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ARMY RD&A BULLETIN

The Copernicus Syndrome...

...Rethinking the Acquisition Process

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Development
Acquisition

RD&A

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NOVEMBER-DECEMBER 1989

PROFESSIONAL BULLETIN OF THE RDA COMMUNITY

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

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FEATURES

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ABOUT THE COVER

The illustration of Nicolai Copernicus on the front cover relates to an article calling for some new approaches to the acquisition process. The back cover is associated with an article on the Army's annual R&D Achievement Awards. Cover prepared by Joe Day, HQ AMC Graphics Branch.

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THE COPERNICUS SYNDROME

Writers of requirements need to be knowledgeable of systems technology

By COL W. H. Freestone Jr.

Background — The Technology Lag

One of the hottest topics in the defense acquisition business today concerns the application of advanced technology products to user systems. To be more specific, electronic components. When one reads about advanced technology, for the most part, the real action is in the world of electronic devices because of their improving capabilities.

In the June 8, 1989 issue of the *Christian Science Monitor*, an article entitled Pentagon Arms Suffer From High-Tech Gap points out that "the new B-2 Stealth Bomber and the SSN-21 Seawolf Submarine are chockful of high technology." Yet these symbols of U.S. industrial capability reportedly have computer chips in key spots that are said to be todays "run-of-the-mill, not state-of-the-art" products.

Non-Developmental Procurement

To alleviate the problem, lately, there has been considerable support for non-developmental item (NDI) procurement as a means of overcoming the electronic technology lag in DOD system development. Another parallel concept is commercial off-the-shelf (COTS) purchases. Both of these acquisition methods sound like a sensible way to deal with the problem of system obsolescence, while at the same time saving money, since off-the-shelf purchases would tend to provide opportunities for volume purchase of any products that already exist.

In many cases NDI/COTS is the best acquisition method. Is there anything wrong with this as a total approach? The answer, simply stated, is that one cannot purchase everything "off-the-shelf" in order to win a war. The reason obviously is that all parties to a potential conflict might have the same opportunity for weapon system development. Also, one must consider what is available for purchase off-the-shelf.

In the world of military electronics, the opportunities are found primarily in the support (tail) areas i.e.; radios, telephones, computers, trucks, etc. Therefore, applying the NDI/COTS philosophy to the purchase of "commercially available" combat (tooth) systems might result in no battlefield advantage to either side of a potential conflict except in total numbers of systems.

The Bureaucracy

In the process of trying to develop appropriate new fighting capabilities, the U.S. military establishment must deal with regulations that govern acquisition. With respect to the technology lag problem, some in the government say the peacetime procurement process is too complicated. Industry, on the other hand, says the basic problem is that government over specifies its requirements. There might be some truth to this charge, in selective cases. Those making that claim, however, assume that all manufacturers work to the same standards.

Industry's Role

The current rules of acquisition require that the military or user community write a "performance" oriented requirement statement. That statement, known as the Required Operational Capability (ROC), drives the entire acquisition process. How the ROC is written determines what industry will deliver.

Conventional practice says in writing a ROC one should not tell the manufacturing community how to build the needed item. The writer of a ROC is

The current center of the acquisition universe is backwards. The true center of the acquisition universe is the user.

requested to provide only a general explanation of a needed capability. The regulations provide that a weapon manufacturer should be allowed to decide what is the best technical approach.

In the final analysis, it is the manufacturer who selects the technology that eventually winds up in the delivered system, based on price competition. The only parameters measured by government regulation are cost, schedule, operational performance, and integrated logistics support. This does not mean that individual project/product managers do not enter into a dialogue on the effect technology has on the technical performance of their system.

In some cases, considerable influence is wielded by a given manager along the way. Whatever is done with respect to measuring system technical performance and technology, if accomplished at all, is done on an ad-hoc basis.

The Appliance Method of Acquisition

In view of the fact there is nothing in the current acquisition process that measures system technical performance, a comparison may be made between the purchase of an appliance and the acquisition of a weapon system. For example, if the lady of a particular household writes a performance oriented ROC, based on a desired capability in the kitchen, it might go something like this: System desired that will cool milk to 40 degrees Fahrenheit, maintain that temperature constant for 30 days, contain 20 cubic feet of internal milk storage space, be human transportable, weigh no more than 300 pounds, be covered by a warranty, and be field repairable, on site (at the home). When the man of this household sets off (as the project manager) for the desired milk cooling system, his interface is with a manufacturer's representative at the local appliance store. Negotiations toward meeting the desired operational capability described in the ROC are focused on system characteristics described in the ROC, and price. Once the model is selected, price is determined and payment method agreed; arrangement for delivery of the milk cooling system is made. A new equipment fielding team, provided by the manufacturer's representative, installs the new system and explains how to operate it.

Within the first 24 hours of operation however, the newly delivered milk cooling system failed, causing the milk to spoil. The lady of the house summoned the project manager to demand an explanation. A repair person was requested. On close examination, the repair person reported that the milk cooling system coolant compressor had failed. The repair person also points out that the compressor was based on an old, no longer used, obsolete design. The project manager quickly returns to the appliance store for an explanation. The store manager points out that compressor obsolescence was never discussed at any point in the purchase negotiation. Not only that, the milk cooling system purchased was "on sale." Unfortunately, it was the real user, with the system in actual field operation, that experienced the effect of a lack of dialogue concerning technical performance of the milk cooling system and its internal components.

Nicolai Copernicus

In the year 1543, an astronomer by the name of Nicolai Copernicus told mankind that the earth is not the true center of the universe. According to the encyclopedia Britannica, mankind on hearing this had considerable difficulty in dealing with the news. For centuries, everyone believed that the earth stood still and the sun revolved around the earth. When it was shown that the reverse is true, and that mankind had previously had the whole thing backwards, it caused a lot of re-thinking and re-education. What has this got to do with technology and the acquisition process?

Today, the acquisition process places the focus for application of technology with the system project manager and his industry counterpart. As with the previous discussion of Copernicus, the current center of the acquisition universe is backwards. The true center of the acquisition universe is the user.

It is the user who writes the required operational capability statement and he or she who ultimately uses what is produced. Yet it is the user, as writer of the ROC, who is not required to know or address anything about the technical performance of a system. From the start, then, there is nothing contained in the acquisition process, by regulation, that is tied to the technology that the acquisition process seeks to acquire.

To understand why this is true, one needs to go back in time to the origins of the current acquisition regulations. Born in the early 60s under the aegis of OMB Circular-109, the current process was founded on the philosophical grounds of price competition, to lower purchase costs, and to strengthen the U.S. industrial base. At the same time, it sought to reduce negative competition among the military services for budgetary dollars.

Interestingly enough, during the same early 60s timeframe, the electronic integrated circuit was just beginning to find its way into military and commercial products. From the early 60s until the present, the electronic integrated circuit has grown by leaps and bounds, while the process that seeks to harness its power remains philosophically frozen in the early 60s.

Thus, the current acquisition process remains primitive in comparison to the technology that it seeks to acquire. What does exist is a continuing expansion of the current empire of obsolescence. This empire is built on the assumption that competing contractors will insure that state-of-the-art electronic components will be a part of weapon system development through a process, for the most part, that leaves the final technology decision up to them.

The Solution

What can be done to change the current regulations to insure that writers of requirements for both new systems and upgrades to existing systems take full advantage of advanced electronic technology? All that one must do is look at the advances in electronic device design and development for the answer. Simply stated, there should be a new element added to the current acquisition process, based on electronic technology advances, called "System Technical Performance." What would be in this new element?

System Technical Performance would include the following:

- A purchase decision made on life cycle cost, rather than current purchase price alone. The reason is that advanced microelectronic devices tend to be much more reliable than older generations of devices, thus lowering the cost of maintaining a system over time.
- A question concerning upward compatibility with succeeding generations of electronic integrated circuits. Computer aided system design today looks to the use of a "hardware description" software language to greatly facilitate a design engineer's job of keeping pace with changes in the evolutionary development of electronic devices. This further reduces costs over the life of a system.
- A question on whether computer aided design/engineering was being used in the development of a system (to capture the design of the system to facilitate future changes). If old manufacturing ways are in use, then the increased cost of obsolete manufacture will continue to be passed on to DOD.
- A question concerning a given systems electronic architecture, as to whether it is being designed to permit/facilitate pre-planned product improvement at a later date. The right electronic architecture will make additions to a system easier once it is in the field. The wrong electronic architecture might mean an entire system must be discarded/replaced to permit an upgrade to take place.
- A question concerning the use of modular construction to reduce the number of internal circuit boards; also to facilitate standardization of printed circuit boards and their maintenance.
- A question concerning the use of built-in-test circuitry to assist in reducing the need for external test equipment and costly test program sets.

Conclusion

Additional questions might be appropriate for inclusion in DOD acquisition process regulations, as might questions concerning the characteristics of other non-electronic technologies. The things to recognize, however, are the simple facts that: current DOD acquisition regulations do not contain provisions to evaluate the effect of applying modern electronic technology to weapon systems; that the electronic technology decision is made principally by the manufacturing community, based primarily on system purchase price; that the current acquisition process is philosophically grounded in the early 60s, at a time when the integrated circuit (as we know it today) did not exist; and, most importantly, that the current regulations insure those individuals who write DOD system requirements are not required to address the internal technical performance of the system they need. As a result, the user probably does not learn what might have been the range of technology possibilities or choices prior to finalizing the ROC. If these observations seem out of step with what you have been led to believe, you could be feeling the effect of The Copernicus Syndrome.

COL W. H. FREESTONE is assigned to the Defense Communications Agency Center for Command, Control and Communications Systems. He is a member of the MAM program, has served as military assistant on a Defense Science Board examining the U.S. semi-conductor industry and has served as military assistant on an Army Science Board examining technology insertion in Army systems. He is a graduate of the Defense Systems Management College and the Army Project Management Course.

ARMY ANNOUNCES RESEARCH AND DEVELOPMENT AWARD RECIPIENTS

Eighty-six Army in-house scientists and engineers have been selected to receive Department of the Army Research and Development Achievement Awards. These awards recognize outstanding achievements that have improved capabilities of the U.S. Army and contributed to the national welfare during 1988.

The achievement awards, which will be presented in coming months in the form of a wall plaque, will honor 45 personnel employed at activities of the U.S. Army Materiel Command, nine assigned to the U.S. Army Corps of Engineers, five employees from an activity of the Office of the Deputy Chief of Staff for Personnel, and 27 employed at activities of the U.S. Army Medical Research and Development Command. Award recipients and their achievements — listed under their employing activities — are as follows:

U.S. Army Materiel Command

• *U.S. Army Armament Research, Development and Engineering Center (ARDEC)*

A team comprised of Dr. Pai-Lien Lu, Dr. Carolyn Westerdahl, Mark Mezger, Bernard Strauss, Anthony Rapko, Joseph Prezelski, John Costello, and Brian Fuchs will be recognized for their work in developing low vulnerability energetic materials for 25mm ammunition. The research team performed a rapid development of technology to provide safer ammunition which will contribute to the increased safety of Army personnel and survivability of weapon systems.

Dr. William P. Dunn will be cited for his contribution to the developing field of hypervelocity impact engineering. Dunn's hypothesis, coupled with a simplified analysis, permits prediction of the size and shape of the hypervelocity impact craters resulting from the impact of spherical projectiles into thick targets. His work will provide design engineers with an accurate assessment of the penetration capability of advanced kinetic energy weapons.

• *U.S. Army Atmospheric Sciences Laboratory*

Dr. Mary Ann Seagraves will be commended for her efforts in developing a tactical decision aid for use on personal computers. This aid will allow the battlefield commander to determine the effects of the weather and environment on the performance of smart weapons and electro-optical devices. Seagraves' work will enable the battlefield commander to more effectively plan the use of his assets and to turn the weather into a tactical advantage.

• *U.S. Army Aviation Systems Command*

Dr. Mark B. Tischler will be honored for his work in collaboration with NASA Ames researchers, for developing, demonstrating, and providing a reliable frequency-domain method for extracting the dynamic characteristics of rotorcraft from flight test data. The analytical and experimental techniques were demonstrated to the U.S. helicopter industry as a way to accurately and reliably measure the bandwidth of a helicopter with its stability and control system active or inactive.

• *U.S. Army Ballistic Research Laboratory*

A team consisting of Dr. Walter F. Morrison, Gloria P. Wren, Paul G. Baer, and Dr. Terence P. Coffee will be awarded for developing theoretical models describing the interior ballistic processes in liquid propellant guns. Their efforts have a major impact on the Army's current and future efforts to develop liquid propellant gun systems.

John N. Groff and Toney R. Perkins will be honored for their technical achievements in systems engineering analysis of the Abrams tank. By developing and using a system simulation code, they have provided a detailed description of the performance of the fire control system against maneuvering targets, and have verified these results through tracking tests.

Dr. Edward M. Schmidt, Dr. Jonathan A. Bornstein, both from BRL, and Theodore N. McCloskey, from Watervliet Arsenal, NY, will receive the award for their efforts in developing a technique to enhance the fall of shot accuracy of the tank fleet. The research team used advanced techniques to measure the extremely short duration events surrounding cannon firing to isolate factors which contribute to inaccuracy. From their analysis of the test results, they developed a modification to the tank cannon manufacturing process which improves consistency of cannon performance and offers the potential of enhanced accuracy within the tank fleet.

A team comprised of Albert W. Horst, Jr., Dr. Thomas C. Minor, Frederick W. Robbins, and Carl R. Ruth will be awarded for their work in developing technologies for improving the propulsion performance of kinetic energy cartridges. The applied research, technology development, and demonstration of principles achieved by this team has already been transferred to applicable military and private sectors involved in the design and manufacture of these types of munitions.

Dr. Steven B. Segletes will be commended for conducting research that

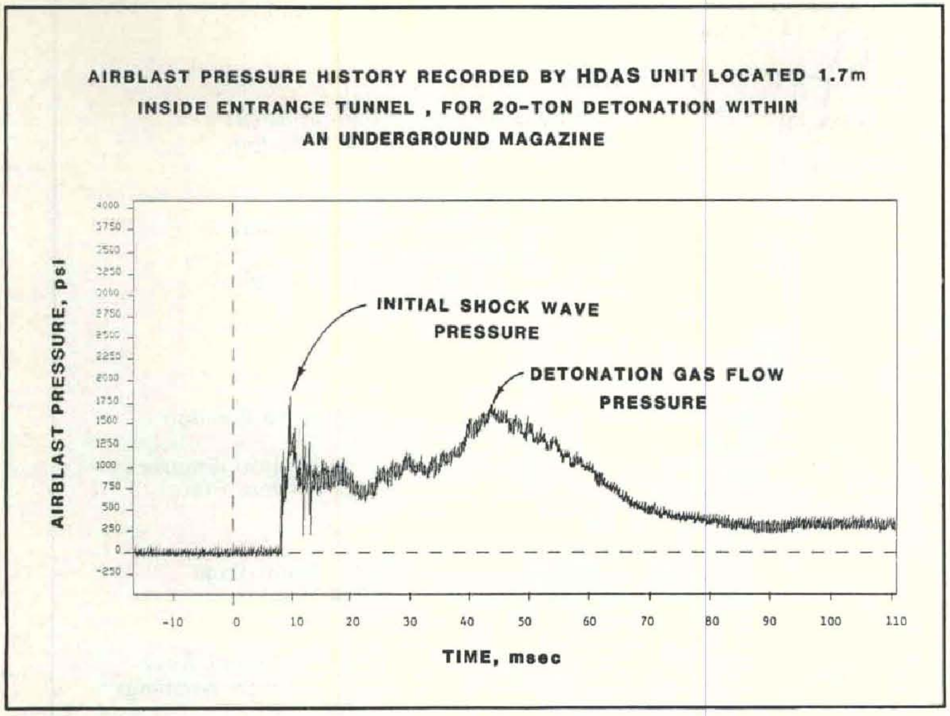


FIGURE 1.
The Hardened Digital Data Acquisition System (HDAS), developed at the U.S. Army Waterways Experiment Station in Vicksburg, MS, is a compact module that can be placed very close to an explosion source for impact testing and uses no external wire connections. Shown to the left is an airblast pressure history as recorded by HDAS.

provides a fundamental theoretical description of the mechanism which induces jet rotation in shaped charge jets formed from metal liners produced by shear-forming. His efforts have made a significant step in the basic understanding of warhead phenomena and provides new guidelines for anti-armor warhead designers.

• U.S. Army Center for Night Vision and Electro-Optics

Mary J. Miller, Gary L. Wood, Dr. William W. Clark III, and Dr. Edward J. Sharp will be recognized for their contributions toward the development of photorefractive materials for protecting the eyes and other sensors against laser radiation. This research will significantly influence the effectiveness of future Army sensor systems when forced to operate in the presence of hostile laser threats on the modern battlefield.

• U.S. Army Chemical Research, Development and Engineering Center

Joseph W. Hovanec and Johnnie M. Albizo will be cited for their studies resulting in a dramatically improved chemical agent decontaminant. The decontaminant has excellent chemical properties and stability while reducing the corrosive effects of current formulations. This accomplishment represents significant progress in the Army's ongoing effort to provide soldiers with the most advanced chemical defense equipment possible.

Dr. Jerold R. Bottiger will be honored for his research accomplishments in the field of aerosol physics. His research in aerosol characterization resulted in pioneering a new generation of light scattering instruments with important applications to military obscurant smokes for screening combat operations and to defend against chemical and biological attack. This effort has advanced the technology in the Army and will also advance fields as diverse as industrial process control, environmental protection and medicine.

Ronald O. Pennsyle will be commended for developing the Dual Binary Non-Uniform Simple Surface Evaporation (DBNUSSE) Model. The DBNUSSE Model is a mathematical model which enhances the Army's ability to analyze the dissemination, transport, diffusion, and deposition of chemical warfare agents produced by the binary chemical process. His work will provide the capability to test and evaluate innovative solutions to extremely difficult problems posed by chemical warfare.

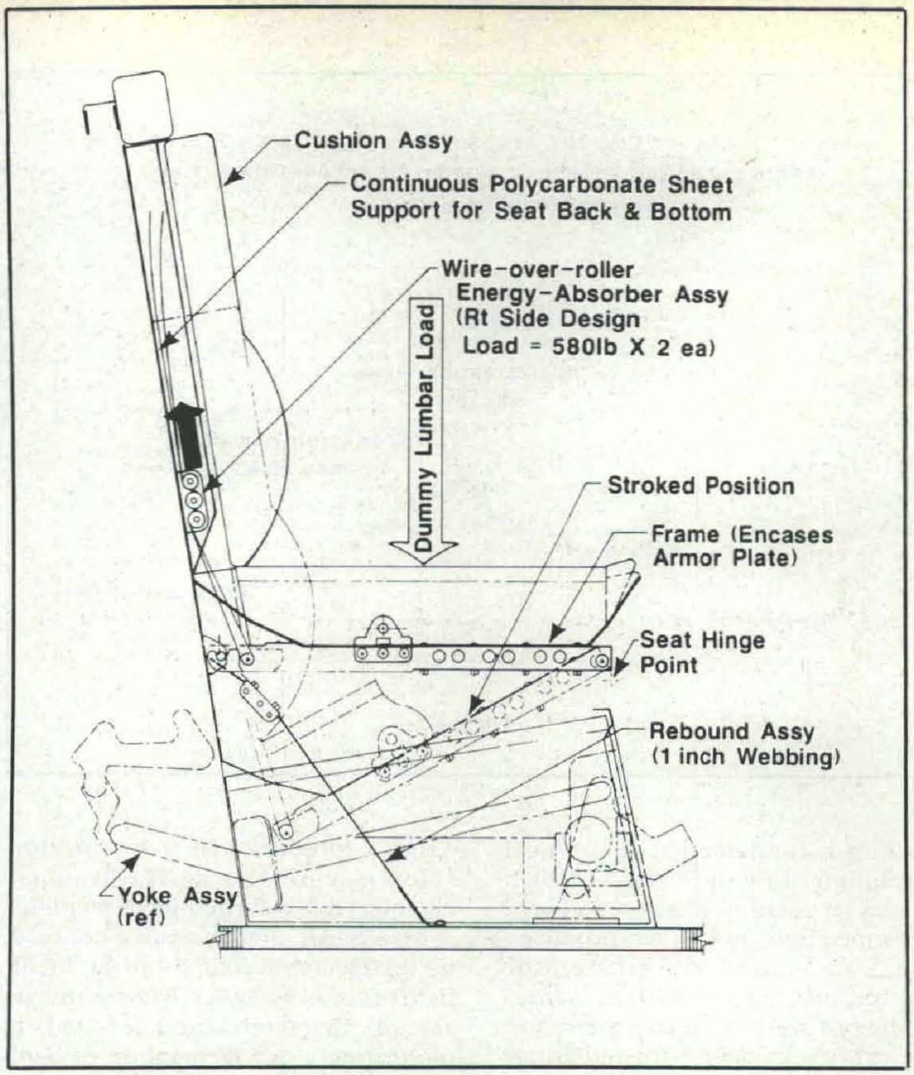
Dr. A. Peter Snyder will be awarded for his analytical mass spectrometry research contributions in discovering novel methods for the rapid detection and identification of chemical and biological agents. Products are envisioned for mobile and portable chemical and biological detection and identification equipment for the soldier on the battlefield, vehicle surfaces, aircraft cockpits and aboard ships. His work in this area will provide innovative solutions to extremely difficult problems in battlefield chemical, biological and microencapsulated compound detection and identification.

• U.S. Army Electronics Technology and Devices Laboratory

Richard A. Stern and Richard W. Babbitt will receive the award for their scientific and engineering contributions to furthering the state-of-the-art in ferrite control device techniques at millimeter wavelengths. Through their efforts, practical microstrip "drop-in" circulators and switches operating at millimeter wavelengths were demonstrated for the first time. The increased capability provided by these devices will significantly improve tactical radar weapon systems while reducing costs.

