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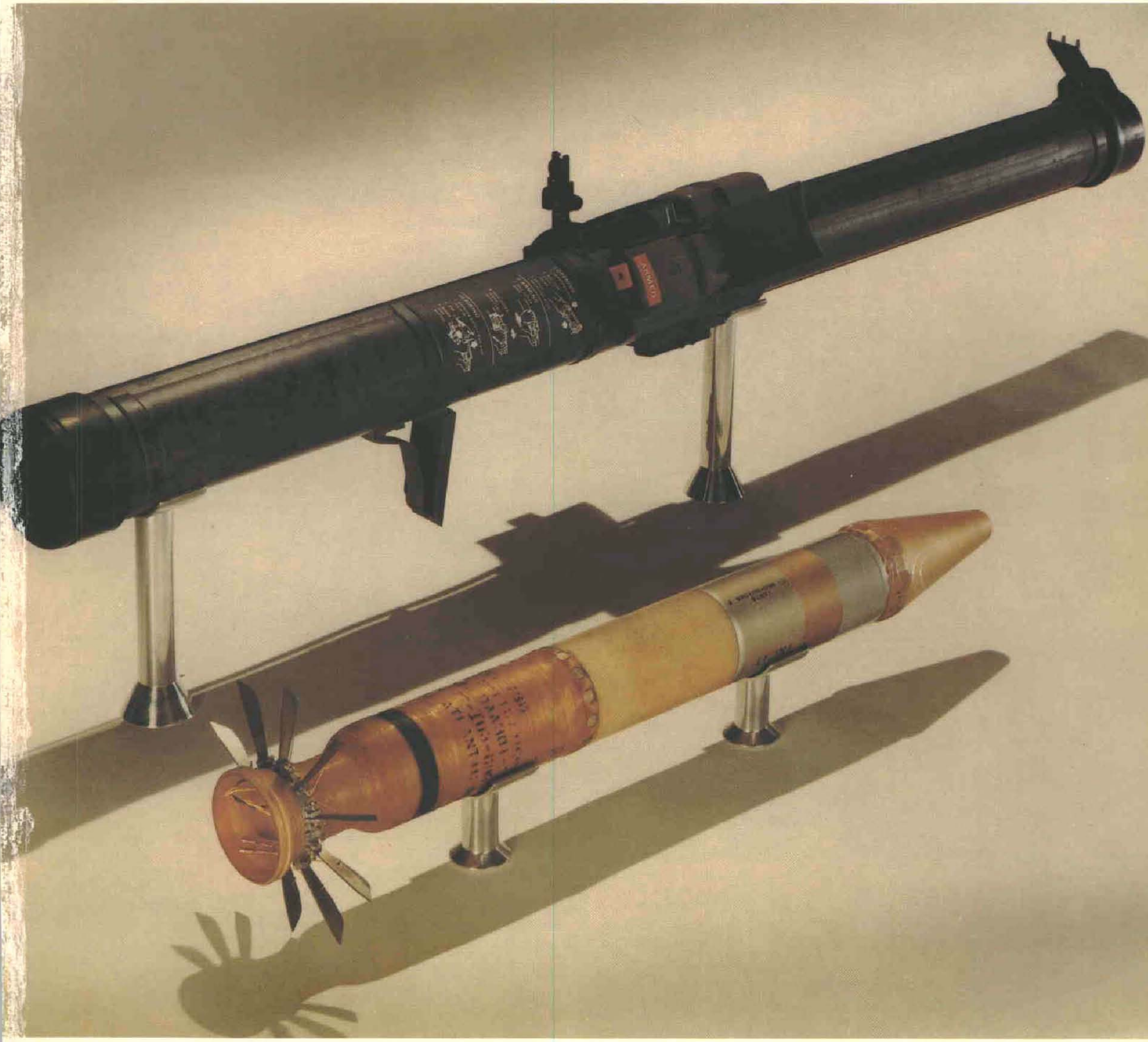

COMPOSITE MATERIALS FOR ARMY APPLICATIONS

(See page 1)

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ABOUT THE COVER:

Front cover shows the Viper antitank weapon, replacement for the M-72 LAW. It uses an all fiberglass launcher and will feature the first "manrated" fiberglass motor. Back cover shows M-60 tank suspension components, another example of potential composite materials application.

FEATURES

DEPARTMENTS

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Army Applications of Composite Materials

By Dr. Robert W. Lewis

One of the more radical departures from conventional military operations in the past two decades has been the growing trend toward air mobility and the resultant tactical reliance on the helicopter for troop and equipment movement and support.

Implicit in this trend is the need not only for lightweight and cost-effective reliable helicopters, but also for lightweight, cost-effective field equipment and materiel to be borne by the helicopter. Consequently, there is a critical need for materials offering high strength and low weight for these applications.

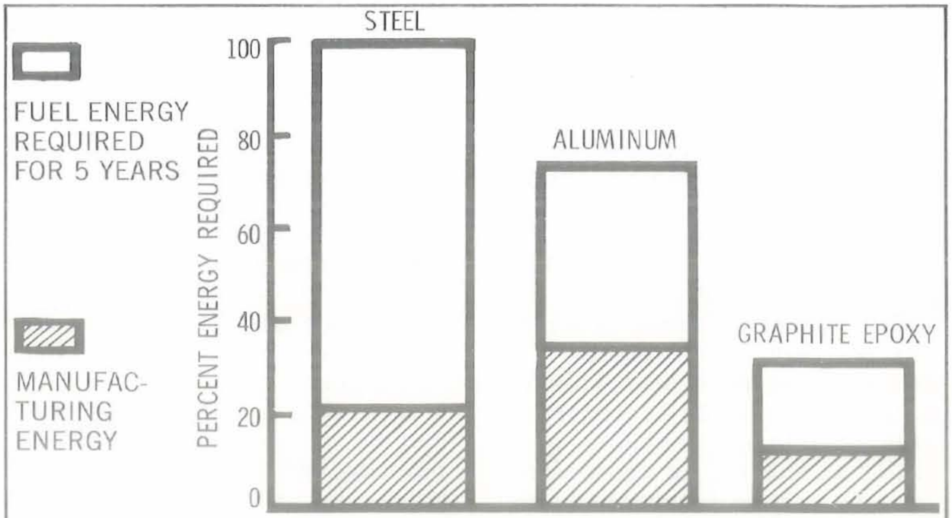
The Army has turned more and more in recent years to the natural inheritor of this mission: fibrous composite materials. Not only do these materials render performance improvements over conventional structural materials, but equally important, their lighter weight can result in substantial energy savings in mobility operations.

A composite material, generally, is a combination of two or more chemically distinct materials with a distinct interface between them. Each constituent performs a specific task enabling the composite to carry out the required duties.

One of the materials is generally a reinforcing fiber or particle and can be metallic (metal fibers), ceramic (glass fibers), polymeric (aramid), graphitic, or combinations thereof. The matrix can be metallic, ceramic or organic. Only fiber reinforced organic matrix composites will be considered here.

Advantages of fibrous composites that make them attractive for Army applications are their very high specific strength and stiffness, good fatigue resistance, damage tolerance, corrosion resistance, design flexibility and economics.

Per unit weight, composites are the strongest and stiffest materials commercially available today. Fiberglass, aramid, and graphite-epoxy systems are two to five times as strong as steel or aluminum, and the aramid and graphite composites two to four times as stiff.



COMPONENT: AUTOMOBILE HOOD

COMPONENT LIFETIME ENERGY SAVINGS WITH COMPOSITES

TABLE 1

Thus, substantial weight savings can accrue when composite materials are utilized. This has been repeatedly demonstrated for aircraft applications where weight savings from 10 to 40 percent have been achieved.

Even more dramatic weight savings have been shown feasible in automotive applications. A fiberglass leaf spring and a graphite coil spring, have been fabricated by Graftek Division of Exxon Enterprises, Inc. These springs offer 50 to 60 percent weight savings over their steel counterparts.

Although the word "fatigue" had apparently not been coined at the time, engineers as early as 1854 recognized the superiority of composite materials in fatigue resistance. Speaking of the Wheeling, VA, "iron" suspension bridge that collapsed unexpectedly, writers at the time submitted that "by frequent changes of—strain in iron, a certain disturbance of the particles takes place—and suddenly—the very same strain—it had sometimes supported—will break it to pieces."

We now call that disturbance of the particles fatigue. They further suggested that "it would seem more prudent to build—with stone piers and wooden superstructure." Wood is a natural composite material with excellent properties including good fatigue life.

In fatigue-critical structures then, composites offer significant advantages over the more common structural materials. This makes composites ideal for helicopters, which are really flying fatigue machines, or for aggressively dynamic applications such as leaf springs or mobile assault bridging.

Damage tolerance of composites is one of their prime features for military applications. This has been dramatically demonstrated with helicopter pitch links.

For example, a composite glass/graphite CH-47 pitch link with a dual-load path structure, was fatique tested for 1,033,000 cycles, between 2,700 lb. compression and 1,300 lb. tension. It was then impacted under compression with a .30 caliber AP projectile and again cycled 1,009,00 times with no visible degradation. Static loading to failure resulted in a breaking strength of 27,500 lb., significantly in excess of design requirements. A metallic counterpart would have failed catastrophically under similar impact conditions.

This property of composites, coupled with their high fatigue life, makes them ideal materials for dynamic control components in helicopters, for drive shafts and for tracked vehicle torsion bars.

