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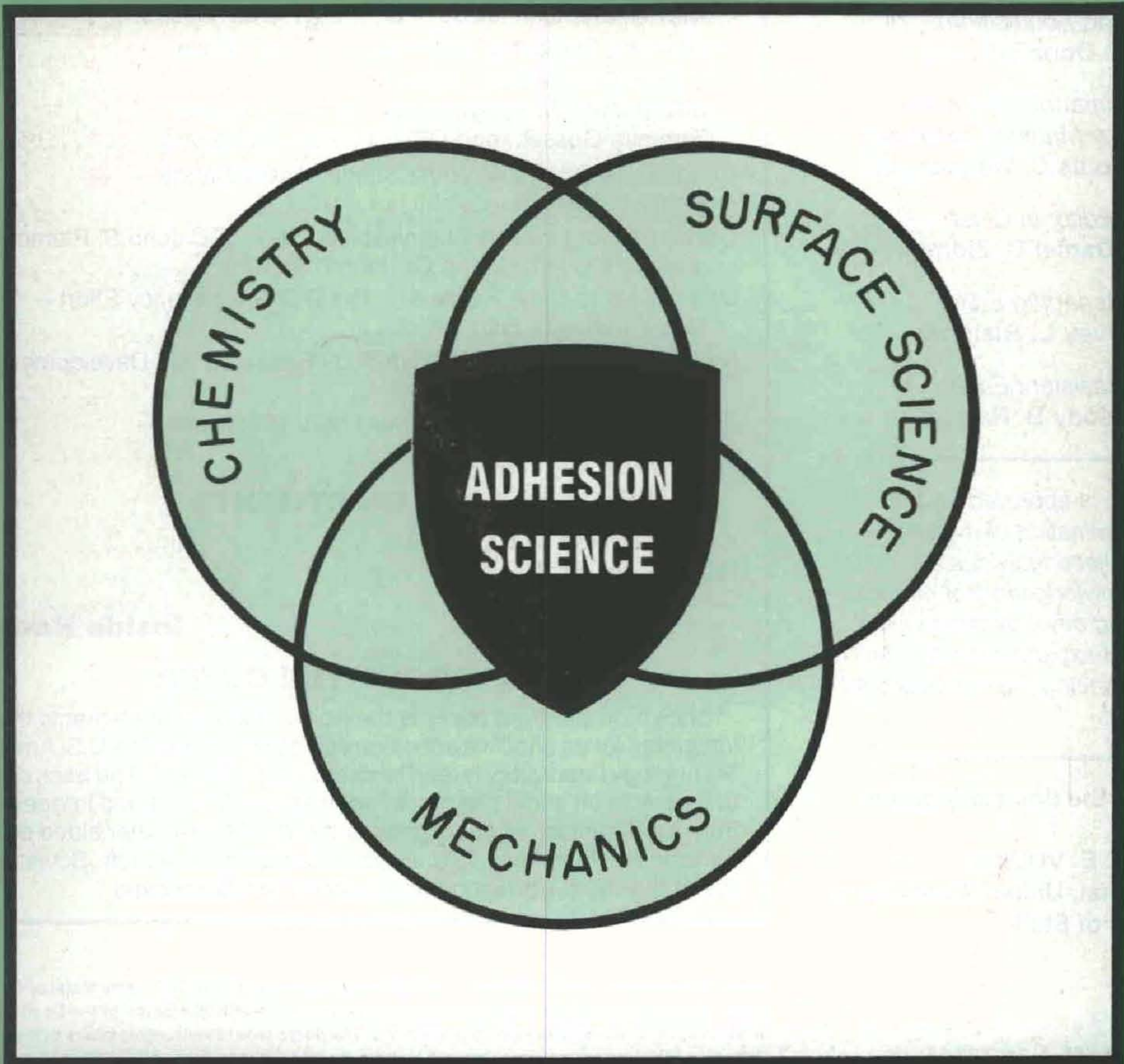

ARMY
Research Development Acquisition RD&A

PB 70-89-2 **MARCH-APRIL 1989**

PROFESSIONAL BULLETIN OF THE RDA COMMUNITY

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

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ABOUT THE COVER

Shown on the front cover is the troika of essential elements that must be integrated for an effective adhesion science program. The U.S. Army Materials Technology Laboratory is lead laboratory for this effort. The back cover relates to an article on item-level modeling. It shows 12 overhead images generated from a different target description and built with computer aided design at the Ballistic Research Lab. U.S. systems are at the lower left, Soviet systems at the upper right. Corresponding systems are juxtaposed.

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ADHESIVE BONDING

By Dr. Stanley E. Wentworth

Introduction

In the summer of 1985, an Army Cobra helicopter in flight lost the polyurethane rain erosion boot from the leading edge of one of its rotor blades. Because of the resulting aerodynamic imbalance, the aircraft was nearly lost, a tragedy averted only through the skill of the pilot.

Subsequent investigation, involving the Army Materials Technology Laboratory (MTL) and representatives of other commands, revealed that the adhesive bond between the boot and the blade had failed. This incident resulted in an exhaustive study of adhesive bonding problems, at first on Army aircraft and then across the spectrum of Army materiel, from missiles to wheeled vehicles, gas masks to fuze components. The results of this study and its recommendations form the basis of the Army's Adhesive Bonding Improvement Initiative, for which MTL has been designated the Army's lead laboratory.

Why Adhesive Bonding?

Properly done, adhesive bonding provides several advantages over other joining methods, such as mechanical joining. The prime advantages are lighter weight, reduced fabrication cost, better damage tolerance and fatigue resistance. Smooth contours, easier fabrication and improved appearance are among the other advantages gained through adhesive bonding.

Short Term Problems

Studying bonding problems in Army materiel brought to light a wide range of deficiencies in bonded structures. Ranging in impact from cosmetic to critical, they ran the gamut from non-adherence of a data plate to a dashboard to the failure of a nose cone to remain bonded to its underlying missile structure during simulated flight conditions.

In virtually all cases studied, the deficiency was attributable to failure to perform the bonding operation properly, rather than to some fundamental lack of knowledge. The single underlying cause for this is failure to treat adhesive bonding as a serious structural issue. Very often the result has been a bonding operation not adequately specified or controlled. For example, improper or incomplete surface treatment has often been identified as the cause of bond failure.

Failure to treat bonding seriously also results in the adhesive joint not being integrated into the total structural design of the system. The joint is therefore not optimized for its structural role and may indeed be unable to serve its intended purpose.

Correlative to this is failing to consider the end-use environment that the bonded structure will operate in. This can lead to selecting an inadequate adhesive, which can cause bonds to fail in service.

Quality control is another area where lack of attention to detail causes problems. Often, there is no requirement to monitor batch to batch variation in the composition of adhesives. Yet, such variations can lead to bonds of differing strength and durability.

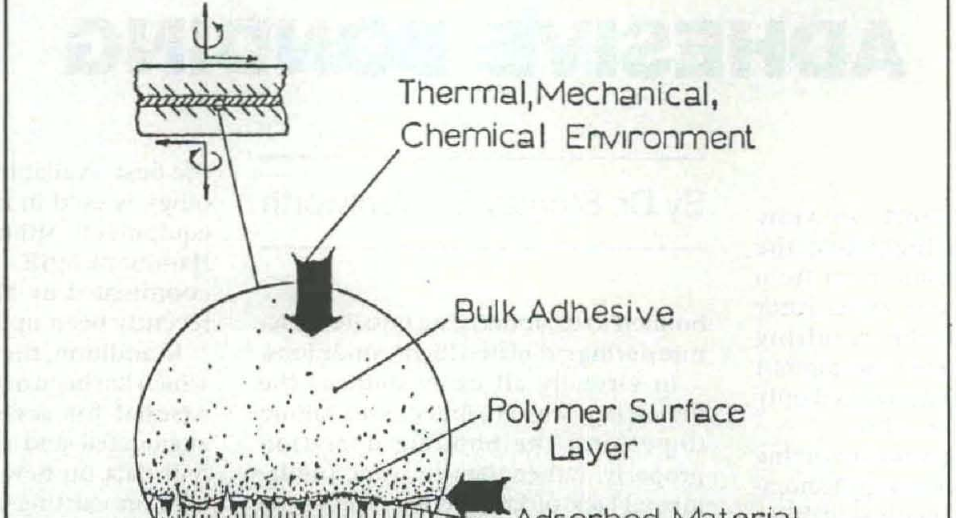
A series of actions has been initiated to correct the identified deficiencies. First, specifications and standards dealing with adhesive bonding have been reviewed and are being updated to reflect state-of-the-art in adhesive bonding technology. By this means, contract documents will ensure that the best available bonding methodology is used in manufacturing Army equipment. Military Standardization Handbook 691B, "Adhesive Bonding," coordinated by MTL, is one that has recently been updated.

In addition, the adhesives data base, which has been maintained at Picatinny Arsenal for several years, is being augmented and expanded. Not only will data on new adhesives and new data on existing adhesives be added, but a new feature entitled "Lessons Learned" is being incorporated. Thus, descriptions of bonding problems and their solutions will be retrievable. This data base will be a valuable resource to those seeking to utilize adhesive bonding in new applications, as well as to those attempting to solve current bonding problems.

The major step in addressing current problems, however, is developing a model approach to their solution.

Each of the Army Materiel Command's (AMC) major subordinate commands has been tasked with selecting a bonding problem to solve. Each of these problems will be analyzed in terms of the shortcomings identified above. Appropriate corrective actions, such as better surface treatment, better process control and adhesive replacement, will be taken. Close coordination between various commands and Army laboratories will highlight this process. Each command will then use this methodology to solve other bonding problems within its purview. Results of this program will be entered into the data base.

To enhance communications and alert academia and industry to the Army's needs in the area of adhesive bonding, an MTL co-sponsored Government/Industry Symposium on Structural Adhesive Bonding was held at Picatinny Arsenal in November 1987.



Schematic representation of the interphase of an adhesive bond.

Also, the Army's annual Sagamore Materials Research Conference, sponsored by MTL, had adhesive bonding as its 1988 theme. Additional meetings of this sort are anticipated.

Non-destructive Evaluation (NDE)

NDE of adhesive bonds is the one exception to the statement that current bonding problems are not the result of a fundamental lack of knowledge. At present, there is no method for non-destructively determining an adhesive bond's strength.

Since the aviation community holds to the philosophy that "if you can't inspect it, you can't fly it," this deficiency is a major technical barrier to the use of adhesive bonding. Because there is no adequate bond-strength NDE method, adhesive bonding is not used for primary structure, even though it would be advantageous to do so. At this point, although there is an immediate problem, only mid- to long-term solutions appear achievable.

Future Needs

Whereas the objective of the programs addressing short-term bonding problems is correcting existing deficiencies by applying state-of-the-art materials and methods, a major objective of the mid- and long-term programs is preventing such problems in future systems. The long-term objective is to develop computer models of adhesive bonds so detailed and sophisticated that the entire life cycle, including end-use degradation, can be accurately described.

In pursuing such a program in adhesion science, it is important to recognize the importance of the multi-disciplinary nature of the undertaking. Elements of chemistry, surface science and mechanics are involved, and MTL's program addresses each of these.

Chemistry

Efforts in chemistry are directed towards developing improved adhesives and identifying surface treatments for emerging materials, such as metal matrix composites. Even though a large number of commercially available adhesives are suitable for a wide range of applications, Army systems now in development need adhesives with performance superior to these state-of-the-art materials. In lightweight bridging, for example, adhesives having the following attributes are needed: long shelf life at ambient temperature; service life of 15 years; and a doubling of bond strength.

Adhesives with substantially higher upper-use temperatures are also needed. They would be used in composite gun tubes, missile structures and in or near aircraft power plants.

The basic approach to meeting these needs is through synthetic modification of the adhesive base resin, along lines indicated by advances in polymer science over the past years. MTL's current in-house program is addressing the need for more thermally stable adhesives. In particular, MTL is preparing a new family of resins called PPQ ionomers, which are expected to be especially valuable in bonding ceramics.

Modifying adherend surfaces to enhance bondability is usually achieved by chemical means, although it is addressed through surface science as well. Work needed in this area falls into two major categories, new surface preparations and surface preparations for new materials.

A good example of a new surface treatment is the P2 etch developed at the Army Armament Research, Development and Engineering Center with funding support from MTL. It is intended as a chromium-free replacement for chromium-containing treatments for aluminum. After five years of use by Piper Aircraft in South Florida, where heavy metal ground water contamination is a major concern, it has been found completely equivalent to its predecessors.

As new materials now in development are proposed for introduction into Army systems, surface treatments for their adhesive bonding must be developed. Examples of such materials are metal matrix composites, thermoplastic matrix composites and aluminum/lithium alloys. MTL is currently developing treatments for the first two of these materials.

Surface Science

Adhesive bonding of structural elements is no longer considered an art. It has achieved the status of an advanced technology with a sound scientific base. The significant advances in surface science have been a major factor in this evolution. The development of instrumentation that permits very high resolution analysis of surface chemistry and morphology has been particularly significant.

These methods allow very precise determination of the locus of failure in a failed adhesive bond and provide the basis for rational approaches to their correction. More important, they permit an understanding at the molecular level of the interactions between adhesive and adherend. Some also provide detailed information on the chemical nature of adherend surfaces, a matter of crucial importance for surface preparation studies. MTL heavily utilizes these methods in its program.

Surface modification by ion-implantation is an area that has barely been addressed. Some recent work has shown that a platinum surface can be converted from one to which no bonding could be obtained to one exhibiting excellent bondability. This is obviously a fertile field for further investigation, and MTL intends to do that.

The importance of the interphase in determining the strength and durability of an adhesive bond can not be overemphasized. The interphase constitutes the entire region where the adhesive and adherend come together and is substantially broader than the interface. It is through the region that the load on the bond is transferred and, most often, where physical and chemical degradation occurs. Thus, an understanding of the chemistry and physics of this region is crucial to the sophisticated models that are the ultimate objective of our program.

An investigation is currently underway in the MTL program of the postulate that adherend surfaces selectively adsorb adhesive constituents, such as curing agents, from the bulk adhesive and thus dramatically perturb the cure chemistry in this critical region. Preliminary indications from thermal analysis show that this does indeed occur. MTL is currently trying to determine the nature of these altered reaction products, to ascertain their likely effect on bond performance.

Mechanics

Since the ultimate goal in forming an adhesive joint is to form a mechanically strong union between two adherends, scientifically sound guidance for designing such joints and meaningful methods to test performance are critical needs. Mechanics must provide these capabilities.

Major advances have been made in this field over the last 15 years, many due to the tremendous increase in the availability of computing power. Much remains to be done, however, especially in areas where the Army has its own special needs. For example, helicopters impose much more severe fatigue loads on joints than do fixed wing aircraft, due to vibrations generated during operation.

The Army must also be more concerned with the effect of high strain rate loading (ballistic impact) on the integrity of adhesive bonds. Applying adhesive bonds to tank-automotive and armament systems also gives rise to concern for bonding thick structures, rather than the thin materials encountered in aviation systems.

Simpler, more reliable bond strength tests are needed. The effect of high strain rate loading, including ballistic impact, on the residual strength and durability must be determined for adhesively bonded armor materials. This requires a combination of ballistic and mechanical testing.

In the design area, more powerful computer codes are needed to more accurately predict the loads on and behavior of adhesive joints. This is both a mid-term goal, and, as already indicated, the ultimate objective of the bonding initiative. Augmenting existing codes, in the near- and mid-term, serves the more immediate needs and provides the basis for reaching the overall goal. Each of these areas is currently being addressed as part of our program.

Conclusions

Successful completion of this adhesion science research program, addressing the essential troika of chemistry, surface science and mechanics, will allow the Army to utilize adhesive bonding to its fullest advantage in current and next generation/future systems.

DR. STANLEY WENTWORTH received his B.S. and Ph.D. from Northeastern University in Boston. After two years on active duty in the U.S. Army, he took his present position as a research chemist at MTL.

Building the Foundation:

ITEM-LEVEL WEAPONS MODELING

By Dr. Paul H. Deitz

Introduction

Item-level modeling involves the study of a single military system such as a tank, aircraft or communications shelter. The objective of such a study normally involves estimating one or more aspects of item performance in terms of its ability to meet a set of requirements.

Typically, a military system may fulfill multiple performance requirements so an item may be examined from many aspects. What are typical examples of item-level analysis? They include estimates of weight, size, ability to withstand enemy fire (vulnerability), mobility, detectability (across many wave-length bands), and ability to inflict damage on a particular target class (lethality).

Item-level modeling and assessment are critical to the DOD for a number of reasons. This is the first level of assessment in which a technology can be properly evaluated in terms of actual benefits. For example, a new material for applique armor may appear promising in off-line tests. However, only when this armor is applied to a vehicle with due consideration to actual placement and mounting constraints and further subjected to the various threats and attack directions, does a reliable picture emerge as to its true utility.

Another example might be the development of a radar coating for the suppression of armored fighting vehicle signatures. A candidate material might show high absorptivity in laboratory tests, however, only when practical constraints of applying such a material to the exterior of a vehicle (maintaining access for personnel, weapons, sights, etc.) can the utility of the approach be assessed. So item-level weapons modeling is the first instance where many technologies join with system design and the compromises and tradeoffs become identifiable and quantifiable.

Second, the results of item-level modeling form the basic building blocks from which larger integral assessments are performed. For example, all battlefield modeling whether at the battalion, division, or higher levels is built on probability of kill (PK) assessments of various firer/target matrices. The data for these matrices are all the result of item-level modeling.

Third, item-level modeling supports and extends the utility of actual weapons testing. Many required field tests are extremely expensive. Item-level modeling assists in weapons assessment by extending the utility of test data for conditions and environments for which tests can't be performed due to constraints of time, cost, or materiel availability.

How Is It Performed?

Item-level modeling can be divided into a two-step process. The first is a Computer-Aided Design (CAD) phase in which a geometric description of the item is assembled. The result of this is a mathematical file which represents the fully described shapes and materials of which the item is composed. Phase two involves linking the geometric description to an application code to gain understanding about the nature or potential of the item.

The U.S. Army Ballistic Research Laboratory (BRL) first embarked on this analysis task some 20 years ago to gain insight into two specific forms of weapons performance: survivability/lethality and neutron transport. Whether a particular anti-tank munition will perforate a tank armor is inextricably related to both the characteristics of the munition as well as the system under attack. This includes the details of hit point, armor fall-back angle, line-of-sight projection, material properties, etc. So too the propagation of neutrons from a nuclear event through free space and potentially to occupants of an armored fighting vehicle is a phenomenon driven by the basic physics as applied to the specific geometric and material configuration encountered.

Early Modeling

In the years following World War II, when the discipline of vulnerability analysis first developed, analysts utilized blue-prints to project bullets through targets. Shotlines were traced manually through a tank or aircraft to catalogue lists of engaged components. Extracted by hand, as well, were points of intersection, surface normals, thicknesses, and materials, clearly a time-consuming process.

Late in the 1960s the shotline interrogation process was automated to support the first item-level analysis, that of TOW warhead optimization against a tank. To accomplish the first of the two-phase process noted above, a so-called target description was assembled of the target vehicle. To do this, a method of target description preparation called solid geometric modeling was developed in which target geometry is described by a family of closed three-dimensional shapes such as cubes, spheres, cones, and the like. The resulting computer input file consisted of the required shapes and defining materials. Upon completion of this input preparation phase, a computer program was invoked which projected rays (or shotlines) through the target description to extract automatically what had formerly been an entirely manual task.

At this point, it was possible to compute literally thousands of shotlines on computers which, by today's standards, were modest machines. The bottleneck of building, modifying, and validating target descriptions soon emerged as a substantial problem. Through the 1970s, that process was accomplished entirely by hand, with nothing remotely approximating today's world of interactive graphics. During the initial design process of the XM1 Tank, for example, none of the automated raycasting analyses could be invoked because it was not possible to model geometrically the competitive designs by hand in a timely fashion.

Early in the 1980s, the BRL made a study of the requirements for a suite of CAD tools necessary to support vulnerability and other kinds of item-level modeling. An in-depth review was performed of possible commercial candidates; at the time, none was found capable. An in-house development program was begun which has resulted in an extensive set of CAD programs which are now called BRL-CAD. Although several commercial products in the area of solid geometric modeling have appeared in the market place, none has equaled the Army-developed package in its ability to support the demands of high-resolution item-level weapons modeling.

BRL-CAD

BRL-CAD is an extensive suite of Army-generated, supported and owned software specifically designed for the geometric modeling of weapons systems. Consisting of some 200,000 lines of source code and approximately 70 individual programs, the heart of the CAD package is a geometric editor called MGED (for Multiple-device Graphics EDitor). This program, when executed on a suitable computer or engineering workstation, provides the visual feedback and operator control necessary to build, modify, and validate highly complex geometric models of tanks, aircraft, communications vans, etc.

There are many possible mathematical approaches to describing three-dimensional geometry. This is why different modeling schemes are generally incompatible with one another. Originally MGED provided for viewing and editing only the basic shapes mentioned earlier which were part of the first modeling scheme developed in the 1960s. However the BRL-CAD data base has been designed to be extensible to new representations.

The data base now supports the modeling representations used by Denver Research Institute, a key provider of geometry for the USAF, and a powerful, so-called, spline entity. This latter mathematical form is capable of following complex surface shapes such as those found in cast turrets and aircraft surfaces which are not amenable to modeling via simpler shapes.

