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INTERNATIONAL COOPERATIVE EFFORTS

THE ABCA PROGRAM

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Professional Bulletin of the RD&A Community

FEATURES

DEPARTMENTS

COVER

The American, British, Canadian and Australian Armies Standardization Program is one of several programs designed to promote cooperative efforts between the United States and its allies.

INTERNATIONAL COOPERATIVE PROGRAMS

...As Simple As ABCA

By COL C.C. Smith

Introduction

Peace has a way of eroding the capability of an Army to fight along-side an ally. The United States has been rudely reminded of this fact throughout this century. World Wars I and II, and the Korean and Vietnam conflicts required adjustments to varying degrees to operating in a theater involving major and minor campaigns where allied forces operated on the flank or as part of a U.S.-allied combined force.

In each instance our capacity to interoperate improved over time but at a high cost in scarce resources. As a result, many international programs promoting rationalization, standardization and interoperability (RSI) through allied and U.S. cooperation exist to reduce the tendency of nations to pursue narrow, unilateral approaches in meeting national defense requirements.

U.S. Army policy supports several basic priorities to enhance our ability to fight beside other allied armed forces using compatible doctrine. This doctrine reflects common tactics, enables the Army to communicate and coordinate plans and actions, permits sharing consumables such as fuel, food and ammunition and provides the ability to care for each other's casualties, ensuring mutually high standards of medical support.

There are now numerous fora in which the Army participates to achieve the degree of RSI necessary to conduct a successful military operation involving coalition warfare. Chief among them are bilateral contacts between friendly armies that encompass regularly scheduled staff talks, the North Atlantic Treaty Organization (NATO) forums involving research groups, armaments groups, panels and other working parties and the American, British, Canadian, Australian (ABCA) (Quadripartite) Armies Standardization Program.

The ABCA Armies Program

The ABCA Armies Program was initiated shortly after the end of World

War II but is not currently well known. The origin of the program can be traced directly to the close cooperation developed during World War II. Within 24 months after "V-E Day" the desires of General Eisenhower and Field Marshall Montgomery to maintain hard earned interoperability between U.S. and UK forces had found voice in the 1947 "Plan to Effect Standardization." The plan was promoted by the United States, Great Britain and Canada and was designed to eliminate obstacles to cooperation. For the first time, equipment began to appear in the three armies with the designation ABC preceding the model and nomenclature of the item.

By 1963, Australia joined the program and in 1964 the formal program was ratified by the current agreement titled "Basic Standardization Agreement 1964" (BSA 1964). New Zealand associated in 1965 and, although not a signatory to the BSA, still maintains a close tie and sends a senior officer to the ABCA TEAL (Tactics, Equipment and Logistics) conference rotated among the four countries about every 18 months. The TEAL is attended by the ABCA Armies vice/deputy chiefs of staff who provide senior level guidance, priorities and direction for standardization action.
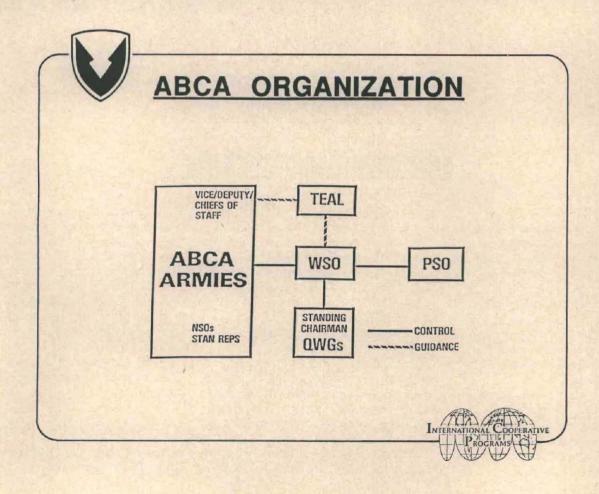
Ask a service member what the ABCA is and most likely you will get a rejoinder that may sound like this, "It is a new musical hard rock group," "It's a training aid for first graders," or "I don't know, but I'll play this game, what is it?" Even though the program has been around for more than 40 years it still remains relatively unknown and poorly understood by most soldiers. With the changes going on throughout the world it is quite possible that ABCA will assume a new significance in the life of a professional soldier and therefore increasing awareness of its existence is important.

Structure

It helps immensely to know the structure of something to better understand functioning. Structurally, ABCA consists of senior officer leaders (usually brigadier generals) appointed by each army and termed the Washington Standardization Officers (WSO). They are the focal point to guide and manage the program through monthly meetings in Washington to discuss policies, programs and procedures and resolve any national differences through direct contact. Deputy WSOs are appointed by the WSO to undertake duties on behalf of, or as directed by, the WSOs as needed.

A Primary Standardization Office (PSO), located in Washington, DC, performs the administrative and secretarial support required to run the program. This office consists of a director (colonel rank), provided by the countries on a rotational basis, and a lieutenant colonel (the Primary Standardization Officer or PSO) from each country plus other required staff provided by the four countries.

The key working elements of the program are the Quadripartite Working Groups (QWGs). Currently, 18 QWGs exist to exchange information, develop concepts, recommend areas for cooperation and standardization, develop Quadripartite Standardization Agreements (QSTAGS) and assist the WSOs