Fiber reinforced plastics will not rot, rust, or corrode. There are resin systems available that will provide resistance to almost any corrosive environment from salt water to nitric acid. This feature is a plus to the Army for surface vehicle applications, especially as the rising acquisition cost of a vehicle demands a longer lifetime of the vehicle.

Use of composites allows the designer to form any shape he may desire, simple or complex, large or small. It is this flexibility that results in such smooth, appealing lines on fiberglass boats and cars and also allows modular modifications of equipment at minimum expense.

Another aspect of design flexibility is the anisotropy of the materials and the consequent capability of putting the fibers only in the direction of the applied loads. This allows design and construction of extremely weight-efficient structures. This advantage, however, is a 2-edged sword.

Putting the fibers where you want them may mean not having them where you need them. Consequently, detailed stress analysis, often using complex computer codes, is much more important for composites than for metals. In addition, building the most weight-efficient structure may mean costly processing techniques, for example hand layup, which may be cost effective for certain aerospace applications, but certainly not for surface vehicle use.

The ability to tailor a composite includes another advantage—hybridization, or the combining of two or more fibers in the same laminate. This enables the use of lower cost fibers to enhance specific properties. For example, glass/graphite hybrids can be used, as in the helicopter pitch link, with the inexpensive glass supplying strength, impact resistance and damage tolerance, and the more expensive graphite contributing stiffness and fatigue resistance.

Through parts consolidation, less handling and finishing, and moderate tooling costs, the construction of items from composite materials results in decreased production costs. A single fibrous composite structure can replace an assembly of many metal parts and associated fasteners and does so using one tool and little machining.

Assembly and handling times can be drastically reduced, and painting can often be eliminated, since color can be molded into the composite for long-lasting effects.

Operation and maintenance costs of composite items are also sharply reduced. Longer fatigue life results in fewer parts being worn out, while corrosion resistance reduces the need for preventive maintenance and painting.

From an economic standpoint, one of the premiere advantages of composite materials is the *energy savings* that can be realized. Considering petro-chemicals as the feedstock for the resins in composites and the fuel to process both metals and composites, it has been shown that the processing of composites can consume considerably less energy than metals for the same application.

The shaded area in Table 1 represents the manufacturing energy for an automobile hood. The composite hood uses 40 percent less energy than the steel hood and 60–70 percent less than the aluminum hood. When the gasoline required to drive that hood for five years is taken into consideration (unshaded area in Table 1), the dramatic potential for energy savings from using composites is evident.

Despite the many advantages of fiber reinforced composites, there must be limitations or we would see much more Army usage today. The most notable limitations are thermal stability, flammability, confidence in their use and, of course, cost. However, as discussed earlier, composite components can be made less expensively than metal ones, particularly if life cycle costs are considered.

Thermal stability of resins currently available for composites processing allows extended service temperatures of up to 500° F. These are generally expensive resins such as polyimides and polyphenylene sulfides. The more commonly used epoxies and polyesters have extended service temperatures in the 300° F range limiting their use in some areas.

Considerable research is currently underway by DOD, NASA, and industry to find heat resistant, economical resins. Heat instability does not present a serious problem for most military applications.

Engines and exhaust systems are currently beyond the state of the technology for composites use but even components in close proximity to an engine can be fabricated from composites through proper choice of resin. This is evidenced by the polyester distributor caps on most automobiles today.

The resin in organic matrix composites under the right conditions can burn. Consequently, proper resin selection is vital to reduce the potential fire hazards.

Government research, notably by NASA, Navy, the Army Materials and Mechanics Research

TABLE 2

ARMY APPLICATION OF COMPOSITE MATERIALS

● AIRCRAFT		
Rotor Blades	Flight Controls	
Drive Shafts	Landing Gear	
Transmission	Fuselage	
● MISSILES		
Rocket Motor Launcher	Fins	
● BRIDGING		
Trusses	Beams	
● VEHICLES		
Body	Drive Shafts	Wheels
Frame	Suspension System	
● LIGHTWEIGHT WEAPONRY		
Stiffeners		
Gun Barrels		
● PROTECTIVE MATERIALS		
Armor		
Tank Liners		
● PIPING AND STORAGE CONTAINERS		

Center (AMMRC), and the Air Mobility R&D Laboratories, is directed toward minimizing the flammability of composites and at developing char-forming resins. For most potential Army applications, flammability is not foreseen as a limiting factor.

Lack of user confidence in composite materials is primarily the result of unfamiliarity rather than any particular failure on the part of components. The lack of a performance data base under environmental extremes contributes to this unfamiliarity. Indeed, it is to establish this data base that much of the current DOD 6.2 RDT&E budget for composites is directed.

The recent emergence of reliable quality control inspection methods, developed by AMMRC and the Air Force Materials Laboratory, has done much to dispel many users' reluctance to accept composites. As more and more composites are fielded, this reluctance will further dissipate.

As might be anticipated, due to the many advantages of fibrous composites, the range of potential applications is quite large and varied. A few of these are listed in Table 2. Due to the early very high cost of fibers (> $200/lb. for graphite), composites were first used only for aerospace applications and strategic missiles. Consequently, the first Army applications were for helicopters.

An article in the January-February 1976 *Army R&D Newsmagazine* detailed the potential for composites in rotor blades and airframes. Many of the prognostications have come true. Composites are being used in rotor blades for CH-47, Black Hawk, AAH, and AH-1 IMRB. It is currently believed that the Army never again will design an all-metal blade.

Prototype development is under way in composite tail booms. More recently the Army has undertaken the Advanced Composite Airframe Program (ACAP), designed to maximize composite utilization in helicopter fuselages. Secondary structures are being fabricated, primarily from glass and aramid, for the Black Hawk and Sikorsky's latest commercial model, the S-76. Thus, composites are being used in helicopters.

TABLE 3

RESULTS - DESIGN STUDY

COMPONENT	WEIGHT	ANALYSIS	WEIGHT SAVING
TORSION BAR	105 LB	NOT FEASIBLE, REQUIRES 56% IN DIAMETER EXCEEDS TANK ENVELOPE	60%
DRIVE WHEEL AND SPROCKET	413 LB	ALL COMPOSITE GRAPHITE EPOXY	63%
SUPPORT ROLLER	22 LB	COMPRESSION MOLDED GLASS FIBER	29%
ROAD WHEEL IDLER	105 LB	STRUCTURALLY FEASIBLE, GLASS/GRAPHITE/EPOXY TAPE NOT PRACTICAL	5%
TRUCK WHEEL	175 LB	AS-GRAPHITE TAPE RIM, S-GLASS MOLDED HUB	65%
END CONNECTOR	2.6 LB	STRUCTURALLY FEASIBLE, REQUIRES CHANGE IN PIN ATTACHMENT, DURABILITY UNKNOWN	69%

But what of the other commodity areas? In the tactical missiles area, the Army has been using fiberglass launch tubes for quite some time. One example is the forward tube of the M-72 LAW (Light Antitank Weapon) launcher. The replacement for the LAW is currently under development by the U.S. Army. Nicknamed the Viper, the new weapon uses extensive amounts of composite materials (see front cover).

Although slightly heavier than LAW, Viper has a much greater probability of hitting the target at greater ranges than its predecessor. The Viper uses an all fiberglass launcher and will have the first "manrated" fiberglass motor.

Although composite rocket motors have been used in defense of the country since the days of Polaris, no previous motor has had to be "manrated." The probability of catastrophic failure which would harm the gunner is equivalent to that imposed on cartridged munitions.

The motor used in Viper is a filament wound S-2 glass/epoxy construction. Each bottle is subjected to a high level proof test. During the development phase of Viper no failures attributable to a pressure overload of the motor have been observed.

When fielded, the Viper, although relatively small, could represent the largest single use of composites to date in the Army because of the anticipated numbers of weapons slated for the inventory.

Bridging is another area where composites can be effectively used either to save weight or improve performance. Currently under development at AMMRC and MERADCOM are concepts for employing high modulus composites in the traversing beam and bottom chord of the main bridge section.

An all-composite traversing beam could weigh as much as 50 to 60 percent less than its aluminum counterpart, and with innovative fabrication methods it could also be no more costly. The selectively reinforced bottom chord would weigh about half as much as a structurally equivalent aluminum member. Its field ruggedness will be evaluated in the coming year. A prototype traversing beam will be fabricated and evaluated within the next two years.

It is in the area of ground vehicles, however, that the greatest volume of composites may ultimately be used by the Army. Just as Detroit is turning more and more to composites to reduce the weight of commercial vehicles, so will the Army.

In addition, composite materials can significantly reduce corrosion and when judiciously combined with metals can increase ballistic resistance, decrease vulnerability to mine blast, while offering substantial weight savings.

Incorporation of nonmetallic materials in newly designed road wheels and track shoes has resulted in substantial improvements in resistance to mine blast. The internal structure of the wheel consists of radial support rings encapsulated in a nonmetallic material. Under load, this structure deforms initially at a single point that is tangent to the outer rim and the inner ring.

Under continued load, both the rim and the ring deform such that the area of mutual contact continuously increases. Because this contact area is changing continually during loadings, structural discontinuity does not occur at a single point. Thus the velocity gradient is spread over a wider area.