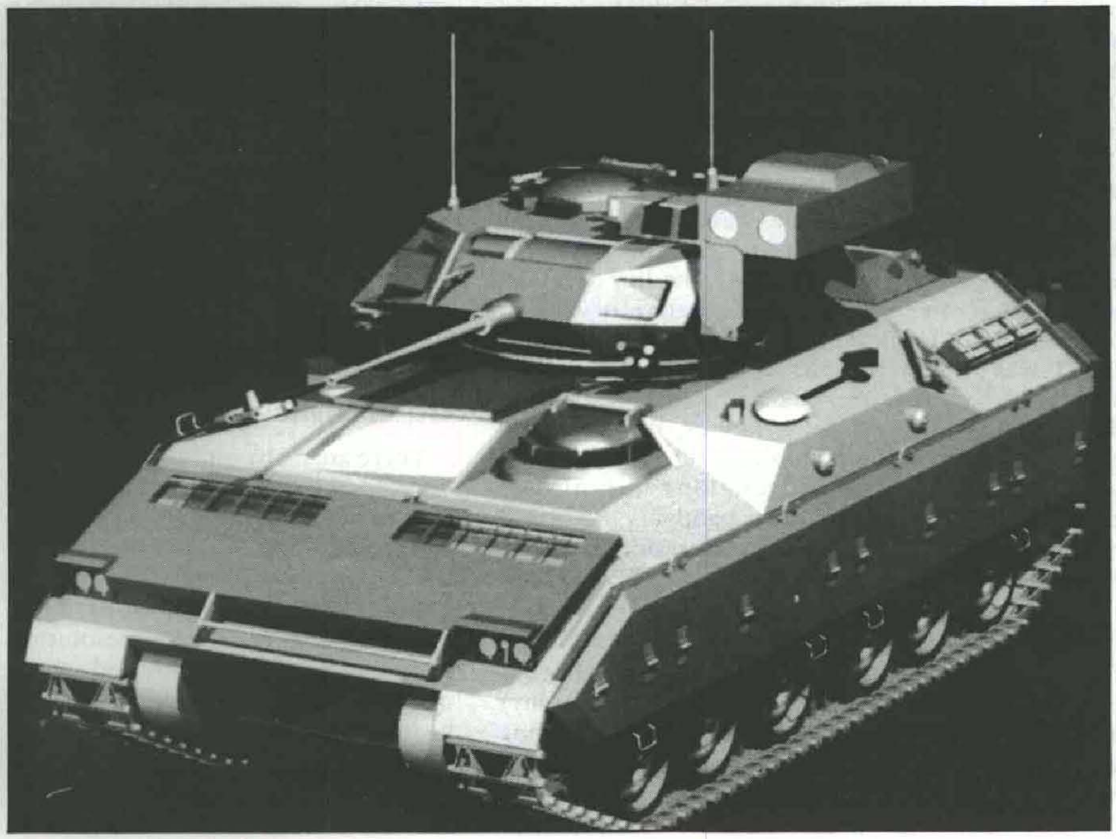


Figure 1. Front view of the Bradley Armored Fighting Vehicle Built and viewed with the BRL-CAD package. The exterior geometry is highly detailed to support high frequency radar and optical simulations.

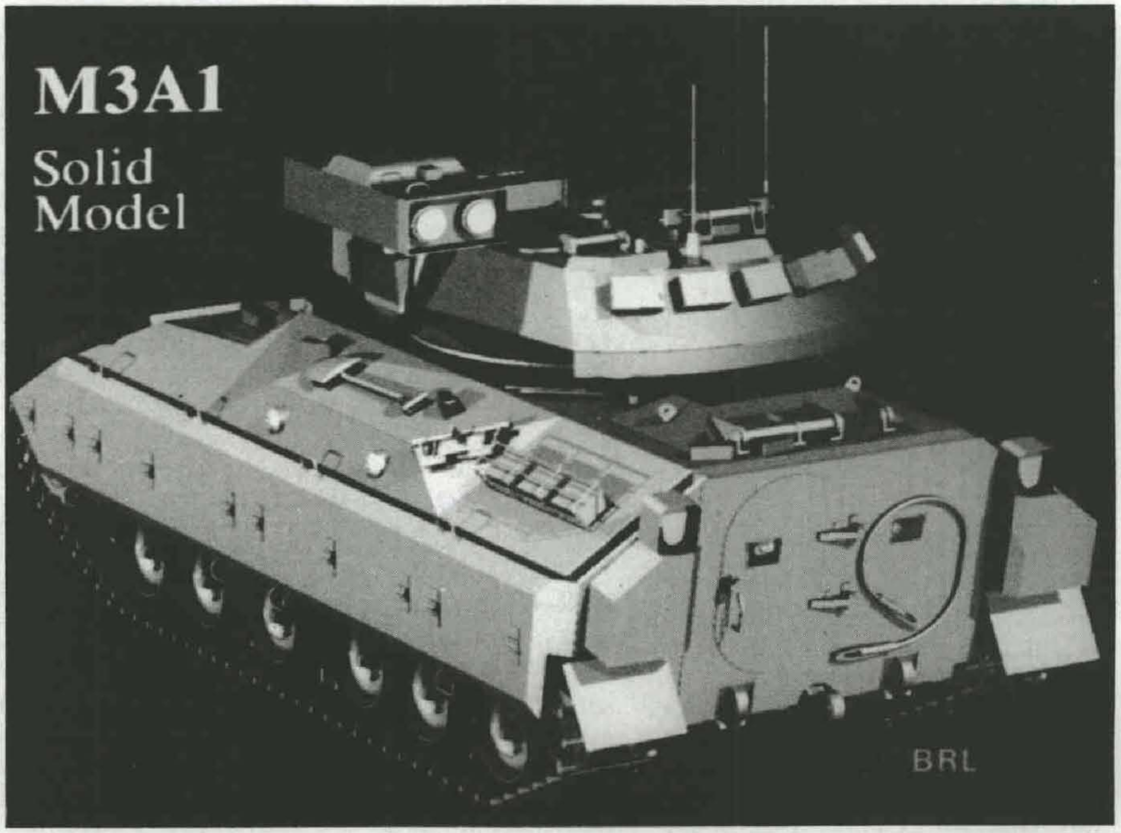


Figure 2. Rear view of the Bradley.

Another significant set of tools in BRL-CAD supports raycasting. In addition to supporting vulnerability/lethality analyses, raycasting is also used to simulate neutron trajectories and blast waves, calculate moments-of-inertia, and compute radar cross sections. These utilities are arranged to operate in parallel so as to take maximum advantage of modern computer architectures with multiple-processors (e.g., Cray, Alliant, Convex etc.).

A third set of BRL-CAD utilities supports the generation of images via what are called lighting models. These models simulate what the eye would see from various positions in space. Of note is the fact that there are many other utilities available for manipulating images, performing comparisons, creating labels, etc.

Examples

Over the past five years, as the new CAD tools have been placed into production at BRL and other sites, many scores of target descriptions have been created. Illustrative of the high-resolution end of the modeling spectrum are the images shown in Figures 1-3. A high-detail version of the Bradley fighting vehicle is shown from the vehicle front-left (Figure 1) and rear-left (Figure 2). The target description used for these images was originally created to support standard vulnerability modeling during the Bradley development cycle. In 1985, the level of internal detail was increased to support the requirements of the Live-Fire Testing Program. The high level of exterior detail (tracks, hinges, handles) was added later to support high-frequency signature calculations in both the optical and radar bands.

A BRL-CAD lighting model was used to make these images. The model supports multiple sources of light, shadows beneath the main gun can be seen in Figure 1 due to two overhead sources. The amount of specular (shiny) or diffuse (rough-surface) reflections can be adjusted to simulate virtually any material, covering, or illumination condition (including stereo-image pairs).

An option exists within the lighting model to assign optical transparency to specific parts. Figure 3 illustrates this option in which the armor has been made nearly 100 percent transparent. This makes viewing of the internal components possible. Some reflection has been given to the armor so that it can be seen. Many other options are available including viewing only certain subsets of geometry and supporting animation for motion studies.

Other Issues

There are many ramifications to the development and exploitation of this technology:

- Level of Detail: These CAD tools were originally developed simply to generate target descriptions more quickly. However as higher resolution geometry could be supported, many new and important applications have been developed.
- Portability: The BRL-CAD package now operates over a dozen computer architectures spanning the range from

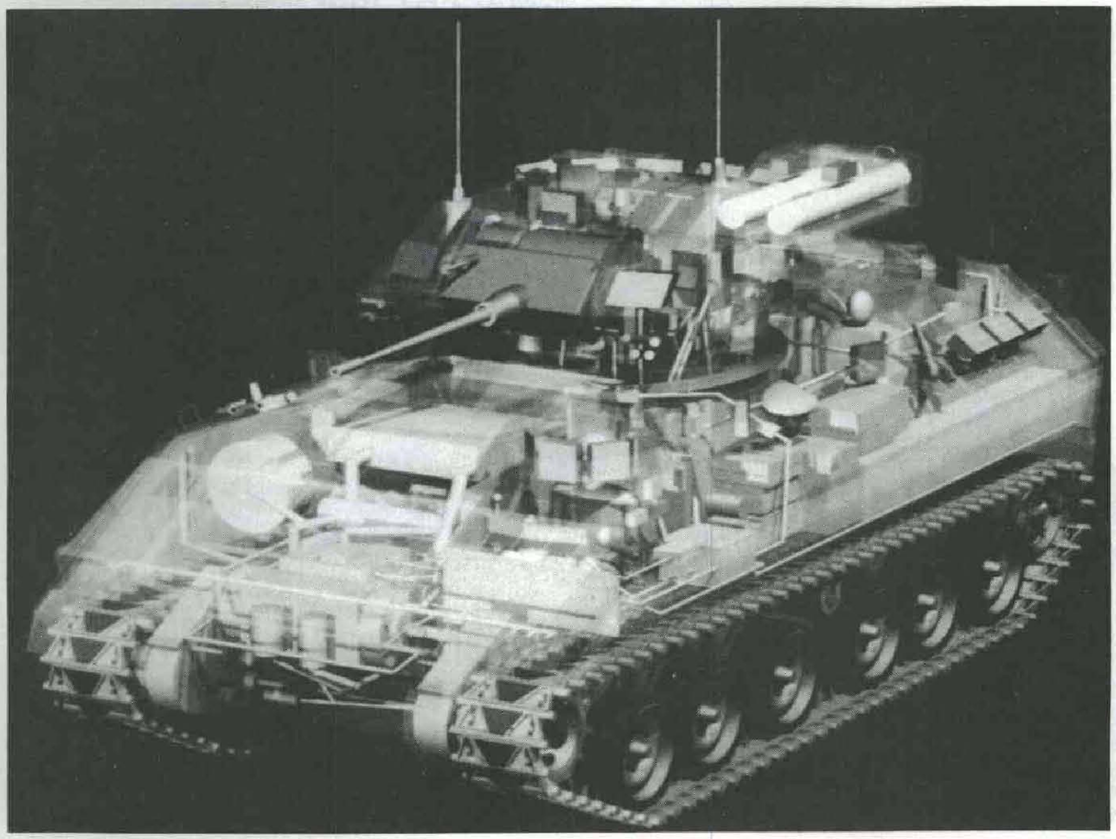


Figure 3. Transparent rendering of the Bradley Armored Fighting Vehicle. Using the same target description file as in Figure 1, a lighting model option allows armor to be rendered transparent, revealing internal component placement.

$10K single-user workstations to $20M supercomputers. The ability to retarget code to new machines quickly has made it possible to exploit more fully the growing wealth of DOD computing resources and at the same time avoid "vendor lock in" to a narrow or cost-ineffective hardware base.

• Extensibility: Since the software is "owned" by the government, source code is available to all users. Required extensions and modifications can be made by users of the code. New applications typically require new features or extensions.

• Applications Codes: There is a large body of applications codes which are linked to the BRL-CAD environment. Future articles will review some of the more prominent ones.

• Distribution: To date, over 400 computer sites, government, academic, and industry, have requested and been sent full source code. As new applications have been found and limits tested, feedback from users has contributed to enhanced releases.

• Sharing of Geometry: Even under the best of conditions, the generation of complex target descriptions is an expensive investment. However, as workers share geometry, an economy-of-scale develops. Some analyses have been made possible because the geometry has been available when a specific need has arisen. In addition, since the BRL-CAD package is now in use at a significant number of contractor sites, an option exists for the Army to require a compatible digital data base with contract deliverables. This greatly reduces the time required to analyze, for example, concept systems and production improvements.

• Networking: The CAD package makes copious use of the same inter-machine networking standards as used in the DARPA MILNET/ARPANET. This means that multiple machines, both within a single laboratory or literally across the country, can exchange files, share data bases, and even aggregate computing power for high-demand tasks.

Future Topics

In future articles, a review will be made of the item-level analysis codes which are currently linked to CAD tools. The first will review the suite of vulnerability/lethality codes; a summary of signature modeling will follow.

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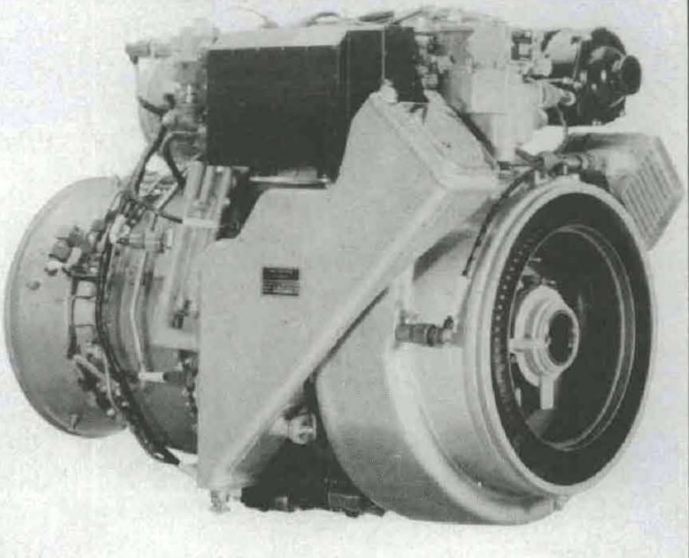
THE T800 ENGINE ACQUISITION STRATEGY

By LTC Sandy Weand



On Oct. 31, 1988 the U.S. Army Aviation Systems Command signed a contract modification with the Light Helicopter Turbine Engine Co. (LHTEC) that provides for the final qualification of the T800 turbine engine (see photo) for use in future Army helicopters. This was a major milestone in the T800 acquisition strategy. Approximately three years ago this full-scale development (FSD) program started with the award of two fixed-price contracts to competing contractor teams. One team was AVCO-Lyoming and Pratt and Whitney (APW), a joint venture between Textron Lycoming and Pratt and Whitney Government Products Division of United Technologies. The other team was LHTEC, a partnership of Allison Turbine Engine Division of General Motors and Garrett Turbine Engine Division of Allied Signal. Both teams were competing for a government contract to produce approximately 5,000 T800 engines.

The T800 procurement approach, based on the streamlined acquisition philosophy, is performance-oriented. Although this philosophy emphasizes the government's requirements, it does not dictate methods for accomplishing these objectives.

Competition was the key to establishing the government's T800 acquisition strategy. Awarding competitive contracts for FSD to more than one contractor team (and after initial development and testing, choosing the winning design), required each team to constantly strive to develop and qualify the engine at the lowest cost.

To initiate this strategy, three teams submitted proposals, two were chosen to develop the engine and try to establish a favored position by meeting stringent requirements during initial development. After that, the winning team was chosen and, once in production, both companies of the winning team will compete to produce the larger portion of the same design, (see Figure 1).

Fixed price contracts were used to enhance the effects of competition. To extend the cost avoidance afforded the government during the FSD into production and sustainment, the contract established three life-cycle cost guarantees: a not-to-exceed guaranteed average design-to-cost for the engine; a guaranteed operation and support cost; and guaranteed reliability and maintainability values. Figure 2 shows additional new initiatives introduced to Army acquisitions by the T800.

In exchange for the contractors assuming the high level of risk for this program, they were given much more flexibility than in past programs in determining how the program was to be run. The result was a performance-oriented, contractor-developed system specification, containing only minor performance requirements from a coordinated (government and industry) Request for Proposal (RFP).

RFP development concentrated on defining those specific items necessary to meet the government's objectives and, at the same time, separating and discarding other traditionally requested data that did not affect the product nor provide useful information for evaluation.

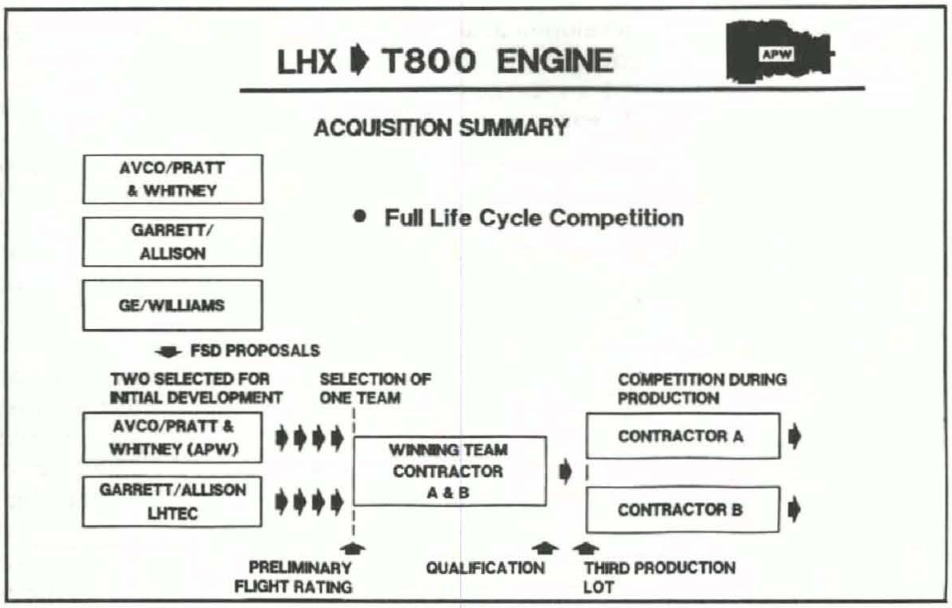


Figure 1.

LHX T800 ENGINE

COMPARISONS WITH PAST PRACTICES

	PAST PRACTICES	T800	GOV'T BENEFITS
COST	o COST PLUS INCENTIVE FEE DEVELOPMENT	o FIRM FIXED PRICE DEVELOPMENT	o NO CHANGE IN DEVELOPMENT COST OR GUARANTEES
	o PROD COST GOAL	o PRODUCTION GUARANTEE	o CEILING PRICE PROTECTION
	o SUPPORT COST GOAL	o SUPPORT GUARANTEE	o PROTECTION, SHIFTS RISK TO CONTRACTOR
	o GOVERNMENT FACILITIES	o CONTRACTOR FACILITIES	o SHIFTS RESPONSIBILITY, RISK TO CONTRACTOR
COMPETITION	o 2nd PRODUCTION SOURCE NOT REQUIRED	o 2nd PRODUCTION SOURCE REQUIRED	o BEST CONTRACTOR PERFORMANCE o REDUCED ACQUISITION COST o EXPANDED INDUSTRIAL BASE
	o ALTERNATIVE SOURCES FOR SPARES NOT REQUIRED	o ALTERNATIVE SOURCES FOR SPARES REQUIRED	o BEST CONTRACTOR PERFORMANCE o REDUCED ACQUISITION COST o EXPANDED INDUSTRIAL BASE
	o SMALL BUSINESS PLAN	o SMALL BUSINESS PARTICIPATION REQUIRED	o EXPANDED INDUSTRIAL BASE
PRODUCTION COMPETITION	o DETAILED GOVERNMENT SPECIFICATION	o GOV'T REQUIREMENT WITH CONTRACTOR SPECIFICATION	o DESIGN FLEXIBILITY WITH TRADE-OFFS
	o PERF/RELIABILITY GOALS DEMO AFTER DEVELOPMENT	o PERF/RELIABILITY REQUIREMET DEMONSTRATED IN DEVELOPMENT	o EARLY VALIDATION PRIOR TO FULL PRODUCTION
	o FRAGFMENTED LOGISTICS SUPPORT	o EARLY CONTRACTOR COMMITMENT	o MANPOWER PERSONNEL INEGRATION o LOGISTICS PLANS IN PLACE
	o ENGLISH MEASURE	o METRIC MEASURE	o IMPLEMENTS DOD POLICY o ENHANCES FOREIGN USE

RDA_1

Figure 2.

The first step was to define performance-oriented objectives that clearly stated the government's expectations. Previously accepted specifications and data requirements were reviewed and questioned, and only those necessary to describe the end product were adopted. The RFP eliminated much of the "how to's" in developing the engine. Next, to provide the desired flexibility, the RFP was structured to describe allowable ranges in performance and weight. This permitted the contractor teams to conduct trade-off studies and make engineering choices that would result in the optimum product at the lowest overall cost (development, production, and O&S).

A limited number of characteristics were retained as untradeable requirements. They dealt primarily with meeting schedules, reliability targets, and production competition goals.

Industry had two opportunities to review the draft RFPs and provide comments to improve the final document. The understanding between the government and the potential contractors was well articulated and coordinated in the draft RFPs and in preliminary meetings. Without these, it would have been far more difficult to instill the concepts of the T800 acquisition strategy.

Once the final RFP was released and proposals solicited from the three contractor teams, each had one more opportunity to influence the program. Each team's proposal contained an engine system specification that included minimum RFP requirements, or if desired by the team, more stringent requirements than the minimum RFP requirements.

Source Selection and the FSD Contract

Proposals from the three competing engine teams were evaluated and two teams were awarded FSD contracts in 1985. The three teams' proposals, program plans, and engine system specifications were evaluated in five areas: technical; reliability and maintainability (RAM)/integrated logistics support (ILS)/manpower personnel integration (MANPRINT); production competition; cost; and management. The three teams knew before submitting their proposals how each area was to be weighted for evaluation.

Once the source selection was made, the loser and winners were debriefed. Each team was apprised of its strengths and weaknesses. Specifically included in these debriefs were the areas, their weighting and elements to be used in the next (final) source selection.

The five year FSD contracts specified selecting one team approximately three years into the program to finish the engine development and to produce it for the government. The contracts also contained a clause stating the non-selected team's contract would be terminated. Termination liability was contractually limited to the government's contract price for the first three years, called the preliminary flight rating (PFR) phase, ending Oct 31, 1988.

To facilitate final source selection, the Army issued a Letter of Instruction (LOI) to both teams in March 1988. The purpose of this LOI was to realign the T800 engine acquisition with the refocused LHX program and to reiterate the selection criteria given to them three years ago. The major changes were a reduction from 10,000 engines to 5,000 engines (based on reduction of 4,500 to 2,100 LHX aircraft) and an extended development schedule for the LHX. These changes required and allowed the contractor teams to repropose their program.

Acquisition Strategy by Area

The final source selection had four areas of evaluation, versus the five of the original evaluation and selection. The four areas of evaluation, their elements and weighting are shown in Figure 3. The significant aspects of the competitive acquisition strategy are described below by each of the four areas.

Technical

The equal weighting of all areas of evaluation under the competitive acquisition strategy produced technical growth and development with up front emphasis placed on RAM, ILS, MANPRINT, cost, and producibility. Of significant importance was the fact that the Army would select the winning team based on how well they performed during the PFR phase. The engine would be selected on actual hardware and demonstrated performance, not a proposed design.

Although the technical requirements for the T800 engine were to be flexible, providing the engine industry much latitude, some specific requirements were included. As an example, lessons learned from the Army's most recent T700 program indicated an Army requirement for a removable integral particle separator was indeed a good requirement.

Significant test requirements were added to the RFP requiring early assessment by the contractors in areas of concern. These included: power turbine rotor droop, fuel system suction, preliminary icing, preliminary sand ingestion, inlet thermal distortion, gear resonance, and bearing endurance. These requirements were based on lessons learned from previous Army fielded aircraft programs.