Dr. Arthur Ballato, John A. Kosinski, Theodore J. Lukaszek, Muhammad Mizan, and Raymond C. McGowan will be recognized for their contributions to advancing the state-of-the-art in acceleration immune UHF/microwave frequency sources. This technology development involves the alteration of a resonator mode shape via a translation of the point at which the resonator operates on its impedance circle. Because of its compact nature, the resulting structure is applicable to a wide variety of next generation weapons platforms, including terminally guided missiles, smart munitions, unmanned aerial vehicles, helicopters, and tracked vehicles. This team's efforts will provide the Army with the frequency source technology

FIGURE 2.
Shown to the right is a profile of the assembly of the crashworthy seat for the OH-58 helicopter. The seat was developed at the U.S. Army Aeromedical Research Laboratory at Fort Rucker, AL.



essential to impact AirLand Battle future doctrine.

• *U.S. Army Missile Command*

Albert R. Maykut, Jerrold H. Arszman, and Dr. Jay S. Lilley will be cited for advancing the state-of-the-art for high performance, low-cost propulsion for long duration, long range tactical missiles. An eightfold increase in delivered impulse over traditional solid propulsion was achieved with hardware costing 10 percent of other military turbojets. These efforts have provided the propulsion technology needed to meet the unusual tactical requirements for the Non-Line of Sight weapon system.

• *U.S. Army Natick Research, Development and Engineering Center*

Dr. Hie-Joon Kim will be commended for developing an ion chromatographic system capable of measuring sulfite, vitamin C, and nitrite in foods with a higher sensitivity, selectivity and speed than current state-of-the-art methods. Kim's methods for sulfite and nitrite detection will help minimize exposure of the populace to these potentially harmful food additives. His method for detecting vitamin C will ensure adequacy of vitamin C supply in military rations and consumer foods.

U.S. Army Corps of Engineers

• *U.S. Army Cold Regions Research and Engineering Laboratory*

Rachel Jordan will be honored for developing an analytical model to predict the surface temperature of a snow cover. The snow surface temperature prediction model provides a method for evaluating infrared background clutter which is militarily important for discrimination of targets in diverse snow-cover backgrounds. This model also can be used to predict whether disturbances in the snow — vehicular or pedestrian activity — should be detectable under varying winter conditions. Further refinement of the model will lead to the capability for estimating age of existing tracks on battlefields.

• *U.S. Army Construction Engineering Research Laboratory*

Frank W. Kearney and Robert A. Weber will be awarded for their efforts in developing the Automated Explosive Ordnance Disposal (EOD) System. This system uses a unique waterjet cutting system to sever the explosive ordnance from its fuse, reducing the risk of accidental detonation. The EOD system has the potential to save lives by taking troops out of direct contact with the explosive ordnance during render safe procedures.

• *U.S. Army Engineer Topographic Laboratories*

Dr. Pi-Fuay Chen will receive the award for his work in developing a system for automatically extracting terrain features from radar imagery and in initiating and leading the development of a software library for future research. Chen significantly advanced research that will improve the Army's capability to use the computer for the automated extraction of terrain features, such as water, fields, forests, and built-up areas, from radar imagery. This information is valuable to the Army because it aids in the rapid analysis of terrain and target data which is required by the Army in the related mission areas of weapons, mobility, and command, control, communication and intelligence.

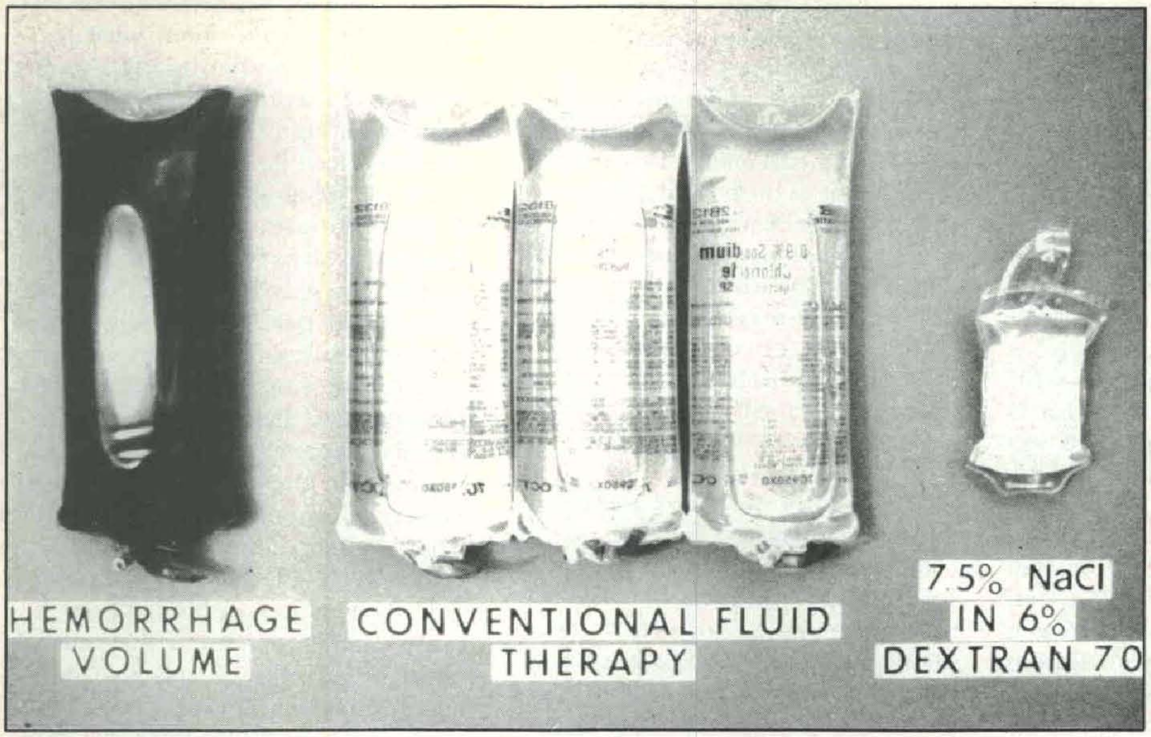


***FIGURE 3.* Hypertonic Saline/ Dextran, developed at Letterman Army Institute of Research at the Presidio of San Francisco, CA, will very likely see extensive use in the civilian community where accidents with resultant hemorrhage are currently a major cause of death in young Americans.**

• ***U.S. Army Waterways Experiment Station***

Dr. Raphael A. Franco Jr. and James K. Ingram will be recognized for developing a new gaging system, the hardened digital data acquisition system, which records severe loads produced by explosions and impacts. (Figure 1.) By eliminating the current need for expensive cables between gages and recording units, the new system is expected to result in significant cost savings on the Army's future explosive tests, as well as providing data that are currently not obtainable due to cable breakage in such harsh environments.

A team comprised of Dr. Daniel H. Cress, Perry A. Smith, and Ricky A. Goodson will be cited for developing new technology for standoff detection of land mines. Their work has resulted in the development of airborne scanning hardware using a combination of active, laser sensing and passive thermal sensing that provides a significant advance in state-of-the-art technology. The results have widespread applicability to minefield detection and target acquisition.

U.S. Army Office of the Deputy Chief of Staff for Personnel

• ***U.S. Army Research Institute***

Dr. Zita M. Simutis, Dr. Joseph S. Ward, Dr. Joan Harman, Dr. Beatrice J. Farr, and Sally Bell will be commended for their research program involving behavioral and technology-based techniques to enhance the teaching of basic academic skills to soldiers. The group's research resulted in the development of innovative programs for remediating basic skills and in a better understanding of the importance of these skills in the Army.

U.S. Army Medical Research and Development Command

• ***U.S. Army Aeromedical Research Laboratory***

Joseph L. Haley will be honored for his contributions to the development of a crashworthy seat for the OH-58 helicopter. (See Figure 2.) The development of this crashworthy seat is a result of Haley's extensive research into the mechanisms and prevention of injury in helicopter crashes. The development and full deployment of the OH-58 crashworthy seat could result in a significant reduction in injuries and fatalities in both military and civilian crashes.

• ***Letterman Army Institute of Research***

Dr. Charles E. Wade will receive the award for coordinating the development of hypertonic saline/dextran, a new resuscitation fluid which will greatly enhance the survival rate of soldiers suffering from hemorrhagic shock. (See Figure 3.) Fielding of this fluid will improve the far-forward treatment of soldiers suffering from severe blood loss resulting from combat wounds.

Louis C. Rutledge and MAJ Raj K. Gupta will be awarded for the development of a new extended-duration topical insect/arthropod repellent. The new repellent formulation has a unique sustained-release property based on principles first demonstrated by researchers at the Letterman Army Institute of Research. The new repellent protects against insects/arthropods such as mosquitoes, chiggers, fleas, biting flies, deer flies and stable flies. These insects can carry diseases such as malaria, scrub typhus, Lyme disease, dengue fever, sand fly fever and Rift Valley fever.

LTC William G. Rodkey will be recognized for the development and evaluation of synthetic products to repair and regenerate traumatized orthopedic soft tissue and cartilaginous joint structures. The biosynthetic collagen scaffold is designed to optimize tissue ingrowth and cell matrix interactions which will lead to eventual degradation and replacement of the scaffold by normal regenerated host tissues. Successful application of this biomaterial will serve as a basis for development of other collagen based substances for use in treating soldiers who have sustained injuries to ligaments, tendons, or various joint cartilages.

COL Robert M. Winslow will be cited for developing a red blood cell substitute. The blood substitute, which is a stroma free hemoglobin made from outdated human blood, will support life and activity for many hours in the absence of red blood cells. This material will be useful in treating injured soldiers and civilians, treating certain kinds of heart attacks, and some situations of severe anemia.

• *U.S. Army Medical Research Institute of Chemical Defense*

Howard G. Meyer will be commended for developing two radioimmunoassays: pyridostigmine, which has been patented, and physostigmine, for which a patent has been submitted. These assays measure drug concentrations in tissues and biological fluids and can be used in pharmacokinetic studies required for Food and Drug Administration approval. Approval of these drugs as pretreatments will provide our soldier with the best means currently available to survive a nerve agent attack.

Dr. Peter K. Chiang and MAJ Richard P. Solana will be honored for their efforts in the development of safe and efficacious antidotes for organophosphate poisoning. Their efforts have resulted in the development and evaluation of the antidote, azaprophen, which is showing great promise as a carbamate pretreatment adjunct in vivo test situations. Their work has contributed significantly to the development of safe and effective prophylactic/therapeutic treatments for chemical warfare agent poisoning.

Dr. Alan D. Wolfe and Donald M. Maxwell will be awarded for their research efforts in the area of prophylaxis and treatment against chemical warfare nerve agents. Wolfe and Maxwell developed a mathematical model which suggests the potential efficacy of scavengers for nerve agents, developed a small inexpensive rodent model which simulates the dose response of primates, and used this model to experimentally test the validity of the scavenger approach to prophylaxis and treatment against chemical warfare nerve agents.

• *U.S. Army Medical Research Unit — Malaysia*

Melinda Lee will receive the award for developing and adapting two new techniques for the detection of antibodies to malaria bloodstage parasites in human blood. Some advantages of the new assays are their accuracy, sensitivity, rapidity, elimination of red blood cell background interference, adaptability to mass field surveys and local health laboratories, long term storage, ability to replace the standard indirect fluorescent antibody test and ability to be read visually or with a light microscope.

• *Walter Reed Army Institute of Research*

A team of scientists comprised of Dr. Kenneth Eckels, Dr. Doria R. Dubois, LTC Charles Hoke, LTC Maria Sjogren, Dr. Leonard Binn, Ruth Marchwicki, and COL William H. Bancroft will be recognized for their efforts in preparing and testing a vaccine to prevent Viral Hepatitis, Type A, for military use. The vaccine was prepared from virus grown in cell culture and was used to compare two dosage schedules in volunteer soldiers. It is anticipated that this vaccine will eventually replace the use of gamma globulin injections which are painful and provide only temporary protection against Hepatitis A.

Dr. James L. Meyerhoff will be cited for his biomedical research that has provided much new information with regard to human stress responses. Using a highly relevant military model of psychological stress, Meyerhoff has defined hormonal and autonomic responses to stress and correlated these responses with performance. By improving knowledge about what happens in the body during stress, Meyerhoff's work will contribute to better prevention and treatment of stress-induced illness.

COL Jeffrey D. Chulay, CPT Christian F. Ockenhouse and Dr. Cathleen Magowan will be commended for their research on prevention and treatment of severe malaria. The work was performed in collaboration with two scientists from the American Red Cross. The group showed that parasite-infected red blood cells bind to the CD36 molecule located on the cells lining blood vessels and on some white blood cells. The binding of infected red blood cells removes the parasites from circulation so that they are hidden from the body's immune cells in the spleen, clogs blood vessels, and also overstimulates some of the body's cells. This research has brought the Army closer to an effective treatment for reversing the life-threatening complications of cerebral malaria, and also closer to an important component of a vaccine to prevent malaria.

A team composed of CPT Max Grogl, Dr. Lawrence L. Fleckenstein, SGT Lawrence D.C. Cordero and SPC Tina N. Thomason will be honored for developing of an effective topical treatment for cutaneous leishmaniasis, a tissue protozoan disease which is a major cause of chronic ulcerative skin lesions and disfigurement in the tropics. Through their work they discovered a formulation consisting of the drug Paromomycin and methylbenzethonium chloride which, when applied directly to the leishmanial lesion, completely cured the disease in two different rodent models. The team's achievement forms the basis from which a non-toxic, effective topical treatment can be developed for field use.

Burning the Dirt. . .

INCINERATION CLEANS UP MUNITIONS CONTAMINATION

By Stuart P. Erickson

In the urgency to produce vitally needed munitions for the war effort, production plants rose and quickly geared into action across America in the 1940s. The plants did their job as the nation's resolve and industrial might turned the tide against the Axis powers in World War II.

Among the plants the Army built at that time was one at Grand Island, NE, in the nation's heartland, and another in the cotton country east of Shreveport, LA. Both performed load, assemble, and pack operations of explosives, producing tens of thousands of bombs and shells that would pound the enemy into submission.

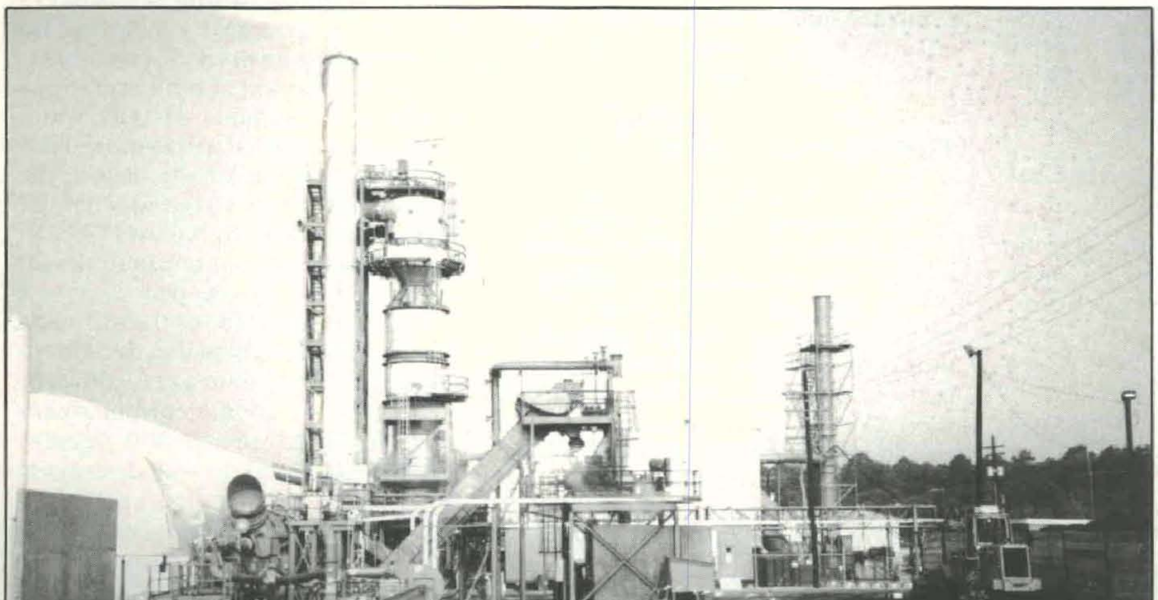
The plants also produced munitions for America's fighting men in Korea and Vietnam. The Cornhusker Army Ammunition Plan (CAAP) at Grand Island has been in a standby status since 1973, but the larger Louisiana Army Ammunition Plant (LAAP) remains operational. Both are Government Owned-Contractor Operated facilities.

Now the Army is spending millions to clean up contamination problems at each site — a problem which may trouble other munition sites — and using an innovative incineration process to do so.

The Problem — Contaminated Wastewater

In producing the weapons of war at the ammunition plants, production residues were created (principally wastewater from washing down operations) that were disposed of on site after a "state-of-the-art" but by present standards, somewhat crude filtering process.

This wastewater was contaminated with explosives, primarily TNT (trinitrotulene) and RDX (cyclotrimethylenetrinitramine), which colored the water pale pink to blood red. At CAAP, the wastewater was deposited by pipeline into 48 cesspools and 10 leaching ponds; at LAAP tanker trucks



Smoke is free of contaminants before being emitted into the Louisiana sky.

hauled the pinkwater, as it is known, to 16 large surface impoundments on the 24 square mile Bossier Parish site across the Red River east of Shreveport.

As is water's nature, it permeated the soil beneath, more easily so in the sandy prairie of Nebraska than the stiff clay of northwest Louisiana. It was a situation that couldn't be allowed to continue, and the Army took action.

In the process of doing a nationwide toxic and hazardous waste evaluation at Army facilities in 1982, the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) found RDX contamination in wells in a new subdivision in northwest Grand Island three miles from the Cornhusker plant. The Army subsequently built a connector for the subdivision with the city water line.

No such contamination of neighboring areas has been found at the LAAP, says Chris Wiehl, the U.S. Army Corps of Engineers' design manager for Army cleanup operations at both the Cornhusker and Louisiana facilities. Wiehl, who works for the Corps' Omaha District's Environmental Branch, and USATHAMA's Bob Turkeltaub have joint responsibility for the projects.

A bit of background: USATHAMA has responsibility for the installation restoration program (IRP) at **active Army installations**. The Corps of Engineers has the engineering assignment for **formerly used** Army sites under the 1983 Defense Environmental Restoration Program (DERP) enactment. In fact, the programs sometimes intertwine and result in coordinated efforts. (The Omaha District also is currently doing substantial work for the Air Force at active installations.)

The Solution — A Center of Expertise

The Corps of Engineers also has the engineering assignment for the more nationally renown "Superfund" program. This came from the Environmental Protection Agency which has been tasked by Congress not only with the protection of the environment but with cleanup of the nation's toxic and hazardous waste.

Two major pieces of legislation, the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA or "Superfund") and the $8.5 billion Superfund Amendments and Reauthorization Act of 1986 (SARA) fund the non-military programs.

The Army designated the Corps' Missouri River Division as its technical center of expertise for both the DERP and Superfund programs. The division's Omaha and Kansas City District, which do the actual design work, each have environmental cleanup engineering responsibilities for about half the nation as defined by EPA regions.

USATHAMA, which since October 1988 has been a part of the Corps, still maintains its active military installation cleanup assignment. But the work at the Nebraska and Louisiana munition plants has been a joint effort. In July 1986, USATHAMA asked the Corps for design, procurement, and construction management assistance in the cleanup project at CAAP and LAAP. This has been provided by the Omaha District in engineering design, contracting, and project management, and through the Fort Worth District in construction management at the LAAP.

The significance of the operations at Grand Island and Shreveport is that they could become a model for other cleanup operations at munitions plants throughout the nation.

The significance of the operations at Grand Island and Shreveport is that they could become a model for other cleanup operations at munitions plants throughout the nation. The methodology of incineration of explosive contaminated soils has proven practical and effective in the cleanup at both munitions production sites.

Three-phase Contract

When the contract for cleanup operations at the two sites was written, it was a three-phase contract. Phase I was for the planning and permitting of the cleanup operations. Phase II focused on the actual physical cleanup at the Cornhusker plant, the smaller of the two jobs. Phase III is for the cleanup at the LAAP.

Wiehl says the Corps received an excellent response, 11 proposals, to its advertisement. In April 1987 USATHAMA and the Corps awarded the contract to the International Technology (IT) Corp. of Knoxville, TN. It was the first Army contract for decontaminating soil by incineration at a munitions site, says Wiehl.

The original specifications called for burning 22,000 tons of explosives-contaminated soil at Cornhusker — but the estimate proved to be low. Before the cleanup operation was completed in July 1988, 40,000 tons of soil were burned. A modification was made to the original contract.

Before any of this, the CAAP operator, Mason & Hanger Silas Mason (MHSM), built a 22,500 square-foot beamed concrete storage pad for the contaminated soil from the 58 cesspools and leaching ponds. The pad had a capacity of 7,500 tons of contaminated soil awaiting incineration. Construction of the pad was completed well in advance of incineration operations.

Operations Commence

In June 1987, the EPA listed the Cornhusker plant on its National Priority List for cleanup. The State of Nebraska, of course, has had its own special interest. The state has done a start-to-finish monitoring of planning and operations through its Department of Environmental Control (NDEC). It used criteria developed by the U.S. Army Biomedical Research and Development Laboratory. A memorandum of agreement on policies, responsibilities and procedures was signed by the Army with NDEC in April 1987.

With everything in place, it was time for the IT Corp. to move in its equipment. IT's proposal was to use its Hybrid Thermal Treatment System — the "world's largest transportable incinerator" — to burn the contamination out of the soil at both munitions plants. In the summer of 1987, more than 50 large flatbed trucks moved onto the rural Cornhusker site, bearing the components of IT's Hybrid Thermal Treatment System. In August IT began incineration of contaminated soil stored on the concrete pad.

The process called for the dirt to be first run through a classifier and shredder before falling onto a belt conveyor feeding into a countercurrent rotary kiln. Temperatures of 800 degrees Fahrenheit burned the soil, destroying the explosives but also creating a gaseous waste containing hazardous organic contaminants. This gaseous material was sucked into a secondary combustion chamber for final destruction at a temperature of 1,600 degrees. A wet guench cooled the gases which were then treated in an air pollution control system so that no toxic material fouled the air. A treatment system subsequently removed suspended solids from the wastewater and controlled the pH of the scrubbing fluid which was then used to treat the ash from the kiln.