Use of one roadwheel per station, instead of the present dual roadwheel, reduces the area exposed to the blast, thus minimizing the debris projected after detonation of an explosive charge.

In blast damage test comparing the new mine hardened suspension with that of the current M60 tank suspension damage to the new suspension consisted of the loss of three non-metallic shoe bodies. The damage to the M60 suspension was quite extensive: the track was completely severed, and a set of dual roadwheels was lost.

Recently, AMMRC completed a program designed to determine the feasibility for incorporation of fiber-reinforced components on Army tracked and wheeled vehicles. Selected components on the M-60 (see outside back cover) and a 5-ton Army truck wheel were analyzed for load and component envelope requirements. The results are shown in Table 3.

Weight savings up to 69 percent can be achieved. It should be noted that while the torsion bar is not feasible for the M-60 due to physical envelope constraints, composite torsion bars could be feasible in the next generation if designed simultaneously with the vehicle.

The end connector link for the M-60 provides a good example both of the advantages and problems with composite materials. The composite link, consisting of fiberglass wrapped over an aluminum mandrel, proved structurally feasible and offered weight savings of 69 percent over the current link, corresponding to two percent of the gross vehicle weight.

Manufacturing costs were estimated at $3.25 per link if E-glass used and $4.34 if S-glass used, compared to $3.50 per steel forged link. The problem is, the link cannot be directly substituted for the steel link. The pin attachment must be modified. This again points up the necessity for considering composites when initially designing a vehicle, rather than considering component substitution at a later stage.

Another area where composite materials can effectively be used both to save weight and to increase performance is in large caliber weapons systems. AMMRC has recently demonstrated the feasibility of using fibrous composite materials to reinforce a barrel extension of a 75mm gun. Increased accuracy and a reduction in round dispersion were the goals.

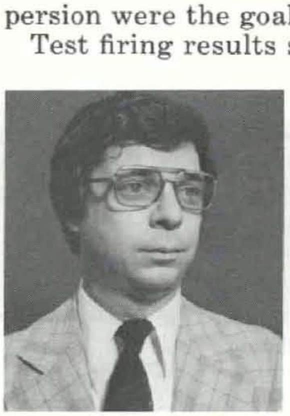
Test firing results showed that the average dispersion for the composite extension was one-third that of the all-metal extension while offering 15 percent weight savings.

High temperatures currently limit somewhat the extent to which organic matrix composites can be used in large caliber weapon systems, but carbon-carbon composites could do the job. These latter materials have been limited to missile, reentry vehicle, and aircraft brake applications due to their very high cost.

Recent breakthroughs in manufacturing costs, however, augur feasibility in many additional applications. The next phase in the gun barrel work, then, will be to incorporate these materials so that composites can be used throughout the entire barrel length.

Composite materials, then, have a great deal of potential throughout the entire Army commodity spectrum. That acceptance has been slow is understandable. DARCOM RDT&E efforts, such as study of moisture effects, nondestructive evaluation and inspection, flammability reduction and repairability, however, have been designed to overcome users' reluctance to accept composites by establishing the data base necessary to support the long term usage of composites in the field.

DARCOM MMT programs have reduced manufacturing costs so that composites are being used in aircraft and missiles. Analogous efforts in other commodity areas likewise will result in composite usage in tanks, trucks, bridging, weaponry, electronics and field support equipment. The future of composites in the Army is bright indeed.



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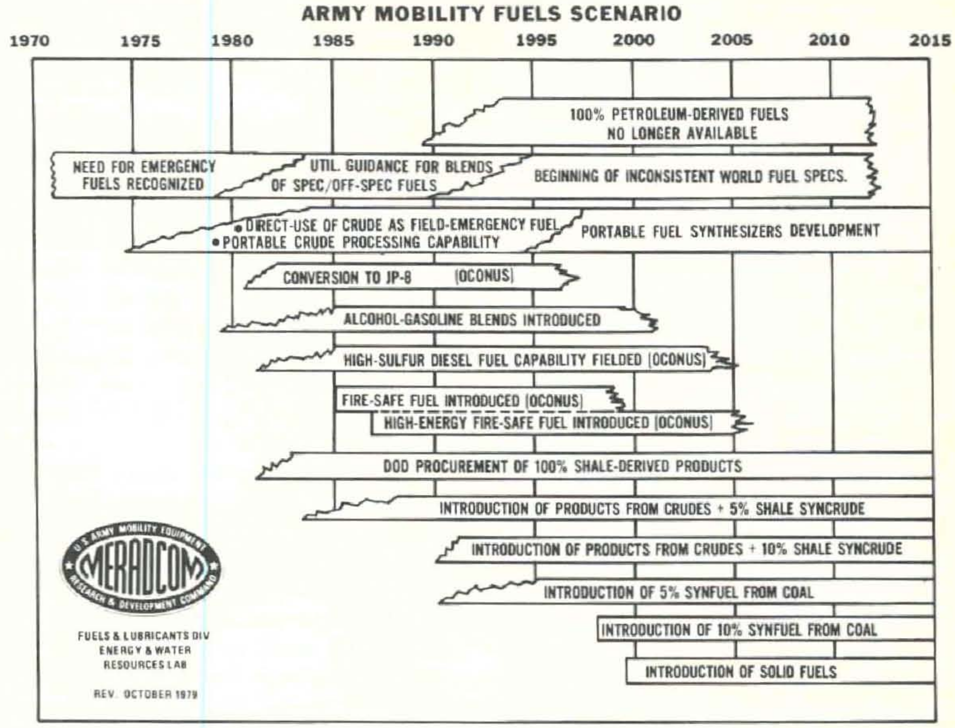
Army Mobility Fuels in the Twenty-First Century

By Dr. James V. Mengenhauser



Mobility fuels are defined as those intended primarily for use in aircraft, watercraft, and land vehicles; secondarily in other equipment such as generators, stoves, and utility modules.

Why does the Army need to worry now about the fuels it will be using in the next century? Just assume, for example, that a requirement for a new vehicle is approved in 1980. The new item spends 10 years in development and is fielded in 1990.

The vehicle then stays in Army inventory for 20 years and is removed from service in 2010. This means that fuel requirements for equipment now on the drawing boards must be projected *30 years into the future!*

Projection of fuel requirements into the future is risky business at best. A complex and interacting array of factors can affect future fuel supplies—geopolitical, economic, environmental, regulatory, and technological.

In spite of these uncertainties, one can make reasonable estimates of which future fuels are most likely to be used. For the foreseeable future, liquid hydrocarbons will be the fuels of choice for Army use.

Although future fuels won't look vastly different from those today, they will differ greatly in the way they are produced and refined. Nevertheless, they must perform well enough in military equipment to insure that combat readiness is maintained.

The most likely resources for future fuels are those which are most abundant in the U.S.—oil shale, coal, and biomass. Another resource, tar sands, is abundant in this hemisphere and large deposits are located in Canada and Venezuela. Smaller, but possibly exploitable quantities, are located in Utah and New Mexico.

U.S. petroleum production has been declining for several years and, barring discovery of any major new oil fields, will probably continue to do so as our oil deposits are depleted. Worldwide petroleum production, on the other hand, is still increasing ans has thus far allowed the U.S. to augment its declining production with increased imports. However, when worldwide production peaks and begins to decline, imported oil will become increasingly scarce or not available.

The date when world petroleum production begins to decline is subject to many uncertainties, but a reasonable estimate is 1995, give or take a few years. This means that the U.S. must develop a major synthetic fuel industry in the next 20 to 30 years if our standard of living is to be maintained.

Oil shortages are not new to the U.S. In 1832 whale oil sold for 23 cents per gallon. The whaling industry was crippled by the Civil War and prices rose to $1.85 per gallon by 1865. Many small oil shale companies were also operating in the Eastern U.S.

However, the discovery of "Colonel" Drake's Pennsylvania oil well in 1859 led to development of a new industry. In a few years cheap petroleum had driven the price of whale oil back to its 1832 level and most of the oil shale companies out of business.

Discovery of huge oil shale deposits in the West was accomplished quite by accident. In 1882, a homesteader in Rio Blanco County, CO, named Mike Callahan, built an impressive new log cabin and decided to have a housewarming for his neighbors.

When the Callahan's guests arrived he built a fire in the fireplace he had crafted with native stone. Shortly after the fire was lit, the fireplace itself caught fire and the entire cabin quickly burned to the ground. Callahan's fireplace had been built of oil shale.

The extent of Callahan's discovery wasn't known until much later when the U.S. Geological Survey estimated the U.S. oil shale reserves at 2.2 trillion barrels. If one-third of these deposits could be recovered, it would be enough to supply oil needs of this country for a century at the present rate of consumption.

In 1944, Congress, anticipating an oil shortage due to the tremendous fuel demands of World War II, passed the Synthetic Liquid Fuels Act. This Act led to the construction and operation of the Anvil Points Oil Shale Demonstration Facility by the U.S. Bureau of Mines. Pilot plants were operated at the facility from 1950 to 1955. A number of other government-supported research or demonstration facilities have operated since then.

Compared to other sources of synthetic fuels, oil shale offers the best possibility for near-term production of mobility fuels. About two-thirds of the world reserves are located in the U.S. and several types of extraction technology have been developed.

Although little or no shale oil is being produced commercially in the U.S., it is now being produced at two locations in China and in Estonia in the U.S.S.R. Commercial production of oil from shale dates back to 1838 in France and 1850 in Scotland and continued for over a century, finally ending in the 1960s.