LHX ▶ T800 ENGINE

WEIGHTING OF ELEMENTS IN EACH AREA

AREAS	TECHNICAL 25%	RAM/ILS/ MANPRINT 25%	PRODUCTION COMPETITION 25%	COST 25%
ELEMENTS	BASIC ENGRG DESIGN & DEV (40%)	RAM (40%)	END ITEM (33.33%)	RDTE (10%)
	SYSTEM TEST & EVALUATION (60%)	LOGISTICS (30%)	PARTS (33.33%)	PROCUREMENT (45%)
		MANPRINT (30%)	PRODUCIBILITY/ ENGINEERING & PLANNING (33.33%)	OPERATION & SUPPORT (45%)
	ORGANIZATION & MANAGEMENT (EVALUATED)	ORGANIZATION & MANAGEMENT (EVALUATED)	ORGANIZATION & MANAGEMENT (EVALUATED)	ORGANIZATION & MANAGEMENT (EVALUATED)

Figure 3.

In addition, new requirements such as electromagnetic interference, corrosion, multiple fuel, and fire protection were added to address multi-service usage, particularly U.S. Navy onboard ship compatibility.

Additionally, because of competition, significant test demonstrations were included in the PFR phase which in the past was normally a part of the later qualification phase.

RAM/ILS/MANPRINT

Equal weighting with other areas, the RAM guarantee, and the guaranteed O&S cost, resulted in significant design impact leading to simplification of maintenance, reduction in mean time to repair, and a reduction in the number of line replaceable units.

The Army's supportability requirements have resulted in reducing the number of bolt head sizes throughout the engine, using captive bolts and fasteners, and location and sizing of line replaceable units for easy removal. Actual maintainability demonstrations clearly indicate the two levels of maintenance (user and depot) can repair the engine by removal and replacement of faulty line replaceable units and engine modules. The user needs only six simple hand tools, and no peculiar tools or support equipment.

The production-configured T800 engine is required to meet specific RAM requirements during LHX initial fielding. If it doesn't pass this test, the contractor is required (at his cost) to redesign, retest and requalify the engine until it does pass. Moving this qualification test from the test cell to the airframe provides guaranteed RAM assurance in the actual operational environment. The RAM guarantee coupled with the guaranteed O&S cost places the burden on the contractor to insure a highly reliable engine.

The initial T800 Source Selection Evaluation Board was the first board to evaluate production competition as a separate area. Never before had the Army attempted to obtain long-term commitments to competition so early in a program.

The requirements and objectives of production competition efforts were to develop and maintain two prime sources capable of independently producing the T800, and to develop and maintain a vendor/supplier base which results in the establishment of two competitive sources for all parts of the engine.

Planning for production typically is accomplished after the design process is completed, making it difficult to make changes/improvements which would reduce production cost, and, as such, the government and contractor are burdened with a more costly design than is necessary. On the T800 program, with not-to-exceed (NTE) prices negotiated up front in development, it was apparent that early attention to producibility and production planning was required for the contractor to meet or better their NTE guarantees. As a result, the production and manufacturing engineers were included so as the design evolved, producibility and production considerations were integrated.

Quality program elements, which have been typically implemented during the initial phases of production and refined as production experience becomes available, have been integrated into the design and development phase of the T800. As a result of this early and concerted effort, hardware and program discrepancies have been identified and appropriate corrective action taken to reduce the potential for costly situations during production.

Specific program initiatives include establishment of a total quality management program to address development hardware, identification and control of flight safety parts, integration of a material deterioration prevention and control program, development of nondestructive test/inspection techniques and procedures, and software quality assurance occurring along with software development. These elements are expected to provide a high degree of cost savings/avoidance through better design and producibility analyses, clearer technical description of components and manufacturing techniques and requirements, and competitive sourcing.

The result is a design which is less costly to produce, a smoother transition into production and a better, less costly sustainment during the life cycle of the T800 engine.

Cost

The cost commitments were the key to binding together the other three areas. Low risk cost commitments can only be obtained during competition. The contract commitments to guaranteed design-to-cost and O&S prices provide the government the ability to accurately program funding requirements through the total life cycle of the engine. Additionally, competition forced the lowest price for each engine. The same holds true for the O&S cost. The cost avoidance provided by these guarantees in unprecedented.

Summary

Competition is the keystone to the T800 acquisition strategy. Three factors contributed to the success of this strategy: substantiated guaranteed NTE design-to-cost, O&S costs, and the equal weighting of all areas.

Finally, the Army, and more specifically DOD and Congress, must be willing to accept our share of responsibility. The success of this approach rests squarely with the government. The Army, DOD, and Congress must not allow the program to vacillate and change continuously. Failure of the government to keep its commitments (i.e., sufficient development or production funding, program slips/redirects, reduction in lot sizes or stretch out of procurements) would put the contractor in a very poor business posture.

The performance-oriented competitive acquisition strategy for the T800 provided the Army with the best engine (technical/performance competition), at the lowest price (production and cost competition), that is the easiest to maintain at the lowest operating costs (RAM/ILS/MANPRINT competition).

LTC ARNOLD E. "Sandy" WEAND is the assistant program manager (to the Light Helicopter Program manager) for the T800 engine. He graduated from the Florida State University, and has a graduate degree from Florida Institute of Technology in systems management.

An Independent Adviser to the Army: THE BAST

By Mark Bello

Introduction

Advice is not a rare commodity, especially in the nation's capitol. The value and usefulness of a specific piece of advice, however, are determined not by its availability, but rather by the quality of its contents.

The main criteria used to judge the quality of advice are the expertise, integrity, and objectivity of the members of an advisory body. High levels of each of these standards are reflected in the composition and activities of the Board on Army Science and Technology (BAST).

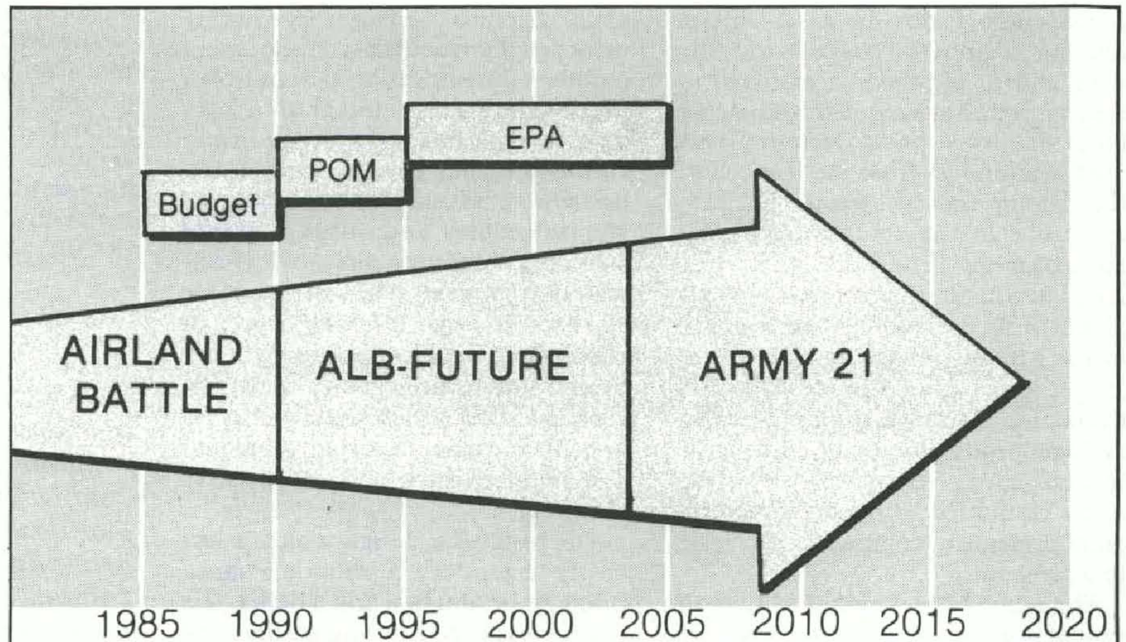
A unit of the National Research Council, the service arm of the National Academies of Science and Engineering and the Institute of Medicine, the BAST was formed in 1982 at the request of James R. Ambrose, recently retired under secretary of the Army. Since then, the independent board, whose members represent a broad range of scientific and engineering expertise, has been called on to study a variety of scientific, technological, and manpower issues confronting the Army.

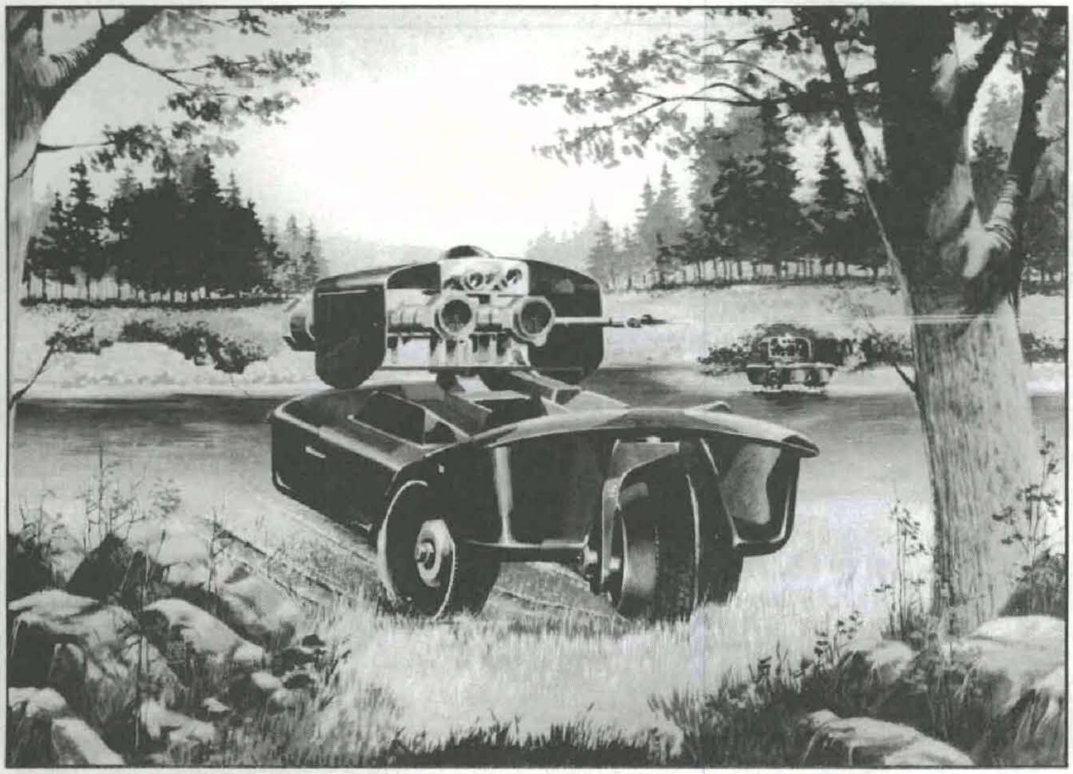
For example, the BAST completed a forecast of the Army's needs for scientists, engineers, and technical personnel through the end of the century; assessed the defense implications of increasing reliance on foreign suppliers of electronic components used in weapons systems; and evaluated the adequacy of the Army's research and development program on explosives, propellants, and other energetic materials. Ongoing studies include a continuing review of the congressionally mandated program to dispose of chemical stockpiles by 1994 and a far-reaching assessment that will forecast the strategic technologies critical to ground warfare in the 21st century.

Historical Overview

The BAST's parent organizations, the National Research Council and the National Academy of Sciences, were spawned, in part, by the exigencies of war. Congress created the academy

We need to think beyond the year 2000.





What will the Army look like in 2010? The Army of the future will have to rely increasingly on a superiority insight, skill and creativity to outwit its adversaries. The Army has tested two versions of a mobile, robotic antiarmor platform, one of which is illustrated here.

during the Civil War, specifying that the independent body "shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art . . ." Among the branches of the military, the Navy was the most frequent user of the new advisory body, whose membership consisted of the nation's leading scientists.

During World War I, the academy created the National Research Council to mobilize scientific and engineering talent in support of the war effort. Study committees formed by the council included not only academy members but others with vitally needed scientific and technological expertise. The arrangement worked so well that in 1918 President Woodrow Wilson issued an executive order that commended the research council for its success "in organizing research and in securing cooperation of military and civilian agencies in the solution of military problems" and perpetuated the advisory body's existence.

A little more than two decades later, the nation was again engaged in a global conflict, and the scores of government-requested studies conducted by research council committees helped guide crucial research and development efforts. Following the war, the research council was called on for advice on a broad array of scientific and technological issues, including those related to national security.

As this abbreviated history suggests, the research council has a long-standing and continuing record of service to the nation's military. During the last decade, but before the formation of the BAST, committees advised the Army on the U.S. machine-tool industry's ability to respond to a military mobilization, robotics applications, protective measures against toxic chemicals, the feeding of combat troops, and military clothing, including the redesign of the old pot-shaped helmet.

Formation of the BAST enhanced this productive relationship between the Army and the research council. By providing core support for the board, the Army maintains a permanent pool of outside expertise. BAST members, who currently number 12, are familiar with the Army's research and development programs, technology needs, and defense responsibilities. This understanding is especially valuable when untangling the complexities of modern defense issues.

Organizationally, the BAST is one of 19 standing boards and committees within the Commission on Engineering and Technical Systems, the research council component that addresses questions and issues related to applications of technology. David L. Bodde is the commission's executive director. Ralph D. Cooper is the director of the BAST, and Martin Goland, president of the Southwest Research Institute, is the board's chairman.

How the BAST Works

Members of the board are chosen on the basis of their expertise in science and technology areas — from materials and aeronautical engineering to communications and computer science — that are the key to the Army's missions and responsibilities. About half the members are from industry, and the other half are from academe.

What technologies will lead to the vehicles of the future?

Because of its affiliation with the National Academies of Science and Engineering, the BAST has access to the best intellectual talent in the nation. Election to the academies is one of the highest honors accorded a scientist or engineer. Seven board members are members of one of the academies. The other members, identified in extensive searches, are acknowledged experts in fields important to the Army.

Board members, who serve voluntarily, compensated only for travel and lodging, meet periodically with the under secretary of the Army, the assistant secretary of the Army for research, development, and acquisition, and their staffs. They also visit the Army's major research and development centers. Through this regular contact, the board is well versed on research initiatives and the major scientific and technological issues facing the Army. In turn, Army leadership learns how best to use the unique capabilities of the BAST.

Most BAST studies are undertaken at the request of the under secretary of the Army or the assistant secretary of the Army for research, development, and acquisition. The issues may be specific, like the ongoing review of chemical-disposal efforts, or general, like the board's 1987 survey of materials technology for the Army of the future. All are issues that are best studied by an impartial, credible body of outside experts, rather than groups of experts internal to a military department. Occasionally, the BAST independently initiates studies of issues it deems to be of major importance to Army decision makers.

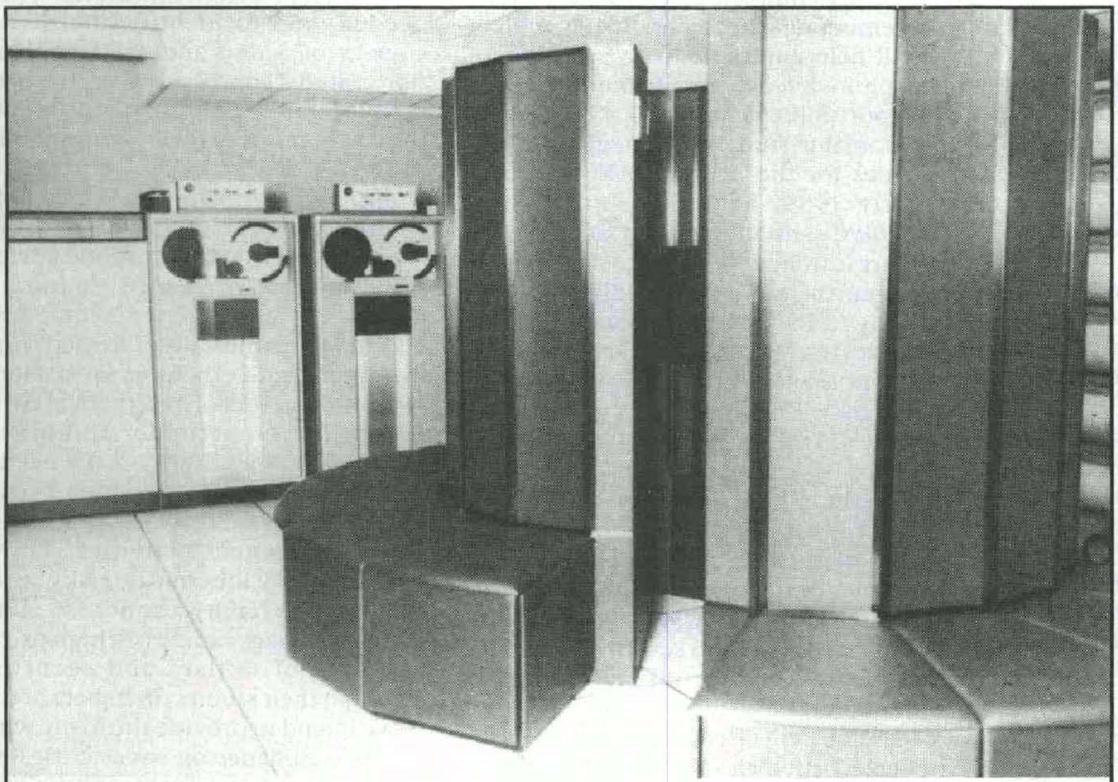
BAST studies draw not only on the expertise of board members, but also on others with knowledge and experience in areas essential to thorough, objective examination of an issue. While all matters that come before the board are related to technology, the dimensions of an issue may be quite broad, encompassing legal, economic, environmental, and social concerns. Experts in these areas also serve on study committees, and are identified with the assistance of other units in the research council and the Institute of Medicine, a sister organization of the academies. Collectively, these units are concerned with all fields of science, medicine and engineering. BAST's relationship with the more than 100 standing boards and committees of the research council links the Army to the nation's large civilian professional community.

Among these standing advisory boards are two sponsored by other branches of the military: the Air Force Studies Board and the Naval Studies Board.

Recent Studies

If the Army aims to increase its combat strength through technological superiority, ceding numerical advantages to potential adversaries, then that technology must be forthcoming. And it must be integrated into modern weapons systems — efficiently and on time.

Although the goal is straightforward in theory, the steps to achieving technological superiority are becoming increasingly complex. Cost concerns are but one complicating factor. Others include shortages of technical personnel, obstacles to technology transfer — whether from the Army's in-house laboratories, private industry,



The CRAY-2 Computer System

What will tomorrow's computer look like?

or universities — and the difficulties inherent in long-term planning of research and development efforts.

A major purpose of BAST studies is to identify research gaps and issues to suggest high-priority topics for the Army's research and development programs. These assessments may be comprehensive surveys of research and development efforts — inside and outside the Army — in a series of technology-related fields. Or, they may be focused on finding answers to problems in a specific area that Army leadership regards as especially critical.

An example of the latter is the board's classified study of U.S. and Soviet capabilities in the development and production of energetic materials. The BAST committee recommended steps that the Army could take to help ensure that conventional weapon systems exploit the best and most appropriate materials over the next two decades. Factors considered in the analysis included ballistics technology, vulnerability, safety, and availability. The committee concluded that the Soviet Union is making major investments in research and development and in large-scale production of explosives and propellants. In contrast, the committee found, the United States has lagged in developing the capability for commercial production of the next generation of energetic materials.

Another study zeroed in on the potential dangers of the Army's growing reliance on foreign-based manufacturers of electronic components. Current trends, it predicted, suggest that these critical foreign-built parts could soon account for half the cost of weapons systems. The study warned of the Army's increasing vulnerability to supply disruptions, a warning echoed in subsequent reports by the Defense Science Board and other bodies. It also recommended steps to ensure a domestic capability for the manufacture of semiconductors and other electronic devices.

Other recent studies advised the Army on measures to assure the timely, cost-effective development of high performance materials, and reviewed the Tactical Explosive System program, a contemplated component of a barrier system to impede the movements of enemy armored vehicles. In a three-part study now in its last phase, an existing committee is conducting an extensive evaluation of the Army's methodology for estimating combat damage to vehicles and equipment, as well as human casualties. It recommended a new approach for estimating vulnerability in combat, which was tested in 1988.

Current Activities

On average, the BAST undertakes about three studies a year. In addition to two projects already mentioned — the evaluation of the Army's methods of assessing the vulnerability of combat vehicles and the review of chemical-disposal program — it is reviewing the technical programs of the Chemical Research, Development, and Engi-

Strategic Technologies for the Army (STAR)

The Army leadership is becoming increasingly aware of the importance of advanced technologies in effectively equipping, training and supporting the Army of the future. The use of warfighting skills and superior technology to offset the numerical advantage of potential adversaries has become a fundamental concept in U.S. Defense planning. In response to this challenge, I have requested the Board on Army Science and Technology (BAST) to conduct a two-year study looking at Strategic Technologies for the Army (STAR). The thrust of this major effort is: (1) to identify the advanced technologies most likely to be important to ground warfare in the 21st Century; (2) to offer technological strategies that the Army should consider in developing their full potential; and (3) to support, where possible, the implications for force structure modernization and strategy.

The Chief Scientist of the U.S. Army Materiel Command, Dr. Richard Chait, will be the Army's point of contact for this effort. Your support to this study is critical to the long term direction and success of the Army's technology programs.

J. R. Sculley
Assistant Secretary of the Army (Research, Development and Acquisition)

neering Center at Aberdeen Proving Ground, MD. In a board-initiated study approved by the Army, a committee recently completed a classified review of emerging space technologies, which will help guide the Army's efforts to exploit defense and communication opportunities in space.

A major study on strategic technologies for the Army (STAR) began in early 1989. Requested by Dr. J.R. Sculley, assistant secretary of the Army for research, development, and acquisition, the STAR study will assist the Army in its long-range planning. It is surveying all areas of science and technology that have the potential to enhance the Army's fighting capabilities in the 21st century. The primary focus, however, is on fields especially relevant to four Army missions: materiel, military engineering, personnel, and medical. Supported by panels concentrating on specific fields, such as logistics, materials and structures, and electronics and sensors, the study committee will identify technologies that offer the greatest opportunities to increase field effectiveness. It will also suggest strategies for achieving these opportunities and project the implications of anticipated technologies on force structure and strategy. Such information can guide resource allocations in current budgets and help assure timely planning and programming decisions.

