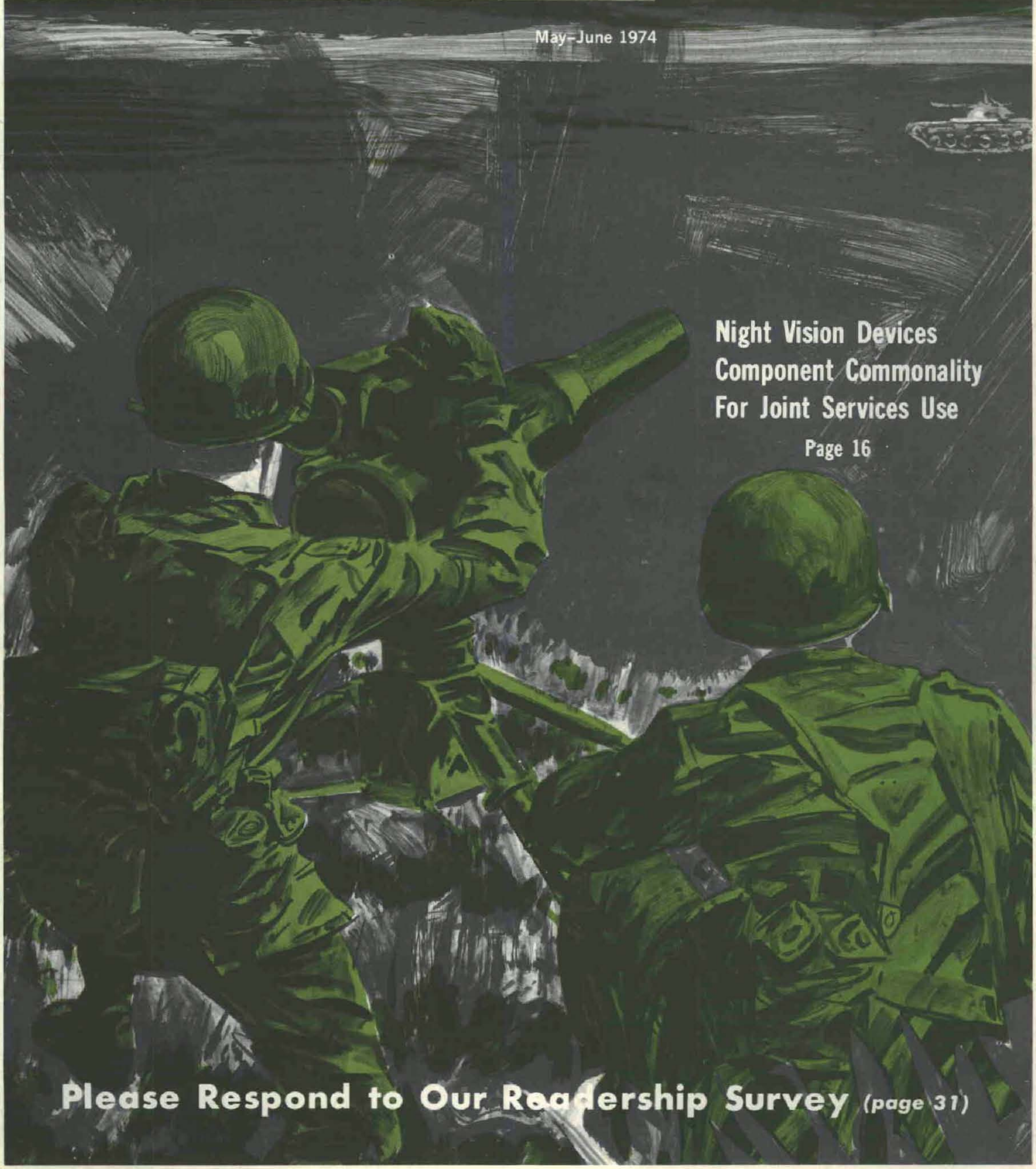
ARMY RESEARCH AND DEVELOPMENT

May–June 1974



Night Vision Devices
Component Commonality
For Joint Services Use

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Please Respond to Our Readership Survey *(page 31)*

SPEAKING ON . . .

Defense RDT&E FY 1975 Budget Proposals Sent to Senate Armed Services Committee

DIRECTOR OF DEFENSE Research and Engineering Dr. Malcolm R. Currie's Department of Defense Program of Research, Development, Test and Evaluation, FY 1975 presentation to the 93d Congress, Second Session, is a 250-page document outlining philosophy and facts in support of a $9.3 billion budget proposal. Space available in this edition permits coverage of only the "Overview."

Dr. Malcolm R. Currie

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I am privileged to appear before this Committee (Senate Armed Services), Mr. Chairman, to present the Defense Research, Development, Test and Evaluation budget request for Fiscal Year 1975 and to respond to questions.

We are requesting a total of $9.3 billion for Defense RDT&E. This is the largest sum ever requested for this purpose, but the real increase in RDT&E effort from Fiscal Year 1974 is relatively small—about 4 percent after proper allowance is made for inflation and for adjustments between appropriations.

Mr. Chairman, I believe this increase is vitally necessary and, in fact, is modest in light of the confluence of events of the past year. These events have affected the world and our perception of our place in the world. They have led, I believe, to an improved understanding on the part of serious Americans of the need for a strong national security program and the role of advanced technology in achieving it.

Events of the past year which directly influenced the level of RDT&E funding include:

- Massive Soviet demonstration of an ability to upset the nuclear deterrence equilibrium.
- The hard fact that SALT II has shown little progress.
- The Middle East war and its disquieting implications.

The Department of Defense has responded to these events with a set of research and development initiatives which are necessary, first, to provide the Nation with continued effective nuclear deterrence in the face of all foreseeable strategic threats and, second, to insure that our conventional forces will have the weapons necessary to cope with adversaries who increasingly use advanced weapons technology, along with the numerical superiority, to achieve their objectives.

We believe that the programs requested are necessary now—and that the return on this investment in Defense RDT&E will greatly strengthen deterrence and avoid hurried and expensive programs which might otherwise be required later.

Further, I believe that the time has come to halt and reverse the erosion of defense research and development buying power and the technological leadership we depend on. For several years our RDT&E effort has not kept pace with inflation, while the Soviets have continued to reduce our technological margin of security.

We do retain an effective margin, today, but the resolute Soviet technological progress now threatens to change the technology balance to our disadvantage within the lead time of our current research and development programs. Therefore, our FY 1975 programs must be right and must be sufficient to compensate for probable future Soviet advances. . . .

I believe that this FY 1975 request will be seen as sufficient and economical, if it is viewed in the context of this crucial juncture of world history and if there is an expectation that the money will be carefully spent.

I firmly believe that a well-conceived and well-managed strategy for the use of research and development constitutes the most powerful mechanism we have to insure our security and the health of our economy and, indeed, our place in history.

Let me express this in simple business terms. What I am talking about is Defense research and development deliberately used as a highly leveraged investment which will yield a return in national well-being immeasurably greater than the initial investment in dollars.

All of us in this room share responsibility for the broad direction our country takes in framing its program for national security. We can ask ourselves this question: Will future historians see us as people who failed to act decisively and boldly at this juncture, or will they see us as a people who reacted with strength, with a sense of purpose, with understanding of the technological well-springs of our strength?

I ask you to regard our research and development resources in this light. In return, I pledge to you the sense of responsibility, the sense of judgment, the sense of accountability that you and the American public deserve.

MAJOR BUDGET INFLUENCES. With your permission, Mr. Chairman, I will turn now to the major influences that shaped this budget request. Some of these influences are long term and enduring—the necessity to maintain world leadership in defense-related technology and the broad national security goals of strength, partnership and negotiation.

Other influences are shorter term—on the one hand, the rapidly evolving international environment which had a direct effect on this budget request and, on the other hand, a set of management initiatives and principles which will help insure that we buy only what we need and at an affordable and controlled cost.

U.S. Technological Superiority. American security, like the American economy, stands on a foundation of technological superiority. We need superiority in defense technology. First, because the openness of our society tells our adversaries what we are planning in military technology while their secrecy forces us to provide for many possibilities.

Second, in military operations, we traditionally depend on superior quality of equipment to compensate for inferior numbers. Third, in order to interpret vital but fragmentary technical intelligence information, we must have had extensive prior experience in the area.

Finally, we react to aggression; we do not initiate it. Consequently, we must be thoroughly and broadly prepared for crises and wars in circumstances and at places chosen by our adversaries. The Soviet technological progress now threatens our superiority. This budget is designed to preserve it.

Basic National Objectives. This budget is designed also to provide technological support for the broad national objectives of our foreign and defense policies. As repeatedly stated by the President, the goals are strength, partnership and negotiation. Defense research and development must contribute significantly to all three.

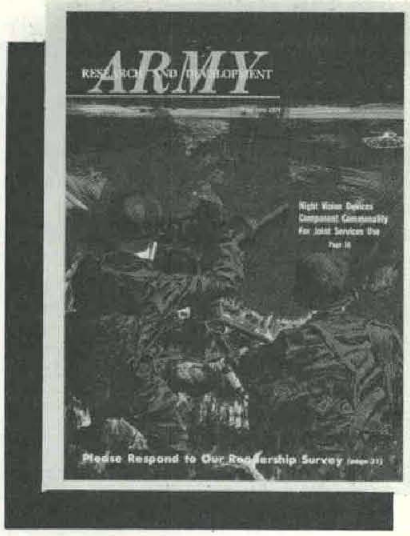
Our strength comes from the strength of our Armed Forces, whose quality—past, present and future—is based on a wise use of rapidly evolving technology. Quality is particularly important if we are to preserve our over-all strength despite sharp reductions in force levels since 1968. In addition, Defense R&D contributes to partnership with our Allies by providing options for systems which can be used effectively by them and be creating confidence in the ability of the U.S. to meet all challenges. Defense R&D contributes to negotiation by maintaining capabilities which our potential adversaries will not wish to confront and by creating incentives to our adversaries to abide by agreements. . . .

Strategic Equilibrium. The Soviet Union is continuing a massive program in strategic weapons development which offers various combinations of numbers, explosive yield and accuracy which could undermine the U.S. effort to maintain essential equivalence in deterrent capabilities.

Soviet demonstrations include four new ICBM systems with increased throw weight—three of which have a MIRV (Multiple Independently Targetable Reentry Vehicle) capability—a new generation of guidance technology and an elaborate program of hardening and testing silos. Other efforts include new SLBMs (Submarine Launched Ballistic Missile), an aggressive ABM research and development, and an impressive implementation of hardened command and control.

Mid East War. During the recent Middle Eastern conflict, various high-technology So-

(Continued on page 28)



ABOUT THE COVER . . .

Night-time destruction of a tank by the TOW weapon system equipped with a night-vision sight is depicted. The U.S. Army Electronics Command Night Vision Laboratory, Fort Belvoir, VA, is assigned Lead Laboratory responsibility by the Army Materiel Command for developing "commonality of components" for night vision sights to meet Department of Defense requirements.

Shown on the back cover is the largest solar furnace in the U.S., relocated from the Natick (MA) Laboratories to White Sands (NM) Missile Range, where it is part of a family of facilities for electromagnetics effects tests on critical weapons components.

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Grateful acknowledgement is made for the valuable assistance of Information Offices within the Army Materiel Command, Office of the Surgeon General, Office of the Chief of Engineers, Army Training and Doctrine Command, Army Forces Command, Office of the Assistant Chief of Staff for Force Development, Office of the Assistant Chief of Staff for Communications-Electronics, Computer Systems Command, and miscellaneous related activities. Use of funds for printing of this publication has been approved by the Department of the Army, Jan. 1, 1974.

Purpose: To improve informal communication among all segments of the Army scientific community and other Government R&D agencies; to further understanding of Army R&D progress, problem areas and program planning; to stimulate more closely integrated and coordinated effort among Army R&D activities; to express views of leaders, as pertinent to their responsibilities, and to keep personnel informed on matters germane to their welfare and pride of service.

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FEATURES

DEPARTMENTS

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Selective Scanner . . .

PRL Reports on 1973 In-House Research Activities

Abstracts describing 117 in-house basic and applied research activities of the Pioneering Research Laboratory (PRL) of the U.S. Army Natick (MA) Laboratories are contained in PRL's recently published 18th annual report—probably the last PRL report.

Activities are listed in the Life Sciences, Physical Sciences, Engineering, and Psychology, including various pollution abatement studies and projects. The PRL supports research on foods, feeding systems, packaging, clothing, and life support equipment.

A new addition to the Natick Labs pollution abatement program is a Bioenvironmental Engineering Facility. Comprised of a multi-purpose pilot plant, support laboratory, and office space, the facility houses biological, chemical, and physical processes equipment.

Major areas of research listed in the report's life sciences category include microbiology, mycology, entomology, biochemistry, and biophysics. Physical science research encompassed analytical, organic, photo and radiation chemistry; quantum physics, thermodynamics; taste and olfaction; and analysis of appetite, choice, and consumption.

Analysis of factors in food acceptance and appetite was a major psychological investigative area in the applied research field. Microbiology, zoology, chemistry, engineering, and military performance in relation to parameters of clothing, personal equipment, acoustics and materiel also are listed under the applied research category.

Supplementing the abstracts is an extensive list of technical publications and reports presented during CY 73. Conferences, seminars and symposia are outlined in the appendix. No contractors reports were published in CY 1973.

Five of the Natick Laboratories are scheduled for abolition as part of an organization realignment expected to establish most of their elements within a Food Engineering Laboratory, Aero-Mechanical Engineering Laboratory, a Clothing, Equipment and Materials Engineering Laboratory, and a Food Engineering Laboratory (FEL). Most of the continued PRL activities will be a part of the FEL; some will be assimilated into other groups.

Realignment Explained Under Deputy ACS *(RDA)*

Key personnel changes linked to establishment of an Office of the Deputy Chief of Staff for Research, Development and Acquisition, as successor to the Office of the Chief of R&D, were unannounced at press time.

Announcement by the Army Chief of Staff of the order effecting the realignment of major functions within the staff is expected about May 20. Pending approval by Congress, the new ODCSRDA will be known as the Office of the Chief of Research, Development and Acquisition, with LTG John R. Deane Jr., the present Chief of R&D, heading the ODCSRDA.

Incorporated in the ODCSRDA will be the materiel life cycle integration functions transferred from the Assistant Chief of Staff for Force Development (ACSFOR), the R&D functions from the Chief of R&D, and appropriate procurement functions from the Director of Materiel Acquisition, Office of the Deputy Chief of Staff for Logistics.

The reorganization plan provides for integration of the procurement and development functions within the Office of the Chief of Staff; also, for a clear definition of relationships between the Deputy Chief of Staff for Research, Development and Acquisition and the Deputy Chief of Staff for Logistics in the area of procurement.

Systems review and analysis functions now performed by the Director of Materiel Programs, Office of the Chief of Staff, will be transferred to the DCSRDA, who also will be concerned with the planning, programing and budgeting for six separate appropriations. These are Research, Development, Test and Evaluation as well as appropriations for aircraft, ammunition, missiles, weapons and tracked combat vehicles, and other procurement.

Staff responsibility for R&D in the behavioral and social sciences will be transferred from the Chief of R&D to the Deputy Chief of Staff for Personnel, including supervision and control of the U.S. Army Research Institute for Behavioral and Social Sciences.

Chief of R&D responsibilities for environmental sciences are being transferred to the Chief of Engineers, and for the life sciences to The Surgeon General. The Army Materiel Command takes control of the U.S. Army Research Office in Durham, NC, and the U.S. Army R&D Groups in London, England, and Camp Zama, Japan. The DCSLOG Data Processing Center, Radford, VA, is redesignated the DCSRDA Information Systems Agency.

The ODCSRDA will consist of four directorates and two separate offices:

- Chief Scientist, Department of the Army, and Director of Army Research (a dual-hatted position with responsibility for research in the 6.1 budget category and for Army Scientific Advisory Panel matters).
- Director of Combat Support Systems, with three operating divisions. The divisions will have responsibility for exploratory development (6.2) through procurement in the areas of command, control and surveillance systems, munitions, and combat support systems.
- The Director of Weapons Systems, also with three operating divisions and similar responsibilities in the areas of aviation systems, missiles and air defense systems, and weapons and combat vehicles.
- Director of Materiel Plans and Programs with staff responsibility for preparation of the budgets; formulation of DA guidance and policy for management, planning, and execution of life cycle management; and international cooperative research and development programs.
- The separate offices will consist of the Systems Review and Analysis Office, with responsibility for performance of independent review and analysis of materiel systems and programs and ASARC matters; and the Office of the Chief of Administration.

New YPG Facility to Support Armament R&D

Support for research, development, test and evaluation of artillery and vehicle-mounted armament systems will be provided by a new $2.3 million facility recently opened at Yuma Proving Ground (YPG), AZ.

Construction on the weapons evaluation facility began in April 1972 following several years of continual increases in the workload of long-range artillery testing. Approximately one-third of the new building will be allocated for physical measurement and nondestructive test activities.

Assigned mission responsibilities of YPG include engineering design and tests of the 155mm, 175mm and 8-inch artillery and their related munitions (conventional, improved standard conventional, and rocket-booster).

Measuring about 300 feet by 300 feet, the new facility features a craneway in three bays for 40-ton and two 10-ton overhead traveling bridge cranes; large exterior doors; a 50-foot concrete apron extending outward from all exterior walls; and a paint shop and sandblast area.

Scheduled facility activities will include assembly, disassembly, magnetic particle inspection, borescoping, optical tooling, measurements, dye and fluorescent penetrant testing, star gauging and total repair, and modifications and maintenance.

Army Contracts for Combustor Engine Research

Demonstration tests of two previously developed low-pollution combustors in a gas-turbine engine, with a view to developing advanced engines without compromising performance or durability, will be performed under a $304,000 contract awarded by the Army Air Mobility R&D Laboratory.

The contract with Detroit Allison Division of General Motors

Corp. is part of a continuing effort by the USAAMRDL to reduce polluting emissions from aircraft engines. Results will be integrated into future combustor R&D programs.

Design criteria for protection of Army helicopter fuel tanks against 23mm HEI-T (High-Explosive Incendiary Tracer) ammunition will be developed by Dynamic Sciences Division, Ultra Systems, Inc., under a 12-month $77,000 contract. The study is titled "Reduction of Fuel Tank Vulnerability to 23mm HEI-T."

Ohio State University Research Foundation is conducting a program, under a $60,000 contract, to reduce testing time currently required to develop new aircraft components. Titled "Investigation of Accelerated Life Prediction Techniques," the research program will derive a mathematical model for wear failure mode of typical helicopter bearings, and develop and conduct accelerated tests to determine the validity of modeling.

Army Expands Electromagnetic Effects Testing

U.S. Army capabilities of evaluating effects of electromagnetic energy on Army missiles and equipment, with emphasis on electronic controls for weapons systems, have been complemented by another new test facility at HQ Missile Command, Redstone Arsenal, AL.

Installed as part of Test and Evaluation Directorate facilities, the new Electromagnetic Radiation Effects Test Division test chamber is described by a MICOM engineer as "similar to a big microwave oven."

Charles Ponds, division chief, said one of the areas of investigation in using the new facility will be the possibility of electromagnetic effects ("stray electrical systems") causing the firing of a missile motor or warhead. Using this knowledge, design engineers can then take protective measures—that is, "harden" motors and warheads.

Among Army missiles now in development that will be tested in the new chamber—large enough to accommodate the entire system as it is mounted—are SAM-D (Surface to Air Missile Development), Heliborne Laser Fire and Forget Missile System (HELLFIRE), the Stinger, and Short-Range Air Defense System (SHORADS). The chamber can simulate almost all electromagnetic environments a missile might undergo in actual flight.

The facility includes a transmitter that can generate a broad spectrum of frequencies from very low to ultra high, and the 40-feet-cube radio frequency test chamber.

Completely computer controlled, the RF facility can transmit, radiate and even absorb energy so that none escapes into the atmosphere. The computer runs the test, gathers data and provides a printout to show how equipment performed.

Prior to availability of MICOM's new test facility, some similar testing was done at White Sands (NM) Missile Range and at Picatinny Arsenal, Dover, NJ.

HDL Modifies Army Sensor for Navy Use

Modification of an Army-designed fluidic-controlled velocity sensor, conceived by the Harry Diamond Laboratories for use in mortar and artillery fuzes, has resulted in its acceptance by the Navy for use in dispensing pyrotechnic devices from aircraft.

Assistance of HDL engineers was provided at the request of the Naval Weapons Center, China Lake, CA, in development of Airborne Pyrotechnic Dispenser SUU-53/A. The dispenser had demonstrated capability of releasing 40mm pyrotechnic devices from primarily fixed-wing aircraft. Improvements were needed to meet newly established Tri-Service ground safety requirements.

The modified sensor functions as a safe and arming device, preventing the dispenser from functioning on the ground and in the air during landing and takeoffs at 150 knots or below.

The sensor permits the dispenser to fire off the pyrotechnic devices at speeds above 170 knots up to altitudes of 35,000 feet. The fluidic velocity sensor transforms incoming ram-air energy into proportional electrical energy.

The discriminatory sensitivity provides the required Tri-Service safety required by the standards to assure that misfirings will not occur prior to takeoff or during landings of high-performance aircraft. Important design features include an ice deflector and a 2-stage self-cleaning filter to enable the fluidic system to operate in air streams containing rain, ice, dirt, salt and nonfluid debris.

Hijacked Truck Detection Technique Studied

Civilian police helicopters might soon be aided greatly in locating hijacked trucks by using a new technique developed by a 3-man research team at the U.S. Army Electronics Command's Electronic Warfare Laboratory, Fort Monmouth, NJ.

Developed at the request of the U.S. Department of Transportation, the technique would involve the placement, on all trucks, of small transponders activated by a transmitter-receiver. A helicopter might then pinpoint, possibly within minutes, the location of a missing vehicle.

Potential application of the system, with permanently positioned ground transmitter-receivers for truck traffic monitoring operations, is being studied. Each truck would be assigned a number programed into the helicopter transmitter and the permanent transmitter-receivers.

A transponder-equipped truck carrying valuable cargo could be routed in such a way as to monitor its passage within an area of the permanent transmitter-receivers. If no signal was received from the vehicle during a specified time, a helicopter would be dispatched to the general area in which the truck disappeared. Ground crews would be notified when the truck was located.

The system has been successfully tested and demonstrated for the DoT using a fixed transmitter-receiver with transponders mounted at both fixed sites and on moving vehicles. Ardell V. Silverhus, Joseph A. Matava and Dr. Dirk R. Klose, developers of the technique, see several other applications for the system.

Curds and Whey Used as Dry Milk Substitute

Fortified curds and whey, a modern version of the fairy tale food of "Little Miss Muffet," has proved acceptable in beverage powder form as a substitute for dry milk powder now supplied under the Food for Peace Program for preschool children in underdeveloped countries.

That is the conclusion of U.S. Army Natick (MA) Laboratories food scientists after more than 4,000 acceptability tests conducted among children, along with 2,000 tests among their mothers, in more than 60 foreign feeding centers. Tests were conducted jointly in response to a request for assistance from the U.S. Department of Agriculture.

Because of the continuing inflation in prices of dry milk powder—more than doubled in recent years—and decreased production, the USDA was requested, in conjunction with industry, to develop an acceptable substitute mixture. A combination of sweet whey, full-fat soybean flour, soybean oil and corn syrup solids—fortified with vitamins and minerals—was found to be an "excellent source of protein."

The USDA Products Laboratory's considerable research on the product established that the beverage powder could withstand overseas storage conditions and offer the same nutritional qualities as dry milk powder. The developers also were confident that they had produced an acceptable food.

Proof of this acceptability was the next step. That brought into play the established expertise of the U.S. Army Natick Laboratories to assist the USDA researchers in a survey. Tests were conducted in Chile, Vietnam, India, Pakistan, Sierra Leone and the Dominican Republic.

Plans are being made to produce and ship overseas, on a monthly basis, one million pounds of the new beverage, and gradually increase exports over two to three years.

More than 10 million preschool children, pregnant women and nursing mothers are expected to begin receiving this nutritional supplement through the Food for Peace Program.

R&D News . . .

Corps of Engineers Continuing Fibrous Concrete Test Program

Fibrous concrete, termed the "Construction Material for the 70s" as the theme of a conference that attracted some 300 concrete experts in May 1972, has entered another phase of study at the Army Engineer Waterways Experiment Station (WES), Vicksburg, MS.

Researchers at the Construction Engineering Research Laboratory (CERL), Champaign, IL, also are continuing intensive developmental and testing activities to determine the potential of fibrous concrete, particularly for airfield runways and highways.

Interest of the Corps of Engineers in the vast potential application of this material dates to the mid-1960s and CERL testing has been in progress since 1970.

WES engineers subjected fibrous concrete to two series of airfield tests (January 1971–March 1972 and March 1972–May 1973), using four strips of pavement. Studies have been conducted in support of Army and Air Force airfield design doctrine, with support from the Federal Aviation Administration.

Simulated and real loadings of the huge C-5A and 747 aircraft have been used in the series of tests to date. Generally, results have showed that outstanding performance can be obtained from relatively thin pavements made from a mixture of concrete and randomly dispersed steel fibers.

Comparison studies of fibrous concrete (see Fig. 1) and plain concrete have definitely established the superior durability and reliability of the material strengthened with steel fibers of varying density dispersion, length and diameter, Corps of Engineers reports state.

Commercially available steel fibers have been used, with the length varying from ½ to 2½ inches and the diameter from 10 to 25 mils. The typical WES mixture contains 1-inch fibers, with the content varying from 100 to 300 pounds a cubic yard. The larger the aspect ratio of the fibers (length/equivalent diameter), the less fiber content is required to produce a given strength.

Experimenters at WES studied the properties of fibrous concrete with respect to the need for expansion joints in stretches of pavement. They laid a road 1,000 feet long, 24 feet wide and 4 inches thick without joints.

Seven "curing" cracks appeared, dividing the road into concrete slabs ranging from 60 to 240 feet long. Crack widths varied from 0.2 to 0.5 inches. Based on the results, it is believed proper joint construction may prove that uniform slabs 100 feet long are practicable for roadways.

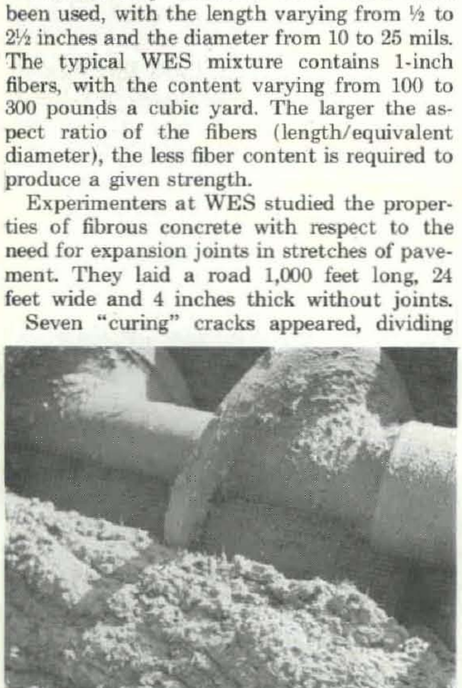


Fig. 1. STEEL FIBERS in concrete matrix.

Fig. 2. VIBRATING SHAKER passes fibers onto conveyor belt at a rate of about 800 pounds per minute. The fibers were dumped into shaker by a front-end loader.

Subsequently, in Green County, IA, an overlay project on three miles of U.S. Highway 30 was conducted under sponsorship of the County Board of Supervisors and the Iowa Highway Research Board. Support was provided by 27 concrete materials and reinforcing suppliers.

The project consisted of forty-one 400-foot sections. Test variables included pavement thickness, steel-fiber content, cement content, joint spacing and bonding. An elaborate system was devised for evaluating results of the overlay experiment and reports will be published by the Iowa Highway Research Board as data become available.

Innovations in the overlay project included the use of a large U.S. Steel Co. vibrating shaker (see Fig. 2) to place the fibers on the conveyor belt that changed the mixes; also, the use of a rotary texturing machine on fibrous concrete.