At various times between 1850 and 1950, oil shale industries were also operated in Australia, Sweden, Spain, South Africa, and Germany. During World War II, both Germany and Japan made use of shale oil to help meet wartime needs. Japan had no deposits of her own, but used resources conquered in Manchuria. All of these industries in general were operated with some form of government support such as subsidies or tax exemptions.

Even though the properties and composition of crude shale oil differ in several important respects from petroleum crude, modern refining technology can be successfully applied to shale oil. U.S. crude shale oil contains about two percent nitrogen, a much higher amount than petroleum crude, and a moderate amount, 0.7 percent, of sulfur.

Crude shale oil is a heavy, viscous oil with a high pour point and is thus unsuitable for pipelining. One way to solve this problem is through hydrogen treatment to upgrade the crude near the retorting site.

This process reduces the amounts of nitrogen, sulfur, and oxygen compounds to levels which are acceptable to conventional petroleum refineries. It also decreases the viscosity and pour point to permit pipelining. Once the upgraded crude shale oil reaches the refinery, it can be processed in a variety of ways to yield gasoline, jet fuel, diesel fuel, and low-sulfur fuel oil.

Army research on shale-derived fuels has been limited in the past by availablility of test fuels. However, availability of much greater amounts of shale fuels is anticipated in the next few years to enable the Army to qualify its aircraft and vehicles to operate on these fuels.

Future plans call for AVRADCOM to qualify aviation equipment of shale-derived JP-4. Qualification of diesel-powered equipment will be performed jointly by three organizations, MERADCOM, TARADCOM, and TARCOM, with MERADCOM functioning as the lead.

For two reasons, only limited tests are planned for shale gasoline. First, the tactical fleet is primarily diesel-powered. Second, production of gasoline from shale crude requires additional hydrocracking and reforming treatments beyond that required for jet and diesel fuel, resulting in additional cost. Gasoline is therefore not expected to be a major product from oil shale in future commercial operations.

Development of fuel specifications will be a major part of the shale fuel qualification program. As engine tests and fleet tests progress, specifications will be modified to accommodate fuel-related problems unique to shale fuel. Particular attention will be given to thermal stability, storage stability, low temperature fluidity, additive response, and engine deposits. Fleet tests will be conducted at locations providing a range of climatic conditions.

Another potential resource for production of future fuels is coal. The U.S. has abundant reserves of coal, estimated at 1.6 trillion tons. The amount of producible coal in the U.S., defined as seams thicker than 14 inches, not deeper than 3,000 feet, and assumed to be 50 percent recoverable, is estimated at 750 billion tons and represents about one-third of the world total of producible coal.

Coal can be processed in a variety of ways to yield combustible gases, heavy fuel oils, lighter hydrocarbon liquids, or methanol. Gases and heavy fuel oils are not suitable for mobility fuels in present Army equipment although limited research has been conducted with direct use of crude oil as a field emergency diesel fuel.

Methanol can be used in fuel cell powered equipment, but the demand from these items is only a small fraction of total Army requirements. The lighter hydrocarbons from coal are high in aromatic compounds and make good gasolines, but poor diesel fuels and jet fuels. This is because the aromatics have the effect of increasing octane numbers, but depressing the cetane number when they are present in fuels. Aromatics also affect the flame radiation and luminosity properties of jet fuels which impacts turbine combustor durability.

Methanol from coal, either alone or blended with gasoline, has been proposed as a mobility fuel. Use of pure methanol in gasoline engines would require extensive changes in the carburetion and intake manifold systems to compensate for a much different fuel-air ratio and heat of vaporization than gasoline.

There are other drawbacks to pure methanol. The fuel tank would have to be twice as large to get the same vehicle range as with gasoline because of the lower heat content per gallon of methanol, and starting in cold weather would be more difficult. Material changes would also be required in the fuel system due to the solvency and polarity of alcohol vs. gasoline.

Engine tests performed at the U.S. Army Fuels and Lubricants Research Laboratory (AFLRL) for the Department of Energy indicate that pure methanol causes much higher wear rates than gasoline, especially at low temperatures. AFLRL is working to define the extent of this problem and to develop lubricants which will minimize wear and be compatible with alcohol fuels.

Gasoline engines will burn blends of to 10 percent methanol in gasoline. Those blends will tolerate only 0.05 percent water before phase separation and precautions must be taken to keep water out of the system.

Production of gasoline and other fuels from coal has been technically feasible for many decades. Germany produced much of her fuel synthetically from coal during World War II. The only coal liquification plant now operating commercially is in the Republic of South Africa where 10,000 barrels per day are produced. A new plant with a capacity of 40,000 barrels per day is on the way and plans call for more than double that in the future.

When new plants (which, incidentially, are U.S.-designed) come on stream, they will provide 40 percent of South Africa's motor fuels. When synfuels from coal become available in the U.S., the Army will conduct equipment qualification tests on these fuels similar to those outlined for the shale synfuels.

Fuels can be produced from biomass by several methods, fermentation, pyrolysis or indirect liquification from gasified products. Of these processes, fermentation to ethanol is by far the most popular. Gasohol, a blend of 10 percent ethanol in gasoline, was sold in a few areas of the U.S. in the 1930s before it died out and re-emerged in the 1970s.

Although Gasohol may not be as important in the long run to the Army as shale synfuels, it has a de facto priority because it can be available commercially right now and shale fuels are not.

The Army's Gasohol test program was officially launched on 13 December, 1979 at MERADCOM when Secretary of the Army Clifford Alexander took the first ride in a Gasohol-powered jeep at the kick-off ceremony. Test plans call for initial operation of all MERADCOM gasoline vehicles on Gasohol.

The program will later expand to include test fleets of tactical equipment at Fort Lewis, Red River Army Depot, Letterkenny Army Depot and Fort Belvoir. Test procedures and results are being coordinated with other reliability fleet tests under way by the Department of Energy and other state governments.

Items of interest to the Army during these tests include driveability and performance, fuel economy, phase separation because of water contamination, possible clogging of fuel filters due to increased solvent action of Gasohol, effects of Gasohol on elastomeric components, and effects on lubricants.

Two types of specialized fuels may also come into use in the future—fire-resistant fuels (FRF) and high-energy fuels (HEF). FRF is a blend of 84 percent diesel fuel, 6 percent emulsifying agents, and 10 percent water intended for use in combat.

FRF has undergone extensive laboratory engine testing and no unusual engine deposits or wear were found. When burned in a diesel engine, FRF yields about 7 to 10 percent less power because of the reduced volumetric heat content of the fuel when the water is added.

However, full engine power can be restored by readjusting the fuel delivery system to deliver slightly more fuel to compensate for the water. Laboratory and ballistic tests with incendiary projectiles have demonstrated that FRF is self-extinguishing even when the FRF is heated above its flash point and ignited.

High-energy fuels are those with at least 10 percent more energy per volume than conventional petroleum fuels. Chief uses of HEF are in applications where the volume available for fuel is limited. Several of these candidate fuels have undergone laboratory testing and work is continuing in this area.

Another classification of fuels that may be seen in the future are broadcut fuels. These are fuels with a wide boiling range, say 100° to 700° F, which require a minimum of refining, and would require development of new engines without limiting octane or cetane requirements.

One type of engine which could burn broadcut fuel is the direct-injected stratified charge (DISC) engine, which has been under development for some time by industry. If DISC engines, which approach the diesel in thermal efficiency, become widely available, it will become advantageous for refiners to produce broadcut fuel to minimize refining costs and get the maximum amount of fuel from each barrel of crude.

Widespread consumption of fossil fuels over the years has produced two environmental effects which may restrict fossil fuel consumption in the next century. One of these effects is the steadily rising levels of carbon dioxide in the atmosphere, which some scientists feel may lead to climatic changes because of the "greenhouse" effect.

So far, no measurable long-term temperature changes have been detected above the normal year-to-year fluctuations, but another decade or two of data may answer the question. The other effect is an increasing trend in the acidity of rain, probably from increased levels of carbon, nitrogen, and sulfur oxides in the atmosphere.

To summarize, Army mobility fuels in the next century will still be primarily hydrocarbons, but with some of the fuel coming from shale or coal syncrudes. Oil shale will be used as a source of jet fuel and diesel fuel, while coal will be a source of some of the gasoline.

Gasohol will be used whenever fermentation ethanol is in good supply. Development of the DISC engine will lead to the use of broadcut fuels. Fire-resistant fuel and high-energy fuels will be used for special applications.

To project the availability of these future fuels on a time frame basis, an "Army Mobility Fuels Scenario" has been developed and is shown in the accompanying chart. This scenario is based upon engineering judgment, current and projected technological developments, and project future fuel policies. Its development evolved in an attempt to provide engine/hardware developers with guidance as to future types of fuel.

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Interview With Former ASA (R&D) Norman Augustine

Interview With
Norman R. Augustine
Vice President
for
Technical Operations
Martin Marietta
Aerospace

Mr. Norman R. Augustine, Vice President for Technical Operations, Martin Marietta Aerospace, was interviewed recently by Army RDA Magazine. *Augustine has corporate responsibility for research, engineering, advanced programs, logistics and capital expenditures. He is a member of the Board of Directors of International Laser Systems, Inc. A former Under Secretary of the Army and Assistant Secretary of the Army (Research and Development), and later Under Secretary of the Army, he provided some very frank responses to a broad range of questions.*

Q. Some people contend that industry is more efficient than government in carrying out its R&D programs. Others believe that the opposite is true. Since you have served in high level positions in both areas, what is your view?

