches initiated at CRDEC in this program recently described only the following are being pursued either in use, development or in validation. The standardized aquatic microcosm as previously described, single species aquatic systems, mutagenicity tests in microorganisms, reproductive effects in drosophila, neurotoxicity in avian species are ongoing studies utilizing species lower on the evolutionary scale. Also in use are studies using macrophages obtained from bronchioalveolar lavage. Under validation in our laboratories are the TOPKAT computer models for predictive toxicology and the EYTEX for non-animal eye irritation predictions.

The objective of the life science part of this program is to study the toxicological properties and hazards posing a potential threat to the U.S. chemical defense posture and to advance the requisite technology for this.

These programs will not replace animal testing, but will help the researcher estimate the toxicity of untested chemicals during the screening process and prioritize those chemicals of a series that should be further evaluated. To test all of the chemicals would be economically prohibitive, too time consuming and use too many animals.

In development in our laboratories is a very promising in-vitro technique to study the effects of chemicals of military interest on sperm cells. The effect of chemicals on sperm viability and motility is a test which requires only the collection of spermatozoa from animals or humans.

The collection of sperm is not an invasive technique, which is a distinct advantage, and can be obtained from mice to men. Viability, motility and swimming pattern can be observed under the microscope and analyzed by computer. Hopefully, the effect of chemicals in this system can be correlated with reproductive effects.

Contrary to what the animal activists claim, of the many alternatives, especially for eye irritation, none have been satisfactorily validated. Validation requires comparing the results of many and varied chemical classes in in vitro and whole animal tests by many laboratories. Although expensive, validation is necessary to assure that a battery of in-vitro tests will provide data to predict human effects in a consistent, reliable and verifiable manner.

Chromium Toxicity

Whetlerite or ASC Carbon is activated granular carbon impregnated with compounds of chromium, copper and silver to enhance its ability to absorb and destroy toxic gases. This is the standard absorbant used in military gas filters. In earlier protective gas masks, a small amount of carbon dust could be released. Because of chromium's potential for carcinogenicity, exploratory studies were conducted to determine whether chromium from Whetlerite was bioavailable when introduced directly into the respiratory tract of rats by intratracheal instillation.

Additionally, if chromium from Whetlerite was bioavailable, it is important to determine its speciation since the National Institute of Occupational Safety and Health has defined the water insoluble hexavalent chromium compounds as carcinogenic and the water soluble hexavalent chromium and trivalent chromium compounds as non-carcinogenic.

Following intratracheal instillation of Whetlerite, chromium was bioavailable and found in the lungs, liver, kidneys and blood of rats. Although

The mission related programs are accomplished by a highly educated and motivated staff.

the chemical speciation studies on Whetlerite indicated that the typical Whetlerite dust contained only insoluble trivalent and soluble hexavalent chromium in less than two percent. The only chromium found in the biological tissue was the reduced form of trivalent chromium. If these data are confirmed and only insoluble hexavalent chromium is carcinogenic, then there is no apparent potential for hazard from Whetlerite.

Bradley Fighting Vehicle

Under some battlefield conditions, soldiers in the Bradley Fighting Vehicle may be exposed to injurious levels of toxic gases following non-catastrophic penetration of an anti-armor munition. If a soldier is to remain in the vehicle and continue combat operations, then his most effective defense against these toxic gases may be the vehicle's collective protection system and/or his individual protective mask.

Studies were conducted to determine the efficacy of individual gas-mask filters and the combination of collective and individual filter options available to the soldier for the removal of toxic gases. The gases and vapors of most concern and their expected maximal concentration are nitric oxide (3000 ppm), nitrogen dioxide (1000 ppm), hydrogen bromide (1000 ppm), hydrogen fluoride (2000 ppm), hydrogen cyanide (100 ppm) and acrolein (5 ppm).

The results of the studies indicated that the individual (M10A1, M24, M12A2, M17A1, C2 and M25A1 masks) and collective protection filter (M18) in the Bradley Fighting Vehicle would adequately protect soldiers against the expected gases generated as a result of penetration by an anti-armor munition.

These studies were completed in a very short period of time and verified the effectiveness of the individual and collective chemical filtration systems within the Bradley Fighting Vehicle. This data generated in these studies supported the Bradley Fighting Vehicle System Live Fire Survivability Test Report which was submitted to the U.S. Congress.