After storage in bins adjacent to the incinerator, the MHSM Co. buried the ash on site, topping the excavation with clay. The old pits were backfilled and also clay topped. A simple operation that worked, says Wiehl.

Jobs Share Commonalities

An October 1987 accident, injuring two workers, temporarily halted operations at Cornhusker. Modifications were made to the system and it got an unscheduled winterization. Incineration operations resumed in February 1988 and were completed without further mishap in July — the first munitions-contaminated soil incineration ever executed by the Army. A total of 40,000 tons of soil were processed and a vexatious groundwater problem resolved.

The cleanup at Cornhusker was a very straightforward job, says Wiehl, made more so by the fact that it was on a federally owned site. "We knew that the problem existed, we knew what it was and why it existed, and that's why we took care of it," he says. The Cornhusker job cost $9 million to complete. LAAP will cost more, largely because of the greater volume of contaminated soil to be processed.

The Nebraska and Louisiana plants share some commonalties. Both were constructed on a wartime fast-track schedule in 1942 following America's entrance into World War II in December 1941. Both were initially in rural areas near their state's "Third Cities" in agricultural based economies where people lived who were used to working hard. And, of course, at both, contamination from TNT and RDX residues are the principal problem.

Rains Fill Lagoon

The Louisiana Army Ammunition Plant is found 22 miles east of Shreveport, on a 15,000-acre site south of the present day Interstate 20 between Haughton and Sibley. The site targeted for initial cleanup is known as "Area P" and has been out of use since 1981. At Area P, 16 unlined lagoons fill a 25-acre plat between a dry ditch and running creek. A perimeter 25-year storm levee surrounds the impoundments, each of which is about three quarters of an acre, and 2 to 3-feet deep.

"We originally thought there were about 15 million gallons of liquid in these ponds," say Wiehl, "but we figured low. It turned out to be double that — 30 million gallons of pinkwater will have to be processed." Usually wet Louisiana weather had swollen the lagoons.

The basins had to be emptied before the contaminated soil beneath could be mucked up for incineration. This was no small operation involving tanker trucks. Plans at first called for processing the fluid through LAAP's carbon filtration system built in the early 1980s. But after looking at the expanded volume of liquid, it was decided to build a separate treatment plant to handle the job, Wiehl said. The plant uses two carbon columns to clean the wastewater which flows through a ditch into a nearby creek.

Operations began on the wastewater phase of the cleanup in the summer of 1988. As ponds were cleared, stripping operations were begun by the IT Corp. in October. An idea to do this robotically proved impractical, and a man-operated backhoe got to work.

As at Cornhusker, a giant 100 by 375-foot holding pad, canopied to protect against the winter Louisiana rain, was constructed for the excavated soil by IT.

"Our concern is not only the ponds but the whole 25-acre area," says Wiehl. "Rains in the past have caused the ponds to overflow, contaminating surrounding soil. It looks like we're going to burn about 120,000 tons of soil." This includes five feet of sludge and dry earth in the lagoons, and one foot from the top of most of the rest of the area.

A Model for the Future?

After finishing its work at Cornhusker, IT transported its Hybrid Thermal Treatment System (HTTS) incinerator along the 800 highway miles from Grand Island. The job it is tackling at LAAP was expected to be more challenging then at the CAAP, and has proved to be so. Not only is there more contaminated soil, but the heavy clay is more difficult to process. There was also the large amount of liquid to remove and purify.

In addition, an on-site change of plan for feeding the incinerator was needed. A screw-type feeding system had been planned at LAAP, but the heavy consistency of the soil made that impossible. The belt conveyor used in the sandy soils of central Nebraska was resurrected.

When in high gear, the HTTS can process up to 26 tons of explosive contaminated soil an hour. "We hope to do around 300 tons a day at the LAAP site," says Wiehl. "Our original goal was to be finished in the spring of 1990. That won't work. It will be at least the fall of 1990 now, but the job is getting done. The incinerator process is doing the job and doing it well."

What has been accomplished at Cornhusker and is being done by the Corps of Engineers at the LAAP illustrates a developing technology that will continue to be refined as the nation learns more and more about handling its immense toxic and hazardous waste cleanup challenge. The projects also point the way to a possible standard of operation for cleanup at similar munition plants.

STUART P. ERICKSON is a public affairs specialist with the Army Corps of Engineers and an award-winning journalist. He has worked as a staff member of a metropolitan daily newspaper, as an editor, and as a public relations director in the health care field.

SPECIAL OPERATIONS FORCES MATERIEL INITIATIVES

By MAJ David Bergum and CPT Tom Gilbert

Historically, the concept and practice of Special Operations Forces (SOF) is as old as warfare. Until recently, few Americans recognized the capability of SOF in all levels of war, and in particular in low intensity conflict.

After the birth and success of the Office of Strategic Services (OSS) in World War II, the U.S. military saw clearly the need to create a "special" organization. This organization would coordinate, train, and execute such diverse functions as unconventional (guerilla) warfare, special assault, target interdiction missions, foreign training missions, psychological warfare, and civil action. Finally, in June 1952, the first Special Forces Group (10th SFG) was created at Fort Bragg, NC.

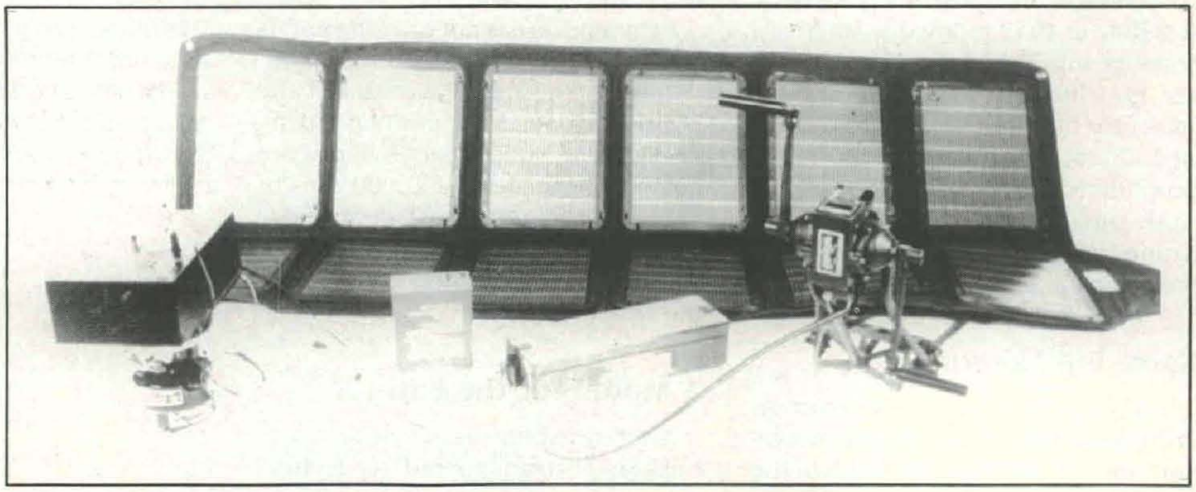
Today, special operations include Special Forces (SF), psychological operations (PSYOP), and civil affairs (CA). Special Forces are the combat arms forces that are primarily organized to conduct unconventional warfare through all phases of deployment. They are well suited to the myriad low intensity conflicts engulfing the world. Additional missions include long range special reconnaissance, counter terrorism, special strike, or direct action operations, and training teams for foreign internal defense.

Psychological operations develop and disseminate information to hostile or neutral populations. This information can be in the form of television broadcasts, radio programs, loudspeaker teams, leaflet production, or graphic posters. These PSYOP products are intended to portray the intentions and actions of the U.S. in the proper perspective and serve as a powerful force multiplier.

Civil affairs is responsible for the assistance or direct administration of a civil population. Civil affairs units are staffed with specialists to facilitate the orderly operation of neutral or hostile population groups.

Recent policy decisions within the (SOF) community have changed the

Special Operations Power Source



way we are developing our materiel and equipment needs. The U.S. Special Operations Command (USSOCOM), in conjunction with the respective services, has taken definitive action to integrate the total SOF procurement system. The missions of the U.S. Army Special Forces detachments, the U.S. Navy sea/air/land (SEAL) teams, and the U.S. Air Force teams are intrinsically similar. This joint effort to produce future SOF equipment will produce mutual benefits through cost reduction and increased interoperability.

This article outlines some of the current programs conducted by the Army combat developer, the U.S. Army John F. Kennedy Special Warfare Center and School (USAJFKSWCS), that have multiservice applicability. The USAJFKSWCS is the Army combat developer and proponent for Army Special Forces, psychological operations, and civil affairs. Each of the other services have similar offices that specialize on their unique operational requirements.

As the resourcing procedures for USSOCOM come on line, all of the service SOF programs will be fully integrated under this single funding source. The following program summaries are a sample of the Army's current work in support of joint SOF modernization.

RAM Air Parachute System

Communications

The continued modernization of SOF communications is progressing well with the renewed interest in special operations. The entire array of SOF communications is being modernized to make the total system fully compatible among the services. The SOF communications modernization effort will be one of the first joint ventures to field a totally integrated, multiservice system.

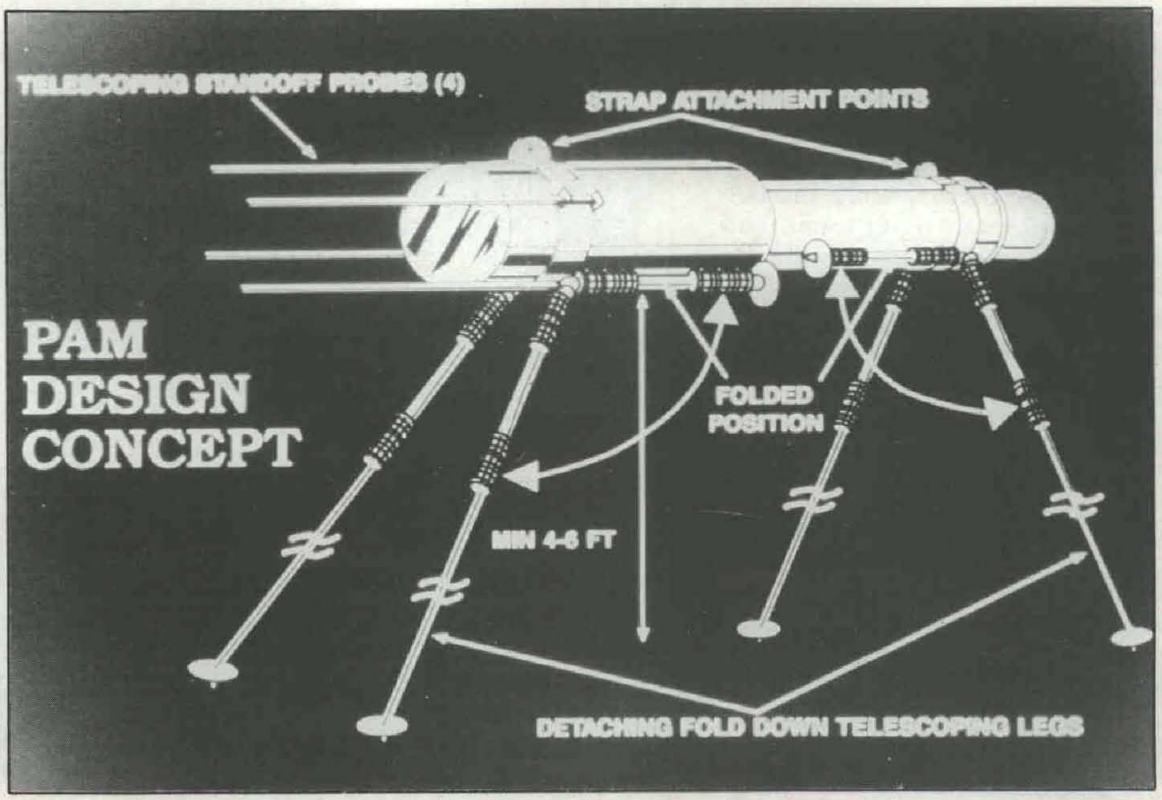
• The Joint Advanced Special Operations Radio System (JASORS) is envisioned to replace the entire spectrum of SOF long range radio equipment. It is being developed as a complete, fully automated, system to meet the needs of the Army, Air Force, Navy, and Marine special operations missions. The two main components of the JASORS are the manpack radio unit and the base station unit. Current milestones reflect an anticipated fielding date during 1995. The overall program manager is in the USSOCOM J-8R.

• Another item in the communications area is the Special Operations Improved Crypto System (SOICS). It is a small, lightweight, high speed data message burst device which uses a National Security Agency approved algorithm to provide automated, off-line encryption and decryption capability. It will replace the Digital Message Device Group to receive, store, and transmit messages and will weigh no more than two pounds and eliminate the need for one-time encryption systems.

• The Army Electronic Filmless Camera System development is based upon the requirements of the SOF psychological warfare and intelligence missions. The need exists to transmit near real time imagery over organic radio systems. Currently, both Special Forces and PSYOP units are scheduled for fielding. The Army will integrate these efforts to save time, resources, and he limited SOF funding to produce a single system that suits the overall SOF mission.

• The Special Operation Radio Antenna Kit (SORAK) contains antenna components and support items for HF/VHF transmission. It is configured so that the operator can choose the components to fit the mission and leave the remainder behind. Lightweight, easy to maintain, and durable, the SORAK provides a highly efficient antenna set for short, medium, and long range communications.

• The Special Operations Power Source (SOPS) is a set of various devices intended to supply power to a universal regulator converter. The power can then be distributed to a vast array of existing Army, Air Force, and Navy radio and special equipment. The SOPS



Penetration Augmented Munition

consists of solar panels, a thermoelectric generator, a miniature hand-cranked generator, and appropriate power connectors and cable.

Tactical Equipment and Supplies

The use of new technologies has enabled SOF access to better armaments, tactical systems and supplies. These innovations will permit detachments and teams to more effectively accomplish their mission with a reduced chance of compromise.

• The Ration Lightweight-30 Day (RLW-30) is a lightweight ration that provides subsistence for the SOF detachment or team at approximately 2,000 calories a day. A 30-day supply weighs no more than 30 pounds and has a volume of 0.8 cubic feet. This ration improvement will enable the detachment/team to sustain themselves totally independent of outside food sources for the duration of a 30-day mission.

• Another program that has successfully been integrated into the joint SOF arena is the Special Operations Laser Marker (SOFLAM). This program has demonstrated joint applicability and has been transitioned into a multiservice effort. The SOFLAM will give the SOF soldier the capability to accurately direct laser guided munitions onto specified targets, increasing the standoff effectiveness of the SOF unit.

• The Multifuel Individual/Squad Stove is a joint USMC and U.S. Army program designed to provide SOF with a lightweight, multifuel heat generation device to heat rations and provide reliable thermo-electric energy. This device can burn any liquid fuel, including gasoline, diesel, JP series, kerosene, and was even tested with vodka.

Demolitions

Several demolition development programs are also currently underway, they include:

• Time Delay Firing Device — a timer selectable from five minutes to 30 days.

• Penetration Augmented Munition — a two-staged device that will accomplish target destruction with explosive weight 75 percent less than what is currently available.

• Selectable Lightweight Attack Munition — a lightweight multipurpose hand-emplaced explosive for soft targets.

• Linear Shaped Charge — a device capable of increased penetration of target surfaces using the hollow charge effect. It will cut structural steel beams up to one inch in thickness.

Psychological Operations

For decades, the PSYOP mission has been considered an important, but all too neglected, sideline of SOF. Now however, the importance of PSYOP has been recognized at the highest levels. Equipment programs are being tailored to the PSYOP mission and soon will be fielded. As mentioned earlier, the Electronic Filmless Camera System was originally developed as a PSYOP program. Programs to fill the need for improved media production and delivery are underway.

• The Leaflet Rolling Machine (LRM) was designed to provide the PSYOP soldier the means for mechanical rolling of thousands of leaflets for use with the current 105mm round, the developmental 155mm round (discussed below), and the M129 aerial leaflet bomb. The LRM can roll leaflets into a tight, consistent roll to permit accurate ballistic performance with artillery rounds and when dropped from high speed Air Force strike aircraft. This machine has completed final testing and the project is nearing completion.

• The Leaflet Artillery Round (LAR) is a 155mm round designed to fire leaflet rolls produced from the LRM. It will carry an LRM produced load equivalent to five 105mm leaflet shells. This capability will ensure the ground commander the ability to reach out and touch his target audience regardless of the level of hostility. The LAR is not deterred by jamming, electromagnetic pulse, acoustics, or other limitations on the other means of PSYOP dissemination.

• The PSYOP Automated Terminal (PAT) is envisioned to be a stand-alone portable computer to assist PSYOP product development, campaign control, information/product transfer, and data processing. The PAT version destined for the Propaganda Development Center, media production, and other specified elements will have the capability of high quality, camera ready products. This system will enable the PSYOP element to deploy with a library of preapproved products at their fingertips. These products will only require insertion of pertinent information on the specific mission and be ready for print.

• The Modular Printing System, a complete printing facility to include typesetters, presses, cutters, and LRMs, is nearing fielding. The first production model was tested this summer and is the state of the art in printing and publication systems.

Infiltration, Exfiltration, and Transport

The following programs have demonstrated improvement over current transport equipment and are a few of the most prominent items nearing completion.

• The Fast Rope Insertion/Extraction System (FRIES) is a braided, 2-inch diameter polyester fiber rope. It is available in various lengths to facilitate the transport of detachments into or out of terrain that is unsuitable for landing. This is an improvement on current rappeling techniques in that an entire detachment can be rapidly placed or recovered at one time. The soldier uses a STABO type vest to attach himself to one of three spliced loops at the end of the rope. The FRIES has a tensile strength of approximately 35,000 pounds.

• The Mobile Over the Snow Transport is a lightweight, off-the-shelf, high speed snowmobile with a 300-pound capacity sled. It provides SOF the means for rapid, long distance land movement over snow and ice.

• The Ram Air Parachute System (RAPS) is a system that will have improved features over the current freefall military parachute systems. The RAPS will have a greater lateral range capability and landing accuracy. It can carry a total suspended weight of 350 pounds, has a high glide ratio, and can be used at altitudes of 2,000 to 25,000 feet.

• The Automatic Reserve Ripcord Release (AR3) is a mechanical device that automatically activates a military freefall parachutist's reserve in the event of an emergency. It is capable of sensing the jumper's rate of descent and altitude. If the jumper reaches a dangerous rate of descent, or if the jumper descends below a preselected altitude, the AR3 will activate. This device will improve safety during HALO/HAHO operations at altitudes of up to 43,000 feet.

• State of the art skis, poles, snowshoes, boots, and related items, known as Snow and Ice Traversing Equipment, will provide SOF the capability to increase operational effectiveness in a winter environment.

• The High Speed Airdrop Container (HISAC) consists of an aero-dynamic container with a cargo compartment intended to be flown in and dropped by high speed Air Force aircraft. It will deliver up to 500 pounds of equipment to deployed detachments or teams. The HISAC will be infiltrated at high speed (mach 1) and dropped from an altitude of 200-300 feet above ground level. The device will effect resupply operations using deep penetration attack aircraft when standard resupply is not tactically feasible.

• After several years of exhaustive research, the Parachutists Rough Terrain Suit is nearly ready for fielding. It will protect a soldier jumping into unprepared drop zones to include forest, desert, hilly/rocky terrain, and built-up urban areas. The suit is made of puncture resistant material and has protective padding.

Summary

In the past, the services developed equipment for their respective special operations elements on their own. This has led to a proliferation of equipment with similar, but often differing, operational specifications. The SOF mission, regardless of service, is essentially the same.

Special operations, by design, is a low density and low quantity procurement effort. SOF is now in the forefront and setting an example for other joint procurement and fielding actions. The integration of the services SOF materiel development effort is a significant step forward that will greatly improve our joint operations capabilities while reducing the overall cost of our ongoing SOF modernization.

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MEDICAL EVALUATION OF LIVE FIRE TEST INJURIES

Predicting Medical Effects Behind Defeated Armor

By LTC Yancy Y. Phillips,
MAJ Gary R. Ripple,
Dr. Kenneth T. Dodd,
and CPT Thomas G. Mundie

Background

The survivability of armored combat vehicles (ACV) depends, in part, on the vulnerability of both the vehicle and the crew. Until recently, evaluation of vehicle vulnerability was limited to an evaluation of an armor's ability to prevent penetration by a specified anti-armor threat. However, questions arose regarding the accuracy of assessing weapons platforms through selective component testing and then extrapolating, by computer modeling, to determine ACV vulnerability/survivability in combat.

This concern prompted the Office of the Secretary of Defense to initiate the Joint Live Fire Program in 1984. Congress then passed live fire test legislation in 1987 to require live fire testing of all U.S. weapons platforms against realistic combat threats (Amendment Title 10, U.S.C. 139). This law stipulated a weapon platform may not proceed beyond low-rate initial production until "realistic survivability testing is complete." The purpose of such testing is:

- To assess the vulnerability of U.S. weapons systems (vehicle and crew) to realistic threats.
- To assess the lethality of U.S. conventional combat systems against foreign weapons systems.
- To produce design changes which would increase crew and/or vehicle survivability on the battlefield.
- To produce a data base to improve computer modeling of weapons system vulnerability.

Behind-armor-events produce a number of potential hazards to the crew. Penetration of armor by a high explosive antitank (HEAT) munitions or a kinetic energy (KE) round creates a spall cone, a spray of hot fragments emanating from the munitions and the defeated armor, which may result in fragment injuries to the crew within the penetration path. Within this spall cone, a thermal pulse occurs which can ignite essentially any flammable material.

Test results indicate that eardrum rupture would occur in a significant number of vehicle occupants not equipped with hearing protection.

In addition to these principle effects, blast overpressure is generated in the crew space, a brief intense flash occurs, the crew is accelerated by motion of the vehicle structure, and toxic gases may be generated by heat from burning materials or from the penetrator.

Previously, these ancillary effects were not calculated into survivability because they were considered inconsequential compared to burns and fragment wounds. However, progress in armored system design has resulted in significant limitations of the direct damage done by threat penetration.