A. It is necessary to define, when one says "government," what part of the government one is talking about. For example, in spite of the criticism that the Defense Department regularly receives in the media, I believe that most impartial observers would agree that the DOD is, in general, a superbly managed large organization. I've even seen where Senator Proxmire has, on occasion, said the DOD is probably the best managed part of the government . . . which is not to suggest that he does not see a few areas for improvement!

Judging from my own associations, only NASA would rank with DOD in terms of overall management quality among governmental organizations. When one deals with most other federal agencies or state and local governments, one finds that the efficiency of management is generally consideraly inferior to that which is found in the Defense Department. Now, having said that, I should like to say that there are some significant differences between government management and industry management, and there is room for improvement in each.

In several respects, the job of industry management is easier. The end objective is much more readily definable and measurable because the need to produce a profit provides a clear "bottom line." In addition, in industry an individual generally has much more direct authority and direct capability to carry out the task at hand. There are fewer political ramifications and there aren't as many layers of approval required. Thus, one simply has more ability to execute a task once it has been assigned. Hand-in-hand with this, however, goes increased accountability and responsibility for achieving prescribed goals.

I recall a story that a reporter once told about an interview with then President Lyndon Johnson. President Johnson, it seemed, had been complaining that one of his favorite programs had been torpedoed by someone in one of the federal departments. The President, to say the least, was extremely upset. The reporter asked why, if the President was so angry, he didn't just fire the person who had caused the problem. President Johnson's reply was: "Fire him? I can't even *find* him."

I think this points out that because of the size of the Federal government alone it is very difficult to manage, particularly with the extreme layering of authority all the way through the OMB, the Congress, etc. Further, the issues addressed in industry are generally less complex . . . although the consequences of a bad decision are often more personal and more immediate . . . at least in peacetime.

Industry also has one other advantage . . . there is competition among companies. I think *constructive* competition usually brings out the best in people. When one looks at the Post Office, or the railroads . . . or similar organizations, one sees, in my opinion, what happens when effective competition doesn't exist. The civil economy of the Soviet Union is a classic case of this problem.

The pivotal factor, in my opinion, comes down to people. There are, fortunately, abundant numbers of competent people both in government and industry. Within each, some pockets tend to be stronger than others. If you have a strong pocket of competent and dedicated people in the government, that particular pocket will probably be more efficient than its counterpart in industry if the latter happens to have less capable people. The opposite is equally true.

Q. Do you believe that Army material requirements submitted to industry are realistic and reasonable in terms of cost, development time, performance, etc?

A. I believe there is still a tendency to over-specify. By that I mean there is a tendency to tell industry *how* to do its job rather than to tell industry what is the end-product that is desired. Worse yet, there is a growing tendency to do industry's job *for* it. In addition, many marginal requirements still seem to be placed on desired end-products. Further, perhaps one of the greatest shortcomings in the Army's material development program has been the tendency to reassess requirements or become discouraged with technical problems in midstream and terminate partially completed programs. These programs are then replaced with new ones which will eventually have their own set of difficulties such that about all that one accomplishes is to trade known problems for unknown problems . . . while losing money, time and fighting capability in the process.

Almost any R&D program, no matter how well managed, is going to run into problems somewhere along the way. Assuming that the item being developed is indeed needed, very often one is better off just to tough it out and go about solving whatever problems may have been encountered. When the requirements change in the middle of the development process, or there is a loss of support for a program, it makes it all the more difficult to have the development process actually produce anything.

The support that is given to a program once a decision has been made to proceed with it represents a major distinction between government and industry activities. In industry it is unthinkable that individuals would continue to reopen questions that were considered and set aside at the time an initial decision was reached to undertake some particular program. In the Defense Department, where discipline is a matter of great pride in operational units, decisions in R&D represent only momentary passages over hurdles that will be re-established over and over again by those who did not concur in the original conclusion or their successors. Every problem which is encountered will be used as a basis to reopen issues that were addressed long before. DSARCs addressing production readiness will spend much of their time re-examining the entrails of earlier decisions with respect to whether the system that has been pursued for typically eight years is really useful or not. Now understand that the question of need and affordability is of the utmost importance . . . but the seventh month of a pregnancy is generally a poor time to be reassessing one's family planning.

Another concern is the time it takes to establish *formal* requirements and the impact that this indecision can have in sacrificing hard-earned technological lead time. I am familiar with one program, not an Army program incidentally, where three years were spent obtaining approval of the project from the time it was clearly shown to be feasible and needed. Subsequently, in order to recoup part of this three years, the development process was compressed into about half of the time which should have been allotted. Major risks were taken during the development phase; configurations were frozen before wind tunnel data was acquired, and so on. One, of course, ultimately pays a price for such imbalances in the use of so precious a resource as time.

Q. What changes would you like the Army to make with regard to the way it conducts business with industry? Specifically, what would make industry's job easier, and the overall R&D management process better for all parties?

A. In my judgement, the problems that still exist in the development process are not wholly attributable either to industry or to the government. There are two sides to virtually every problem as well as to every story. For example, industry's record on cost control of large military systems developments has been anything but enviable.

Let me mention just three changes among the many I would offer which I believe could permit us to produce better equipment for the people in the field who, in the final analysis, are the ones that count.

First of all, the defense industry, by and large, makes much smaller investments in terms of plants and equipment than does its commercial counterpart. Consequently, the defense industry, in the long-term, cannot be expected to be as efficient as most commercial organizations. The reason the defense industry generally makes smaller investments is because profit margins are much less on defense business than on commercial business, and it is, of course, essential to maintain a competitive return on investment (ROI) if one is to have the capability to raise capital.

Since companies involved in the defense sector in the United States have to raise capital from exactly the same sources as non-defense organizations, defense firms necessarily must maintain a respectable and competitive ROI. If "return" as a fraction of sales is small . . . which it is in the defense sector . . . then the way to maintain a competitive ROI is very simple: maintain a small investment. Unfortunately, we all must pay the price for that policy by having less capital for new machines and other productivity-improving devices. It used to be that the government provided the needed plants and equipment to industry, but this is no longer the case with industry itself now providing over 90% of the plants and equipment committed to defense contracts. The first change I would like to see is for the government to provide more incentives for industry to invest capital in a manner which would enable it to better perform on its contracts.

The second change I would suggest, and probably the most important of the three I will mention, is the matter of increasing program stability. An incredible amount of talent, time and dollars is spent in industry, as it is in government, simply trying to keep programs alive that have already been approved.

For example, each year within the Congress there takes place a minimum of 18 votes at a level potentially addressing individual R&D line items. It takes just over 8 years on the average to complete an engineering development program. If you multiply 8 times 18 you obtain the number of individual opportunities for a program to get into funding trouble in the Congress alone. This doesn't include internal reviews within the Services, or the Office of the Secretary of Defense, or the OMB, or the White House, or . . .

We pay a great price for this lack of stability. Robert Townsend, in his book *Up the Organization*, described this behavior as the tendency to go around pulling up flowers to see if the roots are healthy. Unfortunately, a great deal of this root-checking is done in the defense R&D business.

In one program, an Army program in generally good health, the budget was cut nearly in half one year due to a decision reached within the Pentagon. A few months later that same year the Congress nearly doubled the (reduced) funding that had been requested. The result was, among other things, the execution of three different contracts in a single year.

In another case that I recall, a several-hundred-million dollar budget request for an Army program was cut in half one year in one House of the Congress and fully-funded in the other. Unfortunately, the Conference Committee did not meet to resolve this variance until the year in question *was already half-over*! Needless to say, the managers of that program developed a rather intense understanding of the meaning of brinksmanship as they debated whether to cut-back (and thereby undermine their request) or proceed ahead toward a financial precipice.

The need to maintain stability spans from funding approval and moral support to scheduling and longevity of participants. If we could achieve better stability I believe we could obtain a great deal more for our R&D dollars. From an industry standpoint, companies simply will not invest in new machines to efficiently produce products that may not be around next year. From a government standpoint, it is hard to motivate people to give their all to a cause which may ultimately not have the support of management. From the Congress' standpoint it is difficult to accept that programs can be very important in an absolute sense when their requirements vary widely each time there is a change in management of the requirements process. The solution, I believe, involves such things as multi-year funding, guaranteed investment recoupment for industry in case of termination for convenience of the government . . . and the creation of a management system disciplined to leave the flowers alone.

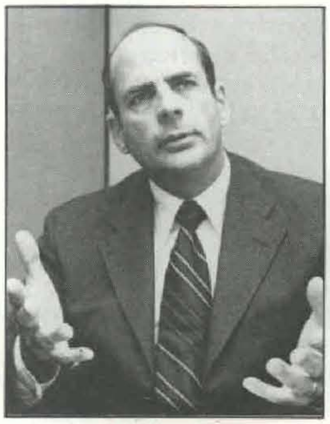
The third area for improvement I would cite is the process for selecting contractors to carry out R&D programs. The process today, in the case of R&D, relies principally on cost-reimbursable contract instruments. I personally believe this is very appropriate for research and development activities having prescribed outputs. As it happens, the predicted cost, or worse yet, the claimed cost, is perceived in industry to be a significant selection factor in picking a contractor to carry out those (cost-reimbursable) contracts.

