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NOVEMBER-DECEMBER 1987

DESIGN-TO-UNIT PRODUCTION COST...

THE MLRS EXPERIENCE

ARMY

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

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CARL E. VUONO
General, United States Army
Chief of Staff

Official:

R. L. DILWORTH
Brigadier General, United States Army
The Adjutant General

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FEATURES

DEPARTMENTS

ABOUT THE COVER

The front cover photo of the Multiple Launch Rocket System is associated with a feature article on Design-to-Unit Production Cost. The back cover photo is related to development of a Robotized Wire Harness Assembly System for use in automated production of missile electrical cables and harnesses. This automated system is highlighted in an article on annual Army R&D Achievement Awards.

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Design-to-Unit-Production Cost . . . The MLRS Experience

By Richard Paladino

Introduction

Design to unit production cost (DTUPC) is a term used to describe the unit cost objective imposed on development contractors. The definition includes all costs over which the contractor has control, and should ultimately represent the hardware unit cost in the production phase of a program.

The design to cost program is based on the objective of enforcing the use of cost as a design parameter in the attainment of the required performance, technical, schedule, and operational capability of a developmental system.

It should be recognized that the DTUPC program is part of an overall development program objective and as such is stressed by the same pressures that threaten the success of the development program as a whole. Figure 1 illustrates the pressures that often cause a DTUPC goal at milestone I to grow into a much larger DTUPC achieved at milestone III. These pressures fall into two major categories. The first is related to engineering activities and the second to program activities.

The engineering pressures on unit cost come from changing requirements of the user, new threats derived by the intelligence agencies, and the host of problems associated with emerging technologies, development problems, testing, and/or related failures. These pressures, although often unavoidable, stress the designers to focus on the technical parameters of the system, with unit cost losing its focus as a design parameter in the shuffle to keep up with design changes.

Likewise, the program management pressures on unit cost come from development program funding constraints, program stretch outs, changes in hardware requirements, cost overruns in development, revised acquisition strategies, and to other programmatic issues.

The DTUPC program, by establishing goals and objectives, is helpful in keeping the focus of the design engineers and program managers on the eventual cost objective of the system. Coupled with the producibility engineering and planning activities, DTUPC has eliminated much of the "gold plating," over specification of materials, and producibility problems that have been designed into hardware previous to its implementation.

MLRS

Several articles were published in *Army RD&A Magazine* (now Bulletin) (Mar-Apr 81, Jan-Feb 84) concerning the success of the Multiple Launch Rocket System (MLRS) program in attaining its development cost, schedule, and DTUPC objectives. Much of that success relates to competition during development and a strong project management team which vigilantly guarded the program from the pressures that diffuse the focus during development. Within that arena of a stable development program, the MLRS DTUPC program contained some innovations and insights which are being applied to other MLRS development programs. These innovations may provide some principles which will be of benefit in establishing DTUPC programs for other Army systems.

In the successful implementation of the MLRS design to cost program, it became evident early in the design process that the DTUPC had to become more than a design parameter if the cost objective was to be achieved.

As the design matured, the pricing of the evolving system took on more realism, and the costs associated with raw materials, basic manufacturing pro-

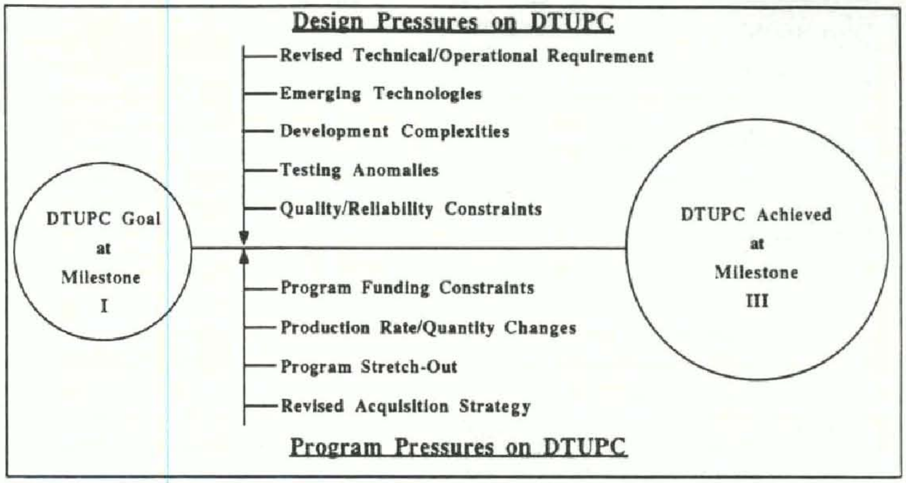


Figure 1. Common Pressures Causing DTUPC Growth.

cesses, and major components of the system led to unit prices that were clearly above the design to cost objective. In addition, there was a realization that there was little that the designers could do to significantly reduce emerging costs and still meet the performance and other technical objectives of the system. This realization caused the DTUPC effort to become an overall program cost objective that required the full attention of the total development team and involved all aspects of the development contractor and government staffs.

While maintaining the technical design focus on unit cost, the development team considered the balance of all costs over which the contractor had control in order to achieve the unit cost objective. These other costs were primarily within the business management areas of the contractor and had previously received very little attention under the design to cost program umbrella.

These cost reduction efforts involved evaluations to reduce corporate overhead rates, production labor rates, selection of alternate corporate facilities in which to fabricate the MLRS hardware, make or buy evaluations, consideration of corporate investment in new plants and facilities in order to be a more efficient producer, and to increase the degree of subcontract competition.

Although these types of evaluations and decisions were clearly outside the realm of the design engineering team, it was determined that they affected the unit price to as much a degree as the design parameters. Therefore, they were controlled as part of the overall effort to reach a design to unit cost objective.

The change in focus from a design cost approach to a total cost approach was key in the achievement of the production cost objectives for the MLRS system. An overriding factor causing the prime contractor to make the difficult but necessary business management decisions was the existence of competition between two development contractors for ultimate production of the system. Only one contractor was to be chosen for production, and hardware unit prices weighed heavily in the ultimate decision.

Don't Constrain DTUPC

Figure 2 reveals the problem inherent in the use of cost as a design parameter and illustrates the potential problems for the design engineers when given a DTUPC goal.

The costs associated with raw materials, manufacturing processes, and direct production labor hours are those which are most sensitive to the control of the designers. However, clearly a large portion of the total costs are dictated by the business management aspects of the parent company, i.e., labor rates, support labor, overhead rates, general and administrative fees, and profit objective.

For the design engineer not normally involved with the pricing policy of his company, a DTUPC estimate/goal based on direct material and direct labor increases dramatically when developed into a "selling price" for the Army customer. This type of data must be fully understood by the government when establishing DTUPC goals, and emphasizes the futility of a designer trying to achieve the goal without the full support of management.

While the design engineering staffs are concerned with the direct material and labor hour content of the design, the program management, pricing, and corporate staffs must be challenged to participate in the DTUPC program as their decisions, made or not made, can influence the eventual production cost of the system as much as the design parameters. This effect is best demonstrated when competition is introduced into a formerly sole source production item.

With the design fixed, savings of 25 to 50 percent or more are often achieved by the pressures the market place puts on the business management aspects of unit price.

Establish Goals Realistically

A key element in the implementation of a successful DTUPC program is the establishment of a realistic goal. A goal that is easily achieved does not challenge the developer to make difficult design choices and leads to a higher price for the customer. Likewise, an unrealistic goal that is not achievable is quickly cast aside and not used as a design trade-off during development.

While developing a realistic DTUPC goal is not an easy task, the MLRS DTUPC goals were based on the following principles that were considered paramount in its successful implementation:

- Stable Specification and Requirement Documents. The Army took the time to think about and clearly specify what the weapon system had to do. These requirements were not overly specific and allowed the contractors to develop innovative ways of achieving the design objectives. These initial specifications and requirements, once established, remained stable. The program was not subject to being "jerked" around in the development cycle as a result of substantial changes in technical requirements or threats. This allowed the designers to go about development in an orderly fashion with a clear focus in mind.

- DTUPC Goal Established in Total and by Fiscal Year. As illustrated in Figure 3, in order to obtain true cost realism in the DTUPC estimates, the MLRS goal was established as an average cost goal for the entire program which, in turn, was developed from cost goals established for each fiscal year of the proposed production program. This

Direct Material	$1.00	1 Hr Factory Labor	$12.11
Attrition & Utilization (10%)	.10	Support Labor (64.8%)	7.85
	$1.10		$19.96
Material Overhead (10.6%)	.12	Manufacturing Overhead (126.3%)	25.21
	$1.22		$45.17
Other Direct Charges (6.3%)	.08	Other Direct Charges (11%)	4.97
	$1.30		$50.14
General & Administrative (21.1%)	.27	General & Administrative (21.1%)	10.58
	$1.57		$60.72
Cost of Money (0.5%)	.01	Cost of Money (3.4%)	2.06
Total Cost	$1.58	Total Cost	$62.78
Profit Objective (15%)	.24	Profit Objective (15%)	9.42
Total Price	$1.82	Total Price	$72.20

Figure 2. Typical Contractor Cost for $1 MTL/1 Hr Direct Labor.

combined approach served several purposes. It required the contractors to realistically develop production plans, obtain vendor prices on quantities that represented the manner in which hardware would eventually be procured by the Army, and it provided a traceable procedure for assuring that the DTUPC costs were being achieved.

Establishing goals for each fiscal year purchase eliminated guessing whether the contractor was on track in achieving the overall cost goal. Yearly goals provided a firm basis for payment of award fees because firm production proposals could be evaluated against the DTUPC yearly objective. In addition, yearly pricing highlighted the business management aspects of production and caused much more emphasis to be placed in these areas of controlling overall production costs.

• DTUPC Quantities Compatible With Procurement Implementation Plans. As noted in Figure 3, the DTUPC quantities utilized in establishment of the goals represented the quantities that were compatible with the approved procurement plans of the Army. This information was continually stressed to the contractor so that pricing exercises for DTUPC contained as much contract realism as possible, and required detailed analysis of costs as the production transitioned from development, to low-rate production, to full scale production.

• Cost and Designs Based on Existing Production Technologies. The MLRS DTUPC program was coupled with the producibility program efforts. Trade studies were structured around technologies proven in the production process that were low risk. Studies identified critical materials, unique manufacturing processes, lead times, high cost items and processes, low yield processes, and potential manufacturing problems. The results of these studies were used to generate improvements to the design or, as in many instances, changes in the production processes which made the hardware more producible and less costly.

Although MLRS was a very stable program, there were changes. These changes in requirements, quantities, or schedules were continually adjusted in the DTUPC program so that there was always emphasis on when and how the Army eventually planned to procure the system. Adjusting the DTUPC goals when the program changed, highlighted to the contractors that the

Constant 87$		Quantity	Goal Unit Price	Achieved Unit Price	
Low Rate Prod.	FY80	1,374	$5,890	$6,870	
	FY81	2,340	4,715	5,210	
	FY82	2,496	4,290	5,710	Decision to co-locate major vendors to reduce volume production prices.
Transition	FY83	23,640	3,650	3,310	
	FY84	36,000	3,160	2,980	
	FY85	50,472	2,890	2,950	Production rate sensitivity
Full Scale Prod.	FY86	72,000	2,690	2,520	
	FY87	72,000	2,540	2,450	
	FY88	72,000	2,450	2,450	
	FY89	30,510	2,390	3,000	Production line phase-out
Average DTUPC		362,832	$2,760	$2,745	

Figure 3. DTUPC Program Showing Impacts of Business Management Decisions.

Army's cost goals were seriously being utilized and that it was recognized that increased requirements led to corresponding increases in the eventual production cost.

Applying Lessons Learned

The MLRS DTUPC experience of the initial development program is being applied to additional warhead developments for the system. It is much too soon to judge the success of the efforts for these programs, but each DTUPC program will utilize a total cost approach with goals established around realistic production program plans and quantities.

• Program Change Control. Each program introduces new and different pressures on DTUPC achievement. For MLRS advance warheads, the introduction of international cooperative development/production, and design requirements which are pushing the state of the art, provide a continuous challenge to develop innovative ideas and approaches to keep unit cost objectives in focus.

It is believed that the major principles described above can lead to a more effective DTUPC effort for any development program to which they are applied.

RICHARD PALADINO is chief of the Program Management Division of the MLRS Project Office, Fire Support PEO, located at the U.S. Army Missile Command. He holds a B.S. degree in mechanical engineering from the University of Arkansas, and an M.S. degree in industrial engineering from Texas A&M University.

New Formula Extends Track Pad Life

Scientists at the Troop Support Command's Belvoir Research, Development and Engineering Center have developed a new formula which has the potential to nearly double the wear life of track pads for armored combat vehicles.

"We must have checked more than 300 different formulations looking for something different," said Paul Touchet of the center's Materials, Fuels and Lubricants Laboratory. What they eventually found was a formula featuring a highly saturated nitrile polymer that was highly resistant to heat and aging.

"We tested six formulas and one completely out-performed all the others," said Touchet.

During the tests, a counter-obstacle vehicle was equipped with experimental pads and standard styrene butadiene rubber pads. The standard pads currently used by the Army failed after 1,200 miles, while the new ones were still going strong after 1,600 miles. Experts estimate that the pads could last 2,000 miles on paved roads and as long as 4,200 miles in cross-country terrain. "It's the first time we've had a pad that could go 2,000 miles," said Touchet.

The new formula also increases the shelf life of the pads. Standard pads go bad after five or six years in storage. The new pads have the potential to last as long as 20 years.

Army R&D Achievement Awards Recognize 77 Employees

Seventy-seven Army in-house scientists and engineers will receive Department of the Army R&D Achievement Awards. These awards recognize outstanding research and development achievements which have improved the capabilities of the U.S. Army and have contributed to the national welfare during 1986.

The award, which consists of a plaque and medallion, will honor 52 employees of activities of the U.S. Army Materiel Command, 17 personnel assigned to the Army Corps of Engineers, and eight Army Medical R&D Command employees.

Listed by major commands and individual installations, the recipients of Army R&D Achievement Awards are:

U.S. Army Materiel Command

• *Chemical Research, Development and Engineering (RDE) Center*

Dr. James J. Valdes will be recognized for program management and scientific contributions in development of a detector for entire classes of chemical agents and toxins on the battlefield. Using protein receptors for detection of chemicals, this approach combines breakthroughs in biotechnology with recent advances in microelectronics. The program will result in a new generation of sensing devices with profound applications in military operations, medical diagnostics, agriculture, and environmental and industrial monitoring.

Dr. Joseph M. Leonard will be commended for developing a package of molecular modeling software which provides computational support for drug design, drug-receptor interaction, surface chemistry, reaction mechanism and physical property estimation. Dr. Leonard produced the Molecular Modeling, Analysis and Display System (MMADS) by combining computer codes from the areas of theoretical and physical organic chemistry, molecular graphics and the VAX/VMS Command language. MMADS' capabilities satisfy the unique requirements of the Army chemical mission by supporting such high priority mission areas as penetrants incapacitants, simulants and decontamination.

Dr. Glenn O. Rubel will be cited for establishing an aerosol physics laboratory which enabled the Army to conduct crucial experiments in microparticle chemical physics. His research in the fog oil replacement program resulted in the initiation of a multi-million dollar smoke program to explore the technology of surfactants and their impact on the persistency of diesel fuel clouds. As a result of Dr. Rubel's lead role in this program, three novel technologies that permitted the direct substitution of fog oil with diesel fuel were discovered. These technologies are: pyrolysis of diesel fuel to soot, microencapulation of diesel fuel, and fractional distillation of diesel fuel.

Dr. Sandra A. Thomson was selected for the award in recognition of her research in inhalation technology. She developed a battery of tests for lung injury mediated by inhaled particulates. The assays measure the impact of particulate exposure on macrophages, the lungs' first line of defense against bacterial infection. Her work provides insight into not only the mechanism of action of toxic insult, but into the basis of observed protective responses to subsequent exposures.

Dr. William E. White Jr. is being recognized for designing and carrying out a program to provide superior alternatives for battlefield decontamination of chemical and biological agents. His approach to use non-caustic enzymes will revolutionize decontamination strategy, and significantly enhance combat effectiveness of allied forces. His work will find broad application in medicine, degradation of hazardous chemicals, restoration of contaminated sites, and development of improved protective filters, fabrics, and self-decontaminating surfaces.

Dr. Robert S. Anderson will be commended for his contributions to immunology and the detection of chemical biological agents. His efforts were instrumental in demonstrating that antibodies could be used to detect threat agents, and in solving problems in protein stability and detector configurations. Dr. Anderson's work provides the basis for an entirely new generation of antibody-based detectors for chemical and biological agents. Additional work in the areas of immune memory and antibody responses of fish and other lower organisms to chemicals and toxins will find broad applications, not only in a military context, but also in studying the environmental impact of hazardous chemicals.

Dr. Robert T. Kroutil and John T. Ditillo will receive the award for their research into the development of an autonomous background compensation algorithm that allows operation of the XM21 standoff chemical agent detector from a moving platform. Their research in the area of chemical sensing has led to vast improvements in pattern recognition techniques for incorporation in various U.S. Army remote chemical sensors.

Dr. August J. Muller is being honored for his research into the synthesis of toxic organophosphorus compounds, commonly referred to as G-agents. His work has led to a new, convenient laboratory procedure for preparing these pure compounds. When modified, this procedure, which is less hazardous than older methods, may also lead to a more effective chemical munition for the U.S. retaliatory capability.

- *Natick RDE Center*

Dr. Frederick M. Robbins is being cited for his technical leadership in all phases of project FLINT STONE — a high priority program utilizing a unique material to afford protection against chemical agents. Dr. Robbins' efforts resulted in the development of a solid polymeric material capable of causing the detoxification of G-agents. This project will have far-reaching impact on the survivability of the individual soldier on the integrated battlefield of the future.

Ann H. Barrett will be recognized for her investigation into the factors that determine how well oils and suspended food particles infuse into porous foods and how infusion depends on the size of the openings, the viscosity of the oil, and the size of the particles. She established the optimum relative size of the openings and the particles and the maximum particle concentration for ideal use. Her achievement is crucial to the development of calorically dense components for highly compact rations. Barrett's work will enable soldiers to carry several days food supply in the smallest possible volume.

- *Electronics Technology and Devices Laboratory*

Raymond L. Ross, Deborah A. Dekanski, Robert P. Moerkirk Jr., and Suzanne Mason are being cited for their contributions to advancing the state-of-the-art of high-performance millimeter-wave sources. Their efforts, combining molecular beam epitaxy and tailored impurity doping profiles, resulted in an advanced class of millimeter-wave oscillators with unsurpassed output power, efficiency and reliability.