ABCA ORGANIZATION

VICE/DEPUTY/CHIEFS OF STAFF

TEAL

ABCA ARMIES

WSO

PSO

NSOs STAN REPS

STANDING CHAIRMAN QWGs

——— CONTROL
~~~~~~~ GUIDANCE

INTERNATIONAL COOPERATIVE PROGRAMS

where required to maintain the standardization achieved to date.

QSTAGS are formal agreements that are ultimately incorporated into "How to Fight" manuals and MILSPEC/MILSTDS and define the level of standardization to be achieved and maintained in materiel and non-materiel fields. They represent the culmination of much thought, evaluation and coordination to enhance interoperability.

The current QWGs are: Air Defense; Infantry; Armor; Intelligence; Army Operational Research; Logistics; Aviation; Nuclear-Biological-Chemical Defense; Combat Developments; Command and Control; Proofing, Inspection, and Quality Assurance; Communications and Information Systems; Surface-to-Surface Artillery; Electronic Warfare; Engineering Standardization; Surveillance, Target Acquisition, and Night Observation; Engineers; and Health Service Support.

Evaluation

In March 1989, a field training exercise (FTX), CALTROP Force '89, evaluated 102 QSTAGS (87 ratified and 15 draft) that were previously reviewed and recommended by the QWGs. Selected U.S. and allied Army, Navy, Marine and Air Force elements participated in the continuous 12 day force-on-force exercise conducted at Fort Hunter Liggett, CA. Friendly maneuver forces included a U.S. brigade headquarters which commanded and controlled one battalion from each ABCA Army. The FTX included ground, sea and air operations with initial airborne, amphibious and air assaults providing an excellent mix of joint and combined forces realistic training. It was also a fertile environment to evaluate procedures, interoperability and identify areas requiring new or revised agreements.

Results

The FTX, using fully integrated ABCA evaluation teams, was invaluable in assessing the capability of the forces to interoperate. The extraordinary training opportunity was unprecedented in the life of the ABCA Program. The results reflected an astonishingly complete interoperability on 50 QSTAGs and partial interoperability on 42 others. Two were found to contain no interoperability, one was recommended to be cancelled while seven

were declared unsuited for evaluation at the level of this FTX.

All in all, a remarkable degree of compatibility existed among the forces as reflected in the evaluations for QSTAGs, some drafted literally decades ago and having been only academically evaluated prior to CALTROP FORCE '89. The end result clearly demonstrated that we are on the right track. ABCA national terminology peculiarities did present sufficient ambiguity to warrant publishing a "Staff Officer's Handbook" to clarify terms, but was not a major hindrance for coordinating activities.

Army Materiel Command Role

To carry out in-country liaison with the ABCA countries, each Army designates a senior standardization representative located in the capital city of each of the other countries. They work directly with the staffs and agencies of the Army to which they are accredited and become an in-country point of contact. Other standardization representatives can be placed in the ABCA countries as required, subject to agreement between the concerned Armies.

Offices are established in each ABCA country's capital, called the National Standardization Office (NSO), to coordinate the ABCA Program within its own Army. These offices vary in size and operating procedures but they manage day-to-day participation in the program by the four armies. The U.S. Army NSO is located in the Army Materiel Command's Office for International Cooperative Programs in Washington, DC. That office staffs and operates the NSO and acts as the U.S. Army action agent for the ABCA Armies Standardization Program, except the TEAL conferences.

The U.S. Army currently has research, development and standardization groups in each ABCA capital. A group in West Germany, and offices in France and Japan that are not related to the ABCA programs, do many similar missions. All are assigned to AMC.

The U.S. Army group in London represents the oldest and largest such Army group. There are five senior officers stationed in London to perform ABCA duties with the group. They perform duties involving various international cooperative efforts between the United Kingdom's R&D establishments and their counterpart at AMC's major subordinate commands and laboratories. They also attend the military standardization programs of the NATO working party and Atlantic Council panel meeting where current or emerging operational requirements are addressed. They also take part in the Technical Cooperation Program subgroups, action groups and technical panels held in the host country.

Conclusion

The ABCA Program will undoubtedly remain an important vehicle to achieve increased combined combat power in an era of declining defense budgets, changing threats, revised R&D objectives, slowing modernization efforts and increased personnel turbulence.

Maintaining a close and mutually beneficial alliance is extremely difficult under the best of conditions. The elusive goal of interoperability is a constantly moving target. The ABCA Program focuses national will and effort and provides the framework so vital to establishing and sustaining a key program that helps us pool our defense resources and build defense muscle — muscle that could be needed if history can be relied upon to reflect our future from our past.

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THE ARMY'S INVESTMENT STRATEGY FOR AUTOMATIC TARGET RECOGNITION TECHNOLOGY

By Dr. Arthur R. Sindoris and Dr. Norman J. Berg

Introduction

The Army has devised an investment strategy to guide its approach to developing automatic target recognition (ATR) technology. This investment strategy provides the philosophy and establishes the appropriate balance for the Army's technology base program in ATR. The strategy balances short-term applications focusing on aided target recognition projects and longer term investments in autonomous target recognition capability. In this way, ATR development should meet the needs of both current and future systems.

At the same time, a technology development plan (TDP) was devised to baseline the program schedule, cost, and major technical milestones for each of the technology base projects that are critical to the advancement of ATR technology. All critical ATR projects were included, whether they are funded by the Army or by other organizations, such as the Defense Advanced Research Projects Agency (DARPA).

Together, the investment strategy and the TDP provide a common set of objectives, exit criteria and guidance for focusing resources and ensuring maximum progress in the development of ATR technology for Army applications.

Background

Recognizing the capabilities prom-ised by ATR technology and its potential for solving many high-priority battlefield deficiencies, the Training and Doctrine Command (TRADOC) has made known its strong support for Army investment in ATR. Accordingly, the deputy assistant secretary for research and technology in the Office of the Assistant Secretary of the Army for Research, Development, and Acquisition (OASA(RDA)) requested the Army Materiel Command and the Army Corps of Engineers to develop a comprehensive investment strategy for ATR technology. The Signatures, Sensors, and Signal Processing Technology Organization of the U.S. Army Laboratory Command led the preparation of the investment strategy and companion TDP.

The investment philosophy was established in a series of technical workshops that were held with the technical directors of the major subordinate commands (MSCs) and the lab directors involved in executing major technology base projects in ATR. Based on their assessments of the technical progress and status of current ATR projects, workshop participants agreed on an investment philosophy aimed at producing the ATR technology needed in the 1990s.

Once the philosophy and strategy were established, a number of technical working group sessions were convened to devise a comprehensive development plan. Senior technical experts from each MSC reviewed the approximately 100 on-going ATR related projects in the Army technology base, examining the technical approaches, expected results, risks, and milestones. The projects were priority ranked based on objectives, timeliness, technical products, and overall support for the technology needs of Army system developers. Project schedules were adjusted to ensure alignment with technology insertion milestones in system development schedules. Program enhancements were recommended to close technical gaps, and joint demonstration projects were recommended to facilitate the transfer of technology from the laboratories to the field.

The TDP that resulted from the deliberations of these expert working groups serves as the road map for the Army's investment in ATR technology. The investment strategy and technology development plan were presented to the MSC technical directors, the Technology Base Advisory Group, and (OASA(RDA)). In February 1990, the deputy assistant secretary for research and technology approved the plan for implementation.

Aided vs. Autonomous Target Recognition

The distinction between aided and autonomous types of ATR is one of degree of automation. Aided target recognition refers to an automatic cueing process in which a signal-processing system assists a human operator in recognizing targets. Autonomous target recognition implies a fully automated process with no operator involvement; once activated, such a system recognizes targets and initiates weapon action. Clearly, autonomous target recognition is a much more ambitious goal than aided target recognition.

Automatic target recognition (ATR) in general comprises varying degrees of automation, including both the aided and autonomous types. ATR is defined as a function occurring after target signature data are collected by a sensor (or multiple sensors), in which signal processing (software and algorithms) and signal processors (hardware) classify, recognize, identify, interpret, and display the significance of target data, for the purpose of initiating real- or near-real-time action or providing options for action to an external system operator. (This general definition of ATR is not intended to cover reconnaissance activities, such as automatic photo interpretation.)

ATR Investment Strategy

During the technical workshops on the ATR investment strategies, different proposals were considered, three of which are shown below:

• Invest in the fundamental underpinnings and systematic understanding of ATR technology, with transitions occurring when the technology is ready.

• Allocate available ATR technology base resources to near-term system applications at the earliest possible transition opportunities to meet system requirements.

• Focus on near-term system applications needing aided target recognition capability, balanced with mid- to long-term investments in autonomous target recognition and moderate- to high-risk, high-payoff ATR projects.

The balanced strategy proposed in the third option was chosen for implementation. These are the objectives, benefits, and key points of the investment strategy:

• The program focuses on dedicated ATR projects, both aided and autonomous, with specific technical products inserted into systems at specific system milestone dates.

• Near-term aided target recognition technology is driven by key system performance parameters, such as probability of false alarms, detection, classification, and recognition.

• Mid-term autonomous target recognition technology is driven by the technical needs of smart weapon system concepts that must autonomously detect, classify, and recognize targets.

• A long-term program is structured to investigate moderate- to high-risk ATR technology, both aided and autonomous, that has high payoff for significantly improving the performance of future aided and autonomous systems.

• In general, the ATR technology base program is structured so that the autonomous target recognition projects build on the technology developed in the aided target recognition projects, and both areas leverage the investment in emerging sensor and signal-processing technologies being developed at the Department of Energy

A second key step in developing the investment strategy and TDP was the analysis of the next-generation and future Army systems concepts that would benefit from the application of ATR technology.

(DOE) and the Strategic Defense Command (SDC).

• Key ATR programs at DARPA and in the Balanced Technology Initiative (BTI) of the Office of the Secretary of Defense (OSD) are integrated directly into the Army's investment strategy; these are considered necessary to advance Army ATR technology and attain system performance goals.

• Also leveraged are ATR technology base programs in the Air Force, Navy, and industry, through formal coordination at the OSD ATR Steering Group and by exchange of technical results at the working level.

Assessment Of ATR Technology

As a first step toward establishing the TDP, the technical directors assessed the current state of the art in ATR technology and the adequacy of the current Army investment to advance the technology on a schedule compatible with the system developers. At an ATR investment strategy workshop hosted by the Institute for Defense Analysis, the participants reviewed the Army's technology base projects in ATR, along with those of the Air Force, Navy, DARPA, DOE, and SDC.

Overall, it was determined that the level of resources invested in aided target recognition was credible, when DARPA and BTI funding was included. In contrast, the level of funding for autonomous target recognition technology was low, even with DARPA and BTI support. However, more rapid advancement appeared to be limited less by low funding than by the lack of a comprehensive understanding of the scientific basis for ATR technology.

The technical directors also determined that in the research, development, and engineering centers (RDEC), uneven levels of effort were devoted to technology base ATR projects and to coupling them with system milestones and schedules. Fragmentation and weak coupling among ATR efforts at RDECs and labs reduced the effective critical mass of the technology base program. Generally, however, the technology base projects in aided target recognition were more supportive of and effectively coupled to system milestones than were those in autonomous target recognition. For smart weapons systems whose ambitious performance goals require autonomous target recognition technology, workers in tech base projects were making their best efforts to achieve a useful level of performance, without "pass/fail" standards for success.

For the detailed assessment, the technology was divided into technical areas, and a judgement was made as to the adequacy of the investment in each area. A summary of the findings is given in Table 1.

Although the investment in many of the technical areas appeared adequate, work in a few areas, critical to the successful advancement of ATR, was not

Table 1. Assessment of Adequacy of Investment in ATR Technology

Technical Areas	Current Level of Investment
Signal Processing	
Algorithms	Insufficient
Hardware	Adequate
Sensors	
Single	Adequate
Multiple	Insufficient
Signatures	
Target	Adequate
Background	Adequate
Countermeasures/ counter-countermeasures	Insufficient
Supporting Technology	
Propagation	Adequate
Modelling	Insufficient
Man/machine Interface	Insufficient
Performance Evaluation	Adequate
Tech Demo/ATTD	Requires Adjustments

up to an acceptable level. These deficiencies, stemming from inadequate resources, inappropriate technical approaches, high risk, or schedule problems, included the following:

• The investment in algorithms, one of the technical areas most critical for the success of ATR technology, was insufficient to meet the performance goals of the systems using ATR technology.

• The investment in multiple-sensor ATR technology was insufficient to realize the significant advantages of a multiple-sensor system.

• Countermeasure/counter-countermeasure work needed to be strengthened.

• Although man/machine interface supporting technology is critical to the success of aided target recognition systems, insufficient work was in progress to develop the technology to interface an operator with an aided targeting system.

• Insufficient ATR modelling work was planned, despite its importance for optimizing the performance of future ATR system concepts.

Correction of these deficiencies, both general and specific, formed one of the major justifications for the recommended enhancements and adjustments in the TDP.

Capability Objectives For ATR Technology

A second key step in developing the investment strategy and TDP was the analysis of the next-generation and future Army systems concepts that would benefit from the application of ATR technology. These Army systems were divided into two groups, according to whether they would benefit from aided or autonomous target-recognition technology. The systems listed in Table 2 involve a human operator in the targeting system and would benefit from automatic cueing of targets. The needs and schedules of such systems would drive projects in aided target recognition. The systems listed in Table 3 are those that, once activated, function without further human intervention, and this might benefit from autonomous target recognition technology. The needs and schedules of these systems would drive projects in autonomous target recognition.

The time lines for development of each system and the major milestones planned for insertion of ATR technology were determined. These system milestones then were grouped into a set of generic capability objectives, around which the TDP was structured.

Three generic capability objectives were established based on the aided target recognition needs of the systems in Table 2. Since the baseline and P3I (preplanned product improvement) plans for the Light Helicopter (LH) include quantitative aided target recognition requirements, these requirements were used as a model for judging current and future capabilities. It was determined that, if aided target recognition was assessed as adequate for LH, it would certainly benefit the other systems on the list. Each capability objective is described below:

• CI — Milestone FY93: For single-sensor systems, an ATR capability that aids the operator to detect and classify targets, with some false alarms allowed in low clutter.

• CII — Milestone FY95: For multiple-sensor systems, an ATR capability to detect, track, and recognize targets with a low false-alarm rate.

• CIII — Milestone FY98: A compact, high-resolution, integrated, multiple-sensor suite for non-cooperative target recognition with a very low false-alarm rate.

Four generic capability objectives were established based on the autonomous target recognition needs of the systems in Table 3. These systems are of three different types: reacquisition after firing, lock-on after launch, and smart mines. From an analysis of these system variants, the following capability objectives were developed for autonomous target recognition technology:

• CI — Milestone FY93: Single-sensor imaging with autonomous tracking, in which some false alarms occur in low clutter.

• CII — Milestone FY94: High-resolution imaging using multiple sensors, fused at voting level, performing classification with a low false-alarm rate.

• CIII — Milestone FY96: Multiple-sensor fusion performing recognition over large scan areas, having a low false-alarm rate in medium clutter.

• CIV — Milestone FY98: Multiple-sensor suite with robust lock-on-after-launch capability in heavy countermeasure environment over a large scan area, having a low false-alarm rate.

Technology Development Plan

The approximately 100 technology base projects that form the ATR TDP are divided into two groups, one supporting aided target recognition, the other supporting autonomous target recognition. Within each group the projects

are broken into the same technical areas used in the assessment (see Table 1, first column).

The technical objective, technical approach, major milestones, and schedule of each project are adjusted to align the project's technical products with the appropriate generic capability objectives. The plan corrects some of the deficiencies identified in the assessment by adjusting existing projects or adding project enhancements.

For example, better algorithm work is needed to lower the risk involved in meeting aided target recognition objectives CI and CII. The following project enhancements were recommended for reducing this risk:

• A two-year effort on hybrid algorithms starting in FY91. This will be aimed at improving current statistically based approaches by including some elements of model-based techniques.

• A two-year effort in knowledge-based algorithms starting in FY91. This will focus on using artificial intelligence techniques to include external knowledge of the target (such as map data and formations) into the algorithm in real time.

• A two-year effort on multiple-sensor fusion algorithms starting in FY91. In this project, existing algorithms will be modified and improved for correlating recognition data from two or more different types of sensors, such as radar and forward-looking infrared (FLIR) sensors.

• A three-year effort on hybrid neural networks starting in FY92. This effort will investigate the advantages of new hybrid neural networks composed of digital and optical signal processors.

• A four-year effort on model-based algorithms starting in FY92. This effort will develop new types of algorithms, based on the advances made under DARPA programs, to perform recognition with computer models of target signatures.

In the TDP, the projects suitable for autonomous target recognition applications are also broken into the key technical areas shown in Table 1. The projects and schedules were similarly structured to align their technical products with the relevant capability objectives for the systems in Table 3. Furthermore, the projects in this section of the plan build on and extend the fundamental capability established by the work on aided target recognition.

However, additional efforts are necessary to substantially lower the risk involved in striving for successful autonomous performance. In general, the addition of longer term efforts, such as the model-based and neural network algorithm projects discussed above, will definitely enhance autonomous capability, especially in lowering false-alarm rates — a primary concern in autonomous system operation.

A number of other program enhancements are recommended to further lower the risk involved in achieving the generic capability objectives. For example, one recommendation is the addition of an ATR smart weapons technology demonstration at the Armament RDE Center (ARDEC). This demonstration would be aimed at integrating various Army, DARPA, and BTI efforts which are developing sensors and algorithms for autonomous operation.

ARDEC's 155-mm fused sensor project is also recommended for an autonomous ATR project. This is a technology demonstration that will jointly support the development of a fully autonomous lock-on-after-launch system for both missile applications at the Army Missile Command and artillery projectiles at ARDEC.

Autonomous operation is indeed a very ambitious goal; however, there is a reasonable expectation for success through the combination of various Army- and DARPA-funded efforts. The projects that have been recommended for enhancement will increase the likelihood of achieving acceptable system performance in time for system insertion.

In summary, the Army ATR program incorporating the restructured and enhanced technology base projects in the TDP has these features and advantages:

• The leveraging of DARPA/BTI funds and cooperation with DOE is critical to the success of the Army ATR technology base.

• The ATR technology base projects are generally focussed on aided target recognition and effectively coupled to system milestones and schedules.

• Selected program enhancements are necessary to insure timely insertion of ATR technology into specific developmental systems.

• For smart weapon systems needing autonomous target recognition capability, the Army tech base builds on and extends the technology developed for aided target recognition. In general, however, the work continues on the basis of a "best effort" to achieve the ambitious performance goals set for these systems.