Still in the early stages, the study is being planned with senior Army advisers. Military and civilian personnel will support the committee's efforts through briefings and other informational activities. The study is expected to take two years.

The Role of Advice

Like all units of the research council, the BAST highly prizes its role as an objective, credible source of advice. Familiarity with Army operations and the issues and problems unique to the Army's national security duties help assure that BAST reports are useful to Army decision makers. This familiarity, however, does not compromise the board's activities. Objectivity and the BAST's high level of expertise are the primary assets that the board offers the Army. The board has the responsibility to be critical when it identifies weaknesses.

Indeed, past studies have highlighted areas in need of improvement. But the board also has the obligation to recommend corrective measures, when needed, and to identify alternative courses of action and their implications. Study conclusions and recommendations are the main products the Army receives for its sponsorship of the BAST.

Although the Army is in the sole position to judge the utility of BAST studies, the importance of good advice is indisputable, particularly in today's complex defense environment. Some current issues must be addressed from many perspectives before a satisfactory solution emerges. Then there are the issues that come under the broad heading of "the future" — the needs, responsibilities, and opportunities that must be anticipated in today's research and development activities. These activities are inherently risky and, though uncertainty cannot be eliminated, mistakes can carry a high price, in terms of dollars and security. Through their studies, members of the BAST intend to provide the Army with valuable guidance on issues critical to the success of its important mission.

MARK BELLO is a science writer and editor based in Alexandria, VA. He has assisted in the preparation of several National Research Council reports and is currently working on a book for the Smithsonian Institute.

WINNING DIGITAL MICROCIRCUIT OBSOLESCENCE WARS WITH VHSIC TECHNOLOGY

By S. L. Everett Jr.

Introduction

Recent experiences with procuring spare digital circuit card assemblies for the Communications Terminal (CT) AN/UGC-74A, a digit-service CECOM-managed fielded item, have surfaced significant digital microcircuit availability problems. The severity of these problems with respect to maintaining fielded tactical military communications equipment is critical. Prompt, efficient maintenance support of tactical communications terminals deployed throughout the world, often in areas of intense active conflict, is essential. Digital microcircuit unavailability is not of course limited to the CT AN/UGC-74 equipment. Any tactical communication equipment utilizing digital microcircuits will sooner or later face this same dilemma. Although the following discussion will use the CT AN/UGC-74 as an example, other equipment could certainly benefit from the basic approach delineated here. This basic approach offers a reasonable course of action not only to resolve the component availability problem for a considerable period of time, but further to accomplish same with substantial life cycle cost savings.

The Problem

The problem stems from today's continuous technology-based progress in the realm of integrated circuit design/microprocessor system evolution and the fact that digital microcircuit component fabrication is most cost effective in very high volume production. It is aggravated by the highly competitive commercial world's large volume users who need constant change and improvement for survival.

Design of commercial electronic equipment utilizing digital microcircuits typically tends to change on a yearly basis. Further, long-term support of commercial devices is not particularly critical. Indeed, greater profits are often obtained by the periodic selling of "improved" models in lieu of repairing existing inventory, (i.e. planned obsolescence).

Conversely, a period of 10 years or more may be expected to pass between completion of a tactical military communication equipment design and that time at which world-wide fielding is completed. Such is the case for the CT AN/UGC-74. The design of the digital electronic control system of this terminal is based upon use of mid-1970s transistor-transistor logic (TTL) microelectronic components. Fielding of the CT AN/UGC-74A (CT with multiple hammer drum printer) was incrementally accomplished commencing in 1980 and completed in early 1988. The CT AN/UGC-74BA (CT with dot matrix printer and expanded functional capabilities) and CT AN/UGC-74C (CT with all CT AN/UGC-74B features, plus removable media auxiliary memory and local area net relay capability) are currently in production. Fielding of these models, which will completely replace the CT AN/UGC-74A model via retrofit modification action within the next few years, is planned to commence in early CY 1989.

All three models share the same mid-1970 vintage microelectronic control system components. The useful life expectancy of these terminals is planned to extend well beyond the year 2000, more than 30 years from the design year of the microelectronic components used therein.

Clearly, the commercial and military worlds hold vastly different viewpoints in the area of electronic equipment longevity and maintenance support philosophy. Whereas, the high volume commercial market can enjoy implementation of frequent design changes affecting digital microcircuit types with little economic penalty; long life cycle, low volume users, such as the military, are adversely affected. Due to shared resources and capacity, it is impractical for a manufacturer to continue microelectronic component production just for the military. Consequently, cost effective long-term equipment supportability concerns, so critical to the tactical military world, are not readily shared by the commercial world.

The Conflict

The conflict arises when a single obsolete microcircuit device fails on a circuit card assembly (CCA) used in the terminal. Although the CCA may contain a large number of other yet available microcircuits, the entire CCA becomes useless unless a direct substitution can be found for the failed component. Unfortunately, digital microelectronic component evolution often involves change in technology base, collocated operational functions, timing characteristics, pinout function locations and package form parameters. Consequently, even new so-called "direct replacement" devices, when they can be found, may not be usable without first requiring some change of the CCA's design.

Severe military environmental requirements imposed upon tactical communication equipment further magnify the problem by complicating corrective CCA redesign action implementation. Two choices exist, assuming that continued use and support of the end item equipment is required. First, the CCA, utilizing the obsolete component, can be removed from service and its parts cannibalized to support those remaining. Second, the CCA can be redesigned to accept currently available components.

To date, both choices have been exercised in order to support the CT AN/UGC-74A. First, the 1 X 4K Dynamic Random Access Memory (DRAM) and masked Read Only Memory (ROM) microcircuits used on the CT AN/UGC-74's Central Processor Unit (CPU) and Memory CCAs are no longer available. Cannibalization is presently used to supplement the severely dwindling stock of these components for CCA repair.

Second, a "new" design Universal Central Processor Unit (UCPU) CCA is now in production which replaces the CT AN/UGC-74A's CPU and Memory CCA. The UCPU CCA was designed in 1984 for the CT CAN/UGC-74B/C models and configured to be downward compatible for CT AN/UGC-74A use to circumvent the then forseen DRAM and ROM microcircuit unavailability problem. However, to minimize design effort and maintain compatibility with the existing CT AN/UGC-74A embedded operating system, the 1970s vintage microprocessor and support logic family were retained in the "new" design.

An additional component, the Universal Synchronous/Asynchronous Receive/Transmit (USART) microcircuit used on the CT AN/UGC-74A Communication (COMMO) CCA has since become unobtainable in 1988. Its updated "direct replacement" microcircuit will not function in the CT AN/UGC-74A COMMO CCA due to sensitivity and timing incompatibilities, e.g. less input loading, more output drive, shorter minimum propagation delays, different dynamic crosstalk and ground-bounce characteristics.

Those CT AN/UGC-74A COMMO CCAs requiring use of the replacement USART have been modified to accept them via installation of multiple foil cuts and jumper wires. Each CCA design iteration necessitates complete functional and environmental testing of all affected areas, update of the automatic testing capability for CCA repair, new component stockage throughout world-wide supply points and rewrite of all pertinent sections of the terminal's numerous technical manuals.

Experience dictates it to be a certainty that an increasing number of the digital microcircuits used in the CT AN/UGC-74 will become unavailable beginning in the early 1990s due to their commercial world obsolescence. Piecemeal modification of circuit card assemblies each time one of the hundreds of digital microcircuits used thereon becomes obsolete is prohibitive in terms of both time and money.

Forced loss of availability of tactical military communication equipment is totally unacceptable. Complete replacement of the existing fielded tactical communication terminals with another type would not only be extremely costly, but would actually compound the problem by adding a whole new set of electronic, electrical and mechanical components to be procured and stocked around the world to maintain and support the new terminal.

The Battle Plan

There is a viable course of action to fight the digital microcircuit obsolescence problem which threatens the longevity of existing, fielded tactical communication equipment. It consists of establishing a direct redesign attack to update the equipment's digital control circuit card assemblies using components of assured availability. The weapon is intelligent technology insertion. The redesign implementation schedule timing will dictate whether the battle will be won or lost.

The CT AN/UGC-74B model's internal control system is comprised of three plug-in digital CCAs containing two embedded microprocessor systems with approximately 150 discrete microelectronic components. The CT AN/UGC-74C model's internal control system utilizes two additional CCAs. These contain another embedded microprocessor system with approximately 50 discrete microelectronic components. The plan is to design a current technology direct plug-in replacement circuit card set using components with assured availability for a considerable number of future years.

The Attack

Enter Very High Speed Integrated Circuit (VHSIC) technology. The VHSIC program was initiated by the Department of Defense (DOD) in 1980 to develop a family of advanced microelectronic circuits to satisfy current and future military system needs. Each VHSIC circuit was designed to meet specific system applications, (e.g. radar, sonar, communications signal processing) and military environmental requirements. During the 1985-88 time frame,multi-sourced VHSIC components have become available.

In general, VHSIC technology components offer many obvious advantages such as high speed processing, lower power consumption, increased reliability, decreased size, decreased weight, etc. A not so obvious benefit is that the overall VHSIC technology component development exercise has inherently resulted in creation of a long-lived family of digital microcircuits via establishment of standardized package configurations and manufacturing techniques.

Further, the VHSIC design can be documented via use of the VHSIC Hardware Description Language (VHDL) which will serve to ease execution/implementation of any future enhancements which may be desired.

In 1986, the U.S. Army Communications Electronics Command (CECOM), Fort Monmouth, NJ, via contract with TRW Electronic Systems Group, Redondo Beach, CA, examined CECOM tactical communication equipment which could benefit from VHSIC technology insertion. The CT AN/UGC-74B/C was identified as one item which could realize significant gains in extended equipment life, lower power consumption, increased reliability and potential life cycle cost savings. It was ascertained that VHSIC technology "gate arrays" could be used to replace the terminal's numerous discrete dual in-line package (DIP) microelectronic operational control components.

VHSIC gate array devices presently exist and are available from multiple sources. No specific VHSIC device development is required for the CT AN/UGC-74 application. Only the functions now performed by the control microelectronic components will have to be translated into the VHSIC gate array implementation.

A value engineering cost analysis delineating the savings to be realized by introducing VHSIC CCA Control Sets into the CT AN/UGC-74B/C as replacement spares for the current technology CCAs was recently completed. The analysis considered only those life cycle savings derived from reduced spare component procurement and inventory cost factors for support of a CT AN/UGC-74B population of 13,000 and CT AN/UGC-74C population of 1,500. Saving estimates were scaled from actual costs established through support of similar CCAs used in the CT AN/UGC-74A. The analysis concluded that savings would exceed $30 million over a 15 year period.

Winning

Effective creation and implementation of the VHSIC CCA design in a timely manner is crucial to winning the war against microcircuit obsolescence. The design of the CCA set must be established and readied for production before critical equipment spare shortages surface. This process will typically require between two and four years to complete. It therefore becomes critical that the appropriate planning and funding actions be taken at the earliest possible time in order to avoid a time interval when the fielded tactical equipment can no longer be supported.

Emergence of such a period of unsupportability equates to losing the immediate battle and if extended via procurement/contractual delays, losing the entire war. Use of existing fielded equipment, representing an investment of hundreds of millions of dollars, could be denied due to obsolescence of a $2.00 digital microelectronic component.

The CT AN/UGC-74A has already received multiple attacks which have been repelled via a series of essentially piecemeal redesign efforts. These early battles were not lost only because the CCA set was upgraded as part of the dot matrix printer/expanded operational capabilities product improvement actions.

The winning strategy is clear. First, plan ahead. Assume a minimum of three years will be necessary to solicit proposals, award a contract to build/test production prototype models and provide detailed production drawings to permit competitive procurement of VHSIC CCAs. Upon successful completion of the production prototype effort, subsequent competitive contracts can be let as required to provide the necessary production spares. Production spare CCAs will typically be available in approximately 12 to 18 months from initiation of the production procurement process.

Secondly, secure funds. Provide for funds to support the planned effort. Either the fielded equipment is to be supported for X number of years or not.

Finally, the production prototype effort must require use of components which are manufactured by multiple sources and are based upon a technology which is finding an increased market. VHSIC technology gate arrays meet these requirements. VHDL should be used to document the design to assure its future transportability.

Conclusion

The only thing constant in the realm of technology is that it will constantly change. The commercial world tends to follow technological changes fairly closely; whereas, required military communication functions are inherently slow to change.

Fortunately, the same military communication functions can be satisfied via different technology implementations. As in the CT AN/UGC-74 example, VHSIC technology components in concert with a VHDL documented design can not only save a widely used, multi-service tactical item from premature obsolescence, but can be implemented at a considerable (millions of dollars) cost savings.

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REVITALIZING SOLDERING TECHNOLOGY

By Paul F. Case

"No one talks about soldering, they take it for granted," says Seymour J. Lorber. "Yet it's the glue that holds everything together." The basic soldering joint, he goes on, can make or break the reliability and producibility of military electrical/electronic equipment.

Sy Lorber should know. Since January 1987 the deputy chief of staff for product assurance and testing at the Army Materiel Command (AMC) has been behind an intensive effort to revitalize the Army's soldering technology, training, and certification program.

Motivating him is the knowledge that a new set of soldering standards, DOD-STD-2000, is in place within the Department of Defense. The result of joint DOD-industry efforts, these documents standardize requirements imposed upon contractors.

The Army currently has three soldering schools, located at Picatinny Arsenal, NJ; Fort Monmouth, NJ; and Redstone Arsenal, AL. The schools turn out more than 600 graduates a year, mostly contractor soldering instructor personnel. But Sy Lorber knew that the facilities, equipment, and programs of instruction at these schools differed greatly in content and uniformity of instruction.

Donald E. Shoemaker, a senior quality manager at the U.S. Army Laboratory Command (LABCOM), was named chairman of a Soldering School Assessment Board committee charged to make an in-depth review of the schools' total operations. Within months, the committee had developed a set of minimum requirements for the training and certification of government and industry personnel, and had come up with a detailed program of instruction. To meet these requirements, school managers renovated their facilities, bought state-of-the-art soldering equipment, and increased the number of instructors.

Comments Lorber: "Soldering school uniformity has ended many years of dispute and frustration, and represents a major step forward in the Army soldering community." He credited Shoemaker's "honest broker" contributions for the Army's "vastly improved" training certification program.

In July 1987, Shoemaker was appointed Army representative to the DOD-STD-2000 Ad Hoc Implementation Group and the DOD Certification Board that were chartered to develop comparable training facilities and standardized curricula for all the services and industry . The Navy runs soldering schools at the Naval Weapons Center in China Lake, CA, and at the Naval Avionics Center in Indianapolis, IN, turning out three times the number of graduates as the Army by running double shifts. The board adopted the Army's recently developed program as a baseline.

After much travel, lively and extended technical sessions, and a lot of team work, the board orchestrated a standardized training program. The program ensures that the services will use a single requirements document for soldering military hardware and put it in contracts to achieve a common industrial base.

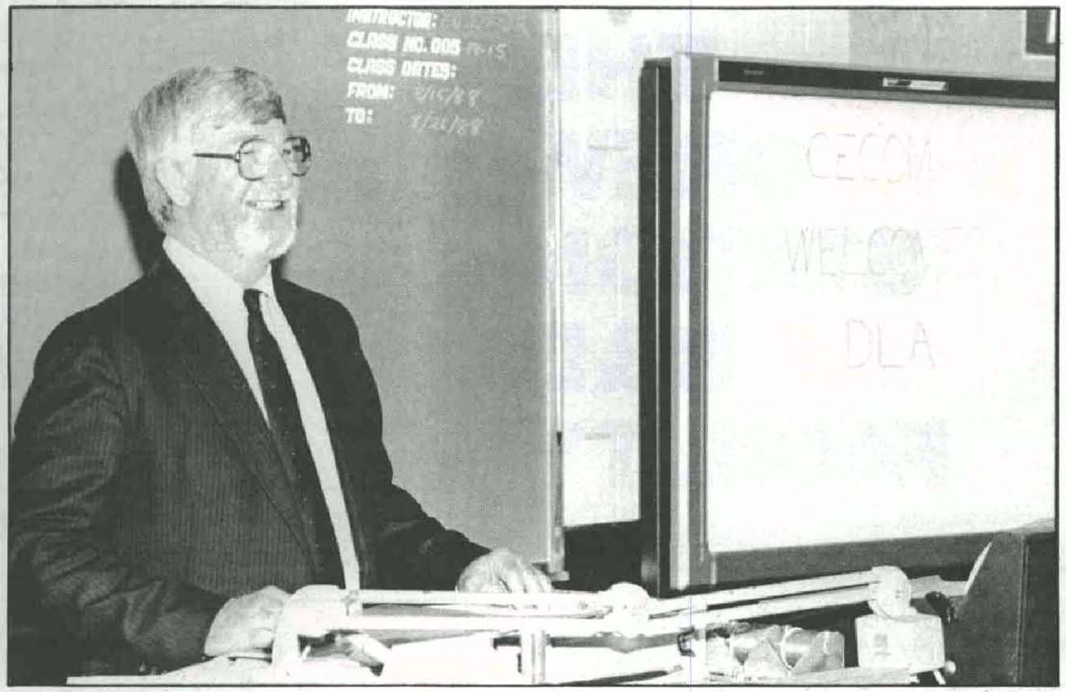
By February 1988, formal training had begun in accordance with DOD lesson plans and the three Army schools became the first service schools to be approved by the DOD-STD-2000 Certification Board.

The board has also provided the lead in:

- developing a generic DOD-STD-2000 series training plan,
- establishing a DOD-STD-2000 transitional/conversion soldering course for individuals recently trained and certified to Army and Navy soldering requirements, and
- supporting the services' efforts to publish their policy relative to implementation of DOD-STD-2000 series soldering requirements in contract programs.

In August 1988, top soldering experts and instructors from the Defense Logistics Agency's (DLA) nine Contract Administration Service regions took an 80-hour class at the Army's Fort Monmouth school. Their goal was to standardize the government's approach in determining contractors' compliance with soldering processes and inspections in the plant.

The next critical step, says Shoemaker, will be to incorporate standard soldering requirements on a commodity basis in service contracts. "Up to now," he explains, "contractors have had to set up different and specialty



Senior Quality Manager Donald E. Shoemaker of the U.S. Army Laboratory Command welcomes soldering experts and instructors to an 80-hour class at the Army's soldering school at Fort Monmouth, NJ.

soldering production processes to satisfy the many and varying soldering requirements contractually imposed by the services for the same or similar type products. While standardization of training facilities and curricula alone will not solve this problem, at least it's a start in the right direction."

Today, three working groups of a tri-service and industry initiative are addressing issues relative to the DOD-STD-2000 series requirements with a goal of reducing the 100 percent visual inspection requirements.

One group is examining process control methods and techniques. A second is assessing acceptance criteria relative to product performance. The third is reviewing 32 technical issues submitted by industry as concerns. Technological projects now underway include automated infrared and x-ray solder joint inspection measurements and how to support surface-mounted technology in the DOD-STD-2000 series.

"We want to increase the reliability of hardware and reduce 100 percent visual inspection of soldering joints," says Sy Lorber. "We are restructuring DOD-STD-2000. We're trying to get a standard that is doable. We can't afford to wait until all the problems are solved. There will be continuous changes."

He concludes: "It's a massive challenge to get the three services and industry together. There is an excellent working relationship between the Army, Air Force, Navy, and DLA. We've invited industry to propose methods and techniques to incorporate process controls into the way they do soldering business. They have responded in an outstanding manner. What I see today is a very aggressive effort to reach our goals and go beyond them."

That's a lot of effort for a technology that people take for granted.

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THE CREW STATION R&D FACILITY

By Major James W. Voorhees, Dr. Nancy M. Bucher, Terrence Gossett, and CPT(P) Loran A. Haworth

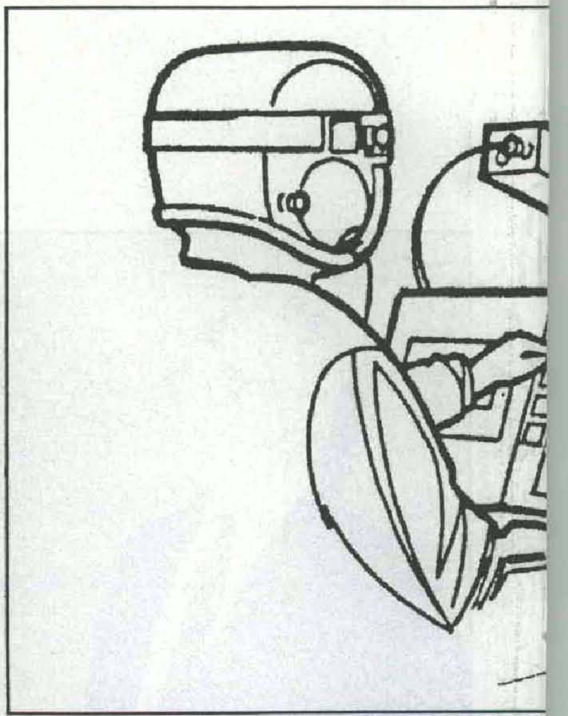
As stated very clearly in "Simulation Networking: A MANPRINT Tool" (Black and Quinkert, *Army RD&A Bulletin*, November/December 1987), simulating before building is a vital part of a successful MANPRINT program for an emerging Army system.

In May of 1985, the U.S. Army Aviation Systems Command (AVSCOM) requested the Army Aeroflightdynamics Directorate and NASA's Directorate of Aerospace Systems to form a special team to address the man-machine integration issues (now a major component of the MANPRINT program) pertaining to the next generation of light scout/attack helicopters via an advanced R&D simulation facility.

Current and projected threat estimates increase the battlefield demands on the operational capabilities of new and existent rotorcraft and the pilots that operate them. These demands mandate new approaches to helicopter design. Higher levels of technology are needed in the Army's new helicopters to meet the emerging threat.

The resulting risks and higher costs that are associated with such applications of advanced technologies dictate the need for appropriately advanced tools for evaluating candidate systems in the area of MANPRINT, with the pilot in the loop, before a full scale engineering development contract is awarded to industry. The Crew Station Research and Development Facility (CSRDF) is just such an advanced tool for dealing with the man-machine integration MANPRINT issues.

The Army/NASA Team began the Crew Station R&D Facility Program with a "blank sheet of paper" and delivered to the Army, in less than two years, the most advanced and flexible simulation facility in the government, a project that could be expected to take four to five years to complete.