Dr. Raymond L. Filler, Vincent J. Rosati, and Dr. John R. Vig will be recognized for their contributions to the state-of-the-art of vibration-resistant low-noise oscillators. The new technology, which resulted in seven U.S. patents being issued to this team, opens the way to orders of magnitude improvements in a technology where commercially available devices had not shown a significant improvement during the past 25 years. Further applications of this innovation promise to play a key role in meeting the requirements of future radar, navigation, and command, communications and control systems that must operate from vibrating platforms such as helicopters, remotely-piloted vehicles, and tracked vehicles.

- *Ballistic Research Laboratory*

Dr. Mark L. Bundy will receive an R&D Achievement Award for analysis and assessment of candidate thermal shrouds for the M1A1, M256 tank cannon, and for his improved thermal shroud design. Until now, all foreign and domestic shrouds have been designed to protect the gun barrel from thermal distortion caused solely by external heating asymmetries. Dr. Bundy's findings that internal heating asymmetries from firing can cause equally large distortions of the barrel should change the future design priorities for thermal shrouds.

Edward J. Rapacki Jr. and Fred J. Brandon are being commended for planning and executing aeroballistic structural stability experiments and developing fin design parameters for fin stabilized, long rod kinetic energy penetrators. Their timely work helped ensure the success of an advanced anti-tank ammunition program.

- *Missile RDE Center*

A team comprised of Robert R. Boothe, Randy R. McElroy, Jeffrey K. Levasseur, Kevin B. Wilson, and Rodney W. Sams will be commended for demonstrating an effective technique to locate and communicate with remote weapons using radar's main beam. The team developed innovative solutions to coding the radar transmitted waveform, to decode received signals, and to create software that controls both the radar's transmission and the remote site display. They used the Track-While-Scan Quiet Radar and prototype remote repeater modulator to demonstrate the concept. This achievement has given the Army an electronic countermeasure resistant data link that is simple to deploy.

Dr. Paul R. Ashley will be recognized for conceiving, implementing, and demonstrating a low cost, high performance amorphous silicon liquid crystal spatial light modulator. Although image

Merlin Robot acquires canister from wire reeling during demonstration of fully automated production of missile electrical cables and harnesses using a newly developed robotized flexible manufacturing cell. The cell was developed at the Missile RDE Center at MICOM in Restone, AL.

processing systems for brilliant terminally-guided munitions are not capable of real time target tracking and discrimination, device technology still limits performance. The liquid crystal light modulator is the key element in the conversion of the input incoherent image into a coherent image for optical processing.

Pat H. McIngvale, Scott A. Speigle, and Margaret A. Bowles will be honored for research and development of small target image processing algorithms and their application to an automated system. Their efforts will serve as the standard for assisting man-in-the-loop fire control system operators to acquire targets. Their work will result in significantly increasing the effectiveness of weapon systems in which human operators must search video displays from a moving sensor to locate distant targets.

James M. Anderson was selected for the award for developing a robotized flexible manufacturing cell for the fully automated production of missile electrical cables and harnesses. (See Photo). Cost benefit analyses indicate the projected unit cost savings resulting from implementation of this technology are at 50 percent or more due to reduced material handling, kitting, and labor intensive tasks.

- *Aviation Systems Command*

LeRoy T. Burrows will receive an R&D Achievement Award for his technical expertise and management skills in developing the Wire Strike Protection System (WSPS). The WSPS significantly reduces the vulnerability of helicopters to in-flight wire strikes resulting in increased mission capability through the saving of lives and aircraft. As a result of Burrow's efforts, a number of Army helicopters are currently equipped with this system and the Army is now committed to installing similar systems on all of its helicopters.

- *Atmospheric Sciences Laboratory*

Dr. Donald E. Snider and Dr. Jon J. Martin will be recognized for developing, demonstrating and evaluating a new approach to artillery meteorology. This new approach makes use of a novel software technique to remotely measure wind profiles in the lower atmosphere with FIREFINDER radars. Their efforts will result in reducing the temporal staleness of wind measurements in the lower atmosphere and in providing a stand-alone artillery computer MET message for cannon artillery, without the need for any additional people or equipment.

- *Center for Night Vision and Electro-Optics*

Dallas N. Barr will receive an R&D Achievement Award for developing and verifying a new theory for characterization of signal and noise parameters in coherent laser vibration sensors. His work provides a solid foundation for development and optimization of a new class of laser sensors for non-cooperative target identification. Barr's theory has already been used to improve design of a laser sensor used in a demonstration of helicopter identification in real time.

- *Armament RDE Center*

Dr. John E. Zweig will be commended for leading the design team which developed the 120mm XM291 demonstrator — a prototype tank gun. Through his leadership, many new and unique features were incorporated into this prototype.

- *Ballistic Research Laboratory and Armament RDE Center*

A team from the Ballistic Research Laboratory and the Armament RDE Center will be cited for their research on the development of "Unicharge" — a new propelling charge for artillery applications. The team consists of: Albert W. Horst and Frederick W. Robbins, from the Ballistic Research Laboratory; and Dr. Anthony J. Beardell, Dr. David S. Downs, Aaron H. Grabowsky, Phillip Hui, and Jane Shih-Thornton, from the Armament RDE Center. "Unicharge", which greatly simplifies robotic handling, is a single increment universal modular charge which is capable of being gun fired to different ranges, depending on the number of increments used.

- *Army Materials Technology Laboratory*

A team consisting of Dr. Dennis J. Viechnicki, CPT William A. Blumenthal, Carl A. Tracy, Holly A. Skeele, Michael J. Slavin, and Jeffrey J. Gruber was selected for the award for research and advanced development of titanium diboride as a superior, yet cost-effective material for future heavy armor applications. Their technical accomplishments have propelled titanium diboride from being an obscure and expensive material to being a prime contender for future heavy armor applications based on superior performance and cost effectiveness.

Dr. Chester V. Zabielski will be commended for developing a family of thermomechanically processed DU-3/4 Ti alloys. These alloys have yield strengths up to twice the current conventionally processed alloy, and ultimate tensile strength which is 50 percent greater than the standard alloy. Dr. Zabielski's work, a breakthrough in thermomechanical processing technology, lays the foundation for a new technology. Future technologies in this area will greatly enhance the capability of high density armor piercing projectiles in future Army weapon systems to function against advanced armors in even more severe battlefield environments.

- *Harry Diamond Laboratories*

Dr. Nick Karayianis and Dr. John M. Pellagrino will be honored for their technical achievements in acousto-optic signal processing and analysis. Their work assured the success of advanced demonstration systems that will serve as a basis for future developments in radar and signal processing systems.

U.S. Army Corps of Engineers

- *Construction Engineering Research Laboratory*

Linda K. Lawrie will receive an R&D Achievement Award for her efforts in developing the Life Cycle Cost in Design program. This program provides an easy-to-use method for performing life cycle cost studies of design alternatives during the facility design process. Her work has resulted in improving cost effectiveness of new DOD facilities.

Dr. Keturah A. Reinbold and Bernard A. Donahue will be commended for their efforts in the development of a computer-aided evaluation process for management of polychlorinated biphenyls (PCB) transformers. This system allows engineers to efficiently evaluate the feasibility and life cycle costs of alternatives for use, repair, disposal or replacement of PCB transformers in accordance with regulations. COL Norman C. Hintz, commander and director of the lab, reports use of the PCB Transformer System results in a 15-fold savings in time at a cost savings of nearly $350 per transformer.

• *Cold Regions Research and Engineering Laboratory*

Michael G. Ferrick will be honored for developing a new theory for understanding river ice breakup by successfully formulating a new basis for the description of hydraulic transients in rivers. His theory quantifies the relationship between the transients and ice cover breakup. This information has application in both the military and the private sectors.

Thomas F. Jenkins Jr. and Daniel C. Leggett will be recognized for establishing a standard analytical method for the determination of residual explosive levels in munitions wastewater. Use of this standard procedure to monitor waste streams at Army ammunition plants will result in the production of dependable data in support of compliance with discharge limitation.

Dr. Malcolm Mellor, CPT Mark F. Wait, Darryl J. Calkins, Barry A. Coutermarsh, and David A. L'Heureux were selected for the award for developing techniques to deploy the ribbon bridge in rivers having a significant ice cover. The procedures, including breakage of the ice cover, removal of the ice debris, and deployment of the bridge, can be accomplished in less than two hours.

Dr. Steven A. Arcone, Paul V. Sellmann, and Allan J. Delaney will be commended for their contributions in the use of geophysical systems for characterizing subsurface conditions in permafrost areas. The team has provided quantitative guidance on resistivity, variation with soil type, moisture content, and temperature, along with suggestions on the selection of potentially low resistivity locations based upon terrain analysis. Also, their work has advanced the understanding of the use of ground probing radar systems.

• *Engineer Topographic Laboratories*

Joni L. Jarrett will be recognized for her research, development, test, and evaluation work in the area of automated digital terrain analysis. Her work led to new and innovative automated digital terrain analysis techniques for tactical and strategic applications.

Michael M. McDonnell was selected for the award for his engineering achievement in target motion tracking research. His key contribution is the use of photogrammetric control in targeting imagery, permitting automatic targeting against a natural background. McDonnell's research will improve the Army's capability for deploying sensor-based platforms on a battlefield.

• *Waterways Experiment Station*

Dr. Nicholas C. Kraus will be recognized for conducting research and developing new and improved methods for measuring sand transport rates and coastal processes in the surf zone and numerically simulating shoreline change.

U.S. Army Medical R&D Command

• *Walter Reed Army Institute of Research*

MAJ Lorrin W. Pang will receive an R&D Achievement Award for validating the effectiveness of doxycycline in prevention of multi-drug resistant malaria. As a result of these studies, elements of the 25th Infantry Division participating in exercises, consumed the drug, doxycycline, daily to prevent malaria. In less than one year, MAJ Pang conclusively demonstrated the effectiveness of the drug and reassured the capability of the Army to conduct operations in the vital region of Southeast Asia.

LTC David R. Franz will be recognized for his development and validation of an *in vivo* rodent model for cerebral malaria, a lethal sequela of human *Plasmodium falciparum* infection. The model allows medical scientists to study, for the first time, *in vivo,* the pathogenesis of severe malaria in a vascular bed which mirrors pathologic changes in the brain. His work resulted in significant advances in the understanding of the disease in this animal model. His findings have important implications regarding the understanding of human cases of malaria — a disease of extreme military importance.

MAJ Daryl J. Kelly and Peggy Lim have been selected for the award for developing and validating an accurate, field portable test kit for the diagnosis of a specific human antibody for the rickettsial diseases scrub, endemic, and tick typhus. They introduced the kit to hospitals in the Asia-Pacific region. The kit is more accurate than the commonly used Weil- Felix test and does not require the use of a fluorescence microscope as does the standard indirect fluorescent antibody test. The kit, for the first time, allows rapid, accurate field diagnosis of these militarily important rickettsial diseases.

• *Biomedical R&D Laboratory*

Dr. James H. Nelson will be honored for his approach to the entire research, development, test and evaluation process. His work has resulted in a focused effort to accelerate the development of field medical materiel needed to upgrade field medical capabilities.

Dr. William H. van der Schalie will be recognized for his work in aquatic toxicology and for his efforts in the design and development of an on-site, mobile, biomonitoring laboratory. The laboratory provides a unique Army capability to conduct state-of-the-art biomonitoring of wastewater effluents.

• *Aeromedical Research Laboratory*

MAJ Glenn W. Mitchell will be commended for developing and expanding the "Integrated Concept for Physiology, Psychology, and Performance." His efforts examined the effects of nuclear, biological and chemical and extended operations on combat vehicle and crew performance. The analysis reveals three environmental zones which yield different effective strategies for enhancement of endurance, prepositioning and prioritization of supplies, soldier training, and unit tactics.

Larrel W. Harris was selected for the award for his work in explaining the mechanism by which one nerve agent, soman, became resistant to treatment. His work, searching for compounds which would protect the soldier against the use of chemical agents in the battlefield environment, has been a major contribution to the chemical defense effort of the U.S. and other allied nations.

Simulation Networking: A MANPRINT Tool

By Dr. Barbara A. Black and Dr. Kathleen A. Quinkert

Introduction

SIMNET and MANPRINT are two buzz words currently circulating within the Army community. Normally, the two are not combined in the same sentence, but the need for a linkage will become more apparent as combat, materiel, and training developers realize the impact that the two concepts will have on the Army.

This article will provide definitions of the concepts, present examples of their linkage, and challenge members of the Army community to consider new ways of doing business based on the advantages now available in the simulation arena which provide a "try before you buy" option.

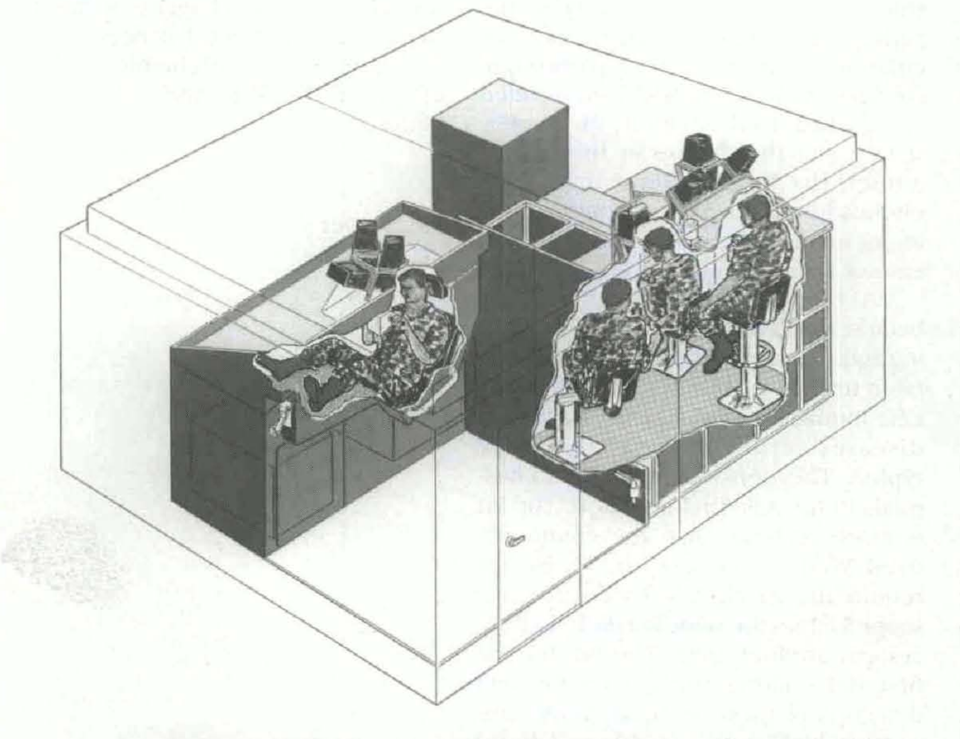
MANPRINT

The Manpower and Personnel Integration program (MANPRINT) is a management and technical program designed to ensure the enhancement of human performance and reliability in the operation, maintenance, and use of equipment and weapon systems. MANPRINT is an Office of the Deputy Chief of Staff for Personnel (ODCSPER) initiative which is the outgrowth of numerous attempts by Army leaders over the years, to systematically control the materiel acquisition process. The Army goal is to consistently "equip the man, rather than simply man the equipment."

The ODCSPER's MANPRINT approach is designed to educate acquisition process participants to ensure they focus on soldier resource goals and constraints throughout the life cycle of the proposed system. These goals and constraints are addressed in six major domains: manpower, personnel, training, human factors engineering, health hazard, and systems safety. This effort is supported by the creation of new Army regulations and the revision of existing ones. These regulations will require additional effort on the part of developers to ensure soldier considerations are given priority in the acquisition process.

Developers in the Army community are currently faced with the responsibility of identifying soldier concerns from each of the MANPRINT domains and specifying how each concern will be addressed in the acquisition process. For example, "What physical and psychological provisions should be considered in the design of hardware to support a tank crew during continuous operations?" or "How could a sustainment gunnery training package be built into the computer system on a future tank?" Answers to questions such as these are now needed up-front, long before industry or test and evaluation reports can provide them. This is especially true given the current estimations that approximately 70 percent of the life cycle costs of any new system are determined prior to the Demonstration and Validation phase of the traditional Life Cycle System Management Model.

While MANPRINT is certainly an admirable goal, it is important to realize that presently, few tools exist to assist developers in addressing soldier con-



Original Artist's Concept of SIMNET M1 Crew Compartment.

cerns prior to the manufacture of prototype hardware. In the past, the absence of solid information has led to educated guessing which resulted in expensive system design errors or training errors. However, many of these errors can be precluded by exploiting recent technological advances, such as new simulation capabilities, which promise cost-effective and reliable solutions.

Simulation Networking

The Defense Advanced Research Projects Agency (DARPA) is currently focusing its efforts on such a simulation capability. These efforts are in support of a series of technology demonstrations referred to as simulation networking or SIMNET.

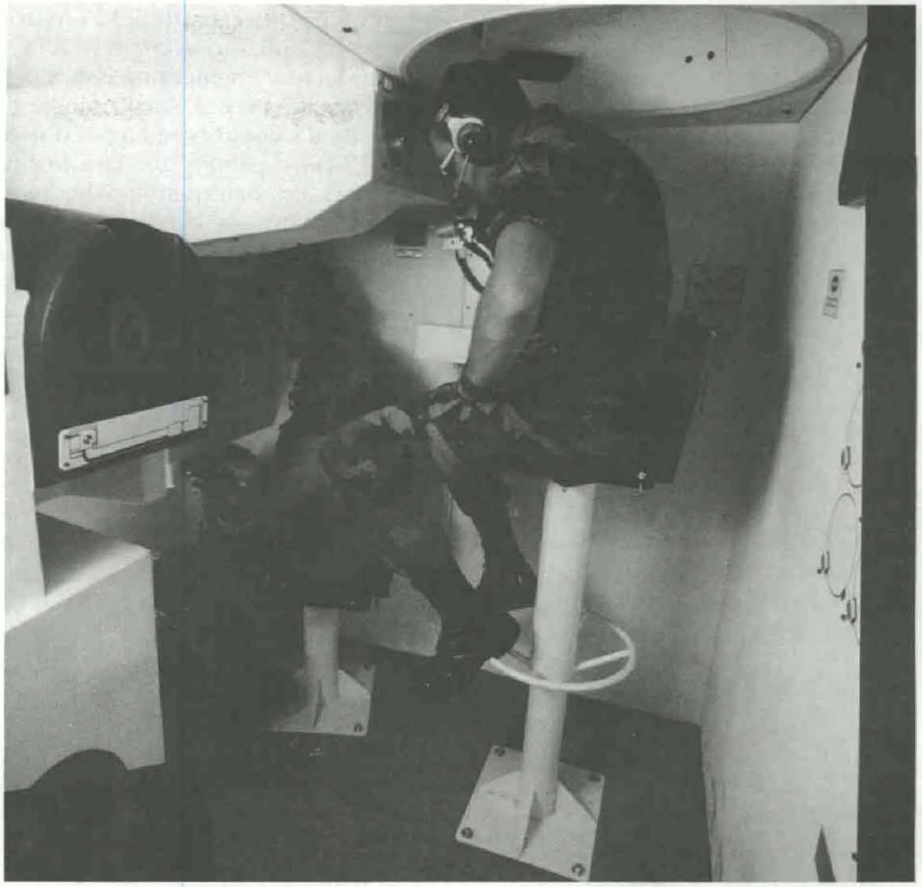
The Abrams M1 tank was chosen as the first DARPA demonstration to apply both local area networking and distributed processing capabilities to interactive weapon system simulation. More recent efforts have added the Bradley Fighting Vehicle, the Forward Area Air Defense System, and attack helicopters.