Construction Engineering Research Laboratory scientists and engineers also are experimenting in using fibrous concrete for other structures such as full-size beams, approximately 12″ × 18″ × 23′, and inflation forming of domes.

Normally, such concrete domes use an elaborate reinforcing scheme of springs and rods. CERL has successfully replaced the reinforcing with steel fibers in domes nine feet in diameter and three feet high (see Fig. 3). A 28-foot-diameter, 9-foot-high dome is programed for construction.

The largest fibrous concrete construction project to date was completed in March 1974, involving a 25,000-square-yard overlay, four inches thick, on an asphalt pavement Hardstand Park Area for maintenance on tanks and half-trucks at Fort Hood, TX.

Various other test pavements using fibrous concrete have been laid, including test areas at airport runways. In all experiments, researchers say the fibrous concrete has demonstrated superior qualities of durability in heavy traffic and heavily weighted vehicles.

Problems remain to be solved, however. Outside of the use of the U.S. Steel Co. shaker for placing the fibers onto a conveyor belt, no new mixing procedures have been established. Balling of the fibers continues to be a problem.

The procedure that is most effective for one project may not work for another. Balling, it appears, can be kept to a minimum by running full-scale trial mixes with the equipment that is to be used for the project.

Recently, the trend has been toward the use of smaller diameter, shorter steel fibers (low-aspect ratio) because of their superior mixing characteristics. Still to be evaluated for more conclusive results, however, is the effectiveness of these short fibers as compared to the larger ones.

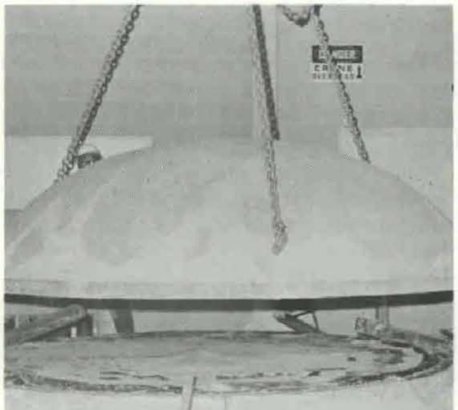


Fig. 3. CERL has fabricated domes nine feet in diameter and three feet high, by substituting steel fibers for the normal reinforcing scheme of springs and rods.

HumRRO Report Stresses Aviator Refresher Training

Maintenance of a minimally acceptable level of U.S. Army aviator flying ability requires refresher training at least every six months, a new Human Resources Research Organization (HumRRO) Technical Report 73-32 states.

Titled "Retention of Flying Skills and Refresher Training Requirements: Effects of Nonflying and Proficiency Flying," the report covers a survey conducted for the U.S. Army Institute for the Behavioral and Social Sciences in response to increased nonflying duty assignments of Army aviators.

Proficiency refresher flying as typically performed in the past has not been effective in maintaining flying skills at acceptable levels, the report states in pointing to large losses in flying ability.

About 90 percent of all losses in flying ability over extended periods of nonflying time occurs within 12 months. Thereafter, the report states, flying ability and required refresher training remain practically constant.

Copies of TR 73-32 may be obtained from: HumRRO, 300 North Washington St., Alexandria, VA 22314.

MASSTER Personnel Considering Feasibility Of Helicopter Ground Movement Systems

How can helicopters be moved quickly and with maximum safety, with the engine turned off, over rough terrain to an area where they can be camouflaged or concealed for refueling, rearming or repairs, under combat conditions in a mid-intensity conflict?

This is the question being studied by test personnel in Modern Army Selected System Test, Evaluation and Review (MASSTER) of six different helicopter ground movement systems at Fort Hood, TX.

Experts have long recognized the problem that a camouflaged helicopter, regardless of the type of material used, still looks like a helicopter—especially when it can't be moved under trees or other natural concealment.

Test officer CPT Preston Forsythe explained that there are several methods now in use to move helicopters on the ground, but all these methods are for use on hard, smooth ground and are not designed for use over unimproved, rough terrain.

Systems involved in the test include fly wheels, a helicopter transporter, an air-cushion field dolly, power ground-handling wheels, a rough-terrain system, and a ground-handling wheel adapter bar. Each prototype will be examined for its mechanical capabilities, repair requirements, and safety and operational human factors.

Basically, the fly wheels are a series of 15-inch-wide tires equipped with either a manual or an electric hydraulic system. Wheels are attached to helicopter skids and the hydraulic system allows the helicopter to be lifted high enough to clear rocks and other small obstacles. A tow bar is then attached to the device and a group of men, a jeep or other vehicle can pull the helicopter to a new site.

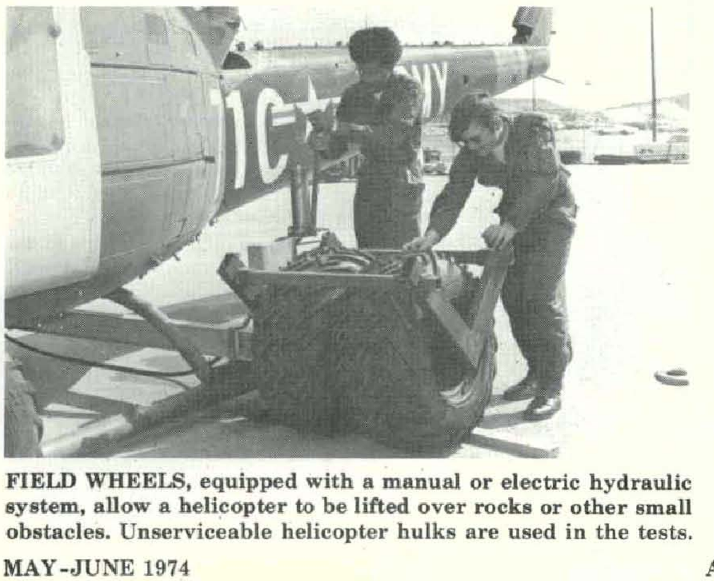
The transporter is a battery-powered tracked vehicle less than two feet high, equipped with a winch and two metal roller conveyors that line up with the skids of a helicopter. The winch is used to pull the helicopter on roller conveyors to the top of the transporter where it is then maneuverable by one operator.

A third device under study is an air-cushion field dolly, similar in principle to commercial hover boats that skim across the water on a cushion of air. Usable on either water or land, the system consists of a 20-foot platform with two separate engines and fans that make the platform hover. The dolly can carry up to 10,000 pounds, but it has no means of lateral propulsion and has to be pushed or towed. The power ground-handling wheels are attached to helicopter skids for mobility. Each set of wheels has a gasoline engine for propulsion.

Another new test item is the rough terrain system self-powered by gasoline engines and using tracked units that look like miniature tanks. A hydraulic lift system places the helicopter onto the carrying tracks and a third wheel in front of the helicopter balances the system.

Under study also is a ground-handling wheel-adapter bar, intended for use only with the OH-58 observation helicopter. Standard ground-handling wheels used on the UH-1 "Huey" helicopter are placed on the OH-58, where they provide increased clearance and more flotation than the smaller standard OH-58 wheels. A tow bar enables a vehicle to pull the helicopter.

Helicopter crewchiefs from the 1st Battalion, 9th Air Cavalry, 1st Cavalry Division, are assisting in tests of the six systems under study.



FIELD WHEELS, equipped with a manual or electric hydraulic system, allow a helicopter to be lifted over rocks or other small obstacles. Unserviceable helicopter hulks are used in the tests.

HELICOPTER TRANSPORTER is a battery-powered, tracked vehicle with a winch to pull helicopter onto roller conveyors.

Rapid Proliferation of Management Studies In Recent Years Traced Back 140 Years

Rapid proliferation of technological forecasts and resource allocation studies on a global basis in recent years, as a top management approach to highly complex decisions involving millions or billions of dollars, is reflected in a recent proposed article for the *Army R&D Newsmagazine*.

Space available does not permit publication of the historical, review-type article, replete with numerous charts and tables. The author, LTC Donald M. Keith, is chief of the Integrated Logistic Support Division, Logistic Management Directorate of the Joint Tactical Communications Office (TRI-TAC), Fort Monmouth, NJ.

The problem of how to spend money most effectively for national defense and studies directed to that goal, LTC Keith points out, can be traced back at least 140 years. With reference to U.S. defense history, he divides his review since 1920 into seven time frames, the last (1969-74) termed "The Age of the Purple Man." He explains:

"Purple is the unofficial color of the Joint Services and operations research. When a serviceman wears the purple suit, he should no longer espouse his own service line, but should emulate a joint rationale. What are the reasons for this new look? There are two major ones.

"First, personnel and equipment have become astronomically costly, almost unbelievable. Second, as the flow of available dollars diminished, people with divergent voices have been more willing to see each other's points of view, resulting in certain economies. . . ."

LTC Keith cites as the source of some of his statistical findings Erich Jantsch's "Technological Forecasting in Perspective," Organization for Economic Cooperation and Development—Paris 1967; also, from a bibliography of selected publications, "Weapons System Acquisition; Strategy Policy and Procedure," Rand Corp., Feb. 1973, and a report bibliography, "Resource Allocation," Defense Documentation Center, Alexandria, VA, Aug. 1973.

These sources indicated that no studies were reported during World War I, only five were reported during 1939-45 World War II years, and 27 were made during the 1950-55 Korean conflict years. During some of the Vietnam years (1963-67), 248 resource allocation studies and technological forecasts were listed.

One U.S. defense contractor alone performed 110 studies in "Weapon System Acquisition" from 1958 to 1972, with 94 of these since 1962. The Defense Documentation Center data bank provided abstracts of 285 reports (1957-73) with all except three published between 1962-73.

Monograph Describes Chemical Immunology

Chemical reactions that occur in the human body to produce immunity against bacteria or other foreign elements are discussed in a new monograph, authored by Dr. Ludwig A. Sternberger, chief of the Immunology Branch, Edgewood Arsenal, MD.

Titled *Immunocytochemistry,* this volume is one in a continuing series of books by noted scientists designed to provide a comprehensive view of immunology, in textbook format, to medical personnel, scientists, students and teachers.

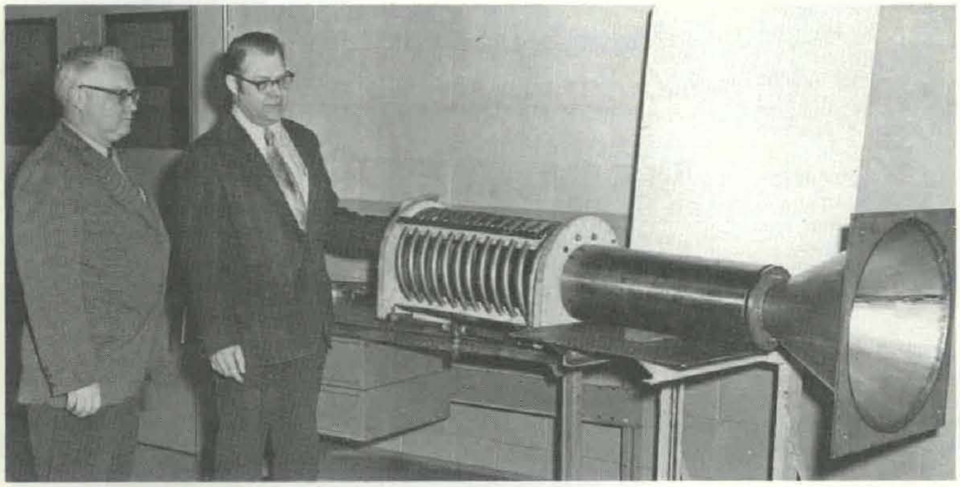
A native of Germany, Dr. Sternberger received his BA degree (1941) and MD degree (1945) from the American University of Beirut. He has authored more than 40 research articles and was a 1972 Paul L. Siple Silver Medallion Memorial Award recipient for his research contributions on a vaccine to combat organophosphorus insecticide poisoning.

Watervliet Autofrettage Techniques Aid Cannon Tube Research at NWL

Heavy weapons test data resulting from in-house laboratory studies at the Materials Engineering Division, Watervliet Arsenal, NY, are aiding cannon tube research efforts at the Naval Weapons Laboratory, Dahlgren, VA.

Joseph Throop, director of the arsenal's Fracture Mechanics Laboratory, is studying the feasibility of applying an autofrettage technique to the development of rapid-fire naval cannons. Longer cannon fatigue life is believed possible with an arsenal-developed autofrettaged gun tube.

Problems under evaluation include metal yielding and changes in tube bore size which are caused by high temperatures and residual effects of autofrettage techniques. These conditions could ultimately reduce firing accuracy and create tube fractures.



TESTING EQUIPMENT designed to determine the possiblity of using the autofrettage process in manufacturing naval gun tubes is examined by Joseph Throop (right) and Bruce Brown. Hot gases, which simulate those generated within the gun tube when the weapon is fired, are directed through the funnel-like device. At the same time, water simulating cold sea spray is forced through the coils at the rear of the gun tube.

A reduction in bore diameter might also cause a projectile to stick in the tube, creating an in-bore explosion from the impact of the succeeding projectile. Severe climatic conditions at sea are also seen as a contributing factor in thermal stress and reduced bore diameters.

Throop is examining the effect of thermal stress on thick-walled cylinders which have undergone various degrees of autofrettage. Results of these tests will determine the amount of autofrettage that can safely be applied in the manufacture of naval cannon tubes. Assisting Throop are metallurgist John Underwood and physical science technicians Ron Abbott and Charles DeLaMater.

Under combined firing and laboratory simulation tests, Bruce Brown, head of the arsenal's Fatigue Laboratory, established the safe firing life for 5-inch guns, a definition of their failure mode and guidance for future improvements. The U.S. Navy is applying this data for establishment of the safe fatigue life for fleet cannons and development of a new 5-inch gun.

Brown is also testing new materials for Navy gun barrels. Data generated from these tests permits selection of materials based on application performance results rather than less accurate reliance on standard handbook information.

Other participating test personnel included mechanical engineering technician George Sogoian; physical science technicians Steve Bell, John Williams, James Kelly, and Bruno Gustini. Ultrasonic testing and training of Naval personnel was provided by electronics technicians Abe Rubin and John Zalinka.

AMMRC Evaluates New High-Strength Alloy

Introduction of hot-pressed aluminum-graphite fiber bar and sheet composites has been evaluated as a meaningful advance in high-strength lightweight material, the U.S. Army Materials and Mechanics Research Center has announced.

Dr. Lawrence A. Shepard

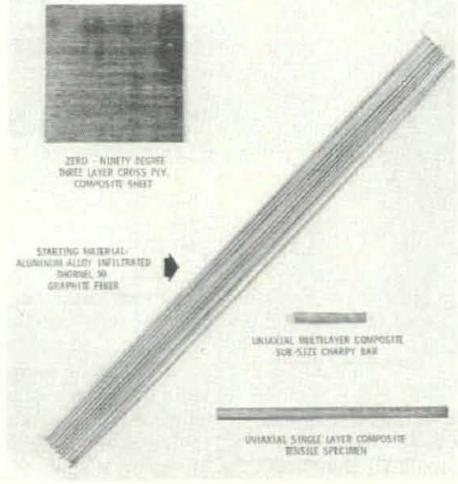
Dr. Lawrence A. Shepard evaluated the material produced under contract by Fiber Materials, Inc., Biddeford, ME. Dr. Roger T. Pepper was the principal investigator, assisted by Dr. R. A. Penty and S. J. Allen.

The composite is a continuously produced wire, one-tenth inch in diameter, consisting of eight strands of 2-ply thornel 50-graphite fiber infiltrated with molten aluminum alloy. The process for cleaning and infiltration of the graphite fiber allows uniform wetting and bonding of the matrix without the formation of deleterious alumunum carbide, researchers say.

Weighing only about one-half as much as titanium and one-third as much as steel, the composite is thus, on a strength-to-weight basis, "roughly twice as stiff as titanium or steel, and as strong as the best alloy of either."

Dr. Shepard and the investigators cautioned, however, that the "processing of the material is still under active development, and the initial test program was quite limited in scope."

Impurity segregation in the alloy during pressing caused a "rather low transverse strength and . . . a lower compressive strength than expected. Failure occurred at the aluminum bond boundaries. Investigators say they are confident that this 'relatively lesser problem' can be overcome."



R & D NEWS

Frankford Develops BLHS To Record Projectile Flight

Precise 3-dimensional measurements of in-flight projectile yaw, velocity, shock wave and fragmentations are possible with a new Ballistic Laser Holographic System announced by Frankford Arsenal, Philadelphia, PA.

Developed in the Ammunition Ballistics Range Branch, the BLHS uses coherent properties of laser light to obtain a 3-dimensional visual record of a projectile flight.

The system is designed to withstand the high-intensity shock environment of weapon firing and supersonic projectiles. Any object located within an 8-cubic-foot area is considered within photographic range.

Since all but laser light is filtered out during activation of the system, the result is a clear image of the precise nature of a projectile sabot interaction at emergence from the muzzle. Previous attempts to examine this ballistic process had been frustrated by intense light flashes of burning propellant.

Utilizing the holographic system, it is also possible to record and measure the expansion of a gun barrel as a projectile accelerates along its length. Additionally, the system can operate as an interferometer, thus providing visibility to the shock waves emanating from a supersonic projectile.

The system duplicates data normally obtained through use of a full-scale wind tunnel, but has the advantages of providing measurements during actual projectile flights, requiring less setup time, and being considerably less expensive to operate.

ERTS-1 Provides Data . . .

CE Takes Inventory of Inland Dams

An inventory of all dams 25 feet or more in height, or which impound 50 acre-feet or more of water, is being taken by the Corps of Engineers (CE) with data provided by NASA's Earth Resources Technology Satellite (ERTS-1). Inventory requirements are established by the National Dam Safety Act.

The U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, has developed a set of computer algorithms to extract inventory data rapidly from ERTS-1 photos and to produce outputs that are readily usable by field investigators.

The ERTS-1 Multispectral Scanner (MSS) contains four sensors, each sensitive to a band of energy in the visible or near-visible portions of the electromagnetic spectrum, ranging from 0.5 micrometers to 1.1 micrometers.

Black-and-white photographs made from each of the bands (see photo below). Color composites, made by combining data from three of the four bands into a color picture, present scenes that look familiar to the layman. However, much less familiar quantitative information can be derived from ERTS-1 results.

Each ERTS black-and-white photograph consists of more than 7.5 million rectangular elements arranged in a 3250×2340 orthogonal array. Each of these elements (referred to as a "pixel") represents a corresponding rectangular area on the earth's surface for which the MSS has measured the reflected radiant energy (radiance).

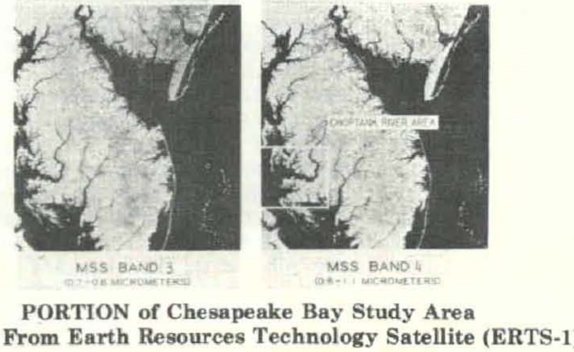
The photographs are the result of exposing successive pixels on a piece of photographic film in an amount proportional to the radiance value of the corresponding area on the ground.

Users of ERTS-1 scanner data have a choice of either a set of photographs or the computer tapes containing the radiance values. Tapes were chosen by WES because radiance measurements could be used with computer algorithms in a variety of engineering applications, one of which is the reservoir inventory.

Since near-infrared radiation is absorbed by water, radiance values measured by band 4 (0.8 – 1.1 micrometers) of the scanner are normally lower for water than for land. Water pixels can be identified simply by scanning the computer tapes containing radiance values and identifying, through computer techniques, those values that are less than a specified threshold value (normally 0.2 mw/cm^2–SR).

Data of this type can be converted to water distribution maps and map overlays that show locations of bodies of water. A film "writing" instrument used at WES can be programed to convert any pixel value recorded on computer tape to a specified shade of gray on photographic film.

By programing the film writer to give maximum exposure whenever a water pixel occurs on the computer tape, a map overlay (at a scale of approximately 1:1,000,000) will be produced, in which water bodies are represented in black and all other features are transparent.



PORTION of Chesapeake Bay Study Area Viewed From Earth Resources Technology Satellite (ERTS-1)

In practice, the small-scale overlays are enlarged to overlay 1:250,000-scale maps accurately. At this scale, bodies of water as small as 1.1 acres detected by the ERTS-1 scanner are clearly visible to the unaided eye.

The capability to distinguish land pixels from water pixels by automatic processing of ERTS-1 data has also been used extensively at WES to produce inventories of bodies of water for much of the southeastern United States. These inventories identify every discrete body of water detected by the ERTS-1 scanner, designate its latitude and longitude, and give an estimate of its water-surface area.

An inventory list for an ERTS-1 scene is normally used in conjunction with an overlay of that scene to provide a rapid means for updating existing maps—some as much as 10 years old. Updated lists show locations of new water impoundments and identify bodies of water that, by virtue of their size and/or capacity, must be included in the inventory required by the National Dam Safety Act.

ARI Develops 'Realtrain' Infantry Exercise

MAJ Larry E. Word

Dr. Robert T. Root

REALTRAIN is a "fun game" training method of teaching infantry forces some of the critical lessons of how to cope with the enemy in a simulated but realistic combat environment.

Developed by two scientists with the Army Research Institute for the Behavioral and Social Sciences. (ARI) and staff members of the Matrix Corp. working with them under contract, the method appeals to the American soldier's competitiveness in a win or lose game.

Based on a simple, effective technique to determine casualties in opposing infantry exercises, REALTRAIN motivates participants to crawl, run at a crouch, hit the ground and roll, scan, plan the next move and be on the alert for booby traps.

Credited with originating the concept and developing it into training exercise methodology are Dr. Robert Root and MAJ Larry Word of the ARI and Dr. Edgar Shiver and Dr. Boyd Mather of Matrix.

A 6-power telescope is mounted on the M-16 rifle and all participants have numbers affixed to their helmets. An individual becomes a "casualty" if he is engaged and his number is correctly identified. A high positive correlation has been established between marksmanship ability and ability to identify numbers at comparable ranges.

After the exercise, the participants critique the individual actions of the opposing force, thus reinforcing the learning experience. The method has been tested extensively at Fort Benning, GA, home of the Army Infantry Training Center, and Fort Carson, CO, and is now

Research on the applicability of this method to armor and anti-armor training also is being conducted.

REALTRAIN is termed a "serendipitous byproduct," as is true of many discoveries in research and development, of another effort to find a way of MOS (Military Occupational Specialty) testing infantrymen in a realistic combat environment.

ON WRITING. Researchers spend considerable time "writing up" the results of their work. They (and those on the administrative side) may well ponder the words of William Strunk Jr. in The Elements of Style. *"Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts. This requires not that the writer make all of his sentences short, or that he avoid all detail and treat his subjects only in outline, but that every word* tell."

Key Stinger System Design Changes Announced

Stinger, a shoulder-fired air-defense system incorporating the latest in infrared technology, evolved from several years of R&D efforts, will undergo some major design changes aimed at reducing costs—without sacrificing Army performance requirements.

"These changes will lower the average unit cost," said Stinger Project Manager COL David Souser, who directs the program for both the Army and Marine Corps. "What we spend now during R&D, we expect to quadruple in savings once we enter production."

Among planned changes are elimination of some electronic parts; manufacture of a reusable grip stock, sight assembly and IFF (Identification Friend or Foe) antenna; and elimination of a nuclear-hardened container that was a requirement in the original Stinger baseline configuration.

Called Stingthrift, the redesign program is the result of a comprehensive study by General Dynamics, prime contractor, working closely with the Stinger Project Office at HQ U.S. Army Missile Command (MICOM), Redstone Arsenal, AL, the Marine Corps, the Army Materiel Command and other Army agencies.

The Stingthrift seed was planted about two years ago in a directive by Dr. John Foster, former Director of Defense Research and Engineering. "DoD must establish a price-per-item copy that is compatible with the minimum required military performance," he said, "and with what we can afford to pay for the quality number of products we need. To accomplish this, we are willing to pay more in time and dollars in the R&D phase to assure achieving the desired unit production price and support cost."

While examining every facet of the program for potential trade-offs and cost savings, the Stinger Project Office and the prime contractor identified 26 areas that might affect unit costs.

"These proposed items were reviewed and evaluated by everyone who had anything to do with Stinger development," Souser said. "We finally narrowed the list to six items that were the most feasible, practical and economical."

The design changes will increase Stinger weight from 32 to 35 pounds and will require a slight extension of the program to complete engineering development, but the return is worth the investment, according to COL Souser.

EPA Grants $5 Billion for U.S. Sewage Treatment

Improvement of sewage treatment facilities to prevent discharge of inadequately treated or untreated municipal and industrial wastes into the nation's waterways is costing taxpayers and industry billions of dollars. Very extensive Department of Defense efforts are not shown in an EPA report.

Since the U.S. Environmental Protection Agency was established in December 1970, the EPA announced Mar. 4 that it has provided states and cities with $5 billion to help them build $8.8 billion worth of sewage treatment facilities. About 3,500 projects serving millions of Americans have been supported under the EPA aid standards. About 2,300 projects are completed.

Texas was reported as receiving the most grants, with 261 new projects, followed by California with 207, Pennsylvania 203, Iowa 152, and Illinois 151.

Monetarily, however, California was out in front with $339.1 million, followed by New Jersey with $305.8 million for 32 grants, and Michigan with $301.2 million for 85 grants. Then came New York with $278.2 million for 44 grants, Ohio with $267.7 million for 125, Pennsylvania with $232.3 million for 203, Illinois $218.5 million for 151, Massachusetts $201.7 for 41, Virginia $156.6 million for 73, Maryland $137.7 million for 43, and Florida $102.7 million for 73.

Indiana came next with $99.8 million for 113, followed by Minnesota with $95.4 million for 126, Missouri $79.7 million for 134, Louisiana $74.6 million for 53, Iowa $71.2 million for 152, North Carolina $71.2 million for 62, the District of Columbia $71 million for 4, Connecticut $67.5 million for 20, Washington $66.3 million for 110, Kentucky $62.5 million for 46, and Oregon $61.3 million for 74.

Alabama received $56 million for 46 grants, Georgia $52.7 million for 117, Wisconsin $52.6 million for 152, Maine $51.4 million for 32, Oklahoma $49.4 million for 82, Kansas $41.2 million for 82, Tennessee $39.9 million for 39, Arkansas $35.2 million for 51, Colorado $35 million for 72, South Carolina $34.6 million for 56, New Hampshire $34.5 million for 21, Puerto Rico $28.2 million for 8, and Nebraska $27.3 million for 84.

Grants to the remaining states were in the below $25 million category.

WSMR Contract Extension Indicates Magnitude of Data Collection Support

Magnitude of data collection activities at White Sands (NM) Missile Range is indicated by announcement of a 5-year contract for $30,099,142—actually a continuation of a 5-year $37 million contract that expired Dec. 31, 1973, and was extended.

The contractor, Dynalectron Corp., Land-Air Division, employs 350 to 400 persons who operate an estimated $35 million worth of U.S. Government-owned instruments and equipment. Fifty-seven companies submitted proposals or competitive bids.

Dynalectron has three other contracts employing an additional 450 persons in the WSMR area—one for logistical support of the Army's Utah Launch Complex, another with NASA for support of its White Sands Test Facility (Apollo Site), and an Air Force contract for operations at the Radar Target Scatter facility on WSMR.

R &D NEWS

COMBINATION OVERCOAT RAINCOAT styles are being evaluated to determine user-preference as a replacement for the current raincoat. Developed by the U.S. Army Natick (MA) Laboratories, both versions are 50/50 percent polyester/cotton poplin, wrinkle resistant, black emerald in color and have a zip-in liner.