Fragment damage has been reduced by the decreased penetrability of the armor, by personal body armor, and the use of spall suppression linings. The threat of interior fires has been markedly reduced by proper stowage and compartmentalization of ammunition and other flammable materials and by an automatic fire extinguishing system.

These improvements, coupled with the operational ruggedness of the ACV, make it likely a soldier will survive a penetration, stay in the ACV, and continue his combat mission. Therefore, the necessity of accurately evaluating these "ancillary" effects as potential causes of crew injury or incapacitation is important. It also raises the question of possible health risks created within an ACV should the crew remain in the vehicle after armor penetration. As a result, the Army Medical Department (AMEDD) was tasked to evaluate non-fragment injuries for live fire testing.

The Walter Reed Army Institute of Research (WRAIR), an element of the U.S. Army Medical R&D Command, was selected to take the lead for establishing injury criteria as well as assessing crew survivability. Other contributing AMEDD organizations include the U.S. Army Environmental Hygiene Agency and the U.S. Army Aeromedical Research Laboratory. In order to meet these goals, AMEDD researchers and weapons testers characterized the environment behind defeated armor and standardized data collection equipment and procedures.

Three basic medical questions are addressed in assessing the health hazards identified by live fire testing:

- Is the crew injured and/or incapacitated by fragments and/or fire immediately generated by the armor penetration?
- Is the crew immediately injured or incapacitated by the blast, acceleration, toxic fumes, or flash effects?
- Is the crew at risk of delayed injury from the initial insult or further injury by remaining in the vehicle and continuing the combat mission?

A short discussion of potential injury mechanisms behind defeated armor follows:

Blast Overpressure

Blast overpressure is the pressure environment developed by exploding munitions. Primary blast injury produces contusion-like injury to air-containing structures of the body, i.e. the lungs, gastrointestinal tract, and ears. Biological effects of blast overpressure have been studied since the years of nuclear testing.

Unless it catches fire, any clothing offers some protection in a brief thermal exposure.

Although much is known about the injury producing effects of freefield explosions, the overpressure environment inside a defeated ACV is not as easy to understand. The blast environment is extremely complex due to the reverberations off of the vehicle's many reflective surfaces. The injurious effects from these complex blast waves cannot be directly assessed by current freefield blast injury criteria.

Until scientifically based injury criteria for complex waves is developed, using biomechanical and physiological modeling studies, accurate measurement of these complex pressure events is necessary to better characterize the event and to provide insight to guide blast overpressure research.

USAMRDC sponsored computer modeling research appears to indicate that total force exerted upon vulnerable body structures is the most important factor in predicting injury. Currently, blast data in live fire testing is related to freefield injury criteria for prediction of injury in these environments.

Test results indicate that eardrum rupture would occur in a significant number of vehicle occupants not equipped with hearing protection. However, eardrum rupture is assumed unlikely to occur under the standard combat vehicle crewman helmet.

Although eardrum rupture itself is not considered incapacitating, temporary hearing decrements are expected from ACV armor penetrating events. No means are currently available for estimating the degree of hearing loss nor the potential decrement of soldier performance following a blast event.

While the Kevlar ballistic vest has been shown to increase injury in both freefield and complex blast environments, the benefits gained by the soldier against fragment injury obviously mandate its continued use.

Thermal Radiation Injury

Accurate prediction of crew survivability in a fire within an ACV is difficult because of the unpredictable thermal environment and the variability of the body's response, especially when protected by clothing. A fire suppressed in less than 250 milliseconds is very unlikely to burn a soldier beneath his uniform. The first 10 seconds after an ACV penetration is considered the most critical period for burn injury.

Automatic fire extinguishing systems are engineered to extinguish fires in 250 milliseconds, and intense thermal events lasting longer than 10 seconds would either be catastrophic or would require evacuation of the vehicle. The pain and swelling from second degree burns is considered at least partially incapacitating; therefore, thermal data in live fire testing is assessed for the incidence of second degree burn on various body parts.

Unless it catches fire, any clothing offers some protection in a brief thermal exposure. However, in a significant thermal environment, no current battlefield garment resists ignition for longer than 10 seconds. Burns have not been predicted in live fire testing under either battle dress uniform or Nomex uniforms. All assessed burns have been on exposed areas (i.e. hands and face) where gloves, helmet and goggles would afford adequate protection.

Three types of optic injuries were considered possible following penetrating events inside ACV: permanent retinal injury (scotoma), corneal photodermatitis (welder's flash) and skin erythema (sunburn) and temporary flashblindness (afterimage). All studies indicate that permanent retinal burns, photokeratitis and corneal surface burns are not expected to be a problem in ACV crews surviving an anti-armor round penetration.

Temporary flash blindness could occur if the crewmen were looking directly at the penetrating event but is considered inconsequential given the crew's combat duties and the lethality of the penetrating event.

Toxic Gas Injury

Toxic gases are generated in a penetrated ACV by a variety of mechanisms. A shaped-charge jet will combine atmospheric nitrogen and oxygen to form nitrogen monoxide and nitrogen dioxide. Burning propellant will release nitrogen monoxide, nitrogen dioxide, carbon monoxide, and carbon dioxide. Thermal decomposition of

Avoiding incapacitation of soldiers is the primary mission.

the Halon 1301 fire suppressant will form hydrogen fluoride and hydrogen bromide. Burning plastics may release hydrogen chloride, acrolein, formaldehyde, and/or hydrogen cyanide.

It is unrealistic to expect that levels of these gases will remain below concentrations generally considered safe by civilian standards. However, since these events only occur in combat, it is reasonable to accept some risk of minor injury in exchange for the protection afforded by the vehicle and its automatic fire extinguishing system.

Avoiding incapacitation of soldiers is the primary mission. That is, when evaluating survivability in combat, levels of hazard and injury should not be equated to civilian exposure limits which are necessarily conservative because of their regulatory nature.

Given the complex interaction between severity of effect, concentration, variety of toxic species involved, time of exposure and individual breathing response, the existing toxicologic data base does not allow an unequivocal statement of the relative hazard for most gases. The Army's interest in survivability studies such as this lies somewhere between the civilian standards for the work place (low dose long duration exposures) and lethality information.

For purposes of injury prediction in live fire testing, soldiers are assumed to undergo strenuous exercise within hours of the toxic gas exposure. Increased ventilation has been shown to increase inhalation injury. If such exertion can be avoided, perhaps for as little as 24 hours, the expected delayed casualty effect will be markedly reduced.

If the ACV is penetrated and there is a fire that has been suppressed, crew members are expected to either don their individual protective mask (attached to the vehicle's main collective NBC system when available) or to exit the vehicle. Obviously, any significant fire which progresses after the automatic fire extinguishing system has discharged will force the evacuation of anyone who is not disabled.

Standard U.S. Army protective masks will protect soldiers from most, if not all, of the most toxic gases produced in these events. Any injury or incapacitation predictions must consider at what point, if at all, a soldier puts on his protective mask and the filter's effectiveness in removing a particular agent.

Acceleration Injury

In the presence or absence of a penetrating event, injury may result when a force is delivered to a crewman's body by bulk motion of an ACV impacted by an energetic threat round. This is most likely to occur in a mine explosion if a soldier is in contact with a vehicular surface violently deformed by the explosion.

Soldiers may also be injured by being thrown into structures within the vehicle or by being struck by displaced objects. Most data applicable to these types of injury have been derived from automotive crash safety evaluation, military aircraft ejection seat design or aviator crash seat testing. Head, chest and lower extremity acceleration injuries were assessed as totally incapacitating injuries. Such injuries were not frequent and, in any case, would be difficult to prevent.

Conclusions

Live fire testing of armored combat vehicles has been important to the Army. The AMEDD has supplied medical effects predictions behind defeated armor and will continue its role as medical evaluators in future livefire testing.

Medical evaluation of fractional incapacitation and of casualties behind defeated armor is an important part of total weapon system's survivability assessments in combat. Involvement in live fire tests is helping define the type of injuries and extent of casualties expected in future conflicts and plan for treatment of injuries not commonly seen in previous conflicts.

Predicting fractional incapacitation depends on a soldier's duties and motivation in combat and will require the cooperation of operational and medical components within the Army.

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SOLDIER-MACHINE INTERFACE IN COUNTERAIR OPERATIONS

By MAJ Paul E. Elliott

Introduction

The Aviation and Air Defense Division (AADD) of the U.S. Army Human Engineering Laboratory at Aberdeen Proving Ground, MD, has the continuing mission of developing soldier performance data, as it relates to Army aviation and air defense operations and materiel design. This data base is used to define design parameters that maximize the combat effectiveness of the operator, the equipment and thus the total system.

The area of counterair/air defense operations poses many questions on how combat assets will be integrated and coordinated. Advancing technology is providing commanders, at all levels, with increasing amounts of battlefield command, control, and intelligence (C2I) information. Managing that C2I information is becoming a more and more difficult and critical task. The design of equipment from a human factors engineering standpoint is aimed at combating this problem.

Historical Overview

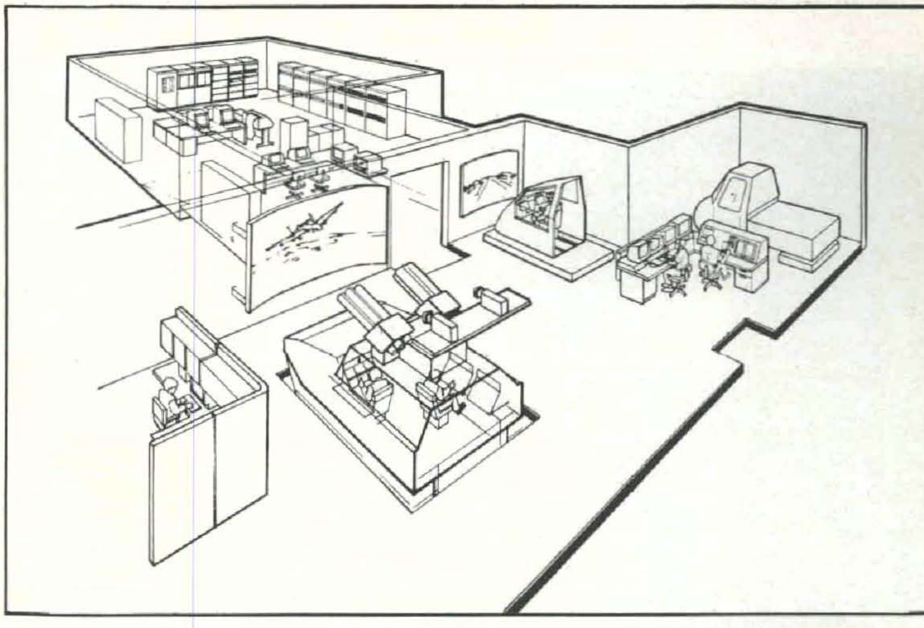
The AADD is in a particularly advantageous position to address issues associated with the coordination and integration of aviation and air defense. The AADD has the capability and expertise to simultaneously provide human factors input to improve the man-in-the-loop performance of systems associated with both operational areas.

In early 1987, the AADD adopted counterair C2I integration as a central research focus under the Human Engineering Laboratory Counterair Program (HELCAP). In August of 1987, the AADD sponsored a HELCAP Conference at Aberdeen Proving Ground, MD, gathering experts and key representatives in the counterair arena. The conference provided the AADD with an in-depth look at conceptual counterair operations and also provided a forum for the assembly and interaction of counterair innovators from throughout the U.S. Army.

Research

The Aviation and Air Defense Teams have research planned to support the division's overall central theme of improving human performance as related to counterair C2I integration.

The initial efforts of the Aviation Team have centered around configuring an experimental helicopter cockpit that is enhanced for the air-to-air mission. The primary experimental device consists of an interactive external visual scene and a generic single-place cockpit. The visual scene provides a gaming area including land features, ground combat vehicles, and friendly and hostile aircraft. The cockpit is designed to be rapidly reconfigured. The operation of every switch, push button, display and control can be



The AADD Simulation Facility configured with PMS, HELCAP cockpit, and command consoles.

monitored by the researcher and the results automatically recorded into the experimental data base for later analysis.

Integrated into the cockpit are technologies for addressing soldier operational issues associated with voice/display interaction, helmet-mounted display configuration, and touch screen data entry. The cockpit also incorporates a multiaxis sidearm flight controller.

Near-term research experiments are addressing the development of generic symbology to display alerting and cueing information pertaining to the presence and location of other aircraft and the parameters of identification as either friendly or hostile. Emphasis is being placed on enhancing human performance through the utilization of new technologies, reconfiguring the controls and display interface, accessing information transfer, and implementing decision aids.

Mission, function, and task analyses are presently underway to determine the C2I information flow between various aviation nodes. A battalion level tactical operations center (TOC) simulator is also being reconfigured. This simulator will interact with the research cockpit and the in-house air defense C2I simulation nodes. The AADD has also contracted Analytics, Inc. to provide additional depth to the Aviation Team's research capabilities.

The Air Defense Team is primarily concerned with the development of the Forward Area Air Defense (FAAD) C2I network at the fire unit and battalion level Air Battle Management Operations Center (ABMOC).

Several experiments have been conducted to determine forward area air defense system performance gains obtained from gunners using various target cueing devices. This resulted in the development of a concept fire unit display device that has successfully undergone field evaluation and validation.

An automated version of the (ABMOC) has been configured and is being programmed into the Division's interactive simulation network. The ABMOC simulator will be used to test control and display concepts and decision aids. The automated ABMOC will also assist the operator in processing an unprecedented volume of information available on the modern battlefield.

Current plans also include the insertion of a Pedestal-Mounted Stinger (PMS) as an additional node in the simulation network. The PMS will be used to further test and explore integrated weapons display concepts. The AADD has contracted Battelle to provide additional depth to the HELCAP research effort of the Air Defense Team.

The AADD research program is divided into two phases. The first phase consists of identifying and prioritizing critical issues and developing the tools to address those issues. The second phase is to experimentally examine and validate soldier-machine interface design criteria.

Phase one will culminate by featuring the demonstration of a laboratory test bed for the simultaneous, real-time investigation of linking select Army aviation and air defense C2I nodes. Phase two will conclude with a field validation of the previously obtained laboratory experimental results.

Conclusion

The development and procurement of effective weapon systems, and associated personnel and training programs to support them, are constantly becoming more costly to the Army. Appropriate, inexpensive human factors design can reduce those costs significantly. Reductions in life-cycle costs can be obtained through reduced training times, maintenance, accident and error rates, and quantity of end-items required because of increased efficiency. The design of systems and equipment with the man-in-the-loop uppermost in mind, makes sense not only from an operator's viewpoint, but from a budget standpoint as well!

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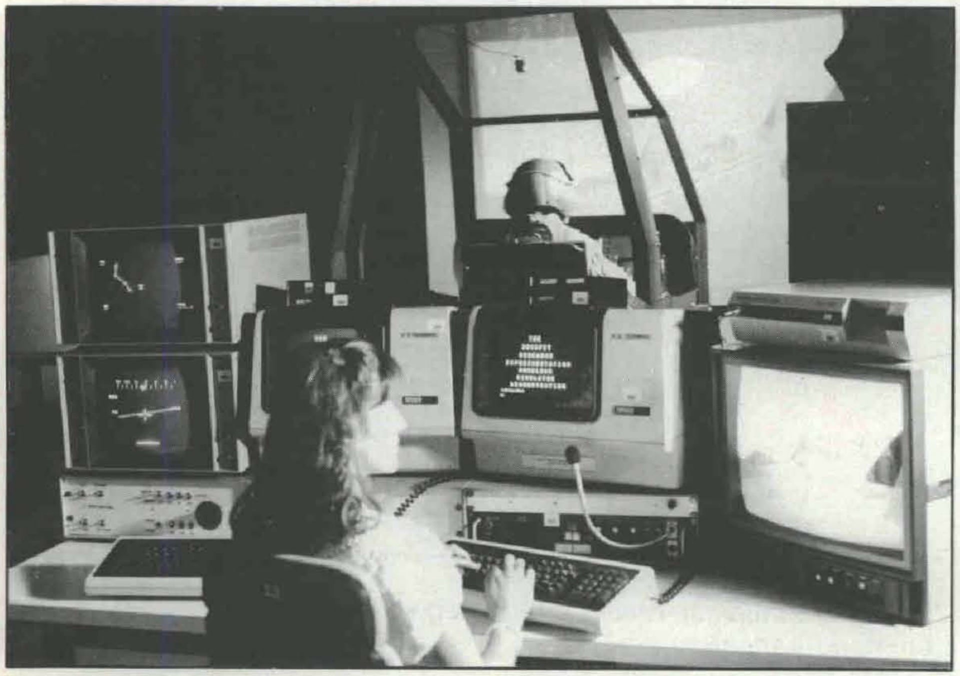


Left, HELCAP Air-to-Air Cockpit and Control Console — Human Factors Research Tool of the Aviation Team.

By CPT John N. Lesko Jr.
and Mr. James T. Garvin

The R&D Coordinator...

FUNCTIONING AS A TECHNICAL LIAISON OFFICER

Introduction

Our continued national security needs depend on our Army's ability to quickly identify, develop, and transfer a multitude of technologies into the hands of our soldiers. The responsibilities and scope of the materiel development community are critical and wide-ranging. If one quickly scans the Army's Compendium of Key Field Activity Scientific and Technical Capabilities, dated March 1, 1988 and published by the Office of the Assistant Secretary of the Army (Research, Development and Acquisition), you will find 99 pages of organizational charts or lists of most of the organizations that are working in research, development, or acquisition.

Recently, the Army Materiel Command's Pamphlet 70-18: *Sources of Expertise During the Army Materiel Acquisition Process* (dated June 1, 1989 and published by HQ, AMC) added to this information base by distributing another 108 pages of addresses and telephone numbers indexed by keywords and expertise categories. AMC-P 70-18 comes with two floppy disks of information to automate the user's search of this data base.

The May-June 1989 issue of *Army RD&A Bulletin* carried an outline of the materiel acquisition Management (MAM) program as its cover story. LTC Daniel Ziomek's, "Restructuring of the MAM Program," mapped out how company, field grade, and general officers would be identified and groomed for future service in critical Army acquisition positions such as project managers, and program executive officer.

In the July-August 1989 issue, *Army RD&A Bulletin* featured CPT Ralph Hay's, "The Uniformed Scientist: An Uncertain Future." CPT Hay claims that "today's Army offers... no coherent professional development program and no assignment placement mechanisms," for uniformed scientists or engineers.

There will be many types of officers tracked in the future MAM program. You can also be certain that further professional development policy changes, resulting from ongoing procurement reforms, will soon fill the pages of tomorrow's newspapers and defense journals. Guessing what might be is speculative at best.

This article's intent is to focus on the role of the R&D coordinator. Furthermore, we would like to suggest a few "how to's" for current and future R&D officers who may find themselves working in any number of technical jobs. The R&D coordinator's job is a difficult one. R&D coordinators are tasked with introducing change into an organization that's trying to build stability and function in accordance with SOP's.

Let's face it, anything within the Army usually runs up against built in resistance. Also, R&D coordinators are not empowered to dictate. Most are staff or action officers.

A Systems Approach

As staff or action officers, R&D coordinators must apply a systems approach to management as their most important function. All parts of the organization must operate together in an optimum manner. "Concentrating only on the immediate element of the problem which is in our area of responsibility or ability to affect causes us to overlook the potential effects the problem may have on the other areas, systems, and organizations. We also forget about the interfaces these problems may have with other areas not yet similarly affected . . . [when we fail to focus on the systems approach]" (*AMC-Pamphlet 1-6: Staff Officer's Guide*, HQ, AMC, April 4, 1988, p. I-7).

The R&D coordinator cannot compartmentalize his or her thinking. If the total systems approach to managing problems is to be effective, then the limiting factor to total systems effectiveness rests with the R&D officer's ability to communicate effectively with all concerned. Consequently, R&D coordinators, program managers, and liaison officers are the links within the organization. They collectively serve as the catalysts for positive change.

Semi-Dialog Versus Communication

Let's next go to a cartoon. In Figure 1 we see two stereotypical characters. The star-studded General on the left knows what he wants. He has a mission to perform and it seems to require competing needs. On the right, we find the tweed-jacketed scientist or engineer (although, today, we'd replace that sliderule with a computer terminal linked in a network of mini- and super-computers). He also has a mission. He seems to have a better idea for a new material. As a matter of fact, he's got a pretty good feel for what his new material is and isn't.

Now look at Figure 2. The General has further defined his requirements. We now can see that mobility equates to lighter and smaller. Deployment equates to air and ship movement into a wide range of hostile climates. Our distinguished scholar has also redefined his understanding of the new material. Now, he's tailoring the material properties to meet design or performance specifications. He even has identified a couple of steps needed to transfer the new material into production. Figure 2 represents a significant improvement in understanding over Figure 1.

What's not shown are the hundreds of others involved in the process of moving an idea from the laboratory bench into production and onto the battlefield. The purpose of this article is to outline the role of one central player in this technology transfer process — the R&D coordinator.

The R&D Coordinator as Liaison Officer

The role of a R&D coordinator is akin to that of an effective liaison officer found at division, corps or higher level staffs. If you've ever had the opportunity to serve as a liaison officer, you know that, at times, you are all alone. Your unit is normally someplace else. You are usually in an alien environment surrounded by others who may not even speak your own language. You've got numerous requests for information from your parent unit and from the unit you're coordinating with. If only your driver also took dictation! Well, you get the picture. An R&D coordinator at times finds himself in a similar situation.

An effective liaison officer or R&D coordinator serves primarily as an interpreter. A good interpreter not only relays the message but also attempts to relay the meaning or context of the message as well. Nuances and subtleties carry a lot of weight in the transference of meaning. Mission success and technology transfer hinge on accurate and timely communications.