Whether cost *is* a significant factor or not, the *perception* that exists generally has the very real effect of causing much of industry to be unduly optimistic in its bids. As a result, industry and the government often enter development programs in a partnership with a cost target that is far too low . . . to the detriment of all involved. This is simply because of the optimism that is bred into the competitive bidding process for cost-reimbursable contracts; coupled with the legitimate uncertainty in estimating the cost of something that has never been done before; that is, "development." The question, of course, is not what is the problem, but rather is what is the solution to encourage more realism in cost estimation? Clearly, the bidding process must further incentivize industry to bid programs at a 50/50 cost probability rather than, say, a 10 percent probability of achievement. One approach which is, incidentally, simple, elegant and wrong . . . for *R&D* contracts with specified output . . . is fixed price contracting.

Q. Should there be a mandatory number of new program starts each year so the U.S. can maintain equal footing in R&D with the Soviet Union?

A. I believe not. I think that to mandate a certain number of program starts would be a mistake. We should be measured not so much by what we start, but by what we complete . . . and by the capability that is ultimately introduced into the field for our forces.

I am not trying to say that we don't have a serious problem in terms of new R&D starts in the Army . . . or the Navy . . . or the Air Force, for that matter. The Soviets are spending probably at least half as much again as we are in the area of military R&D. Unless they are grossly inefficient there is simply no way we can expect in the long term to hold our own with them if we let that pattern of spending persist. Fortunately, they *are* inefficient. But the above figure is based on equivalent U.S. purchasing power and thus has already normalized the relative effectiveness of our two systems.



"... perhaps one of the greatest shortcomings in the Army's materiel development program has been the tendency to reassess requirements or become discouraged with technical problems in midstream and terminate partially completed programs ..."

I have said on previous occasions, speaking from a professional perspective, I would enjoy managing the Soviet Army's R&D budget. It would be a very easy job. In the U.S. tough decisions have to be made day-in and day-out on programs that can't be started. However, in the Soviet Union, they simply start the programs. One can make a very impressive list of what they have developed over the last 10 years because of the additional money they have had available over and above what we have had to spend. Think, for example, what the Army might be able to develop with an extra $2 billion each year.

The solution is simply going to require more funding for military R&D and procurement. This solution is going to require additional programs in the development cycle. The solution is going to require better cost (scope) estimating in industry, more stability in program direction from the government, and better overall performance by all of us. However, I don't believe that mandating a certain number of program starts each year would be the proper solution. Each program must stand on its own merit.

Q. Cost overruns are obviously not a pleasant thing for the Army, the Congress, or industry itself. Can they be avoided?

A. I believe that to a large degree they *can* be avoided. Certainly, we have not been successful in avoiding them thus far. According to the data I have collected, the average program has a cost overrun of over 50 percent even when measured in constant dollars. Various studies show levels of anywhere from 30 to 80 percent growth, depending on the assumptions. In order to discuss how such overruns might be avoided, it is first necessary to discuss the cause of the overruns.

For many years I have been saying that overruns are due in large part to poor cost estimating at the outset of the program, as opposed to mismanagement, although there is some of that too. I recently realized that to many people "poor cost estimating" means poorly estimating what a specific task will cost. That is not all what I intend to convey. For example, in the area of software, if you know with certainty that a program will involve a half million lines of code it is not overly difficult to make a reasonably accurate estimate of the cost of producing that code. The difficulty lies in estimating how many lines of code there will be in the first place.

So, when I suggest that we have a problem of poor cost estimating, it would be more accurate for me to say poor *scope* estimating. We don't accurately size the task to be performed. Sometimes this is referred to as not allowing for unknown unknowns; those things that one can't predict explicitly, but which will occur in a program and will require additional time, dollars and talents for their resolution. One can be certain in a statistical sense that *something* unexpected will occur, and therefore allowance should be made for that in planning program resources.

One difficulty stems from the fact that a program manager has to submit his budget about two years before he actually executes that budget. This is due to the approval cycle in going through the Pentagon and the Congress . . . a story in its own right.

In a dynamic endeavor such as R&D, where the half-life of technology itself is on the order of 5 to 10 years, it is almost impossible to foresee *precisely* how much funding will be needed two years in advance of the time it is to be spent. Thus, when the two years go by and it turns out that a problem occurs that the planner didn't anticipate, the result is a shortfall of funds and the manager then has almost no flexibility to manage. He has a $2 million reprogramming limit which is *far* too small to be useful for any significant development program . . . and even the use of that necessitates disrupting other programs which had a legitimate requirement for the sought-after funds in the first place.

The other alternatives of obtaining newly appropriated or reprogrammed funds in excess of the above ceiling require the approval of four committees of the Congress. This is an endeavor that usually takes months, and even then may or may not be successful.

Some provision needs to be made at the outset of a program to provide funds with which to work one's way out of problems. That is, we must provide our managers some latitude to manage.

Industry wouldn't dream of undertaking the development of, say, a new commercial aircraft without providing funds for contingencies. You will notice that I am careful not to refer to these assets as reserves. This is because it might have the connotation of a slush fund, and I suspect the Congress would be reluctant to appropriate funds for that purpose. What I am referring to is *not* a slush fund, but rather is simply a more realistic way of estimating costs that would include the statistical provision for unforeseen events. Some programs would then come in *under* the estimated costs and some *over* the estimated costs. *On the average*, the amount of money actually expended would equal, in the aggregate, the original estimate for those jobs.

Q. In 1975, you stated in a speech that product improvement should be relied upon as the basic and most effective means of maintaining a quantitatively adequate force structure. In view of the vast strides which have reportedly been made by the Soviets in R&D during the past four or five years, is product improvement really the proper approach in 1979 and for the 1980s?

A. I still believe strongly that product improvement is a very cost effective way of increasing military capability. One must, of course, have a reasonable product to improve upon if the end result is to be of value. Certainly, one is likely to product improve a cavalry horse into a tank only with great difficulty.

Eventually, one has to abandon cavalry horses and develop tanks. On the other hand, one can product improve an M60A1 into a M60A3 and get a major increase in capability for a rather modest increase in cost as compared to the cost of a new tank. However, occasionally, one does have to take quantum jumps to an all new system. The XM1 is an example, in my opinion, of one such necessary and important jump.

In my opinion, there has been an undue tendency in the past to neglect product improvement and instead to take quantum leaps into the development of new systems. It is noteworthy that if one does dedicate oneself to product improvements as part of a balanced development plan, it is not necessary to work so near to the edge of the state-of-the-art when developing the *new* systems. That is, those new systems can be evolved over time to meet any threat growth that may occur. If the average system is to remain in the field for 20 years, which is the case today, in the absence of the potential for future product improvement the developer justifiably feels the need to design to the very edge of the current state-of-the-art to assure that the system will not be obsolescent before the 20 years have elapsed. On the other hand, if one enters a new development with the idea that it will be product improved several times during its life, it is no longer necessary to design to the very edge of the state-of-the-art and hence, one can greatly reduce the risk and cost associated with new development programs. One might call this *adaptive development*.

Both new developments and product improvements are essential. As but one example of how cost effective product improvements can be, consider the TOW Cobra, or specifically, the airborne TOW itself. Here is a missile that had its range increased by fully 25 percent for the price of adding a little more wire to the command link. This clearly was highly cost effective as compared with developing a new system to obtain that additional 25 percent in range.

The two approaches ... new development and product improvement ... thus tend to complement each other.

Q. If the 2-way street of RSI between the U.S. and its NATO allies were operating as it theoretically was intended to, wouldn't it result in a loss of dollars for U.S. industry?

A. Yes.

But, one has to ask what was the purpose of the 2-way street in the first place. There is one perception that the 2-way street should not change the balance of payments between Europe and the U.S. There is another perception, one which I happen to hold, that it is the purpose of RSI to strengthen the military capability of the NATO alliance.

Sad as it may be, these two objectives aren't always in consonance. It may be that the price one pays to strengthen the military capability of our allies in NATO is for them to have a stronger industrial base of their own so that they are more willing and able to spend money on military equipment than they would be if that money were always to represent a negative balance of trade from their perspective.

Certainly, the street or, more accurately, the *highway*, has been fairly one way until recent years. Any real change to make it 2-way is, unfortunately from our perspective, going to result in a decrease of U.S. industry sales to Europe. The question is, do the benefits of increased NATO military capability outweigh the liabilities of having a somewhat weaker U.S. defense industry with somewhat smaller sales. That is a judgement that is obviously a difficult one and it has to be made in a broader context than just the strength of U.S. industry itself.

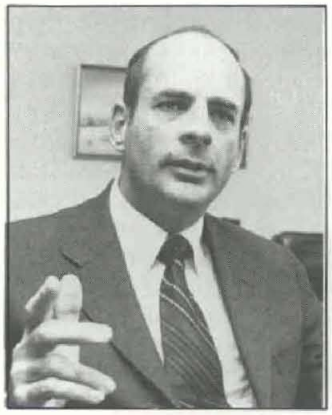
I would hasten to add, however, that the burden now placed on U.S. industry in its ability to compete in non-NATO markets with the ever-stronger industries of our allies needs to be carefully reconsidered to be certain it is accomplishing the objective originally sought. I suspect that the answer is that it is not.