• Mid- and long-term investments in specific ATR technologies are added to the program to enhance ATR system performance and to foster the potential for the technology breakthroughs needed for future smart weapons.

• All major ATR technology base and

Table 2. Army Systems Benefiting From Aided Target Recognition Technology

LOSAT	Line-of-Sight Anti-Tank
LH	Light Helicopter
NLOS	Non-Line-of-Sight
FAAV	Future Attack Air Vehicle
AAWS-M	Anti-Armor Weapon System - Medium
ASM	Armored System Modernization **FIFV** - Future Infantry Fighting Vehicle **AFAS** - Advanced Field Artillery System
AMS-H	Army Missile System - Heavy
TACAWS	The Army Counter Air Weapons System
UAV	Unmanned Air Vehicle Short Endurance

Table 3. Army Systems Benefiting From Autonomous Target Recognition

155 MM SADARM	Sense & Destroy Armor (Cannon Launched)
MLRS SADARM	Multiple Launched Rocket (System Variant)
ATACMS SADARM	Army Tactical Missile System (Variant)
WAM	Wide Area Mine
Anti-Helo Mine	Anti-Helo Mine
ATCMS/MLRS w/WAM	System Variant
AAWS-M	Anti-Armor Weapon System - Medium
TACAWS	The Army Counter Air Weapon System
AMS-H	Army Missile System - Heavy
XROD	Advanced Tank Ammo
FSW	Future Smart Weapon
155 MM FFM	155 mm Fire & Forget Munition

demonstration programs are linked together to increase the effective critical mass of the program.

A Continuing Process

During the review of ATR technology base projects and the establishment of the system-driven capability objectives, the investment in some technical areas was judged to be insufficient. Some of the revisions and enhancements in the TDP correct these deficiencies; in other cases, more in-depth restructuring is needed and will continue as technical progress is made.

Examples of some continuing modifications are the following:

● A subordinate TDP for multiple-sensor fusion technology needed in airborne and ground targeting systems is being developed. The proposed effort not only includes algorithm work for fusing diverse sensor data but also includes technology demonstrations and an advanced technology transition demonstration.

● A man/machine interface technology project has been approved for improving the performance of target cueing systems.

● An initiative is under way to strengthen the understanding of the effects of countermeasures on the achievable performance of systems employing ATR technology.

The TDP will be revised as progress is made, old approaches abandoned, and new approaches instituted. In addition to annual technical reviews, as the deadline for the first two major capability objectives approaches in 1993, the Army technical community plans to convene for the next ATR investment strategy workshop and to perform another in-depth assessment of progress. At that time, the necessary adjustments will be made to help realize the promise of ATR for increasing the warfighting capability of the future Army.

Conclusion

Automatic target recognition is a high-priority technology, included in the category of advanced signal processing and computing on the Army's list of key emerging technologies. The ATR investment strategy and technology development plan put in place an overall approach and a set of common, time-phased technical objectives.

Actions are under way to correct the deficiencies identified by the assessment of the current ATR program. The Army technology base community is now fully engaged in following this guidance in the numerous working projects and the $40 million annual technology base investment in ATR.

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By Joe T. Potts

Introduction

During the Reagan administration, the DOD acquisition process was criticized by many, including Congress, for being too bureaucratic and overregulated. President Reagan established a Blue Ribbon Commission on Defense Management, chaired by David Packard, to study the process and make recommendations. The commission's final report was delivered on June 30, 1986 and stated, "Authority for acquisition execution and accountability. . .have become vastly diluted. Program managers have in effect been deprived of control over programs. They are confronted instead by never-ending bureaucratic obligations for making reports and gaining approvals that bear no relation to program success."

The report provided recommendations for a reorganization with emphasis on improved management responsiveness and reducing the number of layers to two levels between the program manager (PM) and the secretary of defense.

The Packard Commission strongly recommended streamlining major

A NEW PERSPECTIVE ON MATRIX SUPPORT

*Establishing a Partnership
Between the MSC
and the PEO and PM Staffs*

MATRIX SUPPORT TO PMs

MATRIX
SUPPORT
TEAMWORK
TO ACCOMPLISH
THE
MISSION

programs by having the PMs report to newly formed program executive officers (PEOs). The PEOs would report directly to the service acquisition executive. This eliminated the need to report through major commands (MACOMs). From a programmatic standpoint, the creation of the PEO structure did streamline the reporting process, where programmatic refers to the cost, schedule and performance aspects of the weapon system.

In implementing the Packard Commission recommendations, the Army sought small PEO and PM core staffs that relied on support from the MACOMs for execution of the various functional aspects of their programs. The PEO and PM core of managers, coordinators, expediters, and integrators were assigned direct responsibility for controlling weapon system program costs, performance and schedules. The MACOMs would provide the functional support to the PEOs and PMs.

The Army approach to providing this functional support was to adapt the matrix organization concept. An effective application of matrix support entails at least three key elements:

● An effective, efficient and flexible application of centralized resources vs. stand alone organizations.

● A common pool of experts to support program managers on an as needed basis in all the various disciplines of

weapon system development and deployment.

● A partnership between the functional support organizations and the program managers whereby all participants are working to achieve the same programmatic goals.

AMC's Role

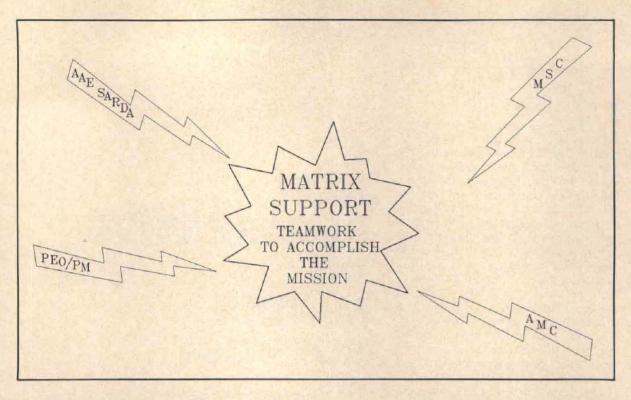AMC performs two supporting roles for major systems acquisition. First, AMC writes weapon system acquisition policy for Department of the Army adoption. Second, AMC provides the PEO and PM with the functional skills to meet the requirements for the development, acquisition and fielding of systems. AMC has chosen the matrix support approach to meet its obligations in assisting the PMs and PEOs in producing quality deliverables on major programs, efficiently and in a timely manner.

How Matrix Support Works

Based on the Packard Commission's findings, the Army implemented its PEO concept. The PMs rely on manpower from the major subordinate commands (MSCs) for execution of functional tasks, but the PM staff manages the efforts. The MSCs provide that functional support either using in-house resources or by contracting out for additional assistance.

Functional experts are provided to the PMs at different stages in the life cycle of the weapon system on an as required basis. Under this concept, functional expertise provided from the matrix organization includes such diverse elements of support as: contracting; resource and financial management; obligation planning and reporting; technical requirements analysis and allocation; test measurement, and diagnostic equipment support; value engineering; and international cooperation.

Funding

Funding aspects of matrix support can, at times, be awkward because more than one organization is involved. According to FY 91 guidance from the Office of the Assistant Secretary of the Army (Financial Management), the PM must specifically reimburse the MSC for in-house software development, engineering support of items in production, RDTE system specific work, new equipment training (in-house and contractor), first and second destination transportation, contractor field service representatives and total package fielding. All other functional support is funded by the MSC.

A Total Quality Management Perspective

We must recognize that matrix sup-

MATRIX SUPPORT
TO PM'S

PUTTING STEEL ON TARGET, ON TIME !

AMC MSC

SAFETY | MANPRINT | FIELDING | ILS | CONTRACTING

port involves more than providing bodies on major programs. Functional support experts and program managers share responsibility for the success or failure of the program. If matrix support is going to work, it must be a partnership between the MSC and the PEO and PM staffs to produce a high quality product on time. The emphasis must be on results (quality products) instead of man-years provided. In the past, our focus may have been solely on the number of in-house resources that were provided. What we need today is a new matrix support philosophy in which we make a commitment to doing whatever is necessary to produce high quality deliverable items on time.

Under the total quality management concept, the PEOs and the PMs are the customers. The MSC commander has established a partnership with the PEO and the PMs with a commitment to achieve program goals. The matrix organization should depend on feedback from the PEO and the PM on how well it is fulfilling its role in the partnership and how to improve the quality of the products.

Support Plans

If we embrace this alternative approach, then the support plan should focus not on the man-years provided, but rather on the tasks that must be accomplished. The MSC's concern, in turn, will be on doing whatever is necessary to assist in completing the required tasks. Success depends on getting the job done and not just meeting an agreed to number of man-years of support.

The support plan is the basis for the annual Memorandum of Agreement between the MSC and the PEO, and is jointly developed and negotiated by the MSC and PEO and the individual PM before the start of the fiscal year. The plan identifies the support required by the PEO and PM and the MSC commander's plan for providing that support.

Summary

Although the PEO concept was implemented more than three years ago, there are still policy issues associated with matrix support. The matrix support system is continuing to evolve, and to clarify new matrix support policy issues as they arise, the military deputy to the Army acquisition executive (AAE) meets frequently with AMC's deputy commanding general for research, development and acquisition.

As issues are resolved, the clarified policy is disseminated to the acquisition community, usually via an AAE policy memorandum. Formal policy is later codified in the appropriate Army regulation, pamphlet, handbook, etc. Today's Army acquisition organization needs to understand this new perspective on matrix support if AMC, its MSCs, and the PEOs and PMs are to produce quality products on time.

The matrix support provided to PEOs and PMs is designed to accommodate the dynamic nature of project management and the total acquisition program. It allows the PEO and PM core staff to concentrate on management of the programmatics (cost, schedule, performance) for major weapon systems while the detailed tasks are carried out by the functional professionals from the MACOMs. The system may not be perfect, but an active partnership between the AAE and MACOMs may be the most effective avenue for improving the Army's acquisition process.

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THE HUMAN FACTOR IN INFORMATION DISPLAYS

Impact of an Air-To-Air Combat Task on Piloting Performance

By Mary E. Dominessy,
Richard A. Monty,
Jeffrey H. Lukas,
Frank J. Malkin, and
Lynn C. Oatman

Introduction

The modern battlefield has become a proving ground for high technology. Army aviation is no exception. Design engineers are faced with requirements to lighten the load, reduce crew size, deliver more firepower, and fight air-to-air battles. To accomplish these goals the helicopter cockpit of the future must be highly computerized and must allow for the simultaneous presentation of large quantities of information. The human factor (i.e., matching the capabilities and limitations of the human to

Figure 1.
The HEL simulator showing an experimenter in the foreground observing the situation display and the navigational display both of which appear on the pilots instrumentation panel. The pilot also viewed an out-the-window scene as shown in the background.

the presentation of that information) must be considered.

The U.S. Army Human Engineering Laboratory (HEL) at Aberdeen Proving Ground, MD, recently compared three computer-generated display formats for presenting tactical information to pilots regarding engagement of specific airborne targets presented on a situation display. National Guard pilots flew the helicopter simulator shown in Figure 1. The long term goals of this research program are to enhance target acquisition performance and to determine if the target acquisition task will overload the pilot, thus requiring assistance from an additional crew member.

Specifically, the formats studied used either text, symbols, or numbers to instruct the pilot to search for a designated target. These formats are illustrated in Figure 2. Following receipt of the instructions, the pilot was required to search the situation display, which is shown in Figure 3, and touch the designated target.

The specific measures used to evaluate target acquisition and flying performance as a function of display format were:

• **Acknowledgement Time.** Time taken to press a button indicating that the target instructions had been read and comprehended.

• **Search Time.** Time taken to search the situation display and touch the target.

• **Altitude Maintenance.** Deviation from the assigned altitude.

• **Airspeed Maintenance.** Deviation from the assigned airspeed.

• **Perceived Workload.** Personal rating of the amount of effort required in each mission.

The Missions

National Guard pilots flew four missions in the simulator using each of the three display formats while serving as pilot and again as copilot. When serving as copilot only the target acquisition task was performed. In addition to the target acquisition task, pilots were required to navigate along a river that meandered through mountains and trees while maintaining an altitude of 150 feet and an airspeed of 50 knots. Periodically, they were alerted by an auditory tone that they were about to receive tactical information. They were instructed to maintain the designated airspeed and altitude as best as they could while performing the target acquisition mission. Failure to attend to the incoming tactical information amounted to mission failure. At the end of each mission, the pilots indi-

cated how difficult it was to perform that mission.

The research produced the following results:

Acknowledgement Time

The test participants experienced a serious degradation of acknowledgement time when simultaneously piloting the simulator. Specifically, it took them 75 percent longer to acknowledge the instructions than when performing as copilots. Further, time to acknowledge the instructions was slowest with the text, 17 percent faster with symbols, and 30 percent faster with numbers.

Search Time

Similarly, search time was also adversely affected while piloting the aircraft. Search times were observed to be 32 percent slower when performing as a pilot than as a copilot. However, the time to search the situation display was the same for all three display formats.

Altitude Maintenance

Just as piloting the aircraft adversely affected target acquisition, the pilots' ability to maintain altitude was

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DISPLAY FORMATS

TEXT

HOOK

ROTARY WING
HOSTILE
4 9

SYMBOLIC

HOOK

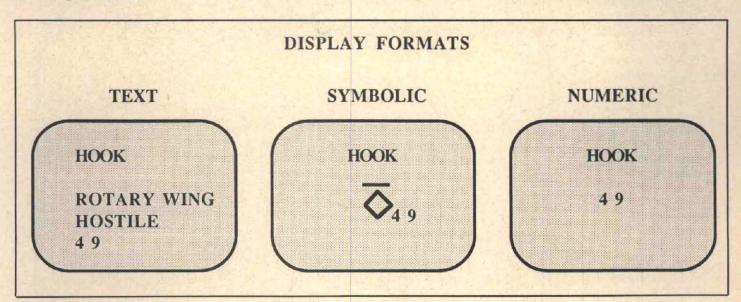◇ 4 9

NUMERIC

HOOK

4 9

Figure 2. The three display formats.
In each case, the word "HOOK" was presented in red while the type of aircraft and track number were presented in green, all on black backgounds.

degraded 27 percent when simultaneously performing the target acquisition task. This degradation occurred regardless of display format.

Airspeed Maintenance

As with altitude maintenance, the pilots' ability to maintain airspeed was degraded 18 percent when simultaneously performing the target acquisition task. Again, this decrement occurred regardless of display format.

Perceived Workload

The effort required was perceived to be much higher when piloting than when copiloting. Although pilots indicated that the three formats required the same amount of effort, as copilots, they rated the text format as the most difficult and the symbol format as the least difficult. These results are shown in Figure 4.

Conclusion

Two important findings emerged from this research. First, the target acquisition and piloting performance deteriorated dramatically when both tasks were performed together compared to when either task was performed alone. We observed that the pilots could not perform the flying and target acquisition tasks simultaneously but alternated between them. The two tasks were physically incompatible since it was difficult to perform the continuous manual task of flying concurrently with the discrete manual task of touching the display. Further, the pilot could not look at the flight instrumentation, the situation display, and the outside scene simultaneously, but alternated among them. One potential solution to perform this acquisition task, may be to provide an additional crew member.

Secondly, with respect to the target acquisition task, the instructions using text required the longest time to acknowledge and were perceived as the most difficult to use. Performance was faster with the numeric format than the symbolic format; but, when copiloting, test participants reported that the symbolic format was the easiest to use. Further research is required to firmly establish which of these two formats is a better alternative.

Continuing research of situation displays at HEL is now investigating such factors as auditory presentation of search instructions and verbal acknowledgement of these instructions. These techniques might make the target acquisition task more compatible with piloting by reducing demands on the visual and motor systems which appear to be overloaded. Color coding of symbols is another variable being investigated which could serve to reduce the visual load.

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Figure 3.
The situation display depicted 12 aircraft with track numbers, designated as friendly (circle), hostile (diamond), and unknown (letter U). The bar over top of the symbol indicated rotary wing and the lines within the symbols are direction vectors.

Figure 4.
Mean subjective workload scores as a function of display format and crew status (pilot vs. copilot).

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ARMY SCIENCE BOARD 1990

By COL Thomas E. Stalzer and
Dr. Juergen L.W. Pohlmann

Introduction

The Army Science Board (ASB) is the Department of the Army's senior scientific advisory body. The board provides advice to the secretary of the Army and chief of staff of the Army on research and development activities and programs, systems acquisition policies and procedures, and other matters involving science and engineering.

The ASB operates under the cognizance of the assistant secretary of the Army (research, development and acquisition) (ASA(RDA)). The assistant secretary appoints an Army colonel as executive secretary of the ASB, who at the same time becomes an ex-officio member of the board and acts as a liaison between the assistant secretary and the board. The chair and the vice of the ASB are also selected from the membership by the ASA(RDA).

Missions

Basic missions of the Army Science Board are:

• To provide independent scientific, technological, and managerial expertise to review major Army programs and/or to render quick assessment of new program initiatives;

• To function in an ambassadorial role between the Army and commercial research and development activities; and

• To act as consultant to the Army on all matters of science and technology.

The Army Science Board is comprised of distinguished academics, corporate officials, private consultants, representatives from National Laboratories, and a few non-DOD federal employees. Members are selected according to their preeminence in their respective fields; a balance of disciplines on the board is carefully maintained to ensure coverage of all fields.

Individual expertise ranges from aeronautics to zoology and includes many of the engineering fields as well as law, psychology, medicine, architecture, material sciences from ceramics to explosives, toxicology, and others.

Often, ASB members are affiliated with prestigious organizations such as the National Academy of Sciences, the National Academy of Engineering, or the National Research Council. Nominations for membership are received by the ASA (RDA) from within the government and the private sector.

History

The history of the Army Science Board dates back to 1951 when it was originally established by the secretary of the Army on a trial basis as the Army Scientific Advisory Panel (ASAP). In 1954, the 10 member panel increased its membership to 25 and became a permanent Department of the Army Board. In 1956, activities of the panel accelerated substantially with the formation of subpanels. However, after a panel reorganization in 1963, the subpanel structure was abolished in favor of an Ad Hoc Group system. The ASB, as it exists today, was chartered in 1977 to perform the duties previously assigned to the ASAP and several other Army scientific panels and committees.

Reorganization

Recently, the ASB underwent a thorough review by the secretary of the Army. As a result of this review, the board has been reorganized to focus on a small number of general issues with long-term impact on the Army. Prior to this review, the individual and group expertise available in a functional subgroup was only exercised when study topics were focused on problems as they surfaced. To make better use of the full potential, the Army Science Board now focuses predominantly on long-term Army tasks and issues. Thus, the mission of the ASB is not changed, just its mode of operation.

Topical Issue Groups

After numerous meetings of the Executive Steering Committee, the board has been organized into six topical issue groups: Research and New Initiatives; Systems; Command, Control, Communications, and Intelligence (C3I); Infrastructure and Environment; The Soldier as a System; and Logistics and Sustainability.

Each of these new issue groups reflects a specific element of the Army organizational structure and is linked to a sponsor with specific funding categories, resources, and tasks.

The Research and New Initiatives issue group is linked to the duties and tasks of the deputy assistant secretary for research and technology. The bulk of the appropriations is RDT&E money and comes in the 6.1-6.3A funding lines. Accordingly, most projects are administered by the Army Research Office and the respective Army laboratories or Army research, development and engineering centers. Their tasks stretch from basic research covering all science and engineering areas to delivery of exploratory or breadboard devices as proof-of-principle or Advanced Technology Transition Demonstrators.

The foremost duty of the Research and New Initiatives group is to advise the secretary of the Army on the health of the Army's technology base, and to validate the results of such specific efforts. Members of this group were recently involved in an ASB review and validation of the Army's Technology Base Master Plan, and participated in a Congressionally directed two-phase technology study of the Electromagnetic/electrothermal Gun System. A study currently getting underway will develop initiatives to improve the participation of historically black colleges and universities in Army research, development and acquisition.

The Systems and the Command, Control, Communication and Intelligence (C3I) issue groups have some basic functions in common. The former is linked to ASA(RDA)'s deputy for systems management, who has OASA(RDA) staff responsibility for development, acquisition, and fielding of weapon systems. The C3I issue group is aligned with the director of information systems for command, control, communications and computers (DISC4), who is tasked with the staff responsibility for development, application, acquisition, and maintenance of software in the field. Both offices receive RDT&E funding in the 6.3 to 6.7 categories, as well as procurement appropriations.

As would be expected, some overlap exists as some weapons systems have specific software imbedded. These two