One form of SIMNET is called Developmental SIMNET or SIMNET-D. It is envisioned as a flexible simulation tool for combat and training developers. Another form is called Training SIMNET or SIMNET-T. SIMNET-T simulators can be found at Fort Knox and in Europe. They are prototypes of future interactive training devices to be used both in the school and in the unit. While both SIMNET-T and -D are useful, SIMNET-D has the greater potential for MANPRINT efforts.

SIMNET-D

The SIMNET-D offers a viable approach to investigating soldier/operator issues for new vehicles and weapon systems early in the life cycle of a system. This is accomplished using a group of networked simulators which can take on configurations of current combat systems (e.g., M1 or M2) or systems envisioned for the future (e.g., Armored Family of Vehicles).

A major advantage associated with SIMNET-D is the capability to realistically simulate new technologies along with their potential soldier-machine interfaces. This is accomplished via rack mounted displays and controls combined with specially developed modular software packages. Using this approach, one now has the capability to rapidly reconfigure the system design and measure performance using a soldier-in-the-loop approach. For example, researchers could evaluate new target acquisition capabilities, new automated command and control systems or a new main weapon system by having soldiers operate them in the simulated environment and yet never run the expense of full scale hardware prototyping. Each system or technology would also have its accompanying display or control handle requirements which could be assessed.



M1 SIMNET Turret with Tank Commander, Gunner, and Loader Stations.

SIMNET-D simulators can be designed for use over a wide range of configurations to explore larger system concerns. For example, the simulators can be used separately, as individual vehicles, or they can be networked to represent separate tank and mechanized infantry platoons. Similarly, they can be networked to form a balanced company team.

Combining the networking and reconfigurability options with the capability to let the soldier actually operate the system, provides an accurate and objective means of gaining the information necessary to address MANPRINT issues — not only isolated issues, such as those relating to a single vehicle, but also those embedded into force structure, doctrine, and tactics.

For some, the marriage between the MANPRINT effort and SIMNET-D is both logical and obvious. In fact, there are those who have suggested that SIMNET-D should be the testbed for MANPRINT research. There are others, however, for whom the relationship is nothing more than a coincidence in timing.

To explain the need for both SIMNET-D and MANPRINT in the acquisition of new systems and equipment, the following examples of Armor issues which could be answered in SIMNET-D are provided. These would allow Army developers to proactively attack problems associated with the design of new equipment or weapon systems for the soldier. These issues are organized around the MANPRINT domains.

- Manpower. SIMNET-D is capable of company team level exercises where crew size and combat support can be varied. Issues such as maneuver unit size and organization can be investigated along with staff manning and organization. This is just one area that allows the impact of manning levels and attrition on combat effectiveness to be empirically measured, that is, where soldiers actually perform their assigned duties in new, innovative systems. SIMNET-D also allows crew sizes and other organizational alternatives to be examined simultaneously within the same scenario with relative ease.

• Personnel. SIMNET-D's flexibility and reconfigurability allow measurement of soldier performance in a task-rich environment. By varying the abilities and experience levels of the soldiers used as crewmen, inferences can be made concerning the personnel requirements, resulting from adding specific technologies or components to the weapons system. This information can address not only what mix of technologies or components provides the greatest combat power or effectiveness on the future battlefield, but what type soldier will be required to operate these technologies.

• Training. SIMNET-D can serve as the training developer's testbed in that issues relating to embedded training, computer-based instruction, automated procedure guides or job aids can be evaluated before the actual hardware is built. SIMNET-D can be used to predict the kind and amount of training required to adequately prepare crewmen to operate a new weapon system. It can also be used to assess the training necessary to prepare commanders and units to effectively employ the weapon system tactically.

In addition, SIMNET-D can be used to determine training device requirements to support new or existing systems. Alternate training device configurations can be emulated and evaluated. SIMNET-D's reconfigurability allows the training developer to answer questions concerning selective device fidelity, cost/effectiveness tradeoffs, and instructional features.

• Human Factors Engineering. The built-in flexibility of SIMNET-D supports a design-test-design approach used to evaluate human factors and human engineering issues for vehicles or weapon systems. For example, multiple monitors can be made available consisting of touch sensitive display panels where switches and functions can be rapidly rearranged and integrated with proposed tank operating characteristics.

Alternative allocations of functions among crewmen, workload, time and accuracy of operating procedures can be directly measured. Again, the capability of testing soldiers in work stations that interface with a realistically presented future battlefield environment is essential to accurately address human factors engineering issues.

• System Safety. A small number of safety issues could be addressed using SIMNET-D's capability for task loading operators, i.e., determining whether or not a crewman is overloaded by the number of simultaneous tasks he is asked to perform. By creating system failures or actions which require immediate attention, the researcher can identify competing tasking, tasks which should be performed by the vehicle not the soldier, and tasks which must be monitored or performed by the crewmen. Improper allocation of tasks posing safety problems could be corrected prior to initiation of the prototype production.

• Health Hazards. SIMNET-D is limited in its usefulness for evaluating issues regarding health hazards. One possible exception might be long term exposure to video display terminals which are a proposed means of displaying information from external sensors to operators of combat vehicles.

SIMNET-D research could be done at virtually any phase of the Army Streamlined Acquisition Process. However, the maximum benefit for a new system would be during the Proof-of-Principle Phase, when there is sufficient time to allow the design-test-design paradigm to pass through several iterations.

It may also be desirable to combine Non-Developmental Items with SIMNET-D configurations to determine their proper integration into the operation of the new system. For example, an existing helmet mounted display capability could be purchased and tested in the context of SIMNET vehicle missions.

The SIMNET-based research process may be time consuming as there are many issues which can be addressed and the amount of information required by the investigators for each issue is extensive. However, SIMNET-D efforts should take only weeks as opposed to current field experiments which can take months. The cost differential also makes SIMNET-D an attractive evaluation option.

SIMNET-D allows combat, materiel, and training developers the opportunity to identify potential problems and obtain the information necessary for trade-off decisions during early phases of the design process. In addition to identifying critical aspects of design which can affect soldier performance, SIMNET allows the Army community to actually quantify the effect. For example, improperly designed command and control displays could result in increased time to make and execute decisions or new, and poorly designed hand controls could reduce the gunner's ability to track and engage targets.

The effects of these new technologies on weapon system performance could be quantified and the numbers used in existing combat models to determine overall effect on mission success. These attributes should make the SIMNET-D welcome alternative to business as usual.

Summary

In summary, SIMNET-D offers the Army community a new means of determining equipment and training requirements to meet the threat of the 1990s and beyond. This method is not a replacement for currently analytic capabilities such as Janus, CARMONETTE, MIST, or HARDMAN, but rather it is an adjunct capability which fills a gap in our knowledge or ability to predict system performance with the soldier-in-the-loop. Additionally, it allows flexibility in the development of new doctrine and tactics. A requirement can be identified and tested before a new technology has been demonstrated. This state-of-the-art simulation capability challenges armor leaders to review and revise current ways of doing business in the materiel acquisition and training development arenas in order to provide a better product designed for the soldier.

Note: The SIMNET-D facility, which is located at Fort Knox, KY, is scheduled to open the first quarter of FY88. Use of SIMNET facilities must be arranged through the process outlined in the DARPA-Army Memorandum of Understanding.

DR. BARBARA A. BLACK is a research psychologist and team leader for soldier performance integration at the Army Research Institute (ARI) Fort Knox Field Unit. She received a Ph.D. in experimental psychology from Baylor University in 1978.

DR. KATHLEEN A. QUINKERT is a research psychologist responsible for MANPRINT issues at ARI Knox. She holds a Ph.D. in experimental psychology with an emphasis in human performance/human factors from the University of Louisville.

Corrosion Prevention and Control

By Susan Dreiband

Introduction

The strength of our armed forces is being threatened. The enemy is subtle — weakening and undermining its prey slowly. Taking a fight-and-conquer stand, the Army has declared war. The enemy is corrosion.

This insidious menace is costing our nation more than $100 billion annually and the Army's losses alone are estimated at more than $2 billion yearly. Multi-million dollar tanks, helicopters and planes, advanced weapons systems, munitions and electronics have all fallen victim.

Like the surprised driver who one day puts his foot through the floorboard of his car, we often do not recognize and attack the problem of corrosion until the strength of the material has been undermind.

Center of Excellence

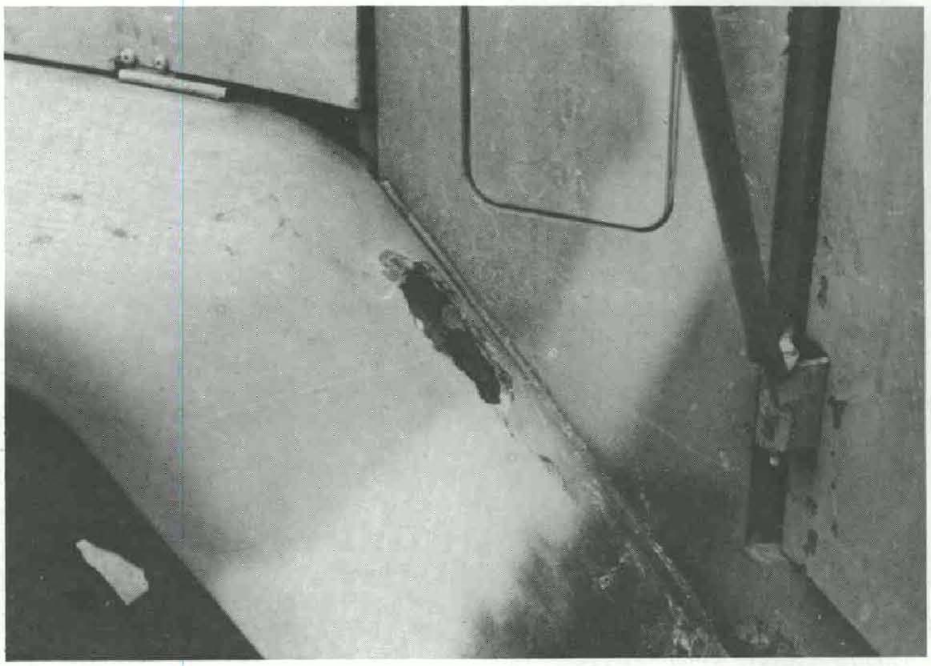
Taking an aggressive stance, the Army named the U.S. Army Materials Technology Laboratory (MTL) in Watertown, MA, as its Center of Excellence for Corrosion Prevention and Control. The designation of MTL for the management of the Center of Excellence acknowledges MTL's long-standing leadership within the Army in materials technology, research and development, failure analysis, and solutions of problems in the field. Moreover, MTL has been involved in bringing corrosion problems to the forefront for more than a decade.

MTL is the Army's lead laboratory in the areas of materials, solid mechanics, lightweight armor, materials testing technology, structural integrity testing, and manufacturing testing technology. The laboratory's mission is directed by the U.S. Army Laboratory Command (LABCOM) in Adelphi, MD, which is the major subordinate command responsible for managing the corporate laboratories of the U.S. Army Materiel Command (AMC) in Alexandria, VA.

Prevention and Control

Corrosion prevention and control is one of the fundamental considerations in assuring the sustained performance and readiness of Army systems and equipment. Active consideration both in the materiel development and the deployment process is required. Now well established, the Center of Excellence actively provides technical expertise, advises major subordinate commands (MSCs), coordinates development of model corrosion prevention and control (CPC) programs, carries out CPC awareness and training, and manages CPC programs. Serving as the AMC CPC advocate, MTL has also drafted the Army regulation on CPC (to be published later this year) and is effectively leading the Army toward workable solutions to this pervasive problem.

Because corrosion is a multi-billion dollar thorn, potential return on investment in this program is enormous. A large part of the cost is attributed to faulty design, improper selection of materials, and inadequate or improper maintenance. For example, implementation of design changes and improved corrosion treatment for just one Army



Surface penetration of corrosion on the fender of this 2 1/2-ton truck at Fort Devens, MA, is a typical example of improper, or inadequate, maintenance of an Army vehicle.

The manner in which material is packaged and stored is a significant Army problem. Poor storage of this trailer, located in Panama, has led to insidiuous degredation of the material.

helicopter has saved the Army $32.4 million, and avoidance of corrosive stripline circuits in one of its missile systems has saved $4 million.

Besides the enormous financial savings, aggressive use of CPC technology will lead to better systems designs and maintenance as well as improved systems training. Overall, this will result in more reliable, durable, and safer equipment to help ensure the survivability of the soldiers in the field as well as the total readiness of our defense forces.

Center of Excellence Program Manager Dr. Joseph Wells has targeted three principal areas of impact for MTL's CPC effort: operational readiness, systems performance, and lowered life cycle costs. "The issues we face, however, are five-fold," he says.

"First, we need to identify the nature and full extent of the corrosion problem in the Army. Then, we need to attribute specific causes and find viable countermeasures and realistic solutions. We also need to be instrumental in transferring and implementing existing state-of-the-art solutions where available, developing new technology for programmatic Army systems, and implementing the most modern corrosion prevention techniques for new Army systems. Finally," says Dr. Wells, "we need to instigate and coordinate full system cooperation, monitor effectiveness, and provide feedback to the field.

"Corrosion and environmental deterioration are acts of nature. There is really no such thing as a corrosion-free design. Nature controls the fact that corrosion will occur; but science and technology can control the time rate, greatly extending a material's useful life," he said.

According to Dr. Wells, continually obtaining feedback from the field is also imperative to the success of the entire program. To do this, survey teams from the Center of Excellence go to depots and installations for data collection and analysis. "Working with the installation and depots brings our work from the conceptual to the 'nitty gritty" of our soldiers' needs."

Life Cycle Management

The Center of Excellence is aiming to incorporate CPC into the life cycle of Army weapon systems, especially tactical vehicles and helicopters. For example, the amount of corrosion repair required on Army tactical vehicles stationed in Hawaii was so large it resulted in a maintenance man-hour backlog equal to 100 man-years, with 4,000 vehicles affected. In the end, it cost the Army $8 million to hire a contractor to repair and rustproof damaged vehicles.

The life-cycle management strategy is specifically geared toward the MSCs and is a product of the collaborative activities between the MSCs and MTL. As a full systems approach, it incorporates CPC into various documents and activities integral to the "life" of a material's development and its inclusion into an Army defense system.

"Today's Army has more complex and technologically advanced equipment than ever before. This sophisticated equipment is required to operate in the most demanding and aggressive environments around the world. Army vehicles and weapons systems must achieve full performance whether in jungle, desert, the arctic, on beachheads, or in the swamps," says Center of Excellence Deputy Program Manager Dr. Carolyn Bonin. "The effects of environmental degradation can seriously hamper system performance and impair the operational readiness of our forces in the field. Loss of equipment due to corrosion and degradation threatens to undermine the capabilities of the armed forces."

Materials Selection

The Center of Excellence reports that 35 percent of the Army's corrosion losses are due to improper selection of materials. The use of magnesium for helicopter components, for example, has been found to be inappropriate for marine environments. Another problem has been the use of dissimilar metals in ammunition castings, causing accelerated corrosion. The remaining 50 percent of the Army's losses are due to improper or inadequate maintenance. Either the maintenance procedures for the equipment were insufficient to cope with the operational environment or they were not correctly understood and followed, causing a great deal of "down time" for Army materiel.

Packaging and Storing

Another Army corrosion problem has been the manner in which materiel is packaged and stored. MTL materials engineer Richard Squillacioti is currently collecting specifications and standards that apply to corrosion and will coordinate CPC for packaging. Corrosion prevention and control techniques will then be adopted as procedures in the packaging, storing and shipping of materiel.

Exposure

"When looking at deterioration," says MTL scientist Dr. Robert Sacher, "we try to find the effects of the environment, such as moisture and sunlight, on the mechanical and structural properties of a material." MTL has been working in this area for more than a decade and has now developed a detailed information base on materials exposure. The focus for the near future also includes programs ranging from developing protective coatings to assessing and improving the corrosion/deterioration resistance of new alloys, polymers and composites.

In metals, MTL's areas of expertise encompass: aqueous corrosion, electrochemical testing, stress corrosion cracking, corrosion fatigue, high-temperature oxidation/sulfidation, chemical defense, erosion/corrosion, wear and abrasion, nondestructive testing, reliability mechanics, and specifications and standards.

In non-metals, MTL specializes in the fields of composites, elastomers and polymers. Composite CPC work includes ultraviolet radiation, humidity/temperature effects and fatigue life; elastomer involvement includes chemical defense, ozone exposure, and wear and abrasion; and, polymer activities encompass change in optical properties, grazing and abrasion, oxidation deterioration, and stress effects.

Assistance to MSCs

The problems that MTL has dealt with involve aircraft, missiles, land-based surface vehicles, subsystems (structural, electronics, machinery and engines), and support equipment. Specifically, MTL has provided corrosion prevention and control assistance to the Army Aviation Systems Command on the CH-47 Chinook Helicopter, UH-60 Blackhawk Helicopter, and AH-64 Advanced Attack Helicopter.

MTL has also provided CPC assistance to the Army Tank-Automotive Command on the Infantry Fighting Vehicle, M113 Armored Personnel Carrier, and High Mobility Multi-Wheeled Vehicle; and to the Army Armament, Munitions and Chemical Command on metallurgical analysis of chemical munitions, failure analysis and problem solving on 105mm, 155mm, and 8-inch projectiles, and Weteye and MCl bombs and M55 rockets (all containing nerve agents).

Additionally, CPC assistance has been provided to the Army Missile Command on the Hawk and Chapparal Missiles; the Army Troop Support Command on water purification vans; and to the Army Communication-Electronics Command on the parametric amplifier (gold-plated brass wave guides) and radar casings.