Conclusion

The role of toxicology in chemical and material development has been reviewed. The life science of toxicology has been defined and an overview of the classical and unique capabilities within CRDEC's Toxicology Division have been presented. Although the organization is pyramidal via branches, the programs are executed by a combination of matrix and line management.

Specifically, the contribution to CRDEC's overall mission in the technical area on CB threat agent chemistry and effects have been detailed. This technical area also provides the funding to accomplish unexpected and critical short fuse tasks such as was necessitated to provide efficacy data for the filter systems in the Bradley Fighting Vehicle.

The mission related programs are accomplished by a highly educated, and motivated staff. CRDEC's Toxicology Division probably has the most concentrated compliment of professional toxicologists within any of the U.S. Army's laboratories. These scientists are dedicated and committed to support CRDEC's mission in an attempt to provide the soldier the decisive edge and enhance his capability on a CB battlefield.

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MAM Program Under Review

Under the auspices of the Army Leader Development Study (LDS), GEN Louis C. Wagner, commanding general, Army Materiel Command, recently directed a major review of the current Materiel Acquisition Management (MAM) Program in order to bring the program in line with the recommendations of the LDS and new Congressional and DOD requirements. The review has been completed and proposed policy changes affecting the MAM Program are now being staffed throughout the Army. *Army RD&A Bulletin* will publish additional information as soon as program details are available.

Functional Area 51/99 Role Up

FA 99, Combat Developments (CD), will become part of FA 51. The intent is for those in the CD field to better understand the materiel acquisition management process and vice versa. This change will also enhance career progression for CD officers by allowing them to work throughout the entire spectrum of the materiel acquisition process. Previously, all FA 99 positions were in TRADOC, which severely limited career growth for FA 99 officers. The cross-fertilization that takes place will benefit both the CD and materiel development disciplines. FA 99 will become AOC 51C, and those positions requiring officers with both combat development and materiel development experience will be coded with AOC 51D. All positions in TAADS will be reviewed for appropriate recoding with either 51C or 51D. A few positions which cannot be coded FA51 will retain the 7Y combat developments skill identifier. All officers currently in FA 99 will become FA 51, with AOC 51C.

MEL-4 Schooling

The Leader Development Study, conducted by the Combined Arms Center, has proposed that alternative training be considered for the award of MEL-4. Most Army officers now achieve MEL-4 through CGSOC, resident or nonresident. AMC, as the Army MAM proponent, recently recommended that the Project Management Course (PMC) at the Defense Systems Management College be considered for MEL-4 equivalency. This would allow an officer, aspiring to become a program/project/product manager (PM) or TRADOC system manager (TSM), to attend a single school (PMC) and thereby meet both the military and DOD/Congressional educational requirements for PM/TSM selection.

ALMC Note

The Army Logistics Management Center offers numerous correspondence courses. One course of special interest to FA 51 and MAM officers is the Basic Procurement Course. For those interested, visit your learning resource center or write for a catalog to: U.S. Army Logistics Management Center, ATTN: AMXMC-ACM-MA, Fort Lee, VA 23801-6048.

PMC Advanced Placement

Recent changes have been made in the structure of the Defense Systems Management College (DSMC) Program Management Course (PMC) which allow advanced placement for qualified applicants. PMC is now taught in two parts — a six-week Part I and a 14-week Part II. Both parts must be completed for graduation. Military or civilian applicants with significant and extensive acquisition experience or training may wish to consider advanced placement. Part I of PMC is designed to ensure that all students have a solid foundation in the basics of the DOD acquisition process. Applicants who believe they already have a solid grasp of the DOD acquisition process may be certified for advanced placement (PMC Part I credit) if they qualify in one of the following categories:

Category One: PMC Part I Certified (Experience). This category includes senior candidates with substantial acquisition experience, designated by their Service, who pass the PMC Part I certification exam. Candidates must be nominated to enter PMC Part II within one year of passing the certification exam. Minimum grade is 04/GS13.

Category Two: PMC Part I Certified (Service Training). This category is not open to Army applicants.

Category Three: PMC Part I Graduate. This category includes graduates of PMC Part I at Fort Belvoir or DSMC regional centers. Advanced placement status is good for three years from the date of graduation from Part I. For graduates with substantial acquisition experience subsequent to graduation from Part I, the three years certification period may be extended by DSMC.

Remember that nomination for PMC (Parts I and II) is in accordance with current TAPA procedures. Officers wishing to seek advanced placement should contact TAPA, Barbara Head, AUTOVON 221-2135. Civilian applicants should contact HQ, U.S. Army Materiel Command, Joan Frazier, AUTOVON 284-8532. Applicants must allow at least two months for Category I advanced placement processing.