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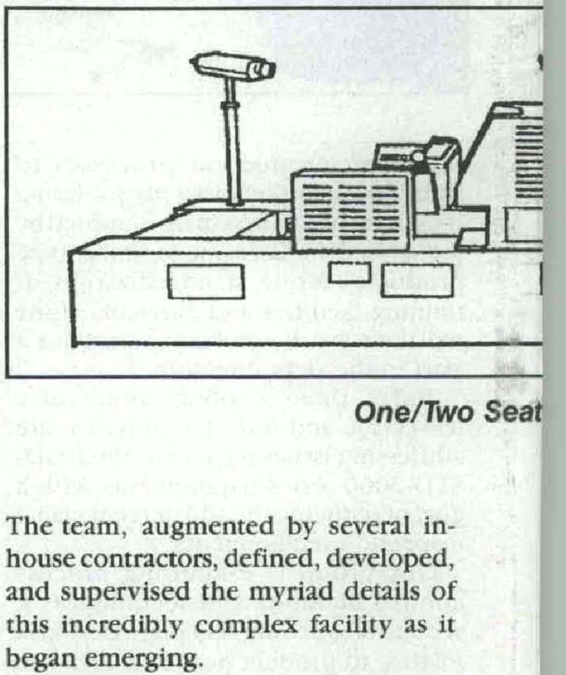
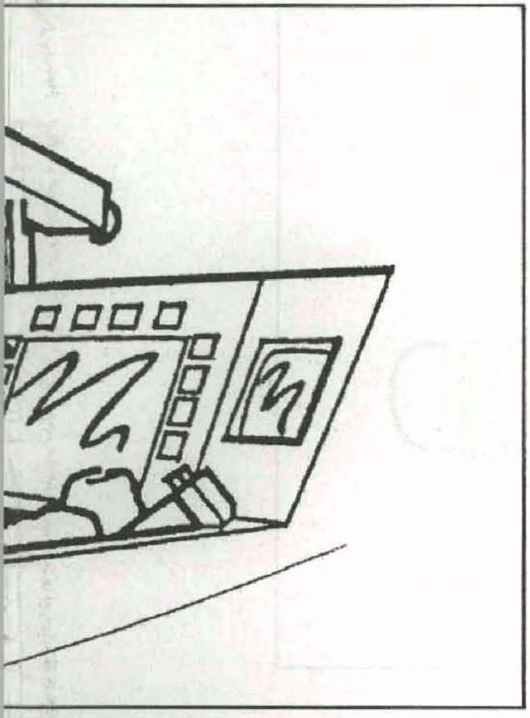


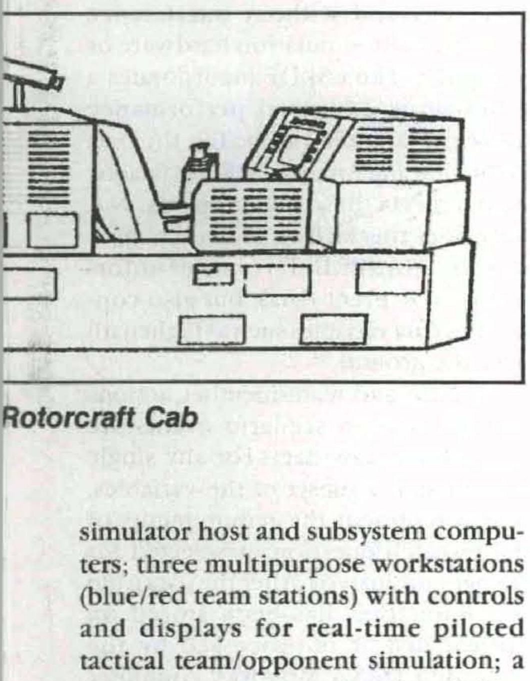
One/Two Seat

The team, augmented by several in-house contractors, defined, developed, and supervised the myriad details of this incredibly complex facility as it began emerging.

The facility, located at the Aeroflightdynamics Directorate, Ames Research Center, includes the following features: Fixed-base, CRT-based, all digital crew stations in a one/two seat rotorcraft cab for single or dual-crew operation; an advanced visual imagery system displayed on a fiber optic wide field-of-view Helmet Mounted Display (HMD); A Digital Equipment Corp. VAX-based



able Cockpit



Rotorcraft Cab

simulator host and subsystem computers; three multipurpose workstations (blue/red team stations) with controls and displays for real-time piloted tactical team/opponent simulation; a communications workstation (white station) for on-line verbal and data link interaction with the crew station representing up to 10 message senders or recipients; and an experimenter/operator console for controlling the simulation and introducing variables of interest during the simulation.

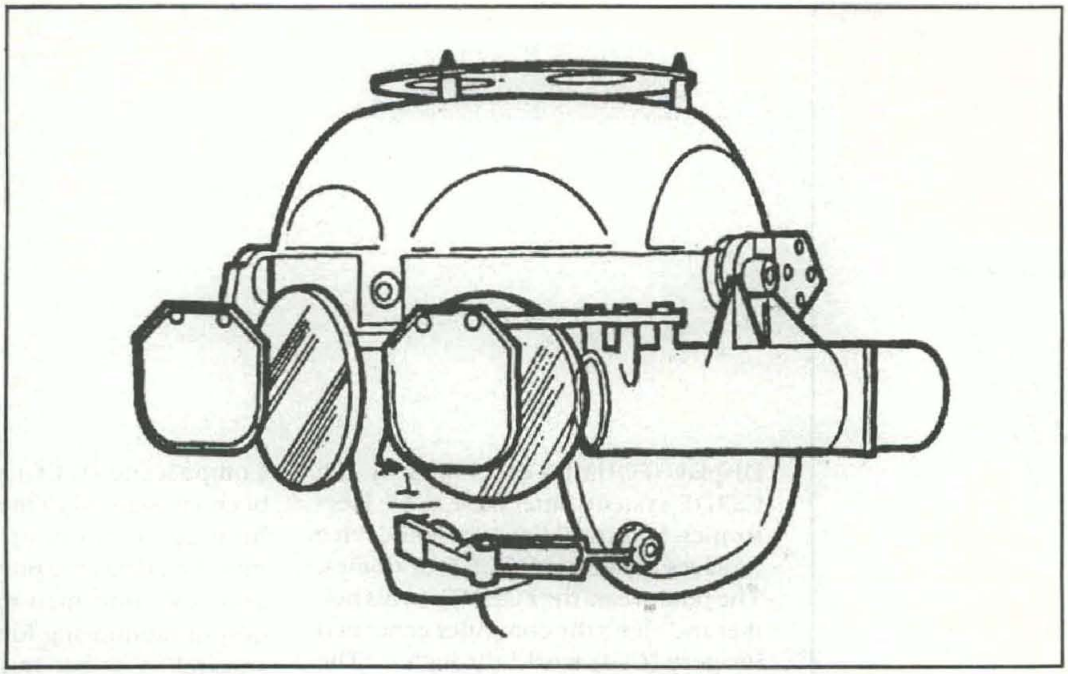
One of the key features of the facility is the Fiber Optic Helmet Mounted Display (FOHMD) developed by the CSRDF systems integrator, CAE Electronics, Montreal, Canada. This device replaces conventional CRTs or domes. The pilot wears the FOHMD on his helmet and views the computer generated imagery (CGI) world through it. The instantaneous field of view is 120 degrees horizontal by 67 degrees vertical. The available field of regard is unlimited since the pilot wears a head tracker that "aims" the field of view where he looks. This type of display device is mandatory for such missions as helicopter air-to-air combat where field of view and field of regard are critical. The FOHMD offers high resolution (up to 1.4 arc minutes per TV line) and the capability for full color and stereo viewing.

Flexibility has been a primary driver throughout the development of the CSRDF. Accordingly, many of the features of the system are accessible and modifiable through the use of editors. The display pages on the CRTs, the programmable push buttons, the voice recognition system, the speech synthesis system, and many other features of the combat mission scenario (CMS) have separate editors. These editors allow the researcher to edit the pilot-cockpit interface systems directly, rather than being limited to indirect interaction via a systems programmer. This feature is expected greatly improve turnaround between simulations, while freeing systems level programmers for more appropriate duties.

The CSRDF provides for visual and adverse weather out-the-window imagery, forward looking infrared, or day TV via a General Electric CompuScene IV CGI system that has been configured to meet the needs of helicopter team operations. The modified data base provides flexibility and real-time man-machine input/output monitoring for human factors research. Combat mission realism is provided via an automated multi-government agency composite combat mission scenario which interacts with the main flight simulation system.

The CMS was derived from the Army's Helicopter Air Combat Effectiveness Simulation which, after translation by Tracor Flight Systems, Inc. of Santa Ana, CA, into a real-time computer program, interacts on-the-fly with the main simulator control program. The purpose of the CMS is to provide the computer simulation with kinematics and probability of kill models. Accordingly, the CMS handles simulations with varying mixes of up to 11 helicopters, 99 threats, 20 moving targets, and six aggressor helicopters. The CMS also provides for simulation of operations which employ air-to-air and Hellfire missiles, laser trackers, a 20mm gun, and countermeasures such as chaff, flares, and IR and RF jammers.

Crew station operations simulate real-world Scout/Attack (SCAT) Team missions to the extent that all actual-mission-support elements external to a combat SCAT aircraft play real-time integral roles in the simulation scenario. For example, ground communications and control will be simulated, and several other simulation support crew members will interactively act out "blue" (friendly) and "red" (aggressor) roles to add realism.



Fiber Optic HMD

Ten channels of radio and data link communications are provided in addition to the multiple team members. Each channel is equipped with voice alteration software (to allow one operator to simulate 10 different speakers) as well as background transmission tapes to put other communications on each frequency.

The CSRDF, as the name implies, is a research simulator facility, rather than a facility to be used for training simulation. Although these two types of simulation facilities share many characteristics, research simulators are different in that they require much more configuration flexibility and a more robust performance measurement system. A research simulator also requires user friendly editors that can be used by the researchers for modifications to many of the software systems. For these reasons, the host computer for a research system is normally much more powerful and flexible than the computer systems used for training simulators.

Prior to the completion of the CSRDF, the Army did not have a research simulation facility for advanced aviation MANPRINT issues that was oriented toward emerging rotorcraft. For the reasons listed above it was impossible to purchase an "off-the-shelf" training simulator and modify it to conduct the required research. A configuration for a highly advanced research simulation facility had to be designed, developed, and implemented from inception to completion by the CSRDF Team.

Research activities planned for the next three years include single-and multi- member variations in crew complement, including associated optional approaches to cockpit controls and displays, and distributions of crew member responsibilities, night/ adverse weather pilotage, command and control issues, air- to-air combat, and cockpit automation requirements. Full combat mission flight operations of entire Scout/Attack (SCAT) Teams are simulated and analyzed for both projected and existent vehicles, threats, and missions, in both full up and degraded mode operations.

A well designed performance measurement capability is a critically important feature of a research simulator complex. Specification of the variables to collect, the formation of these variables into a usable data base, and the subsequent analysis of this data base must be accomplished quickly, accurately and without interference with the main simulation hardware or computer. The CSRDF incorporates a stand-alone advanced performance measuring and analysis facility, the Data Reduction and Analysis (DR&A) facility, which meets these requirements. Not only does this facility provide human factors (MANPRINT) type of information (i.e. event data), but also continuous data variables such as flight path over the ground.

All pilot and team-member actions and all mission scenario events are accessible as raw data. For any single experiment, a subset of the variables, which represent the requirements of the research question, is selected for storage and analysis. After the data from the simulation has been stored on optical disk it is processed by the dedicated DR&A MicroVax computer into a relational data base and is available simultaneously to multiple experimenters via links to their individual PC type computers for more detailed analysis through a series of intelligent queries. An example of one such query would be for the experimenter to get the information on the number of times that one of the friendly aircraft was acquired by an SA-8 that was within 40 degrees either side of the aircraft's nose, and less than 5,000 meters away.

The objective for CSRDF simulations and follow-up data analyses is to provide a level of completeness and fidelity of human-factors/man-machine interface-effectiveness information heretofore unavailable. Even actual flight research cannot provide such data because of the lack of experimental control. Research at the CSRDF will also support the Army aviation acquisition process through design prototype development, system evaluations, and accident investigations.

Initial flight simulations are being conducted with a computer modeled research vehicle, named "LHA (Light Helicopter Attack)." The advanced-design LHA configuration has been created in collaboration with other Army organizations as a synthesis of advanced digital cockpits and systems concepts yet to be flown, excerpted from numerous sources, including LHX Program specifications, advanced rotorcraft technology integration program reports, and other Army operational agency documents.

LHA will be operationally as well as technologically generic. This generic aspect is achieved by configuring the LHA based on a composite view of user operational requirements and proposed solutions. Accordingly, built-in flexibility is stressed in the LHA design — thereby enabling the configuration of the modeled vehicle to be readily changed as research proceeds and concepts evolve.

The cockpit of the LHA simulated aircraft provides for integrated crew member interactions with the full range of controls and displays actually associated with basic flight and the full SCAT mission. This includes simulation of all advanced digital systems for cockpit and battle resource management, manual and auto flight controls, navigation, communications, target engagement, and aircraft survivability equipment.

The CSRDF represents an advanced technology aviation simulation research facility for the Army. Even if the emerging threat forecast did not demand answers to the MANPRINT issues concerning the pilot interface, a facility like CSRDF would be needed in order to examine concepts which represent technological challenges. Examples of technological challenges that require advanced man-machine MANPRINT applications research include: helmet-mounted displays; voice recognition/cockpit control systems; multi-sensor fusion systems; pilot associate systems; advanced mission planning; automatic "fire-flight" systems (i.e. integrated target engagement/automatic flight control systems); automatic nap-of-the-earth flight control systems; and fully-integrated avionics system packages. These advances in technology must be investigated in the context of a full mission simulation before they are incorporated into a fielded system.

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CPT(P) LORAN A. HAWORTH is an experimental/engineering test pilot. He was assigned to the Aeroflightdynamics Directorate in July 1984. He has a master's degree from the University of Northern Colorado.

Even if the emerging threat forecast did not demand answers to the MANPRINT issues concerning the pilot interface, a facility like CSRDF would be needed in order to examine concepts which represent technological challenges.

RANGE DATA DISPLAY AT WHITE SANDS MISSILE RANGE

By Henry L. Newton

History

White Sands Missile Range, since it's beginning in July 1945 as White Sands Proving Ground, has had a requirement to accurately determine the position of missiles and targets during tests for the purposes of flight safety, range control and the conduct of the test itself.

The flight safety and range control operation grew from limited plotted data and voice control communications in the early days to a precision two axis vertical Plotting Board System and a modernized Range Control System in the Range Control Center in the 1960s.

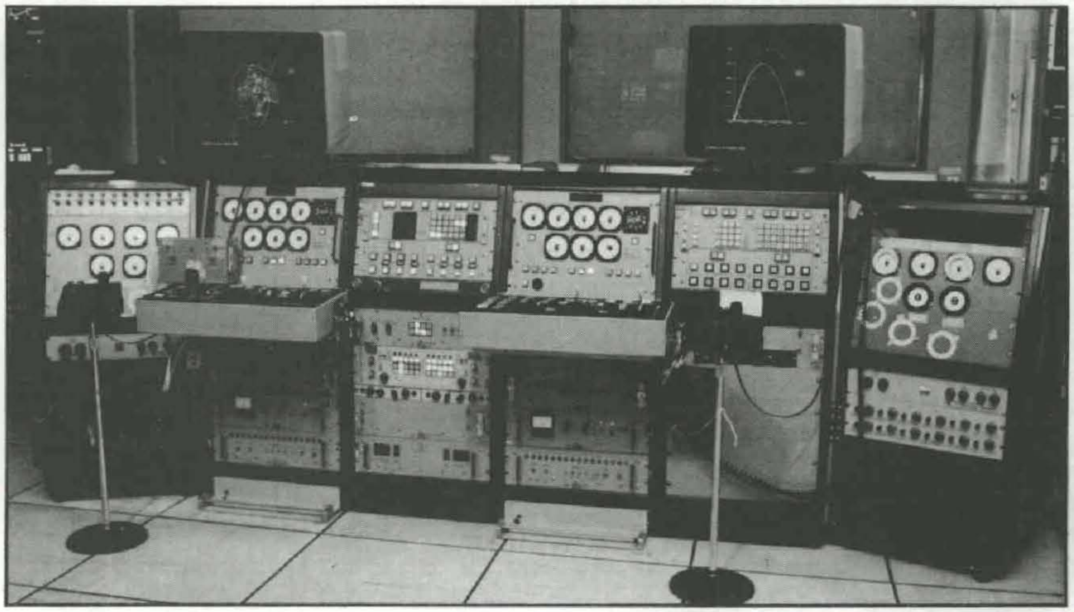
Until recently, the plotting boards, some of the oldest equipment at WSMR, were the vital mainstays of position information. They are being replaced through an interactive graphics modernization program.

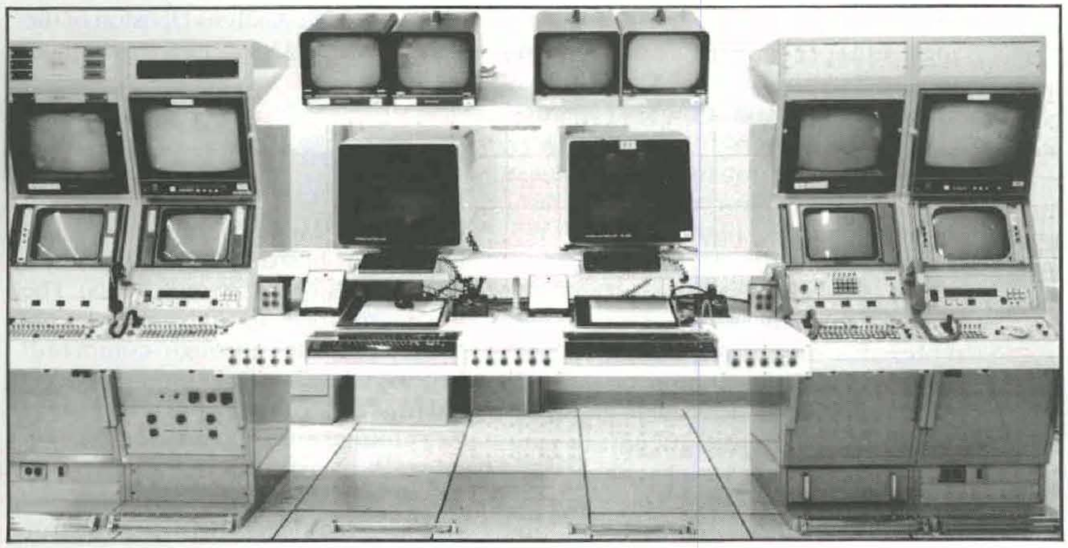
WSMR and Community Safety

WSMR, located in southern New Mexico, is some 3,200 square miles in size with sparsely populated areas on all borders. It is mandatory that all missions be conducted in a safe manner both for the safety of the surrounding local communities as well as range personnel. To this end, the accurate knowledge of the real-time position of flight objects is a prerequisite to safe conduct of range missions.

The range has requirements to display the space position of flight objects and some tests require the additional display of Instantaneous Impact Prediction (IIP). The IIP is used to indicate a "foot print" of where missile or target components will impact if a destruct command were issued at that instant. Use of this real-time position knowledge, coupled with other flight vehicle performance data, allows flight safety personnel to destroy vehicles whose errant path or malfunction might cause an exit from safe WSMR corridors.

Interactive graphics displays are shown on top of Vega target control system. Plotting boards are in the background.





Shown are two interactive graphics displays in center with interactive peripherals. Surrounding the graphics displays are video monitors, range control equipment, intercoms, and count clocks.

Plotting Board Constraints

The latest plotting boards were procured in the 1960s and are a high precision, vertical plane, 45 by 60 inch, two-pen type. The boards, now technologically old as well as physically old, were adequate in their time of supporting mostly single object type mission scenarios.

A plotting board can only display a very limited amount of information at a single station and that information is displayed as an analog line drawn on a prepared map background. The scale is constrained to a mylar map installed on the plotting board prior to the mission. Other related data, such as alphanumeric information on flight dynamics, must be displayed on different equipment.

The constraint to a single previously selected map scale limits the ability to discern, on one plotting board, separation of two objects close to each other while flying across many miles of the range. In some cases it is also difficult to observe the actual pen position due to obscurance caused by the pen arm.

The plotting boards are also difficult to use for multiple object missions. For instance, it requires several plotting boards to display the targets and missiles for both primary plots and back-up plots. As a result, flight safety officers must view several plotting boards to assess the performance of the flight vehicles. Given the short duration and high performance of new missiles, it is difficult if not impossible to digest data from several plotting boards and make meaningful decisions which are very time critical.

Support of multiple target and object missions therefore requires a large number of plotting boards as well as other displays and a large number of personnel to view and correlate the data displayed. The set-up time for plotting boards is about 30 minutes, thereby limiting turn-around time between missions if the same boards are required by the next mission in sequential missions.

Because plotting boards are obsolete and no longer manufactured, there is no source of repair parts or replacement plotting boards.

New advanced technology weapon systems are being tested at the range which are affected by plotting board limitations. As a result, tests must be designed around the limitations of range instrumentation and not the system being tested. New state-of-the-art spatial data display facilities are required to provide adequate display for complex test programs. These new weapons systems require displays with greater capacity for multiple target missions, more reliable operation, better maintainability and faster turn-around time between missions. New spatial data displays need the capability of displaying real-time target orientation data as well as position data. The displays must be able to handle multiple objects at a single display station showing the inter-relationships of these objects/targets. New displays can incorporate multiple colors or other distinguishing schemes to enable observers to recognize critical conditions, locations or targets.

With the increasingly complex multiple object flight scenarios, obsolete plotting boards do not satisfy the greater display requirements of today's missile test programs.

Modernization Program

WSMR has initiated a program to modernize the real-time display of flight objects. This modernization program has centered around the use of Interactive Graphics Display Systems (IGDSs).

Modernization with an IGDS replaces the obsolete system and satisfies the increasingly complex display requirements of the range. A new IGDS allows the range to support multi-object scenarios on one display device, something not possible with plotting boards. The IGDS allows multi-color, flexible format and high resolution displays of numerous objects on one display device.

The IGDSs currently in use at WSMR are composed of an Evans and Sutherland vector based PS350 Graphics Processor system driven by a Digital Equipment VAX 11/750 host computer. WSMR currently has four such systems and each system has one host computer, two graphics processors, four multi-color display stations, and interactive peripherals.

Graphics peripherals include function buttons, control dials, data tablet, and joystick. Interpretation of all of these devices is accomplished through applications software. For instance, the joystick can be used to slew the map across the screen to observe a new portion of the map and a control dial can dynamically change map scale.