Dr. Hamed M. El-Bisi, chief of the Research Division, RD&E Directorate, Army Materiel Command HQ, compares shorter collar of the Army dress-shirt, standard since 1965, with a new modern-looking dress-shirt held by COL Harry Corkill, commander of the U.S. Army Natick (MA) Laboratories. Textile experts at the labs are submitting the proposed shirt, with a 3¼-inch collar and improved material characteristics, to the Army Uniform Board for consideration as a replacement.

Polycarbonate Coatings . . .
May Improve Aircraft Windshield Strength

"Significant improvement in scratch resistance and excellent potential for increasing service life of aircraft windshields" is claimed in a recent report of research results at the U.S. Army Materials and Mechanics Research Center (AMMRC), Watertown, MA.

Environmental scientist John R. Plumer, assigned to the Organic Materials Laboratory at the AMMRC, reported on results of flight testing of a prototype coated polycarbonate windshield at the U.S. Army Aviation Center, Fort Rucker, AL. This windshield was tested in an ongoing program of evaluating it with a side-by-side installation of a standard acrylic windshield.

Developed by the AMMRC as a potential solution to overcoming the primary weaknesses in existing Army helicopter windshields, the coated polycarbonate prototype is the result of earlier experimental configurations to minimize scratching and spalling. These configurations experimented with a hard-surface coating, an acrylic cladding, and a thin glass cladding.

Abrasion-resistant coatings were evaluated in the laboratory, using a windshield wiper apparatus. Spall performance was studied by ballistic testing and high-speed photography of each of the test configurations. Reportedly, the hard-surfaced polycarbonate demonstrated the most effective reduction of spallation. The reduction "was not adversely affected" by coatings applied to either one or both sides of ballistic test samples.

Stretched acrylic cladding on polycarbonate provided inferior abrasion resistance and spall reduction compared to plain polycarbonate. The glass-polycarbonate configuration—which has not yet been subjected to flight test verification—provided the best laboratory abrasion resistance, but at a cost of increased spallation over the coated polycarbonate. However, it was "significantly improved over the current acrylic windshield" and will soon be flight tested at Fort Rucker.

Related Windshield Development

Another potential candidate for an aircraft windshield that will offer the desired improvements was announced in a report by four other AMMRC researchers, Anthony F. Wilde, Richard W. Matton, Joseph M. Rogers and Stanley E. Wentworth.

Evaluation of a polyurethane block copolymer, they stated, has shown that it "provided ballistic energy absorption from 22 to 100 percent greater than that of commercially available materials currently used."

Contending that this material "possesses several other excellent features which combine to make it potentially the best material available to date for this application," they list the benefits as:

- Low cost, in that it is prepared from inexpensive, commercially available starting materials.
- Optically favorable, in that it is nearly water-white as compared to a deeply yellow developmental material currently being considered for transparent armor applications.
- Ductile ballistic failure. Superior to brittle failure, which results in peripheral cracking severely degrading optical clarity; also, brittle failure produces back-spall, posing a serious threat to personnel.

Further investigation of the material, a formulation of 2, 4-toluene diisocyanate, polytetramethylene oxide and 1, 4-butanediol, showed that variations in material processing and formulation produced improvements in the V_{50} values.

High-speed photographs taken during ballistic tests depicted and served to quantify "certain transient events occurring during and after the impacts, viz, bowing of the polymer specimen, the velocities of plugs and fragments generated from the specimen by the impact, and the residual velocity of the projectile."

USAHSC Updates Outpatient Care, Dental Programs, Education

One year after its establishment, effective Apr. 1, 1973, the U.S. Army Health Services Command, headquartered at Fort Sam Houston, TX, reported it has progressed substantially toward its mission capabilities and objectives.

Commander MG Spurgeon Neel stated that the USAHSC is providing effectively, for the first time in history under a single manager, all health services and educational training and functions Army-wide. The command employs some 50,000 military and civilian personnel.

Operational responsibility embraces seven Army medical centers and 37 Army Medical Department activities headquartered throughout the United States.

Other activities controlled by the command include five Medical Department laboratories, 4 regional dental activities, 5 veterinary food inspection stations, and the U.S. Army Optical Fabrication Activity at Sharpe Army Depot, Tracey, CA.

Treatment is provided to about 10,000 dental patients daily, some 1,000 patients daily are admitted to hospital facilities including more than 10,000 beds, and more than 400,000,000 pounds of food monthly are inspected by Veterinary Services personnel.

Placement of all continental U.S. health care planning, programing and budgeting within control of the command included considerations such as an estimated annual saving of more than $4 million, and improved patient services.

Among the key activities under control of the USAHSC are the Academy of Health Sciences, newly established at Fort Sam Houston (formerly at Carlisle Barracks, PA) and the U.S. Army Environmental Hygiene Agency at Edgewood Arsenal, MD.

The AHS administers the health education systems of the Walter Reed Army Institute of Nursing, Washington, DC, the U.S. Army Veterinary School, Fort Sheridan, IL, and the Army Medical Equipment and Optical School, Denver, CO.

Commissioned and enlisted personnel of the Army, other U.S. military services and Free World allied nations may participate in the AHS training programs leading to master's degrees in hospital administration or physical therapy. Associate of science degrees may be gained by enlisted personnel upon completion of the Physicians' Assistant Program.

Established originally as the Army Industrial Hygiene Agency, and located at the School of Hygiene and Public Health at Johns Hopkins University in Baltimore, MD, the Army Environmental Hygiene Agency has expanded in recent years. It now encompasses support of the total Preventive Medicine Program as well as all occupational and environmental health and hygiene disciplines.

The USAEHA functional areas of occupational medicine include nursing and vision, hearing conservation, toxicology, medical entomology, hospital safety, environmental engineering, sanitation and chemistry, industrial hygiene, radiation protection, and pesticide monitoring.

Other responsibilities are air, water, solid waste and noise pollution abatement and control, and radiological, biological and industrial hygiene chemistry.

Army Health Services Command reports indicate that emphasis is being placed on upgrading outpatient care systems (ambulatory patient care), and improved support of the Army Reserve Readiness Training Program.

One of the innovative approaches to upgrading outpatient services is AMOS (Automated Military Outpatient System), which includes the AMOSIST Program currently being implemented at several Army Medical Department activities.

Developed at DeWitt Army Hospital, Fort Belvoir, VA, the AMOSIST Program has shown that it can serve about 65 percent of the adult outpatients at each site. Specially trained medical corpsmen screen patients by symptoms and refer them to appropriate treatment areas, and treat acute minor illnesses—all in direct consultation with supervising physicians.

The Health Services Command also administers a new Chronic Care Program, which permits nurses to help patients manage such chronic diseases as hypertension, diabetes, obesity and arthritis. Innovative also is a Comprehensive Evaluation Clinic in which computers, hospital laboratory facilities and trained corpsmen are used to complete evaluations of medical problems.

(Continued on page 11)

Nuclear Effects Test Facility Termed 'Most Complete'

Department of Defense agencies, universities and industrial defense contractors are offered the use of "the most complete nuclear environmental test facility in the Free World," following the recent opening of additional resources at White Sands (NM) Missile Range.

Army officials announced availability of the facilities to selectively qualified users as the climax of 17 years of development effort "to put it all together" at WSMR insofar as the most advanced capabilities for nuclear weapons effect tests are concerned.

Operation Plumb Bob initiated that effort in 1957 with an experiment extending from February through October. Designed by personnel of the WSMR Electro-Mechanical Laboratories, and approved by the Armed Forces Special Weapons Project—forerunner to what is now the Defense Nuclear Agency (DNA)—the test program was conducted jointly by WSMR and Bell Telephone Laboratories.

The purpose of that experiment at the Nevada Test Site was to gain some insight into electromagnetic effects upon sophisticated controls of advanced weapon systems. Under test was the Nike Hercules, the first air defense missile with an atomic warhead.

The question involved was: What happens to a second missile when it goes through the environment produced by detonation of the atomic warhead of the preceding missile? Operating Nike Hercules guidance packages were exposed to actual weapon detonations and their performance was monitored and recorded.

Results as published by the Defense Atomic Support Agency and titled, "Effects of Nuclear Detonation on Nike Hercules," provided important data. A long-term program was planned to study the problem and how to cope with it, leading to development of the WSMR test and simulation facilities now available.

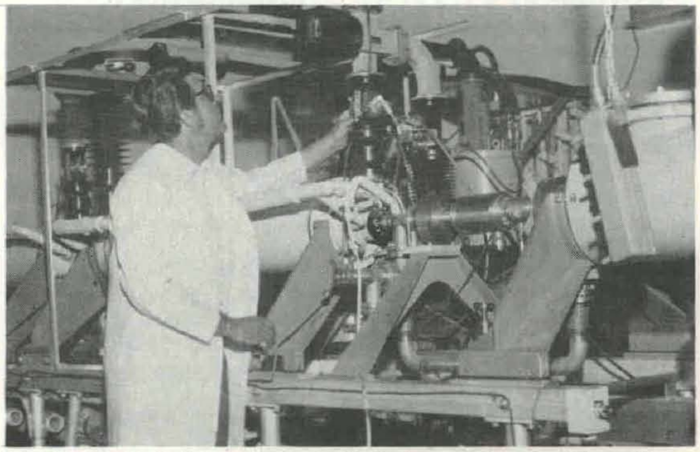
The WSMR 10 MeV Linear Electron Accelerator to produce a gamma spike became operational in May 1960, the Pulse Neutron Generator to reproduce the fusion neutron pulse was put into service in July 1960, and in July 1964 the Nuclear Effects Laboratory and reactor buildings were completed. That same month a 14 MeV Neutron Generator was placed in operation.

Only a month later a Fast-Burst Reactor was added to test facilities and in April 1965 a 25 MeV Linear Accelerator became operational. Seven "lean years" followed with respect to further facilities development. Then the Gamma Radiation Facility was completed in November 1972, followed by the White Sands Electromagnetic Pulse Systems Test Array (WESTA), which became operational in August 1973.

Ceremonies to mark the formal inauguration of the Solar Furnace and the Gamma Radiation Facility were held Mar. 20, 1974. Completion of the upgrading of the Linear Electron Accelerator to 40 MeV was announced Mar. 21.

The accelerator (Gamma LINAC) is a 2-section S-band type, operational in the 1 to 43 MeV energy range, with a pulse width variable from 0.03 to 10 microseconds. Repetition rates vary from a single pulse to 120 pulses per second. A 19′ by 26′ exposure cell is isolated from the accelerator cell by three feet of solid concrete. The maximum dose rate with a tungsten target is 10^{11} roentgens per second.

Neutron Generator. Capable of producing monoenergetic neutrons of either 14 or 2.6 MeV by the use of tritium or deuterium targets, the



Electronic technician Antonio Grijalva in Gamma Linac Room at the Nuclear Effects Laboratory, White Sands Missile Range.

generator permits the use of thermal neutron irradiations. The usable flux for 14 MeV is 5×10^{10} neutrons per square centimeter per second and 1.6×10^{8} for 2.6 MeV. The pulse width is variable from one to 10^{4} microseconds.

Housed in an 18′ by 20′ cell, the generator is used for radiation effects testing or as part of a complete activation analysis system which includes pneumatic transfer systems, single channel and 400 channel analyzers, and a radiochemical laboratory.

Fast Burst Reactor. The FBR is a Godiva-type that produces a neutron environment approximating that of the fission weapon. Nominally, the pulse is 50 microseconds wide (full width half maximum). At the closest approach, a glory hole permits doses five times larger than external to the core.

Operated normally in an underground cell 50 by 50 by 20 feet, the reactor can be moved to an outdoor site on top of the cell for experiments not feasible within the cell. Typical tests are positioned around the reactor core on a test table. Irradiated material is monitored and the data recorded in an instrumentation room. As of Mar. 1, 1974, the reactor had been pulsed 4,992 times and operated in a steady-state mode 1,274 times for a total of 6,266 operations.

Gamma Radiation Facility. The irradiation system, housed in a 90′ by 36′ building, provides for the individual or combined use of any of six cobalt-60 sources with varying activity up to 3.2 kilocuries and six cesium-137 sources varying up to 3.5 kilocuries. Exposure times are individually settable in increments of 0.1 seconds from 9 seconds to more than 24 hours.

Activities of the sources are chosen so that dose rates can be varied from 1.2 roentgens per hour at one meter to more than 14,000 roentgens per hour at one meter using all 12 sources. The exposure cell is 22 by 42 feet. Outside walls are 4-feet thick and the two walls between the control area are 5-feet thick reinforced concrete.

Electromagnetic Pulse Systems Test Array. WESTA is a transportable, high-voltage, large test volume-bounded wave guide electromagnetic pulse simulator. Presently it consists of 16 double-intensity modules configured in a 4 by 4 array 22 feet above the ground plane. The exposure volume is 22 feet in height, 44 feet in length and 44 feet in width. The array is capable of high-level single pulsing to 50,000 volts per meter.

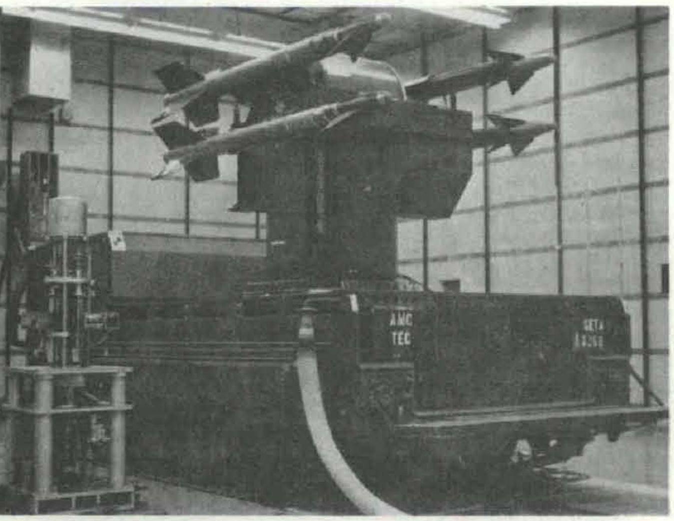
Thermal Effects Facility (Solar Furnace). This facility is the second largest of its kind in the world, exceeded in capability only by the one in Odeillo, France (focusing capability of 5,000 and 7,000 degrees Fahrenheit, respectively). Originally designed and operated by the U.S. Army Natick (MA) Laboratories, the TEF was moved to WSMR in 1972 and reconstructed at a total cost of approximately $230,000.

Set up for the study of effects of thermal radiation on electronic circuits, transistors and other missile components, the TEF can simulate TR bursts such as would emanate from nuclear weapons—by focusing impulses of magnified sun rays onto a small surface.

The heliostat is a 40′ wide, 36′ high perpendicular plane of 356 water-white, 2-foot-square, ¼-inch thick mirrors that can slant and rotate to track and reflect the sun's rays over and around the box-shaped test chamber, through the attenuator and onto the concentrator.

The attenuator is a network of louvres which can be opened, closed

(Continued on page 12)

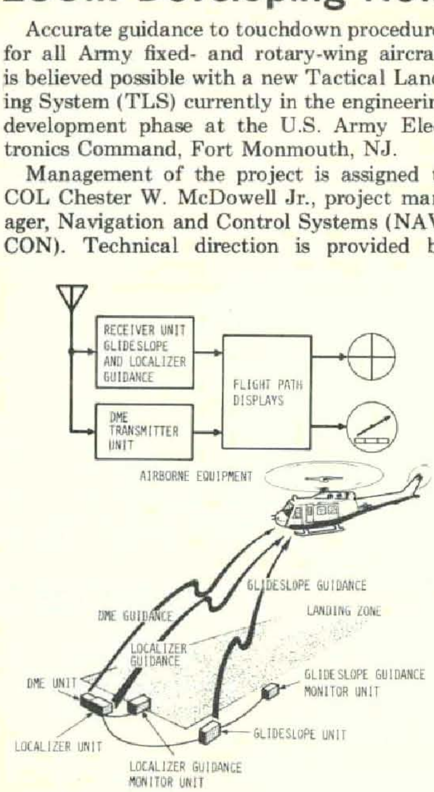


CHAPARRAL missile launcher in hot chamber at WSMR

ECOM Developing New Aircraft Landing System

Accurate guidance to touchdown procedures for all Army fixed- and rotary-wing aircraft is believed possible with a new Tactical Landing System (TLS) currently in the engineering development phase at the U.S. Army Electronics Command, Fort Monmouth, NJ.

Management of the project is assigned to COL Chester W. McDowell Jr., project manager, Navigation and Control Systems (NAVCON). Technical direction is provided by ECOM's Avionics Laboratory.



Basic Elements of the TLS

Interest in the system has been expressed by the North Atlantic Treaty Organization's Air Force Armaments Group, Subgroup 7, and the National Aeronautics and Space Administration for its space shuttle program.

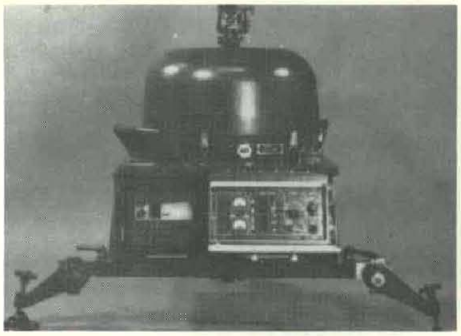
The TLS is a microwave unit which operates on a scanning beam principle, provides glideslope, localizer, and precision distance measuring guidance to all Army aircraft, and is adaptable to any type terrain. Landing guidance is provided during instrument meteorological conditions where ceilings of at least 200 feet and runway visibilities of one-half mile or more exist.

Two primary units of the TLS are identified as Instrument Landing Set, Ground-AN/TRQ-33 and Instrument Landing Set, Airborne-AN/ARQ-31. Ground unit components include glideslope, localizer and distance measuring equipment (DME) module.

Glideslope and localizer units contain scanning antenna and transmitter for communication of elevation and azimuth landing guidance signals to approaching aircraft. The DME module replies to the interrogating aircraft within area limitations.

Rotation of the two scanning antennas is synchronized to effect time-sharing of the transmitted localizer and glideslope guidance data. The DME transponder function is also operated on a time-shared basis.

Components of the airborne portion of the system are a receiver-decoder and a DME transmitter. Data necessary for successful instrument landings are provided by these components.



Localizer, Transmitter Group OT-64 (XE-1)/TRQ-33

During normal operation of the system, a unique pulse code spacing is transmitted to approaching aircraft for each angular position of the scanning localizer and glideslope antennas. The airborne receiver-decoder receives and processes these pulses and converts them to azimuth and elevation guidance data for display to the pilot.

The TLS ground unit is easily transportable, can be operational within half an hour, and may be powered temporarily by 24-volt batteries.

The system is to be delivered for Army development tests (DT-II) and operational tests (OT-II) scheduled to begin in April 1975. Prototype TLS airborne equipment will be installed in the Utility Tactical Transport Aircraft System (UTTAS). Based on the current schedule, the TLS could be operational in October 1976.

USAHSC Updates Programs During First-Year Progress

(Continued from page 9)

USAHSC major installations and activities include:

Medical Centers–Brooke AMC, Fort Sam Houston, TX; Walter Reed AMC; Washington, DC; Fitzsimons AMC, Denver, CO; Fort Gordon (GA) AMC; Letterman AMC, Presidio of San Francisco, CA; William Beaumont AMC, Fort Bliss, TX; and Morgan AMC, Fort Lewis, WA.

Medical Department Activities (MEDDAC)–U.S. Army Hospital, West Point, NY; Valley Forge General Hospital, Phoenixville, PA; and MEDDACs at: Fort Sheridan, IL; Fort Benjamin Harrison, IN; Fort Knox, KY; Carlisle Barracks, PA; Fort Devens, MA; Fort Monmouth, NJ; Fort Lee, VA; Fort Belvoir, VA; Fort Meade, MD; Fort Dix, NJ; Edgewood Arsenal and Aberdeen Proving Ground, MD; Fort Monroe, VA; Fort Eustis, VA;

Also, Fort Campbell, KY; Fort McClellan, AL; Fort Rucker, AL; Fort McPherson, GA; Fort Benning, GA; Fort Bragg, NC; Fort Steward, GA; Redstone Arsenal, AL; Fort Sill, OK; Fort Hood, TX; Fort Wolters, TX; Dugway Proving Ground, UT; Fort Carson, CO; Fort Riley, KS; Fort Huachuca, AZ; Fort Leavenworth, KS; Yuma Proving Ground, AZ; Fort Leonard Wood, MO; Sierra Army Depot, CA; Fort Ord, CA; and Fort McArthur, CA.

Regional Dental Activities–Walter Reed AMC, Washington, DC; Brooke AMC, Fort Sam Houston, TX; Fort McPherson, GA; Alameda, CA.

Army Medical Laboratories–Fort Meade, MD; Fort McPherson, GA; Fort San Houston, TX; Fort Baker, CA; and St. Louis, MO.

Cocoon May Aid Aircraft Rust, Corrosion Resistance

Rust and corrosion formations on stored U.S. Army helicopters, an age-old problem, may soon be minimized by an effective preventative, a new air-tight plastic "cocoon" currently under examination by the Modern Army Selected Systems Test, Evaluation and Review (MASSTER), Fort Hood, TX.

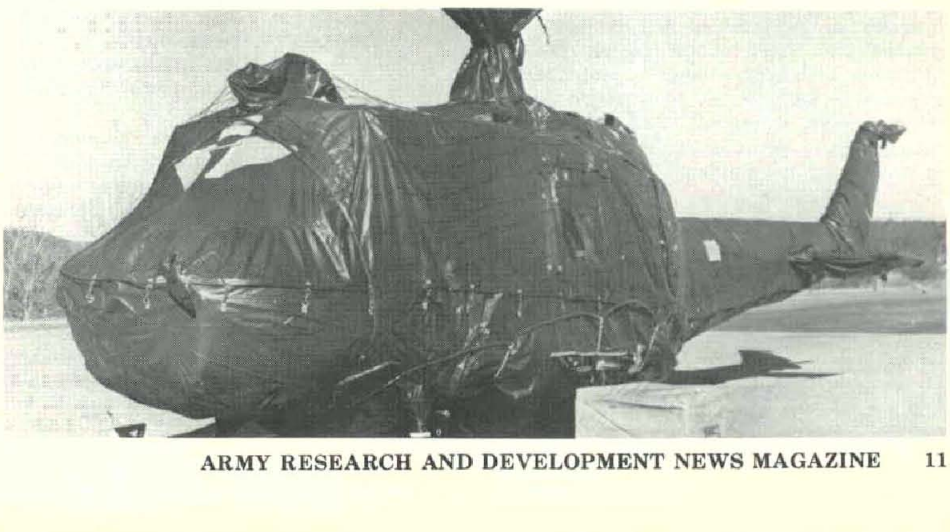
The cocoon concept is being tested to determine its potential to adequately protect helicopters which are placed in warehouses with infrequent opportunities for servicing. Vehicles which are exposed to salt water spray during ship transport are also subject to corrosion.

Constructed of four custom-fitted polyvinyl choloride plastic sections, the cocoon is sealed by a plastic zipper and application of tape around the legs of the helicopter's skids. A special dehumidifier/heater recirculates and controls temperature inside the vehicle and the cocoon.

An electrically controlled box located outside of the helicopter permits monitoring of humidity levels inside the plastic cover. Ideal humidity levels of 40–45 percent have been designated for optimum performance of the unit.

A 5-man team from the 13th Aviation Battalion is now testing the cocoon under a short-term storage basis of up to 45 days and for an intermediate period of 46–180 days. Approximately three hours are required to cover a helicopter with the plastic. The procedure also necessitates removal of the main and tail rotors and sealing of the tape around the vehicle skids.

Following completion of the current tests a technical inspection and flight of all test vehicles will be made to determine actual cocoon capabilities for rust and corrosion prevention.



FDA Approves Army-Developed Meningococcal Meningitis Vaccine

A U.S. Army-developed meningococcal meningitis group C polysaccharide vaccine, used since 1971 as a standard prevention technique by the Army and Navy, was licensed in April by the Food and Drug Administration for general use in the United States.

Following the FDA announcement, Dr. Malcolm S. Artenstein, Walter Reed Army Institute of Research (WRAIR), Washington, DC, commented:

"Since initiation of routine Army vaccinations in the fall of 1971, there have been no reported cases of group C meningitis among Army personnel who have received the vaccine."

Renewed Army interest in meningococcal meningitis began in 1962-63 following many reported cases of the disease at the U.S. Army's Fort Ord, Monterey, CA, and the U.S. Naval Base, San Diego, CA. Sulfadiazine drugs, used traditionally by the Army to contain the disease, appeared to be no longer effective.

Research on the problem was begun by Dr. Artenstein, chief of the Department of Bacterial Diseases at WRAIR, and associates, CPT Irving Goldschneider and CPT Emil Gotschlich. (The latter two are now civilians.) This work was done under the sponsorship of the U.S. Army Medical Research and Development Command.

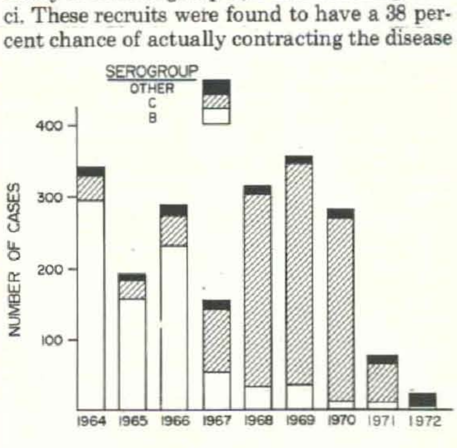
Initial team research revealed that 60 to 90 percent of basic training recruits acquired meningococcal strains in their throats during their first three to four weeks on active duty. This compares with only 20 percent who show the strain in tests at the time of entry into the Army. This increase is characteristic of the rapid spread of respiratory tract microorganisms in basic training recruits.

Findings in the late 1960s also showed that a group C meningococci was apparently taking over as the predominate strain causing disease, with reported group B and the traditional group A strains declining.

Dr. Artenstein has indicated that the Army medical concern about meningitis is the rapidity with which it can kill and the epidemic proportions that it can attain.

Lack of success in controlling the disease with sulfa drugs led the researchers to study its immunology. Susceptibility was found to be due to the absence of a bactericidal antibody in the serums of some recruits.

Dr. Goldschneider found that 14 to 23 percent of recruits, age 19 to 26 at the time of entry on to active duty, lack the antibodies necessary to combat group A, B and C meningococci. These recruits were found to have a 38 percent chance of actually contracting the disease after becoming carriers.



CHANGES in number and prevalence of meningococcal meningitis serogroups causing disease in U.S. Army personnel.

Research for development of a new vaccine began in 1966. Promising results with the meningococcal meningitis group C polysaccharide vaccine were seen during preliminary studies at Fort Dix, NJ, in 1968. Initial trials with small numbers of men demonstrated the safety and immunological capabilities of the vaccine.

Approval was obtained in 1969 from the Army Investigational Drug Review Board to vaccinate large numbers of recruits at various Army training centers. Subsequently, during 1969-70, a total of 30,000 men received the vaccine while another group of about 120,000 was not immunized.

Observations during the test period showed that only two recruits of the vaccinated group contracted the group C meningitis disease; 70 cases of the disease were recorded among the unvaccinated group. The over-all reduction in group C meningococcal meningitis was 90 percent.

Lack of reported group A meningitis disease during recent years in the U.S. has prevented testing of a group A polysaccharide vaccine. However, the vaccine is being tested in Africa by the World Health Organization. Army tests of group B polysaccharides are thus far inconclusive.

Advanced Plans Briefing Informs Industry on Troop Support

"Troop Support for the Future" was the theme of a Mar. 26-27 Advanced Planning Briefing for Industry (APBI) at the U.S. Army Mobility Equipment Research and Development Center (MERDC), Fort Belvoir, VA.

Norman R. Augustine, Assistant Secretary of the Army (R&D), was the banquet speaker, and MG Hugh R. Higgins, commander of the U.S. Army Troop Support Command (TROSCOM), St. Louis, MO, gave the keynote address. The program included briefings by chiefs of MERDC's five R&D departments and directors of TROSCOM's Natick (MA) Laboratories (NLABS).