All of the MSCs and depots are now required by regulation to submit a "problems and solutions" report to MTL semi-annually regarding their CPC activities. MTL uses the information from these reports to create a substantial data base which is disseminated through a publication called The Corrosion Digest to all of the MSCs and depots. This has served to integrate CPC technology throughout the Army community.

The Aviation Systems command, for example, reported several instances of "lake formation" in the tail rotor outboard retention plate and tail rotor blade assembly of the UH-60 Blackhawk helicopter due to the lack of adequate drainage. Suggested solutions included the addition of drain holes where possible, or redesigning the parts. In another case, Tobyhanna Army Depot reviewed the corrosion of steel brackets employed in air conditioning units due to dripping moisture condensation. This problem was resolved by nickel plating the steel brackets.

New Techniques

In a number of cases, new techniques have been introduced to combat materiel deterioration. Tannic acid-based rust transformers are being investigated by several MSCs and MTL as products which react with various oxides on steel surfaces to form a rust-inhibitor capable of providing an excellent base for subsequent primer and paint applications. Also, the Army Communications-Electronics Command is developing chemical vapor deposition of silicon nitride to coat glass fibers.

An important step in the acquisition of new weapons systems and maintenance of fielded systems exhibiting corrosion problems is the review of detailed specifications by materials and process specialists to ensure that the most advanced corrosion technology is employed. Then, once into production, CPC considerations will be included in quality conformance reviews, production readiness and program progress reviews, on-site inspections, requests for waivers, inclusion in technical manuals, and depot maintenance work requests.

Additionally, the Center of Excellence is coordinating efforts to bring CPC into systems designs through design reviews and the establishment of corrosion prevention advisory boards (CPABs). The CPABs are being formed and chaired by each MSC and will each include one member from MTL. They will review the scope of work or request for proposal for each design contract, provide design guidance, review the technical data packages, and ensure full implementation and documentation of corrosion prevention and control measures. One of the initial CPABs, with representatives from the Aviation Systems Command and the Corpus Christi Army Depot, is addressing problems regarding the LHX helicopter.

Open Communications

Not only is MTL serving as a center for corrosion research and development, the Center of Excellence will also serve as an active communications hub for corrosion prevention and control, failure analysis and lessons learned throughout AMC and the Army community. "We feel strongly," says Dr. Wells, "that active, open communications about corrosion failure analysis is as important as communicating the findings of sophisticated prevention-based research. It is certainly as cost beneficial as the research itself."

To facilitate communication with the field units, MTL is establishing an integrated computer network throughout the AMC community. The MSCs and field units will use the network to report problems to the Center of Excellence and the center will have the capability of reporting solutions, offering technical guidance and disseminating pertinent information back to the commands and field units.

The communications function, checks and balances, and ongoing R&D, as well as failure analyses, technical assistance and lessons learned will all lead to a technology synthesis. These initiatives are geared toward getting the research applications and solutions out of the laboratory and into the field.

A key element in the integration of CPC data is technology transfer to industry, academia, and to such professional organizations as the National Association of Corrosion Engineers. Additionally, though the CPC program is an Army activity, it is very much the product of tri-service cooperation among the Army, Navy, and Air Force. Several major conferences have been held and more are planned for the future.

A Tri-Service Corrosion Conference,

in which MTL participated, was held earlier this year and was hosted by the Air Force Wright Aeronautical Laboratory/Materials Laboratory in Colorado Springs, CO. The goals of the conference were to make Department of Defense personnel and contractors aware of important corrosion problems in military equipment, to provide a forum for exchange of corrosion control information, and to present the status of significant corrosion research and control projects being carried out by the military.

Says Dr. Wells, "One of the key elements in the whole corrosion program is training." MTL's Nondestructive Testing School, headed by Walter Roy (chief, Quality Assurance Branch) has taken the lead in training and has so far established an introductory five-day course — An Introduction to Corrosion and Material Deterioration Prevention and Control, offered to MSCs and depot personnel.

Several other courses which are being introduced are: Corrosion and Materials Deterioration Prevention and Control in New System Design, Corrosion and Materials Deterioration Prevention and Control in Aviation Systems, Depot Level Procedures for Control of Corrosion and Material Deterioration, and Corrosion and Materials Deterioration Prevention and Control in Munitions.

"The introductory course is quite comprehensive," says Roy, "and is recommended for personnel involved with securing and maintaining the functionality of a defense system but lacking specific formal education in corrosion and materials deterioration. Our goal is to develop an awareness of corrosion problems and their impact on the functioning and reliability of a defense system with emphasis placed on the practical applications to maintenance procedures, materials selection, and systems design to prevent or minimize corrosion."

Conclusion

Saving money, creating better materiel, and improving the survivability of the defense forces, by giving our soldiers more reliable, safer and durable products, are all possible through the Center of Excellence. By attacking the enemy — corrosion — through its research and development efforts, and applying the power of information and technology sharing, MTL and its Center of Excellence are helping to ensure the success of the soldier, and the Nation, today and in the future.

SUSAN DREIBAND is a public affairs specialist at the Materials Technology Laboratory, Watertown, MA.

Contract Awarded for New Distributed Testing System

A new distributed testing system is being developed to insure the interoperability among command and control systems of the military services and agencies. This test system is called the Joint Interoperability Evaluation System (JIES).

On July 28, 1987, the Army Communications-Electronics Command at Fort Monmouth, NJ, awarded a five-year $51.6 million contract to Martin Marietta Information and Communications Systems, Denver, CO. Under this contract, Martin Marietta will develop computer programs for the JIES, using nondevelopmental item hardware.

The Joint Interface Test Force-Joint Tactical Command, Control and Communications Agency (JITF-JTC3A) initiated the system development.

Development initially will be directed toward validating the new Tactical Digital Information Link J interface standard being implemented in services' command and control systems. The JIES will replace the test system JITF now uses to test interoperability of tactical data systems that use Tactical Digital Information Link A and B standards, said Phillip Lloyd, JITF technical director.

Lloyd describes the JIES development as "predominately a software effort, utilizing commercial equipment." The software design and implementation language will be Ada, the Defense Department's common computer language.

"The JITF's goal is a system that minimizes costs of operation and maintenance, is virtually independent of single hardware and software product lines, and has readily expandable hardware and software architectures and implementation," said Lloyd.

The new system will be comprised of a central test facility at the Joint Tactical Command, Control and Communications Test Center at Fort Huachuca, AZ, and a number of remote test facilities at dispersed command and control tactical data system locations. Dedicated, secure commercial digital data circuits and intermediate processors will connect the central test site and the remote test facilities. The central test facility is the link through which widely dispersed service and agency tactical data systems will communicate with each other as if they were deployed in the same area of operations.

The JIES will monitor the data flow among the tactical data systems through a radio frequency network. The data collected will be automatically reduced and analyzed.

The JTC3 Agency will forward the test results to the Joint Chiefs of Staff for certification of command and control systems under test for use in joint and combined operations.

Lloyd said the JIES development will be conducted in three phases. Completion of the first phase in February 1990 will see the delivery of hardware and software for testing the Tactical Digital Information Link J developmental standard. Five sets of intermediate processors, radio frequency network and sensor simulators will be integrated into the test bed in the first phase.

Phase II, to be completed February 1991, will provide intermediate processors and sensor simulators to bring four more command and control systems into the test bed. It will increase the level of automation of data collection and test analysis by incorporating expert system technology.

The final phase, when completed in February 1992, will provide intermediate processors and sensor simulators, integrating two additional tactical data systems, plus the capability to test Tactical Digital Information Link A and B standards.

Threat Support

By Alexander McGregor Jr., James W. Conlin and Dr. Joel Shapiro

A crucial element in the design and deployment of effective weapons systems and equipment is the understanding of the foreign threat that U.S. military systems might encounter. Threat is defined as "the ability of an enemy or potential enemy to limit, neutralize, or destroy the effectiveness of a current or projected mission, organization, or item of equipment."

Proper threat support to the development and acquisition process will allow materiel developers to prepare in advance for the foreign threat and permit key system deficiencies and vulnerabilities to be rapidly surfaced for correction. Army and Army Materiel Command (AMC) regulations have been issued to govern and define the threat support process.

Major regulations governing threat support include AR 381-11, Threat Support to the U.S. Army Force, Combat and Materiel Development and AMC Supplement to AR 381-11; AR 70-1, Research, Development and Acquisition; AR 70-10, Test and Evaluation; and AR 71-9, Materiel Requirements. AMCR 70-5, Materiel Acquisition and Decision Process (MADP) Reviews, also involves specific requirements which make threat consideration an important aspect of the Materiel Acquisition Review Board process.

All of these regulations have an impact on the program executive officer (PEO)/project manager (PM) system, since they bring threat and threat support into the development and acquisition process at crucial and decisive moments.

The regulations forge a relationship between the PM and their main source of threat support and information, usually the supporting deputy chief of staff for intelligence (DCSI) or senior intelligence officer (SIO) at each Army

Senior Intelligence Officers

AMCCOM COMMANDER U.S. ARMY ARMAMENT, MUNITIONS AND CHEMICAL COMMAND ATTN: AMSMC-SI ROCK ISLAND, IL 61299-6000	MR. JOE WESTON (ACTING)	AV 793-3135
AVSCOM COMMANDER U.S. ARMY AVIATION SYSTEMS COMMAND ATTN: AMSAV-O 4300 GOODFELLOW BLVD ST. LOUIS, MO 63120-1798	MAJ KURRAS	AV 693-1014
CECOM COMMANDER U.S. ARMY COMMUNICATIONS-ELECTRONICS COMMAND ATTN: AMSEL-SI FT. MONMOUTH, NJ 07703-5000	LTC GREGORY	AV 992-7851
LABCOM COMMANDER U.S. ARMY LABORATORY COMMAND ATTN: AMSLC-MI 2800 POWDER MILL RD ADELPHI, MD 20783-1145	LTC COOK	AV 290-2635
MICOM COMMANDER U.S. ARMY MISSILE COMMAND ATTN: AMSMI-SI REDSTONE ARSENAL, AL 35898-5160	COL LEWIS	AV 746-2635
TACOM COMMANDER U.S. ARMY TANK-AUTOMOTIVE COMMAND ATTN: AMSTA-S WARREN, MI 48397-5000	MR. BOB MATSCO (ACTING)	AV 786-6262
TECOM COMMANDER U.S. ARMY TEST AND EVALUATION COMMAND ATTN: AMSTE-SI ABERDEEN PROVING GROUND, MD 21005-5005	LTC BATES	AV 298-4795
TROSCOM COMMANDER U.S. ARMY TROOP SUPPORT COMMAND ATTN: AMSTR-Y 4300 GOODFELLOW BLVD ST. LOUIS, MO 63120-1798	MR. KARL UCHRINSCKO	AV 693-2408
AMSAA DIRECTOR U.S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY ATTN: AMXSY-PF ABERDEEN PROVING GROUND, MD 21005-5071	MR. KEITH TITUS	AV 298-6235

Figure 1

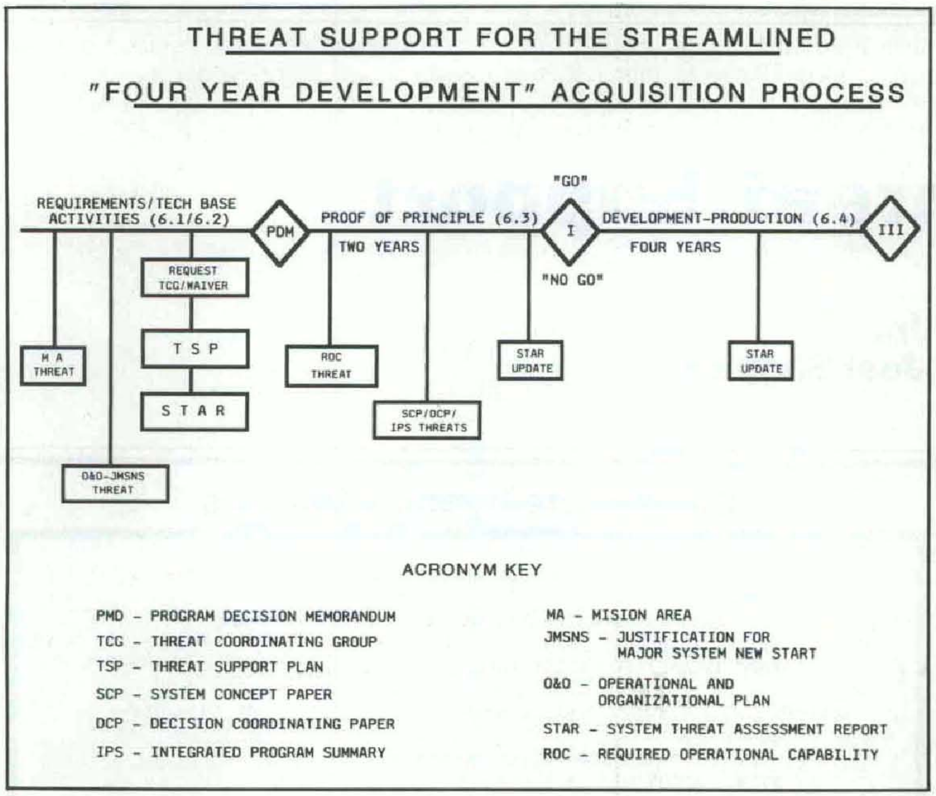


Figure 2

SAMPLE PMSA THREAT CHART

SYSTEM NAME XYZ MISSION SYSTEM

DATE: 9 DEC 86 **THREAT**

TITLE	VALIDATION	STATUS	DATE	UPDATE DUE
SYSTEM THREAT ASSESSMENT REPORT (STAR) ROC	DA VALIDATION REQUIRED	PREPARED VALIDATED	MAY 1977	NONE
TITLE	KEY CIPS	DATE	DISCUSSION	
CRITICAL INTELLI-GENCE PARAMETERS (CIPS)	WHAT IS SOVIET COUNTERMEASURE?	ONGOING	SUCCESSFUL THREAT ELIMINATES LASER WEAPON CAPABILITY	
TITLE	MEMBERSHIP	ACTIVE ISSUES		NEXT/LOC
THREAT COORDINATING GROUP (TCG)	1. ACSI - CHAIR 2. ARMOR CTR & SCH A. TM B. CBT DEV 3. PMO 4. AMC DCSI 5. MSC DCSI 6. AMSAA	COUNTER TO LASER ENERGY		NONE SCHEDULED
TITLE	PREPARED BY	DATE	APPROVED BY	DATE
THREAT SUPPORT PLAN (TSP)	MICOM MISSLE SCHOOL		UNDER DEVELOPMENT	

Figure 3

Materiel Command major subordinate command (MSC). A list of all the MSC senior intelligence officers, their addresses, and telephone numbers is provided in Figure 1.

The main elements of the relationship between the PM and the DCSI/SIO are now inserted into the Program, Project, Product Manager/Materiel System Assessment (PMSA) Cookbook in Chapter 2 (Page 2-E, Threat and Counter-Threat). The purpose of the threat section is to display key threat support elements and documents.

Figure 2 shows how these major threat support instruments fit into the materiel development cycle. The most important ones are the Threat Support Plan, the Critical Intelligence Parameters, the System Threat Assessment Report, and the Threat Coordinating Group.

If the MSCs and PEOs, in coordination with their supported PMs, adopt PMSA as a reporting medium, it is highly recommended that the PMSA Threat chart (2-E) be included. PMs should contact the DCSI/SIO for assistance in compiling this information. An example of the chart and the data required is given in Figure 3. The following descriptions of the threat instruments will illustrate the role of threat support in the materiel development process.

The Threat Support Plan (TSP) is mandated by AR 381-11 and initiated at the start of a study or project. It is prepared by the supporting senior intelligence officer jointly with the Army Training and Doctrine Command (TRADOC) and the project manager, with the assistance of the appropriate Threat Coordinating Group. The Threat Support Plan's purpose is to cause examination of the threat support needs of the project over its life cycle (or as much as can be forecast). These needs include the required threat product/support delivery schedules, the nature of the threat product or service requirement, and the estimated lead time for both threat production and threat use. The Threat Support Plan will be forwarded to HQ AMC, ATTN: AMCMI, for review and approval. It must be emphasized that the process of developing the Threat Support Plan is the real key to successful threat planning.

Critical Intelligence Parameters (CIPs) are those threat characteristics such as numbers, types, mix, or characteristics of actual or projected threat systems identified by PMs that would critically impact on the effectiveness, survivability, security or cost of a U.S. system. Critical Intelligence Parameters are included in the Threat Support Plan and listed in each System Threat Assessment Report. PMs must work closely with supporting Senior Intelligence Officers in the preparation of the CIPs. Once defined, Critical Intelligence Parameters are submitted through intelligence channels for validation and subsequent collection/production guidance.

The System Threat Assessment Report (STAR) is mandated by DOD and DA acquisition regulations. Preparation and approval within the Army is governed by AR 381-11. The STAR summarizes the approved threat provided to combat and materiel developers for a specific system. It provides an assessment of the enemy's capabilities to neutralize or degrade a specific U.S. system or system concept as determined by the interactive analysis.

The STAR is an important base threat document which must be periodically updated to reflect new information. It is prepared jointly with TRADOC by the senior intelligence officer supporting the PM. The PM should task his supporting senior intelligence officer for the preparation of the STAR prior to entry into Proof-of-Principle phase, and for subsequent updating. The validation level depends on system decision level (Defense Intelligence Agency for major; Deputy Chief of Staff for Intelligence for Designated Acquisition Programs; HQ AMC/TRADOC for In- Process Review).

The Threat Coordinating Group (TCG) serves as the principal coordinating/integrating mechanism between threat/intelligence consumers (PEOs/PMs, testers/evaluators, and combat developers) and the intelligence agencies of DA and DOD.

The PM is a full and active member of the TCG since it is the main forum for expressing requirements, receiving updated information and resolving the inevitable question, ambiguities, and details of the threat. The senior intelligence officer supporting the PM is the major subordinate command principal TCG contact point and should be consulted for preparation of the Threat Coordinating Group portion of the PMSA chart.

The whole process described in the preceding paragraphs constitutes the "institutionalization of the threat" within the Army and within AMC in particular.

ALEXANDER MCGREGOR JR., JAMES W. CONLIN, and DR. JOEL SHAPIRO are chief and senior analysts, respectively, with the Threat Evaluation Division, Office of the Assistant Deputy of Chief of Staff for Foreign Intelligence, Headquarters, Army Materiel Command.

Value Engineering Proposal Will Save $11.3 Million

The Aviation Applied Technology Directorate (AATD), Fort Eustis, VA, earned the top money saver position in the U.S. Army Aviation Systems Command's (AVSCOM) Value Engineering (VE) program for FY87 with the proposal, Modification of the UH-60A Black Hawk Wire Strike Protection System (WSPS).