Q. During your tenure with the Department of the Army, you played a rather large role in development of the TRACE concept. How do you view this concept now, and what impact will it have on industry?

A. Having watched the Army's progress in applying the TRACE concept for about five years now, I am encouraged by what has been accomplished. First of all let me say what TRACE is. TRACE is an approach to cost estimating that allows for the unforeseen problems that I was just mentioning which always seem to occur in R&D programs.

In the Apollo Program, it would have been very difficult to say in advance that Apollo XII would be struck by lightning and therefore that additional funds would be needed to handle the consequences of that event. However, it is not difficult at all to say that in every major development program technological lightning will strike somewhere ... that's just Murphy's Law!

The task at hand is to make provision, in terms of



"... If I am to be fully candid, I must say that I doubt that any company would survive if its Board of Directors got involved into operating matters to the extent that the Army's 'Board of Directors' does ..."

assets, so that capable managers who do run into unforeseen problems will have the latitude to manage their way out of those problems. This requires the provision of some financial assets. TRACE merely attempts to make those financial assets available.

I should hasten to add that the program manager must not hold those resources. They must be held at a higher level in the chain of command, being releaseable on short notice if, and only if, they are legitimately required.

There have been a number of cases before TRACE was instituted where major costs were incurred due to modest shortfalls in the availability of immediate funds. As I recall, there was in one multi-billion dollar program a $14 million shortfall in one year which ultimately resulted in a $75 million overall program cost increase, exclusive of inflation. This was a consequence of the prime contractor breaking contracts that had been established with a number of tiers of sub-contractors. The lack of this *relatively* small amount of money caused the entire contract structure to be revamped. Certainly, one should not start rewriting contracts if one can possibly avoid doing so.

The TRACE concept, I believe, could largely protect the Army's reputation from being damaged due to overruns. Unfortunately, TRACE by itself won't solve *industry's* problem. But from the Army's standpoint, even though some in industry may continue to submit optimistically low bids in cost reimbursable competitions, Army managers still have the ability to go to the Congress and the public and say that in their considered judgement the *Army* believes the actual cost is likely to be "such and such."

When this has been done in the past, in every case of which I am aware the Congress was willing to support the additional funds that were needed. Basically, the Congress was given a clear choice at the outset between being advised what a program is really going to cost or, alternately, being told on the installment plan. Given that choice, in my experience, the Congress always chooses to be given the bad news at the beginning and then, knowing that news, getting on with the job at hand as long as it is fundamentally reasonable in the first place.

Q. Since your departure from the Army's materiel acquisition community, you have probably had an opportunity to make some observations about it from an industry standpoint. Given the manpower, funding constraints, etc., is the materiel acquisition community properly structured into R&D and readiness commands to deal with R&D on the one hand and readiness on the other? It is realized that this is a highly controversial issue.

A. There are many reasons why I did, and why I do, feel this separation is preferable. One of those reasons is that the human skills required to be effective in the readiness arena are quite different from the talents required of an individual in managing a research program or even a development program. Both of these areas are of the utmost importance to the Army and they are quite closely related . . . but they *are* different.

Without a strong logistics capability the Army cannot fight effectively. Without modern equipment produced from R&D activities the Army cannot fight effectively. Both are essential. But it does seem that one should optimize the talents applied to the management of each individual area.

A second reason why I believe a separation is appropriate relates to the different time constants associated with the pressures affecting managers in the two areas. A manager of a research program faces some very critical problems. However, these problems usually will not impact the effectiveness of the Army in the field for perhaps 10 years. On the other hand, the manager of a logistics program may have pressures on him for spare parts which impact the effectiveness of the Army in the field *tomorrow*. That being the case, almost any manager will devote the major part of his attention to solving the short fuzed problems. The longer-term undertakings thereby suffer in terms of priority. It would seem to me it is therefore best to select a manager for each separate area to focus his total attention on the problems peculiar to that area. I realize that what I have described requires more personnel for management functions than does a single command which handles both endeavors. Those additional people come dearly to the Army today and at some point, in terms of the reductions in military and civilian manpower, one simply can't afford the luxury of having separate commands for these two functions. It may be that as personnel cuts have continued in recent years the Army is approaching that point at which, at least selectively, it is no longer able to afford separate commands. I am, of course, not in a position to judge that happenstance.

Q. Is it fallacious to structure the military on the same type of corporate arrangement as industry since industry has only to answer to its stockholders whereas the military is under daily scrutiny by the Congress?

A. If I am to be fully candid I must say that I doubt that any company would survive if its Board of Directors got involved into operating matters to the extent that the Army's "Board of Directors" does. The Congress, as with any Board of Directors, plays a very crucial role; but that role is not in day-to-day operations.

Just as a company may have a large number of stockholders, those stockholders can't become involved in carrying out individual tasks within a company. The company with which I am associated, for example, has issued about 25 million shares of stock. Those shares are owned by a large number of individuals and institutions. The manner in which those people and institutions make their desires felt is through a Board of Directors which sets policies and goals, picks managers to carry out those policies and goals, holds them accountable, and gives them the authority and resources needed to produce the desired results.

If the stockholders, through the Board of Directors, are not satisfied with the manner in which those policies and goals are executed, they replace the management with individuals that they believe will perform in a manner which *is* satisfactory. Now, I realize that Congress understandably and properly gets very frustrated with what has unfortunately been a rather poor record in terms of cost control on the part of military development programs. I suspect that the attitude in Congress is that until the defense industry and the DOD do a better job of managing their activities they are going to help do it for us. It is hard to criticize this feeling . . . but as a solution, it falls in the category discussed earlier . . . simple, elegant, and wrong.

The Congress, of course, has the basic responsibility for providing the Armed Forces of our nation. This is an awesome responsibility. But that role does not necessitate detailed management of individual activities.

Perhaps once we establish a better track record

". . . One of the tasks that lies ahead for the Army in the next decade is to build, in large quantities, the many truly excellent items of equipment that are just now coming out of the development process. . ."

we will have less day-to-day involvement by the Congress. Regardless, it does seem to me that a 535 member Board of Directors is a bit large to become involved in operating matters.

Corresponding remarks could probably be made about the role of the Office of the Secretary of Defense. I had the privilege of serving in OSD for five years and was in fact co-"inventor" of several management tools such as the DCP ... but firmly believe those tools should be aimed at the broader (and incidentally, generally more important) issues rather than at detailed operating functions.

Q. How important is R&D to the Army, and how important should it be?

A. R&D is crucial to the *United States* Army. The quality of the Army's equipment, plus the motivation and training of its troops, are the principal factors upon which we rely to overcome enormous quantitative disadvantages.

Unfortunately, there still exists to some degree a belief in many quarters, including parts of the Congress, the OSD and the Army itself that, unlike the other Services, the Army can more readily get along without a complete spectrum of modern weapon systems and that it can somehow win on courage alone. It is widely accepted that there should be F-14, F-15, F-16, F-18 and A-10 fixed-wing aircraft, but the notion that the Army should perhaps have *both* a UTTAS and an AAH somehow seems unacceptable. This is, of course, in spite of the fact that the dominance of personnel costs in U.S. military forces is such that the difference in total cost of ownership of an Army equipped with the most modern equipment as opposed to the equipment of 20 years ago is only on the order of ten percent.

A study was conducted several years ago to examine the actual payoff from the Army's development activities during the ten years from 1964 to 1973. We found that even under relatively conservative assumptions, the fighting capability of the Army had been increased, through R&D, by about three (net) division force equivalents during that period of time. This is obviously an enormous increase in capability; a capability far beyond the investment that went into R&D activities during those ten years.

At the same time, a dilemma exists today. Our forces and those of our allies are heavily outnumbered by the forces of the Soviet Union and the Warsaw Pact. It is very difficult for us to contemplate matching the Soviets tank for tank. In fact, even if we were given the additional 40,000 tanks we would need to match them in such a manner, it is inconceivable that we could afford to *man* those tanks in today's Volunteer Force environment.

The alternative seems to be to count on superior technology. Indeed, we have done this in recent years and we have done so successfully. How long this strategy will work is becoming much more doubtful as Soviet technology begins to catch up with us a direct consequence of the additional funds they are spending over and above what the U.S. is spending.

I believe as we look to the future we must be much more mindful of the importance of numbers of items of equipment. I do not mean to suggest that one can afford to have equipment that has significant technological inferiorities relative to that possessed by potential adversaries. Bows and arrows will not defeat hydrogen bombs. At the same time, the notion that a few high capability items of equipment can defeat large forces with basically comparable *types* of equipment is, in my judgement, very dangerous indeed.

History would seem to show that there is merit to Lanchester's view that numbers are highly leveraged on the battlefield. One of the tasks that lies ahead for the Army in the next decade is to build, in large quantities, the many truly excellent items of equipment that are just now coming out of the development process.

When Jim Schlesinger was Secretary of Defense, in discussing the problem of a numerically small force attempting to make up for its inferiority by means of superior R&D, he used to tell us a story which seems even more appropriate today. He pointed out that when Daniel Boone, who used to shoot 50 bears a year, was replaced by 50 hunters, each of whom was capable of shooting only one bear each year, there was no evidence of the bears having rejoiced at the demise of human marksmanship.