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TOPICAL ISSUE GROUPS

Research and New Initiatives
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Vice Chair: Dr. James A Tegnelia
Sponsor: OASA(RDA), George T. Singley, III
DA Staff Assistant: Dr. Daphne Kamely
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Systems
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Vice Chair: Dr. Wesley L. Harris
Sponsor: OASA(RDA), MG. Richard D. Beltson
DA Staff Assistant: LTC John P. Geis
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Vice Chair: Richard B. Lewis, II
Sponsor: DISC4, LTG Jerome B. Hilmes
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Vice Chair: Dr. Joyce L. Shields
Sponsor: OTSG, MG Philip K. Russell
DA Staff Assistant: COL Roy K. Sedge
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Vice Chair: H. Wayne Pacine
Sponsor: ODCSLOG, LTG Jimmy D. Ross
DA Staff Assistant: Joseph P. Cribbins
TEL: 202-697-0487

ARMY SCIENCE BOARD

Executive Director: Hon. Stephen K. Conver
                                       Assistant Secretary of the Army
                                       (Research, Development and
                                          Acquisition)
Chair: Dr. Duane A. Adams
Vice Chair: (Vacant)
Executive Secretary: COL Thomas E. Stalzer
Asst. Exec. Sec.:   Dr. Juergen L. W. Pohlmann

issue groups will advise the secretary of the Army on the development, integration, and maintenance of fielded systems and verify their viability and effectiveness.

Recent ASB studies performed by these two issue groups include the Tactical Explosive System, Maintaining State-of-the-Art in the Army Command and Control System, the Transverse Mounted Engine Propulsion System, the Sense and Destroy Armor Munitions System, Software in the Army, and an ASB Independent Assessment of the Longbow Program. Studies currently underway include the Stinger Reprogrammable Microprocessor.

The Infrastructure and Environment issue group is closely linked to the Army Corps of Engineers director of research and development. Funding for his tasks and projects span 6.1 to 6.7 funding categories. Massive tasks in conjunction with environmental clean-up and the cost of maintenance or closure of Army facilities require completely new approaches. The secretary of the Army will look to this group for expert advice and recommendations on novel, imaginative, and affordable solutions. The ASB recently issued a report on toxic and hazardous waste management.

The Soldier as a System issue group is sponsored by the surgeon general, whose funding comes in the 6.1 through 6.7 lines and other funding categories. The tasks extend far beyond the purely medical issues; they also include, but are not limited to, biotechnology, clothing/equipment, MAN-PRINT, safety, survivability, and behavorial sciences. The secretary of the Army needs independent advice in these rapidly expanding technology areas. One recently published ASB study is entitled: "Army Community

and Their Families." The board just completed an Independent Assessment on the Life Sciences Capabilities at Dugway Proving Ground, UT.

The Logistics and the Sustainability issue group is concerned with the combat readiness of forces. The sponsor is the deputy chief of staff for logistics, whose tasks are funded by 6.1 through 6.7 appropriations and other funding categories. Rapid international and technical changes require a constant rethinking of logistics, and the ASB's advice will enable the Army leadership to make prudent choices. The ASB just completed the 1990 Summer Study on Reduction of Operation and Support Costs.

Recommendations offered by the last three issue groups often are complementary and intertwined. They will enable the secretary of Army to select those options which ensure the effective maintenance of modern bases with well trained soldiers and combat-ready forces.

The tangible output of Army Science Board studies are reports; five to 10 documents are published every year and distributed to the appropriate agencies. The ASB just published a report on Total Quality Management, and currently is preparing the final report of the 1990 Summer Study on Use of Army Systems and Technologies in Counter-Narcotic Efforts.

In the past, some major Army initiatives affecting hardware, training, doctrine, and policy have had their origin in ASB studies. Findings and recommendations from ASB activities accepted by the Army leadership are assigned for follow-up to the deputy under secretary of the Army for operations research. Working in direct coordination with the ASB's

designated point-of-contact, his office oversees the Army's review and implementation process for specific ASB recommendations.

In addition to the Ad Hoc Panels and the Summer Studies, the Army Science Board each year conducts several Laboratory Effectiveness Reviews. However, findings and recommendations of these peer reviews are only reported to the sponsors and are not published or distributed.

Conclusion

The recent internal reorganization of the ASB into six topical issue groups was undertaken to ensure that the Army leadership is provided timely advice regarding some of the global and hard-to-tackle scientific and technical issues that impact the Army and the nation. Allocating the vast resources of expertise and experience in topical issue groups, the ASB will continue to serve the secretary of the Army as his prime source of independent scientific advice.

COL THOMAS E. STALZER has been the executive secretary of the Army Science Board since June 1989. He is a field artillery officer whose previous assignments include two tours at HQDA and command of a field artillery battalion.

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THE PRECISION RANGE INTEGRATED MANEUVER EXERCISE

By LTC Richard Peters
and Kenneth Lewis

Introduction

In the late 1970s, PM TRADE — the U.S. Army's Project Manager for Training Devices — fielded the first Multiple Integrated Laser Engagement System (MILES), a laser-based direct fire approach to tactical engagement training. Originally developed as a trainer for infantry and mechanized infantry, the versatile MILES technology — over the last decade — has been adapted by both users and PM TRADE to meet a variety of training needs. For example,

MILES has become a key element in the automated and instrumented National Training Center (NTC) at Fort Irwin, CA.

At the NTC, maneuver battalions are outfitted with MILES devices and weapons effects simulators, matched against skilled opposing forces and allowed to engage in force-on-force free play tactical engagements. An automated network of instrumentation allows the capture and after-action review of critical performance data such as casualties and equipment loss, movement of weapons and targets, and

the effects of simulated area weapons such as indirect fire.

The MILES and instrumentation technologies which make the NTC a cornerstone of modern maneuver training are now being applied to existing gunnery training ranges for the enhancement of tactical engagement skills by tank and mechanized infantry crews. PM TRADE, working with III Corps, Fort Hood, TX, recently completed development and installation of the Precision Range Integrated Maneuver Exercise (PRIME) system.

The first PRIME system was installed at Fort Hood in October 1988; it has been modified extensively over the past two years and was moved to Schweinfurt, FRG, in August 1990.

The PRIME system was designed as an enhancement to the existing Automatic Tank Target System (ATTS) range, which uses M1 and M2/M3 MILES with Laser Target Interface Devices (LTIDS) and "pop-up" targets to train M1 and M2 vehicle crews in a non-live fire situation. The fielding of PRIME to an existing range provides:

• Event-driven target control with target shoot-back capabilities for MILES tactical range training;

• Target/vehicle event and data collection through on-board collectors and a sophisticated telemetry data link;

• An upgraded after-action review system that integrates collected range data with recorded thru-sight video images, and graphic display of the range; and

• Vehicle/target player identification to determine "who shot whom."

The Need for PRIME

TRADOC, the Army's Training and Doctrine Command, had long recognized that existing methods of small unit (crew, platoon, and company) training did not adequately integrate gunnery and maneuver training. This deficiency, coupled with the lack of a technology to measure performance and present results in timely after-actions reviews, led to a cooperative exploration of the PRIME concept by PM TRADE and III Corps. A prototype, assembled from off-the-shelf and government-furnished components, was tested at Fort Hood in 1988; further integration and testing was carried out during 1989 and early 1990.

PRIME has been designed to train crews and platoons in the integrated maneuver and gunnery skills encountered in combat situations. Because it incorporates data recording, position locating equipment, and range telemetry with reactive, event-driven targets and a multi-media performance feedback system, a PRIME-equipped range serves as an ideal platform for free-play tactical engagements. Its instrumentation capabilities allow for near-real time assessment of performance deficiencies, while sophisticated after-action presentations provide accurate and timely feedback to the trainees.

PRIME combines the advantages of precision performance measurement, which is characteristic of stand-alone gunnery trainers, with the realism that comes from using an actual weapon system to engage targets of opportunity.

Although PRIME can not be classified as a precision gunnery trainer until the Tank Gunnery Simulation System-Precision Gunnery System is fielded and integrated into PRIME, it can provide some of the functions of limited gunnery tank table operations. Specifically, PRIME can support training in the areas of fire power distribution, fire and maneuver, command and control, target acquisition and identification, and gunnery.

System Description

The PRIME system consists of five subsystems as shown below. These subsystems are overlaid on existing ATTS-

The PRIME system was designed as an enhancement to the existing Automatic Tank Target System (ATTS) range, which uses M1 and M2/M3 MILES with Laser Target Interface Devices (LTIDS) and "pop-up" targets to train M1 and M2 vehicle crews in a non-live fire situation.

type ranges and incorporate existing range equipment such as the ATTS's themselves, control tower, and after-action review facilities.

• **Command and Control Subsystem.** This subsystem, which links individual vehicles and targets to the Range Control Computer, consists of the following elements and subelements: PRIME Computer, Transceivers, Global Positioning System (GPS), Receiver (Differential), Uninter-

ruptable Power Supply, RCC Facility, Graphics Display of Range, Boresight Board, and Cabling.

As its name implies, the Command and Control Subsystem integrates, monitors and controls the collection of data by allowing the RCC operator to interface with the PRIME vehicle and Target subelements.

• **Through-Sight Video (TSV) Subsystem.** The TSV uses an adaptor and video/audio camera to record the gunner's sight picture, tracking technique, trigger pull, and crew commands. This recording is time-tagged and can be synchronized with the other PRIME components to facilitate analysis of crew engagement techniques. Elements are the video camera, optical sight unit, recording module, and cabling.

• **Targetry Subsystem.** The targetry used with PRIME consists of target lifters, thermal blankets, generators, hostile fire simulators, and target silhouettes currently in the Army inventory. The target assemblies are controlled by PRIME through a Laser Target Interface Device (LTID) on the targets or manually by the RCC operator. A target transceiver assembly is used to provide networked command and control of targets and range telemetry. Elements are the PRIME LTID, transceiver, existing targets, and cabling.

• **Vehicle Subsystem.** The vehicle subsystem collects and reports vehicle position and engagement data to the Command and Control subsystem. Elements are the PRIME Console, GPS receiver, transceiver, and cabling.

• **After-Action Review (AAR) Subsystem.** This subsystem combines the playback of TSV and a computerized graphic map display of the actual tactical engagement. Video and graphics can be synchronized with PRIME printouts to provide playback and analysis of a crew's location and performance at any time during the engagement. This feedback is essential to instruct and remediate any observed gunnery or tactical deficiencies. Elements are the PRIME computer, graphics display of range, uninterruptable power supply, VCRs with monitors, AAR facility, cabling.

How PRIME Operates

The PRIME Range Control Computer allows the range operator to control and

monitor the exercise from his single console. Before the start of an exercise, the operator enters into the computer an engagement scenario (provided by the unit) which designates target location and activation data. When the exercise starts, the computer automatically executes the scenario. If necessary, the operator can assume manual control at any time. The exercise can be frozen and restarted at any time.

During an exercise, which consists of M1 and M2 crews or platoons maneuvering through the range and engaging a variety of targets, data is transmitted between the range control tower and the targets and vehicles. The radio network uses a polling technique that allows vehicle position on the range (determined by the GPS receiver) to be updated and stored on a periodic basis.

The vehicle locations are displayed on the range control computer, and are used by the event-driven scenario software to control presentation of the "pop-up" targets. These targets are energized when the vehicle is determined to be in a predetermined "Target Presentation Area." Location and engagement data (shots fired, hits, misses, etc.) are archived for later use in debriefing the exercise.

The target assemblies are activated by the PRIME system through an LTID that controls the ATTS mechanism. After engagement, the LTID responds to the MILES code from the firing vehicle to cause the target to fall when "killed."

Targets have a "shoot-back" capability which is controlled by either the computer operator or by pre-established "rules of engagement." A target is activated when a vehicle enters a predefined target presentation area and satisfies intervisibility requirements.

Crews cannot predict when or where targets will appear. The PRIME LTID records and telemeters back to the central computer all events concerning the target engagement.

Prime Capabilities

PRIME enhances a range through the addition of several new capabilities and by the integration of new and existing features into an automated, centralized command and control system. Some of the key PRIME capabilities include: Automated Player Identification, Programmable Weapon and Target Vulnerabilites, Player Position Location and

Recording, Near Real-Time, Event-Driven Target Control, Adjustable Target Presentation Area, Target Shootback Controlled Through the RCC, Near Real-Time On-Line Data Collection, Computerized Scenario Genera-

> *Because PRIME automatically collects and stores a wide range of performance data, unit training personnel can select from several report formats the information that best supports reinforcement of the specific training objective.*

tion and Control, User-Friendly Menu-Driven Control, and Sophisticated Video and Graphics Presentation of Performance Data for After Action Review.

PRIME collects the following data for use in analyzing and evaluating crew performance: Time Tags to Correlate Vehicle Position and Engagement Events, Range Traverse Times, Time Between Target Up and Vehicle Firing, Rounds Fired, Rounds Remaining, Player Identification, Firing Times, Vehicle Locations, Responses to Weapon Firing, All Operator Input Items, Time Tagged Video and Audio Record of Gunner's Sight Picture and Crew Commands, Audio Record of Crew Intercom and Radio Conversations Between Vehicles.

After Action Reviews

The integration of the PRIME system with the MILES range adds a new dimension to the After Action Review. Because PRIME automatically collects and stores a wide range of performance data, unit training personnel can select from several report formats the information that best supports reinforcement of the specific training objective.

The use of time-tagged printouts coupled with TSV tapes and a computer

generated imagery (CGI) map display allows replay of the exercise events. The entire exercise or any portion thereof can be replayed. Information is factual and immediately accessible.

When reports are coupled with the video/audio from the TSV and the graphics display, the crew which has just undergone training can review the specific actions which led to success or failure of the exercise.

The after-action review process encourages active participation and thorough discussion of alternative actions and outcomes. And, the use of PRIME permits the collection of a considerable amount of data without using controllers or observers as "recorders" or judges.

Summary

Tactical maneuver and gunnery skills are critical factors in the outcome of force-on-force engagements. Especially in non-live fire exercises, the capabilities introduced by PRIME to collect and provide precise feedback on crew performance and skills will improve the effectiveness of the units undergoing tactical engagement training.

A PRIME-equipped range can be used to detect probable causes for poor crew performance, ranging from poor communication techniques to failure to quickly acquire and identify targets to poor gunnery techniques.

And, in an era where live gunnery training is increasingly restricted by economic and environmental constraints, sustaining readiness through the use of training devices like MILES and PRIME has become the way of the future.

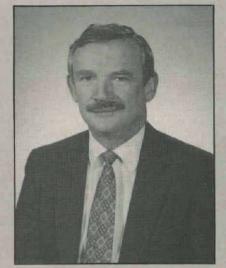*LTC RICHARD PETERS is the project director for PRIME. He holds a B.S. degree in aeronautics from Embry-Riddle Aeronautical University and is a graduate of the Defense Systems Management College.*

KENNETH LEWIS is a program analyst in PM TRADE's Resource Management Division. He specializes in requirements deterministion for training devices and holds a B.A. degree from Florida State University.

PEO — Combat Support

Melvin E. Burcz holds a bachelor's degree in civil engineering from Detroit Institute of Technology, a bachelor's degree in mechanical engineering from the University of Detroit, and a master's degree in industrial management from Central Michigan University. Burcz also attended the University of Michigan Graduate Business School under the Executive Development Program. His most notable assignments have included division chief and deputy program manager of tactical wheeled vehicles, and deputy program executive officer (PEO) — combat support.

As a PEO who is responsible for a large number of systems, Burcz believes that one individual can no longer be the chief strategic leader and ultimate authority in providing guidance and direction in all areas of expertise. Accordingly, he notes that the business of managing the life cycle of numerous systems is too complex and changeable to have one individual responsible and responsive for

Melvin E. Burcz

all significant decisions. His management philosophy has therefore evolved into a participatory type. He provides general guidance regarding program direction and creates the environment within the organization for the flow-down of operational decisions to the project or program level. As part of this process, he allows for challenges even to the merits of general guidance. Final decisions, however, regarding program direction are retained at the PEO level, as well as the establishment of priorities and leveling of resources between the various programs. As the processes of this business become more complex and flexible, Burcz stresses that his personal philosophy is not to manage the details of each program, but rather to provide the general direction, motivation, and the professional and ethical environment for the specific program managers and other support elements to operate or implement the specific programs.

He believes that he is fundamentally job or project oriented but recognizes the importance of people. He also emphasizes a balance between project and people considerations for overall program success.

Burcz emphasizes that a major role for the PEO-Combat Support is to ensure the development of an environment where opportunity exists for the competitive acquisition of systems. For this environment to be conducive to competitive acquisitions, programs must have stable and sufficient funding levels and there must be a committment to implement the competitive process in which contractors recognize that they will all be playing on a level playing field. Says Burcz: "We have worked hard to achieve this goal and when we have had appropriate funding we have been very successful. We will continue to work this policy because it has brought out the best of industry to our programs from a technical standpoint on a cost sensitive basis."

MISSION AND ORGANIZATION

PEO — Combat Support oversees the assigned project managers (PMs), and is responsible for the development, acquisition, fielding and support of light, medium and heavy tactical wheeled vehicles. Under the matrix concept, PEO — Combat Support plans, directs and controls associated U.S. Army Tank-Automotive Command support resources to ensure program accomplishment. PEO — Combat Support interfaces with Headquarters, U.S. Army Training and Doctrine Command and proponent centers and schools to ensure requirements are translated into hardware. Systems are fielded within cost, schedule and performance baselines. PEO — Combat Support ensures MANPRINT and safety considerations are properly addressed during system development, and coordinates with functional staffs at the Army staff and secretariat on matters related to combat support systems.

There are currently 99 people (military and civilian employees) assigned to the PEO — Combat Support. An additional 104 people provide support to the PEO — Combat Support.

PROJECT MANAGERS

PM, Light Tactical Vehicles	COL Joseph H. Mayton Jr.	Warren, MI Comm. (313)574-6470 DSN 786-6450
PM, Medium Tactical Vehicles	COL Lawrence W. Day Jr.	Warren, MI Comm. (313)574-5332 DSN 786-5332
PM, Heavy Tactical Vehicle	COL John W. Stoddart	Warren, MI Comm. (313)574-5800 DSN 786-5800

PROGRAM EXEC
COMBAT S

M939A2 SERIES FIVE-TON TA
Shown is one of the vehicles in the M939A2 Series — an M925A2
is a rebuy of the M939A1 series with the addition of a central tire inf
agent resistant coating in tri-color camouflage pattern. Primary m
medium tactical truck fleet, include: unit mobility, unit resupply
on July 20, 1989, with handoff to the 10th Mountain Division at .

PALLETIZED LOADIN
The PLS is a 16.5-ton vehicle (33 ton capability with trailer). It is ir
Expanded Mobility Tactical Truck (HEMTT) as the Field Artillery Am
or bed of the vehicle and trailer onto the ground and then move o
one is being unloaded, thus greatly decreasing the resupply time.
sition Board and when approved is scheduled to be fielded in e

SMALL UNIT SUPPORT VEHICLE (SUSV)

The SUSV family of vehicles includes four variants (cargo carrier, flatbed, command/control and ambulance). Each variant is a tracked support vehicle that is highly mobile and air transportable. The SUSV is used to conduct operations in nothern and mountainous regions, and carries selected items of equipment required by small units. It is capable of floating, can skijorn two 10-man infantry squads or carry 1 1/2 ton loads (2 ton in flatbed). The SUSV is a nondevelopment item (NDI) program. An original buy of 302 vehicles was made in FY 83. The current rebuy program is scheduled for initial fielding in March 1992.

HEAVY EQUIPMENT TRANSPORTER SYSTEM (HETS)

The HETS consists of an M1070 Truck Tractor and M1000 Semitrailer. HETS will be used to transport the M1 Series Main Battle Tank and other vehicles weighing up to 70 tons. The M1070 has a maximum gross combination vehicle weight of 230,000 pounds and is powered by a 500 horsepower diesel engine using a five-speed automatic transmission. The M1070 and the M1000 are currently undergoing shakedown testing. The M1000 is scheduled to be fielded with the M911 tractor beginning in September 1991. The M1070, which is replacing the M911, is scheduled to begin fielding in March 1992.
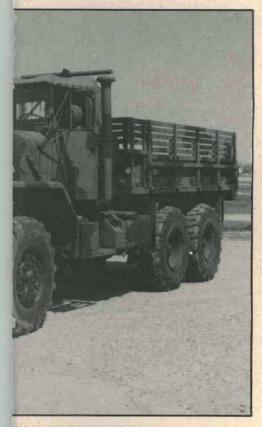

...CTICAL TRUCK PROGRAM