AATD, one of four directorates of the U.S. Army Aviation Research and Technology Activity at AVSCOM submitted the proposal to develop a WSPS design modification that reduces its weight and cost while simplifying field retrofit.

The adoption of the proposal resulted in the directorate being credited with first year VE savings of $2,602,386 and budget year savings of $667,265. An estimated total savings of $11.3M is expected over the 20-year service life of the UH-60 fleet.

The WSPS consists of deflectors and upper and lower mechanical wedge type cutters. It will help protect low-flying helicopters against damage from in-flight strikes of wires and cables, thus saving lives and preserving materiel.

During the WSPS qualification test program, LeRoy T. Burrows, AATD project engineer formed an opinion that the extensive reinforcements of structural materials added by the contractor to the standard UH-60A upper sliding fairing were excessive. The reinforcements had been installed in the areas where the upper cutters were mounted to assure the contractor that the system would accommodate worst-case strike loads without failure.

These reinforcements had increased the upper sliding fairing weight, without the cutters attached, from 35 to 80.3 pounds.

The complexity of the WSPS structural augmentation was such that it could only be done at the contractor's plant. Retrofit of the WSPS to the UH-60s already in the Army fleet would require an exchange of upper fairings between field units and the contractor. This would require a complex and expensive shipment and accountability system.

The 45 pound weight increase was unacceptable and that field retrofit of the WSPS was a design requirement, said Burrows.

Accordingly, Burrows initiated a VE study and assembled a team from AATD engineers and technicians. The VE team conducted analyses and developed four simple, light weight alternative upper fairing mounting configurations to provide the same functions as the contractor structural augmentation.

A design support test program was conducted in the AATD Structures Laboratory for evaluation of these four upper cutter mounting concepts. These were tests of fairing sections with the upper cutter attached. A 3/8-inch seven-strand steel cable, free at one end, was retained in the cutter jaws. Loads were applied by hydraulic actuator situated so that the cable was pulled at an angle 30-degrees from the normal to the cutter. Specimens were subjected to tests designed to simulate worst-case wire strike loads.

Testing of all four AATD concepts resulted in no structural yielding and proved that each concept exceeded design requirements.

A concept consisting of just a .060-inch thick backing plate with six .50-inch bolt spacers provided the best combination of light weight, low cost, simplicity, ease of installation, and field retrofit capability.

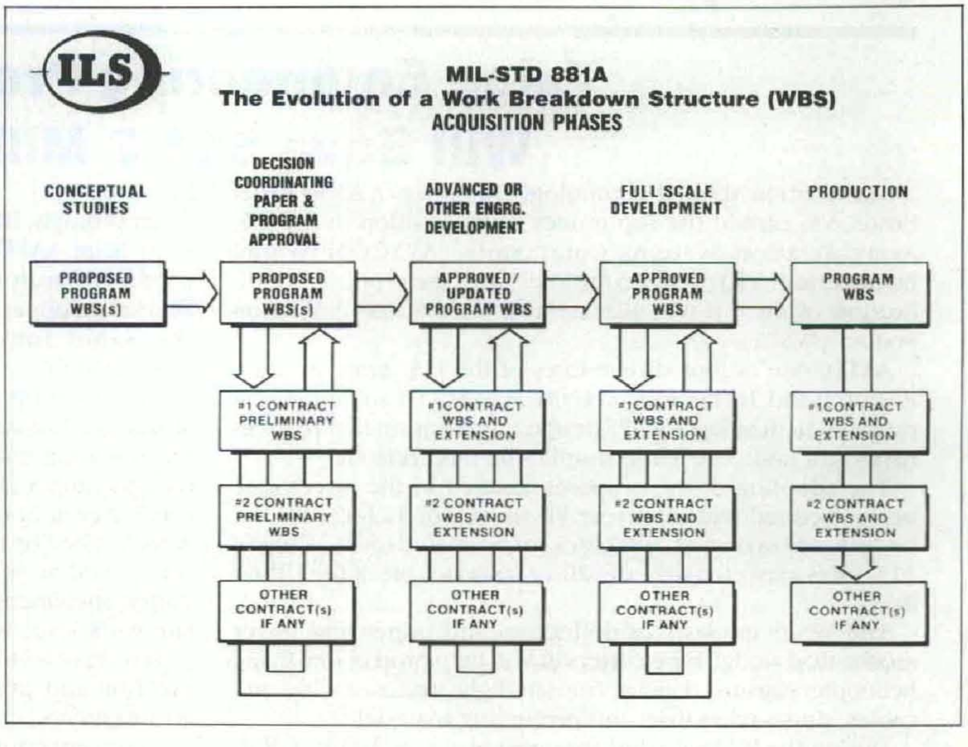
Tests were then conducted on a UH-60A aircraft with cutters attached to a standard upper fairing, reinforced with the best AATD mounting configuration. The test sequence applied loading up to the design limit and ultimate loads, then continued rapid loading cycles to determine the failure point. A lateral load of 4,503 pounds, 1.58 times the design ultimate load was applied without significant distress areas noted.

As a result of this VE program, the UH-60A upper fairing WSPS modification was redesigned incorporating the AATD concept in the engineering change proposal. This reduced the weight of the cutter mounting reinforcement from 45.3 pounds to approximately 0.5 pounds, resulting in the net weight reduction of 44.8 pounds and producing a significant cost savings in WSPS fabrication, installation, and fleet life cycle fuel use.

ILS in the Work Breakdown Structure

By Ewell E. Eubanks

Editor's Note: The following is the first of two articles regarding the management of Integrated Logistics Support (ILS) using the Work Breakdown Structure (WBS) and a contractors approved Performance Measurement System. The second article will appear in the January-February issue of Army RD&A Bulletin.



Background

The purposes of the Work Breakdown Structure, as prescribed under current Military Standard (MIL-STD) 881 A, are to: provide a product-oriented family tree composed of hardware, services, and data, which results from project engineering work efforts during the development or production of a defense materiel item or weapon system; completely define the program; and completely define cost, schedule, and performance reporting criteria.

The WBS is a valued communication link throughout the acquisition process and is the one common link in a process which includes the formal program baseline, cost estimating, budgeting, contracting and program performance discipline, and resulting historical data.

To oversimplify a complex issue, a WBS serves many purposes, to include facilitating planning, scheduling, organizing, etc., by providing a formalized structure for identifying the required work, and the organizational structure for performing the work. The work breakdown structure results in a Contract WBS (CWBS) which displays and defines the products to be developed or produced, and relates the elements of work to be accomplished, to each other and to the products. This simplifies the problem of summarizing contract data, or even project-oriented data, establishes the formal reporting structure for both government and industry, and provides for specific government-required management information.

The first three levels of work breakdown structure are government imposed and should not be negotiated away. The government also has the right and the duty to assign lower level reporting requirements, as required. The lower indenture levels, as prescribed by the CWBS, are negotiable and define mutual agreement on the nature of the work. After negotiations and contract award, a contract work breakdown structure is approved by the government and made a part of the contract and data reporting criteria.

During the first few months after the contract award, the contractor extends the accepted CWBS. This extension covers all the agreed-to requirements. Approval of the extension and attachment to the contract by the buying office, results in the "finalized" CWBS. The contract work breakdown structure then evolves as the program moves through its life cycles.

CWBS Organization

Proper planning on the part of government and industry takes into consideration all the required reporting data. The CWBS recognizes and accommodates the differences in the way work is organized and performed. There is a need for contractor flexibility in the CWBS extension; however, the basic objective is to subdivide the total contractual effort into manageable units of work. Large or complex tasks require numerous subdivisions. Other tasks of lesser complexity or size may require substantially fewer subdivisions.

In establishing the lower level CWBS, it is essential to accommodate the differences between the organization, its performance, and the management control of work in the development and production phases. System design and development normally are organized and performed along the lines of the major systems and subsystems of the overall effort.

The design is normally developed in progressively greater detail until it is established at the component level. In the production or manufacturing phase, components are first fabricated or purchased and then joined together in progressively larger subassemblies until a complete system is produced. In addition, the production sequence normally follows a physical parts breakdown rather than the subsystem breakdown characteristic of design. It may, therefore, be impractical to use the same lower levels of the contract work breakdown structure in production as was used during the development phase.

The finalized CWBS forms the basis for "Cost Accounts" and "Work Packages." It is important that the ILS community recognize that the contractor's organizational structure reflects the way the contractor has organized the people who will accomplish the work. It is integrated with the CWBS, and subsequent cost, schedule, and performance reporting will be managed accordingly.

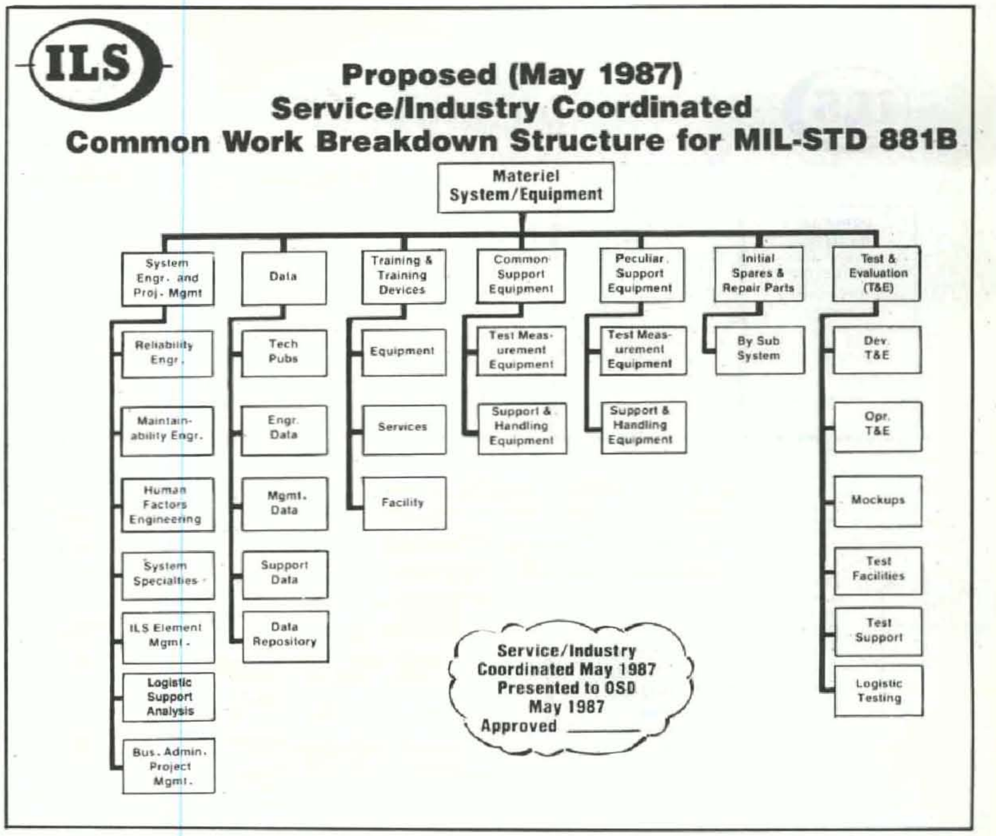
Tools

The Cost Performance Report (CPR) is one of the most meaningful reports or pieces of cost and performance data emanating from the contractor, and is the most useful tool available to a government manager. The CPR (Data Item DI-F-6000C) is prepared by a contractor and consists of five formats (which can be tailored down) containing cost and related data for measuring contractors' cost and schedule performance.

Format 1 provides data to measure cost and schedule performance by summary level WBS element. Format 2 provides a similar measurement by organizational or functional cost categories. Format 3 provides the time-phased contract budget baseline plan against which performance is measured. Format 4 provides the time-phased manpower loading forecast for correlation with the budget plan and cost element predictions. Format 5 is a narrative report used to explain significant cost and schedule variances, and other identified or agreed-to contract problems. (As a minimum, formats 1, 3, and 5 are recommended.)

The ILS manager can either specify reporting requirements for the program Cost Performance Report or obtain the information as a separate CPR for ILS. Since the contract requires that "all information reported to the government shall be derived from a single data base," a separate CPR would not be cost prohibitive for an ILS manager to obtain.

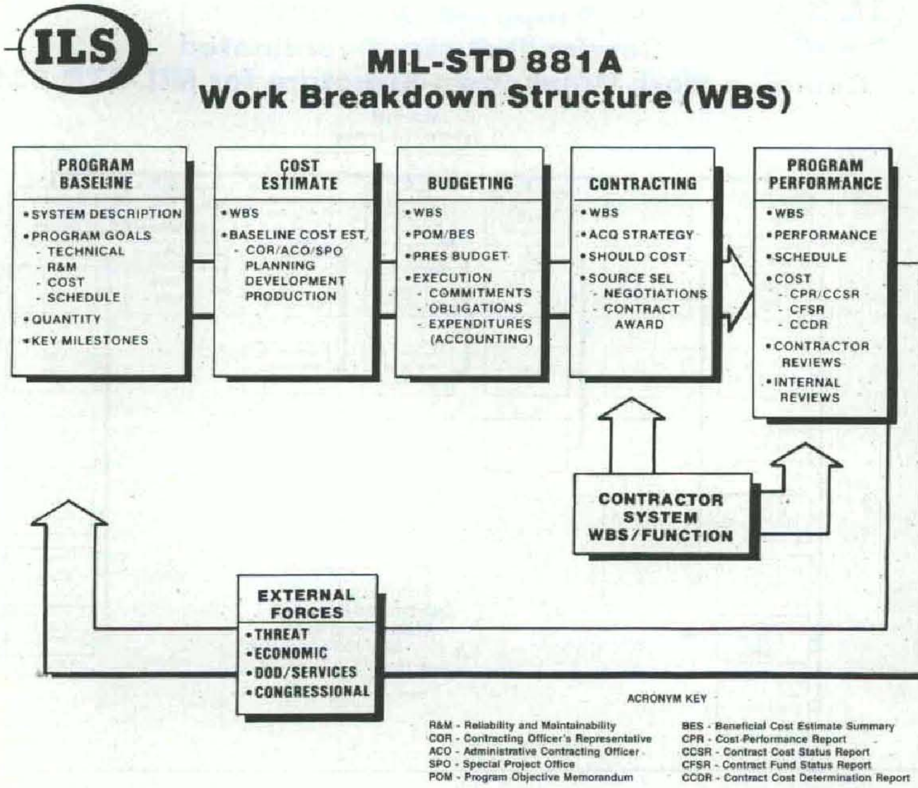
A CPR can be applied to a contract by data item, with or without Cost/Schedule Control Systems Criteria application, and since defense industry contractors all use a management system, this document can become a most useful tool. However, the data gathered is only as good as the effort made in developing and formulating the work breakdown structure and contract work breakdown structure.



Initiatives

The MIL-STD-881 A contains a basic body of requirements and a number of commodity-oriented appendices for application to a given type program, or a given materiel system or equipment contract. A tailored basic WBS called a "Program WBS" is prepared by a government buying office using, as a guide, one or more of the appropriate MIL-STD-881 A appendices. The Program WBS is used as a framework for reporting and managing the government side of the program, and to develop specific Performance Work Statements and reporting requirements for a contract Statement of Work.

A "Preliminary CWBS" is prepared by the buying office from the Program WBS and is attached to the Request for Proposal. The preliminary CWBS, as expanded and refined by the contractor, in response to the Request for Proposal,



provides the appropriate elements for a contract, and specifies the appropriate reporting subelements of cost and performance.

To facilitate change and to make the existing WBS more "user-friendly" to the ILS community, a Joint Service ILS task group (Staff-to-Staff, Joint Policy Coordinating Group (SPG-ILS) for Multiservice ILS Management and Acquisition) was chartered (by the OSD/Service 881B work group) to develop a common appendix for the technical, logistics, management, and engineering efforts associated with all materiel systems and equipment.

The tasking was accomplished between January and May 1987. A service and industry coordinated position was presented to the Office of the Secretary of Defense (OSD) Services 881B working group for the new standard. The proposed common area appendix retains the integrity of the existing WBS to the maximum extent possible, while elevating key aspects of ILS and engineering to levels 2 and 3, and defines specialty engineering efforts and pure services, hardware and data elements. This change provides the upper level CWBS visibility required for effective technical program management.

By establishing ILS in three major categories and defining logistic analyses etc., managers will be able to closely monitor specific logistic tasks and subtasks associated with development and production. The physically deliverable logistic hardware, support equipment, data, and so on will be captured under their existing elements, but the engineering efforts, analysis, and management functions are specifically excluded. This will provide the true cost of services, data, parts, and equipment.

The required reprocurement data, technical data package, logistic, or support data, etc., will be captured under the appropriate level 3 data elements. A new subelement (logistic testing), under the testing WBS element, will capture the cost and performance associated with the logistic testing that ensures the supportability of the new defense system or equipment.

This separation and redefinition of management, engineering, ILS, equipment, data, and test will provide visibility for all elements of ILS and technical accomplishment, while minimizing the impact on the WBS as historical data. This change brings the WBS standard into compliance with DOD directives and current DOD and service policy, and permits a consistent crosswalk between the WBS and ILS contract entries or contract requirements. However, the change will not cause significant changes in the existing contractors' management and accounting system. On the contrary, it will allow industry to establish a total budget for the ILS and engineering effort. This provides for the proper integration of ILS and engineering, via the Contract WBS, and will produce the equality between cost, schedule, performance, and supportability we all strive to achieve.

Conclusion

In summary, the ILS managers must participate in the WBS and CWBS development process and be an active player in this process. They must make their requirements known for cost and for performance reporting, and they must become familiar with the cost and other reports available for their needs.

As a by-product, by asking for the appropriate requirements to be reported, a monthly variance analysis is provided by the contractor, and cost and performance can be plotted on a monthly or quarterly basis against the Contract Budget Baseline. Progress can then be monitored on a regular basis, and baseline maintenance can be established for ultimate control.

The logistic and technical managers should also participate on Cost/Schedule Control Systems Criteria demonstration review teams at the contractors' facilities, and attend training courses regarding management with contractors' data. Some logical schools to attend are: Cost/Schedule Control Systems Criteria at the Air Force Institute of Technology, Wright-Patterson AFB, OH; Management With Contractors Performance Information Management Data at the U.S. Army Management Engineering Agency, Rock Island, IL, or other such government schools. The above will serve the ILS and functional managers well.

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

Army/NASA Aircrew-Aircraft Integration Program

By Earl J. Hartzell

The Army/NASA Aircrew-Aircraft Integration (A3I) program is a joint exploratory development effort to produce a prototype Human Factors-Computer Aided Engineering (HF-CAE) system. The effort, which began in FY85, is conducted by the U.S. Army Aeroflightdynamics Directorate and the NASA Aerospace Human Factors Research Division, collocated at the NASA Ames Research Center, Moffett Field, CA.