One final point, advanced placement is the exception, not the rule. Resident attendance at the full 20-week PMC remains the preferred Army training approach.

ROLE OF CONGRESS IN US/GERMAN ARMAMENTS COOPERATION OVEREXAGGERATES

The recent article by LTC (Dr.) Armin Simbuerger, German Army, writing in *Army RD&A Bulletin,* July-August 1988, attributes to Congress a role in the cooperative process that was never intended nor currently practiced.

Despite Colonel Simbuerger's long tenure at AMC, he appears to have confused the demand by both the Army and Congress for technological sufficiency as the foundation for cooperation, with the delimited policy and oversight functions of Congress.

The role of Congress is to encourage and monitor improvements in the acquisition process. Most responsible members of Congress recognize their relative lack of technical expertise, especially in the RDT&E arena. The compelling interest of Congress, therefore, shifts to encouragement. The streamlined acquisition process itself evidences this relationship, especially at the technology base phase.

Congress did urge greater market surveillance, the logical outcome of which was NDI and the cooperative armaments committees and panels that the Army created. AR 70-1 was the regulatory response to Congress' statutory and non-statutory encouragement. But the programmatics remain the initiative of the services, and OSD to a lesser extent. The perception that success for each individual project is dependent upon "lobbying" and "political support" is grotesquely misplaced. I would conjecture that Colonel Simbuerger has misjudged the congressional hearings process and the role of OSD. In the former case, oversight motivates the authorization committees to assure compliance with legislative guidance. In the latter case, accountability resides for the DOD program budget with OSD. However, there are certain DARPA projects that are subject to direct congressional scrutiny. But the great part of congressional attention is devoted to the individual service elements in the program budget, and, of course, the resources and authority for program execution.

The direct lobbying of Congress by DOD officials, or any other executive branch official paid from appropriated funds, is a violation of the criminal statutes of the United States. Political pressure by such officials, exerted at the "grass roots" level, is also forbidden. Visits by officials for purposes of expressing an official opinion on a matter before Congress may be a technical or term-of-art difference in the minds of some; however, no official should fail to recognize that lobbying, the exertion of influence on Congress for the benefit of a limited community of interest within an agency or department, will invite sanctions, some quite subtle.

Over the past five years, the Army's implementation of its acquisition improvements program has been a source of pride to many of us in Congress. It is true that the Army is perceived as being slow in its validation activities; I would call it more "thorough." But the Army's role in reducing the laboratory-to-field time for such NDI systems as MSE, cannot be divorced from its commitment to international cooperation.

In my role as a member of the Board of Directors of the Office of Technology Assessment, an arm of Congress like GAO or CRS, I urged examination of the LABCOM role in technology market surveillance. The recent OTA study on improving the defense industrial base applauds the Army's approach to international cooperation. Further, I have had direct contact with TRADOC and some of AMC's commodity commands, where I have personally witnessed the determination of these two major commands to save defense expenditures through foreign and domestic industrial cooperation, before and during the development of materiel requirements. As a result of my personal familiarity, I have brought to the floor of the Senate my observations urging support for the Army's R&D, but also O&M, programs not because of some ill-defined, solicitous behavior by the Army, otherwise known as "lobbying," but because of my own oversight functions and the cooperation of AMC, TRADOC and other commands in answering my inquiries.

Orrin G. Hatch, R-UT
United States Senator

Senator Hatch also serves as Ranking Minority member on the Labor Committee, and as a member of the Intelligence and Judiciary Committees.

New EOD Information Retrieval System

The combination of high resolution flat panel displays, optical memory technology, and powerful microprocessors could make life a lot easier — and safer — for explosive ordnance disposal (EOD) teams.

The EOD Information Retrieval System could reduce by up to a third the time it takes a team to identify and neutralize unexploded ordnance, according to Robert F. Miller. He is the display applications team leader in the Microelectronics Division of the U.S. Army Electronics Technology and Devices Laboratory (ETDL).

ETDL, one of seven Army research laboratories nationwide that report to the U.S. Army Laboratory Command is developing a prototype of the system for the project manager, ammunition logistics at Picatinny Arsenal, NJ.

"It's been evident for some time that the present system is inadequate," said Miller. "The soldier doesn't have enough information on site to do his job properly."