Commander (COL) T. R. Hukkala introduced the MERDC presentations with an overview of its facilities and projects. His presentation covered countermine and counterintrusion technology, barriers, camouflage, electrical power, combat construction equipment, bridges, watercraft, water and waste management, environmental control, and materials and fuel handling. Terence G. Kirkland, MERDC technical director, discussed the Technological Long-Range Plan.

COL Robert Chant, NLABS deputy commander, reviewed NLABS programs on personnel armor and individual equipment, airdrop systems, shelters and personal hygiene concepts. James H. Flanagan, deputy technical director for engineering, discussed the Natick Technological Long-Range Plan.

R & D NEWS

Report Stresses 'Hands-On' Approach For Volunteer Army Programs

The Experimental Volunteer Army Training Program: A Pictorial Report is a new publication issued by the Human Resources Research Organization (HumRRO).

The document is the result of a 1970 Department of the Army request for R&D support of two field experiments: A revised Basic Combat Training and Advanced Individual Training Program, and an Evaluation of the Volunteer Army.

A major principle of the Experimental Volunteer Army Training Program (EVATP) is its emphasis on an entirely performance-oriented system. This is designed to minimize the "leaning lag" caused by the inevitable individual differences found in any large group of leaders.

HumRRO concludes that since most skills acquired by a soldier during his initial training are psychomotor, an instructional strategy consisting of minimal physical practice is ineffectual. "Hands-on" practice rather than theoretical lectures is recommended.

Nuclear Test Facility Termed 'Most Complete'

(Continued from page 10)

or slanted to control the amount of rays passing from the heliostat to the concentrator. The latter is a 30-foot-square concave arrangement of 180 spherical mirrors, each 2-feet square, with a focal length of 35.8 feet to direct the sun rays into the test chamber.

With respect to the currently mounting interest in solar furnaces as a potential power and heating source to alleviate the energy crisis in the United States, the TEF at WSMR serves to demonstrate the potential for such development. However, it does not have a power storage capability. It is designed solely to focus up to 5,000 degrees F. sun power into a small area for radiation burst testing.

WSMR Missile Test and Evaluation Directorate scientists and engineers believe that the recent additions to capabilities provide total resources for nuclear weapon effects testing for all current needs. Use of these facilities is expected to increase greatly the knowledge of how to "harden" componentry of critical control systems for missiles—to assure that they will perform as they are designed to do in a nuclear radiation environment.

Authorized users within Department of Defense agencies, as well as those working under grants or contracts on military problems related to missile componentry or other military materiel, are expected to find that the pride of WSMR personnel in "putting it all together," with respect to nuclear weapon effects testing capabilities, is well merited.

"The best teacher is not life, but the crystallized and distilled experience of the most sensitive, reflective, and most observant of our human beings, and this experience you will find preserved in our great books, and nowhere else."—Nathan M. Pusey.

BRL Develops New Technique for Fluid Flow Visualization

By Dr. R. Sedney and Dr. C. Kitchens

Visualization of the complex fluid flow patterns that occur in the aerodynamics of projectile and missile testing is an important aid in the design process. New technology developed by the U.S. Army Ballistic Research Laboratories will help provide solutions to such weapon systems engineering problems.

BRL experimenters at Aberdeen Proving Ground, MD, have been studying flow patterns that involve separation, reattachment, vortex formation and shock wave boundary-layer interactions generated by a protuberance or indentation on projectiles and missiles—most of which are not aerodynamically smooth.

Examples of relatively small protuberances are connectors, bore riding lugs, external piping, and rotating bands. Obviously, these objects affect the aerodynamic drag: first, because of the pressure acting on the protuberance; second, because of the interference they cause in the boundary layer which covers the surface of the projectile.

Vortex patterns set up in the surface boundary layer can induce changes in the over-all separation of this boundary layer from the body surface. In turn, this separation will influence the other forces and moments acting on the body. Protuberances wholly or partially immersed in a boundary layer cause local regions of high shear stress and heat transfer. Effects such as these are not always deleterious to the flight of the projectile and missile.

Gaining an understanding of the highly complex effects pertinent to design problems involves looking at details of the flow. It is difficult to resolve many details on a model in a wind tunnel because the boundary layer is very thin, and some of the interactions with a protuberance occur on a very small scale.

This problem can be overcome by simulating the interactions in the thick turbulent boundary layer, typically 2.5cm, that flows along the walls of a supersonic wind tunnel. The BRL supersonic wind tunnel has been used to study the flow and develop methods for visualizing the flow.

The new technique developed at BRL is the optical-surface indicator method, which makes the surface flow patterns visible. The protuberance to be studied is mounted on one of the tunnel side windows over which the thick turbulent boundary flows. A small amount of lightweight, transparent oil is placed on the window and, after the flow has started, a shadowgraph of the resulting pattern is taken.

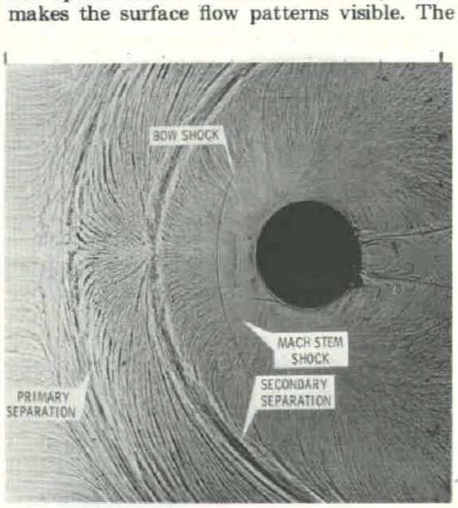


Fig. 1. SHADOWGRAPH, obtained by using the optical-surface indicator technique, shows a plan view of a cylindrical protuberance with the flow from left to right.

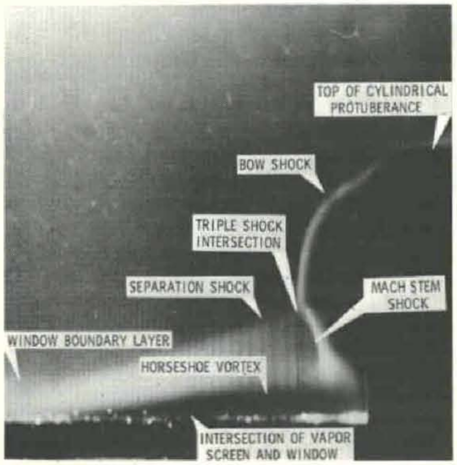


Fig. 2. VISUALIZATION of flow with the vapor screen in the central plane. This is a side view of a cylindrical protuberance.

The oil can be placed on the window before flow starts or introduced after flow has started. Shadows of the shock waves are obtained so that they can be correlated with the separation pattern in the surface flow. Figure 1 is an example of such a shadowgraph.

This optical surface indicator technique provides a great amount of detail, and it is much simpler to use than other surface indicator techniques. By studying these surface patterns, and using principles of fluid dynamics, investigators can deduce the features of the flow near the surface.

To visualize the flow off or away from the surface, tracer techniques must be used, e.g., the smoke flow method which is so valuable in low-speed flows. In high-speed turbulent flows, however, the vapor screen technique is the only tracer method that is practical.

This widely used method involves introducing water vapor into the supersonic wind tunnel system. When a mixture of air and water vapor passes through the supersonic part of the tunnel nozzle, the water vapor condenses and there is a faint fog in the test section.

If a sheet of light, or light screen, is passed through the test section, scattered light from the extremely small water particles is observed. Shock waves appear brighter and vortices darker than the background. This method is tedious to use in its conventional form because a narrow sheet of light at different positions and orientations is needed.

LT Charles Nietubicz has introduced at BRL a versatile vapor screen system which uses a low-power, e.g., 15mw, CW laser as the light source. The beam, approximately one millimeter in diameter, is diverged by passing it through a cylindrical lens to obtain the sheet of light. Orientation of the light sheet is changed by rotating the lens. The light source and lens are mounted on a motorized platform so that the position of the light sheet is easily changed.

Figure 2 is a vapor screen picture showing the flow over a protuberance. Shock waves appear bright because of the increased density of particles that scatter the light; since centrifugal forces tend to displace the particles radially outwards, vortices appear as dark regions. One disadvantage of the vapor screen method is that the particles may re-evaporate because of local heating effects.

Careful study of the detailed surface patterns shown by the optical-surface indicator technique, and correlation with the flow features off the surface revealed by the shadowgraph and tracer techniques, provides an understanding of the protuberance-boundary layer interactions. The multiple separations, attachments, and wake flows shown typically in Figures 1 and 2 have been related to the Mach number and the Reynolds number, the important parameters in fluid flow.

Combining theory with the information provided through the use of the visualization techniques, fluid dynamicists can formulate a physical model of the flow.

Simple to set up and to use, these new techniques for flow visualization save considerable time in experiments. Ultimately, of course, the results of this work will find their applications in missile and shell design.

DR. RAYMOND SEDNEY is chief of the Fluid Dynamics Research Group, Exterior Ballistics Laboratory, U.S. Army Ballistic Research Laboratories (BRL), Aberdeen Proving Ground, MD. Following 13 years service at the BRL (1953–66), he was employed by the Martin Marietta Corp. until assumption of his present assignment in 1971.

He has a BS degree in physics (1948), MS (1950) and PhD (1951) degrees in applied mathematics, all from the Carnegie Institute of Technology, and is a Fellow of the BRL.

DR. CLARENCE KITCHENS JR., an aerospace engineer in the Exterior Ballistics Laboratory, joined BRL as a civilian in 1972 after serving there in a like capacity while on active Army duty.

His academic credentials include BS (1966) and MS (1968) degrees from Virginia Polytechnic Institute and State University and a PhD (1970) from North Carolina State University, all in engineering mechanics. He has authored more than a dozen technical papers relating to experimental and computational fluid dynamics.

Designing Army Aircraft to the Environment

By Dr. John Viletto Jr. and Donald R. Artis Jr.

Natural environment, today as throughout recorded history, limits and even precludes military activities for periods of time ranging from less than an hour to several months. Aircraft, particularly Vertical/Short-Take-Off and Landing (V/STOL) aircraft, are probably influenced and limited by the natural environment more than most military equipment.

In addition to being exposed to normal environmental changes throughout a year at one or a few specific places or in a broad region, aircraft at times are exposed to a wide range of environmental conditions in a time frame of a few hours or less. Some aircraft may be exposed to extremes more often in a few months than most fixed equipment would be over a period of several years.

Great ranges of environmental conditions are experienced in relatively short periods of time for two reasons:

• Aircraft readily traverse hundreds to thousands of miles, crossing many climatic zones which are influenced by their north-south latitudinal position and by coastal versus continental locations.

• A single Army aircraft flight may range in altitude from sea level to some 30,000 feet, all in the course of a few hours or less.

Worldwide recorded ranges of three climatic elements show some of the extreme values to which military equipment can be subjected. Recorded surface ambient temperatures (excluding Antarctica) range from –90° F. to 136° F., but temperatures of 150° F. to 200° F. have been recorded for materiel exposed to direct solar radiation. Rainfall varies from none during an entire year to 53 inches for 12 hours. Snowfall varies from none for much of the world to a recorded maximum of 76 inches in 24 hours.

Horizontal and altitudinal limits of V/STOL aircraft are not as great as those of fixed-wing aircraft. Nevertheless, V/STOL aircraft are subjected to several environmental conditions that are considered very severe.

Proper or adequate design of V/STOL aircraft is a major challenge for design engineers because the aircraft must be stored and operated satisfactorily in many different environments worldwide because:

• It is not always possible to select the time and location for military engagements.

• The state-of-the-art for quickly modifying or controlling most aspects of the environment is limited or nonexistent. (Therefore, it is assumed that the entire world, excluding Antarctica, is the potential zone of operations for Army aircraft.)

Even though it has been recognized that the operational environment is extremely influential in the reliable operation of V/STOL aircraft, only recently have most aspects of the operational environment been considered in the design and test criteria for new aircraft. The Utility Tactical Transport Aircraft System (UTTAS), an Army squad-carrying helicopter being developed for use in the 1980s to replace the UH-1, is a new system in which most aspects of the natural and induced environments are being considered.

Analysis of various problems of current-inventory Army aircraft indicates that the operational and induced environment is a significant contributor to noncombat accidents, high component failure rates, high maintenance manhours per flight-hour, high maintenance costs, excessive logistical support costs, and reduced aircraft availability and effectiveness.

Probably the best-known cases are engine compressor deterioration due to sand particle ingestion and rotor blade erosion and damage due to rain, sand, and various foreign objects. These components demand attention because of high initial and subsequent overhaul costs.

The magnitude of the environmental problems is evident when one reads a few quotations from the summary of a study that analyzed aeronautical equipment failures of 175 aircraft operating for a 2-year period (1966–1967).[1]

• Environmentally induced failures were calculated to account for between $20 million and $35 million in costs for a weapon system consisting of approximately 350 components per aircraft.

• For the approximately 175 aircraft operational during the 2-year period studied, 24,061 failures occurred on those components that could be considered environmentally induced. These 31 components accounted for a total of 46,510 failures. Therefore, for these particular items, 52 percent of all failures were environmentally related.

• Temperature, vibration and moisture dominated as causes and were responsible for more than 21,000 failures which represent 87 percent of the environmental failures.

Several years ago, tests of a helicopter hovering over sand were conducted to document certain aspects of damage to the aircraft.[2] Within a short period of time, the blades had to be replaced three times and the engine changed once due to sand erosion. Consequently, several research and development and product improvement programs have been conducted to minimize the sand erosion effects associated with helicopter engines and rotor blades.

Many environmental elements can adversely affect (deteriorate) materials selected for use on military equipment. The rate and degree of deterioration are highly variable, influenced by certain ranges of critical values including the frequency and length of time between threshold values that promote deterioration; the simultaneous occurrence of values of elements which in combination have a synergistic effect; and the order of occurrence of climatic elements.

With increasing temperature above critical values, some materials deteriorate exponentially; but below critical values, there may be little or no deterioration. Moreover, for temperature sequences having different ranges but the same average, the deterioration of identical material will be greater where the temperature range is greater.

Material problems and failures due to many environmental conditions are known and documented in many scattered sources. A few examples, which are only a very small part of all the environment-related material problems and failures, follow:

1. A particular type of electrical insulation deteriorates when a specific level of relative humidity is exceeded. This material, however, partially recovers its insulation properties when the relative humidity decreases below the critical value. Temperature and relative humidity are a very common combination which can promote a synergistic effect. However, if either temperature or relative humidity is below its critical value, the combined deterioration is insignificant.

2. A contrasting example is the photochemical deterioration of some plastics by solar radiation, which is dependent only on the total radiation absorbed; intensity and con-

DR. JOHN VILETTO JR. is a research geographer for the Geographic Sciences Laboratory, U.S. Army Engineer Topographic Laboratories. He earned BS, MS and PhD degrees (1959–61–68) at Pennsylvania State University. His BS is in geography and both advanced degrees are majors in geography and minors in geology with an emphasis on geomorphology.

His work in the past five years has been primarily coordinating and writing reports on various aspects of the natural environment, including climatic elements and particulate matter pertinent to V/STOL operations and storage. Considerable time has also been devoted to terrain field work and report writing relative to off-road mobility.

DONALD R. ARTIS JR. has worked since 1969 on various aspects of defining the Army aviation operating environment at the U.S. Army Air Mobility Research and Development Laboratories (USAAMRDL). He graduated from the University of Texas in Austin with a BS in aerospace engineering and is working on a master's degree in transportation management at Old Dominion University. Prior to employment at USAAMRDL, he was assigned to the technical management division of the UTTAS project manager's office, USAAVSCOM.

[1] **Allan Dantowitz, George Hershberger, and David Pravidlo, *Analysis of Aeronautical Equipment Failures*, Tech Report AFFDL-TR-71-32, Grumman Aerospace Corp., Wright-Patterson Air Force Base, OH, May 1971.**

[2] **S. J. Rodgers, *Evaluation of the Dust Cloud Generated by Helicopter Rotor Downwash*, USAAVLABS Tech Report 67-81, U.S. Army Aviation Materiel Laboratories, Fort Eustis, VA, March 1968.**

tinuous or intermittent absorption are unimportant.

3. Certain mechanical difficulties can be caused by differential thermal expansion or contraction. Two examples are differential contraction of an aluminum alloy airframe, and steel cables control response of aircraft. This was shown in a test where cable tension decreased from 52 pounds to 21 pounds with a temperature decrease from 0° F. to -65° F., and the moving parts of electromechanical devices functioned less than reliably at cold temperatures.

Many materials, such as plastic, fiberglass and rubber, become brittle and may even crack if subjected to low temperatures. Subjected simultaneously to vibration and low temperature, they often will fail structurally. Power available from batteries, both wet-cell and nickel cadmium, decreases with decreasing temperatures. A fully charged wet-cell battery freezes at -61° F. At around -72° F., wax in some aircraft fuels begins to adhere and accumulate in the fuel tanks and other parts of the fuel system, thereby restricting or even stopping the flow of fuel to the engines.

Research results in recent years have determined that the useful life of many small, seemingly insignificant components is similarly being limited by an Army aviation operational environment much more severe than anticipated by the designers and/or developers. None of these small components demands much individual attention when viewed within a total aircraft system; when combined, their relevance with regard to both cost and effectiveness is of great concern.

The over-all problem of environmental effects has reached such proportions that the Army has initiated a broad research effort to determine those changes in design specifications/standards and qualification requirements that should preclude recurrence in future V/STOL aircraft systems.

Current aircraft system specifications have been reviewed to determine environmental qualification requirements. None of the system specifications reviewed addressed the environmental qualification requirements except in very broad, general terms.

For example, MIL-H-5440E states that the aircraft hydraulic system is to be "designed to operate satisfactorily under all conditions that the aircraft may encounter."

Based on the specification/standard review findings, it was concluded that (1) there are virtually no detailed design requirements relating to the Army aircraft operational environment, and (2) although some general environmental qualification requirements are stated, these have seldom been applied to V/STOL aircraft systems or component development programs in a responsive manner.

Since it is difficult to place the major portion of the blame on either of these contributors to the poor environmental record of Army helicopters, the question arises: What can be done to alleviate environmentally induced V/STOL aircraft problems?

Two schools of thought apply to this issue. One view is that if you give the designer "good" requirements and perform "good" design reviews, a satisfactory product will be assured. The second contention is, that regardless of the design criteria imposed, rigorous qualification testing must be performed throughout the development process.

Investigations conducted by the Eustis Directorate of the U.S. Army Air Mobility Research and Development Laboratory (USAAMRDL) have indicated that adequate design criteria should be the first order of priority from an environmental standpoint. Consequently, the directorate has initiated a program aimed at developing an environmental design guide for future Army helicopters.

Much of the data to support the conclusions and recommendations of such a design guide were judged to be available, but extremely scattered and in formats not readily usable by the Army. The Eustis Directorate responded by requesting the assistance and advice of Army experts in the environmental design criteria field, i.e., Geographic Sciences Laboratory (GSL) of the U.S. Army Engineer Topographic Laboratories (USAETL), Fort Belvoir, VA.

GSL is currently assessing several elements of the natural environment, a major component of the operational environment. The induced environment will be assessed by industry specialists who deal directly with helicopter design, test and qualification constraints.

Following completion of the GSL studies and the induced environment investigation, the results of both efforts will be used as primary data inputs to the proposed development of the design guide for Army aircraft.

Cooperative efforts between the Eustis Directorate and USAETL are examining several elements of the natural environment to determine if quantitative measures exist that might be used as design and/or test requirements for future Army aircraft systems.

Reports recently completed by USAETL for the Eustis Directorate include:

- Potential Sand and Dust Source Areas.
- Particulate Matter Considerations in the Design of V/STOL Aircraft.
- Worldwide Distribution of Mean Dewpoint: Surface and Lower Atmosphere.
- Distribution of Mean Monthly Precipitation and Rainfall Intensities.
- Occurrence of Ice in the Form of Glaze, Rime and Hoarfrost with Respect to the Operation and Storage of V/STOL Aircraft.
- Extreme 24-Hour Snowfalls in the United States: Accumulation, Distribution, and Frequency.
- Worldwide Distributions of Ambient Temperatures and Temperature of Material Exposed to Direct Solar Radiation.
- Hail and Its Distribution.

Deterioration and/or failures of material and equipment presented here are only a small sample of the thousands that undoubtedly occur. Likewise, the selected climatic extremes and other values are microscopic compared to the total data and information presented by the series of reports noted earlier on aspects of the natural environment most pertinent to Army V/STOL aircraft.

Commanders should be able to rely on their transport and support aircraft to respond when required by the situation. They should not have to curse the designers for not adequately considering the operational environment when designing, testing and qualifying the aircraft.

Future studies of various aspects of the natural environment should contribute specific and detailed data that will more accurately define the Army aviation environment. Nevertheless, the information currently available should be sufficient to establish much more realistic and accurate design and test criteria for future Army V/STOL aircraft.

New Control Systems May Improve Cobra Helicopter Flexibility

Increased versatility and flexibility of Cobra helicopter gunship operations are envisioned with either of two new control systems being studied by the Modern Army Selected Systems Test, Evaluation and Review (MASSTER), Fort Hood, TX.

Developed by commercial competitors, the systems are designed to provide the Cobra pilot with a greater variety of options in selecting, arming and firing 2.75-inch rockets. Maximum payload for the Cobra is 76 rockets arranged in four pods under the wings.

Current control systems permit rocket firings only in pairs from either the two inside pods or the outside pods, but at no time simultaneously. Present fuze settings which determine where rocket bursts occur, in the air or upon target contact, must be preset prior to takeoff.

Features of the new systems provide capabilities for changing fuze settings while airborne and for selection of firing rockets individually, in pairs, in series of fours, or in combinations of numbers up to 19 at one time.

ARMY and civilian mechanics work together to rewire the weapons system in the wing of a Cobra helicopter gunship in preparation for evaluation by MASSTER.

CIVILIAN inventor Nelson Foley explains workings of new weapons control system to WO2 William Sorenson. The "little black box" is one of two systems designed for the Army's Cobra helicopter gunship.

Remotely controlled firing rates also permit greater pilot flexibility. Replacing the standard 167 millisecond, are firing rates of 70, 110 and 170 milliseconds. Tests will be conducted to determine the effect these new rates may have upon target impact and aircraft tuck.

The control systems feature an inventory unit that informs the pilot of the number of rockets remaining in each pod, and whether they are high-explosive or armor-piercing.

A new type of illumination rocket, capable of being fired by the Cobra, is scheduled to be tested during night-operation evaluations of the control systems. Although not yet in production, the rocket is designed to permit the pilot to light an area without need of dropping a flare or waiting for artillery-fired illumination rounds.

Army Night Vision Technology . . .
Advances Toward Services Components Commonality

U.S. Army efforts to advance the state-of-the-art in night-vision devices for military operations are being directed to a new family of systems having commonality of major components to serve precise requirements of each of the U.S. Armed Services.

In the Southeast Asia conflict, the U.S. Army introduction of night-vision devices was hailed as a far-reaching breakthrough that "took the night away from Charlie"—meaning dramatic curtailment of effectiveness of guerrilla cover-of-darkness attacks.

During the years since the Electronics Command press conference announcement of the highly successful use of the first-generation night-vision devices in Vietnam—as reported in the July-August 1966 edition of the *Army R&D Newsmagazine*—NV technology has made great progress. It is now possible to field vastly improved image-intensifier systems as well as unprecedented "real-time" thermal imaging or far-infrared devices.

Objectively, the goal of current U.S. Army research and development activities is to make the new devices undetectable by enemy forces, and thus less vulnerable to counterattack; to make them effective against smoke camouflage, fog and other all-weather day-night operations; and to achieve cost reduction consonant with austerity funding.

The U.S. Army Materiel Command has assigned Lead Laboratory responsibility for developing NV devices to satisfy the new improvement goals to the U.S. Army Night Vision Laboratories (NVL) at Fort Belvoir, VA, under the U.S. Army Electronics Command (ECOM), headquartered at Fort Monmouth, NJ. The program includes ground, ground-vehicle, airborne, and missile system applications.

Predominantly, the effort is centered on applications of advances in far-infrared technology, visionics, radiation sources, and image intensification—the technique on which most early NV devices were based.

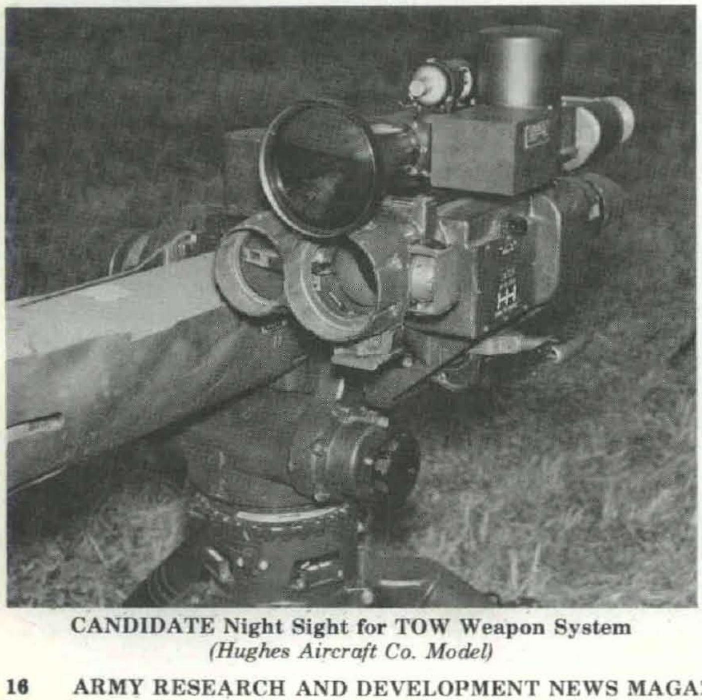
The objective is a basic set of building block components that will meet commonality of parts goals in building systems designed to meet specialized requirements of each of the military services.

A study completed in January 1973 by the Office of the Director of Defense Research and Engineering revealed that the Army, Navy and Air Force collectively had at least 200 far-infrared systems, using 30 different designs, either in inventory or under development.

Meanwhile, the Army Night Vision Laboratory was wrestling with the same problem after having shown to the Department of Defense that to satisfy the forecasted requirements for Forward-Looking Infrared Systems would cost more than $500 million.

Ability of thermal imagers to detect targets under all conditions far exceeds that of image-intensifier systems. They detect temperature differences between targets and their backgrounds—not the dim light reflected off targets.

Further accenting the need to develop advanced systems were the "Lessons Learned" in the Middle East War in October, during which



CANDIDATE Night Sight for TOW Weapon System
(Hughes Aircraft Co. Model)

CANDIDATE Night Sight for TOW Weapon System
(Texas Instruments Co. Model)

many engagements evidenced the critical importance of NV devices.

While custom designing thermal imagers in early developmental efforts, the Army NVL investigators learned that about 70 percent of the cost went into four components—the basic detector, the detector cooler, the scanning mechanism, and the processing electronics. The remaining components are the objective optics and the display.

The current commonality of components approach was originated and developed by NVL investigators seeking to research, develop and produce easy-to-operate night-vision devices with an "affordable" price.

Prototype components of a standard design were procured from two firms to test the validity of the concept. Results established the soundness of this approach and these common components have been applied to some requirements by the other services.

The Director of Defense Research and Engineering has encouraged this Army approach and requested the Navy and the Air Force to follow suit. A presentation to the Department of Defense Joint Logistics Commanders (JLC) aroused further interest, leading to the chartering of a Joint Technical Coordinating Group.

Composed of representatives of the three Services, and presently chaired by the director of the Army NVL, the group is charged with implementing a DoD-wide Thermal Imager Standardization Program expected to reduce by 50 percent the development and production costs.

Called the Standard Far-Infrared Components Program, the NVL ongoing expedited research and development efforts are directed to determination of the requirements of different users, and how infrared technology can achieve acceptable performance and cost tradeoffs.