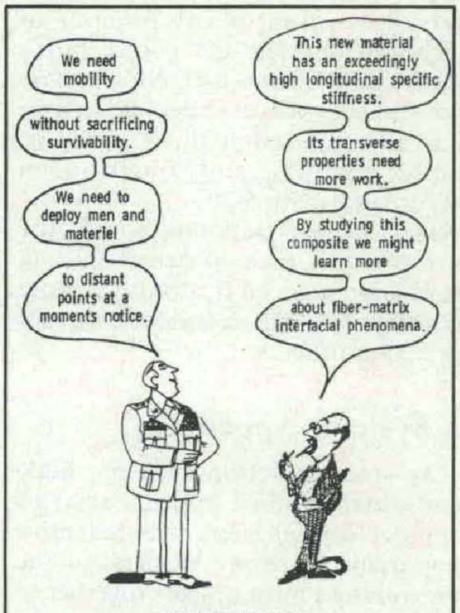
So what sort of training is there for our technical liaisons? How does the R&D coordinator succeed at relaying the message and the meaning? What skills and abilities must these officers possess? And how has our Army gone about developing these critical staff officers?

Just like operational requirements for liaison between multinational units, coordination, liaison, and language skills are vital to our success in the technical community. The R&D coordinator must be able to communicate in the language of the community within which they operate.

Very few Army officers know enough of the technology, let alone of the scientific or engineering jargon, to function as effective liaison with technical professionals in government laboratories or industry. An increased effort to train and develop technically competent officers is a must. Our Army is becoming more and more sophisticated in its weaponry and in employment techniques for these weapons. High technology may make future systems easy to operate through black boxes (making the technology appear "transparent" to the user), but an R&D coordinator will still be needed to explain why a system is or isn't ergonomically feasible.

Doctrine

"Liaison is the contact maintained among separate military organizations to ensure mutual understanding and unity of purpose, cooperation and understanding between commanders and staffs or headquarters or units working together, and tactical unity and mutual support by adjacent units." (FM 101-5: Staff Organization and Operations, May 84 ,p 4-5) Change the word "tactical" to "technical" and you have defined the function of the R&D coordinator.



THE "SEMI-DIALOG"

FIGURE 1.

"Liaison officers are representatives of the commander... [They] represent their commanders at other headquarters. Through personal contact, they promote cooperation, coordination, and exchange of essential information." (FM 101-5: Staff Organization and Operations, p. 2-5) FM 101-5 further states, "the selection criteria for liaison officers should include experience, ability to communicate effectively (language capability), and other criteria which will enhance effective liaison activities." The selection criteria for R&D coordinators should, in great part, parallel that of tactical liaison officers.

The R&D coordinator's experience base should have enough field duty in it to make this officer credible to those who depend on his judgment about future combat and tactical systems. The R&D coordinator should also have served in a laboratory or research, development and engineering (RD&E) center to balance his or her experiences. Language requirements differ only in that the R&D coordinator should be fluent in the jargon of scientists and technologists. Graduate education in the sciences or engineering is a plus.

Professional development courses, such as the MAM course at the Army Logistics Management College, or the Program Management Course at the Defense Systems Management College at Fort Belvoir, VA, must also be scheduled. As for the other criteria, let us suggest that R&D coordinators learn from the liaison officer in that they must understand "the big picture."

R&D coordinators work the interfaces. They must function between organizations, not exclusively within them. An effective R&D coordinator serves as the technology/information gatekeeper. He or she must learn to use non-traditional, non-organizational communications channels. Whether formal or informal, they all contribute to the integration of a new system into an existing organizational structure or organizational process.

"Liaison should, when possible, be reciprocal between higher, lower, and adjacent units. Liaison must be reciprocal when U.S. forces are operating with, or adjacent to, forces of different nationalities. When liaison is not reciprocal, it is established from left to right, higher to lower, and supporting to supported." (FM 101-5, p4-5). Since the materiel development community is in a supporting role, adequate staffing of R&D liaison billets is critical for the successful technology transfer from laboratory to fielded systems.

Innovative Examples

Consider the situation where a military laboratory exploits a promising technology to develop prototype components and hardware to test the principles in a battlefield simulation. If the technology offers a potential increase in military capability, what mechanisms exist to channel this technology into military applications? The answer can be few or many, depending on one's exposure and point of view.

While the procedures and processes of materiel acquisition are constantly analyzed and codified and reorganized, the "actual" process is elusive. From the point of view of a laboratory, what has been traditionally needed is a "Big Brother" or a sponsor, in the form of a commodity command, to shepherd this technology into a systems application. While this method should work, often it is fraught with the uncertainties caused by the "not invented here mentality" and by the rivalries inherent in a vast bureaucracy.

To avoid these problems, the less conventional approach of driving the requirement is a strategy who's time may have come! The contractor community has been using this method for years quite successfully. In this instance, the laboratory communicates with the user directly to inform him how his desires on the future battlefield may be met through exploitation of an available or emerging technology. Whether the contact is directly with the combat development staffs at the centers and schools, the analytical community (e.g. TRADOC Analysis Command) or with operational units, the purpose is the same, that is, sidestepping the entrenched bureaucracy (while not forgetting to keep them informed of what you as a technical liaison or "scout" have found) to bring to the soldier in the field the best technology appropriate to meet his needs on the future battlefield.

FIGURE 2.

This concept is not entirely without precedent. The Army Development and Employment Agency (ADEA), collocated with the 9th Infantry Division at Fort Lewis, WA, explored the concept of "user as developer," shortcutting the usual requirements and acquisition process to field equipment to the light divisions quickly. There is also the TRADOC Concept Evaluation Program (CEP) where technologies are evaluated directly by the user troops in operational environment scenarios.

The Army Materiel Command Field Assistance for Science and Technology program (AMC-FAST) places senior scientists and engineers on the staffs of the commanders-in-chief of the Army commands in the field to provide scientific and technical counsel to the CINC's. These sceince advisors are supported by a network of FAST POC's at the laboratories and RD&E centers with whom they communicate quickly via the Defense Data Network (DDN).

In this endeavor, an effective R&D coordinator is crucial to achieving the goal. Communicating with diverse activities having different vocabularies, concerns, perspectives and mind-sets requires an individual with broad experience and understanding of both the R&D community and the Army in the field. A working knowledge of the processes used by these diverse organizations to reach decisions is also important. In order to apply an innovative (non-traditional) approach, some feathers may need smoothing and a few fragile egos may need reassurances that serving the Army's needs is not a threat to them. After all, we are all apart of the same national defense team, the same Army.

Conclusions

The Army has a tremendous investment in its R&D infrastructure. There are brilliant minds with the capability to explore and develop a myriad of ideas, and technologies. Effective R&D coordination can provide the conduit to harvest the best future capabilities and put them in the hands of the soldier in the field. The technical liaison mission is critical to our sustained combat readiness.

What the U.S. Army needs is to identify and develop a corps of R&D coordinators who exhibit the same bold and independent, yet integrated actions which tomorrow's AirLand Battle doctrine demands. This will assure that the Army has the force multipliers it needs for the future battlefield in an atmosphere of ever shrinking resources.

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JAMES T. GARVIN is a materials engineer in MTL's Technology Integration and Management Division. He is a graduate of the Defense Systems Management College Program Management Course and has served an internship at HQDA, the Pentagon. He holds a B.S. in chemical engineering from the University of Cincinnati.

MULTIPLE POWER INPUT ENVIRONMENTAL CONTROL UNITS

By Thomas J. Sgroi

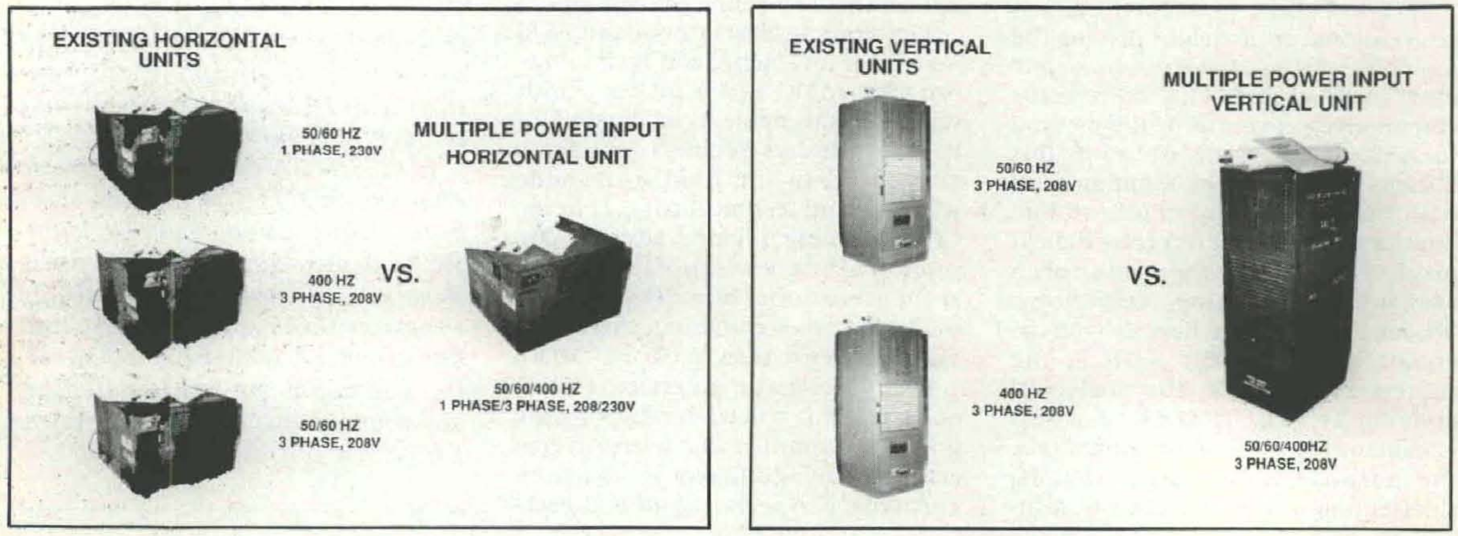
Army environmental control units (ECUs) provide critical cooling and heating for equipment and personnel operating in the various command, control, communications, computer and intelligence (C4I) systems housed in mobile vans and shelters.

The need for different cooling capacities ranging from 6,000 to 60,000 Btu's per hour (Btuh) and for vertical and horizontal physical configurations constitutes a requirement for only nine models of ECUs. However, since the ECUs must operate from several different types of electrical power (50/60 and 400 Hertz, 115, 208 and 230 volt, and 1 and 3 phase) depending on the mission equipment, the Army must support 23 different models of compact ECUs.

In an effort to reduce the procurement and logistics burden associated supporting so many different models of ECUs, the Logistics Equipment Directorate of the Belvoir Research, Development and Engineering Center (Belvoir) has developed two new 18,000 Btuh Vertical and Horizontal Multiple Power Input (MPI) ECUs. These two units will replace five of the present models. These models were selected because they represent the largest percentage of ECUs in the Army. This technology will also be applied to the other sizes of ECUs.

The reduction from five units to two units was achieved through the internal installation of solid state motor controllers (commonly referred to as inverters or variable frequency drives) within the ECU enclosure. These motor controllers are capable of accepting all of the nominal types of input power required for the 18,000 Btuh ECUs (50/60 and 400 Hertz, 208 volt, 3 phase and 50/60 Hertz, 230 volt, 1 phase) and providing 60 Hertz, 208 volt, 3 phase output power to the motors and compressors within the ECU. This eliminates the need for 400 Hz ECUs with their expensive and long lead time 400 Hz motors and compressors.

The addition of the motor controller also provides a "soft start" capability to the ECU. Soft start is defined as the limitation of the initial start-up (or inrush) current of the ECU to less than its normal operating current. The across-the-line start-up current of induction motors used for compressors and fan motors is typically five to six times the



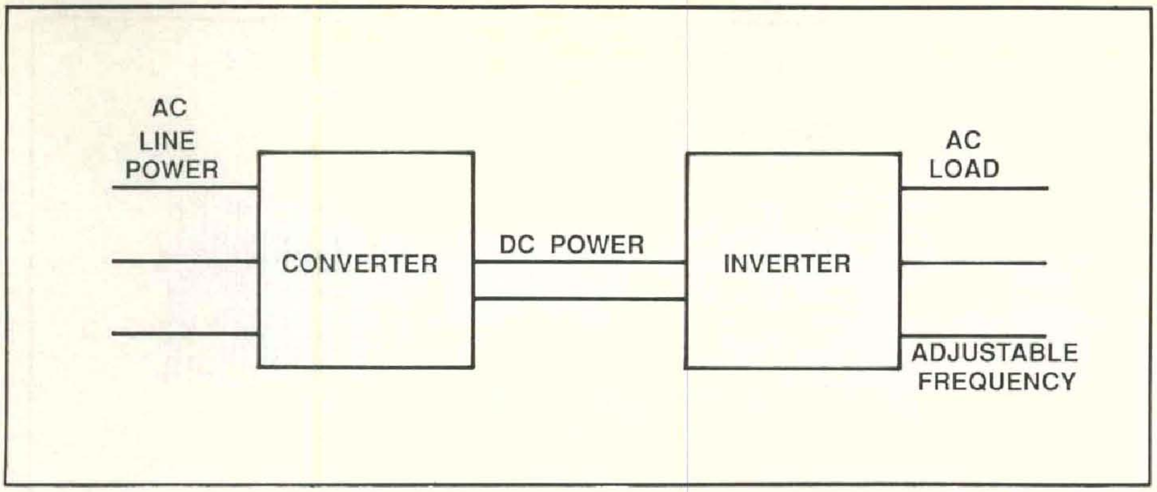


***FIGURE 1.* Motor Controller Design**

steady state current. This large start-up current can cause the power line voltage to dip or decrease for a fraction of a second, resulting in flickering lights, computer dysfunction, and disturbances to electronic equipment. For tactical military systems, this voltage dip is severe because small tactical generator sets connected through long cables are used the power supply. Typically, an ECUs demand is equal to 1/2 of the generator set's rating. If the compressor were allowed to cycle on and off, the resulting start-up current would cause repeated voltage disturbances. Even though the voltage returns to its nominal value, the electronics and computer equipment inside the shelter cannot tolerate these low voltage transients.

To avoid cycling the ECU on and off to control cooling capacity, the present Military Standard units use a complex plumbing system which allows the compressor to operate continuously while not producing cooling. This plumbing system is called a "hot gas bypass" system because it allows the hot refrigerant gas from the compressor outlet to bypass the condenser and return to the compressor inlet. The disadvantage of this approach is that even though the ECU is not providing cooling, it continues to use about 80 percent of its full load power.

Since the motor controller provides a soft start to the motors in the ECU, the need for continuous operation is avoided; hence, the hot gas bypass system has been eliminated. As a result, the compressor in the MPI units will cycle on and off depending on the demand for cooling, duplicating the operation of commercial air conditioning units without the high current in-rushes at each start. Depending on the environmental conditions and power generation equipment, this will result in significant energy savings.

Elimination of the hot gas bypass system has reduced the mechanical complexity and internal equipment density, yielding a more easily maintained unit. This was validated through a maintenance assessment conducted on the new units using soldiers with the Military Occupational Specialty for ECU repair (MOS 52C-Utilities Equipment Repairer).

The Army program to establish the viability of this technical innovation began in 1985 when Belvoir conducted a market survey of commercial motor controllers. Typical commercial applications of variable frequency motor controllers are for the control of fans, pumps, assembly lines and machine tools. The incentive for using variable frequency drives instead of other means of controlling speed is that there are decreased power losses at low speeds and speed can be more finely controlled. Because of the advancements in high-power transistors, the availability of motor controllers has increased over the past several years making their use more widespread and cost more affordable.

The most popular variable speed motor controllers are called Pulse Width Modulation (PWM) drives and consist of two sections, a converter section and an inverter section, as shown in Figure 1. The converter section rectifies (converts) the alternating current (AC) line power into direct current (DC) power and is capable of accepting a wide range of input frequencies. The inverter section is then used to change the DC power into adjustable frequency AC power for a motor. For the Army's purposes, the converter and inverter act as a "frequency changer," changing 50, 60 or 400 Hertz power into 60 Hertz power.

The inverter section produces a soft start by maintaining a constant voltage-to-frequency ratio while accelerating the motors from standstill to full speed. The constant voltage-to-frequency ratio produces a constant magnetic flux density in an AC induction motor's rotating field. Keeping the flux constant avoids saturation of the motor magnetics and enables the motor to produce the full load torque throughout the speed range. Since the inverter starts the acceleration of the motor at a low voltage, the initial start-up current to the air conditioner is very low.

Figure 2 depicts the input current and its affect on input voltage for the present 18,000 Btuh ECUs and the 18,000 Btuh MPI ECUs when operating from a 10 kilowatt diesel engine-driven generator set. The in-rush current to the present ECU results in an 18 percent voltage dip that cannot be tolerated by most electronics and communications equipment. The soft start of the MPI units results in a gradually increasing input current that has no affect on the input voltage.

The main challenge to using commercial motor controllers in military ECUs was finding sources that were small enough to fit within the compact ECUs and rugged enough to operate under the severe Military environmental conditions.

The initial verification of using commercial motor controller

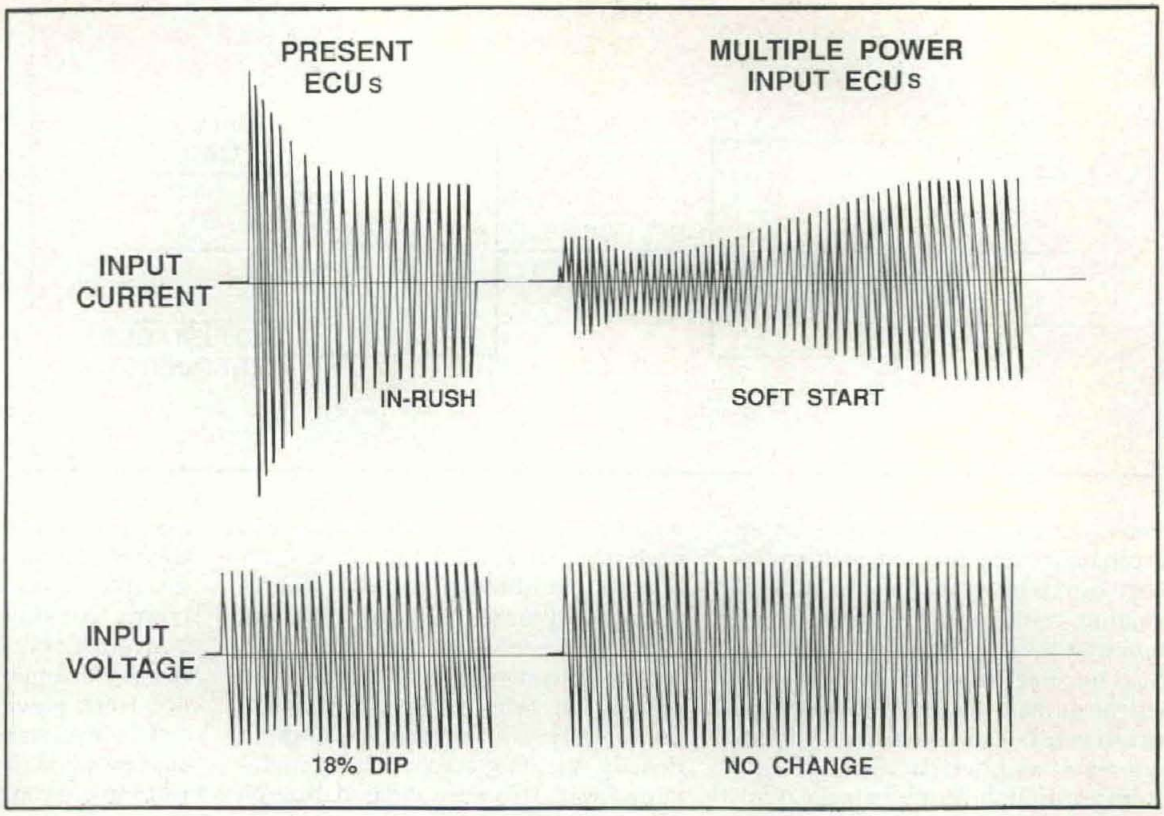


FIGURE 2. Input Current and Voltage

technology in military ECUs occurred when Belvoir conducted a demonstration of a test bed air conditioner using solid state motor controllers at the Test and Evaluation Command's (TECOM) Tropic Test Center in Panama. The satisfactory operation of the test bed for over 2,000 hours in the tropical climate of Panama successfully demonstrated the feasibility of this technology.

Having proven that the technology was mature enough for military equipment, a contract was awarded in March 1987 to modify the design of the present 18,000 Btuh vertical and horizontal ECUs to enable them to utilize solid state motor controllers. The modification of six units each (12 in all) of the vertical and horizontal configurations was required in order to conduct the necessary testing.

Upon modification of the 12 units, Belvoir proceeded to conduct over 100 different engineering and reliability tests. The engineering tests included cooling capacity, high temperature operation and storage, low temperature operation and storage, electromagnetic interference, vibration, humidity, salt fog, and noise. The reliability testing consisted of over 8,000 hours of testing under varying environmental conditions.

In order to ensure compatibility with existing power generation equipment, several "worst case" tests were conducted with military generator sets. The testing of the MPI units was an expedited in-house effort requiring coordination between design engineers, reliability engineers, project engineers, and technicians. The successful completion of these tests confirmed the adequacy of the design of the units. The final engineering drawings for the two vertical and horizontal MPI ECUs were prepared and delivered to the U.S. Army Troop Support Command, St. Louis, MO, in February 1989.

The working team that was established at Belvoir ensured that all of the appropriate maintenance, reliability, human factors, safety, integrated logistics support, and configuration management issues were considered in the design and evaluation of the MPI ECUs. In less than two years, this team achieved these substantial improvements to the 18,000 Btuh vertical and horizontal ECUs through use of this innovative commercial technology.

Since five of the present 18,000 Btuh ECUs will be replaced by two of the new Multiple Power Input (MPI) ECUs that use only 60 Hz components, a reduction in spare parts support with attendant costs and an increase in standardization, interoperability and commonality will be realized. Also, since the complex hot gas bypass plumbing system has been eliminated, the soldier will find the MPI units much more maintainable.

The center's development of these ECUs illustrates the usefulness of maintaining our environmental control equipment technical expertise in order to provide the best support to the soldier and to ensure that superior equipment is available to our Army customers.