To identify a piece of ordnance, an EOD team member will consult the appropriate identification guide. The guide will then direct the EOD specialist to the proper "render safe" procedures. A Soviet high energy anti-tank round, for example, is rendered safe by disarming a fuze in the nose of the round.

However, the data base of render-safe procedures is stored on 15,000 pages of paper and 1,600 sheets of microfiche. This data base is kept by an EOD detachment. Because of its volume and classification, the data base cannot be carried on site.

The EOD Information Retrieval System, on the other hand, stores data on a portable disc. In response to prompts displayed on the flat panel screen, an EOD soldier enters answers to questions about the ordnance by pressing the screen in designated places. When the system is given enough data to identify the ordnance, it lists the proper disarming steps.

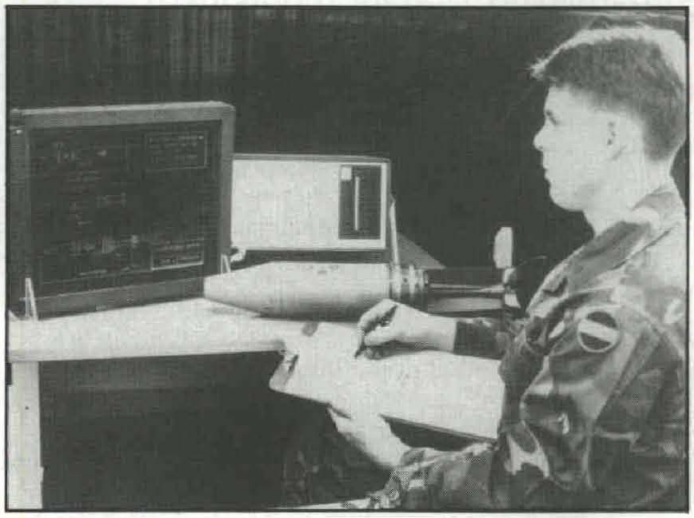
The system weighs 11 pounds, draws 32 watts of power, meets full military specifications, and is man-portable. This compares with the militarized cathode ray tube display now used to periodically update the ordnance data base. It draws 350 watts and because of its weight, 110 pounds, is not man-portable.

The only drawback to the new system, according to Miller, is the 20 to 30 man-years he estimates it will take to computerize the data base. "We hope to show the benefit would justify the cost," he said. "EOD has to go to an electronic format. They have no choice, if they're going to get the job done."

A prototype was demonstrated this past August at the Naval EOD School in Indianhead, MD. The test involved EOD-trained soldiers identifying real but disarmed rounds.

For both EOD and command and communications purposes, the Special Operations Forces have expressed interest in the new system. At present, Miller said, units below the division level rely on paper maps and overlays to display battlefield information.

"With flat panels, you could send digital information over the new field radio and show it on the screen at the brigade or battalion level for use much closer to the front line of troops," Miller said.



SGT Jeffrey J. Christensen of the 54th Explosive Ordnance Disposal Detachment at Fort Monmouth, NJ, uses the graphics and text of a flag panel display to identify a Soviet anti-tank round.

Acquisition Streamlining Update

Training

In the July-August issue of *Army RD&A Bulletin*, we reported that the Acquisition Policy Branch, Office of the Deputy Chief of Staff for Development, Engineering and Acquisition, HQ Army Materiel Command was in the process of presenting a series of pilot courses in the principles of the Army Streamlined Acquisition Program (ASAP). Those courses (six in all) have been completed and we are currently reviewing a plan for continuation of this much needed (and much requested) training.

Students participating in the course have provided us with excellent feedback, to include some highly productive suggestions for additions, deletions, and revisions. Once we incorporate those suggestions, and determine the feasibility of providing a broader range of more specialized instruction, we will announce a new series of courses. Current target date for beginning the FY89 series is December 1988.

Streamlining Update (continued)

We anticipate being able to offer at least one course monthly in the Washington, DC. area. Besides publication in this bulletin, we intend to issue announcements to the streamlining advocates in each AMC subordinate command as well as to those advocates in each major command (e.g. HQ TRADOC, HQ ISC) and all program executive offices (PEO), plus invitations to our defense contractors through several defense industry associations which have expressed interest.

We also intend to contact personally those individuals who responded to the July-August Army RD&A Bulletin article too late to be included in the initial six pilot courses.