The commonality approach has a potential payoff in three areas:

- Initial acquisition costs of building block components could be lowered by the anticipated high-volume production.
- Savings could be realized through reduced maintenance, support, training and other ownership costs. (Formerly, each thermal-imaging NV device was of such specialized design that correspondingly special maintenance and support were required. With standard components, one group of technicians can be trained to maintain systems spread across the board—missile sights, combat-vehicle sights, airborne sights and ground sights for the individual soldier.)
- Future NV R&D could be simplified through standardization. The developer would consider his design parameters and requirements, put the common building blocks together, and build a new shell to fit new system needs.

Short-range systems are being considered for incorporation of standard far-infrared components. Modules will be compatible with the short-range handheld devices, since the detector module will accept different types of coolers. The thermoelectric cooler will, NVL researchers believe, probably be incorporated into the handheld devices used by the individual soldier.

Established as the only Department of Defense laboratory wholly dedicated to military night operation problems, the Army NVL has "unique facilities for simulating night conditions, and for fabricating its basic sensor technology with in-house personnel."

NVL employs 344 professional scientists and technicians including 40 military personnel and 304 civilians. Researchers in the Far Infrared Technical Area (FIRTA) are advancing the technology of critical components of conventional infrared scanners, and new approaches to thermal imaging.

Developmental effort in the FIRTA involves new infrared detectors, miniature coolers, charge-coupled signal processors, pyroelectric vidicons and solid-state imagers. This group developed the first man-portable, "real-time" thermal imager, the Handheld Thermal Viewer, which has proven very useful to the Army due to its many applications, ranging from ambush detection to the potential of detecting buried land mines.

The Image Intensification program gave the U.S. Army its first passive night fighting capability. More recently, NVL scientists produced, for the first time in the U.S., very sensitive photocathode structures. Called the third-generation program, these photocathode materials will be retrofitted into second-generation equipment such as the Starlight Scope and Crew Served Weapon Sight to increase considerably their performance range.

The Crew Served Weapon Sight and the Starlight Scope utilize a different gain mechanism for amplifying light than was used in the first-generation equipment, which coupled together three separate intensifier tubes to achieve a light gain of 40,000 times.

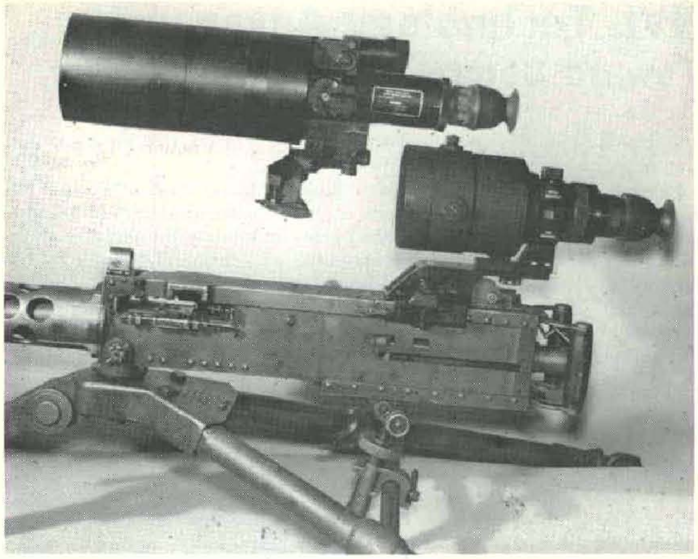
Second-generation items use a single-stage image intensifier employing a microchannel plate (MCP) as the light amplifier. Application and perfection of the MCP as a gain mechanism, accomplished by NVL personnel, reduced by 50 percent the weight of second-generation equipment as compared to the equipment used in Vietnam.

The concept of Pulse-Gating, a hybrid technique of night vision using an intensifier tube and a laser illuminator, was developed by NVL staff members. Pulse-gating systems give the user high-resolution images, range determinations of targets down range, and the ability to see through smoke, fog and haze.

NVL Systems Development Technical Area personnel develop equipment for airborne, ground, ground vehicle and missile system night sights under Army Materiel Command project managers of commodity commands charged with total weapon system responsibility. Technologies of image intensification, far infrared, and radiation sources are used to achieve developmental goals.

The SDTA organization also builds prototype systems, performs in-house studies to prove system feasibility, prepares specifications and guides contractors through the end-item development. This guidance extends throughout the system life-cycle.

An entirely new technology of night vision called Visionics has evolved over the years through NVL developmental efforts to design



SECOND GENERATION Crew Served Weapons Sight, AN TVS-5 (mounted on weapon) is not only lighter than its first generation predecessor, AN TVS-2 (above), but the TVS-5 solves the first generation model's problem of "blooming" in the face of bright light sources such as tracer rounds.

optimized NV systems. One area of Visionics is Laboratory Image Quality Testing. An advanced DoD image evaluation facility can effectively evaluate the newer, more complex infrared imagers.

Another Visionics discipline is that of Visual Perception studies, which examine the man-viewer relationships between a soldier and a night-vision device. NVL's singular capability of simulating thermal targets permits laboratory evaluation of thermal systems.

Visionics Technical Area personnel formulate analytical models to predict performance and costs of proposed NV devices. In the event a system is proposed but not fabricated, these models can be used to determine if the system will meet performance and cost requirements.

The NVL Support and Evaluation Technical Area performs field and environmental testing, including evaluation of modifications, all to determine the fieldworthiness of equipment before it is released to military test agencies. The SETA also gives logistics support to other NVL organizations.

Aside from the common modules program, NVL scientists and engineers are preparing several new devices for production. Second-generation Starlight Scopes and Crew Served Weapons Sights (image intensifiers) are expected to enter production within a year.

The original 6-pound Starlight Scope, when mounted on a rifle of almost equal weight, was cumbersome. The improved version weighs about three pounds and solves its predecessor's problem of "blooming," when the image is momentarily cut off in the presence of bright light sources such as tracer rounds.

Similarly, the Improved Crew Served Weapons Sight weighs only seven pounds as compared to its 16-pound predecessor. The weapon sights and the new Starlight Scope are designed to have parts commonality for all replaceable components except the objective lens. The original devices were not designed for the interchange of parts except the intensifier tube, oscillator and battery.

Another image intensifier unit close to production is the Night Vision Goggles, AN/PVS-5. Arctic tests are completed and limited rate initial production is in progress. The goggles were designed originally for vehicle driving during lights-out conditions, but infantrymen are finding them useful for patrols, local security, first aid and repair and maintenance in darkness.

Army aviators have tested and found the goggles a valuable aid in night flying. The Air Force has tested and adapted them for air-sea rescue operations. Doctors have determined, in experimentation over many months, that the NVGs can provide sight for many affected with the night blinding disease, Retinitis Pigmentosa.

The Handheld Thermal Viewer (HHTV), AN/PAS-7, will soon complete final engineering development and is scheduled to enter production within the year. Operating in the 3-5 micron region of the spectrum, the HHTV will enable the individual soldier to see in total darkness—even through some smoke, fog and haze—and detect possible

(Continued on page 18)

DONALD J. LOOFT is director of the U.S. Army Night Vision Laboratory. He is one of the early managers of NV technology developmental efforts, having served as project officer on image converter tubes and sniperscopes developed in the latter stages of World War II.

Looft continued to work in this area until 1957, when he became chief of the Electric Power Division and later chief of the Electrotechnology Laboratory of the U.S. Army Engineer Research and Development Laboratory, forerunner to the U.S. Army Mobility Equipment R&D Center, Fort Belvoir, VA.

After serving as acting technical director of the center, Looft rejoined the night vision program in 1969 as deputy director of the NVL. He was promoted to prestigious PL313 status when he became director in October 1973.

Looft holds AB and MS degrees from George Washington University. He is a member of the Institute of Electrical and Electronics Engineers (IEEE), American Society of Military Engineers (ASME), and the American Association for the Advancement of Science (AAAS).

His honors and awards include the Fort Belvoir commanding general's medal for leadership, and two Department of Army Decorations for Meritorious Civilian Service.

NVL Technology Advances Toward Components Commonality

(Continued from page 17)

ambushers hidden in foliage. Tested in Vietnam for this purpose, the viewer gained wide acceptance by users.

Several HHTV models have been modified and furnished to the U.S. Bureau of Mines, where inspectors are using them to detect loose and hazardous rocks in mine walls which appear solid to the naked eye.

The Army also is exploring the possible application of the HHTV to detection of buried land mines. Since the earth is disturbed by the "planting" of a mine, the earth's thermal emissivity is changed, regardless of the efforts expended in hiding the explosive.

The U.S. Army Night Vision Laboratory is applying the Standard Far Infrared Components Program as a main thrust to reduce the cost and complexity of NV devices for ground forces, ground vehicles, airborne and missile weapon systems, and to give all Department of Defense forces a new broadly diversified and highly effective NV capability.

AN PAS-7 Handheld Thermal Viewer is in final engineering development and is scheduled for production within 1974. Operating in the 3-5 micron region of the spectrum, the HHTV will enable the individual soldier to see in total darkness—even through some smoke, fog and haze—and detect possible ambushers hidden in foliage. Tested in Vietnam, the viewer gained wide acceptance by users.

U.S. Army Night Vision Program Milestones

Night vision research and development was initiated in the United States before World War II. Development of thermal imaging systems began over 25 years ago and during the 1960s was devoted to fielding image intensifiers for use by combat forces in Vietnam.

Army night vision scientists at Fort Belvoir were experimenting in 1947 with an NV device called Scanrod. This was a single-element far infrared thermal imager that displayed a night scene 20 minutes after the detector took its first look into the darkness.

In 1957, U.S. Army engineers emerged from a darkroom after seeing, for the first time, an image intensifier outperform a pair of 7 × 50 binoculars. For the next 10 years image intensifiers, such as the Starlight Scope, dominated the NV scene.

In 1967, NVL scientists proved the feasibility and state-of-the-art of thermal imagers for Army applications. The then-classified Handheld Thermal Viewer (HHTV) was introduced into more widespread usage.

The HHTV Program provided the infantry in Vietnam with a means to detect potential ambushers hidden by foliage and camouflage. Inhouse NVL scientists who developed the concept of ultralightweight thermal scanners are now preparing the HHTV for production.

Night Vision Laboratory Slates Demonstration for Conference

Night vision devices will be demonstrated to participants in the second biennial Night Vision Symposium at Fredericksburg, VA, Sept. 18-19. Camp A. P. Hill near Fredericksburg will be used for the nighttime demonstration of such devices as the TOW missile competitive candidate night sights, the use of Night Vision Goggles AN/PVS-5 to enhance night aviation capabilities, and the latest far infrared modules.

The first Army Night Vision conference was held in 1972 at Fort Belvoir, VA, home of the Night Vision Laboratory, an Electronics Command element assigned NV Lead Laboratory responsibility by the U.S. Army Materiel Command. This role, by Department of Defense direction, involves development of componentry for all Armed Services.

Department of Defense interest in expediting the development of second- and third-generation NV devices also explains the broadening of the scope of this year's conference to include representatives of the other services. About 300 Army NV scientists and engineers participated in the first conference.

Commonality and modularity of components will be emphasized in the presentation of invited papers and by the guest speakers. Open discussion of the presentations also is programed.

4 MERDC Personnel Win Commander's Awards

Dr. Glenn E. Spangler

James L. Allen

Four winners of the most prestigious awards presented annually at the U.S. Army Mobility Equipment Research and Development Center (MERDC), Fort Belvoir, VA, were honored May 10 at the 17th Commander's Awards ceremonies.

Each of the winners received an engraved plaque and, along with 15 additional nominees in the four awards categories, also received a Certificate of Achievement and a $50 cash honorarium.

Scientific Achievement. Dr. Glenn E. Spangler, a research physicist with the Mine Detection Division, Countermine-Counter Intrusion Department, was the winner in this category. He was cited for his investigations in trace gas detection, membrane technology, and plasmachromatography.

Paul D. Hopler

Technological Achievement. James L. Allen, an engineering technician in the Electrotechnology Department, was honored for his work in resolving electromagnetic interference (EMI) problems on MERDC-developed equipment and his guidance in revising EMI standards.

Leadership Achievement. In recognition of his role in focusing MERDC attention on problems of noise abatement, fluid power systems and contamination control, protective provisions for vehicle roll-over, and the need for international standards for product acceptability, Paul D. Hopler was presented with this award. He is an engineer in the Mechanical Equipment Division, of the Mechanical Technology Dept.

Frank J. Gillispie

Gelini Medal. Presented in recognition of Technical/Administrative Support, this award was made to Frank J. Gillispie, a program analyst in the Operations and Programs Office. He was cited for outstanding performance in scheduling research, development, test and evaluation milestones; also, for his knowledge of new materiel acquisition prerequisites and procedures, and application to planning/scheduling.

Participating Dignitaries. MG Stewart C. Meyer, director, Research, Development and Engineering, U.S. Army Materiel Command, was the featured speaker at the public outdoor ceremonies, attended by several hundred MERDC employes. The awards were presented by Dr. Marvin E. Lasser, chief scientist, Department of the Army' Dr. A. Louis Medin, assistant director, Environmental and Life Sciences, Office of the Director of Defense Research and Engineering; BG John E. Sterling, deputy commander, U.S. Army Troop Support Command; and COL T. R. Hukkala, MERDC commander.

$87 Thousand Granted for Stall-Flutter Research

Fixed-system stall-flutter damping on a CH-47C helicopter is being investigated under an $87,000 research contract awarded by the U.S. Army Air Mobility R&D Laboratory (USAAMRDL), Moffet Field, CA.

When a helicopter flies forward at a high speed and a high value of thrust, stall flutter exerts large loads on the rotor and control system. These loads often determine the flight envelope of the aircraft, according to project engineer Paul H. Mirick of USAAMRDL's Eustis Directorate.

As a possibility for reducing these loads on the CH-47C, the Boeing Vertol Co. has examined the feasibility of installing a damper in the control system. Data obtained from CH-47C flight tests by Boeing will be examined to determine if the introduction of damping into the control system significantly reduces rotor control loads.

EPA Examines Pollution Control Techniques

Results of a comprehensive examination of the principal air and water pollution control and residue disposal techniques are presented in a recent report by the U.S. Environmental Protection Agency.

Intermedia Aspects of Air and Water Pollution Control, a 358-page document, lists the major pollutants of air and water, sources of pollutants, and problems associated with them.

Copies of EPA-600/5-73-003 are available through the National Technical Information Service, Springfield, VA 22151.

In Weapons Systems Evaluation . . .
It's Time to Simulate!

By MAJ Mark H. Machina and Gregory A. Goolkasian

Advances in computer simulation during the last 10 years have made its application to many and varied fields possible. We have only begun to realize the potential of this technique in weapon systems development and evaluation.

Consider the problem of conducting weapon systems analyses. This involves an array of critical considerations. The decision to accept a proposed system involves not only a dollar cost; it may also have a profound effect on military doctrine, tactics and organization. Because future weapons systems may be of a hypothetical nature, problems which surround the analysis are often difficult to define and quantify.

Field testing can be used to analyze the effects of existing systems or systems for which prototypes have been produced. This means is as close to combat testing as we can get without the risks and hazards of actual combat. However, due to the high cost of field testing, it is becoming more impractical for all aspects of a proposed weapon system.

Another tool must be found that, when used in conjunction with field testing, will help reduce analysis costs. Computer simulation is that tool and it has been playing an ever increasing role in weapons systems analysis over the last quarter century.

One of the most beneficial uses of computer simulation (CS) is in dealing with systems so complex that it is either impossible to develop an analytical expression to represent the system or impossible to manipulate such an expression to yield a solution.

Simulation involves the use of models which may be analytical or symbolic. The sand table, which has been used by tacticians for years, is an example of a symbolic model. Collection of mathematical expressions which can represent the working of some physical system is an example of an analytical model.

Both of these types of models are used to simulate reality in testing new ideas or predicting effects of changes in a system. Only the very simple analytical model, however, can be used without the assistance of a computer.

Analytical models can be further separated into deterministic and probabilistic models. Deterministic models are those in which a certain input results in a specific output; and given any input to the system, we can confidently predict the output.

Probabilistic models are dependent upon probability distributions. These models are useful in industry, as well as in the military, especially where there are numerous variables and parameters whose values can be, at best, only estimated. Examples of such unknown parameters in probabilistic models are expected demands that will be received in the next quarter or the number of casualties that can be expected in the impending operation.

CS allows the analyst to study the major factors of the system and their interrelationships. Frequently, simulation is the only means available to study such systems.

Possibly the most important advantage of using CS is that it permits sensitivity analyses in an efficient, low-cost manner (as opposed to field testing) that identifies the effects of varying the parameters of a system. In reviewing the effects of parametric excursions, the analyst can explore more alternatives and relationships between factors.

Cost/performance trade-offs, in a sensitivity analysis, can be studied with sufficient replication of alternatives to allow decisions to be made with increased statistical confidence. The cost and time involved in prototype development necessitate the most thorough sensitivity analysis before physical changes are made that may prove undesirable.

In the Spring of 1972, the Systems Analysis Group (SAG), Combat Developments Command, was involved in the Main Battle Tank (MBT) Task Force, with responsibility for the CS for parametric analysis. Of interest to the task force were the effects of three parameters in a tank engagement—lethality, mobility and accuracy.

Unable to control these parameters in an actual combat engagement, the SAG used CS along with parametric analysis to evaluate the effects and interactions of the proposed tank. Two ground combat simulation models, DYNTACS and Bonder/IUA, were exercised. By changing the input data, one variable at a time, statistical tests were performed on output to measure differing effects.

In evaluating the effects of mobility on a tank in combat, the mobility parameter was varied to allow the tank to travel at speeds of 5, 15 and 25 miles an hour. Lethality and accuracy were varied similarly. Results of the simulation, therefore, could be linked directly to the changed variable. Computer simulation along with parametric analysis provided the Systems Analysis Group with a tool for testing the effects of different variables in a tank engagement.

Another experiment employing CS is Tactical Effectiveness Testing of Antitank Missiles (TETAM). TETAM includes a field experiment which examines three different antitank missile systems in as near combat conditions as possible. Attempts will be made to verify certain subroutines of ground combat models: DYNTACS, IUA and CARMONETTE.

Subsequently, the Concepts Analysis Agency (CAA) and the Combined Arms Combat Development Activity (CACDA) will exercise the models with the three antitank missile systems and change parameters to assess the effect of each weapon system. Once the simulations are exercised, statistical differences can be determined for a comparative effectiveness evaluation. This gives the decision-maker a quantitative basis for judgment.

In TETAM, as was done in the MBT evaluation, CS is being used along with parametric analysis to assess the effects of current weapon systems. In both studies actual combat testing was impractical, though the analyses required a detailed study of the proposed system in combat. In the MBT study, simulation was used to assess a range of hypothetical changes.

From these two examples alone, several advantages of using CS become apparent. Proposed weapon systems and changes to existing systems can be evaluated prior to production. Parametric analysis via CS provides for the assessment of more possible configurations and alternatives. Finally, CS reduces field testing cost, time and personnel.

CS can model the battlefield, thus giving the analyst an additional tool in the evaluation of a weapon system. The biggest question in weapons proposals is, "How does it perform in combat?" A better insight into this question can be gained with parametric analysis via CS.

Weapons development and improvement have long been an expensive, time-consuming process. Only in recent years have we begun to exploit CS in this field. With the rapidly increasing cost of weapons development, the necessity of finding new, fast, inexpensive analysis techniques has become urgent.

Although simulation may require considerable computer time, it is frequently the only feasible means available to the analyst. It may be, as the number of probabilistic parameters increases, that CS is the *only* possible way to solve the problem or even estimate the solution.

Still it must be remembered, that simulation is *not* a panacea. This technique is based on estimates and assumptions, but it does provide insights to which the decision-maker can apply experience and sound judgment.

MAJ MARK H. MACHINA, assigned to the Safeguard Systems Office, Arlington, VA, received his BS degree from Lafayette College and his masters in operations research from Georgia Institute of Technology. He also is a graduate of the U.S. Army Command and General Staff College.

GREGORY A. GOOLKASIAN, manager of Operations Research for Peterson, Howell and Heather Corp., Baltimore, MD, received his BS degree from Boston College and his masters in operations research from Northwestern University.

NATO Inventory Net (loaded), manufactured in Great Britain, is airlifted by a CH-54B Flying Crane, during an evaluation at Yuma Proving Ground, AZ.

Antiballistic Missile System Evaluation

By MAJ Craig R. Ailles

Long lead times required to develop, produce and field weapons systems—often as long as 10 years or more—as well as the current rapid increase in costs, emphasize the need to demonstrate that a system will perform to design objectives in a cost-effective manner before production begins.

Accordingly, an extensive system evaluation, using a combination of analytical studies, simulations and prototype testing, is conducted to validate that a system's design responses will meet performance specifications.

If the system fails to meet some part of the specification, the design is changed and the system is modified and retested. After demonstrating that the design performance specifications can be met with high confidence, the system design is released to production.

Because of unique features of the Safeguard ABM (Antiballistic Missile) System, the function of evaluation is to estimate total system responses in order to validate, with high confidence, that design objectives will be achieved.

The primary mission of the Safeguard System Command is to establish an ABM site complex for defense of the land-based United States retaliatory forces in the vicinity of Grand Forks Air Force Base, ND (Figure 1).

Based on this mission and reasonably stated, the Safeguard System must be able to detect and intercept multiple nuclear-tipped reentry vehicles in a nuclear environment. Within threat capabilities system designers have met these requirements, using phased-array radars, data processors and nuclear armed missiles.

Many factors prevent validating the tactical Safeguard System by testing alone. For example, the system must be able to operate in a nuclear environment, but the Nuclear Test Ban Treaty prohibits atmospheric testing. The system must defend against a mass attack of ICBMs, but producing this environment at a test site is impractical and costly.

Full operational testing at the Grand Forks site is not possible because of safety requirements imposed by its location in the Continental United States (CONUS), its close proximity to the Canadian Border, and costs and schedule restraints.

Because of these factors and for other reasons, a balanced combination of live tests, both field and laboratory, and computer simulations were employed to evaluate the Safeguard System design.

System evaluation involves two major phases of activity which, in some instances, are conducted concurrently. The first phase focuses attention on the performance and functional requirements specified by the tactical designer. The purpose is to verify that subsystems, such as phased-array radars, missiles and data processors, will work in the system context.

System and subsystem computerized simulations are developed to model the system response, to insure that critical system performance characteristics are identified and reflected in the system requirements.

Simulations are validated with field-test data and then "exercised" to insure that critical performance and operational characteristics can be met.

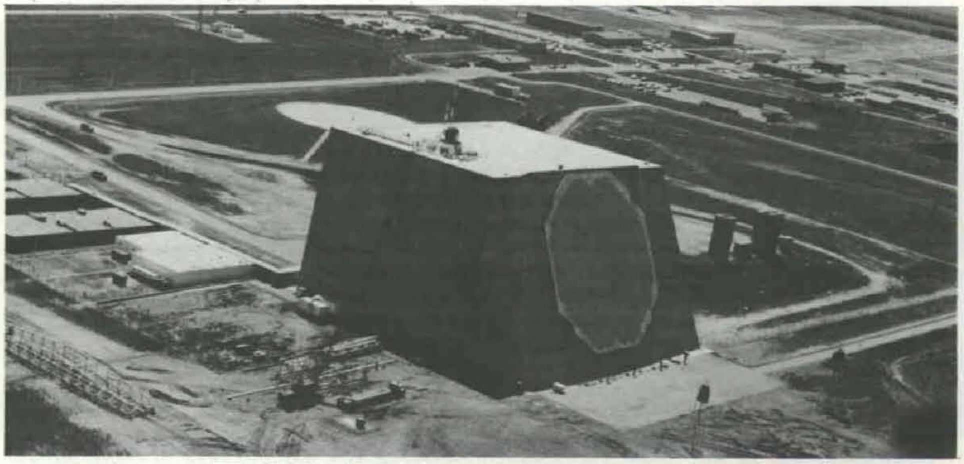


Fig. 1. SAFEGUARD SYSTEM under construction at Grand Forks, ND.

The second-phase evaluation focuses upon the system's capability to perform in a specific configuration, such as the Grand Forks site deployment. System and subsystem simulations are used to validate tactical system response.

These simulations are first validated by data collected from a selective set of field and laboratory tests configured to be representative of the specific system deployment. Models then are exercised over the full range of system deployment response to validate the tactical system's ability to meet design performance specifications and/or demonstrate where design modifications are required.

Evaluation proceeds from system requirements to design implementation, with the objective of obtaining adequate data to permit a realistic, confident and cost-effective assessment of system capability.

This Safeguard System objective has been met by first identifying the requirements that define the collecting and use of "live" test data produced at Meck Island at the Kwajalein Missile Range in the Pacific (Figure 2), the Tactical Software Control Site in Madison, NJ, and the Tactical Site at Grand Forks.

The next step has been to establish how these data and the Safeguard System Simulation (SAFSIM) and subsystem simulations, i.e., Sprint Engagement Simulation (SES), Missile Site Radar Simulation (MSRSIM), Perimeter Acquisition Radar Simulation (PARSIM), Spartan Simulation (SPARSIM), provide a balanced and realistic compromise to extensive and costly statistical testing as proof of design capability.

Ideally, detailed system analyses and sensitivity studies should be conducted before defining the integrated test plan. Practically, the pressure of schedules required that the identification of test objectives proceed in parallel with the development of simulation tools and preliminary analyses of system requirements.

Consequently, the test program is continually reviewed in terms of the additional information obtained from increasingly detailed system simulations.

Figure 3 diagrams the primary interfaces between the design, evaluation and test activities for the Safeguard System. The output of System Design is documented in the form of Performance Requirements provided to designers of both hardware and software. Their responsibility is to implement designs that satisfy the performance requirements in the most efficient and practical manner possible.

Clearly, this task involves continual interaction among the design, evaluation, and test groups. Performance Requirements for both hardware and software are a primary input to System Evaluation.

Evaluation must rely heavily on both simulation and analytical analysis. For simplicity, system evaluation is also represented in Figure 3 in terms of the major simulation tools that are continually being updated and extended.

The SAFSIM is designed to provide insight into over-all system operation, with particular emphasis on the battle-planning functions.

Initially, the simulated system is made to operate in accordance with the Performance Requirements. Since, quite properly, the Performance Requirements often permit the designer considerable latitude, modeling of the system simulation in this initial phase often entails considerable invention.

Again, the goal is to ensure that the defense objectives will be achieved if the system operates in accordance with the Performance Requirements; also, that inadequacies in sys-

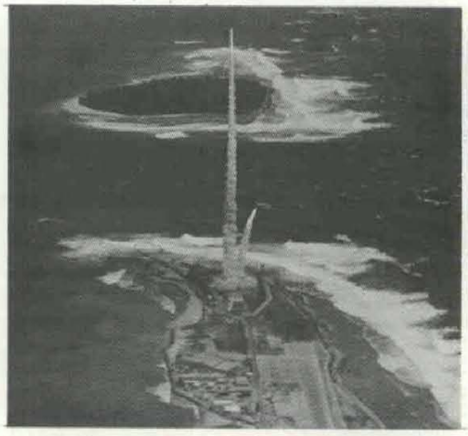


Fig. 2. MULTIPLE Sprint launching from Meck Island in the Kwajalein Range.

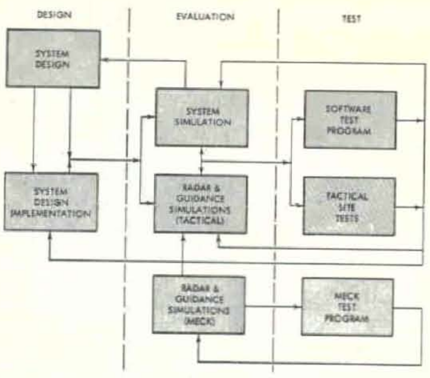


Fig. 3. System Evaluation Procedure

tem design will be identified and corrected before extensive resources are committed to implementing a faulty design.

Practicality limits the level of detail in which the various weapon system functions can be modeled in SAFSIM. Supplemental effort includes far more detailed simulations of the particularly critical functions of surveillance, tracking, target selection and guidance.