...ive-ton cargo with self recovery winch. The M939A2 program ...lation system, a new commercial diesel engine and chemical ...issions of the five-ton, which is the workhorse of the Army's ...id equipment transport. First unit equip date was achieved ...ort Drum, N.Y.

...G SYSTEM (PLS)

...itially being brought into the inventory to replace the Heavy ...munition Resupply Vehicle. The PLS can off-load the flatrack ...n to other locations to pick up other flatracks while the initial ...he system is currently being reviewed by the Defense Acqui- ...rly 1992.

HIGH MOBILITY MULTIPURPOSE
WHEELED VEHICLE (HMMWV)

The HMMWV is performing those 1 1/4 ton missions which cannot reasonably be performed by the less expensive Commercial Utility Cargo Vehicle (CUCV). The HMMWV is the high mobility member of the light fleet and provides the Army with a high performance, light load vehicle for the forward area. Primary missions are weapons transport, command and control, and troop/cargo transport. Over 70,000 vehicles have been fielded since October 1985. A contract for 33,000 additional vehicles was awarded in August 1989.

Simulating Human Figures...

THE HUMAN PERFORMANCE MODELING PROGRAM

By Virginia A. Pilgrim

The ability to simulate a dynamic human figure by simply using a computer can be a powerful tool in predicting and understanding how people will interact within a given environment. It is important in the Army to perceive how well a soldier would accomplish a mission in a given environment using the materiel provided and to design new equipment to enhance the soldiers' effectiveness.

Knowledge of the design constraints imposed by human body size, physical, and cognitive capabilities and limitations is important to materiel developers in understanding the interaction between human performance levels and equipment design.

The U.S. Army Human Engineering Laboratory (HEL) at Aberdeen Proving Ground, MD, has initiated a program to develop a technique for simulating the interactions among operators, tasks, materiel and their operating environment. This Human Performance Model (HPM) program is based heavily on the use of Jack, a three-dimensional Computer Aided Design (CAD) human figure model developed by the Computer and Information Science Department at the University of Pennsylvania under the direction of Dr. Norman Badler, with guidance from HEL.

Jack, which runs on a Silicon Graphics Iris 4D computer workstation, is being developed for a number of civilian and Government agencies.

As described by Dr. Badler, "Jack is a program which displays and manipulates articulated geometric figures. There are many different aspects of Jack, such as facilities for constructing geometric objects, positioning figures in a scene, performing various types of analyses with the figures, and describing motion of the figures. There are also facilities for specifying lighting and surface property information, and for rendering high quality images.

"Jack is primarily an interactive system. It is predicated on the belief that geometric operations are best performed interactively and graphically. Most operations in Jack use the mouse, both to pick commands from menus and to specify geometric transformations. Parameters and values may also be entered directly from the keyboard."

Jack provides an anthropometrically and biomechanically reasonable representation of the human body. The Jack figure has progressed from a simple "skinny body" representation composed of 112 polygons based on NASA data to the current "contour body" representation composed of nearly 5300 polygons based on data from the Air Force Armstrong Aerospace Medical Research Laboratory.

Body dimensions are accessed and manipulated by means of Spreadsheet Anthropmetric Scaling System (SASS) (see Figure 1). SASS can accept data from any population. For example, the results of the latest (1988) Army Anthropometric Survey (ANSUR) can be entered into SASS for use by those designing systems for the Army population.

POPULATION	: NASA Crewman data						
FIGURE TYPE	: Skinny Body		STRENGTH TYPE:	Isometric			
GENDER	: Male		MOTION SPEED :	0			
MASS	: 82.20kg (50.00%)		HANDEDNESS	: Right			
STATURE	: 182.20cm (50.00%)		TRAINING	: 0			
GROUP %TILE	: 50.00%		FATIGUE LEVEL:	0			

Segments	Width (x)		Thickness (y)		Length (z)	
	Values	(%)	Values	(%)	Values	(%)
0) BOTTOM HEAD	10.00cm	50.00%	7.85cm	50.00%	22.70cm	50.00%
1) NECK	6.15cm	50.00%	6.15cm	50.00%	10.00cm	50.00%
2) CENTER TORSO	12.50cm	50.00%	19.60cm	50.00%	47.60cm	50.00%
3) LOWER TORSO	11.60cm	50.00%	16.95cm	50.00%	13.10cm	50.00%
4) RIGHT UPPER ARM	5.35cm	50.00%	4.55cm	50.00%	33.40cm	50.00%
5) LEFT UPPER ARM	5.35cm	50.00%	4.55cm	50.00%	33.40cm	50.00%
6) RIGHT LOWER ARM	3.76cm	50.00%	5.63cm	50.00%	28.80cm	50.00%
7) LEFT LOWER ARM	3.76cm	50.00%	5.63cm	50.00%	28.80cm	50.00%
8) RIGHT UPPER LEG	7.60cm	50.00%	7.60cm	50.00%	43.40cm	50.00%
9) LEFT UPPER LEG	7.60cm	50.00%	7.60cm	50.00%	43.40cm	50.00%
10) RIGHT LOWER LEG	5.70cm	50.00%	5.70cm	50.00%	36.80cm	50.00%
11) LEFT LOWER LEG	5.70cm	50.00%	5.70cm	50.00%	36.80cm	50.00%
12) RIGHT FOOT	14.55cm	50.00%	4.95cm	50.00%	13.90cm	50.00%
13) LEFT FOOT	14.55cm	50.00%	4.95cm	50.00%	13.90cm	50.00%
14) RIGHT HAND	1.50cm	50.00%	4.45cm	50.00%	11.50cm	50.00%
15) LEFT HAND	1.50cm	50.00%	4.45cm	50.00%	11.50cm	50.00%
16) RIGHT CLAVICLE	0.50cm	50.00%	0.50cm	50.00%	17.20cm	50.00%
17) LEFT CLAVICLE	0.50cm	50.00%	0.50cm	50.00%	17.20cm	50.00%
18) RIGHT EYE	2.20cm	50.00%	2.75cm	50.00%	2.20cm	50.00%
19) LEFT EYE	2.20cm	50.00%	2.75cm	50.00%	2.20cm	50.00%
20) EYE LOCATION	9.80cm	50.00%	1.55cm	50.00%	11.60cm	50.00%
21) RIGHT TOES	5.55cm	50.00%	4.95cm	50.00%	6.00cm	50.00%
22) LEFT TOES	5.55cm	50.00%	4.95cm	50.00%	6.00cm	50.00%
23) RIGHT FINGERS	1.50cm	50.00%	4.45cm	50.00%	8.10cm	50.00%
24) LEFT FINGERS	1.50cm	50.00%	4.45cm	50.00%	8.10cm	50.00%

Press LEFTMOUSE to select items.   [page : 1]

Figure 1.

A major advantage of integrating computer models of the human body with computer models of system design is that "what if" analyses can be performed. Changes in the system design can be made on the computer and the designer can look at the impact of the changes on both the system and the human using it, all without the time and material expenses associated with building prototypes.

Jack enables the analyst or designer to perform several types of human factors analyses in three dimensions. These analyses include tests of whether the soldier will fit in the system, whether the soldier will be able to reach controls and mechanisms, the soldier's field of view, and whether the soldier has enough strength to operate or maintain the system and perform his tasks. Each analysis is important in evaluating a soldier's ability to use the materiel being developed.

Traditionally, analyses such as these had to be performed using paper and pencil or by placing crude two dimensional mannequins on blueprint drawings of the system being tested. In either case, blueprints had to be tediously redrawn each time a new design option or solution needed to be evaluated.

Many problems were missed because the analyst or designer never really got the whole picture until an expensive (in terms of time and materials) mock-up of the system was built. By the time a mock-up was built, design options and solutions were limited becuase of the difficulty and expense of rebuilding the mock-up.

Jack also has an animation feature which is useful in depicting the postures and movements that each soldier would go through in performing a set of tasks in a specific operating environment (see Figure 2). Animation of the system design can aid the designer in visualizing the operator dynamics and interactions with the system.

Interactions among soldiers can be inspected frame by frame if desired and at any scale or from any viewpoint. The animation sequences can be replayed and reanalyzed as required. Images in Jack can be viewed as wireframe drawings or fully rendered, solid objects.

By using a system like Jack, the designer can take easy-to-alter com-

Figure 2.
The Jack model can animate various postures and movements that a soldier might experience in a specific environment.

puter design drawings of the system and perform human factors analyses in three dimensions allowing him to better identify problem areas early in the design process. He can then change the drawings of the system and investigate a myriad of design options and solutions in a relatively short period of time, with time to make the changes on the computer being the only cost.

According to Dr. Badler "by building computer models early in the design cycle, we avoid having to build physical mock-ups of the actual situation or environment. This does not mean that mock-ups are useless, but early on, the designer may not know where people and items will be placed inside the environment, and it's much more flexible to have a computer graphics model that can be changed, instead of going to a machine shop and having them retool a portion of the mock-up."

Jack is a very complex model, but the interface has been designed to make it user friendly. "We try to build software that is general, flexible and usable. An average user should be able to operate Jack with about two days of training," said Badler.

The basic premise of Jack is that better system designs will result from

enabling designers to explore more design alternatives and to evaluate these designs before constructing costly and time consuming prototype hardware. "The goal of the Jack model is to produce computerized figures which can be manipulated and animated easily, so that they perform tasks in a working or operating environment," Badler said.

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LIFE CYCLE SOFTWARE ENGINEERING CENTERS

Introduction

The U.S. Army's dependence on computers and the computer software used in automated weapon systems has grown dramatically over the last two decades. In 1970 there were only three automated weapon systems in the Army inventory. By 1980, this figure had grown to 91. Today, the Army is developing and supporting in excess of 250 distinct automated weapon systems (Figure 1). This exponential growth has been necessary to serve as a force-multiplier and to provide a cost-effective and flexible means of responding to changing threats (Figure 2).

To help manage the ever-growing dependence on computer software, which is a direct consequence of the rapid growth of user requirements, the Army Materiel Command (AMC) has established Life Cycle Software Engineering Centers (LCSECs) within four of its major subordinate commands: The Communications-Electronics Command (CECOM), the Missile Command (MICOM), the Aviation Systems Command (AVSCOM) and the Armaments, Munitions and Chemical Command (AMCCOM) (Figure 3). Each of these four centers serves as a software focal point within the command and as the source of expertise for project managers (PMs) and readiness system managers across all phases of their systems' life cycle.

Origins

The need for such centers had its origin in the late 70s, when the Army began to recognize that software sup-port for fielded systems would require some special attention. In particular, because PMs were chartered only up through the initial fielding of systems, the Army needed to assign responsibility for Post Deployment Software Support (PDSS) to an organization with a readiness mission. To meet that need, the Army created a number of PDSS centers in 1980 as part of the command structure that existed within the former Development and Readiness Command (DARCOM).

The initial concept, while a step in the right direction, demonstrated two major shortcomings. First, transitions from the PMs proved to be very difficult because the PDSS centers were not actively involved in the initial development phase and PMs, more or less, "handed-over" the systems to the centers for support. Second, it became apparent that independent decision-making (including the choice of computers and programming languages) across PMs was adding unnecessary diversity and cost to the total Army PDSS resource requirements.

The earlier concept was modified to give the PDSS centers an opportunity to "observe" the initial development and to "advise" PMs on key decisions. The result was some improvement, but the concept was still not totally effective because the role in development was more "passive" than "active," and because PMs were motivated to follow advice when it was consistent with the goals of their charters (which, typically, did not address the PDSS time frame).

The final adjustment to the concept came when regulations were approved and implemented authorizing LCSECs to take an active role in assuring that software was developed and documented so as to ensure its long-term
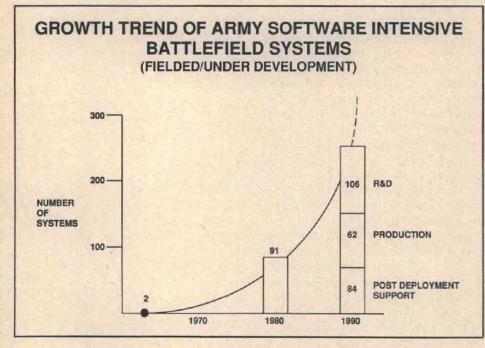
GROWTH TREND OF ARMY SOFTWARE INTENSIVE BATTLEFIELD SYSTEMS
(FIELDED/UNDER DEVELOPMENT)

Figure 1.

supportability in PDSS. Coupled with the matrix support concept implemented with the establishment of the Program Executive Office (PEO) structure, it enabled the LCSECs to act as a total focal point for technical support and software policy and support planning.

This concept has allowed the LCSECs to implement standardization in the use of programming languages (Ada, for instance); in software development processes and documentation procedures; in interoperability testing; in verification and validation techniques; and in other software technology insertion.

Operational Role

The operational role that governs the LCSECs has been evolving for more than a decade to its current state of development (Figure 4); a brief synopsis follows:

The science of developing and producing software that will function in accordance with its requirements, reliably and error free, is a discipline and emerging science called "software engineering." The focal points in the Army for ensuring that modern software engineering practices are employed for weapon systems are the AMC Life Cycle Software Engineering Centers.

The primary mission of the AMC Life Cycle Software Engineering Centers is to provide software engineering support for battlefield automated weapon systems during acquisition and in their world-wide use. This software engineering support is provided throughout the life cycle of the system — from the time the software is initially developed and produced, through the duration of the time the system is used in the field.

Life Cycle Software Engineering Centers ensure that the software does what it is supposed to do — especially when it is being used in a weapon system in a battlefield situation. Another purpose of life cycle software engineering is to make sure that the software is produced according to schedule and that the costs attributed to software are properly contained and controlled.

Life Cycle Software Engineering Centers have a continuous focus on improving both the quality of software and the methods of controlling the costs and schedule of developing and supporting software. These software

Figure 2.

Figure 3.

technology efforts employ software engineering principles to improve the processes of developing and supporting software. Software engineering principles are also applied in standardizing the methods of evaluating and measuring the quality of a software product and the technical progress of its development.

Among these cost, schedule, and quality-focused efforts, are methods of reusing software that have already been developed for other systems or projects; improving software development processes to eliminate rework; developing methods of measuring the quality of the software and the processes used in its development; and methods and

tools for automating and improving both the software development process and, through reverse engineering and technology insertion, the support process as well.

Life Cycle Software Engineering also includes providing technical support to PMs in directing the software development and production efforts of contractors by evaluating the contractor's capability, monitoring the contractor's development and production, and measuring and assessing the contractor's overall performance.

Benefits

A classic example of the benefits that can be derived from making improvements to a weapon system through software enhancements is the Air Defense Patriot missile system.

The original Patriot system was designed to engage aircraft. The capability of the system was subsequently expanded to engage tactical ballistic missiles as well as aircraft. The improved capability was implemented through enhancements to the software programs, at a cost of $32 million. However, the cost of making the same improvement in hardware or a new missile system is estimated to be many times the $32 million. Rather than looking at the cost of software alone (in "abso-lute" terms), we need to look at the cost-advantage (in "relative" terms) of software. Making an investment in software yields a measureable return, which is the cost-advantage of using software, over achieving equivalent capability through hardware implementation alone.

Instead of thinking of how much software costs, we might better think in terms of "how much software saves." Because software, indeed, is an efficient force-multiplier that provides a cost-effective and flexible means of responding to changes to hostile threats.

The exponential growth within the Army of computerized weapon systems and their accompanying software has created a number of new management challenges, especially in the current environment of diminishing resources. The common theme among these challenges is that the LCSECs must perform their work faster, cheaper and better. Facing up to the realities of this theme has fostered a variety of management and technical initiatives which are aimed at improving the software process and the quality of the products that it produces.

Training

One of these initiatives is the AMC Software Engineering Intern Program, which can lead to a master of science degree in software engineering. The two-year training program begins with one year of classroom training at the Army Materiel Education and Training Activity (AMETA) School of Engineering at Red River Army Depot in Texarkana, TX. In the second year of the program, interns are assigned to the CECOM Center for Software Engineering (CSE), Fort Monmouth, NJ, where they receive on-the-job training through hands-on projects and pursue a master's degree in software engineering at Monmouth College, West Long Branch, NJ.

To date, some 60 interns have successfully completed the program, providing an expanded base of software expertise for the Army. Interns completing the program are permanently assigned throughout AMC, based on software skill needs and command priorities. While the program is regarded as extremely successful, "retention" concerns have been emerging. Government salaries are not competitive enough with the private sector, and the skills produced by the program are highly marketable. Mechanisms need to be found to make it more attractive for young software engineers to make a career of government service.

Senior government software engineers and experienced software managers, already in short supply, also constitute a diminishing resource. Like the interns, they possess very valuable skills that are highly marketable. There is also the problem of retirement which further reduces our pool of senior software experts. This trend must be reversed if we are to successfully develop and adequately support the complex automated weapon systems that will be required in the future (Figure 5).

Another important initiative is the creation of an AMC-wide task force which has been given a number of major assignments by the deputy commanding general for RD&A at HQ AMC. One of these assignments is the development of a software awareness program for general officers and members of the Senior Executive Services (SESs). Increased software awareness at General Officer and SES levels is essential in today's high-technology environment.

The majority of the Army's senior leaders have spent their entire careers

EVOLUTION OF ARMY LCSEC CONCEPT/ROLES NOTE OVERLAP

TIMEFRAME:	PRIOR TO 1981	1981 THRU 1983	1983 THRU 1987	1985 THRU PRESENT
PLAYER(S):	• PMs	• PMs • PDSS CENTERS	• PMs • "LIFE CYCLE" SW ENGINEERING CENTERS	• PMs • LIFE CYCLE SW ENGINEERING CENTERS
FOCUS:	• PM: SOFTWARE DEVELOPMENT	PMs: SW DEVELOPMENT PDSS CENTERS: POST-DEPLOYMENT SW SUPPORT	PMs: SW DEVELOPMENT LCSECs: • PDSS • PDSS PLANNING DURING DEVELOPMENT	PMs: • "MGT" OF SW LCSECs: • TECH SUPPORT TO PMs DURING DEVELOPMENT • PDSS PLANNING DURING DEVELOPMENT • PDSS
COMMENTS:	• INADEQUATE EMPHASIS ON SUPPORT NEEDS • DIVERSITY CREATED THRU INDEPENDENT DECISION MAKING • DUPLICATION OF SW EXPERTISE ACROSS PMs • LIMITED CAREER PATHS FOR SW PERSONNEL	• FILLED SUPPORT VOID • "HAND-OVER" PROBLEMS EMERGED • INADEQUATE ABILITY OF PDSS CENTER TO INFLUENCE DEVELOPMENT DECISIONS	• EASED (BUT DID NOT ELIMINATE) HAND-OVER PROBLEMS • IMPROVED PDSS PLANNING	• ELIMINATED HAND-OVER PROBLEMS • PROVIDES HEALTHY BASIS FOR STANDARDIZATION ACROSS SYSTEMS • IMPROVED CAREER PATHS FOR SW PERSONNEL

LEAST DESIRABLE   MOST DESIREABLE

Figure 4.

dealing with hardware and they are not always sufficiently aware of the unique issues that software and its rapid growth have created. AMC is developing a program called "ARmy Executives for Software (ARES)," which is intended to provide senior Army leaders with greater insight into the rapidly increasing dependence on software and management issues which surround it. ARES is a two and one-half day forum, which will be held at the Software Engineering Institute (SEI) in Pittsburgh, PA. Ultimately, it will be hosted at the Army War College.

Several versions of ARES have already been held and well-received by the attendees. As an institution, the Army has not kept pace with software advances and ARES is providing the information that our leaders need in order to sponsor the cultural change that is required to place software in its proper perspective as a cost-effective, force-multiplier in Army weapon systems.

Figure 5.

Funding

A critical management challenge that needs to be addressed, in this environment of increasing work-load and decreasing resources, is the funding of software support for systems in development as well as those in the field. Historically, the funding required has been substantially less than that which was budgeted. For example, in FY90, $108 million was required for support, but only $51 million was available. By FY94, fielded systems' requirements are projected to rise to $217 million, with only $151 million expected to be available.

The wide discrepancies between the funding required and the funding available, traditionally, has posed the dilemma of prioritizing systems work and allocating resources, as far as the money would go. This process, which has been pursued jointly by AMC and TRADOC, required the constant "scrubbing" and re-establishment of priorities, and the piecemeal doling-out of resources to fill support requirements on a "most needed" basis. Needless to say, some system requirements were sparsely funded and others went unfunded. This short-fall dilemma is expected to continue and negatively

impact the capabilities of Army battlefield automated systems.

The funding and prioritization process for software support needs to be institutionalized. Systems in development and production need to be examined to re-evaluate their support requirements and determine whether some requirements can be combined and others eliminated, or whether work on certain systems should be stopped. For systems in the field, an evaluation should be made to determine whether a system should continue to be supported with software enhancements and improvements (such as the improvements discussed on the Patriot missile system), or whether just software sustainment (maintenance) and correction of software "bugs" (problems and errors) should be made, in order to ensure that the funding for support is there. In short, the requirements for automated battlefield capabilities must be carefully and continuously reviewed and prioritized; and user appetites for increased capabilities must be tempered by available funding.

Conclusions

With the Army becoming increasingly dependent on computer software as a force-multiplier, the AMC Life Cycle

Software Engineering Centers have become key organizations for guiding that growth in a manner that provides a cost-effective response to user needs.

In the current environment of declining resources, however, a number of management concerns have emerged which must be resolved. Principle among them are issues surrounding resources, such as, diminishing funds versus growing requirements; and increasing workloads versus declining staffs in the LCSECs.