Acquisition Streamlining Excellence Awards

On Sept. 6, 1988 Dr. Robert Costello, under secretary of defense (acquisition) presented the 1987 OSD Acquisition Streamlining Excellence Awards in a ceremony held at the Pentagon. Two Army organizations received recognition for their contributions to the principles of acquisition streamlining. We would like to congratulate AMCCOM's ASAP training team for its initiative in establishing and presenting a course of instruction on ASAP, and TACOM's Engineering and Data Directorate for their efforts in challenging unnecessary contract and data requirements. These organizations exemplify the trend, which we certainly applaud, towards going beyond policy formulation into the actual implementation of streamlining principles in every day acquisition management.

AR 70-1, System Acquisition Policy And Procedures

On July 13, 1988, Under Secretary of the Army Michael Stone approved the draft of AR 70-1 as interim guidance pending formal publication by the Army Publications and Printing Agency. Pre-publication copies of the regulation have been provided to all Army PEOs and installations involved in the acquisition of Army materiel.

Implementation

A comprehensive plan is being developed to institutionalize the ASAP throughout the Army. The plan will take ASAP beyond the current thrust of getting the word out and address specific actions necessary to make streamlining a reality in Army acquisitions.

TACOM Evaluates Composite Drive Shaft For HMMWV

The U.S. Army Tank-Automotive Command's (TACOM) RDE Center is evaluating a composite drive shaft for the Army's HMMWV (High-Mobility Multipurpose Wheeled Vehicle that is lighter and stronger than a comparable steel shaft. Composite shafts have been shown to be cost-effective for several commercial applications.

The 4x4 HMMWV uses two drive shafts, a 27.1-inch shaft for the rear wheels and a 57.8-inch multiple-piece shaft for the front wheels. Because of its length — some two to three feet longer than most automotive drive shafts — the front shaft had to be designed as a two-piece unit with a bearing at its center to provide stability during high-speed operation.

When a shaft rotates rapidly, it begins to vibrate at its center due to the tendency of centrifugal force to bend the center of the shaft outward as it spins. This is especially true with a long shaft.

Since the HMMWV's introduction in 1985, the two-piece drive shaft has performed well. But according to the RDE Center's Donald Ostberg, in charge of the composite drive shaft project, the new shaft, which was developed for TACOM by the California-based Composite Materials Division of Ciba Geigy Corp. and is now undergoing tests, is a one-piece shaft made of a combination of graphite and epoxy.

Noting that the purchase cost of the composite shaft would be about the same, he said this shaft is stronger and more rigid than its standard steel counterpart. Thus, it needs no center bearing, which Ostberg said would mean a reduction in life-cycle costs through elimination of the bearing and associated support brackets as well as bearing maintenance. He added that the new shaft weighs about 60 percent less.

Ostberg also said that the new shaft has the same shape as the original steel shaft and uses the same end connectors, and would therefore be interchangeable.

"In one year of field-testing eight shafts at Fort Lewis, WA," said Ostberg," we encountered no problems. The tests involved putting the drive shafts on regular field vehicles and letting the troops subject them to normal daily use. The tests were severe," Ostberg said. "They included operation in a temperate environment at Fort Lewis, and traveling cross country over mountains to a desert where it is extremely hot and dry — conditions that are tough on composites."

Ostberg said no decision concerning future use of the drive shaft on HMMWV's will be made until the project manager, light tactical vehicles reviews the Fort Lewis tests to determine if it would be cost-effective and sufficiently durable to survive in a military environment.

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

Correction

The photograph shown on page 6 of the September-October 1988 issue of Army RD&A Bulletin was incorrectly identified as an Apache helicopter firing 2.75mm rockets. The cutline should have correctly identified the helicopter as a Cobra which is firing 2.75-inch rockets.

We apologize for the error.

FROM THE EDITOR . . .

With this issue of the *Army RD&A Bulletin,* I replace LTC David C. Smith as editor-in-chief. Both I and the staff thank Dave for his outstanding contributions and wish him success in his new assignment as product manager, M9 (ACE).

Having been an avid reader and strong supporter of the bulletin for many years, I welcome the challenge of serving as its editor-in-chief. I don't envision any major changes in what has proven to be a successful and well received publication. However, in my capacity as proponent officer for the Army Materiel Acquisition Management (MAM) Program, I do hope to expand the use of the bulletin for disseminating professional development information to both our civilian and military acquisition career force.