Considerable insight can be gained into detailed system operation by properly employing these simulations in concert. For example, SAFSIM can be used to examine the total system response to a representative attack scenario. External environment affecting the tracking history of a particular threat object of interest, such as location and time history of defensive bursts, can be determined from examination of SAFSIM output and provided as input to the detailed Sprint Engagement Simulation.

Two Sprint Engagement Simulations, the Tactical Version and the Meck Version, are used because of the differences between the tactical deployment and the "live" test facility at Meck Island. The latter is used primarily for testing guidance and data-gathering functions by intercepting ICBM targets, tailored to program requirements, with Sprint and Spartan missiles under the control of the Prototype Missile Site Radar (MSR) and data processor.

The tactical SES uses the input from SAFSIM to determine the performance of Sprint in a multitude of engagement situations, all of which will take place in a specified volume. The results are analyzed and a matrix produced that identifies the "live" tests essential to validate the model.

All combinations of tests required for physically validating the model cannot be performed; only a representative subset is actually tested. This subset bounds system performance and closely approximates engagements the deployed system must be able to perform.

Figure 4 is a representation of the intercept volume of the Sprint missile. The points designated P1 through P4 represent the intercepts which bound system performance.

The next step is to simulate the "live" test using the Meck SES, with all applicable inputs from SAFSIM and the Tactical SES, to insure that the Meck system can perform the intercept and that the data required for validating the various models will be produced.

After the "live" test is conducted, the Meck SES is exercised, using the environmental parameters that existed during the test. Results are compared with the test data and the Meck SES modified, as required, to reflect actual performance. Once the Meck SES is validated, these results are extrapolated to the Tactical SES with a high degree of confidence. In turn, the Tactical SES is used to validate the more approximate engagement model incorporated in SAFSIM.

As the designs of the tactical hardware and software solidify, these simulations are continually updated to provide a more accurate representation of tactical operation, and the evolving system is continuously evaluated. Validity of these simulations depends upon the fidelity with which tactical software, external environment and system components are modeled. Confidence in these models can be achieved only through carefully designed tests on appropriate test facilities.

In addition to validating the capability of the Tactical System to defend against a variety of representative attacks, SAFSIM provides a means of defining requirements for tests to be conducted at the Tactical Software Control Site (TSCS) and a frame of reference with which to compare the results of such tests.

The TSCS is used to test the tactical data-processing hardware and software for both the Perimeter Acquisition Radar (PAR) and Missile Site Radar (MSR). Full-load tests of the tactical software in which the external environment is faithfully simulated are required to validate that the tactical data processor will function as represented in SAFSIM.

The requirement for effective system evaluation is met, using extensive computer simulations and a bare minimum of "live" testing. The goal is to enable the United States to deploy an ABM system at Grand Forks that will meet national objectives at a minimum of costs and within the required time frame.

Experience gained in evaluating the Safeguard System by live testing and simulations is directly applicable to the site defense system prototype development. The Strategic Arms Limitation Treaty (SALT I) between the United States and the Soviet Union allows only two ABM sites to be constructed in each country. Deployment in the United States is limited to the Grand Forks site and one site in the Washington, DC area.

National policy is to develop an ABM system to protect the Minuteman Forces and be able to responsively deploy the system in the event the treaty is modified or abrogated. The Site Defense System, consisting of internetted radars, data processors, and Sprint missiles, has been selected to fulfill this mission.

The concept of prototype development is to design the Site Defense System to protect the Minuteman Forces, validate by live testing only those important, critical system uncertainties, and be prepared for a responsive deployment.

As with the Safeguard System, total validation of the Site Defense System will be by extensive computer simulations and minimum live testing. This will insure that the United States has a viable defense of its Minuteman Forces at minimum costs.

MAJ CRAIG R. AILLES has been serving as an R&D coordinator since 1970 at the U.S. Army Safeguard System Command (SAFSCOM), Redstone Arsenal, AL, where he is responsible for analysis of foreign strategic weapons systems and tactics.

During 1970–73, he also was responsible for engineering and scientific research in the area of national effectiveness for the Safeguard System at SAFSCOM. Additionally, he participated in the Source Selection Evaluation Board for the Site Defense Prototype Demonstration Program and design review of the Safeguard System.

MAJ Ailles served a tour of duty as S2/3 with the 99th Combined Services Support Battalion, 3d Brigade, 9th Infantry Division in Vietnam, subsequent to service (1968–69) with U.S. Army Europe (USAREUR) as chief, Operations and Training Division, Advanced Weapons Support Command; chief, Support Services Division, Advanced Weapons Support Command; and CO, 529th Ordnance Company, Advanced Weapons Support Command.

He has bachelor's and master's degrees in mechanical engineering from the University of Cincinnati.

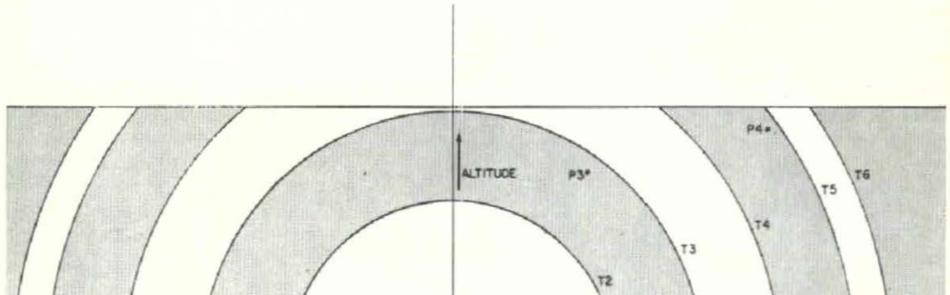


Fig. 4. SPRINT TIME of Flight Contours—Intercept Volume

USAAMRDL Efforts in Reducing Gas-Turbine Pollution

By Robert G. Dodd & CPT Timothy D. Balliett

Recent efforts by the Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, VA, have illustrated that significant reduction in gas-turbine pollution levels can be achieved with attendant increases in over-all combustor efficiency.

Based on Detroit Diesel Allison's background and test experience in the gas-turbine exhaust emissions area, a contract was awarded to develop a combustor having a 50 percent over-all reduction in mass emissions, without increasing the amount of any individual pollutant (CO, HC, NO_x, smoke) when tested over a typical Army light observation helicopter duty cycle.

Initial program efforts were directed towards an analytical evaluation of several low-emission concepts using both chemical kinetics and empirical correlation techniques. Following that evaluation, 17 experimental combustors were designed and fabricated to incorporate one or more of the low-emissions concepts developed in the analytical phase. Combustor rig testing revealed that several concepts had the potential to reduce emissions without severe penalties in performance.

Data were obtained by using the Detroit Diesel Allison T63 engine combustor. Tests at nonregenerative operating conditions made it possible to gather emissions data representative of current low-pressure ratio helicopter gas turbines. Regenerative engine test conditions provided data more representative of future helicopter gas-turbine engines with higher combustor inlet temperatures.

The T63-A-5A combustor consists of a dual-orifice pressure-atomizing fuel injector, a capacitive-discharge spark igniter, and a can-type film-cooled combustor liner. This combustor was desirable as a test vehicle due to its simplicity; however, the concepts developed under the program should be applicable to future annular combustors.

The initial analysis of concepts utilized a computer model to predict CO, unburned HC, NO_2, and NO. The emissions reaction kinetics model was a finite-rate hydrocarbon combustion reaction model that predicted emission trends as a function of fuel/air ratio, inlet temperature, pressure, and residence time.

A second analysis method consisted of predicting changes in emissions from empirically derived correlation equations. Equation coefficients were found by normal least-squares curve fitting to enable prediction of carbon monoxide and total nitrogen oxide emissions for steady-state operating conditions.

The third analysis method involved application of emission reduction-test data available from the literature to the T63 over the light observation helicopter duty cycle. Data were extracted from internally published Allison test results, technical literature, and U.S. Government-sponsored combustor test results.

Concepts analyzed included air-blast/air-assist, premix and vaporization, staged fuel, air-fuel ratio variations, variable geometry, early quench, reverse flow, delayed dilution, swirl, massive recirculation, heat-rejection, water and cold-air injection, volume changes, and rapid conversion to plug flow.

Results from analysis of these concepts produced the following design guidelines for reducing emissions:

- For droplet combustion, use air-blast or air-assist fuel injectors.
- For lowest emissions, use a pre-vaporized, pre-mixed fuel preparation system.

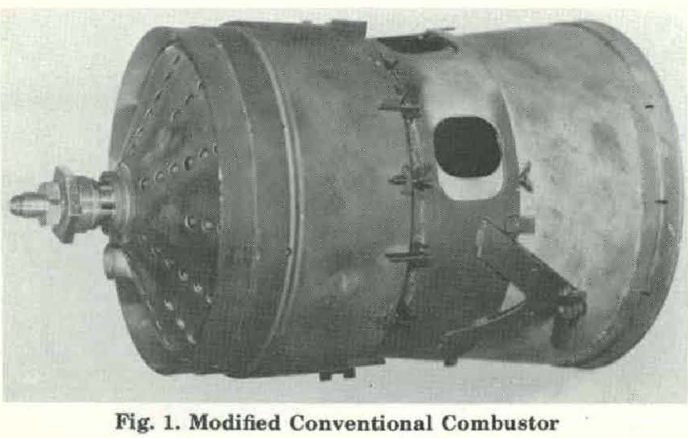


Fig. 1. Modified Conventional Combustor

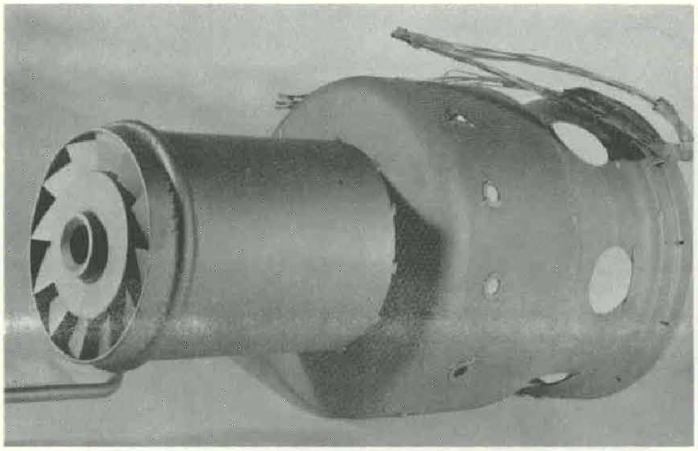


Fig. 2. Final Prechamber combustor

- Primary zones should be small, and should approach kinetically a stirred reactor region.
- The intermediate zone should be converted to plug flow as soon as possible.
- Variable geometry combustors can reduce emissions from comparable fixed-geometry combustors.

From the original 17 combustors, two approaches were selected for final design and experimental evaluation. One method incorporated

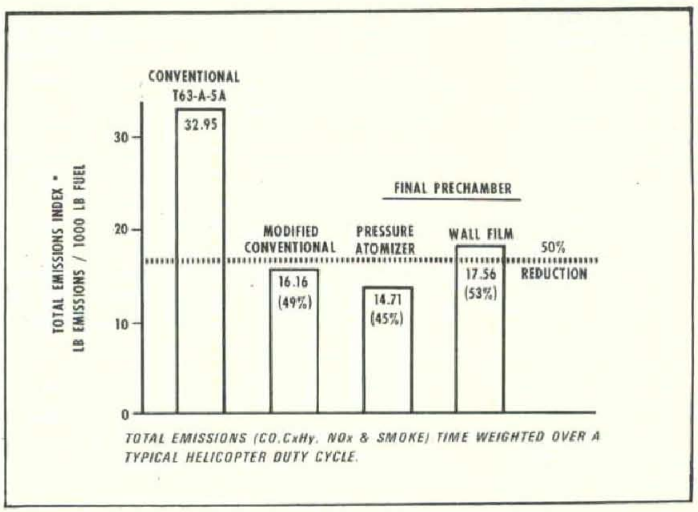


Fig. 3. Total Combustion Emissions Reduction

ROBERT G. DODD, the responsible aerospace engineer for this research project, serves with the Technology Applications Division, Eustis Directorate of the U.S. Army Air Mobility R&D Laboratory (USAAMRDL), Fort Eustis, VA.

He plans, initiates, monitors and conducts programs in advanced and exploratory development, including R&D programs in gas-turbine combustors, engine exhaust emissions, combustor noise and gas-turbine engine costs.

Prior to joining the Eustis Directorate in June 1971, he was a UH-1B pilot in Vietnam and a UH-1D and CH21C helicopter pilot at Fort Belvoir, VA.

Graduated from the University of Alabama in May 1971 with a BS degree in aerospace engineering, he is studying for a master's in fluid mechanics and thermal sciences at George Washington University.

modifications to the conventional T63-A-5A combustors; the other represented advanced technology offering greater emissions reduction potential but requiring greater developmental effort.

The two approaches were identified as the Modified Conventional (MCC) and the Final Prechamber (FPC). The MCC (Figure 1) employed variable-dilution geometry and air-blast fuel injection and the FPC (Figure 2) utilized a swirl-dome premix cup and extended overall length.

Both methods used primary-zone convective cooling and delayed dilution. The FPC was tested with both pressure-atomizer and wall-film fuel systems. Results indicated that both combustors, using the pressure atomizer, met the program objectives, while the FPC with a wall-film fuel system did not (See Figure 3).

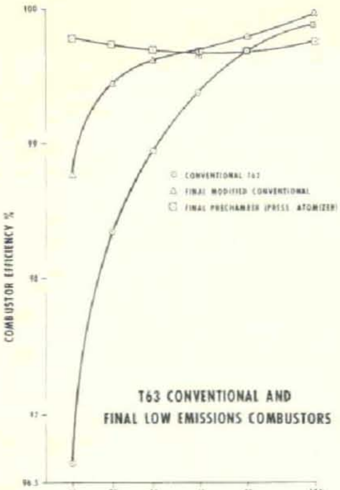


Figure 4

Test data from the combustor test rig were comparable to data from an actual engine. Although variable geometry was efficient in emissions reduction at the idle- and high-power operating modes, it was concluded that the effectiveness was reduced significantly when tested over the selected light observation helicopter's duty cycle—due to the heavy time weighting (about 80 percent) at mid-power conditions.

Ignition testing revealed deficiencies in the FPC. Further development to improve altitude relight, exhaust-temperature profile, pressure drop, and fabricability would be required before the combustor could be incorporated in an engine.

The 50 percent emissions reduction goal was attained by both the MCC and the FPC with the pressure atomizer. Both combustors demonstrated increased efficiency at cruise and lower power ratings (Figure 4). More important, however, the experience and knowledge gained during the program represent an appreciable improvement in combustor design techniques for emissions reduction.

CPT TIMOTHY D. BALLIETT has been an aeronautical engineer since September 1973 with the USA AMRDL Eustis Directorate, Technology Applications Division, serving currently as a technical adviser for programs involving noise in turbomachinery.

Graduated from the U.S. Military Academy in 1968 with a BS degree and from Purdue University in 1973 with a master's in aeronautical and astronautical engineering, he completed the Airborne Qualification Course, Infantry Officers Course, Jumpmaster School and Ranger School in 1968; Air Mobility Course, 1969; and Infantry Officer's Advanced Course in 1972. He served with the 82d Airborne Division, Fort Bragg, NC, 1st Air Cavalry Division, Tay Ninh, Vietnam, and as a company commander with the 1st Infantry Division (Mechanized), Fort Riley, KS.

AMMRC Researchers Investigate . . .
Structural Effects From Combat Damage

By Dr. Thomas P. Rich and Peter G. Tracy

A growing concern for the effects of ballistic damage on the residual strength, structural response, and operational life of military equipment is reflected in the current design philosophy for materiel fabrication.

An awareness has evolved for the need to incorporate knowledge of these effects in the initial phases of the design process—to build in an increased tolerance to combat damage and thus achieve a reduction in vulnerability of military hardware.

Current research into the development of analytical approaches for estimating the residual strength of ballistically damaged materials is being conducted in the Mechanics Research Laboratory, Army Materials and Mechanics Research Center (AMMRC).

(Dr. Thomas Rich, research mechanical engineer, and Peter Tracy, physicist, have developed a statistical model for representing the probability of failure of a given structural element in terms of the degree of damage suffered and the mode of failure of the element in the undamaged state.)

With the AMMRC model, the authors have demonstrated the method of application of Weibull extreme value probability functions to representation of damage strengths and the utility of statistical results to assessing the vulnerability of potential and/or current hardware designs.

Ongoing research is active in the area of ballistic damage assessment incorporating applications of fracture mechanics concepts. Conventional measures for assessing the extent of ballistic damage have been expressed to a point that barely incorporates the various modes of observed ballistic damage: through holes, cracking, spallation, petalling, and other out-of-plane deformations.

Because of their oversimplification, the roles of combined loadings, variation in failure mechanisms between damage modes, and material properties (anisotropy, etc.) are excluded from resulting residual strength estimations. This is one area where knowledge of fracture mechanics can lead to better residual strength predictions by providing parameters that more closely assess the influence of ballistic damage (i.e., stress intensities, or other parameters reflecting failure mechanisms).

Associated with the application of fracture mechanics to damage assessment is a 2-part approach to failure analysis. First is the stress analysis for structural elements containing ballistic-like damage. Second is the formulation of a failure law that reflects the observed modes of failure in terms of the parameters available from the stress solution.

The Modified Mapping Collocation Technique developed at AMMRC is being employed to meet the first requirement by a study of the elastic stress state in panels containing star-shaped damage. The "worst" cases of stress intensification will be sought by using a computer to define a better measure of damage extent for employment in the statistical model.

For the second phase of failure analysis, an experimental program is being conducted with controlled damage aluminum specimens to define appropriate failure criteria and correlate the statistical representations obtained for actual ballistically damaged structural elements.

Knowledge of this type will enable designers to assess more reliably the combat tolerance of a critical structural component or assembly.

Peter G. Tracy

Dr. Thomas P. Rich

PETER G. TRACY is an AMMRC physicist who received his bachelor's degree from Northeastern University, Boston, MA, in 1972. While employed at the AMMRC under the student cooperative program, he was involved in research on the dynamic loading of structures using the shock tube. With Dr. Rich, he has worked in development of a statistical model to represent the probability of a failure of a structural element and in the stress analysis for a structural element containing ballistic-like damage.

DR. THOMAS P. RICH, research mechanical engineer at the AMMRC, is currently a visiting scientist and teaching fellow at the university in Southampton, England. He received a BS degree in mechanical engineering from Carnegie Mellon University in Pittsburgh, PA, and master's and doctoral degrees from Lehigh University, Bethlehem, PA.

His doctoral study was in friction welding, under a fellowship award from the National Aeronautics and Space Administration. In 1971 he received the William Spraragen Award from the American Welding Society for the best research paper published that year in the Welding Journal, *titled "The Forge Phase of Friction Welding."*

Dr. Rich is technical reviewer for Applied Mechanics Reviews *and the* Journal of the Society for Experimental Stress Analysis.

Another Kind of Armor Problem . . .
Suppression of Infrared Radiation From Army Aircraft

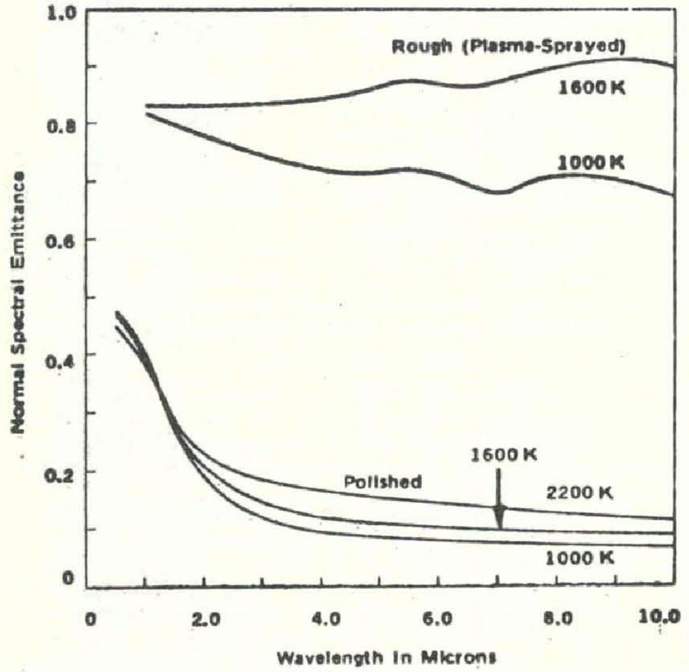


Fig. 1. Spectral emittances of polished and plasma-sprayed tungsten at 1000 K. and 1600 K.

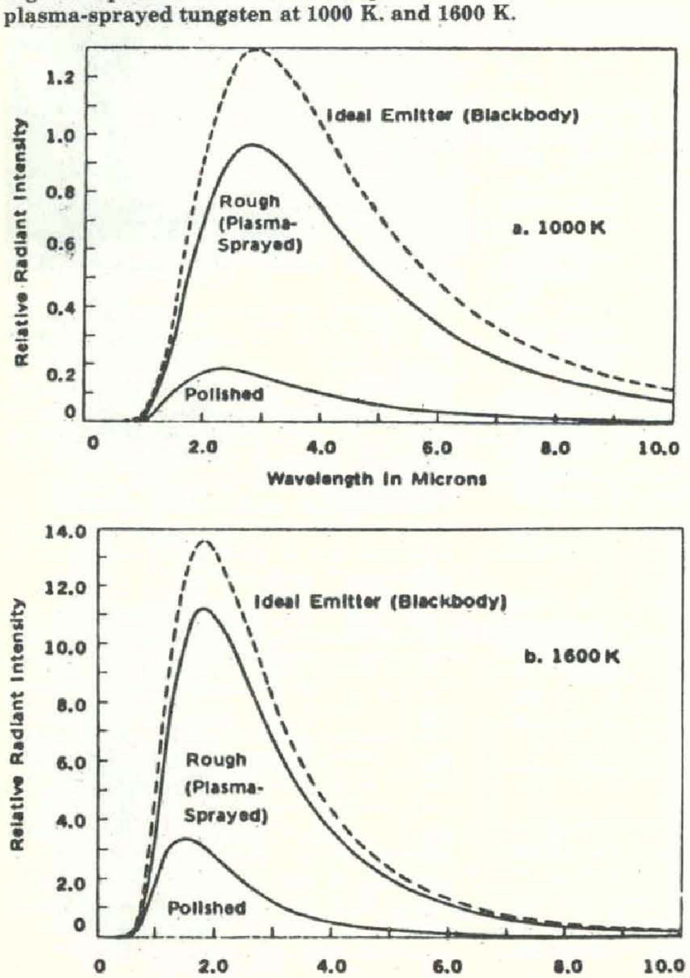


Fig. 2. Relative Radiant Intensity of Tungsten

By Albert F. Grenis and Albert P. Levitt

Proper selection in using coating materials can substantially alleviate problems in development of advanced infrared (IR) weapon systems where structural components are exposed to high temperatures and become IR radiators, such as in U.S. Army aircraft.

Further research and development of new materials and methods of application are needed, however, to control IR in aircraft, and this effort can be regarded as another kind of armor problem.

Basically, if one could control the temperature of a material together with its thermal radiative properties, called emissivities, then one could control the IR emanating from a material surface, that is, enhance or suppress IR over different wavelengths.

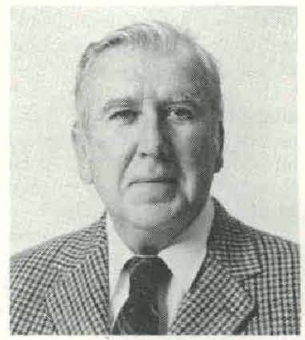
This may not appear to be a difficult requirement, but it can become most difficult to fulfill in practice. To give some insight into the field of IR, some basic facts must be understood. Rather than describe facts by mathematical formulae, it is easier to state some essentials.

- First, IR is a form of electromagnetic radiation. One of the differences between IR and microwave radiation is the order of magnitude of the frequencies (or wavelengths) involved.
- The visible region of the electromagnetic spectrum extends from 0.4 micron to 0.8 micron in wavelength; the IR extends from 0.8 micron to 1,000 microns in wavelength, approximately; and the microwave region extends from 1,000 microns in wavelength and beyond.
- Normal spectral emissivity and normal total emissivity are ratios of IR measured from a material surface to that of an ideal emitter (blackbody reference) when both are at the same temperature. These ratios, which can vary from near zero to near unity, refer to one particular frequency and to the sum of all frequencies, respectively.
- IR intensities of materials can be readily obtained if the emissivities are known (since IR intensities of the ideal emitter, derived and formulated by Planck, are also known quantities).

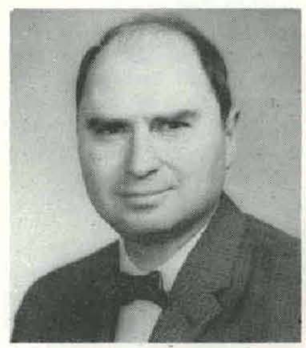
To illustrate the effect of material emissivity on the emitted IR, two refractory coatings, one of tungsten and the other of aluminum oxide, have been selected as examples. Since the radiation intensities from materials are more discernible at high temperatures, those from both of these coatings at HT are shown.

Referring to the normal spectral emissivities (or emittances when the •

ALBERT F. GRENIS is a physicist in the Metals Research Division of the U.S. Army Materials and Mechanics Research Center (AMMRC), Watertown, MA, where he is employed in the areas of infrared radiation, molecular physics, and thermophysical properties of various materials. Currently, he is engaged in experimental and theoretical studies of fiber-reinforced metal matrix composites. Grenis holds BS and MS degrees from Northeastern University.



ALBERT P. LEVITT, supervisor of metal matrix composite development at AMMRC, received an AB degree in engineering sciences, and an MS in mechanical engineering from Harvard University. In 1961 he was awarded an Army R&D Achievement Award. He is editor and a contributing author of "Whisker Technology," recently published by Wiley-Interscience. Levitt also is the author of numerous publications on high temperature and composite materials. He has lectured at the University of New Hampshire and Ohio State University.



surface is rough) of tungsten, Figure 1, and to the corresponding IR intensities, Figure 2, it is readily observed that a 5-fold decrease in total IR can be achieved by using a polished rather than a rough plasma-sprayed tungsten coating (assuming no oxidation effects).

The normal spectral emissivities [1] of the plasma-sprayed tungsten coatings were obtained experimentally by members of the Metals Research Division, Army Materials and Mechanics Research Center (AMMRC), Watertown, MA; similarly, those of polished tungsten were selected from published data on the open literature [2-5] and were used for the emissivity curves shown.

When employing aluminum oxide coatings,[6,7] for which the spectral emissivities and corresponding radiant intensities are shown in Figures 3a and 3b, respectively, the reduction in IR is not as dramatic. However, this material illustrates the possible use of a ceramic coating to combat detection within the infrared region by reducing the total radiation.

Results discussed thus far pertain to data obtained under a vacuum environment. Figure 3c illustrates the radiation characteristics of aluminum oxide [6,7] in an air environment. The effect of the absorption bands for the H_2O and CO_2 vapors in the atmosphere, as well as the transmission effects of a CaF_2 window used in determining the radiation intensity experimentally, are shown.

The data demonstrate that the use of special coatings on the high temperature components of Army aircraft can significantly reduce their IR emissivity, thereby reducing their vulnerability to IR-seeking missiles.

Since the thermal efficiency of any combustion engine rises with increasing operating temperature, there is a continuing effort to develop Army aircraft engines having higher operating temperatures. Suppressing the enhanced IR of these new engines is a major problem that will require development of new and improved IR-suppressing coatings for utilization in advanced heat-shielding designs.