The challenges of these concerns will be resolved as senior Army leadership becomes increasingly aware that the issues facing them will require the initiation of "cultural" changes. This will enable the unique capabilities of computer software to assume an even more prominent battlefield role in the future.

The preceding article was provided by the CECOM Life Cycle Software Engineering Center.

MODEL ADEQUACY IN TEST AND EVALUATION

Weak Spots
In Vulnerability Modeling

By James F. O'Bryon

Yogi Berra said, "Predictions are hard to make, especially about the future." In the world of computer predictions, Yogi was not far from the mark.

Defense applications of computer modeling have come a long way since the early days of vacuum tubes and relays. Computers have become faster, more reliable and user friendly. They have also increased orders of magnitude in computing capacity. Computer analysis tools enable us now to even visualize the outputs from the mathematical models.

Congress recognized that computer modeling also has its limitations, and enacted legislation requiring realistic operational and live fire testing. The legislation requires realistic testing to allow the physical laws of nature to play out, regardless of how simple or complex the physical laws seem to appear.

The focus of vulnerability and lethality computer modeling over the years has been on ballistic penetration of targets. Recent live fire testing shows that these penetration model predictions are quite reliable against standard known materials. In one recent series of live fire tests, 95 percent of all penetration predictions were correct. However, once penetration occurred,

the success of the models to predict the damage that occurred dropped dramatically. For example, the models did not properly identify over half of the critical components actually damaged during this series of tests. This occurred even though more than 3,000 shots against components and subsystems of the same type target had preceded these tests.

I would like to address four key areas associated with DOD weapons vulnerability assessment models: Phenomenology, Methodology, Real World Challenges and Benefits.

Damage Phenomenology

Probably 90 percent of the entire focus of vulnerability and lethality modeling has been on ballistic penetration and spalling. Indeed, this type of damage mechanism has and will continue to be a major source of concern. However, too many people accept the notion that if penetration does not occur, no significant damage occurs. Conversely, many believe that penetration equates to significant damage. Neither is always true. Accountability for other damage mechanisms — some simple, others complex — must also be

accomplished. Their relative importance depends on the specific weapon/target combinations considered.

● **Distortion/Bending/Cracking.** Impacting munitions can cause significant distortion of equipment affecting its ability to rotate, elevate or otherwise operate. Externally mounted devices (optics, fire control) are subject to bending and cracking. These phenomena may yield firepower or mobility kills. Current models are seriously deficient in their ability to handle these effects.

● **Shock/Blast.** Munitions, including high explosives, fuel-air explosives and high velocity penetrators can generate shock damage upon impact or proximity burst. Although considered in ship vulnerability modeling, this damage mechanism is just now beginning to receive more attention in the armor and aircraft modeling world. It is becoming even more critical to consider with the advent of complex high technology, computer-dependent weapons platforms.

● **Fire Initiation/Propagation.** Fire continues to be the primary killer on-board ship, and is a major contributor to crew casualties aboard aircraft and armored systems. Even the latest models handle this major source of

vulnerability using rather crude empirical relationships.

• **Toxic Fumes/Heat/Burns.** Toxic fumes were not contained in the model predictions as a damage mechanism for the original Bradley Fighting Vehicle live fire tests (LFT). Yet, the LFT results showed that this was the primary source of system vulnerability. The effects of heat/burns on crew and equipment is another major source of vulnerability needing greater attention.

• **Hydrodynamic Ram.** The imparting of energy on thin-skinned enclosed components like fuel tanks causes hydrodynamic ram damage. We need to focus on this critical damage mechanism since many of our developmental munitions depend on this mechanism to defeat targets.

• **Projectile Breakup/Debulletization/Secondary Debris.** Recent experience where our helicopters were hit by enemy fire graphically revealed that when a projectile enters a target, it often breaks into several pieces and ricochets, and in the case of bullets with lead cores, often shed their jackets. Each of these pieces then takes on its own path, generating additional damage. Impacts may cause equipment to break from mountings and fly freely about producing secondary debris. Model upgrades need to account for these effects.

• **Non-nuclear Electromagnetic Pulse (EMP).** Nuclear EMP effects have been studied and modeled for some time. However, the EMP generated by conventional munitions impact is neither well understood, nor modeled. Weapons systems dependent on integrated circuits and similar electronic components must be assessed as to their vulnerability to non-nuclear EMP.

• **Directed Energy Threats.** Threats including charged particle beams, high powered microwave and lasers will soon populate the battlefield. Modeling the vulnerability of equipment and personnel to these threats must be accomplished.

Methodology

Beyond these specific damage mechanisms is a generic set of problems which cut across most vulnerability assessments. They have yet to be successfully tackled. Several are as follows:

• **Kill Definitions.** Traditionally, conventional land system probabilities of kill have been defined as K-kills (catastrophic), M-kills (mobility) and F-kills (firepower). Except for K-kills that have a binary outcome (killed or not killed), kill categories are not probabilities at all but rather degradations in performance. Yet, most force-on-force analyses have used them for years as probabilities. What does a mobility kill of 0.5 really mean? There's a 50 percent chance that you will be totally immobile? There is a 100 percent chance that you will be able to move half as fast? There is a 100 percent chance that you can move just as fast but only half as far? The definitions selected must parallel the damage assessment process used to assess system vulnerability.

• **Soft Kills.** Historically, combat doctrine has taught soldiers to continue to deliver fire until there is a visible sign of target defeat (explosion, major fire). With the advent of highly sophisticated, computer-dependent weapons platforms, it is not essential to cause overmatching damage to achieve a kill. New emphasis needs to be placed on modeling "soft" kills for both U.S. targets and U.S. munitions effectiveness. Computer failure, engine shutdown or fire control misalignment are examples of "soft kills."

• **Multiple Hit Assessment.** Most vulnerability models assume that a target is undamaged until hit. History shows that targets can be repeatedly hit, both sequentially (time-spaced hits as in rapid fire systems) and spatially (multiple fragments hitting simultaneously from fragmenting munitions). The current approach for assessing the probability of kill for multiple hits on a target is to use the "Survivor Rule"

Factors such as damage control aboard ship, or the decision to fight fires in a tank or abandon it or the decision to eject from a damaged aircraft must be accounted for.

which assumes that the effects of individual impacts are independent of one another. Since nearly all targets have time-dependent characteristics (liquids which can leak, catch fire and evaporate; fire suppression systems which may be activated only once or twice and other parameters), assuming total independence of multiple hits can cause serious miscalculation of target vulnerability.

• **Shotline Selection.** There has been much discussion about the need to select shotlines carefully. There is the tendency by modelers to assume that they "know the relevant unknowns" in their models. Hence, shotline selection to assess vulnerability tends to be driven by the known unknowns. Recent LFT has shown that the randomly selected shotlines have yielded valuable information about "unknowns that were unknown." There is a role for "engineering shots" to assess known uncertainties. But there must always be a role for random shot selection and assessment. After all, this is how the enemy will strike.

• **Target Edges, Welds and Discontinuities.** Most computer descriptions are unable to handle the changes in vulnerability due to manufacturing methods. They can account for different material properties such as steel and titanium. But, computer models have a very difficult time assessing the change in vulnerability due to bolted or welded joints. This is also true for bending or other processes which alter the material response to threats. A testing program against targets with these characteristics, not just flat homogeneous plates, is the only way to gather this information.

• **Non-orthogonal Shot Selection.** Historically, shotlines taken at 90 degree increments around the target was the basis of computed vulnerability. This was done for the ease of the analyst. It presents, however, some artificialities since most targets are also assembled orthogonally, with many components being mounted at right angles or parallel to the centerline. Vulnerability assessments based only on orthogonal shotlines can create some artificialities. For example, if a shotline enters a vehicle parallel to a fuel tank wall, the apparent fuel tank thickness may be assessed as being several feet thick rather than a fraction of an inch thick. Selecting from a full off-axis

To enable a better understanding of the intensity and complexity of the weapon/target interaction, vulnerability modelers must routinely observe the testing which they are modeling.

spectrum of combat shot azimuths and elevations would minimize this problem.

● **Threat Multi-Dimensional Shotlines.** Often shotlines are just that, infinitely thin lines. They are not treated as if they have a size or caliber but rather as a ray. Munitions must be treated as having their full physical dimensions. Additionally, models must consider the relative yaw and pitch at impact.

● **Warhead Damage vs. Debris Damage.** Recent testing has shown that static testing of warheads often yields different lethalities than dynamically fired warheads. Often the difference is due to the lethality contribution from things other than the warhead itself. Much of the USS Stark damage was not directly attributable to the Exocet warhead alone. The unexpended rocket fuel and the kinetic energy of the missile body were also major factors. The effects of non-warhead components (booster motor and propellant, guidance package) must be considered.

Real World Challenges

Someone has said "To computer modelers, the real world is a special case." We need to move toward the real world. We need to quantify those significant effects which are not quantified and improve on those that are poorly modeled including the following:

● **Crew Action.** The role of crew action in the midst of combat is critical for vulnerability assessment. Factors such as damage control aboard ship, or the decision to fight fires in a tank or abandon it or the decision to eject from a damaged aircraft must be accounted for. Studies of recent combat and behavior under combat stress provides modelers with some valuable insights. Additional data gathered from man-in-the-loop simulators or operational tests may also be useful although the combat stress factor is missing.

● **Cascading Damage Effects.** Live fire testing has shown that component testing is not adequate to identify sources of weapon system vulnerability. Testing against combat-configured weapon systems allows for the identification of synergistic vulnerabilities which are often not possible to identify from mere component testing. One future challenge is to "capture" these real world effects from testing and place them into model upgrades.

● **Realistic Combat Configuration.** Computer models often assume that combat loads will be exactly as the manuals instruct. More often than not, the load-outs of fighting platforms in actual combat are different. For example, lubricants and fuels may have spilled or leaked. Also, doors or hatches may be open. Modeling must capture at least the major variables to get at a realistic vulnerability estimate. Vulnerability assessment of aircraft is typically made without considering the contribution of the on-board munitions. These must be accounted for in the context of the mission.

Benefits of Vulnerability Modeling

Major benefits can be derived from getting our vulnerability modeling house in order.

● **Excursions from Test Results.** It is virtually impossible to test every point for every condition. Modeling enables modest excursions between test observations.

● **Sensitivity Analysis.** Models allow the perturbation of specific parameters to assess the relative payoff of changing a weapon characteristic.

● **Interpretation of Test Data.** There is an important interactive relationship between models and test results. Test data can help calibrate models. At the same time the computer

models can provide insights into understanding the results of tests.

● **Basis for Future Weapons Design.** There is no other effective tool as a basis for designing a new weapons concept. The only alternative — trial and error prototyping — could be expensive and time consuming.

Where Do We Go From Here?

We have come a long way in developing computer methodology to represent the target to the computer through solid geometry techniques. We have also come a long way in understanding penetration phenomenology particularly for conventional materials. The modeling community now needs to understand and address some of the other significant issues discussed above. New defeat mechanisms, new kill criteria, and new methodology are of particular importance.

To enable a better understanding of the intensity and complexity of the weapon/target interaction, vulnerability modelers must routinely observe the testing which they are modeling. Some work is underway to address several of the above-mentioned issues. Much remains to be done. Live fire testing will provide many of the necessary insights to bring this to fruition.

JAMES F. O'BRYON has served as director, live fire testing in the Office of the Secretary of Defense since November 1986. He is a graduate of The King's College, George Washington University and M.I.T. and has 25 years of experience in weapons RDT&E.

THE COLOR OF MONEY AND THE MILITARY'S BAD PRESS

By Kenneth J. Oscar with George Taylor

It seems that hardly a day goes by when a newspaper reporter or TV news commentator isn't taking a potshot at the Department of Defense for buying a vehicle or weapon system that is not living up to expectations. Though any new piece of equipment — whether military or non-military — usually brings with it some risk that it will prove to be a disappointment to its buyer, many of the hardware-related risks DOD faces are caused by the way we allocate money for the development, procurement, and maintenance of weapon systems. I am convinced that we can dramatically reduce the likelihood of these risks. This reduction can come if we are willing to change our funding strategy.

A common complaint voiced by critics today is that we do not fully test equipment and the tests we do conduct often show equipment deficiencies, yet we buy it anyway. To understand why this may sometimes happen, it is necessary to take a look at how military funds are appropriated. These funds are earmarked by Congress for specific purposes, including research, development, test and engineering (RDTE), procurement, and operation and maintenance.

Once money is committed to a particular category, or equipment line within a category, it is as though it has taken on a different shade of green which identifies it as money that will buy only a limited type of goods and services. It cannot be used elsewhere, and significant changes cannot be made without Congressional approval. Such spending limitations can cause problems not only during the development of new equipment, but throughout the entire acquisition cycle.

When developing a new vehicle, for example, a program manager must estimate required funds years ahead of time for both RDTE and procurement. Once a program spending plan is approved, the manager is locked into a budget that might not provide adequate funds to deal with unforeseen problems that may crop up. If, for instance, tests reveal a vehicle design deficiency just as RDTE money runs out, the program manager faces a real dilemma. The smart thing to do would obviously be to spend more time in development and correct the problem. But RDTE funds have been used up, only procurement money is available, and it cannot be spent on further development.

If the program manager goes back to the decision-makers and asks for more money or to transfer the procurement money to RDTE, the program must be stopped until Congress approves a new appropriation or transfer, which could take up to three years. So, rather than delay the program, the program manager opts for starting production, even though correcting the problems during production has considerably higher risk.

Our approach to budgeting defense dollars also makes it more difficult to correct problems once they have been discovered in fielded equipment. A current example involves the troop heater used in our tanks. The heater we buy wears out quickly and is not very reliable. But, replacing it with a better one is not an easy task. This heater is a unique military item that cannot simply be replaced with a commercially available unit. Thus, a replacement would have to be developed from scratch — a job requiring RDTE money. Although a new heater was recently funded under the Field Assistance Science and Technology (FAST) Program, all of our RDTE money was previously tied up in the development of new vehicles and weapons. Consequently, the Army was unable to procure a better heater that would last longer and save money in the long run. Instead, it spent additional procurement money for replacement of tank-heater components that wear out quickly — money that would have been better spent is it could have been used to pay for the needed improvement.

The Services are often criticized in the press for not doing more to reduce the operating and support cost of weapon systems. This is again caused by the inability to change the "color" or category of funds in any timely way. For example, to operate a tank's sensor systems in silent overwatch at night, it is necessary to run the main tank engine, which requires a considerable amount of fuel. This fuel is paid for out of the operations and maintenance accounts, which have been rising at about five percent a year.

A technical solution was developed to put a small auxiliary engine under armor in the tank to power these sensors, but sufficient procurement money (which must be used to buy equipment) was not available to buy this equipment. As a result, many times the amount of money needed to procure the auxiliary engine is being spent in fuel costs. There is no incentive and little money available to DOD agencies to work on money-saving ideas, since the money saved is in different appropriations, and it is almost impossible to transfer it for use in funding further saving efforts.

Problems such as the examples above are very often the cause of negative publicity about the Defense Department. They are all caused by the different "colors" of our defense money. Two quick alternatives to solving these problems are to either reduce the number of categories or colors of money, or to dramatically increase the Defense Department's authority to transfer moneys between categories.

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17th Army Science Conference Held in Durham

The 17th U.S. Army Science Conference, sponsored by the assistant secretary of the Army for research, development, and acquisition, was held during June of this year in Durham, NC. The traditional objective of the conference is to provide a forum for presentation, discussion and recognition of significant accomplishments by Army scientists and engineers. This is achieved primarily through presentation of technical papers.

In addition to the 96 technical papers presented at this year's conference, a number of general session speeches were given. Among these was a keynote address titled "Science — Investment for the Army's Future," by Dr. Gordon J. MacDonald, vice president and chief scientist of the MITRE Corp., McLean, VA.

Other general session presentations included "Army Technology Base Master Plan," by George T. Singley III, deputy assistant secretary for research and technology and chief scientist, Office of the Assistant Secretary of the Army (RDA); "Army as a Strategic Force," by COL Raoul H. Alcala, Office of the Chief of Staff; "BAST STAR Study," by Dr. Richard Chait, chief scientist, Army Materiel Command; and "Medical R&D Forecast," by COL Gerald C. Sadoff, chief of bacterial diseases, Walter Reed Army Institute of Research.

The technical papers were arranged in four parallel sessions representing the broad technology groupings: chemical, structural, and fluid dynamics; electronic components and equipment including soldier compatibility; biochemical and medical research; and battlefield environment including detector and materials behavior.

Of the 96 papers presented during 24 subsessions of the conference, 12 were cited for special recognition. A select committee of the Army Science Board chose the papers to receive awards.

A team of outstanding scientists and engineers from the U.S. Army Electronics Technology and Devices Laboratory (ETDL), Fort Monmouth, NJ, was the recipient of the first prize, Paul A. Siple Memorial (silver medallion) Award. The team will share a $2,500.00 award. Anderson Kim, Dr. Robert Zeto, Robert Youmans, and Dr. Maurice Weiner co-authored the winning entry, which was titled "Sub-Nanosecond Risetime High Power Photoconductive GaAs Switch and Its Transient Electric Field Profiles." This paper describes a new sub-nanosecond pulser, a device applicable to high-power, wide-bandwidth radar systems, which will provide a new improved resolution capability for identifying targets. The device is expected to lead to further improvements in system efficiency and compactness.

Three papers were also selected for outstanding achievement. The authors of each paper received certificates of achievement and bronze medallions, and shared a $1,000 cash award.

Dr. Anderson Kim receives the Paul A. Siple Memorial Award for his team from George T. Singley III, deputy assistant secretary for research and technology, Office of the Assistant Secretary of the Army (RDA). ARO Director Dr. Gerald J. Iafrate is at the podium.

Dr. George J. Simonis, Kenneth G. Purchase, CPT (Dr.) Ralph G. Hay, Dr. Neelam Gupta, and Dr. Paul Ashley, employees at the U.S. Army Harry Diamond Laboratories, Adelphi, MD, and the U.S. Army Missile Command (MICOM), Redstone Arsenal, AL, were

Dr. George J. Simonis receives an outstanding achievement certificate for his team from George T. Singley III, deputy assistant secretary for researcch and technology, Office of the Assistant Secretary of the Army (RDA). ARO Director Dr. Gerald J. Iafrate is at the podium.

CPT Harry E. Cartland receives an outstanding achievement certificate for his team from George T. Singley III, deputy assistant secretary for research and technology, Office of the Assistant Secretary of the Army (RDA). ARO Director Dr. Gerald J. Iafrate is at the podium.

recognized for their work on the paper titled "Optoelectronic Generation, Control, and Distribution of Microwaves."

COL Jerald C. Sadoff, MAJ Daniel Gordon, Dr. Anita Aggarwal, Dr. Louis Baron, and Dr. Stanley Cryz, who work at the Walter Reed Army Institute of Research, Washington, DC, and the Swiss Serum and Vaccine Institute, Bern, Switzerland, were awarded for their efforts on the paper titled "Development of Vaccines Against Malaria."

COL Thomas H. Johnson and CPT Harry E. Cartland, both from the U.S. Military Academy at West Point, NY, were honored for their work on the