The program will result in development, by 1991, of a predictive methodology for helicopter cockpit design, including mission requirements and training system implications, that integrates human factors engineering with other vehicle/system design disciplines at an early stage in the weapons system development process. The program's HF-CAE workstation is intended for use by design professionals as a graphic designer support system.

The goal is to aid in the production of cost- and performance-effective man-machine systems. The effort involves the design, development, integration and evaluation of software and hardware architectures, employment of artificial intelligence techniques/tools, and an integrating environment which provides for the interaction of numeric/computational and symbolic algorithms.

Program focus is on the conceptual design phase of the weapons system development process leading up to the demonstration and validation phase. It is in this phase, leading up to the final design and demonstration of any system, that 70 to 80 percent of the life-cycle cost is determined. After hardware is built, mistakes are very hard to change and it is difficult to modify concepts. Traditionally, it is only after a prototype cockpit has been built that training system and simulator designers are provided with an idea of the training device/system requirements they will meet. The motive behind the joint program is to provide these designers, in the conceptual design phase, with an opportunity to "see it before they build it," ask "what if" questions, and be told "why" ideas will or will not work. The goal is to make mistakes in software...not hardware.

The HF-CAE system is conceptually a model and principle based computer graphic simulation of a manned simulation wherein models and heuristics of human performance and behavior replace the pilot of a manned simulation. The simulation consists of generic and selectable vehicle dynamics, editable scenarios and mission functions as inputs, and the loop is closed by models of pilot performance and behavior. The performance and behavior of the pilot is represented in the system by computational models of vision, audition, vestibular function, learning, anthropometry and workload, and heuristic models where more analytic methods are lacking.

This interactive environment will allow analysis and estimation of the impact of cockpit design decisions and mission specifications on system performance. As an example, the central issues of pilot workload, performance and training needs, and appropriate use of automation are interrelated and interactive and effect all integrated design considerations in future man-machine systems. The goal is to aid designers in understanding and appreciating these complex interactions before costly mistakes are made. Though the focus of the A3I program is on advanced technology rotorcraft, the methodology can be generalized to be used with other complex man-machine systems.

The products associated with the A3I program contained in the HF-CAE workstation are:

- an automated mission editor;
- a designer's simulation workbench which incorporates aircraft simulation models, human behavior/performance models, system function models, and workload assessment and prediction models;
- training requirements expert system models;
- computer-aided design utilities to render cockpit layout, instruments and concepts;
- a dynamic interactive anthropometric pilot model (graphic manikin);
- a designers state variable/data information and analysis center; and
- a simulation and integrating executive control system.

Elements of this program involve engineering psychology, artificial intelligence/expert systems, math modeling, computer science, and contributions by subject matter experts from many other technical areas. The Army Research Institute and the Army Human Engineering Laboratory are cooperating with elements of the program and there is heavy dependence on support from the NASA Intelligent Systems Research Division, as well as a special study group of the National Research Council, Committee on Human Factors.

EARL J. HARTZELL is the director of the Army/NASA Aircrew-Aircraft Integration Program in the Army Aeroflightdynamics Directorate at the NASA Ames Research Center in Moffett Field, CA.

Somalia Jeep Project

By Julie McCutcheon

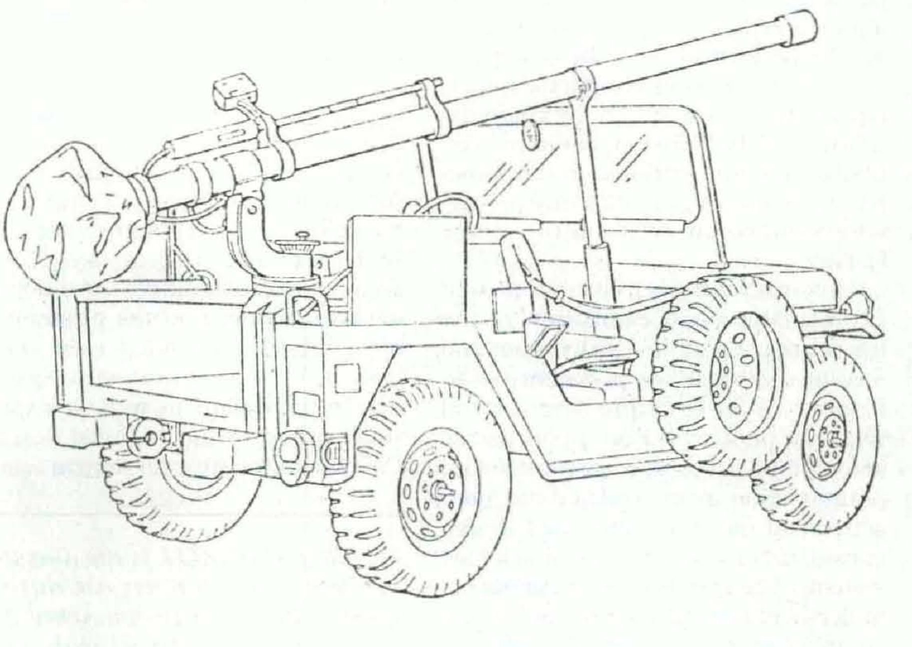
The U.S. Army Tank-Automotive Command (TACOM) RDE Center's Design and Manufacturing Technology Directorate has recently completed a project to convert 25 M151A2 1/4-ton trucks to an M825 configuration for the government of Somalia.

The project, which involved the fabrication and installation of conversion assemblies, took only 77 days to complete. The conversion transformed the M151A2s from personnel and general cargo transporters to mobile weapon systems, each carrying a 106mm recoilless rifle on an M79 rifle mount.

Somalia, located in sub-Saharan Africa, will use the vehicles in their fight against Soviet-backed Ethiopian forces, a conflict which began in the late 1970s.

The U.S. government provided funding for the project — approximately $300,000 — through the Military Assistance Program. Subject to certain limitations, money allocated by Congress to countries around the world may be used by the nations approved for this program, for the purchase of defense articles and related services.

With these funds available, the Somali Democratic Republic approached the Office of Military Cooperation, part of the U.S. Embassy in Somalia, with a request in early 1986. After the request was evaluated and approved, a Foreign Military Sales case was written for 25 M151A2 1/4-ton trucks with the intention of converting them to the M825 configuration in the future. Later, additional funding was obtained to allow for this, and TACOM's Directorate for International Logistics went to commercial sources for a conversion kit and the conversion of the vehicles.



M825 Configuration.

(Although the U.S. Army commissioned widespread use of the M825 1/4-ton truck beginning in the early 1970's, and it was for many years available in the Army inventory ready-to-use, modern warfare tactics do not require use of the vehicle and it has been withdrawn from the inventory.)

Since the lead times from commercial sources were too long to suit the government of Somalia, and no assets existed, TACOM was asked about the possibility of fabricating the M825 conversion assemblies for each vehicle and installing them. At that point, the deadline for delivery of the M825s, based on the urgency of Somalia's requirement, was only some 12 weeks away.

The conversion of the trucks took place in four main phases: acquisition of the technical drawings; the ordering of the parts and materials; fabrication of the assemblies for conversion; and the installation of the assemblies.

The two initial phases of the project were accomplished almost immediately. The production and installation of the assemblies, though, required 12-hour days and 7-day work weeks for some of the RDE Center's machine shop, sheet metal, painting, and welding and assembly personnel.

The modifications began with the removal of the trucks' rear panels in order to make the rear end large enough to accommodate a frame assembly. The frame assembly, bolted to the rear of each vehicle, provides the means by which the recoilless rifle is secured. This assembly also structurally strengthens the rear of the vehicle, while furnishing locations for additional seating over the rear wheels.

Next, an overload kit was installed, which involved the incorporation of additional springs to the suspension, enabling it to support the added weight of the rifle and mount.

An ammunition box was fabricated

from sheet metal and bolted to each vehicle's left rear outer wheel well for a .50-caliber spotting rifle mounted atop the 106mm recoilless rifle. When the gunner fires the .50-caliber gun, each chemically treated tracer round will glow as a result of air friction, allowing the gunner to follow the path of the bullet and judge the accuracy of his aim.

Both a spare wheel assembly, installed on the front right side of each vehicle, and M14/M16 rifle mounts, attached to the dashboard, were obtained ready-made — from Army inventory, when that was possible, or from the private sector. The rifle mounts will enable the driver and one passenger to transport two M14 or M16 rifles securely, while leaving their hands free for other duties.

A fuel can bracket, which will be used to carry a 5-gallon fuel can, was bolted to the front left fender. Left and right hinged covers were installed on the rear of the trucks to secure the 106mm rounds carried there.

A socket assembly and travel lock, both of which will work together to hold the front of the rifle barrel in place while the vehicle is moving, were bolted to the floor. A retainer, also fastened to the floor, will prevent the wheel of the rifle's mount, or tripod, from bouncing.

The tripod consists of two rear legs with carrying handles and a hard rubber tire for the front wheel. The removal of the tripod for ground-mounted firing is a three-man operation: two men lift and carry the rear legs of the mount while one man steadies the gun. Once the tripod is on the ground, a traversing mechanism allows 360 degrees of controlled or free lateral movement.

After all of the conversion assemblies were in place, and a forest green paint was applied to cover the trucks' new parts, personnel from the Product Assurance and Test Directorate successfully road-tested one of the vehicles on 230 miles of the types of terrain the vehicles are likely to encounter in actual use. The trucks were driven over paved and unpaved roads, both flat and hilly, and off-road in four-wheel drive for a short period.

At the end of June, a rollout ceremony was held for the vehicles. TACOM Commander MG Arthur Holmes Jr. and MG Christian Patte, director of logistics and security assistance, U.S. Central Command, were among the speakers who praised the efforts of TACOM personnel involved with the project.

The M825 with 106mm recoilless rifle on an M79 rifle mount.

Immediately following the rollout, the M825s were shipped from TACOM by auto carrier to Sunny Point, SC, where they were loaded onto a military exercise ship for their journey to Somalia. The 106mm recoilless rifles and mounts were also shipped to Sunny Point by the U.S. Army Armament, Munitions, and Chemical Command at Rock Island, IL, from Anniston Army Depot, AL.

JULIE MCCUTCHEON is on the editorial staff of TACOM's RDE Center. She has a Bachelor of Arts degree in Communication Arts and Sciences from Michigan State University.

Tech Data Prepared for Arctic Fuel System

Engineers from the Fuels Handling R&D Team, Belvoir Research, Development and Engineering Center are in the process of preparing the technical data package for the Arctic Fuel Dispensing Equipment (AFDE) that will operate in temperatures as low as minus 60 F. Currently, there is no Army system that can store and dispense military petroleum fuels at temperatures below minus 25 F.

The AFDE program breaks down into two systems: the Arctic Forward Area Refueling Equipment (AFARE) which will be deployed by helicopter, and the Arctic Fuel System Supply Point (AFSSP) which will perform a bulk fuel storage and supply mission.

AFARE will be utilized to refuel helicopters and ground combat vehicles in the forward area of the battlefield. It consists of a turbine engine-powered 200 gallons-per-minute (gpm) pump, filter separator, hoses, gaskets and 500 gallon collapsible fabric drums.

The turbine engine will also be used to drive the electromagnetic clutch 600 gpm pump for the AFSSP. Some AFSSP components will be common to the AFARE, i.e., the filter separator, nozzles and scaled-up versions of hoses, gaskets, manifolds and valves.

The AFDE was successfully tested in Alaska last winter. Fielding is scheduled for late FY90.

Nuclear Magnetic Resonance

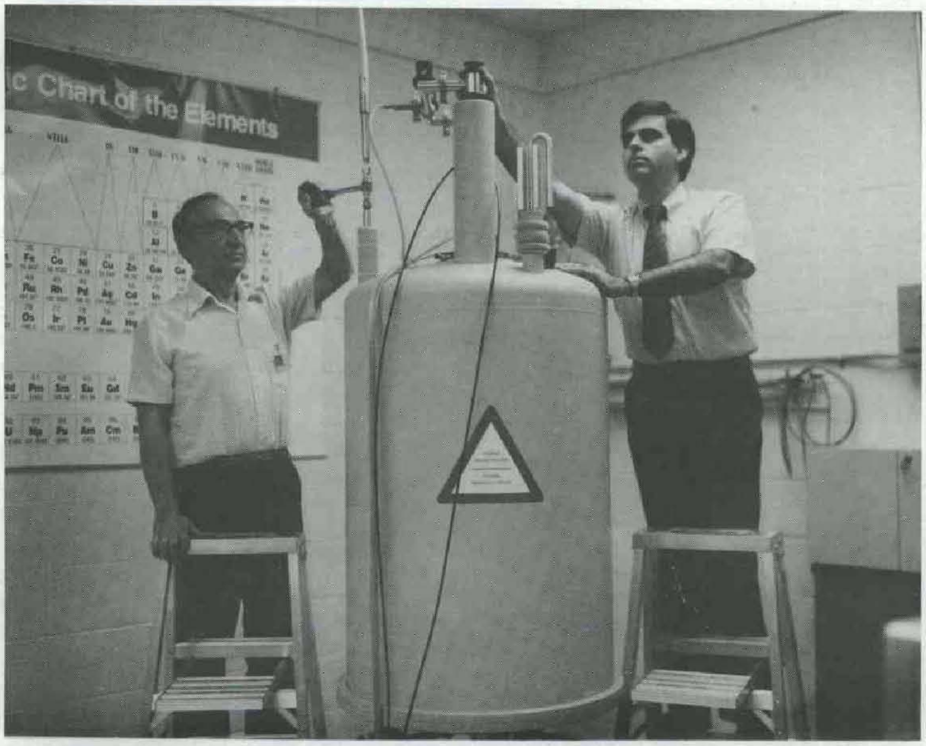
By Hilary J. Winiger

As with much of the work done at the U.S. Army Materials Technology Laboratory (MTL), understanding the structure of materials precedes the selection of which materials to incorporate into military systems. With the increased emphasis on the importance of using ceramics, polymers, and other chemical compounds as the basic materials for our country's defense, scientists are turning to MTL's state-of-the-art equipment to determine which materials will withstand the challenge of protecting our soldiers on the battlefield.

One of the newest and most in-depth means of studying the properties of organic compounds is being conducted in MTL's Materials Characterization Division. Dr. Louis Carreiro, research chemist, and Dr. Paul Sagalyn, research physicist, determine the structure of these compounds through the use of the Nuclear Magnetic Resonance (NMR) Spectrometer, a high strength, high resolution, superconducting magnet.

"Understanding how compounds are 'built' and predicting how to combine them to form new materials," says Carreiro, "can determine how effective they will be in new applications."

The NMR experiment is based on radio frequency (rf) transitions between energy states of magnetic nuclei that have been placed in a magnetic field. Each nucleus experiences a magnetic field strength which is modified by its chemical environment. The purpose of the NMR spectrometer is to measure the distribution of magnetic fields of a sample to determine its molecular structure.



Dr. Paul Sagalyn (left), research physicist, and Dr. Louis Carreiro, research chemist, in MTL's Materials Characterization Division, check to ensure the proper functioning of the superconducting magnet prior to performing an NMR experiment.

At the heart of the NMR is a 4.7 Tesla magnet positioned inside a metal dewar (cylinder). Surrounding the magnet core is a dewar containing liquid helium stabilized at a temperature of minus 452 F. Maintaining this low temperature is necessary to ensure that the solenoid coil (magnet) within the dewar will remain in the superconducting state, allowing current flow without heat dissipation.

In order to determine the structure of a sample, the spectrometer applies strong pulses of radio frequency energy to the material. From the transient response of the nuclear spins, called the Free Induction Decay (FID), the computer in the spectrometer can determine the distribution of magnetic fields for a particular sample. This distribution can be used to determine the molecular structure of the sample; a procedure which, in some cases, may require an elaborate and sophisticated analysis.

Samples are placed inside a "probe" containing a coil which generates rf pulses and detects the FID. Different probes are used depending upon which chemical element is being studied and whether the sample is in the solid or liquid state.

After the receiver detects the FID and sends the signal information to the computer for processing, the results are displayed on a computer screen or plotter in the form of a plot of absorption versus magnetic field (the NMR spectrum).

MTL's spectrometer, called the MSL 200 (Multi-Nuclear Solids and Liquids), is an intricate computer-controlled machine capable of performing a novel, highly sophisticated technique called Magic Angle Spinning which is required for high resolution in solids. This technique requires that a sample be spun on an axis forming a particular angle, 54.7 degrees (the so-called "magic angle"), with respect to the magnetic field. Tremendous spinning speeds are needed, ranging typically as high as 10,000 revolutions per second, which at times may approach the velocity of sound.

Though liquid NMR has been around for the past 25-30 years, the study of solids by high resolution NMR is a relatively new technology. MTL's system is the only one of its kind in the Army — operating since January 1986, yet working on solids only since October 1986.

Located in Watertown, MA, MTL manages and conducts the Army's materials research and development program as designated by the U.S. Army Materiel Command in Alexandria, VA, and the U.S. Army Laboratory Command in Adelphi, MD.

In addressing the Army's materiel needs, MTL is the lead laboratory in structural integrity testing, corrosion prevention and control, materials, materials testing technology, solid mechanics, lightweight armor, and manufacturing testing technology.

During the coming months, Carreiro and Sagalyn will be concentrating their efforts on supporting MTL's three laboratories — Organic Materials, Metals and Ceramics, and Mechanics and Structural Integrity. Analyses will be performed for MTL scientists and engineers on a wide range of materials including polymers, ceramics, metallic alloys and organic compounds.

Presently, NMR is playing a significant role in the characterization of the new class of high temperature ceramic superconductors. The information obtained on these copper-based oxides at the atomic scale is already leading to a better understanding of the mechanism of superconductivity. Prior to this, NMR was an integral part of the M1 Tank Track Pad Program in the analysis of different blends of rubber for their composition.

In addition to spectroscopy work, MTL will be extending its efforts to include NMR imaging, a process whereby materials can be scanned to detect flaws in their structure. This nondestructive technique is capable of detecting such problems as trapped water or leaked fuel which can degrade materials during their lifespan. For the future generation of military equipment, NMR imaging is an important method of assuring a better quality of systems with greater performance and durability for the American soldier.

Up to now, NMR technology has been applied mainly to the petroleum and pharmaceutical industries. Carreiro and Sagalyn are looking forward to making the military an avid user of this new technology by supporting not only MTL's in-house laboratories, but agencies and commands throughout the Department of Defense.