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By Dr. Herbert L. Meiselman
and Jane Simpson

The Army's Latest Weapon System...

THE SOLDIER SYSTEM

It's new but it has been around for a long time. It's not generally recognized, but it is the most important weapon system in the Army arsenal. It is the most complex system we have and it has unlimited potential once it is fully understood. Increasingly, it depends on high tech support just like other major weapon systems. We're not talking about a tactical, multi-weapon, multi-sensor fighting vehicle, we're talking about the soldier system.

The same concepts that are used to measure weapon systems now form the benchmarks for defining our latest weapon system, the soldier system. Weapon systems are defined by how they improve force effectiveness and force survivability. It is commonplace to view weapon systems within this framework. Force effectiveness refers to how well the force is able to accomplish its mission. Force survivability refers to the ability to avoid or withstand the effects of enemy action and continue the mission.

The soldier system is composed of the individual and all his equipment, to include clothing, communications equipment, ammunition, weapons, food and personal tools. Weapon systems are composed of subsystems that contribute to the overall effectiveness and survivability of the force. Ultimately, the subcomponents are assembled into a single overall system.

The proper integration of these subcomponents can yield a result greater than the sum of the parts. This integration represents the greatest challenge to weapon systems developers. The same challenge, integrating the components of the soldier system to improve individual effectiveness and survivability, confronts those pursuing the concept of a soldier system.

The essence of the challenge before the Army is to treat the soldier and his equipment as a system and, thereby, to enhance the soldier's system fighting effectiveness. To do this, requires focusing on soldier system designs which promote enhanced soldier system performance. The optimum combination of man and equipment is greater than the sum of its parts. The combination of technology, motivation and training can overcome more obstacles than the individual or equipment was designed to do. A less than optimum combination of man and equipment produces a weakening effect, draining the potential effectiveness or output of the individual and his equipment.

Traditionally, we have developed individual equipment for the soldier, including weapons, communication gear, clothing, food, and individual shelters, and in essence hung them on the soldier. The result is, at best, a soldier fully equipped who can maintain a status quo or minimal level of performance. More often, the result of simply adding equipment to the soldier is a soldier with decremented capability to survive and to fight. The decrement derives from the tremendous physical load and corollary psychological load placed on the soldier, from the incompatibility of some of the soldier equipment items, and from the lack of overall understanding of the soldier system. The goal of the soldier system approach is to ensure that, as a minimum, the fighting soldier operates at full potential but preferably with an enhanced capability.

As an initial step towards this goal, the requirements development process needs to be re-evaluated. Requirements documents are the driving force behind the development of new systems and are the key to begin treating the soldier as a system. They specify the parameters that are used to measure success in meeting the enhanced capability desired by the user. They are also key to describing the differences between how major weapons development is approached in comparison to how systems for the soldier are developed. A specific example of this is comparing weapon systems requirements against clothing systems requirements.

The criteria for describing weapon systems are transportability, reliability, availability, maintainability, vulnerability, fightability, and durability. In comparison, criteria for a typical clothing system include sizing, fitting, donning/doffing, cleanliness to wearer, compatibility, climatic conditions, waterproofing, launderability, safety, and CB/ballistic protection. There are important differences between the two documents:

First, the requirements for the weapon system are for the entire system. The weapon system is composed of subcomponents that must function as an integrated system. The requirements for the clothing system worn by the soldier do not specify how the soldier and uniform interact as a system to enhance performance, nor how the system interacts with other weapon systems and missions.

Secondly, requirements for weapon systems specify an enhanced capability which makes perfect sense. Why develop a new system if there is not greater capability obtained? With the exception of CB/ballistic capability, the emphasis with the clothing system is on reducing performance degradation rather than enhancing mission performance. The soldier system needs to specify not only increased survivability but how the soldier's performance of his mission is enhanced above a baseline of "normal" performance.

Taking this one step further, it may be necessary to specify a soldier system for each of the personnel in a specific system (e.g. — in an armor system, the gunner, loader, driver and tank commander) or at least conduct trade-off analyses to define the optimal single system.

At the outset we pointed out that large weapon, transportation and communication systems in the Army are designed as complete systems. If a soldier system were designed as an overall system, what types of criteria might apply, and how would these criteria relate to typical weapon systems criteria? As a first cut at identifying dimensions of product quality for soldier systems, we used seven dimensions of quality proposed by Professor David Garvin in the *Harvard Business Review*. Professor Garvin lists the dimensions of quality as item performance, features, reliability, durability, serviceability, aesthetics, and perceived quality. These seven dimensions have been placed on a matrix together with the dimensions of soldier performance (Figure 1).

The dimensions of soldier performance in Figure 1 are those typically influencing a variety of soldier actions and decisions. Overall troop performance is often divided into physical performance and cognitive performance. Physical performance is demonstrated by tasks such as running and lifting, whereas cognitive performance is demonstrated by higher mental tasks such as problem solving or reasoning.

The combination of physical and mental performance is troop effectiveness. Overall troop performance would be a synonym for troop effectiveness. Survivability is more basic than doing one's job; it is the ability of the soldier to literally survive battlefield threats in order to be present to do his job, preferably at or near full performance levels.

The matrix contains two factors which are not directly related to performance or survivability. Retention is a major concern in the Army. With regard to weapon or solder systems design, one should ask whether Army policies and equipment affect a soldier's attitude and actual decision to stay in the Army.

Finally, training itself can be related to Army equipment and systems. Some systems are training intensive while others are not. Some systems assume training will occur in order for their optimal use. Training is always a critical issue because there is currently inadequate training time for all the information that must be presented to the soldier. The impact of increasing technology will probably place more demands on the already burdened soldier training schedule.

The soldier system can be viewed as the interaction of the soldier dimensions with the weapon systems analogue dimensions in Figure 1. Exploring these interactions helps to better understand what is really involved in a soldier system. In Figure 1 each checkmark indicates that the two variables significantly interact. First, the physical performance of the soldier is clearly related to individual equipment performance in terms of how it enhances his performance, and whether that equipment is reliable, durable, and serviceable. For example, a soldier cannot run without adequate footgear, and that footgear must perform every time (reliability), must have an adequate life (durability), and must be capable of simple repair (serviceability).

Further, an item's performance is so critical to the soldier that it probably contributes to every soldier factor other than retention. Thus, every block on the top line of the matrix other than retention is checked.

The secondary features of certain systems also contribute to soldier factors. They may not contribute directly to soldier physical performance or to soldier survivability, but they probably contribute to cognitive performance and training. Added features often give the soldier that effectiveness edge, but there may be an offsetting cost in added training time to familiarize the soldier with the more complex item.

As noted above, reliability, durability, and serviceability are most related to troop physical performance and survivability. Serviceability (ease of repair) also involves training, either formal or on the job.

The overall aesthetics of soldier equipment is given lip service but not necessarily a real vote when items are evaluated. Similarly, the perceived quality of troop equipment is often well known to developers and evaluators, but is not often factored into equations on how/when/where the equipment will be used properly. Both equipment aesthetics/acceptance and equipment perceived quality relate to cognitive performance. They are not clearly related to survivability yet they can substantially affect retention and training. Soldiers who think they are being provided with poor equipment will no doubt have a poor image of the Army as a whole. And, equipment which is not well designed or accepted will require more training time to ensure proper usage.

The matrix (Figure 1) combining soldier factors and weapon systems criteria shows how the two systems interact. The ultimate goal of soldier systems is the integrated design of all Army systems to include soldier considerations in order to achieve improved troop effectiveness and survivability and improved force effectiveness and survivability. The matrix shows how, for example, system durability contributes to troop performance, and how training is related to serviceability.

The U.S. Army Natick RDE Center, Natick, MA, has taken the first step in the development of a soldier system. Natick is currently developing a Soldier Integrated Protective Ensemble (SIPE) (Figure 2). This first generation soldier system will combine protection against multiple battlefield threats and hazards, including chemical/biological, ballistic, flame/nuclear thermal, surveillance, directed energy, environmental/heat stress, and acoustic. The overall SIPE system will be composed of the following subsystems: protective clothing, protective handwear, protective footwear, integrated headgear including respiratory protection, and microclimate conditioning. The key to the planning and execution of SIPE will be integration at the fiber level, the material level, and the ensemble level to achieve a balance or trade-off between soldier protection and soldier performance capabilities.

One advantage of integrated developments such as SIPE is the increase in payoffs for the soldier. Expected improvements resulting from SIPE include enhanced performance/survivability, improved communications, improved weapons interface, and reduction in total weight/bulk. When an individual item is developed separately, that item might function properly if adequately designed, but it might have a neutral or even negative impact on total soldier performance if it is not properly integrated with other soldier equipment.

By integrating various aspects of individual protection, SIPE is being designed to enhance soldier survivability and performance. This will be accomplished through minimization of heat stress and protection against a variety of threats. The soldier would also benefit from improved waterproofing, comfort, reduction in total weight/bulk, and improvements in both feeding and waste elimination.

The approach which has been highlighted by our planning for SIPE is the need for overall requirements or criteria for a soldier system. When a weapon system is developed, it is developed against a set of overall system criteria which define the desired operating capability on the battlefield. This is the ultimate goal for a soldier system, to specify objective criteria against which soldier equipment and systems can be developed and tested. The user requirements for SIPE are defined in the relatively brief Combat Vehicle Crewman's Protective Ensemble (CVCPE) draft Operational and Organizational (O&O) Plan, and the Maneuver Arms Tactical Protective System (MANTAPS) draft O&O Plan.

What is needed to achieve a true soldier system? As with so many changes, the notion of a soldier system must be supported at the top and preached to the mid and working levels of the Army acquisition system. Most importantly, requirements must begin to include reference to soldier system critical aspects of design and performance. They should address mission requirements, combat scenarios, and other system interfaces as well as threats and deficiencies.

Another aspect of soldier systems is that they tend to cut across traditional lines of Army end items. Natick has learned this first hand with the SIPE system which requires support from many Army organizations as well as from academia and industry (Figure 3). The development of requirements documents in the future should also require close coordination among multiple Army players to ensure that mission issues, soldier issues and materiel issues are all integrated into the requirement.

Possibly the only way to achieve such a fundamental turnaround from

SOLDIER SYSTEM MATRIX

	SOLDIER				
WEAPONS SYSTEM ANALOGUE	PHYSICAL PERFORMANCE	COGNITIVE PERFORMANCE	SURVIV-ABILITY	RETENTION	TRAINING
ITEM PERFORMANCE (OPERATING CHARACTERISTICS)	X	X	X		X
FEATURES (SECONDARY NOT PRIMARY)		X			X
RELIABILITY	X		X		
DURABILITY (TECHNICAL LIFE)	X		X		
SERVICEABILITY (EASE OF REPAIR)	X		X		X
AESTHETICS/ ACCEPTANCE		X		X	X
PERCEIVED QUALITY (IMAGE, MARKETING)		X		X	X

FIGURE 1.

SOLDIER INTEGRATED PROTECTIVE ENSEMBLE (SIPE)

GOAL: TO DEVELOP, FABRICATE AND EVALUATE A PROTOTYPE HEAD-TO-TOE COMBAT CLOTHING SYSTEM WHICH WILL AFFORD IMPROVED COMBAT EFFECTIVENESS WHILE PROVIDING THE INDIVIDUAL SOLDIER BALANCED PROTECTION AGAINST MULTIPLE BATTLEFIELD THREATS/HAZARDS

FOOD AND WATER

CLIMATIC PROTECTION

WEAPONS & AMMUNITION

LASER PROTECTION

LOAD CARRYING EQUIPMENT

COMMUNICATIONS

BALLISTIC PROTECTION

NBC PROTECTION

COUNTER-SURVEILLANCE

NIGHT VISION DEVICES

DECISION SUPPORT

FIGURE 2.

SIPE 6.3A TECH DEMO

SUPPORT FROM OUTSIDE AGENCIES

- USA CHEMICAL RD&E CENTER - RESPIRATORY PROTECTION, TESTING
- USA MATERIALS TECHNOLOGY LAB - BALLISTICS MATERIALS EVALUATION, COMPOSITES
- USA BALLISTIC RESEARCH LAB - CASUALTY REDUCTION ANALYSIS, MATERIALS TESTING
- USA BELVOIR RD&E CENTER - LIGHTWEIGHT POWER SOURCES, MCC SUPPORT
- USA COMMUNICATIONS AND ELECTRONICS COMMAND - COMMO, ELECTRONICS
- USA HUMAN ENGINEERING LAB - MANPRINT, HUMAN FACTORS SUPPORT
- USA TRADOC - USER INPUT, TEST SUPPORT
- SURGEON GENERAL/USARIEM - PHYSIOLOGICAL EVALUATIONS, MEDICAL SUPPORT
- INDUSTRY, ACADEMIA

FIGURE 3.

traditional materiel development to soldier system development is to identify a proponent for soldier systems, with the responsibility to address soldier system issues in Army R&D. It will require shifting emphasis in current perspectives from materiel performance to soldier performance. Most importantly, the materiel and combat developers will have to form a true and complete partnership that will fully integrate the requirements process with the acquisition system.

A proponent for soldier systems would symbolize the commitment of the Army leadership to the survivability and performance of the individual soldier. Such a proponent for soldier systems might achieve the following goals through appropriate actions:

- Formulate an overall Soldier System Tech Base Investment Strategy, including next generation and future systems, working closely with other Army organizations.
- Extend coordination of soldier system requirements (e.g., O&O Plans, ROCs) into major weapon systems; seek weapon system funds to support soldier system development.
- Based on requirements documents (ROCs) for soldier equipment and work coordinated with TRADOC, develop and utilize criteria of soldier survivability and performance in the development of integrated equipment and systems.
- Coordinate a systems analysis program of studies of the soldier system in its various configurations and operational deployments, assess system cost and operational effectiveness, conduct trade-offs analyses, and provide recommendations for enhancing soldier system cost effectiveness.
- Review, define, and establish functional interfaces with TRADOC, the Office of The Surgeon General, mission areas managers, program executive officer/program managers, and other government organizations.

The essence of a soldier system is to refocus on the soldier instead of on the equipment which the soldier uses. Soldier systems are defined by the survivability and performance outcomes of the soldier — whether he survives and how well he does his job. Our first soldier systems focus on a soldier and his individual equipment. Future soldier systems should include the soldier, his individual equipment, and the larger weapon, and transportation systems. The goal is to place the emphasis on the Army's most important system — the individual soldier.

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SHAPING INTERNATIONAL COOPERATION WITH INDUSTRY AT AMC

By Bryant R. Dunetz

International armaments cooperation has long been a policy of this government, especially with NATO allies. That cooperation has now expanded to major non-NATO allies including Israel, Egypt, Australia, Japan and Korea. Many studies (from a 1978 Defense Science Board study on *Achieving Improved NATO Effectiveness Through Armaments Collaboration*, to the 1983 Denoon report on *International Coproduction/Industrial Participation Agreements*, including more recent studies) indicate that international armaments cooperation is an increasingly necessary DOD investment strategy.

Army participation in armaments cooperation can contribute to the health of the U.S. industrial base and enhance battlefield capabilities through standardization and interoperability.

In concluding its recent six month study on *International Cooperation and Data Exchange to Enhance the Army's Technology Base*, the Army Science Board strongly recommended the development of an "overarching strategy" for international activities. The study emphasizes leveraging more from existing Army centers of excellence and supports industry-to-industry teaming to advance international cooperation and sharing of technology.

One issue receiving increasing attention is that of the defense industrial base and the potential impacts on that base from international cooperation. The U.S.-Japan codevelopment of a future fighter, based on the U.S. F-16, is the most recent interagency and Congressional debate on the subject. It focused public attention on the impact of technology transfer on the long term competiveness of our industry in commerical markets and the benefits to the U.S. selling off-the shelf versus coproduction.

The Army Materiel Command has recognized for some time that industry plays a key role in conducting effective international armaments cooperation. In November 1988, the Army Materiel Command hosted a conference with U.S. industry on the subject of "Improving U.S. Industry's role in International Armaments Cooperation."

The conference report, released last January, highlighted a new approach to industry-to-industry cooperation (see article published in July-August 1989 *Army RD&A Bulletin* by this author)

The study emphasizes leveraging more from existing Army centers of excellence and supports industry-to-industry teaming to advance international cooperation and sharing of technology.

One unanimous recommendation of industry, which AMC has already acted upon, was the formation of a committee, sponsored by one of the defense industry associations in the Washington area.

and summarized some 41 recommendations by industry dealing with impediments to exports and international R&D cooperation.

To address the many industry-raised issues and recommendations, an AMC action plan was coordinated and issued. Key topics addressed in the plan included:

- Cooperation between USG and industry in international programs: USG role in marketing overseas; Army-industry information exchange on requirements and opportunities; and Industry's role in the MOU process.
- Defense trade and offsets: Reforms of foreign military sales/direct commercial sales in accounting systems; Defense trade protectionism; and USG offset policy.
- Technology security and licensing process: Restriction on third country transfers; and Reform of export approval/licensing processes.
- Bolstering defense industrial competiveness and USG procurement policy.

Many of the recommendations will require changes to legislation and policy at the highest levels of government and therefore are beyond the authority of the Army. Those in that category were forwarded to the Department of the Army for discussion with the Department of Defense and other cabinet departments.

A schedule has been established for the Army to take timely action on those issues that warrant close attention while providing industry a complete set of responses at a follow-on conference. Currently in the planning stages, the conference with industry representatives will be held in the Washington area before the end of this year.

One unanimous recommendation of industry, which AMC has already acted upon, was the formation of a committee, sponsored by one of the defense industry associations in the Washington area. The committee's purpose is to assist the Army in providing "industry's view" on the entire range of international materiel issues.

On May 25, 1989, the American Defense Prepardedness Association (ADPA) agreed to assist the Army in this endeavor and chartered a commitee to be named "U.S. Army-Industry Committee for International Programs." Its mission is to provide a forum for sustaining a U.S. Army-U.S. industry dialogue on issues concerning international cooperation in defense RDT&E and production. Other issues will include those involving foreign military and direct commercial sales, foreign non-developmental item acquisition, foreign direct investment in the U.S., and U.S. direct investment abroad in the equity of our allies' sectors and the impact of these activities on the health of the U.S. industrial and technological base.

In association with ADPA chapters at AMC's major commodity oriented commands, a sub-committee structure is being considered to work with and assist commanders with international materiel problems.

To provide liaison and coordination within AMC, GEN Louis C. Wagner Jr., former AMC commander, has designated MG Thomas Lightner, commander of the AMC Security Affairs Command, and myself as the proponents for the maintenance of the industry dialogue. Future meetings of the committee will address progress on the action plan and further meetings with industry on international armaments cooperation.

The Army recognizes the critical role that industry plays in the execution of international cooperative programs. Moreover, senior Army leaders understand that U.S. industry success in international markets and its ability to capitalize on promising foreign technologies directly affects the quality and cost effectiveness of the entire range of products and services it delivers to the Army. Establishment of an infrastructure for dialogue and information exchange between the Army and U.S. industry is critical to meet the growing challenge of the global defense industry and technology base.

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U.S. ARMY SURVIVABILITY INFORMATION RESOURCE

Centralizing Information to Address Survivability Issues

By Mark Reches and Benson King

Combat survivability is defined as the ability to avoid or withstand the effects of hostile environments and enemy action and continue the mission. To achieve survivability, combat systems should be difficult to detect and acquire, difficult to hit if acquired, difficult to damage if hit, and easily and rapidly repaired if damaged. These aspects are illustrated in Figure 1.

Survivability is important because it contributes to improved mission and force effectiveness. The increasing importance of combat survivability is due to emerging factors, such as the following:

- **Battlefield Distance From Resupply Sources.** Resupply may take a long time or may not be sufficient. Battles must be fought with existing equipment which must survive until replaced or until victory is achieved.
- **Equipment Cost.** Modern military equipment is expensive and costs are constantly escalating, resulting in limited numbers of systems being built. Thus, fewer replacements will be available during wartime.
- **Equipment Complexity.** Equipment is becoming more complex requiring highly trained personnel that are difficult to replace. The survivability of these key personnel is of critical importance.
- **Increased Threat.** Threat systems are increasing in number and in effectiveness, outnumbering and often outshooting our systems. Survivability of our systems is necessary to overcome potential enemy advantages.

Survivability encompasses many technical and analytical disciplines. The skills, models, data, and responsibilities for these disciplines reside in the various Army Materiel Command (AMC) subordinate commands, laboratories, and research, development, and engineering centers. The increasing attention being given to survivability for developmental and existing Army systems has resulted in the need for a centralized survivability information directory and database system in order to more effectively address survivability issues.

The U.S. Army Survivability Management Office (SMO) is the focal point for survivability for AMC. As part of its mission to facilitate survivability enhancement of Army materiel, the SMO has compiled detailed information on survivability expertise, computer models, and data sources. This information has been made available in an Army Survivability Information Resource which consists of the following three directory and database systems: the Army Survivability Expertise Directory and Database, the Army Survivability Models Directory and Database, and the Army Survivability Data Source Directory and Database. Attributes of this resource are illustrated in Figure 2.

Army Survivability Expertise Directory and Database

The Army Survivability Expertise Directory and Database is the cornerstone of the information resource. It was developed to serve as a comprehensive record of survivability expertise within the Army.