COL Jerald C. Sadoff receives an outstanding achievement certificate from George T. Singley III, deputy assistant secretary for research and technology, Office of the Assistant Secretary of the Army (RDA). ARO Director Dr. Gerald J. Iafrate is at the podium.

paper titled "Xenon Chloride Laser Scaling."

In addition, eight papers were selected for honorable mention. The authors of these papers received certificates of achievement and shared a $500.00 cash award.

Dr. Charles M. Bowden, Dr. Mark J. Bloemer, and Dr. Joseph W. Haus, who are employed by MICOM, Redstone Arsenal, AL, and the Rensselaer Polytechnic Institute, Troy, NY, were cited for their accomplishments on the paper titled "Nonlinear Optical Properties of Metallic Microparticle Composites."

Dr. Doran D. Smith and Ravi Khanna, who work at ETDL, were recognized for their efforts in authoring the paper titled "A Selectively-Contacted

Dual Channel High Electron Mobility Transistor."

Dr. Charles H. Murphy, James W. Bradley, and William H. Mermagen, Sr., of the Ballistic Research Laboratory in Aberdeen Proving Ground, MD, were cited for their work on the paper titled "Side Moment Exerted by a Spinning, Coning, Highly Viscous Liquid Payload."

Dr. Raphael A. Ranco, Jr. and James K. Ingram, employees of the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, were honored for their paper titled "A Very High Shock, Self-Contained Data Acquisition System."

Dr. Herbert A. Leupold, who works at ETDL was cited for his efforts on the paper titled "Novel Magnetic Field Sources for Micro, MM and Optical Wave Devices."

Dr. James J. Valdes, from the U.S. Army Chemical RD&E Center, Aberdeen Proving Ground, MD, was recognized for authoring the paper titled "Detection of Toxins with a Reversible Biosensor."

Dr. Jack N. Rinker, of the U.S. Army Engineer Topographic Laboratories at Fort Belvoir, VA, was cited for his work on the paper titled "Hyperspectral Imagery — A New Technique for Targeting and Intelligence."

Melanie W. Cole, Dr. Mitra Dutta, and Peter Newman, all of ETDL, were honored for authoring the paper titled "Microstructural Characterization of Semiconductor Materials as Related to Device Performance."

The 96 technical papers were selected from more than 400 narrative summaries that were submitted for consideration by working scientists from the Army Materiel Command (AMC), The Surgeon General, the Corps of Engineers, the Army Research Institute, and the U.S. Military Academy.

Members of the Army Science Conference planning committee noted that this year's selection was unusually difficult because of the exceptionally high number of qualified papers that reflected the theme "Science — Investment for the Army's Future."

The final papers chosen for presentation were submitted by the following agencies (specific totals from each are in parenthesis): AMC (66); Surgeon General (15); Corps of Engineers (8); Army Research Institute (5); and two from other sources. All papers presented, as well as supplemental papers, were considered for awards which included cash honorariums, medallions, and certificates.

SCIENCE:
Investment for the Army's Future

By Gordon J. MacDonald

The following remarks, which have been edited to meet space limitations, were originally presented June 13th, 1990 at the U.S. Army Science Conference in Durham, NC. Gordon J. MacDonald, vice president and chief scientist of the MITRE Corp. in McLean, VA, discusses some key areas of science which he believes may be of future benefit to the Army.

Army of the Future

For the Army, the rapidly changing face of the world will require the creation of a future structure that is far different than the one created to counter the forces of Warsaw Pact nations in the post World War II era. The Army of the 21st century will have the unprecedented opportunity to exploit current and developing technologies as it responds to new threats and demanding economic realities. As the cupboard of applicable technologies is depleted in the process of meeting new challenges, it must be restocked through science.

This era of rapid change and new challenge presents the Army with another unprecedented opportunity, that of strengthening and enlarging the foundation of science within Army laboratories, academia, and industry. Such a foundation will provide the Army with a window through which it can view the opportunities of the future.

In past times of economic stringency and general perception of lessened external threats, the budgets for research and development (R&D), particularly in basic science, were the first to be cut. Such cuts must be avoided if available opportunities are to be taken. I have some specific thoughts on how to deal with this very real problem, but first, I wish to examine broadly the major areas of science where rapid developments can be anticipated and by whose support the Army stands to gain. Scientific opportunities span such a wide range of disciplines that it is possible to discuss only a few of the most significant. If I miss your favorite, it is not intentional.

Three Fundamental Technologies of the Future

The Army research program has quite properly given and will continue to give priority to novel applications of relatively well understood areas of science. However, in my view, there are three areas of basic research that are likely to lead

to dominating technologies in the future — -technologies that will shape the nature of the Army in the mid-21st century.

The three areas of existing knowledge that have not been fully exploited are: exploration of the physical and biological environment of the earth; the science of complex information-processing networks, exemplified in the extreme case by the brain; and the science of genetics and cellular physiology at the molecular level. No doubt there will be other innovations of comparable importance, but whatever else may happen, technological revolutions in these three areas will change the conditions of human life and, in so doing, will affect the Army in major ways.

The Global Environment

Concern about the environment, particularly about global changes such as greenhouse warming and ozone depletion, will impel the development of a new class of observing tools and data management capabilities that will greatly deepen our understanding of the oceans, atmosphere, and biosphere. Understanding global environmental change requires knowledge about the entire earth system. The ultimate goal is to develop a capability to predict both natural and human-induced changes that will occur in the future.

Limits on Predictability

By seeking to predict future environments, a critically important problem is now being brought into focus: the limits on predictability. The behavior of environmental systems is irregular or non-periodic, and is governed by coupled sets of non-linear differential (or integral) equations. From recent research, a clearer picture is emerging of non-linear behavior and of the limits to which one may be able to predict the outcomes of specific and precisely established initial conditions, even with virtually unlimited computing capability.

The key observation is that all non-linear systems contain an inherent mathematical instability that causes errors in the specification of a system's state to grow exponentially in time. A roundoff error or a finite-state representation of a floating point number in a computer are both subject to this same instability.

The study of non-linear systems for diverse applications will take as its goal the determination of the intrinsic instabilities of a system's dynamics. Statistical prediction will then

be based on an analysis of the way in which the system is seen to behave. Apparent statistical behavior is governed by quantities that are independent of any particular orbit and can thus be applied to the analysis of all orbits. This new point of view suggests the use of innovative software design for the analysis of simulations, and of diagnostics for the determination of predictions. Such a viewpoint differs dramatically from one in which infinite accuracy is expected with increasingly powerful and precise computing capability.

The limits to predictability have implications that go beyond the modeling of environmental systems. Many of the simulations the Army uses are inherently nonlinear, and their fundamental limitations need to be clearly understood.

Sensing the Environment

A start on quantitatively more intense exploration of the environment will be made in the Earth Observing System. This is a joint program that involves the European Space Agency, Japan, Canada, and the United States, with NASA playing the lead role among government agencies. Present plans call for two series of polar-orbiting platforms.

A 15-year observational period will begin in the late 1990s using three identical satellites per series, each with a 5-year lifetime. One series, EOS-A, will focus on atmospheric soundings and surface imaging over many spectral bands.

The EOS-B series will contain sensors for monitoring changes in the high atmosphere, atmospheric chemistry, and

> In the future, advanced automation and neurophysiology can be expected to flourish as separate sciences, with exploration of neural networks providing a bridging function.

ocean circulation. The platforms have been sized to accommodate sensors in a way that maximizes the use of coincident observations and minimizes atmospheric uncertainties. In addition to the large platforms, a number of Earth probes carrying instruments that do not depend on simultaneous observations will be launched, including a Synthetic Aperture Radar, which goes up in 1999.

The real challenge of EOS is not in the design of the sensors or platforms but in the management of the data. The complexity of the data management problem is illustrated by the simple observation that during the lifetime of EOS, some 50,000 terabytes of data will be collected. The tasks of processing, archiving, and distributing this data to a very large number of users scattered over the world present enormous new challenges. In addition, these data must be com-

bined with ground-based observations from large numbers of sources. The Army will be faced with the task of integrating the flood of new information into its data bases.

Over the decades, observations of the sort envisaged for EOS will enhance our ability to predict weather and other environmental parameters within the limits discussed earlier. The construction of very large data bases with global coverage will provide information that can be translated into products that will assist the Army in carrying out its missions. Clearly, the integration of vast amounts of new information into the Army's structure requires both planning and an understanding of how the data can be used, how large data bases can be effectively managed, and how derived information can be rapidly disseminated.

Artificial Intelligence

The issues related to the management and understanding of data obtained by environmental sensing systems are closely tied to the second technological development of the future: the science of complex information processing networks. This topic is often referred to by the unfortunate but universally used term artificial intelligence. The revolution in complex information processing is already well underway, as illustrated by the rapid development and proliferation of computers and computer networks. Computers in offices and homes are only the beginning; artificial intelligence is an enterprise with grand aims and even grander claims.

It is useful to divide activities in artificial intelligence into three areas — A, B, and C — following Sir James Lighthill's analysis of artificial intelligence for the United Kingdom in 1972. Area A, where A stands for advanced automation, has the objective of replacing human beings by machines for specific purposes; for example, industrial assembly, military reconnaissance, or even scientific analysis. A great deal of work in area A has gone into pattern recognition, which involves programming computers to read documents or to recognize spoken words. In the more challenging tasks, such as recognizing speech from an untrained speaker in the presence of noise, little progress has been made.

Before referring to area B, the third area in Lighthill's classification is labeled C, where C stands for computer-based central nervous system research. The objective here is to understand the functioning of brains, either human or animal, using the computer as a tool to complement and interpret the facts of experimental neurophysiology. A more remote aim is to understand the architecture of the brain so completely that we can borrow from the brain's architecture to build new generations of computers.

The A, B, Cs of artificial intelligence are completed by area B, the bridge which aims to connect automation with brain function. For many years, the principal activity in area B was building robots. Sophisticated robots have been constructed and their programs loaded with increasing amounts of external information, yet the ability of a robot to sense its surroundings and make judgments independently of its preprogrammed set of instructions remains vanishingly small.

Neural Networks

Over the last five years, another bridge has been built between areas A and C, through the development of neural networks. Neural networks attempt to mimic the basic building blocks of the brain: the nucleus; the signal input path to the nucleus through dendrites; and the output path, the axon. In a computer, the processing element has many input paths and usually combines the values of these paths by simple summation. The combined input is then modified by a non-linear transfer function before the signal is passed on to the next layer. The neural network can be trained by comparing its output with the output that is desired for a given input.

A number of examples of working neural networks have been created, including text-to-speech, encoding of image data, character recognition, and target classification. Although impressive progress has been achieved in constructing working neural networks, the process remains as much art as science. Like robotics, neural networks are in their infancy.

Computers of the Future

In the future, advanced automation and neurophysiology can be expected to flourish as separate sciences, with exploration of neural networks providing a bridging function. The building of bridges connecting these sciences will be hastened as the brain architecture in area C begins to be understood in detail, and the program architecture in area A begins to acquire the sophistication of natural human languages.

In time, computer designers will be able to incorporate the structures of neurophysiology into their designs, and neurophysiologists will be able to monitor neural processes with properly matched connections between brains and computers. When progress has reached this point, the grand claims of artificial intelligence, so prematurely made and so justly ridiculed, will be closer to fulfillment. The building of truly intelligent machines will then be possible. I would project that these goals might be reached by the mid-21st century.

Even if artificial intelligence clears the first fence in the 21st century, human intelligence will remain far ahead for the rest of the steeple chase as humans continue to learn from machines. Despite the clear limitations of artificial intelligence, future work in this area is of immense importance to the Army. As developments in the understanding of the brain's architecture join with improvements in automation, myriad advances in signal processing and data management can be expected. The automated battlefield will become reality, and the whole concept of projection of force may change drastically as machines replace men.

Genetic Engineering

The science of genetics and cellular physiology at the molecular level goes under the infelicitous terms genetic engineering and biotechnology. Genetic engineering is already established as a tool of manufacture in the pharmaceutical industry: bacteria are infected with alien genes and cloned to produce in quantity the proteins which the alien genes specify. But the quantities of chemical materials that can be produced in this way are at present small.

Genetic engineering makes economic sense today only for producing drugs that can be sold at high unit price; it does not yet begin to compete with conventional industrial processes for mass production of common chemicals. A genetically engineered bacterium in a tank produces as much material in one day as a conventional combustion reactor in the same tank would produce in one second. Biological reactions are slow and require large volumes to produce a substantial throughput of products. For this reason, genetic engineering will not replace conventional chemistry as long as genetically engineered creations are confined to tanks and retorts.

But why are genetically engineered production processes confined to tanks? One reason for confinement is concern for environmental safety. Regulations in most countries forbid the release of genetically engineered creatures into the open air, and even though fears of genetically engineered monsters overrunning the earth are often exaggerated, it is reasonable to be cautious in relaxing regulations.

Newly engineered creatures must be studied and understood before they are released; still, it seems likely that we shall learn in time to transfer genetic-engineering technology from enclosed tanks to the open field without serious danger.

The implications of genetic engineering for the future Army are, like those of artificial intelligence, immense. The capability to specifically design materials means that the Army would have access to novel, low-cost materials made for a particular purpose.

Even without advanced outdoor genetic engineering, advances can be expected in the design of the CBW-Toxin biosensor, which can be remotely deployed for perimeter or far-forward troop warning. In addition, soldiers can be immunologically enhanced to increase their protection from novel agents that the enemy might obtain from his genetic engineering activities. Similar techniques can be used to protect soldiers from naturally occurring, endemic infectious disease organisms.

The benefits of genetic engineering have come at a slower pace than many anticipated, but there is no doubt that genetic engineering will be prominent in shaping the world of the 21st century. Although the specific applicability of genetic engineering to Army problems is still hazy, I am sure that the future science of genetics and cellular physiology at the molecular level will burn this haze away.

Conclusions

The sweeping changes now occurring in world affairs present a unique opportunity for the Army to strengthen its research activities. I have argued that three technologies — environmental exploration, artificial intelligence, and genetic engineering — will exert a primary influence on the world and the Army of the 21st century. Others may wish to add, delete, or modify this list; the details are not significant. The science that underlies the technologies of the next century is being conducted today, and the Army must be an active participant if it is to wisely use these incipient technologies in the future.

ASSIGNMENT LOCATIONS FOR RD&A OFFICERS

In response to a number of inquiries from officers concerning possible assignment locations for members of the Army Acquisition Corps (AAC) and the RD&A related Functional Areas (FA), *Army RD&A Bulletin* will run a series of articles listing current assignment locations for specific FAs. The number of positions vary at each location according to FA and grade requirements. Our intent is to provide readers with a general knowledge of where the majority of RD&A related assignments can be found. For specific information on individual assignments, readers are advised to contact their appropriate PERSCOM assignment officer. Following is a list of duty locations for Army officers in FA 51 (Research, Development and Acquisition), and Area of Concentration (AOC) 52B (Nuclear Weapons Research), where 51 and 52B are the primary position requirements. Those locations having AAC Critical Positions (4Z) are also listed. A future issue will list assignment locations for FA 53 (Systems Automation), FA 97 (Contracting and Industrial Management) and AAC related 15C35 (Aviation/Intelligence) positions.

ALABAMA

Fort Rucker:
US Army Aviation Center	(FA 51)
US Army Aviation Dev Test Act	(FA 51)

Redstone Arsenal:
HQ US Army Missile Command	(FA 51/514Z)
US Army Missile & Space Inst	(FA 51)
US Army Missile Munitions Ctr & Sch	(FA 51)
PEO Air Defense	(FA 51/514Z)
PEO Fire Support	(FA 51/514Z)

Fort McClellan:
US Army Military Police School	(FA 51)
US Army Chemical School	(FA 51)

Huntsville:
US Army Strategic Defense Command	(FA 51/514Z)

ALASKA

Fort Greely:
US Army Cold Regions Test Activity	(FA 51)

ARIZONA

Fort Huachuca:
US Army Electronics Proving Ground	(FA 51)
US Army Intelligence School	(FA 51)

Yuma:
US Army Proving Ground	(FA 51)

CALIFORNIA

Moffit Field:
US Army Aviation Research & Test Act	(FA 51)

Livermore:
US Army Research Associate Group	(FA 51/52B)

COLORADO

Colorado Springs (Peterson AFB):
US Army Element US Space Command	(FA 51)

FLORIDA

Orlando:
PM Training Devices	(FA 51/514Z)

MacDill AFB:
US Army Element US Southern Command	(FA 51)

GEORGIA

Fort Benning:
US Army Infantry School	(FA 51)

Fort Gordon:
US Army Signal Center	(FA 51)

HAWAII

Camp Smith:
US Army Element Pacific Command	(FA 51)
US Army Element PACOM Spec Act	(FA 51)

ILLINOIS

Rock Island Arsenal:
US Army Armament Munitions Activity	(FA 51/514Z)
US Army Armament Munitions & Chem Cmd	(FA 51/514Z)

Fort Sheridan:
US Army ISC-USAREC	(FA 51)

INDIANA

Jefferson Proving Ground:
US Army Jefferson Proving Ground	(FA 51)

Fort Benjamin Harrison:
US Army Reserve Full Time Support	(FA 51)

KANSAS

Fort Leavenworth:
US Army Comb Arms Ctr Cbt Dev Act	(FA 51/52B)
US Army Space Institute	(FA 51)

KENTUCKY

Fort Knox:
US Army Armor School	(FA 51)

MARYLAND

Andrews AFB:
LNO HQ AF Systems Cmd	(FA 51)

Fort Meade:
Operational Group	(FA 51)
USA Foreign CI Act	(FA 51)
USAMC Intell Mat Act	(52B)

Aberdeen Proving Ground:
USA Ordnance Center & School	(FA 51)
USA Ballistic Research Laboratory	(FA 51)
USA Human Engineering Laboratory	(FA 51)
USA Materiel Systems Analysis Act	(FA 51)
HQ USA Test and Eval Command	(FA 51)

Chemical Research Dev & Engr Ctr	(FA 51/514Z)
USA CSTA	(FA 51/52B)
Fort Detrick:	
US Army Medical R&D Command	(FA 51)
Adelphi:	
HQ US Army Laboratory Command	(FA 51/52B4Z)
Harry Diamond Laboratories	(FA 51/52B)
US Army Survivability Mgt Office	(FA 51)
Bethesda:	
US Army Element AFRRI	(FA 52B)

MASSACHUSETTS

Boston:	
Natick Research Dev & Engr Ctr	(FA 51)
Watertown:	
Materials Technology Lab	(FA 51)

MICHIGAN

Detroit:	
HQ US Army TACOM	(FA 51/514Z)
TACOM Research Dev & Engr Ctr	(FA 51)
PEO Combat Support	(FA 51/514Z)
PEO ASM	(FA 51/514Z)

MISSOURI

St. Louis:	
HQ US Army Aviation Systems Cmd	(FA 51/514Z)
HQ TROSCOM	(FA 51/514Z)
PEO Aviation	(FA 51/514Z)
PM Light Helicopter	(FA 51/514Z)
Fort Leonard Wood:	
US Army Engineer Center	(FA 51)

NEBRASKA

Offutt AFB:	
Joint Strategic Planning Staff	(52B)

NEW JERSEY

Fort Monmouth:	
Information Systems Mgt Activity	(FA 51/514Z)
AMC Aug Element-US	(FA 51/514Z)
US Army Avionics Research Dev Act	(FA 51)
US Army Electronics Tech & Dev Lab	(FA 51)
US Army Communication & Elec Cmd	(FA 51/514Z/52B)
PEO Command & Control Systems	(FA 51/514Z)
PEO Communication Systems	(FA 51/514Z/52B)
CECOM Space Center	(FA 51)
PEO Strategic Information Systems	(FA 51/514Z)
Lakehurst:	
Comm & El Cmd Abn Elec Activity	(FA 51)
Picatinny:	
Office of PM for Nuclear Munitions	(FA 51/514Z/52B)
PEO Armaments	(FA 51/514Z)
Armament Research Dev & Engr Ctr	(FA 51)

NEW MEXICO

White Sands Missile Range:	
White Sands Missile Systems	(FA 51/52B)
US Army Atmospheric Sciences Lab	(FA 51)
Dir EO GW CM/CCM Joint Tst & Eval Dir	(FA 51)
US Army Vulnerability Assessment Team	(FA 51)
Kirtland AFB:	
US Army Elm DNA Fld CM	(FA 51/52B/52B4Z)

NEW YORK

West Point:	
HQ Staff & Faculty USMA	(FA 51/52B)
Watervliet:	
Watervliet Arsenal	(FA 51)

NORTH CAROLINA

Fort Bragg:	
US Army JFK Special Warfare Center	(FA 51)
Durham:	
Army Research Office	(FA 51)

OKLAHOMA

Fort Sill:	
US Army Field Artillery Ctr and Sch	(52B)

PENNSYLVANIA

New Cumberland Army Depot:	
US Army Depot New Cumberland	(FA 51)

TEXAS

Fort Hood:	
Test Eval & Exp Cmd (TEXCOM)	(FA 51)
Fort Bliss:	
US Army Air Defense Artillery Ctr	(FA 51)
Kelly AFB:	
US Army Element JT ELTRWFA	(FA 51)

UTAH

HQ US Army Dugway Proving Ground	(FA 51)

VIRGINIA

Pentagon:	
DCS Personnel	(FA 51)