"The importance of high resolution NMR to a materials researcher cannot be underestimated," says Carreiro. "With the knowledge obtained from these experiments, compounds can be analyzed and properties correlated with structures, making it possible to modify structures to meet the requirements of future military systems."

HILARY J. WINIGER is a public affairs specialist at the U.S. Army Materials Technology Laboratory, Watertown, MA.

New Equipment Aids Explosive Ordnance Detachments

The Army has initiated an order to buy 150 protective ensembles for use by Explosive Ordnance Detachments (EOD). This protective system, designed by the U.S. Army Natick Research, Development and Engineering Center, Natick, MA, will give EOD soldiers an edge in safely diffusing small explosive devices favored by terrorists and prevent injuries to the maximum extent possible.

Until now, the Army hasn't had a complete armor system to provide the needed protection for the Explosive Ordnance Disposal technician performing his delicate task of disarming explosives and to prevent, or, at least minimize injury from an accidental explosion.

Consequently, the Armor and Special Project Branch at the Natick RDE Center was tasked to develop state-of-the-art protective equipment that would provide maximum protection yet be light weight, flexible and create no unnecessary encumbrance problems.

After an evaluation of foreign and domestic EOD equipment and user input, the new system was developed.

Stan Waclawik, chief of the Armor Section, states that "Our system offers the best protection possible without sacrificing flexibility and visibility and without the extra burden of completely encapsulating the technician. By keeping the design simple, we have provided a comfortable, functional safe suit."

The Natick suit is made of KEVLAR, a tough synthetic fiber woven into a durable, strong fabric that, pound for pound, is twice as strong as steel. The outer shell is made out of fire retardant NOMEX, which is light but durable.

For head protection, the new PASGT helmet is used and reinforced with a bonnet that contains 12 extra layers of KEVLAR. A great deal of consideration was given to head protection, not only from a ballistic point of view, but as to weight and heat stress. Comfort is a prime concern. The chest plate and face shield are designed as one piece. The face shield is made of a polycarbonate and acrylic material, mounted on a form-fitted fiber glass chest plate that is inserted in the chest pocket of the protective jacket. For added protection, ballistic eye wear is also worn.

The Army Ordnance Missile and Munitions Center and School at Redstone Arsenal, AL, the training facility for all U.S. Explosive Ordnance Disposal technicians, is now using the Natick developed suit for training exercises.

Several local, state and federal law enforcement agencies are using the Natick suit on lease agreement. These include the Defense Intelligence Agency, the FBI and the Massachusetts State Police. The Connecticut State Police and other law enforcement departments in the U.S. have indicated they plan to purchase this protective equipment.

"We've had the Natick ensemble on loan for more than a year, and, found that not only does the suit protect, but it's comfortable and doesn't restrict movement. One veteran EOD technician wore the suit for several hours on a detail and had no complaints," said police SGT Robert Malloy, head of the EOD unit, Boston Police Department, Boston, MA.

Career Development Update . . .

Research Opportunities With the Arroyo Center

Craig Baker and LTC Paul Setcavage

Each year, six Army officers and two Department of the Army civilians are selected to serve as research fellows at the Arroyo Center, the Army's Federally Funded Research and Development Center for studies and analyses.

The Arroyo Center's mission is to provide an independent view of mid- to long-term issues affecting the organization, structure, composition, and policies of the Army. The center is operated as a division of The RAND Corp., a private nonprofit research institution located in Santa Monica, CA.

These officers and civilians contribute to research projects of interest to themselves and the Army; enhance RAND's understanding of Army systems, policies and procedures; and learn from RAND potential ways to improve Army systems throughout their careers. Officers apply through branch channels and civilians apply in response to the U.S. Army Civilian Personnel Center's annual long-term training announcements.

This past year has seen Army fellows involved in a number of extremely interesting projects. Enhancing NATO Conventional Defenses is a joint Army/Air Force project analyzing realistic options NATO could adopt that would effectively raise the nuclear threshold. AirLand Warfare and Deep Operations is helping the Army design and evaluate systems for the conduct of deep operations. Managing the Introduction of New Technology is trying to improve the Army's integration of manpower and training concerns into system acquisition.

Other Arroyo Center projects to which Army fellows have made contributions include: Army Logistics Assessment — Extended, which seeks to enhance simulations to determine the impact of various logistical theater strategies; Improving Combat Capability Through Support Alternatives is assessing the potential warfighting payoffs of radically enhanced transportation and stockage procedures for combat repair parts; Designing Flexible Physician Teams for Wartime seeks to recommend alternative configurations for emergency surgical and medical teams; Improving the viability and survivability of Army fixed sites is the aim of Operability of Fixed Facilities Under Nuclear, Biological, and Chemical Attack; and Enhancing the Effectiveness of Army Family Programs is surveying Army families in an effort to define future needs for family support programs.

The research projects in which Army research fellows are currently involved represent just a sampling of ongoing Arroyo Center research. RAND's research program for the Army now exceeds $15 million per year, involving about 90 professional man-years. The program is divided thematically into five areas: policy and strategy; force deployment and employment; readiness and sustainability; manpower, personnel, and performance; and applied technology.

Up to 25 percent of the Arroyo Center's budget can be used for exploratory research. When exploratory research results in a promising project, the Arroyo Center staffs seek an appropriate Army study sponsor. All center research projects are sponsored by general officers or Senior Executive Service civilians. Such sponsorship helps assure high visibility for the research findings and their policy implications.

Management of the Arroyo Center is governed by Army Regulation 5-21. The Army provides additional guidance and oversight through the Arroyo Center Policy Committee. The committee is co-chaired by the Army vice chief of staff and the assistant secretary for research, development and acquisition and includes the commanding generals of the Training and Doctrine Command and the Army Materiel Command as well as the deputy chief of staff for operations and plans.

RAND has been the setting for the Arroyo Center since 1984. Formerly the Arroyo Center was operated by the Jet Propulsion Laboratory of the California Institute of Technology. Since 1948, RAND has conducted research and analysis on matters affecting the nation's security and domestic welfare, and regularly conducts studies for the defense agencies and other services as well as for the Army. In addition to the Arroyo Center, it houses two other Federally Funded R&D Centers, Project AIR FORCE (for USAF) and the National Defense Research Institute (for OSD). When appropriate, the three national security Federally Funded R&D Centers conduct joint projects or draw on common methodologies and data bases.

As the Army's only Federally Funded R&D Center, the Arroyo Center provides a unique perspective on Army issues. Because it is "in the family," but not "in house," it can conduct its research in close interaction with the Army without sacrificing objectivity or independence. Its Army research fellows play a central role in this interac-

RAND/Arroyo Center Fellowships

Applications for six military (04/05) and two career civilian (GS/GM 13 or 14) fellowships are being solicited. The tour of duty, with the RAND Corp. in Santa Monica, CA, will be from July 1988 to June 1989. Military officers interested in applying for the fellowships should contact their assignment officers at MILPERCEN for details. Civilians in the 1515 and 346 career programs should contact their career program office. The selection board will convene no later than Jan. 20, 1988. Announcement of selected candidates will be made no later than Jan. 27, 1988. HQDA POC is MAJ Mark Olson at AUTOVON 225-1071 or commercial (202) 695-1071.

tion. While at RAND, they help the center to better understand the issues facing the Army, and contribute their expertise to specific projects. When their fellowship year is over, they can help the Army to apply the lessons of Arroyo Center research. For more information in the Arroyo Center, contact Herb Shukiar at (213) 393-0411.

CRAIG BAKER is chief, Cost Analysis Branch, Comptroller Directorate, White Sands Missile Range, NM. He is currently serving as one of the Army's first Arroyo Center civilians.

LTC PAUL SETCAVAGE is attending the Defense Systems Management College at Fort Belvoir, VA. He co-authored this article during his Arroyo Center fellowship earlier this year.

Belvoir RD&E Center Taps University Resources

The Belvoir Research, Development and Engineering Center has begun an ambitious program to encourage and facilitate increased interaction with academic institutions. Contract negotiations are currently under way with eight leading universities where faculty and graduate students are conducting research in areas of interest to this center.

"The dwindling supply of scientists and engineers is confronting us with an ever-increasing problem and we must find ways to overcome this situation," says Dr. Karl Steinbach, the center's chief scientist.

Current strategy at Belvoir includes active recruiting at university campuses, cooperative student programs, summer faculty employment, regional seminars to solicit support in selected high technology areas, and aggressive training programs designed to keep the workforce in touch with technological advances elsewhere.

"One of our most exciting and promising initiatives is to augment the Belvoir workforce by engaging university research teams in collaborative efforts with our scientists," said Steinbach.

To set up the program, the center established a University Relations Action Group which has already begun discussions with 17 universities throughout the United States. This group relates the center's technical problems to the research interests of established university teams. At first contact, Belvoir's problems have, as a rule, little appeal in the academic community. However, once the underlying research issues are explained, the faculty's interest may be aroused. The next step then may be a commitment to assign graduate work in areas of mutual interest.

A key feature of the program is its emphasis on collaboration, calling for active participation by Belvoir scientists, graduate students and members of the faculty.

"These joint efforts are contracted primarily for the commitment of talent. We do not want to be locked into a narrow course of research early on, i.e., before the team has an opportunity to review past research data, and before a consensus has evolved on critical technical issues. We are, in fact, looking at the universities for support on various aspects of our R&D work, including program formulation, execution and assessments," explains Steinbach.

This university relations initiative is of obvious benefit to both the Belvoir RD&E Center in fulfilling its Army mission and the university in meeting its educational and basic research functions.

"My view is that the best education for students at the PhD level would be to have them doing research on real problems, not something completely generated within the 'ivory tower.' I have found that by working on real problems, excellent basic science is the result," said Professor Bernard Widrow of Stanford.

Through this program, students will indeed be provided with real-world problems, together with financial support. At the same time, the Belvoir RD&E Center obtains the services of these talented, highly-motivated individuals during some of their most productive years.

One only needs to add to this equation the benefits derived from faculty supervision, opportunities for professional development of center employees, the likely influx of new ideas and the direct access to some of the best minds and facilities in the United States, to conclude that this program is an all-win proposition.

ARO Technical Note:

Supercritical Fluids

By Dr. Robert W. Shaw

The Army's potential uses for powerful solvents range from demilitarization of chemical and explosive munitions to the development of new high-strength, light-weight materials.

An ideal demilitarization solvent would allow the contents of a munition to be dissolved safely and the various ingredients to be separated and recovered for re-use. If the ingredients were dangerous and no longer useful, the ideal solvent would promote the reaction of those ingredients to harmless products.

In materials development, a solvent could be used to dissolve and mix two materials that would not ordinarily combine. The solvent would then be removed and an intimate mixture of materials would remain.

The word "solvent" suggests a liquid used to dissolve some material. Unfortunately, there are no ideal liquid solvents now available to tackle the problems outlined above. If such solvents were developed, it is likely that they would be expensive, difficult to handle, and toxic.

Usually, we do not think of gases as solvents and, under normal conditions of temperature and pressure, most common gases are not very effective at dissolving materials and would not be useful for the problems we have been discussing. At very high pressures, however, gases become very dense, approaching the densities of liquids, and they can become very effective solvents. Roughly speaking, very dense gases are stronger solvents than liquids because of the much greater freedom of molecular motion in a gas.

Imagine that we have a sample of gas at some temperature and we want to compress it to increase its density and dissolving power. We can only compress it until the pressure of the gas equals its vapor pressure at that temperature. At that point the gas will begin to condense into a liquid. If we raise the temperature of the gas, its vapor pressure will be higher and we can compress it further before condensation begins. If we continue to raise the temperature, we will eventually reach a point where the gas will not condense into a liquid no matter how much we compress it, no matter how dense it becomes. This point is called the "CRITICAL TEMPERATURE" and "SUPERCRITICAL FLUIDS" refers to gases above this temperature.

The properties of supercritical fluids were discovered over a century ago, but the high pressures of supercritical fluids made them difficult to use until the last 10 years when vessels and pumps able to handle high pressures became commercially available.

Now, scientists and engineers are rapidly developing applications for supercritical fluids both in the laboratory and on large scale for commercial products. These uses include reactive destruction of hazardous wastes, separations and analyses of complicated mixtures, and production of new materials.

The chemical industry is pursuing the use of supercritical fluids for destruction of toxic chemical wastes. Extensive testing and development of supercritical water has already been carried out and a demonstration unit has been built that is capable of oxidizing a broad range of hazardous chemicals. Because this process operates at much lower temperatures and is enclosed, it is likely to be safer than burning of chemical wastes and economic analyses indicate that destruction using supercritical water is also cheaper than incineration. This technology could be adapted to demilitarization of chemical and explosive munitions and to environmental cleanup, including soil, around munition storage and production areas.

Commercial extraction of ingredients from complicated mixtures is now proceeding on a large scale; one of the major suppliers of instant coffee is using supercritical carbon dioxide to remove caffeine from coffee. This process, which is cost effective, has the additional advantage that no toxic solvent residue remains in the coffee.

Supercritical fluid extraction may also be useful in military problems: separation of chemical agents from thickeners for subsequent analysis or decontamination, separation of valuable ingredients from faulty munitions.

Use of supercritical fluids in materials processing has not yet had wide commercial application although they have been used in production of single crystals and fine powders. Research, however, has shown that solutions of materials in supercritical fluids can produce powders, fibers, and thin films, depending on experimental conditions.

Because of their great dissolving power, supercritical fluids can be used to mix materials at lower temperatures than other methods; this may permit safer processing of thermally unstable materials such as explosives and propellants.

The Army has already been supporting research on analysis of complex samples and on materials processing using supercritical fluids through the contract programs at the Army Research Office and at the Chemical Research, Development and Engineering Center. One of the most important accomplishments of this work has been the analytical separation and detection of mixtures of tricothecenes — important biological toxins.

The Navy has been supporting supercritical fluid research for fuel clean-up and hazardous waste destruction. In May of 1987 the Army Research Office and the Office of Naval Research sponsored a workshop on DOD Applications of Supercritical Fluids. Experts in supercritical fluid research came from universities, industry, and national laboratories. Army research workers came from the Ballistic Research Lab, the Armaments Research Development and Engineering Center at Dover, NJ, the Natick Research, Development and Engineering Center, the Missile Command, and the Army Medical Research Institute of Infectious Diseases.

Discussions at the workshop centered around the topics: separations in supercritical fluids, reactions in supercritical fluids, materials production from solutions in supercritical fluids, and chemical analysis using supercritical fluids. Presentations ranged from fundamental studies of the kinetics of chemical reactions in supercritical fluids to development of reactors for destroying hazardous torpedo fuel wastes. After two days of presentations and discussion, participants divided into groups to develop recommendations for research on supercritical fluids to support DOD needs. Those recommendations and summaries of the discussions and research presentations will soon be issued as an Army Research Office technical report.

Because of the extreme demands of the Army mission, problems such as hazardous waste destruction and materials processing are more demanding than corresponding problems in the civilian sector. These and other problems may be solved by the remarkable supercritical fluids.

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

Cadets Solve Real World Problems

Cadet John Duhamel recently spent five weeks at the U.S. Army Materials Technology Laboratory (MTL), Watertown, MA, working in the dramatically expanding field of high-temperature superconductivity. Until very recently, superconductivity was possible only under conditions of extreme cold, making the process very expensive and therefore basically unfeasible. In conjunction with MTL staff experts William Spurgeon, Dr. Gary Vezzoli and 2LT Richard Benfer, Duhamel endeavored, as many top scientists throughout the world have been doing, to facilitate superconductivity at higher temperatures.

In all, eight cadets from the U.S. Military Academy (USMA), West Point, NY, spent the early part of the summer at MTL participating in the MTL/USMA Summer Research Program. In addition to Duhamel's superconductivity project, their research activities included developing a finance and accounting system for laboratories, fabrication and testing of composites, ultrasonic nondestructive testing, and various other materials analysis research.

The most important goal of the program is, according to Dr. Thomas Hynes, MTL's director of technology planning and management, "making the officer community aware of what's available in R&D (research and development) to solve material problems. Hopefully when [the cadets] return, they'll have a better appreciation for what we do."

Hynes' hope seems to have been realized. Cadet Dan Olexio said he learned a lot during the relatively brief period of time he spent at MTL. He learned about metallurgy and microstructure, but the most important thing he felt he learned was just how important materials research is. He says that as a future field officer he will be far less likely to complain about equipment now that he understands the detail that goes into the research and development of each small part of that equipment. "So much work goes into these things," he said, "right down to a single nut or bolt." Olexio, a mechanical engineering major at USMA, was so impressed that he is strongly considering altering his senior year course load to include some materials classes.

Although the cadets certainly acquire much knowledge, the research program is more than a mere training exercise. This cooperative effort yields mutual dividends. MTL Deputy Director/Commander MAJ Melvin Adams said MTL received "a rather extensive gain" from having the cadets on board. Hynes agreed, saying that in most cases the cadets were able to lend valuable assistance to MTL researchers.

One cadet, Robert Fabrizzio, who was stationed in MTL's Nondestructive Testing (NDT) Division, helped out by writing a computer program which allows for calculation, tabulation and printing of certain mechanical property characterizations. MTL acting NDT Division Chief Robert Brockelman, under whose tutelage Fabrizzio worked, said, "The program is versatile and very user friendly." He also stressed that, although the program had to be written in a computer language Fabrizzio had not previously used (Pascal), the task was accomplished quickly and with little assistance.

"The program will also serve as a resource for the physics department at USMA," Brockelman said. He believes that most of the "expertise" Fabrizzio acquired at MTL will be transferable to West Point and that eventually some of the research that MTL does not have the human resources to accomplish may be conducted at USMA.

Maintaining this contact with USMA is very important, according to Hynes. "Contact with the West Point instructors allows us to get a view of the kinds of problems young officers know a lot about," he said.

The major benefit for the cadets, Hynes says, is "hands-on experience." Cadet Garth Conner, who undertook an ambitious project to develop a centralized finance and accounting system for laboratories, could not agree more. "Real-world problem solving was my biggest gain," he said. Conner emphasized the contrast between the structured classroom environment at USMA and the less rigid, but also less secure, lab setting, where he was given a problem and tasked with solving it with very little guidance.

The cadets also learned about the unifying link that binds the soldier and the researcher. Cadet Shawn Penning, who was placed in MTL's Mechanics and Structural Integrity Laboratory, said, "My five-week experience at MTL was helpful in that it furthered my knowledge of computer science as well as demonstrated the link between those who research and develop the Army's technology and those who use that technology in defense of the nation."

The cadets were given tours of MTL and the Natick Research, Development and Engineering Center in Natick, MA, when they first arrived, and some were overwhelmed from that point on. Referring to the tours, Conners said with a smile, "I learned that [research, development, testing and evaluation] is a very long process."