New Capabilities

Modernization of the Range Control Center with the IGDS has resulted in a system that can display the required scenes of complex multi-object scenarios in real-time. The use of high resolution, multi-color, format flexible displays that can display complete test information on a single display device has decreased confusion and the probability of error in information interpretation and has resulted in increased range safety.

The new IGDS allows displays of both target and threat vehicles, natural terrain features, range borders, and corridors on one display screen. Each screen display incorporates a vector driven high resolution multi-color cathode ray tube.

Different colors are used to display different features such as roads, boundaries, instrumentation sites, and trails for flight history. The IIP display can also be added to indicate where debris will impact if missiles or targets are destroyed at any given instant.

The system can present position information on six primary and six secondary vehicles simultaneously. Colored symbols are used to differentiate vehicles. Using the IGDS, a safety officer can observe a detailed real-time representation of a complex test flight moving across selected colored scaled map sections of WSMR.

The system can also present digital data, such as altitude, compass heading angle and speed, on the display screen adjacent to the vehicle symbol. An operator can select a number of formats, including a profile format. One of the possible formats is an X-Y axis plot of missile horizontal or "X" distance from the launcher versus "Y" distance or missile altitude.

The IGDS also has the capability to provide paper hard copies of screen representations. This is accomplished through a high resolution laser hard copy unit attached to each graphics processor. The hard copy unit has an internal memory which can queue 20-40 pictures, depending on the number of vectors, for subsequent printing. These paper copies of the screen images are available for post-flight analysis by both range and project personnel.

Applications Software

The flexibility and speed offered by the IGDS is attained through an applications menu driven software system developed by the National Range Operations Directorate's Analysis Division-Software Branch for each IGDS. This government developed software is a cost effective solution that provides real-time display updates every 30 milliseconds. WSMR's flight safety officers indicate the system is user friendly and provides vehicle information that is more accurate and accessible than ever before. This software reduces the need for additional range support resources, shortens mission setup time, decreases turn-around time, and generally increases the productivity of the Range Control Center personnel.

IGDS Acquisition and Operation

The IGDSs were competitively acquired by the Data Systems Division of the Instrumentation Directorate (ID) at WSMR. Overall task planning, automatic data processing equipment approval management, acquisition, installation, system integration and training were provided by ID.

The IGDS serves the range user and range control personnel. The IGDSs are operated by the Analysis Division of the National Range Operations Directorate.

Drone Control

In March 1988, WSMR installed an Evans and Sutherland and Digital Equipment based IGDS adjacent to a Vega Target Control System (VTCS). The VTCS controls the flight of full-scale pilotless drones through command/control/telemetry links on the tracking radars. The VTCS previously employed two plotting boards to provide position information to the drone control pilots. The plotting boards have been removed and the drone control pilots now monitor a color cathode ray tube graphics display to observe the real-time position of the drone by viewing a symbol, representing the drone, moving on a scaled map background.

The drone symbols, map background, boundaries and digital drone performance parameters are displayed with different colors. Use of an IGDS to present real-time drone position color-coded information for pilots is a first at WSMR and represents a significant achievement in the processing speed, display resolution and user friendliness of the IGDS.

Additional Information

Government personnel desiring additional information on the WSMR IGDS may contact the author at: U.S. Army White Sands Missile Range ATTN: STEWS-ID-D (Mr. H. Newton), White Sands Missile Range, NM 88002.

HENRY L. NEWTON is an electronics engineer with the Instrumentation Directorate, White Sands Missile Range, NM. He is the project leader for range data display and interactive graphics and has been with the range since graduation in 1967 from Texas A&I University.

By LTC John S. Plummer, John L. McNerney, and Dr. John I. Stevens

CONTAINERS FOR LEAKING CHEMICAL ROUNDS

Single Round Containers

A new storage container for leaking toxic chemical munitions (TCM) was released early last year. This new device, the single round container (SRC), was designed to serve as an individual container for each leaking chemical artillery round. Both the 155 mm. projectile, M121A1, and the 8-inch round, M426, have been adapted for toxic chemicals. During extended storage, these rounds are subject to normal deterioration.

To ensure safety for all personnel, the U.S. Army has established a continuing surveillance program at all storage areas. When leaking munitions are identified, they must be sealed and isolated in order to minimize further contamination and to permit safe removal to disposal sites.

During routine maintenance in 1979-81, a 100 percent inspection of the TCM storage sites revealed a small number of leaking 155mm projectiles. Propellant charge containers were considered adequate for limited storage at the site, but it soon became apparent that these would not be adequate for longer periods and would not withstand the handling required for any kind of movement.

At the request of the storage personnel, an accelerated development program was begun in January 1988 by the U.S. Army Chemical Research, Development and Engineering Center at the Aberdeen Proving Ground, in Edgewood, MD. The development was completed in March of last year and the initial shipment of SRCs to the sites made early in April. One pallet with eight 155mm SRCs, and one pallet with six 8-inch containers were shipped. Training equipment and instructions for training of storage site personnel in the proper use of the SRC are in place.

A Letter of Instruction has been prepared, together with a Certificate of Equivalency showing that the SRC will match the original leak free performance of the round. Hazardous material data sheets have also been prepared to meet the requirements of the Department of Transportation. Handling protocols have been prepared and personnel training plans have been completed.

Each SRC is designed to enclose one single TCM and to maintain the same level of freedom from leaks as the original round. The body of the container is fabricated by welding a flange and a domed elliptical head to a tubular body, as in Figure 1, then fabricating a similar flanged head assembly. The details of the design are shown in Figure 2. Butyl rubber has been accepted as a barrier for toxic chemical agents, and was selected for the O-ring type of closure.

The extensive welding operations used to form the tubular body and to attach the flange and the domed end can generate thermal stresses in the metal segments. The addition of the stress relief groove minimizes these in the flanges. After rough machining, the entire item is heated uniformly to relieve any remaining stresses, which could result in failures in the leak tests. The assemblies are then numbered

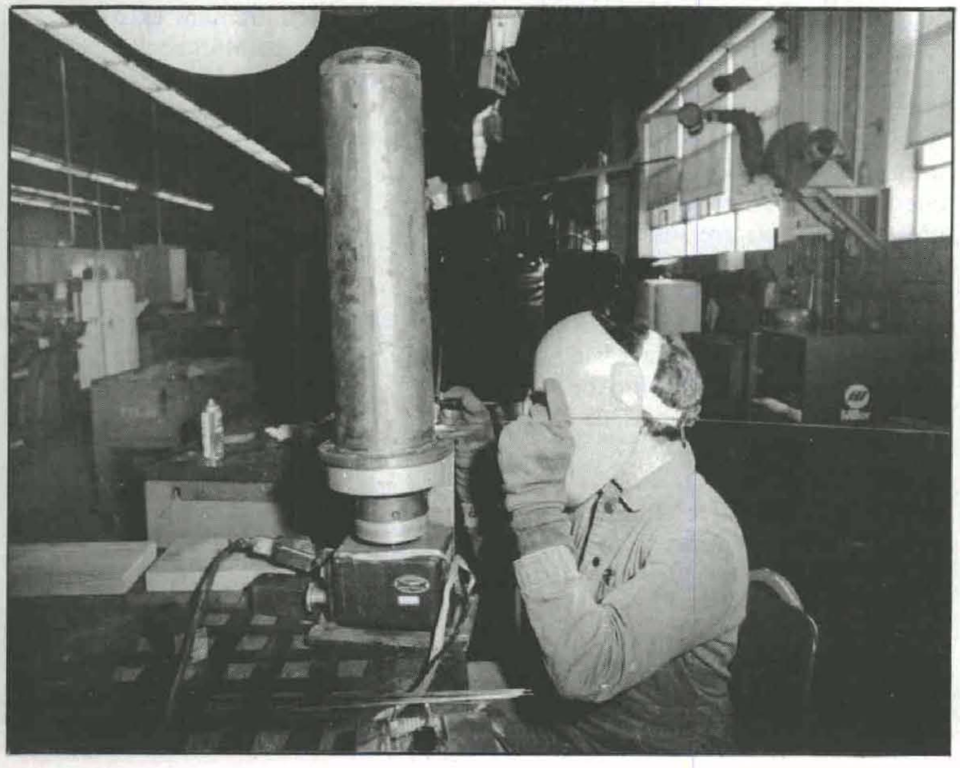


Figure 1.* *Welding a flange and a domed elliptical head to a tubular body.

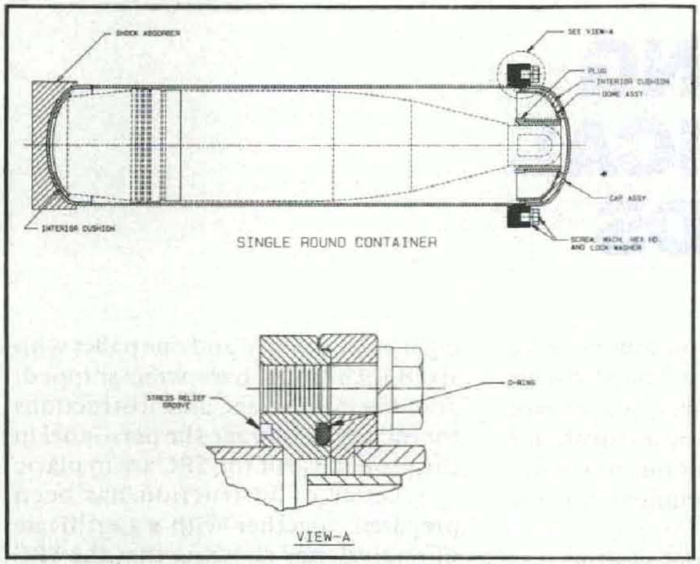


Figure 2.
Details of the Design.

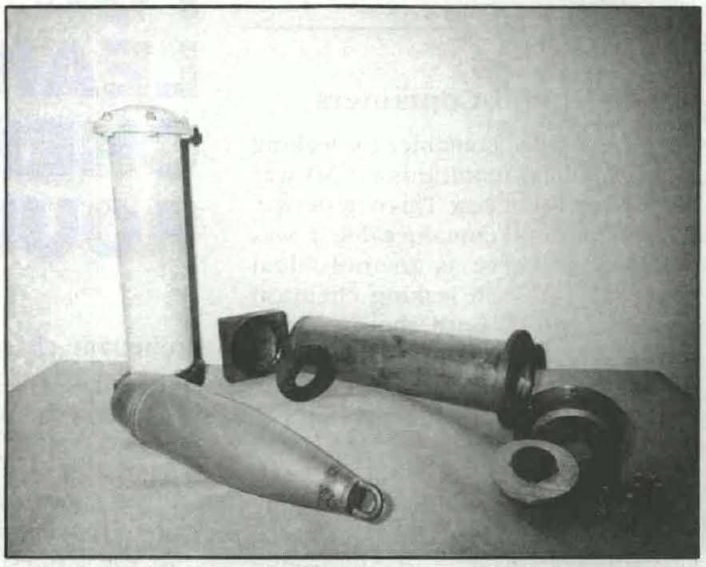


Figure 3.
Finished Components.

serially, finish machined to 0.006 maximum flatness in the flanges and hand worked to give a 16 micro-inch finish in both the O-ring groove and on the mating seal surfaces.

During the production cycle and prior to painting, each SRC is subjected to a helium leak test. Any nonconforming container is reworked, heated again to relieve stresses and refinished until it meets the leak test requirements. The containers are then sprayed inside and out (excluding the internal flange faces) with a chemical agent resistant coating.

The round is placed in the container using a funnel shaped guide. It is held internally by one butyl rubber ring placed in the bottom and another around the ogive at the top of the round. The flanged top dome contains a plug which fits over the lifting ring and prevents any horizontal movement. These are rigid requirements, but continuing production and testing have confirmed the need to adhere to them strictly. The finished components are shown in Figure 3.

Testing

Each SRC is thoroughly tested to ensure that it will form a seal. Acceptance criteria require that any leak be less than 1 X 10 minus 6 atm cc He/sec. The following tests are run on each SRC after preconditioning at minus 25 degrees and again after preconditioning at 135 degrees Fahrenheit.

- ***Loose Cargo Vibration Test.*** Each SRC is preconditioned and run at each of the two temperatures.
- ***Six-Foot Drop Test.*** Pallets loaded with SRCs containing projectiles (eight 155 mm or six 8-inch) adjusted to the proper weight are preconditioned and tested at both the high and low temperatures. The pallets are suspended and released to drop on a steel floor in varying orientations: the long or short edge, the top or bottom, or the bottom corner. While the pallets have had to be replaced in some instances and the SRCs have been dented or scraped, the SRCs pass the leak test.
- ***Secured Cargo Vibration.*** Again, the SRCs are preconditioned and run at both temperatures. The Hz level is varied through several cycles, as are the G levels.
- ***Static Pressure Tests (preconditioned and run at both temperatures).*** No more than 1 X 10 minus 6 atm cc atm of He/sec were lost.
- ***Thirty-Six Inch Drop Test (individual SRCs).*** Each individual SRC is preconditioned and dropped at both temperatures. Varying attitudes are used: base down, top down (angled to protect the valve), top edge and bottom edge, and both horizontal axes.

A similar requirement exists for an enclosure for the M55 rocket, which has also been adapted for use with TCMs. The CRDEC is working on a similar SRC for this munition.

LTC JOHN S. PLUMMER is currently acting director of the Munitions Directorate, U.S. Army Chemical RDE Center.

JOHN L. MCNERNEY is a packaging specialist in the Technical Data Division, U.S. Army Chemical RDE Center and is responsible for packaging chemical munitions.

DR. JOHN STEVENS is a research chemist at the U.S. Army Chemical RDE Center. He is currently on special assignment to the Advanced Concepts Systems Directorate.

DOG COLLARS TO DELTA ROCKETS...

THE DCAS RESIDENCY EFFORT

By MAJ Charles S. Fulmore

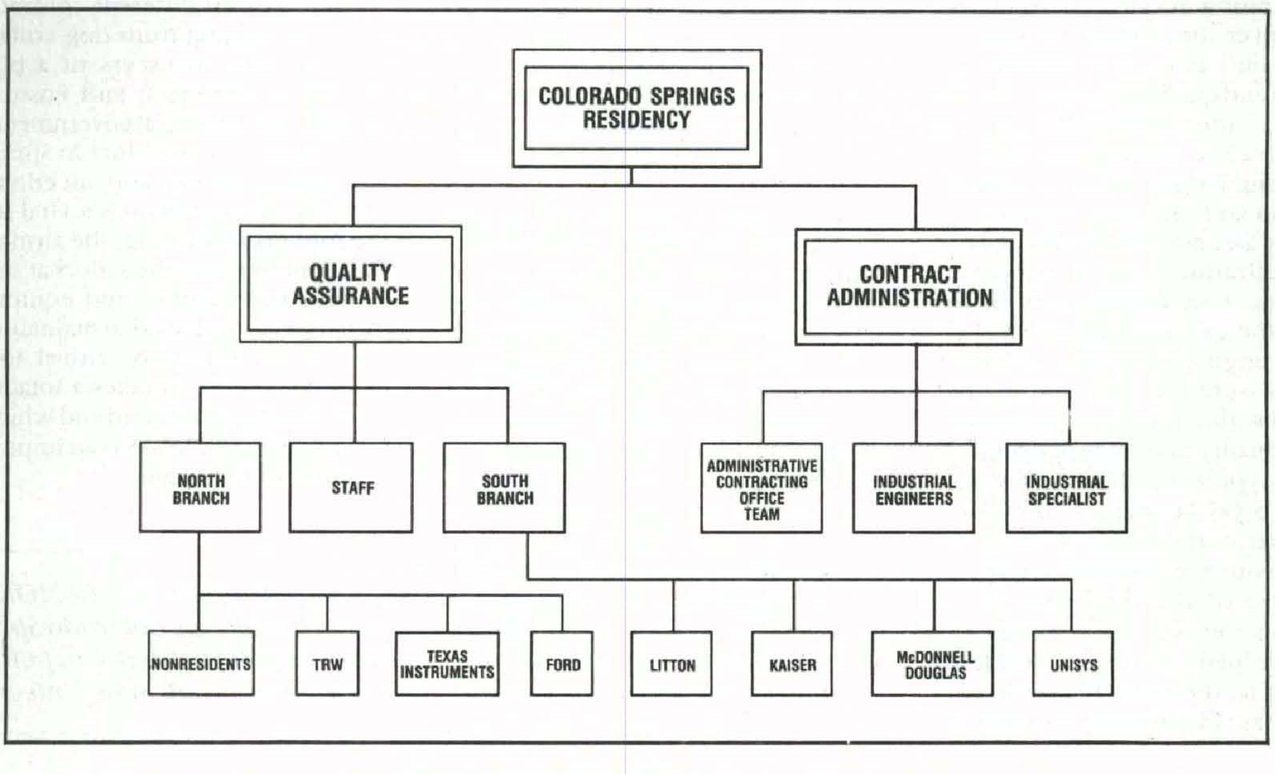
Recently, on a cold wintery day in the foothills of the Rockies, several government representatives set out in different directions on long, weary drives. Some hours later, in the sleepy little town of LaJunta, CO, not far from the Kansas border, one of the representatives carefully checks a camouflage poncho liner against a long list of specifications.

Across the state, another representative has just arrived in Trinidad, CO, to witness an acceptance test of blasting devices that will go to the Army to simulate the firing of the TOW. Meanwhile, back up the road about 90 miles, another team is out on the floor of the massive McDonnel Douglas plant in Pueblo carefully verifying the final tests of a Delta rocket.

All of these individuals are members of the Defense Contract Administration Services (DCAS) Colorado Springs Residency, an organization very much at the front line of the acquisition process. They are the eyes, ears, and in some cases, the voice of the myriad of buying activities throughout the Department of Defense and the federal government.

The Colorado Springs Residency is responsible for the administration of a broad spectrum of contracts awarded to business in central and southern Colorado. The value of these contracts exceeds one billion dollars. Geographically, the residency covers an area of some 12 thousand square miles. Contractors vary in size from a one man research and development effort to the giants of the defense industry such as UNISYS, Ford Aerospace, and Texas Instruments.

While the area is primarily recognized for its high tech industry, there is considerable product diversity among contractors. That diversity ranges from



With over 40 different contractors, products ranging from dog collars to delta rockets, in excess of a billion dollars in contracts, and customers throughout the federal government, the DCAS Residency in Colorado Springs is continually facing and meeting the challenges.

a small business specializing in the manufacture of canine equipment (to include dog collars) to sophisticated battlefield command and control systems. Customers include all Department of Defense services and their various buying commands, NASA, NSA, and some foreign governments.

As shown on the organization chart, the residency has a staff of approximately 50 personnel. As with its higher headquarters, the Defense Contracts Administration Services Management Area, Denver, the residency is basically divided into two functional areas: contracts and quality assurance. On the contracts side of the house, is an administrative contracting officer (ACO) team, a team of industrial engineers, and an industrial specialist.

Quality assurance forms the bulk of the organization from a manpower standpoint. A staff of three specialists support the two branches with skills such as engineering and software quality assurance. The companies indicated within each branch represent resident quality assurance personnel in plant. A typical resident staff would include a GS-11 quality assurance representative (QAR) and three GS-09 quality assurance specialists (QASs).

The size of the staff depends of course on the workload within the respective plant. The non-residents shown under the North Branch handle as many as 15 different companies on a part time or itinerant basis. It is the non-residents QARs that were described on the road at the beginning of the article.

The DCAS mission is much more than just a paperwork responsibility. Up front in the acquisition process, DCAS can provide buying activities with a thorough analysis of a prospective contractor with a pre-award survey. Questions answered range from whether vendor deliveries will arrive in sufficient time to support the proposed production schedule, to the contractor's ability to maintain a reasonable cash flow throughout the contract, to whether the proposed price is fair and reasonable to all parties.

DCAS is exactly what the name says; a service. Once a contract is awarded to a company, the buying activity has a number of options with regard to employment of the service. The ACO team and its supporting staff are capable of providing complete administration of the contract.

Services can include post-award conferences with the contractor to ensure that all conditions of the contract are clearly understood by all parties, to negotiation of contract changes, to the monitoring of production for the purpose of making progress payments, to the surveillance of Cost and Schedule Control Systems.

From a quality assurance standpoint, DCAS personnel can provide surveillance throughout the production process to ensure that the customer receives what has been ordered. That surveillance may include assuring that subcontractor or vendor supplied products meet specifications, that required inprocess testing is completed and passed, that government property provided the contractor is properly maintained, and that the final product is packaged and shipped in accordance with the buyer's directions.

With over 40 different contractors, products ranging from dog collars to delta rockets, in excess of a billion dollars in contracts, and customers throughout the federal government, the DCAS Residency in Colorado Springs is continually facing and meeting the challenges. Its mission is a vital one if the soldiers in the field, the airmen on the flight line, and the sailors at sea are to have the supplies and equipment they deserve and need to maintain that level of readiness so critical to our national defense. It takes a total team effort to achieve that end and while not known by many, DCAS is an important member of that team.