A key feature of the Army Survivability Expertise Directory is the ability to query the database using various search criteria. By using the query function, the user can locate organizations with expertise in specific areas of interest. Upon locating organizations based on the search criteria, more detailed point-of-contact information can be viewed. In addition, the search criteria can be broken down by the role the organization plays; i.e., research and development, test and evaluation, modeling and simulation, design and production, and management. This feature permits

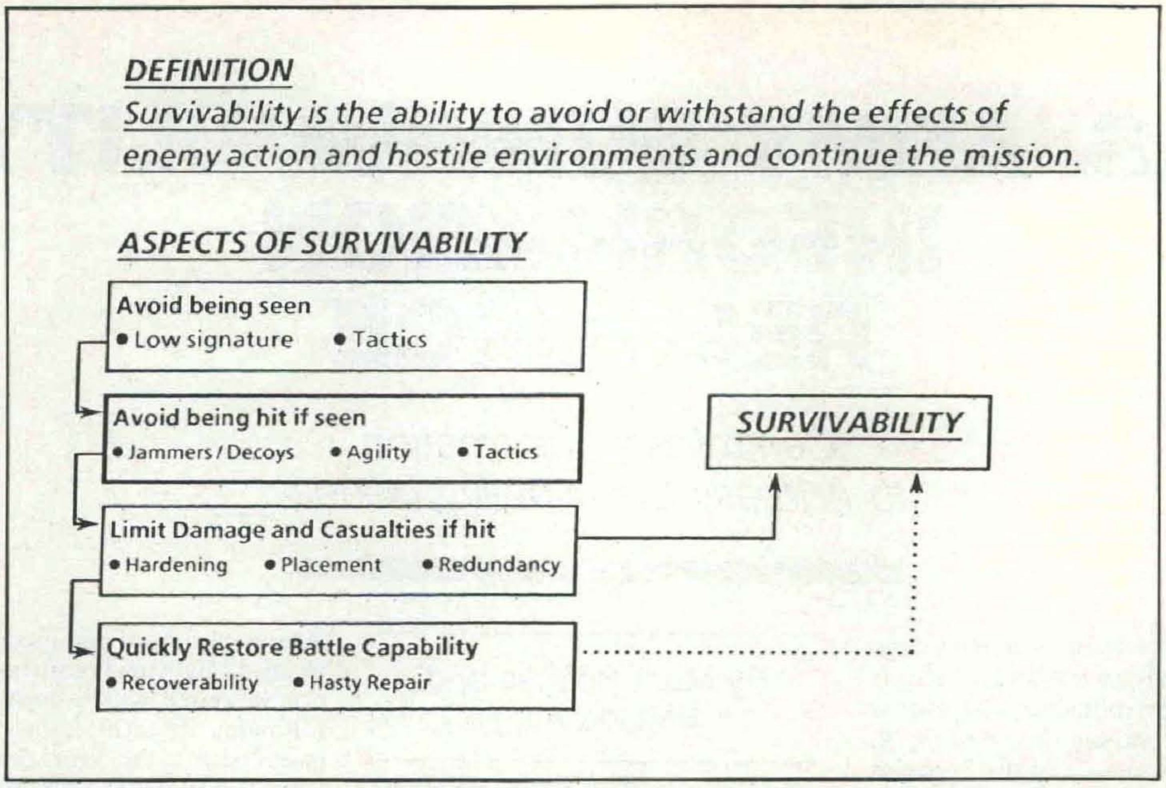

FIGURE 1. *Aspects of Survivability*

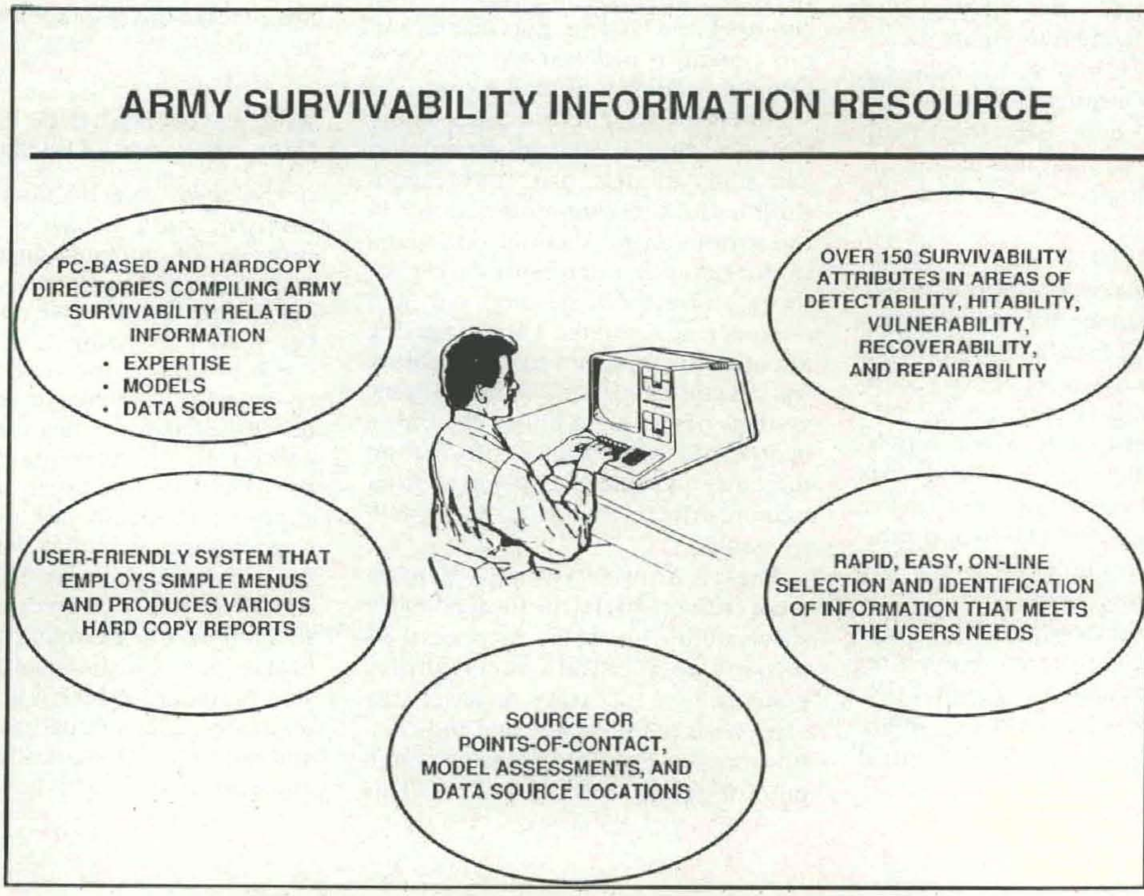

FIGURE 2. *Survivability Information Resource Attributes*

The Survivability Data Source Directory and Database contains detailed information on data sources used in Army survivability analyses.

the user to rapidly locate Army experts to solve the specific problems at hand.

A hard copy version of this directory is also available. The organizations are broken out alphabetically as well as by major survivability data area (i.e., detectability, hitability, vulnerability, and repairability).

Army Survivability Models Directory and Database

The Army Survivability Models Directory and Database is the second in the series of information resources. This system was developed to furnish a current collection of information on survivability-related models and combat simulations. Models selected to make the initial core of the directory were categorized as those treating item-level characteristics, one-sided combat, duels, or force-on-force engagements. These models were then evaluated on their ability to address specific aspects of survivability to include U.S. systems, threats, tactics, detectability, hitability, vulnerability, recoverability, repairability, and studies to date.

Presently, the directory contains information on 100 models. Like the other databases, it is designed as a complete, interactive system with an emphasis on simplicity for the user. The user can retrieve information such as aspects of survivability that the model addresses, point-of-contact data, computer resource data, and an overall model summary. In addition, the system can be used to identify all models applicable to a given problem through the query function. The system provides several options for producing hard copy of the information desired. A listing of the models is available in hard copy.

Army Survivability Data Source Directory and Database

The Survivability Data Source Directory and Database contains detailed information on data sources used in Army survivability analyses. It contains information on 102 key sources, such as the Atmospheric Aerosols and Optics Data Library. Information contained in the directory includes a point-of-contact, a brief description of the data, its format, and the aspects of survivability which are addressed, to include detectability, hitability, vulnerability, and repairability. There are several options for obtaining hard copy reports of this information.

The database has a query function similar to the other two directories. The user can input a series of search criteria, such as terrain and weather data, to locate sources which focus on such details. Information is then provided on how to obtain the data source. Use of this directory can circumvent difficulties in obtaining information necessary for high priority system assessments.

A hard copy is also available which lists the data sources numerically, and by major survivability data area (detectability, hitability, vulnerability, and repairability).

Database System Requirements

In order to effectively use the databases, the following hardware and software resources are needed: IBM PC XT or AT with floppy drive and fixed drive; 640k of main memory; monitor; dot matrix/letter quality printer; floppy disks containing the database files; and DOS 3.1 or higher.

Additional Information

The Army Survivability Information Resource has been distributed to appropriate Army organizations. Information concerning the resource can be obtained by contacting: U.S. Army Survivability Management Office, ATTN: SLCSM-GS (Mark Reches or Benson King), 2800 Powder Mill Road, Adelphi, MD 20783-1145 or telephone (AV) 290-3160, commercial (202) 394-3160.

Requests for copies of the Army Survivability Information Resource should be directed to: WRDC/FIVS/SURVIAC, Area B, Bldg 45, Wright Patterson AFB, OH 45433, or telephone (AV) 785-4840, commercial (513) 255-4840.

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Proven Technology...

THE INTEGRATED METEOROLOGICAL SYSTEM

By Robert C. Brown

Weather. It affects to some degree every aspect of our lives, from minor discomfort to major disasters. We can predict it within limits, but we cannot control it. On the battlefield, the weather is a serious matter, with impacts far beyond a rained out picnic. The modern Army must be prepared to fight at any intensity of combat, virtually anywhere in the world, under a wide range of weather conditions.

A tactical commander cannot change the weather, but with the aid of the Integrated Meteorological System (IMETS), he will be able to use it to his advantage and to his opponent's disadvantage. When fielded, the IMETS will receive battlefield weather information from multiple sources, fuse that data into a comprehensive depiction of the atmosphere and produce weather effects products for the commander.

On April 25, 1989, the IMETS proof of concept was conducted at the U.S. Army Atmospheric Sciences Laboratory (ASL) and clearly demonstrated the maturity of the required technologies, both hardware and software. The IMETS program is ready for elevation from tech base to the proof of principle phase of materiel development.

The U.S. Army Intelligence Center and School (USAICS) will continue as combat developer. The Communications and Electronics Command will assume the role of materiel developer, and the Joint Tactical Fusion Program Office will perform overall program management.

In Army Intelligence jargon the weather is part of a three tiered effort — enemy, weather, terrain — known as the Intelligence Preparation of the Battlefield (IPB). The IPB is the collection, fusion, and dissemination of relevant battlefield information in a form that the commander readily understands and uses. Enemy is concerned with the location, strength, actions, intent, and structure of threat forces. Terrain defines relevant

FIGURE 1. ***Shown is the Proof of Concept IMETS as it appears in the field. Satellite communications antenna is not in photo. In the foreground are two surface sensors which would normally be remotely deployed.***

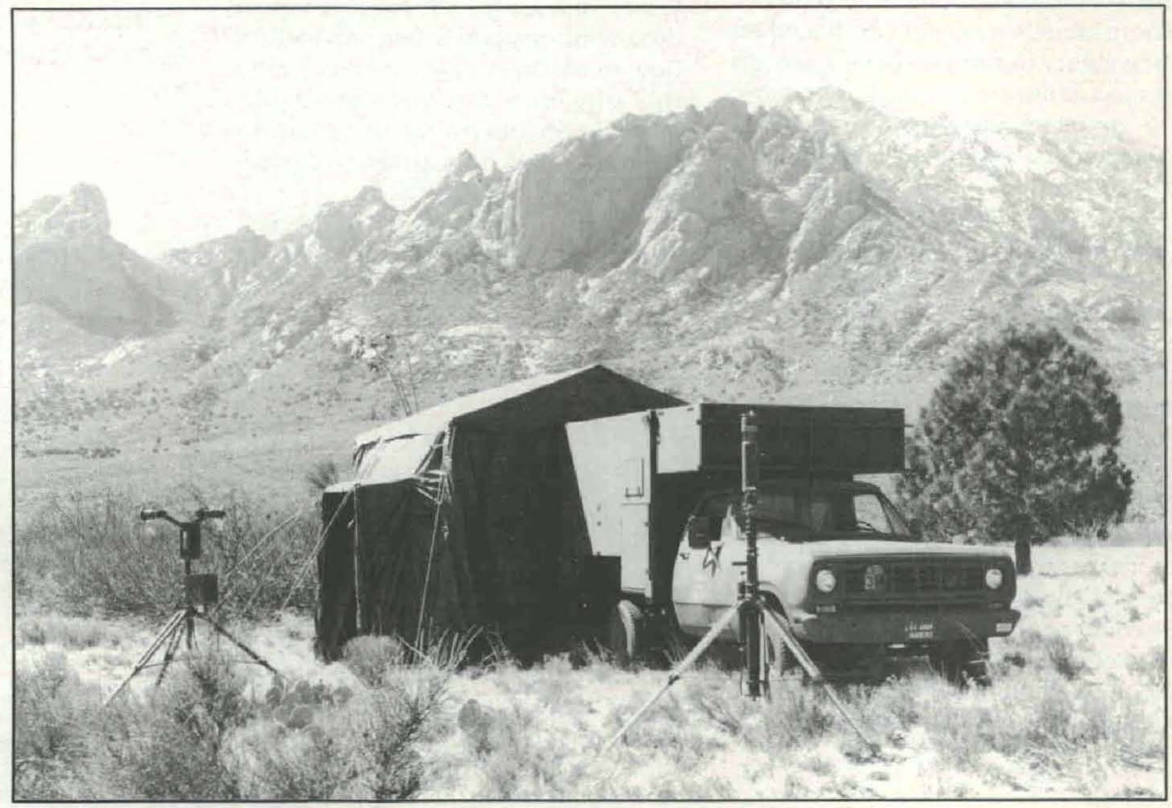

***FIGURE 2.* Shown is an example of an enhanced infrared image from a geosynchronous satellite as it could appear on the forecaster's workstation.**

geophysical features, for example, vegetation, soil types, and rivers. Weather defines the present and forecast weather effects on personnel, weapons, and tactics.

Since the weather cannot be controlled, we must have the ability to sense the existing conditions, predict the future changes, and then convert that information into tactical decision aids. Thus, weather data usable to the USAF meteorologists supporting the Army must be translated to a form meaningful to the non-meteorologist Army commander in the shortest time possible.

The process can be drastically improved through automation, which in most cases will improve the accuracy as well as the timeliness of the products. Sometimes automation can produce graphic descriptions of the battlefield that would be impossible without the aid of a computer, at least not within the time constraints imposed by combat. The combat force that can best perform these tasks will have a definite advantage on the battlefield. Thus, the goal of IMETS is to turn weather information into a force multiplier.

By methodically analyzing the impact of weather on our ability to win, the Army identified weather related battlefield deficiencies. As new sophisticated weapons systems that rely on electro-optic sensing devices are developed, the list of deficiencies will probably increase. These deficiencies formed the foundation for the IMETS Operation and Organization (O&O) Plan, the initial Army requirements document.

A tech base proof of concept system was developed by the ASL to meet the essential functions defined in the O&O. The system receives and integrates weather information from surface sensors, upper air soundings, meteorological satellites, and weather networks to produce weather effects products. It merges high resolution Defense Meteorological Satellite Program (DMSP) imagery with synoptic scale surface and upper air data from the USAF Global Weather Central (AFGWC) data bases, and surface and upper air soundings from the sensors organic to the system.

Key requirements for independent operations include mobility, independent operations, and self-contained power. The hardware is installed in a lightweight, tactical shelter mounted on a standard Army 3/4-ton truck. It is equipped with generator, uninterruptable power supply, and equipment environmental control. Despite the fact that most of the components are commercial, non-militarized equipment, the baseline mobility requirements were met.

The need for mobility not only placed severe restrictions on the size, weight and power consumption of the required hardware, but it also eliminated most of the standard, peace time communications such as land-based telecommunications networks. The system is connected to AFGWC via a high-speed communications satellite link.

FIGURE 3.
View inside the tent. Left is the dual screened Tactical Decision Aid Workstation. Right is the forecaster workstation.

The AFGWC creates and maintains a comprehensive set of worldwide meteorological data bases for military applications, so the IMETS could acquire relevant portions of that data base for Army applications anywhere in the world. This capability was demonstrated during the proof of concept by displaying satellite imagery over Central America, Europe, the Middle East, and Korea.

The task of acquiring and processing high resolution, earth locatable meteorological satellite imagery was the critical design factor. Low resolution, non-earth locatable data cannot be effectively merged with digital terrain data. The large antennas required to receive high-resolution data from the present generation of satellites in orbit, both geosynchronous and polar orbiting, are unsuitable for tactical applications.

Acquisition of the meteorological satellite data via AFGWC provided an opportunity to demonstrate the use of high resolution visible and infrared (IR) data from all of the military and civilian satellites with a single, non-tracking, cost effective, small antenna.

The system is equipped with six Meteorological Sensor Packages. These surface sensors can automatically measure wind speed and direction, temperature, pressure, and relative humidity. These compact sensors measure winds with orthogonal hot wire technologies so they have no propellers, vanes, or other moving parts. The data are automatically collected and then transmitted back to the main processor via radio modem.

Upper air soundings can be acquired from AFGWC via the communications satellite and can receive data from other local sources such as the Army AN/TMQ 31 Meteorological Data System.

It has two powerful graphics workstations, one to perform met analysis functions for the forecaster and one to determine weather effects. The two-workstation configuration provided a cost effective way to leverage existing software.

One of the goals of the IMETS program is to improve the timeliness and accuracy of the tactical weather forecasts in a cost effective manner. The Air Force has already developed some powerful techniques and software packages to automate the met analysis and forecast production effort. The IMETS program will leverage these efforts by using the Air Force software. This software can produce a wide range of met analysis products in an interactive environment. For example, it can produce an upper level chart, overlay that chart onto a satellite image, and then loop the pair of images through several time series. It can annotate any product or image with predesigned symbols, or the operator can create new symbols as needed. In a sense it is an extremely flexible tool box available to react to a large number of different synoptic situations and operational scenarios.

The weather related tactical decision aid software developed by the AirLand Battlefield Environment Program was used to demonstrate the integration of weather into the Army decision making process. The program has demonstrated over 60 software modules with a wide variety of applications. These applications include smoke screen effectiveness, detection and recognition ranges for various sensors, nuclear fallout or toxic chemical predictions, aviation hazards, and areas that are favorable, marginal, or unfavorable for various operations. Most of the products are in color graphic format and can be either displayed on the workstation screen or produced as high-resolution hardcopy.

Adverse weather can have a significant effect on the four basic tenets of Army AirLand Battle Doctrine: initiative, agility, depth, and synchronization. Threat forces have used weather to their advantage in the past and intend to use it in the future. Our reliance on modern, sophisticated weapons systems that can be degraded by adverse weather places us at a distinct disadvantage.

The requirements for an IMETS are undisputed — weather can mean the difference between winning or losing the war, the difference between life and death for the combatants. The IMETS proof of concept has conclusively shown that the required technology is a proven reality.

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By MAJ Mary C. Berwanger

FROM DIAGNOSTICS TO PROGNOSTICS USING ARTIFICIAL INTELLIGENCE

Introduction

The January-February 1989 issue of this bulletin featured a summary of efforts currently underway in the use of maintenance expert systems. ("Army Initiatives in Expert System Maintenance Aids," by COL Don L. Bullock and Gregory Winter, PM-TMDE).

The future of artificial intelligence in maintenance is emerging from such diagnostic "expert" systems — to diagnostic, training, and (ultimately) prognostic systems based upon more powerful methods of representing knowledge and reasoning about that knowledge. Use of these techniques can improve the maintainability of future Army equipment, and will have far greater payoff than the development of expert systems intended to improve the diagnosis of equipment after it has been designed.

Background

Expert systems were originally developed to assist in the diagnosis of malfunctions in complex modern weapons systems, for which BIT (built in test), ATE (automatic test equipment), and TMs (Technical Manuals) proved inadequate. It seemed a natural approach, because the best human diagnostician was better at overcoming inadequate test results than the average inspector or mechanic. Also, the expert system promised to institutionalize the knowledge and experience of the expert human diagnostician in software form, and make it available to the field.

Most diagnostic expert systems contain symptoms that the operator or mechanic would observe and the associated troubleshooting rules, obtained from an expert diagnostician during "knowledge engineering." (This "associative" knowledge is also referred to as "empirical," or "shallow," because it is based upon experience and observations rather than theory).

However, for modern, complex weapons systems, it is extremely difficult to anticipate all symptoms, and link them to specific failure causes. The number of diagnostic rules can grow indefinitely, leading to continued refinement of the rule base and software maintenance problems. It is also extremely difficult to develop rules for prognosis — that is, predicting future failures.

Researchers and practitioners in the field of artificial intelligence have been aware of the limitations of traditional expert systems, particularly for application of complex hardware. They realized that mechanical, electronic, and other physical devices are not unknown problem domains which can be discerned only by the knowledge an expert has gained over the years. They are consciously designed according to physical laws and engineering principles to behave in predictable ways. They began to investigate methods of causal reasoning, to make use of the cause and effect connection between faults and symptoms inherent in the structure of the device itself. This causal knowledge is more complete and powerful than the symptom-to-fault associations which form the rules in traditional expert systems.

Model Based Reasoning

The predominate method of causal reasoning used in the diagnosis of complex designed devices is model based reasoning . A software model of the device, at one or more levels of detail, is represented in the diagnostic system. In some cases, it may be sufficient to model the functions or behavior of the device. This could include modeling of components to be "removed and replaced" under the maintenance concept. For other devices, it may be necessary to accurately model the physical structure of the device, such as the circuit level.

Prognostic as well as diagnostic reasoning can be performed by qualitatively simulating the model. Commonly, what is simulated is a causal chain of behavior resulting from the functions of a device as implemented by its component structure. An example is the sequential functioning of the interdependent components of a drive train system.

Diagnostic reasoning starts with a symptom. The model is evaluated "backwards," using the functional constraints of the device, to identify one or more states of the device which would account for the malfunction.

Prognostics is possible by iterating the model and propagating constraints forward, making behavioral predictions from (variously) working, degraded, or failed conditions.

More powerfully, this approach could be applied to design. The design process creates a structure which will implement the specified functions. Reasoning from the structure of the device in order to predict its behavior could be used to determine if the design will behave as intended. Design errors could be discovered and corrected. In contrast, traditional diagnostic expert systems are typically developed "after the fact," and cannot improve the design process.

Thus, model based reasoning shows great promise for design of future integrated prognostic and diagnostic maintenance systems. There are significant advantages to this approach:

• The model can function without a pre-enumerated list of associated symptoms and faults, eliminating one of the most time consuming and imprecise tasks of developing traditional expert systems, and one reason for their continual refinement. In addition, a model is more powerful than a traditional expert system, because the model can handle the device's entire range of functionality, not merely behavior falling within a set of rules which may be incomplete or contradictory — a significant limitation of the traditional approach.