Recent realignments within Army Materiel Command (AMC) Headquarters further support the increasing visibility and importance being given to development of a highly professional Army acquisition career force. The *Army RD&A Bulletin* Office, along with the MAM and Functional Area 51 (Research and Development) Proponency Offices have been consolidated within AMC Headquarters in the Office of Project Management. The Office of Project Management reports directly to LTG Jerry Max Bunyard, the AMC deputy commanding general for research, development and acquisition. This reorganization brings together, in a single office, the functional proponents for acquisition careers and the major Army publication supporting the needs of that career force. For the immediate future, there will be no change in the bulletin mailing address or phone numbers.

In closing, I encourage your comments and recommendations regarding the Army RD&A Bulletin. Both I and the bulletin staff are here to serve you, our readers.

Daniel D. Ziomek

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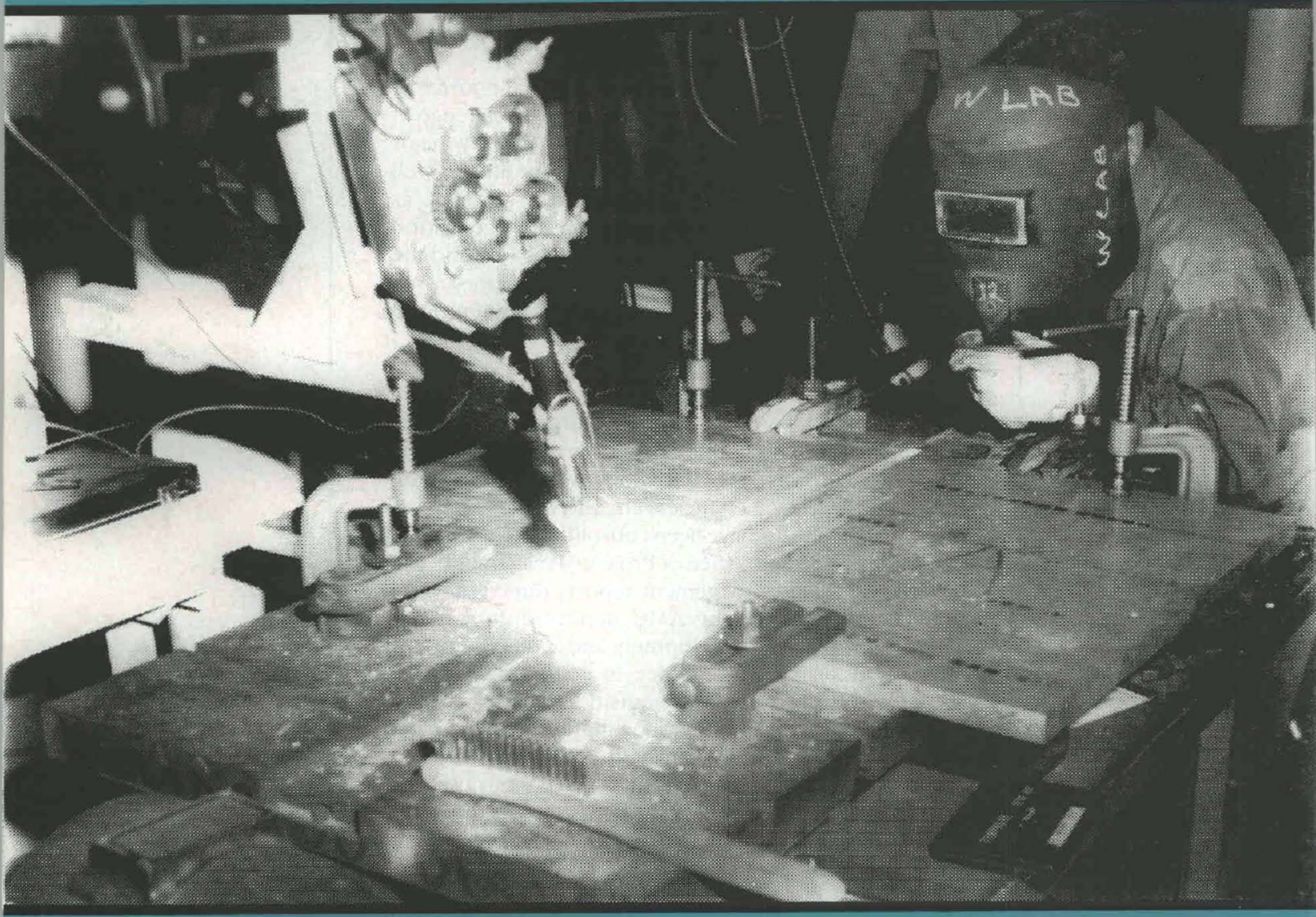

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