From all involved, the research program was a success. Olexio, for one, called the experience extremely positive and said that he would love to return to MTL for another stint. "The things that I learned here are far more important than anything else I could have done this summer," he said.

From Industry . . .

The M1A1 Multiyear . . . Challenge and Benefit

By Michael W. Wynne

Overview

On May 29, 1987, General Dynamics Land Systems Division and the Army Tank-Automotive Command (TACOM) reached a definitive agreement on a four year multiyear contract for delivery of M1A1 Main Battle Tanks. The agreement met certain guidelines dictated by Congress, the most prominent of which was a requirement to demonstrate at least a 10 percent savings to the government when compared to single year procurements.

As profits on previous tank contracts rarely achieved 10 percent, this requirement essentially challenged General Dynamics to either forgo earnings or identify and implement sufficient cost saving actions to earn them back.

The opportunities afforded by a long-term, four-year procurement provided the incentives that General Dynamics management found acceptable to pursue the procurement. This article provides insight into the procurement process and opportunities afforded by this multiyear contract.

Background

The multiyear procurement concept is founded on the principal that buying large quantities over an extended period will encourage a planning and investment environment similar to the commercial sector and, therefore, will result in significant savings when compared to the usual annual procurement process for major weapon systems. However, because the multiyear procurement establishes the rate of delivery allowing manufacturing planning, it represents a significant commitment of future resources by the buying agency, the U.S. Army, and places a demand on the budget cycle that the planned delivery rate be satisfied in outyear funding. This commitment is not only true for the prime manufacturer, but also for the associated equipment (powerpack, track, fire control), which is supplied by the U.S. Army and constitutes approximately 50 percent of the tank end value.

Thus, the commitment of resources goes beyond the value of the prime contract in a significant way. Realizing the magnitude of this commitment, the Congress established certain criteria for multiyear candidates.

The most important of these criteria is the benefit to the government, but the criteria also addresses stability of the weapon requirement and maturity of the production; both of which were positively responded to with the M1A1 Main Battle Tank. The benefit to the government is addressed below.

Motivation of the Buyer

What motivates the buyer to consider the multiyear procurement for a weapon system like the M1A1? Clearly, the most dominant factor in the decision process is the savings which can be realized. The savings on such a major procurement item could provide the opportunity to either invest in other systems or to meet ever-stiffening budgeting targets. In this particular instance, savings from the prime contract alone approach $400 million.

Including the additional savings from the multiyear procurement strategy on the associated equipment, the projected total weapon system savings are well in excess of a half billion dollars. So again, clearly economics is the dominant factor.

However, there are other motivating factors. For the Army, stabilizing the rate of delivery and establishing the values for several procurement periods is of great assistance in planning budgets, training and fielding requirements, and the overall logistics efforts associated with the planned force structure.

Motivations of the Seller

The other side of the motivation equation is what motivates a seller to offer, at essentially a discount, a best selling product like the M1A1 Main Battle Tank in return for an extended procurement span of four years? While there appears to be no competition for the M1A1 Main Battle Tank, the perspective must be broadened. In fact, there is competition for programs in general and scarce budget resources. Competition on a single product does not sufficiently define the broader perspective and requirement for the best product at the best price.

The recognition of the competition for utility to the U.S. Army, succinctly described at an Atlanta Conference by GEN Richard Thompson, former commander of the Army Materiel Command, as a desire by AMC "...to get the Best Buy for the Buck," is the dominate driving motivator for industry. This was recognized by General Dynamics, but a tempering skepticism of whether the savings challenge could be met. To meet this objective, a series of reviews and planning sessions were created and the Multiyear Steering Committee was formed by General Dynamics Land Systems Division.

The committee found, as had the Army, that there are other motivating and enabling factors to be considered. A stable delivery plan means a stable planning period for capital investment. It also means stable manufacturing planning and procurement to a long range schedule.

Multiyear Process

With both the U.S. Army and General Dynamics willing to analyze the multiyear and determine its advantages, the process for implementing the multiyear began in earnest. Realizing that this would require a sustaining commitment on the part of Congress to achieve the stable deliveries over the contemplated four year period, Congress was approached with a recommendation that the Army be authorized to enter a multiyear contract if the analysis proved it to be beneficial. The Congressional response is shown below:

"The Committee has consistently supported multiyear contracts as a means to achieve program savings and stability. In view of the success of previous multiyear contracts the Committee recommends approval of the administration's request to enter multiyear obligations for the M1A1 tank provided that actual savings meet or exceed 10 percent." — Senate Armed Services Committee Report, April 29, 1985

"The committee recommends authorization for the Secretary of the Army to enter a Multiyear contract for the procurement of M1 Abrams chassis and subsystems, providing that the Multiyear contract offers no less than 10 percent savings when compared with annual contracts." — House Armed Services Committee Report, May 10, 1985

The specificity of a 10 percent goal had not been mandated previously and, despite the initial satisfaction of gaining the sought after conditional authorization, both sides wondered how to meet the now-mandated savings criteria.

Savings Thrust

To achieve the Congressionally mandated savings criteria required very aggressive actions including creative approaches within the supplier base as well as within the company itself. The more significant actions taken were as follows:

- Long-Term Capital Planning was possible for General Dynamics Land Systems and its suppliers now that four years of sales could be used to justify the purchase of major productive equipment. The multiyear procurement also became a means to modernize production tooling — again at a savings to the government.
- Manufacturing Productivity Improvement programs were initiated and funding by General Dynamics. A special steering committee examined a list of over 100 productivity improvement programs. Based on an extensive matrix evaluation of technical, financial, and timing parameters to fit the multiyear period, 30 "best" projects were selected by the committee.
- Economic Order Quantity Funding Requirements that directly drive major supplier savings through volume leveraged material buys were identified. This funding was a fundamental element of the multiyear savings.
- A Component Clustering approach was developed to allow suppliers to bid on several similar components as a group and thereby maximize savings through economies of scale.
- New Supplier Evaluation and Qualification were emphasized to attract more efficient companies and thereby enrich the supplier base. Smaller sized annual orders failed to attract many of these firms during previous procurements.
- Winner-Take-All Competitions for selected components that were previously multiple sourced items were used to increase the attractiveness of supporting the M1 program and to encourage a more efficient production base.

Due to the timing of the multiyear initiative, many of the savings elements had to be implemented well in advance of the definitive agreement. As a result, the requirement for options and alternatives in the procurement and the capital investment arena were enormous.

The multiyear encompassed FY86 through FY90, spanning a first order to final delivery period of May 1985 through September 1991, including the option quantity of 299 vehicles. The time span dictated commitment of capital in a timely manner as if a multiyear procurement was the only outcome, by both General Dynamics Land Systems as well as suppliers. Although penalties would be involved, this proved to be a risky, but rewarding, investment.

Supplier conferences were very complex. Some training, some cajoling, and some hard fought winner-take-all competitions were the order of the day. With the bulk of the supplier base consisting of medium to small manufacturers, General Dynamics had to be careful to explain the requirements and, in some cases, advise suppliers on how to generate the substantial savings through enhanced production processes, capital investment planning, and optimized production runs.

Conclusion

On May 29, a press release said in part: "The U.S. Army Tank-Automotive Command (TACOM) announced today that the General Dynamics Land Systems Division has received the largest multiyear contract ever awarded by TACOM for up to 3,299 M1A1 Abrams tanks to be delivered over the next four years."

Sponsored by the TACOM program manager, General Peter McVey, a press conference and short reception celebration was held at the Detroit Arsenal Tank Plant. Said McVey: "We met the (Multiyear) goal and exceeded it. The (Abrams) tank is the centerpiece on the battlefield."

It's important to review what was celebrated. First and foremost, the government and, ultimately, the taxpayers are winners. Savings of more than 10 percent are guaranteed to the Army. More bang for the buck supports critical Army goals to effectively field modern weapon systems to meet the worldwide threat. In addition, multiyear encourages the modernization of production facilities at both the prime and subcontractor level, providing a solid base for production of high quality, least cost next generation weapon systems.

Industry also wins, especially with the efficiencies that long-term stable production provides. In fact, with internal stability and a stronger vendor base, these efficiencies translate into strategic, competitive advantages. In this case, the General Dynamics team has reinforced itself as a low cost/high quality producer of combat vehicles. That remains an important continuing objective.

So what happens next? Multiyear procurement of the M1 tank will provide the base for production of future combat vehicles. Recent testimony before Congress indicates that the Authorized Acquisition Objective (AAO) for modern tanks should increase to over 12,000 vehicles.

If the AAO is increased, the Army and Congress should be encouraged to purchase the remaining tanks using the same philosophy. For the savings quality and modernized production base benefits to continue, the multiyear philosophy for procurement of Main Battle Tanks also must continue.

General Dynamics Land Systems Division is already preparing a plan for the next round of investments and further innovative procurement approaches in anticipation of offering a follow-on multiyear contract to extend the savings and encourage the U.S. Army to buy and field the world's finest Main Battle Tank — the M1A1.

MICHAEL W. WYNNE is vice president of marketing for General Dynamics Land Systems Division. He holds a B.S. degree from the U.S. Military Academy, an M.S. degree in electrical engineering from the Air Force Institute of Technology, and an M.B.A. from the University of Colorado.

From the Field . . .

Technician's Solo Effort Pays Off Big

The Atmospheric Sciences Laboratory (ASL) boasts one of the world's few fully automated wind tunnel test facilities. A wind sensor now can be tested and calibrated in the tunnel in just nine minutes, versus three hours before automation. Accuracy of measurement has also improved dramatically.

"We have less than a two percent margin of error," said Joe A. McHam. "We now have a far superior calibration standard than we've ever had before." McHam should know. An electronic technician, he single-handedly automated the tunnel in just nine months. What is more, because McHam used surplus computer equipment and wrote his own software programs, the total conversion effort cost less than $13,000.

"I'm a frustrated engineer," said McHam, who has chalked up 70 hours of college credits in computer electrical engineering and math. "We had to change to a new control system, but the system lent itself very easily to automation. It took a couple of months to write the program."

In May of 1985, McHam evolved the idea to automate the tunnel. At the time, he served as chief of ASL's Meteorological Instrumentation Support Section.

Although he no longer works in the tunnel, McHam uses it on a regular basis to assess the accuracy of his own instruments. "Calibration verifies that an instrument is within tolerance," he said. "The tunnel now has the capability to test 12,000 wind sensoring devices a year. Presently, demand is 2,000 a year."

McHam stands ready to hand out advice on automating wind tunnels. "Every university physics department has some sort of wind facility," he said. "I'd be willing to consult with them on automation." McHam can be reached on AUTOVON 349-9630 or commercial 505-678-2096.

For his novel idea and many hours of extra effort, McHam earned a $475 award. Today he works for Thomas H. Pries in the Atmospheric Technology and Applications Division and helps to maintain the Surface Atmospheric Measurement System.

Capsules . . .

Army Names Top R&D Center of the Year

The U.S. Army has named the Armament Research, Development and Engineering Center (ARDEC), at Picatinny Arsenal, the winner of its 1986 Center of the Year Award.

BG Richard D. Beltson, then ARDEC commander, received word of the prestigious award from Dr. J. R. Sculley, assistant secretary of Army for research, development and acquisition.

In his letter, Sculley congratulated Beltson and cited ARDEC as "one of our nation's best." Sculley said this distinction is based upon ARDEC's "collective outstanding achievement with respect to Technical Accomplishments, Management Initiatives, Program Content, Human Resources Management, and Fiscal Management."

The Center of the Year Award is presented annually to the research and development organization that has demonstrated an exceptional degree of excellence in the areas mentioned above.

All Army R&D centers and laboratories, as well as those within the Corps of Engineers and the Office of the Surgeon General, that perform research and development work and are more than 50 percent funded by the Army research, development, test and evaluation appropriation, are eligible for the award.

Being recognized as the Army's top R&D center was no easy feat. In 1985, ARDEC placed 14 out of 18. Consequently, ARDEC had much work to do. ARDEC's most important strategy was to employ the combined talents and efforts of the entire ARDEC team.

In a nomination packet submitted for the award, ARDEC highlighted 1986 programs in the following areas:

- ARDEC type classified 32 items and fielded 14 others. Type classifications and the fielding of highly effective armament systems are considered the ultimate measures of success.
- ARDEC advanced major, new armament concepts such as: smart artillery systems; anti-armor initiatives; advanced artillery systems; lethal mechanisms; and new, more powerful explosives.
- The center moved several technology based concepts into full scale engineering. Among these were the Sense and Destroy Armor munition and Low Vulnerability Ammunition.
- ARDEC greatly increased productive collaboration with other agencies, including the users — those groups that use ARDEC products such as the U.S. Army Forces Command; U.S. Army Training and Doctrine Command; U.S. Army Laboratory Command; other Army centers; and industry.
- ARDEC initiated a number of novel management actions. These included institution of a Technical Director's Advisory Group; periodic commander and contractor reviews; and establishment of a Center for Energetic Materials in cooperation with the National Science Foundation.
- Finally, ARDEC developed and implemented innovative training programs and emphasized the recognition of employee accomplishments. In addition, many ARDEC employees won high-level awards for technical and scientific accomplishments, participated in fellowship and exchange programs of various types, and published numerous scientific and technical articles.

Conferences & Symposia . . .

Upcoming Conferences

- First International Seminar on Organic Matrix Composites for Structures, Feb. 15-19, 1988, Ocean Resort Hotel and Conference Center, Deerfield Beach, FL. Registration, exhibit, or detailed program information: Shawmco, Inc., 4227 East 99th Street, Tulsa, OK 74137, (918) 299-7483.
- Armed Forces Communications and Electronics Association (Kansas City Chapter) Fifth Annual Symposium and Technology Display, Dec. 1-3, 1987, Officers Club, Fort Leavenworth, KS. Additional information: Patricia Robbins, c/o Kansas City Chapter of AFCEA, P.O. Box 456, Leavenworth, KS 66048, (913) 651-7800.
- National Conference on Strategic R&D, June 14-16, 1988, Arlington, VA. Additional information: STRATRAD Staff, AIAA, 370 L'Enfant Promenade, S.W., Washington, DC 20024, (202) 646-7452.

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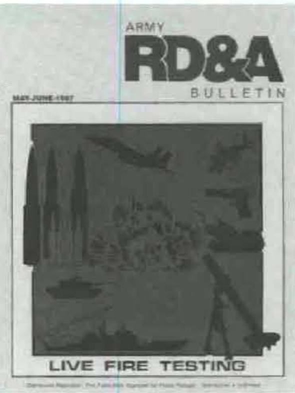

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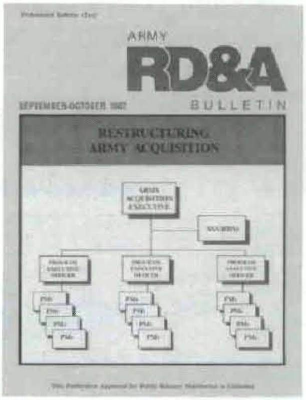

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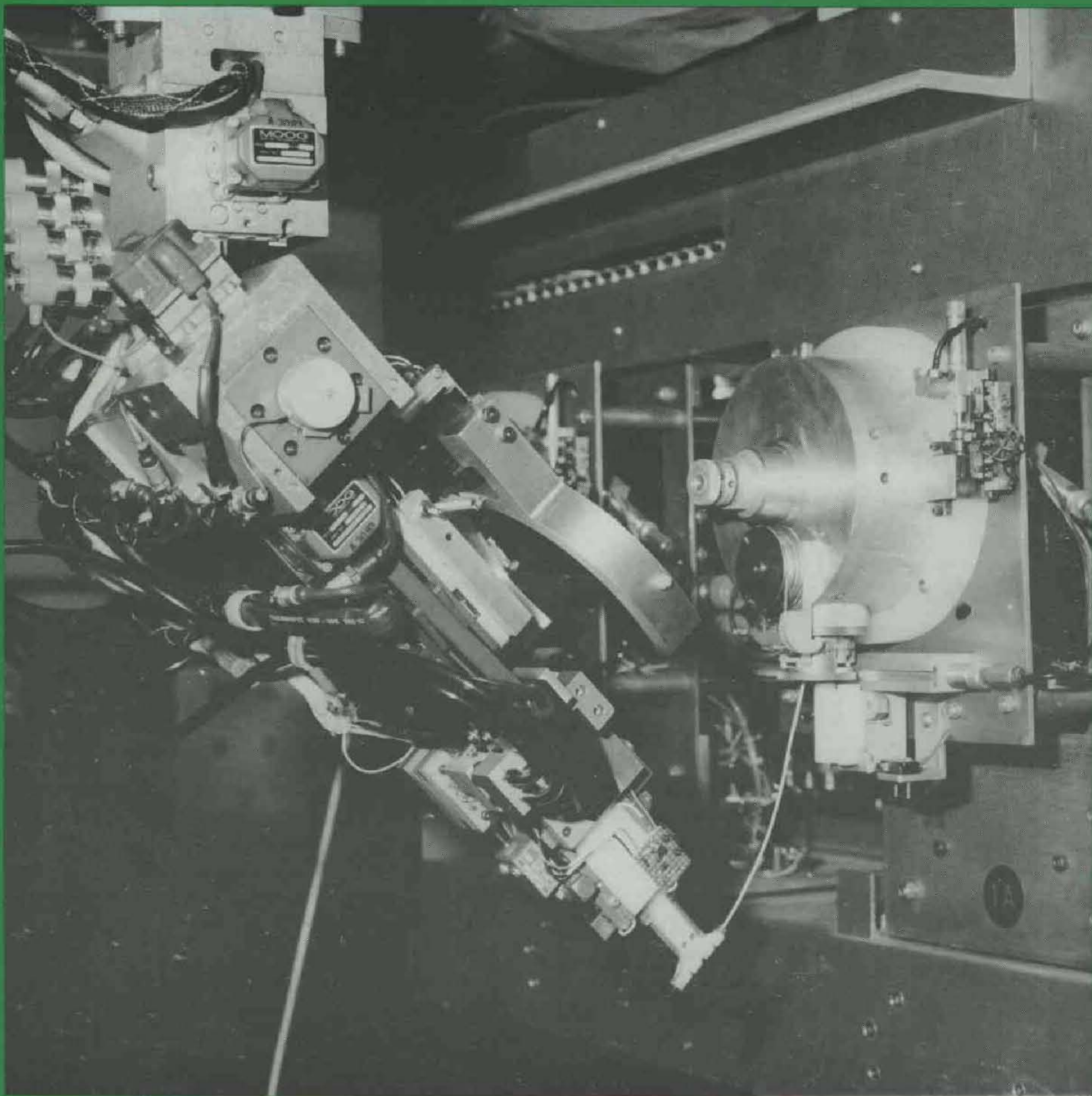

R&D ACHIEVEMENTS