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

NEW TECHNOLOGY REQUIRES METROLOGY RESEARCH AND DEVELOPMENT

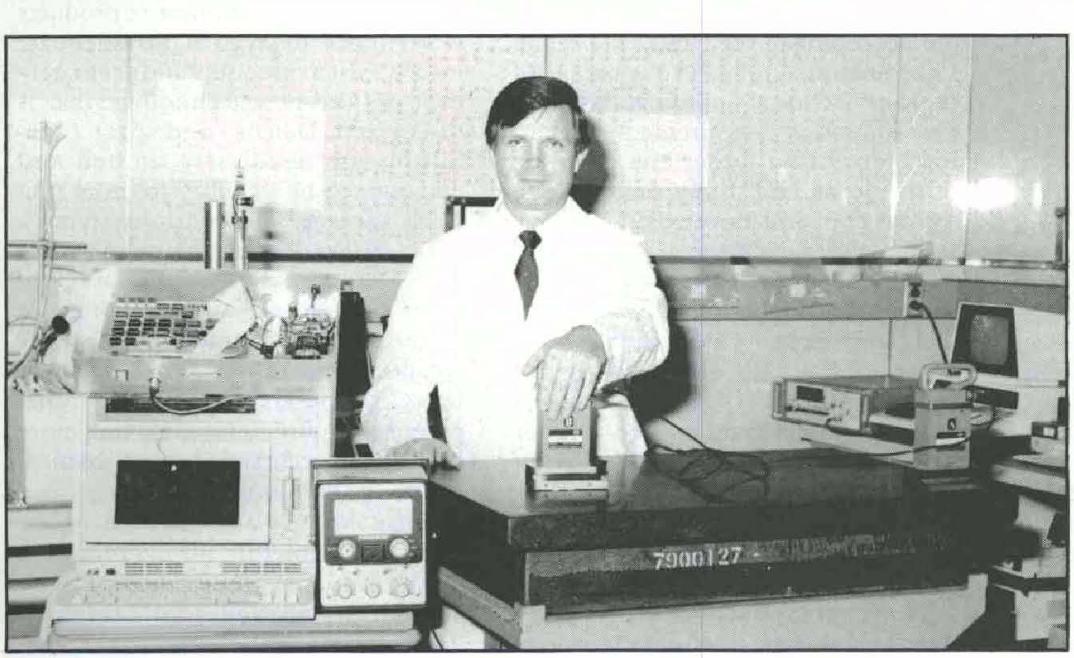
By Dr. Frank G. Westmoreland

Background

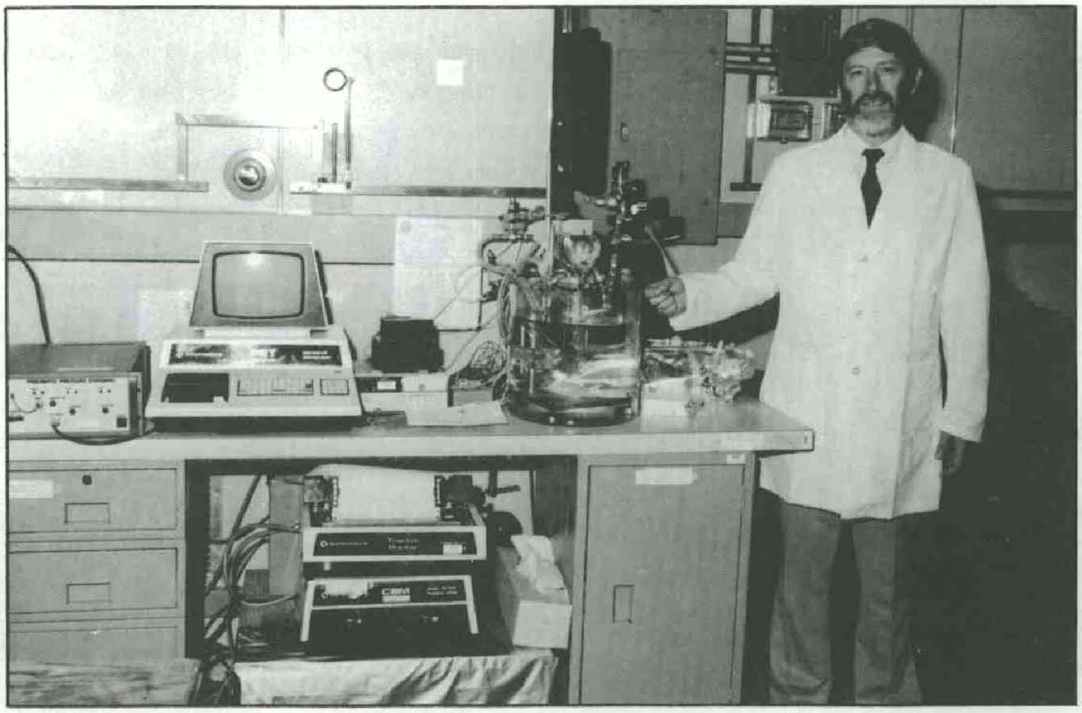
The Army successfully defended our national freedom through World War II without great concern for the accuracy or precision of its test, measurement, and diagnostic equipment (TMDE). The increased sophistication of weapon systems introduced toward the latter part of World War II and in the Korean War created maintenance complexities that had not been previously experienced. These complex technological advances and a few regrettable experiences manifested the need for an organized program of calibration using measurement standards directly traceable to the national standards of reference maintained by the National Institute of Standards and Technology (NIST), formerly known as the National Bureau of Standards (NBS).

In the Fall of 1963, independent calibration programs that had evolved within the Army's various technical services were consolidated into a single Army calibration system. At the same time, the U.S. Army Metrology and Calibration Center (USAMCC) was organized to perform fundamental metrology research, develop calibration standards for the Army, and serve as a single source of technical direction for the new Army calibration system.

In November 1978, the vice chief of staff approved recommendations of a Department of the Army study which expanded the role of the USAMCC to include operation of all Army calibration laboratories throughout the world. In 1981 the USAMCC was reorganized into the U.S. Army Test, Measurement, and Diagnostic Equipment Support Group (USATSG). The group has not only wholesale logistics responsibility for the life-cycle management of calibration standards for the Army, but also the retail logistics responsibility for using those standards to provide both calibration and repair support to users of TMDE throughout the Army.



John Ball shown with a prototype system to automatically calibrate surface plates.



J. R. Miller is shown with his apparatus developed to measure the lead rates used in gas mask testing.

Standards and Labs

The retail support mission is accomplished through a hierarchy of calibration standards and calibration laboratories. The highest order of Army calibration standards is called primary standards. These standards are maintained at the Army Primary Standards Laboratory collocated with USATSG Headquarters at Redstone Arsenal, AL. A lower order of standards, called secondary reference standards, is contained in 11 environmentally controlled laboratories.

Seven of these laboratories are located in the continental United States, three are in West Germany, and one is in Korea. The lowest order of calibration standards is called secondary transfer standards. These standards are used in both fixed and mobile configurations around the world.

The secondary transfer standards are used to calibrate most of the Army's TMDE. These standards are calibrated against the secondary reference standards which are, in turn, calibrated against the primary standards. The primary standards are calibrated against the national standards of NIST. Through this system of standards, the Army is assured that its measurements are directly traceable to the national standards. The other services and industry have similar systems to assure measurement traceability.

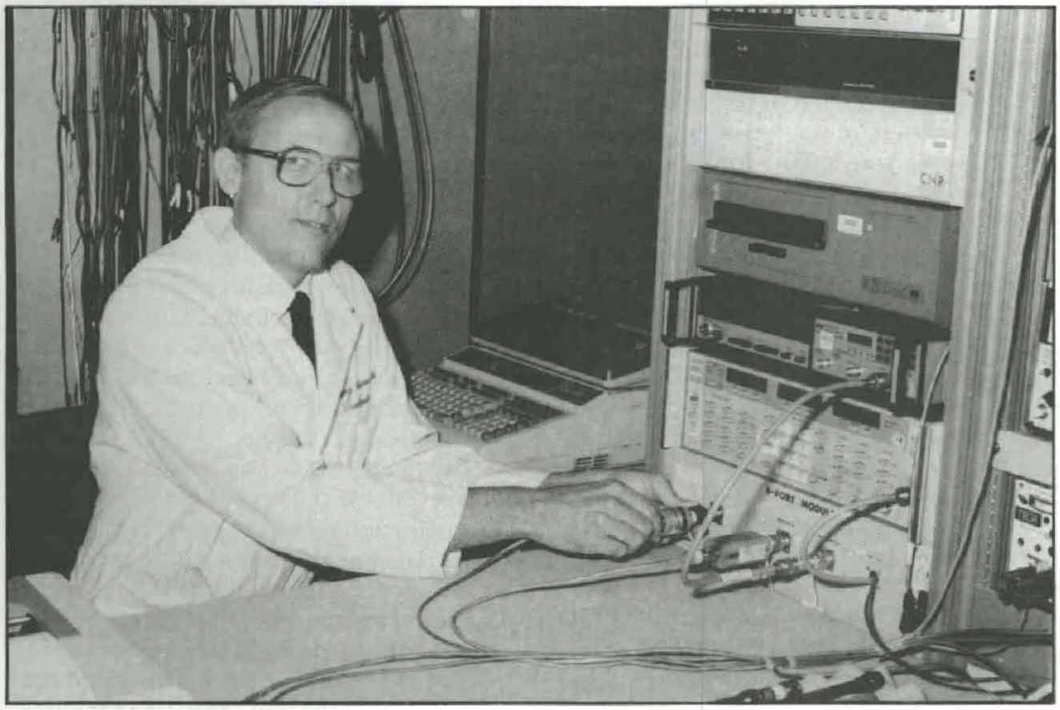
The Army system has performed very well for the past two decades, but according to the DOD Calibrating Coordinating Group, a subelement of the Joint Technical Coordinating Group for Calibration Measurement Technology, operating under the auspices of the Joint Logistics Commanders, serious concerns now exist: "Military systems currently being developed and fielded are demanding calibration support and measurement standards that cannot be provided by NBS or DOD laboratories. This situation, if not immediately rectified, will result in unreliable performance, higher development cost, and a multitude of logistical problems."

Concerns

The current lack of calibration standards and the need for metrology research and development have been well recognized by private industry. The Congress of the United States has also been made aware of the problem through testimony at various hearings. Dr. Russell C. Drew, representing the Institute of Electrical and Electronics Engineers (IEEE), has told Congress that "Manufacturing of innovative products is seriously delayed if no adequate means exist to precisely and accurately measure the new technology that is discovered. Defense and space capabilities are needlessly limited and endangered by inability to more precisely measure and control systems."

Dr. Walter Beam, chairman of the IEEE Defense Research and Development Committee, warned Congress: "Faulty measurements mean faulty weapons and flawed combat operations. We are gravely concerned that defense requirements demand more precise and accurately controlled measurements than are now available to our defense industry and the military."

Edward Nemeroff, former president of the National Conference of Standards Laboratories, told Congress, "Whenever the development of ade-



Larry Tarr, physicist, is shown adjusting a component on a six-part microwave test set he developed.

quate standards lags the development of new technologies, or new products, the only certain result is that whatever competitive edge may have existed rapidly disappears."

Gary Davidson, also president of the National Conference of Standards Laboratories, stated to Congress, "DOD measurement experts in the services are keenly aware of these needs, but because of the dispersed nature of these needs, they have not been successful in securing adequate funding for measurement R&D." Davidson went on to say, "Thus, awareness of the problem within DOD is growing, but adequate support does not appear on the horizon, and our nation cannot afford to wait any longer."

According to an article by Brian Belanger and Helmut Hellwig in the February 1988 issue of National Defense magazine, navigation systems, imaging and fire control radar, communication systems, and electronic countermeasures are being developed with operating frequencies in the millimeter region up to and above 100 GHz; new measurement techniques and standards must keep pace with these advances. Even for traditional measurements, scientific progress is stressing the Army's measurement capability.

Belanger and Helmut also stated that the development of improved pointing and tracking systems for the Strategic Defense Initiative requires angle measurements to accuracies which exceed current measurement capability by 100-fold. Similar problems exist in dynamic force, dynamic pressure, and other physical measurement parameters involved with various Army systems.

The relatively unpublicized science of measurement, or metrology, is considered by many to be the basis for all other sciences. According to Lord William Thompson Kelvin, the noted British physicist, in his book of addresses between 1891-1894, "When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stages of science." The same idea has been attributed to the great Russian scientist, D.I. Mendeleyev, who stated, ". . .science begins when one starts to measure."

In spite of the importance of metrology, Army scientists and materiel developers sometimes take the science for granted. They assume that calibration standards exist or that they will exist when their system is ready for fielding. They fail to realize that the development of workable standards in a new technology by NIST normally requires at least six years. Another two to four years is then required by USATSG to develop, procure, and field Army standards that can support systems in the field.

Early Identification

The solution to the Army problem obviously begins with early identification of new measurement requirements. The USATSG is currently reorganizing its existing manpower resources to strengthen its engineering staff and to establish a direct working interface with scientists involved

The advantages of laser doppler over traditional high accuracy acceleration measurements include non-contact remote sensing, no effect of the measurement on the process, and the ability to relate acceleration measurements to fundamental and precisely determinable properties of nature.

with new technologies in the Army's R&D community. This interface is expected to bring about an early identification of the need for metrology research and development.

Once a need is identified, the USATSG will coordinate with counterparts in the Air Force and Navy through the Joint Technical Coordinating Group for Calibration Measurement Technology to avoid duplicative effort in standards development within DOD. As funds become available, USATSG will lead the development effort, which may be performed in house, by NIST, or by the academic community.

Funding

The Army program element 63001A, project D594, for metrology research and development was established in 1987. The project is currently funded at about the $600,000 level from FY89 through FY94 against a recognized requirement ranging from $4,400,000 in FY89 to as much as $10,000,000 in FY93. In spite of this funding deficiency, the scientists and engineers at USATSG have been able to achieve significant advances in infrared, millimeter wave, pressure, torque, and other branches of metrology that directly affect the reliability of weapon systems or the safety of the soldier in the field. One USATSG engineer, Larry Tarr, has made significant contributions in the field of electromagnetic standards development:

The USATSG has brought on-line several new measurement systems for characterizing microwave and millimeter-wave (MMW) components. A single 6-port system built in-house provides routine calibrations of coaxial power and reflection standards in the 2-18 GHz frequency range. Current plans are to extend the frequency range of the system to at least 40 GHz. In addition, the USATSG has supported the development of three dual 6-port complex network analyzers for characterizing one- and two-port devices operating at frequencies of .1-1000 MHz, .5-18 GHz, and 93-96 GHz, respectively.

An automated MMW reflectometer has also been developed, with limited funding, for wideband WR-10 waveguide measurements from 75-100 GHz. R&D is in-progress for a new Q-band (33-50 GHz) measurement system to support measurement requirements of the MILSTAR communications system, and others.

In the area of time domain metrology, an automated time domain measurement system has been developed which is used extensively for characterizing picosecond electrical waveforms and for automated time domain reflectometry (TDR) measurements.

James R. Miller, III, a scientist at USATSG, has done extensive work in pressure measurement: Pressure measurements, from the vacuum of outer space, 10-9 Torr or less, to high dynamic pressures up to 150,000 psi or higher have presented challenging measurement problems. These challenges have been or are being met by USATSG. Work over the last 20-25 years has provided a means to calibrate vacuum gages, standard leaks, air data test set calibrators, and modern hydraulic/pneumatic pressure standards. Future work will concentrate on high dynamic pressure measurement problems. Current methods at most test ranges do not faithfully calibrate transducers under user test conditions.

Another USATSG engineer, John Ball, is involved in applying laser technology to precision measurement. Recent experiments by him have demonstrated the practicality of applying laser doppler technology to the calibration of accelerometers.

The advantages of laser doppler over traditional high accuracy acceleration measurements include non-contact remote sensing, no effect of the measurement on the process, and the ability to relate acceleration measurements to fundamental and precisely determinable properties of nature.

A laser doppler system has been successfully mated to an automated accelerometer calibration system at USATSG, and measurements have been successfully performed proving the technology. However, additional R&D will be required to refine the system, improve its accuracy, and construct a practical prototype.

The USATSG has a small, highly specialized and very competent staff of engineers and scientists who are eager to develop solutions to the technical problems associated with the current lack of certain measurement standards. Technical progress is limited directly by funds available. In addressing the funding problem, the USATSG has initiated a strategy of encouraging managers of systems to fund USATSG standards development work required to assure the system can be supported when fielded. Discussions thus far with the project manager, Multiple Launch Rocket System (MLRS), project manager, Fiber Optics Guided Missile (FOG-M) System, and representatives from the Strategic Defense Initiative indicate that this approach may help produce a successful solution to the Army's metrology R&D problem. Other managers interested in this method of solving metrology R&D problems are invited to contact the USATSG at AUTOVON 746-1134.

DR. FRANK G. WESTMORELAND is the civilian deputy to the commander and technical director of the U.S. Army Test, Measurement, and Diagnostic Equipment Support Group. He has a B.S. degree in industrial engineering, a master's in business administration, and a doctorate in management.

THREE FIRMS GET GREEN LIGHT FOR FMTV PROTOTYPES

By George Taylor, III

On Oct. 21 of last year, the U.S. Army Tank-Automotive Command (TACOM) awarded separate contracts to three companies to build competitive prototypes of vehicles proposed by each firm for a new family of 2½ and 5-ton tactical vehicles. Dubbed the Family of Medium Tactical Vehicles (FMTV), they are planned for introduction in the early 1990s. They will replace the M44-series 2½-ton trucks and the M39- and M809-series 5-ton trucks now used by the Army, Marine Corps and Air Force. Additionally, they will supplement the newer M939-series 5-ton trucks.

The contracts went to Teledyne-Continental Motors Corp., Muskegon, MI; Stewart and Stevenson Services Inc., Houston, TX; and the Tactical Truck Corp., Warren, MI, a joint venture involving General Motors Military Operation and Bowen-McLaughlin-York.

The companies' concepts were among four submitted last April in response to a TACOM request for proposal. That proposal called for a new generation of medium tactical vehicles that would use exiting or modified off-the-shelf commercial hardware and common components wherever possible, to keep developmental costs and lead time to a minimum.

Under the terms of the contracts, each company will build 15 trucks — eight 5-ton and seven 2½-ton versions — along with three 5-ton and two 2½-ton trailers over the next 14 months. These will undergo 10 months of durability and performance tests at Aberdeen Proving Ground, MD; Yuma Proving Ground, AZ; and Vicksburg, MS; and user evaluation at Fort Knox, KY. The Army will then review the results and, if all goes well, choose a winning FMTV concept and award a production contract in early 1991.

Specific FMTV design details will not be known until the winning concept is selected, because the contracts only spell out vehicle performance requirements and do not specify a particular design to meet them. But from a general standpoint much is already known about the vehicles.

According to TACOM's Dennis Mazurek, deputy project manager, Medium Tactical Vehicles, the trucks will have all-wheel drive and an improved suspension system offering better off-road mobility than the existing 2½- and 5-ton vehicles. The 2½-ton version will have a four-wheel design and the 5-ton truck will use six wheels.

Specific FMTV design details will not be known until the winning concept is selected, because the contracts only spell out vehicle performance requirements and do not specify a particular design to meet them.

Mazurek said the 2½-ton version will have only a van and a cargo-truck variant, but the 5-ton version will include practically the same number and types of variants available in the current 5-ton vehicles. He said the only exception will be the addition of a tanker and an ambulance.

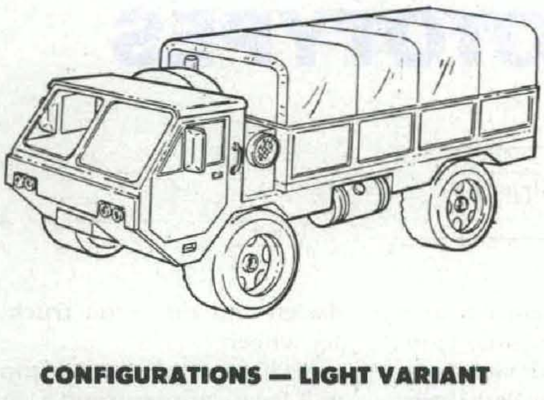
Mazurek also noted that, like the current M44-series vehicles, a limited number of the new 2½- and 5-ton trucks in cargo and dump configurations will be air droppable and deployable by a Low-Altitude Parachute Extraction System (LAPES). In a LAPES deployment, a parachute pulls the pallet-mounted truck from the rear of a cargo plane flying about 20 feet above the ground.

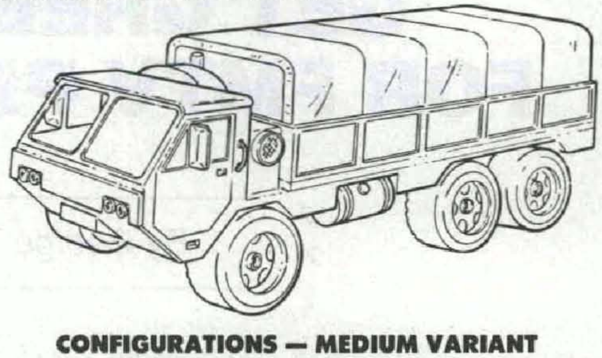
Noting other FMTV features, Mazurek said the trucks will include radial-ply tires, a central tire inflation system, lighter, more powerful diesel engines and improved automatic transmissions that will combine to provide better fuel efficiency. There will be common instrumentation and controls that will simplify training requirements. Additionally, the trucks will use a common three-man cab and share many of the same mechanical and electrical components, thereby minimizing the number of unique spare parts that field units will be required to stock. Both trucks will also have a material-handling crane which will provide a self-load/unload capability.

FAMILY OF MEDIUM TACTICAL VEHICLES (FMTV)

PRIMARY MISSIONS

- UNIT MOBILITY
- UNIT RESUPPLY
- TRANSPORT OF EQUIPMENT & PERSONNEL





CONFIGURATIONS — LIGHT VARIANT

- CARGO
- SHOP VAN
- CHASSIS

CONFIGURATIONS — MEDIUM VARIANT

- CARGO W/WO MHE
- LONG WHEELBASE CARGO W/WO MHE
- CHASSIS W/WO LWB
- EXPANSIBLE VAN
- TACTOR
- DUMP
- WRECKER
- TANKER
- AMBULANCE

"It is true," said Mazurek, "that some of the improvements, such as a three-man cab and radial-ply tires, already exist in the M939-series 5-ton trucks. But these trucks, as well as the 2½-ton vehicles, basically still represent 1950s and the 1960s technology.

"In the FMTV," he continued, "we are looking for improvements in mobility, ride, performance and durability that will enable us to meet requirements which we did not have when the existing trucks were designed. For example, we now have requirements for a 5-ton ambulance and a LAPES deployment for the 5-ton, which we never had before. So we need a state-of-the-art suspension system that will give us a better ride from the standpoint of crew comfort as well as reduced shock to the equipment in the vehicle."

The FMTV trailers will complement the trucks' cargo carrying capacity. Moreover, the trucks will have increased towing capacity. The 2½-ton truck will be able to tow a trailed load of 7,500 pounds, and the capacity of the 5-ton version will be 21,000 pounds. This compares with current ratings of 6,000 pounds and 15,000 pounds for the 2½- and 5-ton trucks, respectively.

"Right now," Mazurek explained, "we have a mishmash of many different types of trailers, but we don't really have anything that is standardized. What we are trying to do is come up with a total system package. That package would provide a truck and trailer with the same payload and cargo capacity, and would also give us a certain amount of off-road speed and mobility with the trailer."

"Despite all the performance improvements that have been stressed," said Medium Tactical Vehicles Program Manager COL Donald W. Derrah, "our main goal was to reduce the maintenance burden and cost of operations. In this regard, reliability should double, maintenance diagnostics will be built in, and other MANPRINT (Manpower and Personnel Integration) improvements will be provided to facilitate maintenance. We estimate a $3½ billion savings in operating costs accruing when FMTV replaces the old trucks."

According to Mazurek, the Army expects to buy some 80,000 vehicles over a 15-year period totaling $9 billion to meet its needs. He said the number of trucks and trailers to be bought in each weight class is not known yet. He added that the Army will also be buying an unspecified number of vehicles for the Marine Corps, Air Force and Navy.

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.