• The model is created from design information, substantially reducing or eliminating the need for a human diagnostic expert and the labor intensive knowledge engineering process. Some researchers plan to automate capturing the model from the CAD (computer aided design) representation, which will greatly benefit model based systems since it is time consuming to develop an accurate model from scratch. This may be especially valuable for new weapons systems, for which there are no human expert diagnosticians or failure rate experience.

• Model based systems also provide a more natural and comprehensive explanation facility than traditional expert systems, making the approach ideal for integrated maintenance and training systems. In fact, finding a way to explain the behavior of devices, rather than diagnostics, was the impetus behind early research in causal models and qualitative simulation. The inherent power of this approach is obvious: as the model is simulated, it shows (explains) how the device operates.

Some causal models are referred to as qualitative models, to distinguish them from the quantitative engineering models (of systems of equations) which have long been in use.

Graphics animation of the model could show the operation of the device at the speed desired for human understanding. The explanation features of the model could be used to increase understanding of the diagnosis sequence; to visually describe components for operator checks or for repair actions; and for separate training sessions, allowing the operator or maintainer to perform "what happens if" simulations. User "documentation" would be generated according to the requirements of the session (eg. by iterating the model — which after all is a representation of technical data).

BBN Laboratories has developed several model-based explanation and training projects for the Navy, including an intelligent tutoring system to teach principles and troubleshooting of electric circuits. Also developed is the STEAMER project for teaching the operation of Navy propulsion plants.

Qualitative Models

Some causal models are referred to as qualitative models, to distinguish them from the quantitative engineering models (of systems of equations) which have long been in use. The appeal of qualitative models is that considerable explanatory power is possible from qualitative knowledge (i.e. stating a direction of change rather than an equation to show how one component or process relates to another).

Qualitative knowledge may also be used when a deterministic (quantitative) solution is not available, or when it would be too computationally expensive. In fact, a model can combine qualitative and quantitative information.

Model representations are likewise flexible. The type of model representation used for an electrical device will likely be different than for a mechanical device or for a fluid system. In addition, model based systems can have as many levels of detail as are required for the particular type of device. For some components, a functional or behavioral model may be sufficient. Other components may be modeled at the physical level. All or only part of the functional model may need to be supplemented by physical models, to be invoked when needed.

Most experience developing model representations has been for diagnostics or training, and experience with model based prognostics is needed. It is worthwhile to examine these related problems in more detail, as the level of knowledge needed and the level of knowledge available are not necessarily the same for diagnosis, training, and prognosis.

To perform diagnostics to the level of the Line Replaceable Unit (LRU) or major component to be replaced, the model must represent at least that (component) level of detail. At this echelon of maintenance, it is enough to know which replaceable component is faulty, not what specifically is wrong with it. For fault isolation to the component level, a functional model may be sufficient. (Higher echelons of maintenance may require even deeper levels of knowledge).

To diagnose a symptom, the model is simulated to determine what portion of the structure would have to be faulty to cause that malfunction. The fault isolation process is thus based upon the function of the device as implemented by its structure. The device was engineered precisely to accomplish the intended functions, so the causal model is virtually the same thing as the design, at some determined level of detail (or design "breakdown"). Hence, causal knowledge is available and it should prove feasible to develop (at least) functional models to represent this knowledge in diagnostic systems.

Explanation and training would also have to describe the component level, so again the causal or "deep" knowledge is available. This deep knowledge in the model can assist the individual user to reach a "deep" understanding of how the device operates or what happens to the device if a given component fails. The operator or repairer can also be guided in actions and operations, as the model simulates the outcome of his choices. Thus, simulation of a model of the device itself, from any given working or failed state, will predict the future behavior of the device.

But this level of knowledge may not be sufficient to enable simulation from degraded states in order to predict impending failure, which is the type of prediction needed in the maintenance arena.

Consider a model of a drive train. If we had a sensor to tell us that the drive shaft had just broken (a failed state), and did real time prognostic reasoning, it would not help us very much to find out that the wheels are no longer being driven. We need the prediction far enough in advance to make a corrective intervention so that the mission is not jeopardized and equipment is not unnecessarily damaged. We need to be able to detect and reason about degradation, prior to actual failure.

This simplified example demonstrates that, whatever the level of knowledge needed to provide diagnostics or explanation for a weapons system in the field, more than likely the level of knowledge needed to do useful prognostics will have to be at one or more levels "deeper."

In order to predict the impending failure of a component, it will be necessary to step further back in the chain of causality. We are no longer, then, within the realm of the understood device or structure in order to accomplish specific functions — but into the arena of the materials of which the components are made, the chemical structure of lubricants, and the structural integrity effects of friction, wear, vibration, cumulative stress, heat, load factors, etc. While specific materials and lubricants are chosen because of their functional properties, and some degradation is understood well enough for causal predictions, we do not yet adequately understand all of these interactions in enough detail to universally predict failure. Research is underway to develop the needed sensors and to understand the relationships involved. (For example, analysis of vibration signals shows promise for prognostics). Thus, in terms of the knowledge required for prognostics, it may or may not be true that we have enough "deep" knowledge for the development of an adequate causal model.

However, this does not mean we must wait to include models in maintenance (prognostic and diagnostic) systems. Weapons systems developers will be able to predict the occurrence of some critical failure modes using conventional means, such as comparing measurements to threshold levels. Causal modeling can integrate these limits (or algorithms and equations that have been used in the past), or incorporate them qualitatively. New techniques combining AI and conventional methods will continue to develop, such as understanding predictions from vibration signals.

Combined Approaches

Approaches combining models with shallow knowledge are likewise important, because at the existing state of the art, there are still pragmatic considerations which discourage development of full causal models for complex devices — especially at the physical level of detail. The causal model can be difficult and time consuming to develop, and implementation can be computationally expensive or prohibitive.

Model based systems can be supplemented with associative rules, failure probabilities, heuristics, or expert-opinion assessments (shallow knowledge) to first evaluate those possible causes of a symptom which are most likely; or if the level of causal (deep) knowledge required to make a decision is not available.

Artificial intelligence approaches should gracefully incorporate the best knowledge currently available for each aspect of the problem. Causal models can be combined with other available knowledge in that way.

Several efforts have added models to existing rule-based systems. The AH-64 Apache Caution/Warning/Advisory system reported on in the January-February issue added causal models of selected components to a 2,000-plus rule base. In a slightly different approach, Southwest Research Institute's Automotive Diagnostic Assistant (Prototype Two) or ADAPT, now performs simulation of the functional model before searching the knowledge base.

Summary

As a strategy for future systems, the place for model based reasoning is concurrent engineering. Improved Computer Aided Engineering (CAE) tools will be increasingly used to "diagnose the design" and to optimize the design for reliability, testability, maintainability, and the ability to manufacture it. Prognostic and diagnostic hardware and software must be part of this concurrent design process.

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MORE MAM SURVEY INFORMATION

In the last two issues of *Army RD&A Bulletin* we presented survey data covering demographics and opinions taken from the MAM officer occupational survey. This issue covers the remainder of the opinion questions and excerpts from the Executive Summary.

Officers responded to the following opinion questions:

How would you improve the MAM Course (asked of those who have attended)?

Provide more training in areas of interest to an officer (tracks)	18%
None — fine as is	16%
More realistic/parallel real acquisition process using fictional system	13%
More practical exercises/hands-on training	6%

How would you improve the Program Managers Course (asked of those who have attended)?

Excellent course — No improvements needed	14%
More emphasis on service specific training	10%
More realistic/reality based training	6%
More emphasis on case studies/practical exercises	6%

How important are the following "attitudes" (or attributes) to being an outstanding MAM officer? (Responses reflect the top 10 attributes rank ordered as extremely or quite important.)

Caring about soldier needs	89%
Honor first and always	86%
Balancing performance, cost and schedule demands	85%
Acquisition supports warfighting	84%
Productivity thru people	79%
Being close to user	79%
Selfless service	78%
Confidence in MAM ability	72%
Bias for action	61%
Hands-on, value-driven	59%

The following information highlights the principal findings of the final survey report:

• **Lack of Skill 6T Identifier.** One of the objectives of the MAM program is to ensure that only qualified and trained officers fill positions identified in TAADS as requiring officer skill code 6T. Selection requirements for attending acquisition training courses include a provision that candidates should have been awarded the 6T identifier prior to selection. One fifth of the majors through colonels who responded to the survey indicated that they did not carry the 6T identifier and, therefore, have little or no opportunity to be selected to attend the acquisition training courses. A majority of these "non 6T identified" officers also reported that they were sitting in validated 6T slots and were in at least their second acquisition assignment. Assigning officers to a second or a third acquisition position when they have not been awarded the skill 6T identifier and have not completed either of the formal acquisition training courses is certainly not in line with the stated program objectives.

Note: The MAM course is also the qualifying course for Functional Area 51.

• **Acquisition Training.** The majority of officers surveyed have not attended any of the available acquisition training: 62 percent of the captains and majors have not completed the MAM course and 57 percent of the majors through colonels have not completed the PMC course. There is a need, not only to clarify time frames in which officers should attend available training courses, but also to ensure that officers are routinely scheduled into those courses at the proper times in their acquisition careers.

• **Acquisition Experience.** The majority of survey respondents have relatively limited experience in filling Army acquisition positions (72 percent of the respondents are either in their first (42 percent) or second (30 percent) acquisition assignment and 66 percent have less than five years of acquisition experience). This limited acquisition experience is not necessarily a concern when looking at captains or majors. However, one out of six of the lieutenant colonels and colonels are in their first acquisition assignment and have less than three years of acquisition experience. Under current requirements, these senior officers cannot accrue the years of experience they need to be competitive for selection to a PM position.

Late entry into acquisition was identified as a problem in FY 87 by the Office of the Deputy Chief of Staff for Plans and Analysis (Force Plans Branch), in a report on creating a future MAM officer personnel system. This report highlighted the qualifications of the 22 officers selected to fill PM positions in FY 87 and stated "MAM accessions, in general, are not occurring early enough to ensure [that] certification requirements can be met." The MAM survey was conducted in FY 88 and clearly points out that late accession into acquisition is still occurring.

• **Job Areas.** The changes to the MAM program personnel structure proposed by AMC establish five job categories or areas of concentration (AOC): Research and Development (FA 51A), Test and Evaluation (FA 51B), Combat Development (FA 51C), Acquisition (FA 51D), and Contracting and Industrial Management (FA 97A). The MAM survey job structure analysis supports each of the AOCs in the proposed restructure. However, the analysis also identified financial management as another major function or potential AOC involved in materiel acquisition management.

***Editors Note:** The restructured MAM program, described in the May-June issue of the Army RD&A Bulletin was developed in large part, to respond to the aforementioned problems with the current MAM program. The restructured MAM program was approved for implementation by the Army in August of this year. Details on program implementation will be forthcoming in future issues.*

YOUR OFFICER RECORD BRIEF (ORB)

Your officer record brief (ORB) is a key part of your Official Military Personnel File (OMPF) and is maintained at the U.S. Total Army Personnel Command (PERSCOM) in Alexandria, VA. Otherwise known as the DA Form 4037, the ORB is a record of personal and professional data primarily used by personnel managers. It is your military resume and precedes you to your next assignment, providing gaining commanders with an opportunity to review your qualifications and make an appropriate determination in assigning you to your new duties.

Along with the OMPF, your ORB is also forwarded to various selection boards. Considering the potential impact of these factors, it is of paramount importance that your ORB contain accurate, up-to-date information. To do this effectively, you are encouraged to exercise pride of ownership and ensure that each edition of your ORB is thoroughly reviewed by both you and the military personnel officer. Discovering an error following your non-selection may be a painful reminder of ORB neglect and an unfortunate experience for you and others concerned. It behooves the principal owner, therefore, to take the ORB seriously as a critical and sensitive official source of information. Before we go on, it is important to learn some of the facts pertaining to the ORB:

- The ORB applies only to active duty commissioned and warrant officers.
- The ORB is automatically produced from information contained in the officer master file (OMF) maintained by PERSCOM.
- Mandatory review of the ORB is held annually, usually during the quarterly period of the officer's birth month.
- When the annual review of personnel qualification records is complete, the officer and the personnel services unit representative will compare the data on the ORB with the data on DA Form 2B. Signatures of both individuals will attest to the completeness, accuracy and legibility of data on the ORB.
- Detailed instructions for reviewing each data item on the ORB are in table C-1-1, AR 640-2-1.

Personnel and assignment managers at PERSCOM manage thousands of officers, and are faced with similar manpower and budget constraints as are experienced elsewhere. This adds more significance to each officer's personal role in keeping their ORB both current and accurate.

The real secret is to always complete your annual birth month audits, and follow-up on the action taken. MILPOs only receive ORBs quarterly so your input won't be immediately viewable on a hard copy ORB; however, changes made by MILPOs do generate by-name listings of automated entry changes, normally a week following the date of input. It is advisable that you revisit your MILPO about two weeks after the annual audit and review in detail all changes made. Remember, the ORB is a record of your career and its accuracy is a reflection, at least in part, of your interest in that career. Take the time to get it right! One final point: if you know of an R&D officer (FA 51/FA 97, Skill 6T) not receiving the *Army RD&A Bulletin*, it may be because the address on their ORB is in error.

New Binoculars Get High Marks

According to an Army unit in Korea, they have better range pickup. A chopper outfit says they're safer to use. Recent usage reports from Army units in West Germany, Fort Sill, OK, Fort Hood, TX, Fort Bragg, NC, and the North Carolina Army National Guard didn't contain a single adverse remark.

A "must" for tankers, chopper crews and ground pounders alike, the Army's newest version has been rolling off the assembly line since March 1988 with little fanfare, trickling into Army units worldwide almost unnoticed.

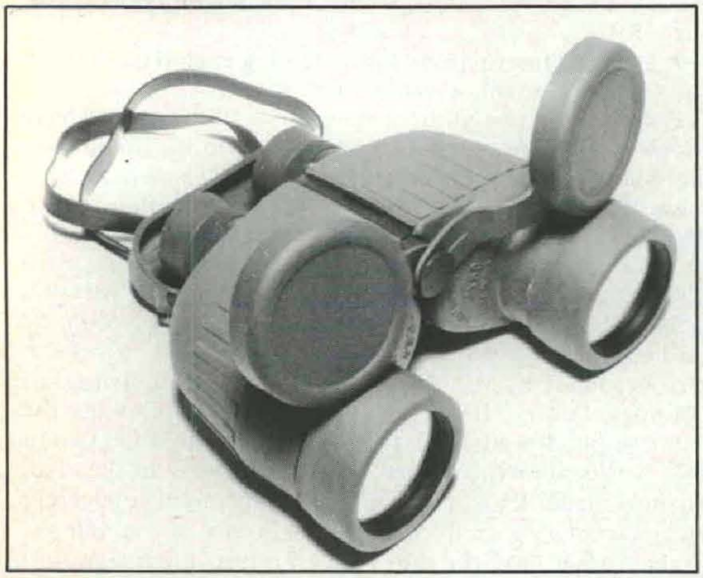
What's being produced at the rate of 5,000 a month are the Army's new binoculars, or "binocs," as soldiers call them.

A specially modified commercial version, the field glasses were developed at Picatinny Arsenal, NJ, over a three year period.

The new M22, encased in green rubber, replaces the old metal M19 version. It can be produced for one quarter the cost, has no carrying case and sports a special filter to neutralize laser attacks. Its body is made out of lightweight temperature resistant and unbreakable fiber-reinforced polycarbonate.

Produced by Steiner Optic of West Germany, it closely resembles the 7x50 military binocular which is being marketed in the U.S. by Pioneer and Co., Westmont, NJ, through hunting and marine stores.

Pioneer has the prime contract with the Army to build 72,000 M22s through 1991 and has subcontracted all but the laser filter production to Steiner. The filter contractor went directly to Optic Electronics Corp. of Dallas. Each binocular, including the special laser protection inserts, will cost $190.28.



With removeable front and rear protective covers, the Army's new binocular is much quicker to operate than the old M19 version, which is stowed in a bulky carrying case.

The new binocular, without the laser filter, is standard West German Army issue and other NATO armies are buying it too. Unlike its predecessor, the M22 is basically a "non-repairable" item, that is, if the body breaks it will be totally replaced. The only exchangeable items are the eye cups, eye lens cover, carrying strap, front cover and laser filter.

At 3.5 pounds with the laser filter, it weighs less than a half-pound more than the M19 with its carrying case and, like its predecessor, it has a 130 meter field of view at 1,000 meters. It comes with a removable neck strap and covers for both the eye lens and front glass and has foldable eyecups that helicopter crews say are safer to use because of the eye cushioning.

An adapter ring permits the user's optical characteristics to be set in both eyepieces. One of the telescopes includes a horizontal and verticle reticle graduated in 10-mil increments. The reticle is used to determine range based on known target widths.

ARO Selects AI Center Site

The Electronics Division of the Army Research Office (ARO) has competitively selected the University of Pennsylvania (Philadelphia) as the site for a continued initiative in artificial intelligence (AI) research. This 5-year contractual effort will include basic research in a number of thematic AI areas, and an educational program for Army/government personnel.

The University of Pennsylvania was selected because of the quality of the multi- and interdisciplinary AI research offered, the integration of this research with a strong program in systems engineering oriented computer science, and the strong overall educational program which is available.

Why an Army AI research center? There are at least two reasons. First, recent technology assessments have identified advances in the areas addressed by AI as being crucial to future Army systems development. Stated another way, attaining the performance and functionality requirements of future automated and computerized Army systems requires revolutionary advances in information systems science. Second, the ARO goal of a balanced research program, which blends the perceived advantages of individual investigator research efforts with an institutional level effort, has the potential to opportunistically exploit the "best-of-both worlds." That is, the individual focused contributions are augmented by the "integrating" aspects of the institutional effort.

Attempts to imbue computers with capabilities beyond automated paper and pencil routines have been fraught with frustration, and disappointment. However, significant progress towards the goal of adaptive, interactive, and intelligent systems have been made through application of AI principles. Examples of this include the expert systems now in use for systems maintenance, logistics, and training.

Ideas originating in the AI domain have altered the way we perceive and think about automated systems. AI based ideas are central to exploiting the many advances in hardware capability, and may be the key to addressing the growing software crisis.

Research at the University of Pennsylvania will include multifaceted projects in natural language processing; machine perception and robotics; investigations of programming structures for data and knowledge bases; study of parallel, distributed, adaptive, realtime and connectionist approaches for AI; and interactive interfaces with a focus on human task and performance evaluation and assessment.

This research is expected to produce new insights into the nature of opportunities for implementation of machine intelligence. Significant scientific publications, and the ongoing Army/university interactions should facilitate technology transfer to the Army user community.

Broadscope and continuing Army guidance and research assessment will be accomplished by the Scientific Adhoc Army AI Steering Committee, and additional evaluation will be provided by the participants in the annual 2-day research reviews held at the University of Pennsylvania. Further, there will be a mid-contract peer review of the research.

The AI educational program offering will consist of at least seven or eight courses each year (generally 3-5 days in duration). Course topics will vary from year to year, will be selected to meet the Army's needs, and will reflect the directions of current research. Some examples of likely course topics are natural language understanding; introduction to parallel architectures and processing in AI applications; multisensory integration; and databases and knowledge bases.

The courses are available free of charge to any government employee, and each year a booklet advertising the course schedule will be distributed to the ARO AI mailing list. Anyone interested in the courses or scientific participation on the Adhoc Steering Committee is encouraged to contact ARO.

Tuttle Becomes AMC Commander

GEN William G. T. Tuttle Jr. recently assumed command of the U.S. Army Materiel Command in Alexandria, VA. Tuttle formerly served as the deputy commanding general for logistics at the U.S. Army Training and Doctrine Command and the commanding general of the U.S. Army Logistics Center and Fort Lee at Fort Lee, VA. Tuttle succeeds GEN Louis C. Wagner Jr., who retired recently from active duty service.

Tuttle is a graduate of the U.S. Military Academy with a B.S. degree and has an M.B.A. degree in business administration from Harvard University. He has also completed the Infantry School, Basic Course; the Transportation School, Basic and Advanced Courses; the Armed Forces Staff College; and the U.S. Army War College.

During 1984-86, Tuttle served as commanding general, U.S Army Test and Evaluation Agency, Falls Church, VA.

Other key assignments have included chief, Policy and Programs Branch, Policy Division, Supreme Headquarters Allied Powers Europe; director of Force Management, Office, Deputy Chief of Staff for Operations and Plans, U.S. Army, Washington, DC; commanding general, Eastern Area, Military Traffic Management Command, Bayonne, NJ; and commander, Division Support Command, 3d Armored Division, U.S. Army Europe.

Tuttle's awards and decorations include the Distinguished Service Medal, Defense Superior Service Medal, Legion of Merit, Bronze Star Medal with two Oak Leaf Clusters, Defense Meritorious Service Medal, Meritorious Service Medal, Air Medal, and the Army Commendation Medal with Oak Leaf Cluster.

CONFERENCES

Power Sources Symposium Announced

The 34th International Power Sources Symposium will be held June 25-28, 1990 in Cherry Hill, NJ. Sponsored by the U.S. Army Electronics Technology and Devices Laboratory, other DOD agencies, NASA, and DOE, the symposium will feature 14 unclassified technical sessions devoted to presentations of scientific papers on new developments.

In addition, three investigators engaged in power sources R&D will address the attendees. Professor John W. Lorimer, University of Western Ontario, Canada, will speak at a rechargeable lithium batteries session. Professor Brian E. Conway, University of Ottawa, Canada, will be a guest lecturer at an unconventional power generation and storage session, and Dr. Roger Boom, University of Wisconsin, will address a session on superconducting magnetic energy storage.

Detailed symposium information may be obtained by writing Dr. Carl Berger, U.S. Army Electronics Technology and Devices Laboratory, LABCOM, ATTN: SLCET-P, Fort Monmouth, NJ 07703-5000 or telephone (201) 544-2084.

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