SAOASA RDA	(FA 51/514Z)
DCS Operations & Plans	(FA 51/514Z/52B)
US Army Element OSD	(FA 51/52B)
US Army Element OJCS	(FA 51/514Z/52B)
Def Mob Sys Planning Gp	(FA 51)
Navy Activities	(FA 51/514Z)
Air Force Activities	(FA 51)
US Army Equip Eval Act	(FA 51)
US Army IG Agency	(FA 51)
US Army Dir Mil O	(FA 51)
Office of the Secretary of the Army	(FA 51)
Legislative Liaison	(FA 51)
Fort Belvoir:	
US Army Element Def Sys Mgt College	(FA 51/514Z)
US Army Belvoir Resch Dev & Engr Ctr	(FA 51)
US Army Nuclear Chemical Activity	(52B)
PEO STAMIS	(FA 514Z)
Fort Eustis:	
US Army Tng Spt Ctr	(FA 51)
US Army Aviation Logistics Act	(FA 51)
US Army Transportation School	(FA 51)
Aviation Applied Technology Dir	(FA51/514Z)
Fort Lee:	
US Army Log Mgt College	(FA 51/514Z)
Arlington:	
PEO Army Strategic Def Cmd	(FA 51/514Z)
PEO Unmanned Aerial Veh Jt Program	(FA 51/514Z)
Cmd Sys Integration Office	(FA 51)
Baileys Crossroads:	
PEO STAMIS	(FA 514Z)
US Army Element Joint Test Activity	(FA 51)
Alexandria:	
US Army Elm Def Nuclear Agency	(FA 51/52B/52B4Z)
US Total Army Personnel Command	(FA 51)
US Army Research Institute	(FA 51)
US Army Space Program	(FA 51/514Z)
HQ Army Materiel Command	(FA 51/514Z/52B)
US AMC IG Activity	(FA 51/514Z)
US Army Special Project Activity	(FA 51)
Army Acquisition Exec Spt Agency	(FA 51/514Z)

CAREER DEVELOPMENT UPDATE

Falls Church:
US Army Operational Test & Eval Agcy — (FA 51)
Fort Monroe:
HQ US Army TRADOC — (FA 51/52B)
TRADOC Combined Field Operations — (FA 51)
US Army TRADOC Field Element — (FA 51)
Vint Hill Farms Station:
Communications & Electronics Activity — (FA 51)
PEO Intelligence & Electronic Warfare — (FA 51/514Z)
McLean:
PM Joint Tactical Fusion Program — (FA 51/514Z)
Charlottsville:
US Army Frgn SCI Team — (FA 52)

WASHINGTON DC

US Army Studies & Analysis Ctr — (FA 51)
US Army Strategic Defense Initiative — (FA 51/52B)
US Army Suppport outside DOD — (52B)
US Army Elm Natl Def University — (FA 51)
Def Comm Agency CC Engr Ctr — (FA 51)

WASHINGTON

Fort Lewis:
US Army Developmental Employment Act — (FA 51)

OVERSEAS LOCATIONS

AUSTRALIA

Canberra:
US Army Standardization Group — (FA 51)

GERMANY

Bonn:
US Army Standardization Group — (FA 51)
Heidelburg:
HQ UASAREUR & 7th Army — (FA 51)

BELGIUM

Brussels:
NATO Intl Mil STE — (FA 51)

CANADA

Ottowa:
US Army Standardization Group — (FA 51)

ITALY

Naples:
HQ Armed Forces South — (FA 51)

JAPAN

Yokota:
Technical Science Center — (FA 51)

KOREA

US Army Element JUSMAG — (FA 51)

UNITED KINGDOM

London:
US Army Standardization Group — (FA 51)

RD&A NEWS BRIEFS

Army Patent Successes

The Army was awarded 163 patents in 1989, gaining a tie for 50th place with Ford Motor Co., in a list of top U.S. patent recipients reported in the April 30, 1990 issue of *New Technology Week*. The Air Force and the Navy received 137 and 124 patents to place 64th and 73rd, respectively.

Army patents can be separated into three categories: advances that serve a need specific to the Army mission, advances that have a clear application for civilian use, and discoveries likely to be important in the future.

There are, of course, numerous examples of the first group — those serving a specific Army need and for which there is no comparable civilian industry. The Army is the lead service in developing propellants and explosives. Patents in 1989 from the Armaments RD&E Center (ARDEC) in Dover, NJ and from the Ballistics Research Lab at Aberdeen, MD cover new methods for munitions synthesis and loading of flame resistant materials.

The Army also has primary service responsibility for chemical/biological defense. The Chemical RD&E Center (CRDEC) at Edgewood, MD produced patents in 1989 for detection of toxic agents, decontamination, and protective garments.

Natick RD&E Center (NRDEC), Natick, MA developed patents for improved parachutes and the Tank-Automotive Command in Warren, MI produced patents for improved armor and turret traversing mechanisms. The Materials Technology Lab in Watertown, MA has also patented a design for a reduced weight gun tube.

Many patents support the Army mission but also have clear implications for civilian use. The Army is the principal driver for helicopter evolution and, in 1989, the Aviation Systems Command in St. Louis patented advances in helicopter cargo carriers and new anti-torque and air-foil designs. A particularly interesting patent covers an optical assembly that permits a pilot better control over trailing ground lines — enabling pick-up of soldiers from a battlefield or civilians from a burning building.

The Tank-Automotive Command received patents on tracked vehicle suspensions and steering mechanisms; both may be useful in the design of heavy construction equipment.

Toxic waste disposal is a critical world-wide need and the Army is leading the way in developments. In 1989, CRDEC, ARDEC, and NRDEC patented discoveries in air purification and toxic agent detection and decontamination. Army med-

ical research has produced patent activity in the development of vaccines effective against infectious diseases, a wound gel for burn treatment, a blood substitute and a blood preservative.

Discoveries with important long-range implications have been made by the Army Missile Command in Huntsville, AL on optical computing devices and super-directive antenna arrays; while the Electronics Technology and Devices Lab at Fort Monmouth, NJ and the Harry Diamond Labs at Adelphi, MD have been prolific in the patenting of new devices including memories, infrared detectors, and magnetic field sources.

Advanced composite materials have been patented by ARDEC and MTL. Perhaps most importantly, Army medical research has produced patent activity in the development of a vaccine against the AIDS virus.

The Army, while pursuing its mission, contributes to the growth of maturing technologies, thus staking its claim in the U.S. market as a leader in developmental science.

System Promises Faster Spares Acquisition

Tobyhanna Army Depot has been designated an Army site for a new, progressive manufacturing technology that promises to reduce the acquisition time for spare parts by as much as 90 percent. Rapid Acquisition of Spare Parts (RASP) is a flexible, computer integrated manufacturing system that is part of the Army's plan to establish an Army Materiel Command-wide automated fabrication network, according to Frank Estock, chief of the depot's Engineering Branch.

There are currently two components of RASP: Small Manufactured Parts (SMP) and Printed Wire Assemblies (PWA). "Anniston Army Depot and Letterkenny Army Depot are both conducting feasibility assessments to determine what is required to become a SMP RASP site. Tobyhanna's effort will be investigating PWA requirements but it will later be expanded to include SMPs," Estock said.

"With RASP, if someone wants a part or a circuit card, they will send us a computer file which will contain the drawing in a digital, neutral format as well as all the product information necessary to quickly manufacture the part," Estock explained.

One of the inherent problems with the Army's current spares manufacturing process is the lack of a unified computer software system. With RASP, one standardized software system will be chosen so that all personnel will have the information formatted and stored identically. This total integration of all facets of the manufacturing process, including order entry, production, inventory control, and manufacturing engineering, will provide a highly efficient and top quality manufacturing environment that will reduce not only procurement time but cost as well.

The first phase of the program, a feasibility assessment, will be completed in the fiscal 1991 timeframe. The design phase will take place in fiscal 1992 and implementation is scheduled to begin in fiscal 1993.

Study Compares Housing Construction

A 5-year study by a Corps of Engineers lab could dispel beliefs that manufactured housing is of lesser quality than conventional construction.

"A well built manufactured home is just as sound as a well built conventional one," says Robert Neathammer, team leader at the U.S. Army Construction Engineering Research Laboratory (CERL). Neathammer, who led the study, points out "you can also have shoddy conventional construction — it all depends on the builder."

In the study, 200 factory-built housing units were compared to 144 conventionally constructed units in a family housing complex at Fort Irwin, CA. All units were basically the same, with two bedrooms, one bath, and 950 net square feet. Congress authorized the project in 1982 to determine if the defense construction budget could be trimmed by using manufactured housing.

The study compared first cost, annual operation and maintenance (O&M) costs, and occupant satisfaction over five years. O&M data were collected for only those O&M costs related to the structure. "We were studying the construction type — so we took out items like refrigerators, other appliances, roadways, sidewalks, and so on that have nothing to do with the way the house was built," Neathammer explains.

The O&M data collected over the five years showed minor differences in the two types of construction. A major expense was incurred for repairing the eaves on the manufactured units. To transport the roofing sections more easily, the manufacturer had provided hinged roof eaves that were folded into place onsite. These were secured with only metal straps and a few nails so that with time, they began to sag, and in one case, even fell off the house. All of the eaves needed repairs.

Gas and electrical consumption were monitored during the study. The manufactured housing consumed more energy than the conventionally built units; however, the difference was less than $27 per unit per year.

Critical to the factory units' acceptability was occupant satisfaction. According to LTC John Wright, director of engineering and housing at Fort Irwin, "Residents' satisfaction was about the same in both types. In fact, most residents did not know how the units were built and could not tell a difference from living in them." The results of a questionnaire given to vacating occupants confirmed this, showing no difference in satisfaction for the overall units and specific components such as floors, walls, and heating and cooling systems.

The study concluded that, with tighter quality control at the factory and during onsite assembly, this type of manufactured housing could provide the durability and esthetics required of military construction. Whether it can do this at a significantly lower first cost to the government than conventional housing was not supported by this study.

"For the study, DOD specified how manufacturers were to design their units," Neathammer says. "This may have affected the first cost. As it turned out, the housing units cost

about the same." He notes that, given the flexibility to design their own units, manufacturers may be able to offer a lower first cost, but "that isn't evident from the study."

Neathammer further notes that the manufactured units are providing much needed housing for military families at Fort Irwin. He said "participation in the study was productive and results support the Corps' recent policy to allow manufactured housing as a contractor option for new Army facilities."

CERL, Industry Sign CPAR Agreements

The U.S. Army Construction Engineering Research Laboratory (USACERL) in Champaign, IL, has signed three Cooperative Research and Development Agreements (CRDAs) with non-government organizations to jointly conduct research into innovative construction technologies. The CRDAs solidify partnerships between USACERL and the industry that will share the cost of the projects as part of the Construction Productivity Advancement Research (CPAR) program.

The three advanced technologies that USACERL and its partners will study are mechanically assisted masonry construction, destruction of asbestos-containing waste material using a plasma arc torch, and a low-cost personal computer-based system for compliance with the federal Occupational Safety and Health Administration (OSHA) hazardous communications standard.

"These agreements are a unique opportunity to share R&D resources between the Corps labs and the private construction industry," said Dr. Louis R. Shaffer, USACERL technical director. "For several years we've been working with the private sector in marketing our products, but under CPAR, we'll actually be co-developing technologies. We're very excited about expanding our relationship with the industry."

USACERL's partners for these projects represent a diverse cross section of the private sector. To study robotically assisted masonry, USACERL has joined with the International Masonry Institute (IMI), an organization that serves union masonry craftsmen and contractors. The plasma arc project will be conducted jointly with three partners: the Georgia Institute of Technology, Asbestos Abatement Technology, Inc., and Plasma Energy Corp. Each will contribute equipment, personnel, or funding to the study. For the OSHA compliance PC system, USACERL will work with Northeast Louisiana University and local chapters from two labor unions.

The CPAR program is funded by Congress under the amended 1988 Water Resources Act as an effort to enhance the U.S. construction industry's productivity and competitiveness through the use of new or innovative technologies. The opportunity to form partnerships between government labs and industry had earlier been made possible by the 1986 Stevenson Wydler Technology Transfer Act. To participate in a CPAR project, a non-government partner signs a CRDA and agrees to share the research cost with the Corps of Engineers.

Negotiations for the three CRDAs ranged from one to six months. Acknowledging the relatively long process, USACERL Attorney Bill Woodard said "This is a brand new program and many of the legal aspects simply could not be anticipated for the original working document." He added that the past year's experience has been valuable in suggesting a more flexible legal framework, so that "Hopefully we'll see a smoother process for the next round."

The projected start and completion time lapse before products are available is one to three years. This timeframe is in comparison to the average of 17 years that studies have shown as the normal time for bringing a product from concept to market in the construction industry.

When a product is ready for commercialization, profit sharing among the partners will be renegotiated through contracts such as exclusive licensing agreements. The CRDA is simply an agreement to joint ownership of the technology. Because of the wide diversity in products expected from CPAR projects, all contracts must be handled on a case-by-case basis. But profit may not be the only motive for some CPAR partners. According to Dr. S. L. Camacho, vice president of research at Plasma Energy, Inc. and inventor of the plasma arc torch, "We don't expect to make a lot of money on this particular use of the technology. We're mainly involved in the CPAR project because we have an interest in doing what we can to help clean up the environment." He added that using the plasma arc torch to destroy asbestos will provide exposure for his company's technology, which they would like to expand to other environmental cleanup and recycling efforts.

The Corps has approved three more CPAR projects at USACERL for FY90. Total funding for USACERL's FY90 projects will exceed $1 million.

Competitive Procurement Saves $9 Million

Government savings of $9 million are estimated as the result of competitive acquisition of spare parts and elimination of manufacturer rework associated with the AN/TPQ-37 Firefinder Radar system.

The AN/TPQ-37 is used for locating hostile artillery weapon systems. A high power microwave transmitter is a major subsystem of the AN/TPQ-37. Recently, the U.S. Army Electronics Technology and Devices Laboratory (ETDL) assisted the U.S. Army Communications-Electronics Command's (CECOM) Manufacturing Technology Directorate in overcoming a problem that prevented the competitive acquisition of spare parts for the transmitter.

The Army had previously purchased, on a sole source basis, isolation and power transformers as required system spare parts. However, 40 percent of the spare parts failed, causing system manufacturers the expense of repairing the failed units or custom-building replacements.

At CECOM's request, ETDL reviewed the technical data package recommending changes to the spare parts specifications and acceptance test criteria to insure the transformers are of high quality and fully compatible with the current system. A survey of potential vendors indicates that a competitive acquisition and elimination of the system manufacturer's rework should result in the $9 million savings.

CONFERENCES

● **International Seminar on Plastic Waste Minimization Through Source Reduction**, Jan. 28-30, 1991. Additional information: Dr. S.P. Wolsky, Ansum Enterprises, Inc., 1900 Cocoanut Road, Boca Raton, FL 33432, Telephone (407) 391-3544 or Fax (407) 750-1367.

● **Fifth International Seminar on Lithium Battery Technology and Applications**, March 4-6, 1991. Additional information: Dr. Sumner P. Wolsky, Ansum Enterprises, Inc., 1900 Cocoanut Road, Boca Raton, FL 33432, Telephone (407) 391-3544 or Fax (407) 750-1367.

● **CORROSION/91**, March 11-15, 1991, Sponsored by the National Association of Corrosion Engineers. Additional information: Peggy Parsons, (713) 492-0535.

● **Smoke/Obscurants Symposium XV**, April 16-18, 1991, sponsored by the U.S. Army Chemical RD&E Center. Additional information on presentation of papers, abstracts, or the conference: Judy Cole, (804) 865-7604 and telefax (804) 865-8721; or Walter Klimek, (301) 671-2260, AV 584-2260, or telefax (301) 671-2968.

● **22nd Annual Pittsburgh Conference on Modeling and Simulation**, May-2-3, 1991, sponsored by University of Pittsburgh School of Engineering. Additional information on paper submissions or the conference: William G. Voght or Marlin H. Mickle, Modeling and Simulation Conference, 348 Benedum Engineering Hall, University of Pittsburgh, Pittsburgh, PA, 15261.

BOOK REVIEWS

MANPRINT — An Approach to Systems Integration

Edited by Harold R. Booher
New York, NY: Van Nostrand Reinhold, 1990

Reviewed By MAJ Elaine Howell,
U.S. Air Force Impacts Office

Dr. Harold Booher and his cast of contributors have created what will surely become a standard text for introducing human elements in systems design to the layman. I must point out immediately that this book addresses MANPRINT as a philosophy for integration, and not the specific Army program of the same name. The MANPRINT philosophy, which has been enthusiastically adopted by the Army over the past few years, is an idea whose time has come.

Living as we are under increasing pressure to cut our forces, yet faced with the undeniable need to modernize and maintain our technological edge, MANPRINT offers managers a palatable alternative. To make the MANPRINT philosophy work, however, leaders and managers must be educated — both to the problem and to the solution. This compilation of papers by recognized human factors experts may prove to be a giant step forward in providing that education.

The book itself is written by a miscellany of contributors that comprise a wide range of human factors expertise and experience. The book is organized into four parts: Part I, Organization/Management Context; Part II, User-Centered Design Advances; Part III, Systems Integration Methodologies; Part IV, Sources of User-Centered Technology. But don't let the titles mislead you — the writing is interesting and refreshing, laced with many examples and plentiful references, and with few exceptions, understandable by those who are not engineers. The graphics and illustrations are clear and well situated to the relevant text.

Chapter VI, Conceptual System Design and the Human Role, should be made required reading for every military manager, engineer or operator who might possibly have contact with systems design and acquisition. The sermon that we in the daily "manpower, personnel, training and safety (MPTS) business" have been preaching for years has been set down cogently, coherently, comprehensively and concisely by Harold E. Price of the Essex Corporation. In this chapter you will find some eye-openers for the unconvinced, as well as a double shot of affirmation for those already in the choir.

The MANPRINT book brings home the major points of why we need integrated human factors in systems design and acquisition: the effects of the "domains" (manpower, personnel, training, safety, human engineering and health hazards) on each other; the huge life-cycle cost of MPTS and the potential for savings when the man-machine interface is designed-in from concept initiation; the consequences of trying to compensate for design by increasing manpower or training; and the opportunity to use our full technological capabilities. It is capped, in Part IV, by a series of articles on relevant data bases, the state of current knowledge about MPTS issues, proposed research and development, and strategies for providing MPTS expertise through our national educational system.

MANPRINT — An Approach to Systems Integration is oriented to managers, designers, users and students. The book should be of value to anyone interested or involved in systems design or acquisition. The cost is $42.95. Copies are available from Van Nostrand Reinhold, Mail Order Department, P.O. Box 668, Florence, KY 41022-0668, 1-(800) 926-2665.

FROM THE ARMY ACQUISITION EXECUTIVE...

Declining defense dollars have exposed flaws in the way that we, in government, and our industrial partners have approached the funding and management of many of our development and production efforts.

Reductions in defense dollars will lead to the production of smaller numbers of fewer weapon systems, and this limited production will inevitably lead to a smaller and more competitive industrial base. Both government and industry need to reexamine some of our past practices.

Although the basic concept of the defense acquisition process is simple, that process is complex in its execution. The process starts with research and development and ends with the production and fielding of new weapon systems. Production has been performed in nearly all instances by the developing contractor.

In the past, some firms would "buy-in" during the development stage, assuming that they would be able to "get well" several years later in production. Some firms would invest their own money in development (often with government encouragement), again expecting to "get well" later.

In past years, "buy-ins" and "get wells" were low-risk to the contractors because development was invariably followed by substantial production. In today's environment, development programs may conclude without any production or with substantially reduced production. The current fielding squeeze has exposed what has always been the flaws in the practice of "buy-ins" and "get wells." In my opinion, that practice was never appropriate.

The solutions to this problem are severalfold:

The government must pay fully for research and development and all other up-front efforts. We must secure technical rights from the developing contractor so we can preserve the option to compete in production. Contractors should keep fair profits in mind when bidding these contracts. These practices will have the added benefits of exposing true development costs and precluding an automatic commitment to the contractor who developed the technology. Follow-on production should be considered a new effort with no guarantee for the developer. We may, in a competitive environment, select another production source.

Development contracts will rarely be fixed-price. A major challenge in cost-type development contracts will be injecting cost and schedule discipline into the process. Adding tough cost incentive features to these contracts may be necessary.

While it is likely that tight defense budgets will be with us for the next several years, the changes to our acquisition strategies will serve as a foundation on which an improved relationship between government and industry is built. Our goal is to develop new technologies and produce modern weapon systems to meet our future defense needs. Because production is no longer assured, we, in government, will pay contractors fully, including a fair profit, to develop new capabilities. This is just plain good business. Even if our funding were to return to the relatively robust days of the 1980s, I believe we should continue to pursue the approach described here for managing our development and production efforts.

Stephen K. Conver