DOD Announces New Graduate Fellowship Program

The Department of Defense (DOD) has announced plans to award approximately 150 new three-year graduate fellowships in April 1989 under the National Defense Science and Engineering Graduate (NDSEG) Fellowship program.

This $10 million program reflects concern that a declining number of U.S. citizens have been pursuing advanced degrees in science and engineering fields that are important to national defense. In engineering, for example, more than 50 percent of U.S. doctoral degrees are now awarded to foreign citizens. The new program will more than double the number of DOD science and engineering graduate fellowships to be awarded in 1989. In addition to the 150 NDSEG fellowships, about 140 fellowships will be awarded in 1989 through existing programs.

The fellowships will go to students who intend to pursue doctoral degrees in mathematics, computer science, physics, biosciences, chemistry, chemical engineering, toxicology, geosciences, electrical engineering, mechanical engineering, naval architecture and ocean engineering, aeronautical and astronautical engineering, and oceanography.

Only citizens or nationals (native residents of U.S. possessions) are eligible. Applications are encouraged from women and minorities, and persons with disabilities. Ten percent of the awards will be set aside for members of ethnic minority groups which are not adequately represented in the advanced levels of U.S. science and engineering.

Application information can be obtained from Battelle-Columbus Division, Graduate Fellowship Program, P.O. Box 12297, Research Triangle Park, NC 27709. The phone number is (919) 549-8291.

Personnel Changes at PERSCOM:

MAJ Tom Resau has replaced MAJ Ed Coughlin as the Functional Area 51 Assignment Officer.

Rick Yeager has replaced Barbara Head as the Materiel Acquisition Management (MAM) Program Coordinator.

Their new mailing address is: Total Army Personnel Command, (PERSCOM) ATTN: TAPC-OPB-A, 200 Stovall Street Alexandria, VA 22332. AUTOVON 284-3125/3127 Commercial (202) 325-3125/3127

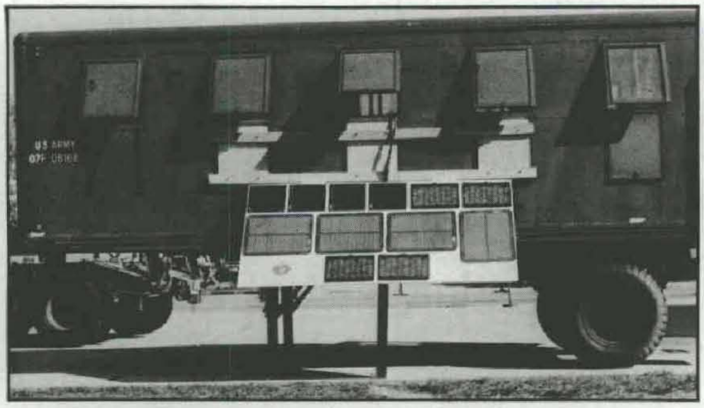
TACOM Evaluates Solar Energy for Vehicle Readiness Role

Solar energy may someday help to maintain Army Vehicles in a state of readiness by keeping batteries charged during long periods of disuse, thanks to research now going on in The U.S. Army Tank-Automotive Command's (TACOM) RDE Center.

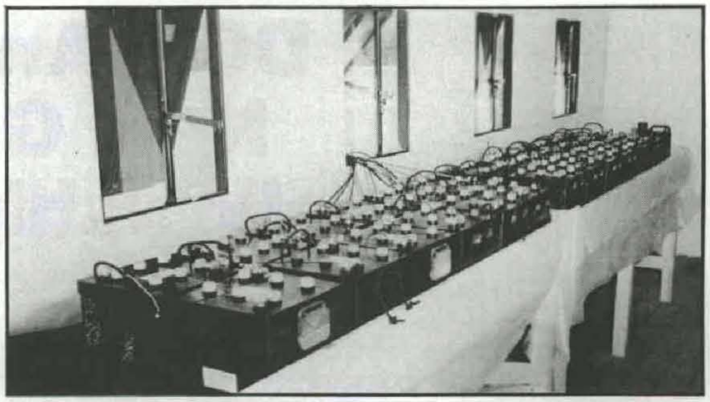
When a lead-acid storage battery is idle, it discharges at a rate of .7 percent of its charge per day. And, if not recharged either by a vehicle generator or battery charger, it eventually loses most of its charge.

If your driving habits are typical, your car seldom, if ever, stands idle long enough for this to be a problem. But many Army vehicles, particularly those in National Guard units, are sometimes left standing for long periods — plenty of time to permit a battery's state of charge to fall below the level needed to start an engine.

At TACOM, RDE Center engineers are evaluating the potential of using vehicle-mounted solar panels to maintain batteries by providing a trickle charge to offset the discharge during idle periods. The project falls under the Army's Military Adaptation of Commercial Items (MACI) program. The MACI program objective is to determine those instances where the Army could use standard or modified commercial equipment in military applications, thereby eliminating the time and cost of developing special-purpose hardware. The approach used involves first conducting technical feasibility tests of existing commercial equipment to determine its performance and durability in a specific military role. Then, using the test data as a guideline, engineers prepare a performance specification, and industry is asked to provide either existing or modified commercial hardware that will meet that specification.



Solar panel-trailer installation.



Twelve sets of military batteries being trickle charged by solar panels.

According to the RDE Center's Martin Snyder, who heads the solar project, tests of solar panels in a battery charging role have been under way since August 1987, and the results have so far been encouraging. Snyder said the tests involved mounting panels made by three companies on 10 five-ton trucks at a National Guard unit in Ypsilanti, MI to determine if they could maintain a charge on battery systems in vehicles that are normally not used during the winter. "January, February and March are probably the most critical months to keep batteries charged in our local climate," said Snyder. "But the panels demonstrated a capability of adequately maintaining the batteries during that period."

Snyder said more extensive tests are now under way in three locations — Yuma Proving Ground, AZ, Fort Lewis, WA, and TACOM — to evaluate solar-panel performance in a variety of climatic conditions.

At each site, 12 battery sets are placed in an outdoor shelter to keep them dry, and each is connected to a solar panel made by one of three manufacturers. (One battery set includes two 12-volt batteries, connected together to produce 24 volts, the standard voltage used in all military-designed Army vehicles. Some vehicles use as many as five battery sets.) The batteries' state of charge will be checked weekly for one year.

"The geographic locations of these test sites give us a good range of climate for evaluating the panels," Snyder explained. "Yuma offers a very high average ambient temperature. This makes it ideal for the test because batteries don't charge as well at high temperatures and the output of solar panels falls off when they are exposed to a hot environment."

"Michigan offers the snow and ice conditions with alternating sunshine," he added, which could be a potential problem for solar panels because of ice and snow buildup. And Fort Lewis offers a predominantly overcast environment where you really don't get the full solar effect that you would otherwise achieve."

TACOM (Cont.)

Snyder said that in addition to these tests, TACOM plans to provide other solar panels to National Guard units in Little Falls, MN, Nashville, TN, and Austin, TX, where they will undergo a year of testing on vehicles. He said the purpose of the National Guard tests is to evaluate various ways of mounting solar panels on different types of vehicles.

When asked how much solar panels would cost the Army, Snyder said one panel and associated mounting hardware would cost approximately $120. But he pointed out that maintaining a battery's state of charge during idle periods would greatly extend its service life, and the resulting replacement-cost savings would offset the cost of a panel in the long run.

According to Snyder, if the panels prove to be effective and the Army decides to adopt them, they would be issued to field units as retrofit kits. He said troops would then be able to install them in vehicles before extended idle periods and remove them prior to a resumption of operation.

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

Natick Developing New Command Post System

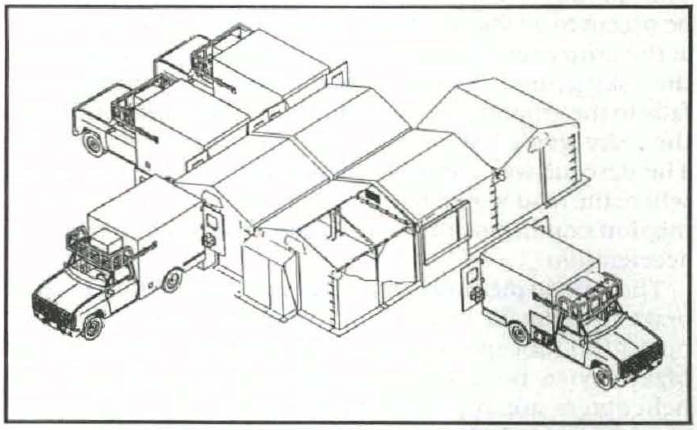
Engineers at the U.S. Army Natick Research, Development and Engineering Center are developing a Standardized Integrated Command Post as a highly mobile facility to house command, control and communications electronics. The program includes the development of three command posts: Tent Command Post, Shelter Command Post, and Track Command Post.

The Tent Command Post is 11 feet square, 9 feet a the peak and features a collapsible, one-piece aluminum frame. All tent walls are of equal size and are removable allowing the tents to be complexed end-to-end or side-to-side. Ancillary components to the Tent Command Post are two tables, two mapboards, fluorescent light set, heater and surface wire ground system.

A DA-directed Type Classification-Limited Production Urgent buy of 1,500 Tent Command Posts was initiated in August 1987 to fill the need of seven infantry divisions. Fielding of these Tent Command Posts began in August 1988 and will continue through April 1989. Upon completion of further testing, the Tent Command Post will be type classified as a standard inventory item in the second quarter FY90.

The Shelter Command Post is designed to fit on both the High Mobility Multi Purpose Wheeled Vehicle Shelter Carrier and the Commercial Utility Cargo Vehicle with the cargo bed removed. The shelter will be integrated with onboard power generation equipment, air conditioning, chemical/biological and electro-magnetic interference protection, racks for mounting electronic equipment, lights, and an overcab rack for storage. The Shelter Command Post will house the new Army Tactical Command and Control System to be fielded starting in FY92. It will complex with the Tent Command Post by means of a special tent interface wall.

The Track Command Post will consist of an M577 tracked vehicle modified to be compatible with the new Army Tactical Command and Control System computer hardware. Primary modifications will include the addition of an environmental control unit for heat, air conditioning and ventilation and the replacement of the present generator with a larger one plus the addition of an overpressure system to protect the unit against chemical/biological threats. The Track Command Post also will complex with the Tent Command Post.



Artist rendering of the Standardized Integrated Command Post System set up in conjunction with Commercial Utility Cargo Vehicles.

Rotorcraft Ammunition Delivery System

Presently, air resupply of ammunition means the use of a parachute, some method of free drop, or landing and unloading. Natick Research Development and Engineering Center, Natick, MA, has been investigating concept methods to combine the positive aspects of these approaches. The objective is to develop a new Rotorcraft Ammunition Delivery System which will maximize the survivability of aircraft, minimize drop zone signature, and ease ground handling of loads.

The concept is being developed as an ammunition resupply method for light infantry rifle companies. It would consist of two parts, a lowering device and manportable modules. Used together, loads are lowered to the drop

Rotorcraft (Cont.)

zone on a rope from helicopters flying at altitudes too low for parachute drops. This concept is presently being developed for use with the UH-60 helicopter to deliver up to four, 450-pound loads of small arms ammunition per sortie.

The manportable module is a harness and shoulder strap system that is quickly adjusted to fit any small arms ammunition case. It permits one person to easily carry one case of small arms ammunition. The harness is easily secured around an ammunition case with quick release buckles. Once a load is delivered, the harness unhooks for reuse.

Two methods of dropping the load from a helicopter are being investigated. The first method involves a commercially available device called a "sky genie." It uses friction on a rope wrapped around a cylinder to control the rate of descent. The amount of friction can be adjusted but the rope must be precut to a length equal to the altitude of the helicopter at the drop zone. When the end of the rope passes through the "sky genie," the load is free of the craft and the rope falls to the ground with the load. During the spring of 1988, the "sky genie" was tested from a stationary position. The descent was controlled from near freefall to a point where the load would hardly move. However, under actual mission conditions the load would descend at a constant acceleration.

The second method employs an automatically controlled brake to maintain a constant drop speed. Rope is supplied on 50-100 foot spools and can be quickly attached to the brake device. Both of these settings can be made while the helicopters are approaching the drop zone. The brake would automatically control the velocity of the drop load until the exact length of rope reeled out to touch-down. At touchdown time, the brake would completely release and any remaining rope would drop to the ground.

The delivery system can accurately deliver six case bundles of small arms ammunition without landing or stopping and thereby reduce helicopter vulnerability to ground fire.

Natick Tests Commercial Stove Pipes

In an effort to apply the values of total quality management by reducing guidelines, the Natick RDE Center has been evaluating commercial stove pipes for use with field stoves.

Current pipe specifications call for extremely tight tolerances on seam construction and for rivets to provide a permanent connection at the seam overlap, a safety specification not considered necessary in commercial stove pipes. These additional requirements, added to Army specifications in the name of safety, have restricted the number of qualified bidders in past procurement actions.

In seeking a final determination, samples of both pipe types were tested by the Test and Evaluation Command to see if the Army specifications were overly conservative. The tests indicated no difference in permanence or safety value between commercially available pipe and the Army specification pipe.

The U.S. Army Natick Research, Development and Engineering Center will now update its specification and eliminate the requirement for rivets, and relax the tolerances on pipe seam fabrication to allow alternate seam designs. This should increase the base of potential suppliers and competitive bidding.

Contract Option Awarded for Mobile Subscriber Equipment

Department of the Army officials have announced that the U.S. Army Communications-Electronics Command has awarded the third option to its multi-year production contract for the Mobile Subscriber Equipment system to GTE Government Systems Corp., Mobile Subscriber Equipment Division, Taunton, MA.

The option, valued at $948 million, brings the value of the basic contract and options awarded thus far to a total of $2.3 billion. The basic contract was awarded to GTE in December 1985.

The Mobile Subscriber Equipment system is being acquired as a non-developmental item (NDI). The NDI approach was selected both to avoid expending research and development funds on equipment and technology already available and to provide more rapid fielding to the Army field units which will use the system.

Mobile Subscriber Equipment is an array of electronic telephone switches, facsimile and voice terminals and radios which provide the Army advantages similar to those of any mobile telephone system. For the battlefield commander that means ease in placing telephone calls through fully automated dialing; mobile unit security to the secret level; data transmission capability; assemblages that can be torn down quickly and reassembled easily; and system control.

The GTE contract and options provide MSE equipment to outfit each of the Army's five corps. Fielding of the system began in February 1988 with the Signal Battalion, 1st Cavalry Division at Fort Hood, TX. All active and reserve components will receive the system by 1993.

Army Fields New Sniper Rifle

The Army delivered its first package of new sniper rifles when 36 M-24 weapon systems were released recently to the John F. Kennedy Special Warfare Center at Fort Bragg, NC. The entire system was developed in less than three years at Picatinny Arsenal, NJ. The Army approved its performance characteristics in May 1986.

Sniper (Cont.)

The M-24 is the first system developed to specifically fill this critical role. To be employed as a force multiplier in low and high intensity conflicts where U.S. forces are outnumbered on the battlefield, it will be used to engage specific targets with precision fire beyond the effective range of standard issue rifles. This will provide battlefield commanders with a reliable, deep strike capability against key enemy personnel and other high value targets.

Unlike its predecessor, the M-21, it can be maintained by the operator, has a backup sighting system and incorporates many other improved characteristics that significantly increase its reliability as a combat weapon. The M-21, a modified M-14 semi-automatic rifle, can't be maintained under field conditions and its inflexible design makes it highly susceptible to malfunction.

"One problem," says Jim Glenn, an M-24 project engineer, "was that the M-21's scope couldn't be removed by the operator. If anything happened to it, it couldn't be repaired in the field. It had to be sent to Anniston Army Depot for repair." The M-21's barrel-receiver group is bedded in fiberglass epoxy material that only an armorer or gunsmith can rebed, he says. The M-24's free floating barrel rests on an aluminum bedding system which is an integral part of the stock.

"Because the scope wasn't detachable, the M-21 was being damaged when soldiers were making their combat jumps. The M-24 has a detachable scope with its own case. So when the soldier jumps, he packs the scope in his rucksack and only the rifle is subjected to the impact of the jump," Glenn adds.

Similar to the Remington Model 700 sold in the private sector, the bolt-action rifle has an 800-meter range and has an adjustable stock and trigger pull. It weighs about 11.6 pounds and is 43 inches long when the stock is in its shortest position. The scope has a mil dot reticle pattern and comes equipped with a sunshade. When reattached to the rifle, the sight can be repositioned (zeroed) within a half a minute of angle.

Another advantage is that the new system has backup metallic front and rear sights which can be used if the scope is damaged. These iron sights also have their own case.

The M-24, because of its long action, is also capable of being easily modified at a later date to accommodate up to a .300 Winchester magnum round. It also comes with a detachable bipod, five round internal magazine and standard issue leather sling. The overall weight of the rifle with its various repair and carrying equipment is about 14.2 pounds. Both weapons fire the standard 7.62mm M-118 military cartridge.

Says Daniel Surman of the Close Combat Armaments Center, "The system comes complete with its detachable scope (10x), carrying case and deployment kit containing all of the parts that the user can replace in the field. We also

M24 SNIPER WEAPON SYSTEM (SWS)

have an 18-month warranty that replaces any part that is not damaged by abuse, plus an agreement that sets repair costs for a five-year period. We have been given a 22-day repair turn around from turn-in to return to user."

In March 1986, the Armament Research, Development and Engineering Center at Picatinny Arsenal conducted a world-wide survey to determine if a commercially available item could satisfy the Army's requirements. It included small arms and rifle manufacturers and an evaluation of the U.S. Marine M-40A1 sniper rifle and various NATO sniper rifles. Based on this study, the Army determined that there were sufficient systems available on the market that once modified could meet its requirements.

Systems provided by bidders were tested by Army marksman for accuracy and by Army paratroopers for ruggedness before a decision was made to award the contract to Remington Arms Co., of Ilion, NY. Remington will produce 1,000 systems over the next year and a half, with options to build up to 3,000 more.

According to Glenn, special operations, ranger and other light infantry units will be receiving most of the systems first. Both overseas and stateside units are included in the initial shipment plans, he says. Glenn will provide technical assistance during the field stage.

WRAIR Scientist Gets Siple Award

A scientist assigned to the Walter Reed Army Institute of Research (WRAIR) received the Paul A. Siple Award for the best paper presented at the biennial Army Science Conference.

Held at Fort Monroe, VA, the conference drew representatives from research and development organizations of the Army Materiel Command, Army Corps of Engineers, the

RD&A NEWS BRIEFS

WRAIR Scientist (Cont.)

Army Medical R&D Command, and the Office, Deputy Chief of Staff, Personnel. Researchers presented 96 scientific papers.

COL Jerald J. Sadoff, MC, chief of the Department of Bacterial Diseases, WRAIR, was the principal author of the winning paper, titled "Immunologic Prevention and Treatment of Septic Shock." The paper described preparations of new vaccines to protect against septic shock, a frequently lethal complication of combat casualties. Sadoff collaborated with researchers from the Stanford University School of Medicine and the School of Medicine, University of California, San Diego.

Septic shock occurs as a result of battlefield trauma, burns and surgery, when bacteria enter the blood stream. A toxic component of the bacterial cell wall, called lipopolysaccharide, interacts with the immune system, causing the patient to go into shock and organ failure. The condition is fatal in up to 70 percent of the cases.

Sadoff and his colleagues used a mutant form of a common bacteria (E. coli) to produce antibodies to the toxic substance. Cells of the mutant bacteria were used in a vaccine which successfully immunized test animals and humans. Serum taken from immunized humans helped prevent septic shock in numerous post-surgical patients in intensive care wards. A monoclonal antibody has also proved effective, and is now in clinical trials. The monoclonal antibody has been used to make an experimental synthetic vaccine which will also be tested.

Significant reductions in mortality from septic shock were achieved in tests. A successful vaccine could be used in all military personnel in anticipation of combat because of the high risk of injury and subsequent septic shock.

Researchers assigned to WRAIR also won the Siple award at the Army Science Conference in 1984 and 1986, for development of new vaccines against infectious diseases that pose threats to deploying military personnel.

WRAIR Named Top R&D Organization

The Walter Reed Army Institute of Research (WRAIR) received the Army Research and Development Organization of the Year Award for 1988. Dr. J.R. Sculley, assistant secretary of the Army for research, development and acquisition, presented the award to COL Fred Tyner, MC, commander, WRAIR in a ceremony at WRAIR late last year.

The award is presented annually to the Army research, development test and evaluation organization judged most productive and best managed during the preceding fiscal year. This is the second time in three years that WRAIR has received the award.

Outstanding accomplishments during the period of consideration (FY87) included both scientific and administrative achievements in support of the internationally recognized DOD AIDS research and screening program, conducted by WRAIR. WRAIR integrated a $50 million AIDS research effort into its existing organizational structure, with no new manpower authorizations, and no major sacrifices of existing programs.

During the same period, WRAIR researchers discovered a way to reverse drug resistance of malaria parasites, which still pose a major medical threat to deploying soldiers. New antimalarial drugs and new vaccines against hepatitis A and meningitis B were field tested.

CONFERENCES

Defense Analysis Seminar V Announced

The Defense Analysis Seminar V (DAS V) will be held Sept. 16-23, 1989 in Seoul, Korea. The seminar is co-sponsored by Deputy Under Secretary of the Army (Operations Research) Walt Hollis, and Hwang, Kwan Young, president, Korea Institute for Defense Analyses.

The purpose of the seminar is to foster international discussions of analysis pertinent to current ROK-U.S. issues. Emphasis is placed on improved analytic methodologies rather than specific study results.

The U.S. delegation for the seminar will be composed of representatives from the Department of Defense as well as from the contractor and academic communities. Papers proposed for presentation will be competitively selected by the deputy under secretary of the Army (OR).

Seminar inquiries should be directed to the Office of the Deputy Under Secretary of the Army (OR), ATTN: SAUS-OR, Washington, DC 20310-0102 or telephone MAJ Jim Grussmeyer on AV 227-0367 or commercial (202) 697-0367.

Call For Papers

Non-linear optical polymers (NLOP) will be a featured topic at a science symposium, June 13-14, 1989, at the U.S. Army Natick Research, Development and Engineering Center, Natick, MA. Specific subjects will include non-linear optical affects in organic crystals and polymers, NLOP as eye protection against low power lasers, NLOP as conjugated unsaturated segments in the main chain, orientation of NLOP by electric fields, and NLOP as functional elements. Abstracts of papers should be submitted by April 30, 1989 to Thomas Sklarsky, U.S. Army Natick RDE Center, STRNC-EMP, Natick, MA 01760-5041. Telephone AV 256-4687 or commercial (508) 651-4687.

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