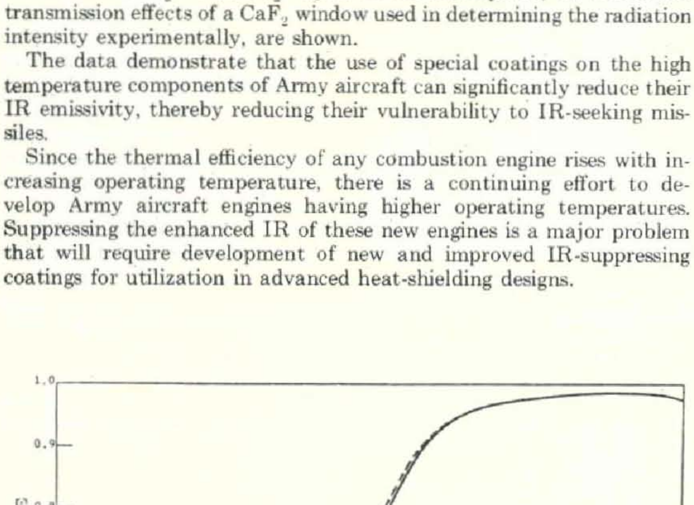


Fig. 3a. Spectral Emittance of Flame-sprayed Aluminum Oxide at temperature of 1300 K.

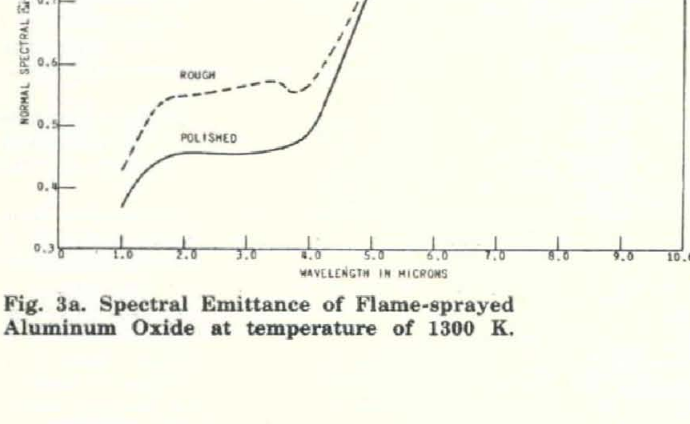


Fig. 3b. Relative Radiant Intensity of Flame-sprayed Aluminum Oxide at temperature of 1300 K.

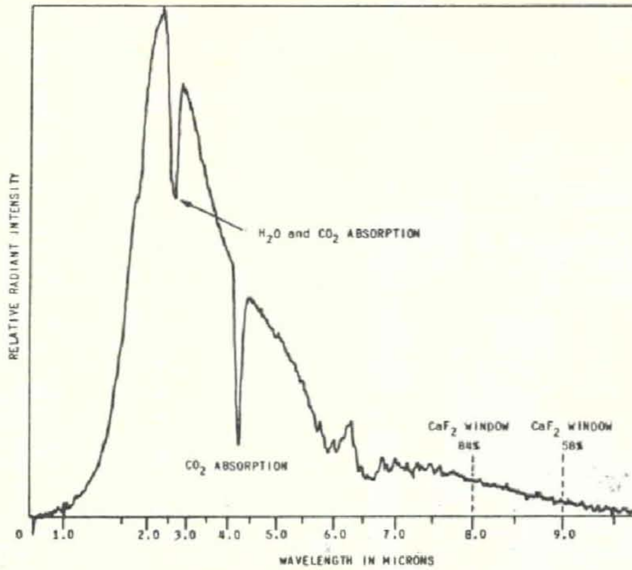


Fig. 3c. Relative Radiant Intensity of Flame-sprayed Aluminum Oxide (polished) in Air at 1300 K.

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NBS Publishes Research Calibration Guide

Industrial and scientific specimens which can be used to calibrate or coordinate desired research measurements are contained in a new catalogue and guide recently issued by the National Bureau of Standards (NBS), U.S. Department of Commerce.

Standard Reference Materials (SRM)-1973 Catalogue describes research materials (RM), general materials and SRM's currently distributed by NBS, and provides advance data on new materials under preparation.

Materials listed in the catalogue are classified under the topic headings of "Standards of Certified Chemical Composition," "Standards of Certified Physical Properties," "Engineering Type Standards," "Research Materials," and "General Materials."

NBS reference specimens, commonly known as "standard samples," were first issued in 1950. Today, there are more than 800 SRM's characterized for a wide range of chemical and physical properties.

EPA Issues Citizen Guide, Solid Waste Report

A bibliographic guide and a booklet for citizen action are among publications recently released by the U.S. Environmental Protection Agency (EPA), Washington, DC.

Solid Waste Management: Available Information Materials lists in bibliographic format, various publications and other educational materials pertaining to solid waste. Among the categories covered in this document are: the Federal Waste Management Program; collection of solid wastes; land disposal; management, planning and economics; and marine disposal.

Don't Leave It All To The Experts, The Citizen's Role in Environmental Decision Making is a general guide intended to stimulate environmental action by concerned citizens. Utilization of the public media and the law are suggested as avenues for voicing concern about environmental problems.

Career Programs . . .

Army Announces ROTC Scholarships

COED RECRUITER Kathy Garrison, University of Florida, displays an array of brochures and posters about the Army and the benefits of commissioning through the Army ROTC program, during the Gator Nationals drag racing championships held recently in Gainsville, FL.

The U.S. Army Reserve Officers Training Corps has produced, since World War II, many of the scientists and engineers who have contributed immeasurably to the success of Army research and development activities.

Consequently, the recent Army announcement of a new program and the selection of 1,177 outstanding high school seniors to receive 4-year ROTC scholarships, valid at any of the 290 colleges and universities participating in the ROTC program, is considered of interest to the R&D community.

The scholarships pay for tuition, books, lab fees, and provide $100 per month subsistence allowance up to 10 months each school year. Applications for 4-year Army ROTC scholarships must be completed by Dec. 31 each year.

A scholarship board selected the scholarship winners from finalists recommended from approximately 9,000 qualified applicants. Nonselected finalists were named as alternates in order of merit.

Included among this year's selectees are 50 women to whom the Army ROTC program was opened during the 1972–73 school year. Upon completion of the ROTC program and graduation, women may receive a commission in all branches of the Army except Infantry, Armor, and the Field Artillery.

Selection of scholarship recipients is based on academic excellence, extracurricular activities, physical standards, scores received on either the Scholastic Aptitude Test (SAT) or the American College Testing (ACT) Program, and evaluation of motivation and leadership potential.

The Basic Course of the 4-year ROTC program, taken in the freshman and sophomore years, provides instruction in the fundamentals of leadership and management, with emphasis on leadership development. It is elective at most schools offering Army ROTC.

The Advanced Course, normally taken in the junior and senior years, is offered to students who have demonstrated a officer potential. It includes advanced leadership and management, the theory and dynamics of the military team, and development of students' abilities to think creatively and to speak and write effectively.

A 6-week Advanced Camp is attended by each cadet enrolled in the Advanced Course, normally during the summer between the junior and senior years, where evaluation of leadership potential is stressed. Some selected students attend the Ranger Course at Fort Benning, GA, in lieu of Advanced Camp. During the 6-week period, the student receives one-half the pay of a second lieutenant.

In addition to the 4-year scholarships, the Army is awarding 661 3-year and 524 2-year scholarships to outstanding college students already enrolled in the ROTC program. Like the 4-year awards, these pay tuition, books, lab fees and $100 monthly subsistence allowance.

The Army ROTC also offers a 2-year program enabling a student who did not take the Basic Course, or who attended his first two years of college at a school not hosting Army ROTC, to join the program.

The student is required to attend a 6-week Basic Camp at Fort Knox, KY. Upon completion, he may enroll in the Advanced Course and be commissioned upon completion and graduation. Women may attend Basic Camp beginning in 1975.

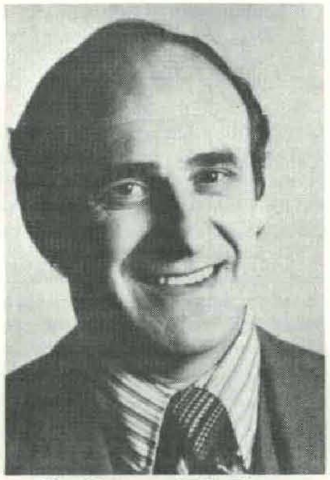
Army active-duty enlisted personnel may compete for 2-year scholarships. General requirements for qualification include achievement of a score of 115 or higher on the General Technical Aptitude Area.

Competing enlisted personnel also must have been on active duty for one year and have completed two years, but not more than 2½ years of college. If selected, individuals are discharged from the Army. Application dates are Jan. 15 to Apr. 15, annually.

Upon graduation from college and successful completion of the Army ROTC program, scholarship students are commissioned as second lieutenants in the U.S. Army and serve on active duty for four years.

High school students who will be seniors in school year 1974–75 and desire to compete for a 4-year scholarship should write to Army ROTC P.O. Box 12703, Philadelphia, PA 19134, between July 1–Dec. 1, 1974.

FRL Scientist Studies in Europe Under SARS



Dr. Raymond Walker

Under a Secretary of the Army Research and Study (SARS) Fellowship Program, Dr. Raymond Walker will devote a year of effort to explosives science and technology studies at Cavendish Laboratory, University of England, and at defense laboratories in Holland, Sweden, Germany and France.

An international authority in the fields of explosives, high-energy chemistry, and solid-state decomposition, Dr. Walker is chief, Explosives Division, Feltman Research Laboratory, Picatinny Arsenal, NJ. He has a BS degree from London University, a BA degree from George Washington University, and his PhD from Cambridge University.

Prior to joining the FRL he was a research chief with the National Bureau of Standards, Washington, DC. He has also been employed by the British Coal Utilization Research Association and the Atomic Energy Research Establishment, England.

A Fellow of the American Ceramics Society, Institute of Physics (England), and Washington Academy of Sciences, he has published four books and numerous papers on energy conversion and materials research.

Awards . . .

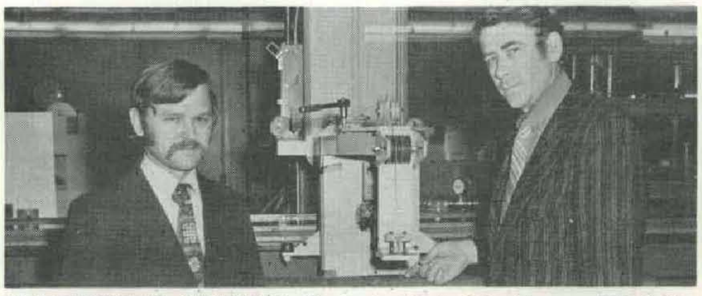
Watervliet Team Earns $1,000 Special Award

Research resulting in the development and fabrication of an 81mm lightweight recoiless rifle and a protective shroud for the 105mm tank gun has earned a joint $1,000 special award for a 9-member team at Watervliet (NY) Arsenal.

Constructed of nonmetallic composite materials, the two components have successfully undergone extensive field testing. The 81mm weapon is a one-shot disposable unit composed of fiberglass filaments embedded in an epoxy matrix.

The prototype shroud is designed to protect 105mm gun tubes from external temperature changes, and thus reduce bending caused by a thermal load. A low thermally conductive high-strength glass filament is embedded into an epoxy matrix or binder.

Award recipients are Robert Cullinan, chemist; Paul J. Croteau, mechanical engineering technician; Royce W. Soanes, mathematician; William Golden, machinist; Philip J. Giordano, physical science technician; Harold F. Scheck, machinist; Martin S. Ferguson, chemist; Ralph E. Peterson, physical science technician; and John J. Kebea, machinist. The team effort was directed by Dr. Giuliano D'Andrea.



WATERVLIET ARSENAL Organic Materials Group Chief Dr. Giuliano D'Andrea (left) and chemist Robert L. Cullinan demonstrate filament winding machine that fabricates a thermal shroud to protect a 105mm tank gun from temperature changes.

Women in Army Science . . .

Weapon Sight Improvements . . .
Credited to Army Systems Engineer

America's most famed markswoman, Annie Oakley, whose exploits with guns about half a century ago provided the inspiration for a popular Broadway musical in the 1940s, might have learned about the fine art of sighting small arms from Miss Ellen L. McGrody, a U.S. Army employe.

Assigned to the Frankford Arsenal Artillery and Infantry Weapons Branch, Fire Control Development and Engineering Directorate, Miss McGrody has been named the Philadelphia (PA) Federal Business Association's 1973 Federal Employe of the Year (scientific category). She was honored for her contributions to small arms sighting concepts.

In competition with some 75,000 other federal employes representing the entire standard metropolitan statistical area of Philadelphia, the 33-year-old systems engineer became the 10th arsenal employe honored with the award since its inception 17 years ago.

Miss McGrody was recognized specifically for her efforts in planning and directing the development of a new Reflex Collimator Sight for small arms weapons. Termed "revolutionary" by arsenal personnel, the concept was generated by requirements in Southeast Asia for a low-light-level sighting capability during hours of dawn and dusk.

Obtaining the support of the U.S. Army Small Arms Systems Agency, Aberdeen Proving Ground, MD, and Army Armament Command, Rock Island, IL, Miss McGrody accumulated a mass of data which served to establish the potential advantages of using the sight with small arms weaponry.

The prototype sight has demonstrated capabilities of reducing the time required to hit a target; improving shooting effectiveness, as high as 50 percent; and reducing soldier training costs because of simplicity of operation.

Employed at the arsenal since 1962, Miss McGrody's previous R&D contributions have included preparation of the technical specifications of the Laser Rangefinder AN/GVS-3 into a production package, and development of its laser cavity.

She is credited with development of a lightweight, low-cost fire control system for the Advanced Light Antitank/Assault Weapon; also, for the development of inspection procedures and equipment for optical componentry for use in the Frankford Arsenal Optical Shop.

Miss McGrody has a BS degree in physics from Chestnut Hill College, has taken graduate courses in engineering at Pennsylvania State University, and is a member of the Optical Society of America and the Smithsonian Institute. Among her leisure pursuits are skiing, reading and, believe it or not, motorcycling.

People in Perspective

Unquestionably Unique . . .
Chemist Terms Art 'Dimensional'

Dimensional art, the term Joe Smith, a Picatinny Arsenal chemist, uses to describe his hobby, is an outgrowth of the requirements of his job in the Ammunition Development and Engineering Directorate.

Normal terminology in the multiple facets of art does not apply, in Smith's opinion, to the unique creations that come out of his studio. Some artists might classify the result as mosaic, high relief, or even sculptured painting, but to him it is Dimensional Art. That gives him at least one claim to being an innovator in a field he entered in 1972.

Often stressing a medieval Byzantine theme, his art is the result of

carving, shaving, sanding and fitting shaped pieces of white pine onto a masonite like a mosaic.

His initial effort was a religious theme delineated on a masonite, gradually evolving to a colorful high relief of a Byzantine Christ. His interest in the medieval setting was so intense that he conducted intensive research so his work would painstakingly depict the lines and folds of the robes of religious figures.

Smith's productions are not limited to those based on religious themes. His collection includes Japanese motifs and other ethnic type designs. His Indian designs resemble sand paintings in vogue throughout much of the southwestern United States.

Local recognition of Smith's talent has not been lacking. His portrayal of pseudo-Byzantine triptychs won third-place honors in an art show while other creations have been displayed at public libraries and exhibition halls.

Reader's Guide . . .

NTIS Publishes Special Interest Bibliography

A sampling of the wealth of information available to scientists, engineers and program managers through the National Technical Information Service (NTIS) is found in its *Special Interest Publications Catalog.*

The fall 1973 catalog lists such reports as: "Conflict and Integration in the Federal Bureaucracy," by Richard E. Walton of Harvard University, $6.75; "Biocybernetic Factors in Human Perception and Memory," by David C. Lai of Stanford University, $3.75; "The U.S. Energy Problem," by G. C. Szego of InterTechnology Corp. (three volumes), $29.85; and "Privacy and Security in Data Banks," by William A. Garrison and C. V. Ramamoorthy of the University of Texas, $3.00.

Brief descriptions of these reports and hundreds of others are included. The catalog is available free by writing to NTIS, 5285 Port Royal Road, Springfield, VA, 22151.

HumRRO Outlines Effective Teaching Criteria

Characteristics of effective teaching methods and classroom management techniques are explored in a recent report by the Human Resources Research Organization (HumRRO).

Technical Report 73-23, A Model of the Functions of a Master Instructor includes an analysis of a "model" of good teaching criteria which might be useful in evaluating the performance of U.S. Army instructors. Information and evaluation materials for this research were received from 18 Army schools.

The four major areas of teacher performance are identified as: development and implementation of instructional programs; instructor classroom behavior; professional growth; and innovative practices in the classroom. These areas are further classified into 17 functions and 40 tasks with identification of instructor objectives.

Produced for the Office of the Chief of R&D, HQ DA, the report was coauthored by William H. Melching and Paul G. Whitmore. Copies are available for $2 each from HumRRO, 300 North Washington St., Alexandria, VA 22314.

SPEAKING ON . . .

(Continued from inside front cover)
viet and U.S. weapons were used by the combatants. It will take some time to pin down all of the conclusions we should reach about our own research and development directions but, in general, the profound change that will be brought to future warfare by today's technology is now clear.

The first findings from the Mid East reinforced and expanded our initiatives in the areas of command and control, precision weapon delivery, air mobility, defense suppression and air defense. . . .

Management Initiatives. There is a final major influence on this budget request which I feel is important to emphasize in this statement. My colleagues and I bring to this job certain management convictions which helped shape this program and which will increasingly guide the changes which I will pursue aggressively through the future.

These principles, which I will describe, are shared by the Secretary of Defense, the Deputy Secretary of Defense and the Assistant Secretaries and Military Chiefs of Research and Development. Together we will use these principles to manage our business and to build the confidence of the Congress and public that defense research and development is managed the way you have a right to expect.

When we have demonstrated that research and development can be managed to your reasonable satisfaction, we hope that the attention of defense leaders, Members of Congress and the public can dwell more on the vital issues of defense technology and less on past mistakes.

Management problems must be addressed directly and openly. However, what we can do, and what we are determined to do, is use proven and sound basic business practices to control program cost, set realistic schedules and technology objectives, and demonstrate that the public is getting its monies worth.

Let me say that it *is* realistic to expect to manage defense RDT&E well. A GAO report, for instance, shows that in the 70s, there has been impressive progress in the Defense Department in identifying cost-growth causes and bringing under control the cost of major development projects. But these results are not good enough; I promise you better.

The progress, so far, of cost control in defense R&D has been the result of many positive actions by many persons through the community. No one has found a simple or single formula. I am encouraged to believe that a broad, renewed attack by the truly dedicated people in the research and development management community will bring the kind of further progress which will restore the faith of the Congress and the American people in our ability to manage our funds well. I believe it would be worthwhile here to review several of the concepts which I believe will contribute to this objective.

Top Down Planning. The details of the thousands of defense research and development projects make it difficult to view and manage the parts as one interrelated whole. The budget tends to be built from the bottom up as individual programs are proposed by the military users and the technologist innovators.

It is necessary for the senior military and civilian leaders with whom I work to look together at the totality of programs, aggregate them by military mission areas, prioritize and balance the area needs, and formulate the most effective over-all RDT&E investment strategy within a limited financial resource. We are making encouraging progress in doing this.

User Needs vs Technology Opportunities. It is often debated whether the technical opportunities or the military needs should drive the defense research and development process. In fact, both have validity. I believe that we must use both in a 2-pronged, integrated approach to programing and budget formulation and review.

One key function of my office and those of my colleagues in the Military Departments is to insure that the military users will thoroughly understand the opportunities of science and technology and that the technical community will be guided by real military needs.

Responsible Program Planning. A successful development project must be well conceived, well laid out and adequately funded. It is our responsibility to insure that the need for a new advance is clear, that the technology is ready, and the schedule attainable. Then, we will ask you for realistic funding. Realism implies greater care and selectivity from the start but greater payoff in security at the end.

Test and Evaluation. I believe that programs should be paced by successful milestone demonstrations and not by fixed calendar dates. In the long run, we will achieve better deployed systems more quickly and for less total investment in this way.

Fundamental to this approach is careful test and evaluation at each stage, both to demonstrate technical progress and to validate military utility. Objective test and evaluation must be used to modify and guide the project—even at the risk of greater short-term cost in time and dollars.

We have recently restructured the SAM-D program to follow this approach and also to provide for simplified and more cost-effective versions of a final system. The Surface Effects Ship program is another example. Here, we are slowing the pace of development until certain key technologies are better in hand. The restructured B-1 (bomber) program is still another example. These decisions were all difficult, but I believe they were necessary.

Return on Investment. My commercial background leads me to approach any investment analytically—to attempt to quantify the return I can get from the investment I make. It's a more difficult process in management for national security, but I believe that the discipline that such an effort brings to the decision process is extremely valuable. It forces recognition of limited resource availability and forces a conscious evaluation of how much additional deterrence or fighting capability we will get for the investment—and by investment, I mean the total cost of research and development, acquisition, operation and maintenance. It also forces a realistic appraisal of the risks in the program, since in any business venture we must evaluate the risk versus the potential payoff.

In the end, return on investment must be seen clearly in terms of superior deployed capabilities and reduced logistics and maintenance costs. I would note, for instance, that the NAVSTAR Global Positioning System, which we are initiating, will bring an enormous future return by reducing the numbers of systems used.

Competition. One way to help insure a fair return on investment is to foster competition at many stages of the research and development process. Competition is by far the most leveraged method of reducing our costs. Our prototyping efforts are probably the most dramatic examples of competition—funding two highly competent companies to design and build competing prototype models.

We did this in the A-10 program and it has proven to be a good way of doing business. The real benefits will be demonstrated in the production program. The lightweight fighter program is using this concept, as is the AAH (Advanced Attack Helicopter), the UTTAS (Utility Tactical Transport Aircraft), and many other programs.

Without having the effect of competition, the cutting edge of any organization grows dull. Bad practices develop; high costs result.

We cannot tolerate the results of the lack of some kind of competition anywhere in the system. Insisting on it may cost more money in research and development, but it will pay off over the life of the program.

Viable Options. Our basic research and development strategy is to develop viable options. We must avoid two unacceptable alternatives—either to fully develop and deploy all systems that might be needed or to wait until the adversaries show new capabilities and then develop counter from scratch.

A better strategy is to concentrate on generating optional solutions to anticipated problems in the exploratory and advanced development programs, but make an explicit decision on need before full engineering development is approved.

After advanced development, the technology is certain, but the clear military need may not be. At that point we will proceed with some options, delay others and terminate a good many. If we have the managerial strength to follow through this selection process, the strategy of viable research and development options will provide better deployed systems and flexibility to respond rapidly to change.

Design-to-Cost. Inherent in this term, much misused and misunderstood, lies an extremely powerful management concept. It is well understood—and is commonly used—in the commercial world. The major automobile manufacturers, for instance, ordered their design departments to develop a car to be cost competitive with the VW. The Pinto and Vega are testimony to design-to-cost effectiveness.

In defense, the sacredness of the "requirement," the inflexibility of the specifications, and the complexities of the development and procurement process have made use of design-to-cost most difficult. The past result is well known—extremely expensive equipment. I believe that considerable progress is being made now by the Services to accommodate this business concept.

A number of design-to-cost programs, such as the A-10, Advanced Attack Helicopter (AAH), TACAN, Radar Altimeter, Shipboard Electronic Warfare Suite, etc., are in various phases in the development cycle, and the results are encouraging. The details of approach are almost all different, and we encourage flexibility. We believe that we are getting significant results.

Let me outline in some detail now the thrusts of the specific programs in strategic and general-purpose forces RDT&E.

STRATEGIC PROGRAMS. The purpose of our strategic forces is to deter war by making it clear to a potential attacker that the losses to him will far outweigh any possible gain.

In the past, we have sought to do this with a balanced force of offensive retaliatory weapons, defensive systems and their associated command, control and communications. Under the agreement with the Soviet Union after SALT I, both sides gave up efforts to deploy more than token ballistic missile defenses. Both sides are continuing, however, to work on defensive technology, and we will make every effort to keep an offensive force that will deter any level of nuclear attack.

For *now*, we need and have adequate forces in being. For the *future*, we must have in development a range of viable alternatives from which a timely selection for deployment can be made. The B-1 (bomber) and TRIDENT (submarine) are at present our major development programs. We have added a set of strategic research and development initiatives which will provide hedges against failure of arms control. Developing these options is not a commitment to produce and deploy them; it is to provide us with a ready posture so that we can respond quickly if necessary. Let me highlight what these initiatives are.

• Investigation of a new basing mode to maintain the survivability of land-based missiles has been under way for some time. We have accelerated this program to permit choosing the preferred mode from among land-mobile and air-mobile options, thereby permitting a timely decision to initiate engineering development should the threat develop faster than anticipated.

• To maintain the ability of aerodynamically delivered weapons to penetrate, we have started prototype development of two subsonic cruise missiles: an air-launched version for bombers and a submarine-launched version which would also be capable of launch from surface ships.

The Air-Launched Cruise Missile (ALCM) will increase the flexibility of the B-52 and B-1 bombers in a way the Soviets will find difficult to counter, thereby enhancing the effectiveness of the bomber. The submarine-launcher version will permit attacking perimeter targets from a variety of unexpected directions. It will also have a tactical variant with a conventional warhead.

Note that the cruise missile is a concept whose time has come, technologically speaking. The availability of small, efficient turbofan engines and precise navigational updates using terrain comparison permits development of long-range, accurate cruise missiles which can fit into extremely small volumes such as bomb racks and torpedo tubes. We have allowed sufficient funds in the budget to pursue competitively this technology and prototype development.

Just as a bomber requires a fast escape for survivability, so do the accompanying tankers. We propose to examine a variety of methods of achieving this capability, including variants of commercial aircraft and newly designed ones.

To provide a more effective but limited hard-target capability, we are initiating programs which would permit us to extract from our present missiles all the accuracy of which they are capable and to develop for the TRIDENT options which will permit substantial improvements in its accuracy. We are continuing the development, initiated in FY 1974, of an improved version of the Mk-12 reentry vehicle. We are also exploring other conceptual possibilities for improving capabilities in this area.

Finally, we are initiating the conceptual design of a new submarine, slightly larger than the present 640 class, capable of carrying the TRIDENT I missile. This ship will cost considerably less than the TRIDENT submarine and will be suitable for Atlantic deployment.

The cost to our Nation of these added options is small compared to that which will be required if we do not achieve agreements limiting arms. **I will now provide you with the supporting rationale for our Strategic RDT&E programs.**

Offensive Forces. The strength of our strategic systems is provided by our advanced technology and by the diversity and flexibility which that technology permits. Our deterrent systems—bombers, submarine-based missiles, and land-based missiles—provide a variety of basing modes, penetration techniques, and command, control and communications systems, which an aggressor would find impossible to overcome.

We have a clear lead in technical capabilities today, but we must not remain complacent. Soviet technology already has the potential to threaten the pre-launch survivability of a significant portion of our deterrent forces, their penetration capability, and the survival and effectiveness of our command and control.

In estimating the survivability of our strategic forces, we carefully consider their vulnerability to a well-planned surprise attack and select from several paths we can take to improve survivability: mobility, escape, hardening attack dilution through proliferation, defense, and warning.

For our bombers, the greatest threat is from submarine-launched ballistic missiles. In the future, our present capabilities will be inadequate against fast missiles on depressed trajectories. Short warning times require a bomber with quick reaction (start-up, acceleration, etc.), high speed and increased hardness. These are features of the B-1 bomber, whose survivability is every bit as important as its improved ability to penetrate.

Fixed, hardened missiles can also be subjected to surprise attack and, as Soviet accuracy improves, such an attack becomes feasible. We have been raising the hardness of our missile silos to the highest level achievable with steel and concrete, but in the long run this may be inadequate. Preservation of the land-based missile force requires the new basing mode initiative. This will give us the option of using uncertainty of position combined with moderate hardness to gain survivability.

The survivability of our submarine-launched missiles depends upon their remaining hidden in the ocean depths. It would be prohibitively costly for an enemy to survey large regions of the ocean for quiet submarines, so we want to expand the area of operations of our missile submarines.

This objective has led to the TRIDENT missile system, which has such long range it can attack targets from all the oceans of the world. Companion to this missile is the TRIDENT submarine which will replace the old POLARIS and some aging POSEIDON submarines with a new, much quieter submarine, better able to avoid detection and keep a greater percentage of the force on patrol.

Survivability is only one facet of concern in our strategic forces. Also of vital importance is their ability to penetrate and their effectiveness. The Soviets have deployed the most formidable air defenses the world has ever seen: SAMs, interceptors and surveillance systems. In the future, the SAMs will be mobile, and the interceptors and surveillance systems will have "look down" capability. To counter these requires low, fast flight and small radar cross-section—all attributes of the B-1.

Although the ability of our ballistic missiles to penetrate is assured as long as the Soviets honor the treaty limiting ABM systems, the effectiveness of our missiles is limited by the yield and accuracy of warheads. High yield and, more important, high accuracy, are needed to destroy hard targets.

If our goal were solely to provide forces capable of killing Soviet people, only a few hard targets would need to be hit. But as Secretary Schlesinger explained in his testimony, an all-out nuclear counterattack on people is not always a credible deterrent. We need effective limited nuclear options, which requires precise force application. Such a capability—I wish to emphasize—is not a disarming first strike capability nor should it be interpreted as such. A disarming first strike capability is beyond us technically, and we do not seek it.

The MIRVing of our current forces hedges against the rapid deployment of a light Soviet ABM system. However, an upgrade of their numerous SAMs could give them a widely deployed ballistic missile defense capability.

One potential counter is the evading Maneuvering Reentry Vehicle (MaRV) which can nullify such simple systems and thereby remove Soviet motivation for upgrading SAMs. We are carrying through development (but not planning to deploy, unless necessary) a MaRV for TRIDENT, investing $45.7 million in FY 1975 (and $175 million total) to achieve a fully tested advanced equipment model.

Defensive Systems. The goals for our strategic air defense system are to provide warning, maintain airspace sovereignty in peacetime and provide a mobile air defense force. The major program here is the over-the-horizon warning radar which I have mentioned.

The rationale for our ballistic missile defense program is based on our strong belief that we must have technology available to counter any Soviet unilateral deployments, that we must have visible programs which foreclose potential developments on their part,

(Continued on page 30)

SPEAKING ON . . .

(Continued from page 29)

and we must stay in the forefront of technology. By so doing, we will explore new concepts before our enemies do, and we will be able to interpret . . . intelligence indicators correctly.

To achieve these objectives, we need both strong BMD technology programs and ongoing systems work. Separate system work is needed because there is really a technology of systems every bit as important and every bit as difficult as component technology. Radars, interceptors and computers, alone, do not comprise a BMD system. Their integration, and the hardware and software to accomplish this, constitute system technology.

Our technology efforts are conducted by the Advanced Ballistic Missile Defense Agency. The focus of our system-related efforts is the Site Defense system, although we are also funding the last of the Safeguard RDT&E for system testing and performance verification. We have developed a minimal program of $91.4 million in technology to continue to push the most advanced BMD concepts across a broad spectrum and $160.0 million in Site Defense to continue prototype development and maintain the system-capable industrial team.

Along with the remaining Safeguard efforts, these add to $312 million, well below the $500 million planned for this area only one year ago. I believe that this new level is an appropriate yearly investment in this pivotal area as long as international relations remain as at present.

SALT. All our Strategic Programs have SALT implications. Our intent in the strategic arms limitations talks is to enable maintaining our security through reaching essential equivalence in strategic weapons with the USSR by reducing the over-all levels of strategic armaments. A specific objective is to assure that the Soviets are made to feel the necessity to nemotivated to keep agreements already signed.

The Soviets have shown that they will not accept agreements which change their perception of strategic relationships. Thus, they will give up real strategic capabilities only in exchange for what they consider to be real concessions from ourselves. Unilateral cutbacks on our part are not credited by them in that process, and there is no *quid pro quo* for our forebearance. Thus, we should continue to pursue worthwhile developments and deployments, even though they may be made obsolete by future agreements, in order to help achieve those agreements.

Strategic Command, Control and Communications (C^3). Strategic C^3 is an integral and essential element of our nuclear force posture. Technology, in the form of communications satellites, electronic microminiaturization and data processing, has provided us with a significantly enhanced worldwide communications capability. We must continue our efforts to insure that C^3 can survive a massive attack and that our nuclear forces will be responsive under all conditions to the National Command Authorities. Programs such as the Advanced Airborne Command Post, special communications satellites and Sanguine will make this possible.

Space Programs. Space is a medium—not a mission. Many of our space programs are intimately tied to warning, attack assessment, command and control, and advanced concepts for our strategic forces touched on previously. Tactical purposes have also been served by communications and weather satellites.

We have been able to focus our navigation satellite needs on the development of a universal positioning system—NAVSTAR—which will provide worldwide, highly accurate fixes while permitting long-term economies in overall navigation systems for our strategic and tactical forces. This program . . . could revolutionize world navigation and weapon delivery.

GENERAL PURPOSE FORCES. I will turn now to general-purpose forces. A remarkable series of new technical developments has brought us to the threshold of what I believe will become a true revolution in conventional warfare.

Some of the new technology, in its model-T stages, has already been proven in combat; we are continuing to work on terminal guidance for weapons—leading to first-shot kill, day or night and in all weather—ability to incorporate large stand-off ranges for these weapons, and application of remotely piloted vehicles to military missions.

I believe that advances such as these, further developed and widely applied, can change a broad spectrum of conventional warfare in the next decade the way tanks once revolutionized ground combat and radar revolutionized air defense.

The research and development program for our general-purpose forces is designed to build on and accelerate these advances and to maintain the technological balance in our favor.

I believe the programs will not only keep us ahead in weapons technology but will enhance deterrence of conventional warfare and help establish enduring peace and safety for the United States and preserve its interests abroad.

The significance of some of the research and development innovations has been reinforced by the recent Middle East War. . . . My major perception from that conflict has been that our research and development has, in fact, anticipated the decisive new possibilities well and is on the right track.

With this reconfirmation of our general directions, and with the sharpening of focus and the urgency provided by recent events, the proposed research and development program will accelerate the evolution of these concepts, create from them options based on firm demonstration of technical performance and cost, and allow selection from these options the systems we will finally develop for introduction to our inventory.

Precision Delivery. The effectiveness and importance of precision delivery through terminal guidance, which was first demonstrated in Southeast Asia and reconfirmed in the recent Middle East War, is enormous.

Essentially, we would like for every missile, bomb or shell, when properly employed, to kill its target. In many cases this capability would make unnecessary repeated attacks on a target by large numbers of aircraft or tanks or cannon and thereby reduce the loss of life and equipment in our own forces.

This class of weapons is in its infancy, but the first generation of daytime electrooptical weapons, such as TOW and MAVERICK, has had outstanding success. Sensor concepts which can extend this capability to night and all-weather operations at an affordable cost, and which we have been developing for the last decade in our technology base, are emerging from the laboratories. Each of these is a subject of intensive efforts and could provide a flexible and decisive new set of capabilities.

These efforts are being addressed and coordinated on a DoD-wide basis to eliminate unnecessary duplication and to arrive at . . . for production at costs we can afford.

Defense Suppression. The broad area of defense suppression is receiving special attention, including one-shot/one-kill weapon delivery through precision weapons—which holds great promise also for low-cost precision weapons—and improved radiation-seeking missiles.

It (defense suppression) also includes systems to locate and precisely attack missile and gun sites, and expanded electronic warfare capability to cover projected threats (e.g., EF-111A), and the use of remotely piloted vehicles for both reconnaissance and strike against dense air defenses.

Real-Time Intelligence. In the same concept, AWACS (Air Warning and Control System) will join various intelligence sensors with the powerful new overland radar surveillance technology for efficient command and control of airborne and ground air defense and air battles over extended geographical areas. . . .

Air Defense. Air defense is receiving major emphasis and redirection. AWACS will become an important element. SAM-D will continue as the major technological thrust to a new plateau of capability for defense of high-value targets. It will be complemented by the acquisition, initiated this year, of a low-cost, highly mobile all-weather air defense system which can be proliferated and widely dispersed in forward battle areas.

Air defense, including defense against the antiship cruise missile, is also a critical and difficult problem for our fleet. Major development efforts are directed toward this continuing serious problem including AEGIS, Vulcan/Phalanx and the Low-Cost Electronic Warfare Suite.

Ground Warfare. In the end, battles are won or lost and territory held or given up by individual soldiers. A prime objective of research and development is to enhance the effectiveness of the individual soldier. How might the Middle East conflict have been different had either side possessed, in quantity, high-quality night-vision equipment and the training and tactics to use it most effectively?

We are driving toward the goal of ubiquitous employment of infrared imaging sensors on the ground and in the air for detection, acquisition and attack of targets at night. Nighttime will become our ally. Difficult problems must still be overcome in attaining this goal at a reasonable cost, and we are devoting much effort to this end.

Other programs that will help the individual soldier include a new tank (XM-1) with vastly improved armor, other highly mobile armored vehicles and close-support aircraft (A-10 and Advanced Attack Helicopter) providing unprecedented and highly mobile lethality. . . .

In an era in which conflicts may be brief and intense and demand quick reaction, mobility of forces has become paramount. Helicopter and advanced transport programs are being directed to this crucial area. The capability simply must be there when we need it.

Modernization. Our objective of deterring all kinds of conflict requires that we continually renew our forces. Also, we must be in a position, if needed, to be able to procure equipment in quantity and expand our force capabilities and those of our Allies on short notice at an acceptable cost. Thus we have evolved the "high-low force" concept—a mixture of high-performance, high-cost systems and limited performance, lower-cost systems. A lightweight fighter is under development at a prudent pace which will make available one such option for ourselves and our Allies when and if it is needed. Other examples of this approach are the Patrol Frigate as a supplement to full-size destroyers and the Sea Control Ship as a supplement to present aircraft carriers.

Anti-Submarine Warfare. Finally, I want to mention anti-submarine warfare. The Soviet Union continues to build an impressive nuclear attack submarine capability. In my mind, this is an area of increasing concern. It is a complex and difficult problem, and it requires a broad spectrum of approaches.

We are making progress in our capability to detect, localize and attack submarines. Programs to improve airborne acoustic sensors, new concepts for deployable surveillance systems, basic technology and ship-based and airborne systems are being encouraged. I believe that our future security may well depend on these efforts, and I want to assure you that we are mindful of its urgent importance.

Through these major thrusts, we expect to enhance significantly the deterrent and warfighting capabilities of our conventional forces. We shall continue to press for development of low-cost alternatives, modernization through modification and the exercise of firmer management to get useable, needed capabilities in the field. This is the return on our investment in general forces research and development.

THE TECHNOLOGY BASE: OUR LONG-TERM SECURITY. Successful development programs—and ultimately our continuing security and strength—must derive from the basic exploratory and research which constitutes our defense-related technology base. It is this effort and generates from selected fields of science and engineering the devices, techniques, materials and concepts which become building blocks for our developing systems.

Here, for instance, is where one major investment over the years married solid-state device physics to military needs and produced basic sensor capabilities for night-vision systems, precision weapons and space surveillance. Here in the technology base are the explorations which could some day make transparent the undersea world and thus change the nature of the strategic balance; here, also, are the explorations which insure against that kind of technological surprise.

Materials which make possible higher-temperature jet engines and new aircraft structures also evolve from this effort and, when combined with new aerodynamic principles, make possible continuing superiority for our aircraft and our aerospace industry.

Rapidly evolving generations of microminiaturized computers and electronic devices and systems revolutionized our capabilities in the past decade. Now we are exploring new billion-bits-per-second communication techniques, propulsion technology, new kinds of radar and lasers which can, in the future, give us important new capabilities for reconnaissance, weapons and weapon delivery. The technical opportunities could well provide another, broader revolution in the next 10 years.

All of these results depend upon the dynamism, innovation and aggressiveness of the people who contribute to our technology base programs—people who accept the challenge to generate technical opportunities to meet defense mission needs. Indeed, our Nation's position in the world will be measured by how well they respond to this challenge. I want to stress that, in reviewing technology base efforts, I see much of which all of us can be proud:

- The existence of a team composed of industry, university and government laboratories with complementary strengths and with strong and vital interaction among the elements.
- The creation of a pool of talented professionals, recognized experts, who are knowledgeable in areas of defense technology and who can be called on in formulating and executing a dynamic program.
- The flexibility to exploit aggressively new opportunities provided by these teams.

The technology base consists of many

(Continued on page 32)

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You Are Invited to Participate in Our Readership Survey. Please DO!

*Are you a member of the R&D Scientific Community? Yes ☐ No ☐

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*Do you have any suggestions that would make the magazine more useful to you in your R&D activity? ____________

____

SPEAKING ON . . .

(Continued from page 31)

thousands of individual programs which must somehow coalesce to provide the major thrusts for the future. This is a difficult management challenge—particularly at a time when research for the sake of research is not enough, and when defense-supported science and technology must clearly be related to the defense side of our Nation's needs.

I have specifically not requested this year the substantial increase in technology base funding which may be necessary in the future to preserve our technological superiority. Such a request, I believe, would be premature until I strengthen the framework in which such an increase would be used. My specific approaches to this goal will follow these general directions:

- The technology base is a DoD-wide asset and is being addressed by the Service Assistant Secretaries and my office acting together.
- The thousands of programs are being aggregated into areas of special potential and areas of perhaps diminishing return on investment. This helps us to see how proper over-all emphasis and balance can be achieved. An evolving series of Technology Coordinating Papers will also aid in this selectivity.
- Tri-Service "topical" reviews and planning sessions are being used to focus on mission area technology barriers, increase inter-Service cooperation and interdependency and reduce unnecessary duplication and overlap.
- The balance between in-house and contract research is being reassessed in the face of limited resources.

From time to time, high pay-off opportunities emerge which warrant major commitments in the technology base. One which well merits your special interest is our work on high-energy lasers. I feel that this is the time to present a consolidated review for you of the impressive progress so far, our assessment of high-energy laser importance, and the problems which lie ahead. This review is contained in Chapter 7 of this statement.

Also, in that chapter I have devoted a special section to the programs of the Defense Advanced Research Projects Agency. DARPA plays an extremely important role in providing the flexibility needed to initiate work rapidly in new areas—such as the high-energy laser— . . . vital to missions of the entire Department.

(Dr. Currie, at this point in his presentation, summarized briefly some of the salient aspects discussed earlier, including a submission and explanation of budgetary tables.)

I want to conclude my remarks, Mr. Chairman, with a recognition that Defense research and development is paid for by the hard work of all Americans; it is their investment in the preservation of their freedom as individuals in a unique society.

In the final analysis, the exact size and texture of this investment will be determined by a composite of judgments—on affordability, lessons from the past, confidence in those who manage the investment, and perception of the world environment. And there is an element of faith—faith that science, technology and an adventuresome spirit remain a vital part of the foundation for the future, as they have been for the present and past.

In your deliberation, I ask you to step back and view the Defense research and development investment in this larger context. I believe that now is the time to renew our faith, to renew our commitment and to reverse trends of the recent past.

The dividends we seek will follow.

DOD BUDGET PROPOSAL BY 1975			$ Millions
CATEGORY	FY 1973	FY 1974	FY 1975
Research	304.3	307.8	309.4
Exploratory Development	1,071.4	1,095.1	1,129.9
Advanced Development	1,322.9	1,474.9	2,043.1
Engineering Development	2,186.7	2,562.5	3,987.0
Management and Support	1,099.1	1,129.7	1,223.2
Operational Systems Development	2,031.6	1,763.0	1,529.9
Total RDT&E	8,016.0	8,333.0	9,322.5

DOD BUDGET PROPOSAL FY 1975			$Millions
MISSION AREA	FY 1973	FY 1974	FY 1975
Tactical	2,938.7	2,928.2	3,254.3
Strategic	1,894.4	1,942.2	2,358.0
Defense-wide Systems	532.1	730.9	764.5
Technology Base	1,381.4	1,410.2	1,447.7
Management Support	1,108.2	1,135.6	1,235.7
Advanced Technical Development	161.2	185.9	262.3
Total RDT&E	8,016.0	8,333.0	9,322.5

DOD BUDGET PROPOSAL FY 1975			
DEPARTMENT	FY 1973	FY 1974	FY 1975
Army	1,881.1	1,970.5	1,986.0
Navy	2,541.6	2,743.4	3,261.9
Air Force	3,120.0	3,125.7	3,518.9
Defense Agencies	473.3	493.4	555.7
Total RDT&E	8,016.0	8,333.0	9,322.5

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Packaging of Critical Munition Components

By Sylvestro J. Ruffini

What protective measures does the U.S. Army take to insure that a complex munitions system, replete with highly sensitive and delicate instruments, arrives at a distant deployment destination in combat-ready condition?

Picatinny Arsenal at Dover, NJ, has the proper answers to that question, based upon research and development to ascertain protective requirements and progressive actions to meet them. Picatinny's Munitions Packaging Branch (MPB), Ammunition Development and Engineering Directorate, is assigned responsibility for designing and verifying the packaging of munitions components.

Preparation of a Technical Data Package (TDP) requires that the MPB be informed of packaging requirements as early as possible after the inception of any new R&D munitions program—to provide adequate time to design, develop and produce efficient and economical protective packaging.

For example, a typical packaging program is the recent development of the XM543E1 Shipping and Storage Container for the Safeguard's Sprint Warhead Section Adaption Kit Subassembly (see photo below). During initial program coordination, the packaging engineer reviewed the item's military characteristics to establish which type of package would meet the environmental hazards (inputs) imposed by logistical deployment.

The packaging engineer based his decision upon information obtained from specifications such as the missile Stockpile to Target Sequence (STS), missile Qualitative Military Requirements (QMR), warhead section QMR operational requirements, and performance specifications.

From these documents, the engineer obtained the design physicals, expected environmental and handling conditions, and modes of transportation of the Adaption Kit Subassembly pertinent to over-all needs.

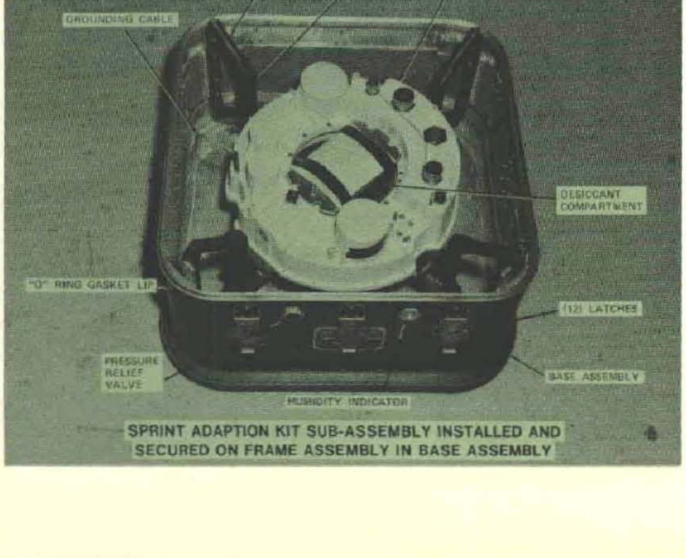
Parameters for determination of the packaging design and test criteria included item weight, shape, size, center of gravity, moments of inertia, shock and vibration fragility levels, humidity and temperature needs.

In addition, the movement of the Adaption Kit Subassembly, was restricted to within the Continental United States (CONUS) via truck, railroads and commercial air transport.

The most important component design requirements were the shock "G" level and temperature environment—parameters that dictated the type of "cushioning" the container must provide. The lower the "G" value and the more extreme the temperatures—in this case 25Gs and -40° F. through +160° F.—the more complex the isolation system.

Based upon his findings, the packaging engineer established the type of container to ship the item safely. In general, the design and test requirements for the XM543E1 container must assure that the Sprint Adaption Kit Subassembly will receive the necessary protection against physical damage and adverse natural environments; and that the container will provide the best possible facilities for handling, storage inspection and security.

To accomplish the design objectives, a transit-type container of an accepted design, "meeting various transit case MIL specs," was selected



SPRINT ADAPTION KIT SUB-ASSEMBLY INSTALLED AND SECURED ON FRAME ASSEMBLY IN BASE ASSEMBLY

SYLVESTRO J. RUFFINI has been employed as a mechanical engineer supervisor with the Munitions Packaging Branch, Ammunition Development and Engineering Directorate, Picatinny Arsenal, Dover, NJ, for 15 years.

As a project engineer, he was engaged in design, development and testing of packaging for nuclear and conventional munitions such as Hawk and Lance warhead sections, bomb dispensers, mines and grenades.

Ruffini also has technical responsibility for packaging programs for Safeguard Missile System munitions, and is associated with researching new isolation concepts that use elastomeric and metallic isolators, as well as cushioning materials.

to form the basic structure for an all-attitude resilient-mount isolation system, with positive "O"-ring seal for humidity control.

The aluminum container shell is 26 inches long, 26 inches wide and 17 inches high, weighing 68 pounds. The shell is split approximately ⅓ down from the top, which serves as a cover.

The main feature of the container design is a resilient suspension for the Adaption Kit Subassembly to attenuate the shock and vibration loads applied externally and omnidirectionally to the container. The frame is attached to the base assembly through eight butadiene styrene resilient mounts focalized at the center of gravity.

Development of this system required an extensive stress analysis to establish the proper mount spring-rate, spacing and sway space.

To control humidity, the container was designed to hold a seal at ± 3 psi, using an "O"-ring-type gasketed joint between the cover and base assemblies to limit the number of air changes during shipment. To preclude excessive buildup of pressure within the container, an automatic pressure relief valve was provided.

The container was designed to accept desiccant to absorb entrapped moisture and lower the humidity to 30 percent or less. An indicator in the base assembly monitors the humidity during shipment and storage. This dehumidification system prevents corrosive humidity levels from forming around the payload.

Other features include handles for flexibility and convenience in handling operation, mating embossed ribs for positive stacking of containers in storage areas, security seals to prevent unauthorized entry, and a ground cable to drain off potentially dangerous static electricity.

Design objectives were verified by a comprehensive test program performed on a prototype container. Requirements of this test program were formulated to simulate the shock and rough handling to which the container (and its payload) might be subjected.

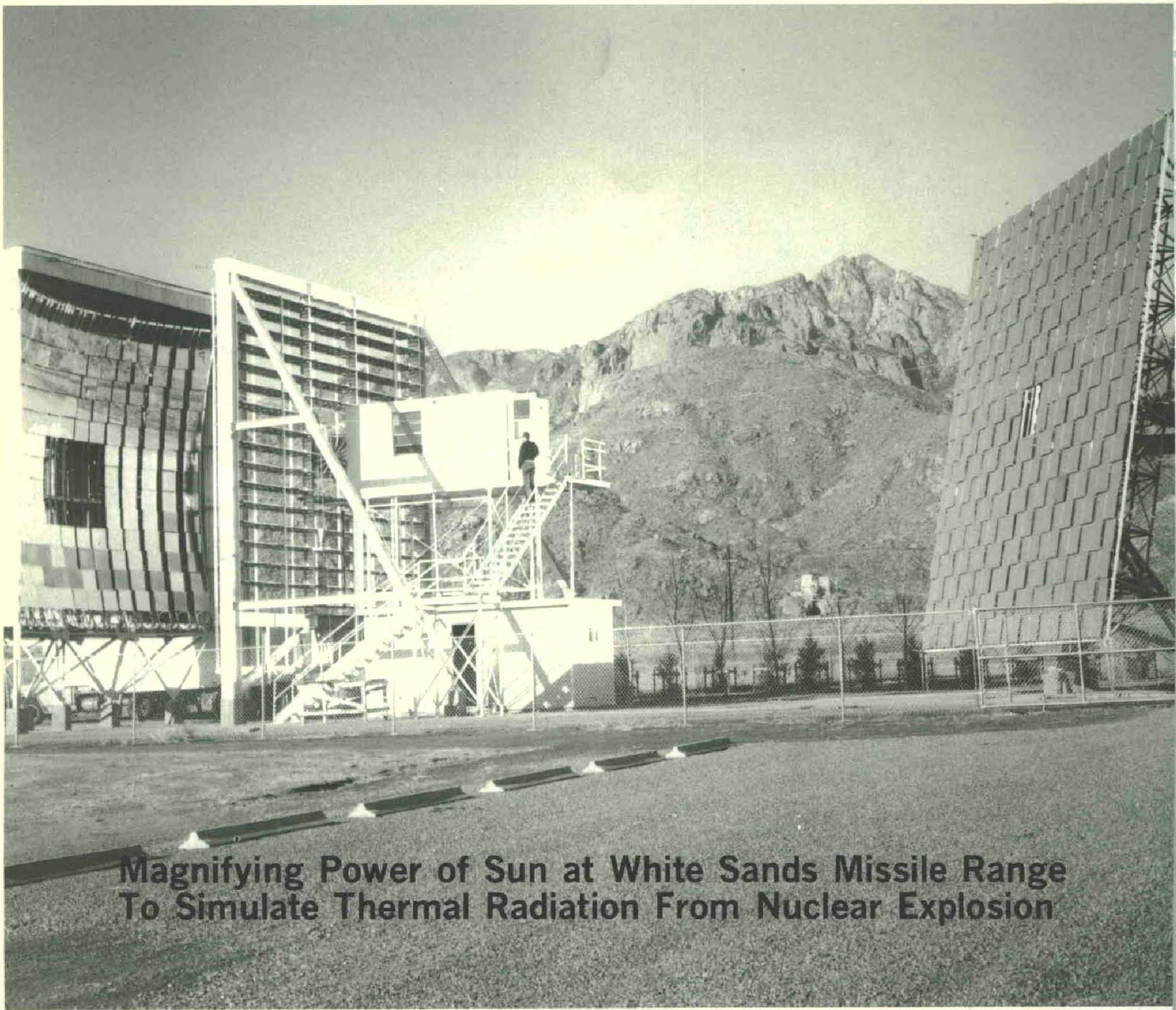
The rough-handling tests included a series of electronically instrumented free-fall drop tests in various attitudes from a height of 24 inches and a simulated cushion-car railroad humping test of 9Gs for 53 milliseconds. The design requirements limited the deceleration of the Adaption Kit Subassembly for all temperatures between -40° F. and +160 F. to a maximum of 25Gs for the drop and shock tests.

The vibration tests included electronically instrumented sinusoidal transmissibility, resonance dwell, and cycling tests as well as random vibration and decaying sine-shock tests. These tests were conducted at temperatures of -40° F. and +160° F., through frequency ranges of 5 to 500 cps, and inputs of .4G to 5G for the sinusoidal tests. For the random tests, power spectral accelerations of $.015G^2/Hz$ at 10 Hz to $.001G^2/Hz$ at 500 cps were used.

An analysis of test results indicated that the container will limit transient payload shock to below the 25Gs requirement during handling and storage operations, and reduce the effects of harmful input vibrations to an acceptable level during any mode of transportation.

In addition, the container maintained its structural integrity when subjected to the expected rough-handling shock and transportation vibration during its life cycle, maintained a seal to insure meeting the low-humidity requirements, and met all handling and mating requirements including service vehicles. These determinations provided assurance that the Adaption Kit Subassembly, packaged according to painstaking scientific design, would reach its final destination combat-ready for installation into the Warhead Section.

Please Respond to Our Readership Survey *(Page 31)*



Magnifying Power of Sun at White Sands Missile Range To Simulate Thermal Radiation From Nuclear Explosion

NATIONAL INTEREST IN SOLAR FURNACES, as a potential means of harnessing the energy of the sun to help meet power and heating source requirements of the United States, has mounted greatly during the current "Energy Crunch." Placed in operation recently (see article page 10) at the Army's White Sands (NM) Missile Range is the largest solar furnance in the U.S. (second in energy output only to one in Odeillo, France). Relocated from the U.S. Army Natick (MA) Laboratories to WSMR, the solar furnace does not have a capability of storing energy for power or heating requirements. Set up for the study of thermal radiation effects on electronic circuits, transistors and other electronic components of missile systems, the furnace can simulate bursts such as would emanate from nuclear weapons—by focusing very brief impulses of highly magnified sun rays onto a small surface of units in a test chamber.