Q. How do you view the current trends in U.S./USSR military strength?

A. By almost any parameter one could choose to measure, we are being passed or have been passed by the Soviets. This is not a trend that has occurred in the last year, or even in the last five years, or even in the last decade. The Soviets, going back to 1962 or perhaps back as far as Sputnik, have been greatly increasing their emphasis on building military and technological strength.

Of course, one can't, in general, compare Soviet military strength and U.S. strength in isolation from that of our allies, or even in isolation from our economic strength and our will to endure. The fact remains, however, that there is a great deal of reason to be very concerned today about the trends in the U.S. defense posture as compared to those of the Soviets and their allies. For the first time, there is also reason to be concerned over the relative technological strengths of the two nations as measured not by technology in the laboratory *but by equipment in the field.*

Somehow, the public has been reluctant to accept the severity of this trend and its implications. This is partly because most of the people who describe it tend, like myself, to at least appear to have something to gain by increased U.S. military expenditures.

I have felt for some years, and continue to feel, that it would be very worthwhile for the Secretary of Defense or the President to establish *from outside the defense community*, a "Blue Ribbon" commission of individuals possessing absolutely impeccable reputations for impartiality, objectivity and integrity. Such a commission would be assigned the task of reviewing all of the available evidence at all levels to assess the adequacy of U.S. military forces against the backdrop of stated national goals. The group, which must be genuinely uncommitted could then offer to the President and the citizens of our country their views, as informed but independent observers, regarding the acceptability of our current and projected military stature.

This undertaking is far more important than politics, defense budgets, or the health of the defense industry. It addresses a matter upon which all else that is important to our nation might depend.

If indeed such a Blue Ribbon Panel were to view the problem as being as serious as I do, perhaps they would be more credible in increasing the concern of private citizens and the Congress to pay the price to reverse the trend I perceive. If, on the other hand, based on a considered judgement of the facts, they were to conclude that my view is unduly concerned about the problem, then I would be most encouraged and could sleep much better each night.

Q. In reviewing your professional career, both in and out of government, what would you do differently if you could do it over again?

A. I guess the main disappointment during my tour with the Army was that we devoted a great deal of rather precious time to matters that could perhaps have been avoided altogether or which did not make a *major* contribution toward giving us a better Army. One such item was base closings. Another concerned some of the details of seeking international R&D cooperation. Still another was the matter of dealing with the honor code violations at West Point.

This is a rather mixed bag of topics . . . each important in its own right. However, a Presidential appointee will probably only have the privilege of three or four years in which to make a contribution. As a result, one can't afford to spend much time on items that don't have a high payoff in comparison to the time they consume or to addressing problems that should have been avoided in the first place.

All of the above items certainly consumed a great deal of time, all were important, but all detracted from our ability to address other pressing problems offering potentially large payoffs. Consider the matter of base closings. During my tour we set out to close a number of bases that we felt were no longer cost effective to operate. I firmly believe that in most, if not all, of those cases we were, in fact, correct . . . and that it was our duty as a custodian of the taxpayer's money to close such installations.

Regardless of this, the difficulties encountered in closing a base under today's environment are enormous. So much time is consumed that one might perhaps conclude that more could be contributed to the Army and the taxpayer by admitting some of these modest inefficiencies and devoting one's time to items with more readily available payoff. This is a terribly unfortunate admission to make. One could certainly argue that if there is a known problem it is one's duty to correct it.

On the other hand, the list of opportunities that one has available to help make a better Army is *in truth* so great that one simply can't afford to spend very much time on items toward the lower part of the list no matter how legitimate they may be. I guess I am becoming a pragmatist!

Another thing I would do would be to encourage the Army, in its development programs, to "tough out" problems. As I mentioned before, even the best managed R&D programs will have problems. Unless those problems are such that they bring into doubt the fundamental viability of the endeavor, one has simply to continue ahead, work out solutions, and get the item into the field.

Then there is the matter of a few R&D programs which I would like to have had us handle differently. One that comes to mind is the Heavy Lift Helicopter. That was a technology *prototype* flight-test program which was approximately 90 to 95 percent completed in about 1975. At that point for some reason the Army, with my participation, arrived at a conclusion that it did not intend to deploy that HLH even though the need for such a decision on affordability was still several years into the future.

Once the Army stated that it didn't intend to *deploy* the HLH, the Congress terminated the technology prototype program. As I said, this occurred with only about five to ten percent of the overall effort remaining to be completed. It would have been much better, in my judgement, had we obtained the important engineering data being sought and *then* decided whether or not the system should be deployed. One day we will, I suspect, see a heavy lift helicopter flying in the U.S. We have, unfortunately, already seen one flying in the Soviet Union.

In the way of a conclusion, I would hope that in our future R&D activities we could provide for intense scrutiny before starting new programs, including consideration of product improvements as alternatives, but once having decided to proceed that we would then *fully-fund* those programs, providing multi-year funding, and then eliminate the on-again/off-again turbulence that is undermining the efforts of the very dedicated and capable people, both within the government and outside, who are seeking to produce new hardware for our Army.

Czech OT-65, 4x4, scout vehicle, produced in Hungary (1963).

FOREIGN ARMORED REC

This photospread, the eighth in a series submitted by the U.S. Army Foreign Science and Technology Center, was prepared by Messrs. Edwin W. Besch and William A. Gooch Jr. Photos illustrate the diversified armament, automotive technologies and design philosophies incorporated into foreign armored reconnaissance vehicles based on differing perceptions of tactical and terrain requirements. (The year the vehicles entered service is shown in parenthesis). Previous issues include: Novem-

Brazilian EE-9, Cascaval 90mm gun, 6x6, armored recon vehicle, used in Latin American and the Mid-East (1975).

Canadian Cougar, Fire Support Vehicle mates Scorpion turret with Swiss MOWAG Piranha, 6x6, APC chassis.

French AMX–10RC, 6x6, equipped with 105mm gun and advanced fire control, designed for corps-level reconnaissance and as a heavy-fire support vehicle by mechanized infantry divisions (1979).

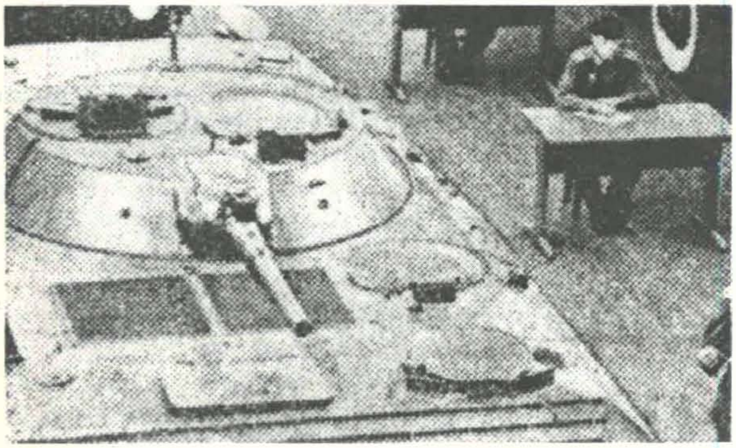
FIAT-OTO Melara 6616BM, 4x4, used by Italian Army and National Police (1978).

British Scorpion, 76mm gun, combat vehicle reconnaissance (1972).

British Scimitar, CVR(T), mounting 30mm Rardan gun (1973).

NNAISSANCE VEHICLES

ber-December, 1979—Foreign Armored Support Vehicles; September-October—Foreign Tank Destroyers; July-August—Foreign Combat Engineer Technology; May-June—Russian Infantryman's Arsenal of Weapons; March-April—Foreign Infantry Fighting Vehicles; September-October, 1978—Advances in Foreign Transportation Technology; March-April, 1978—Photos of 1977 Red Square Parade.



Soviet BMP IFV recon variant has 2-man turret, but no antitank missile armament (1976).

Royal Netherlands Army M113A1 Command and Reconnaissance Carrier rearmed with Oerlikon KBA-B, 25mm automatic cannon (1966/1978).

Soviet BRDM-2, 4x4, scout vehicle (1966).

West German Luchs, 8x8, divisional recon scout vehicle ha front and rear driving positions (1975).

French Panhard ERC-90, Sagaie, 6x6, excellent export potenti (prototype, 1977).

British Fox CVR, 30mm Rarden gun (1973).

West German A.P.E. combat engineer and tank and armor infantry battalion-level scout vehicle (1979).

Armament Concepts Office Stresses 'New Ideas'

The unique Armament Concepts Office at HQ ARRADCOM has the unusual mission of evaluating and marketing new weapon concepts. Established three years ago at Dover, NJ, its office staff is small, totaling only 15. Most of them are military officers with combat qualifications in field artillery, armor or infantry, and civilians experienced in the fields of science or engineering. They are complemented by a "skunk works" operation which further evaluates concepts and tests their feasibility.

The small size of the Concepts Office is deliberate—for several reasons: to serve as an impartial "broker" of revolutionary ideas, to preclude having the inclination or the capability to infringe upon the responsibilities of mission laboratories, and to provide a stronger communications link between the field soldier and the bench scientist or engineer through more central concentration and better control.

Recognizing that new ideas and their application evolve from necessity as well as chance, all roads of communication are kept open. Publication of information and visits to other military agencies, industry and universities by staff members are intended to make these agencies aware of the office's readiness to help further incipient ideas.

The assistance of industry has reportedly been of particular value, especially through the intelligence it provides by way of its independent research and development programs and unsolicited proposals.

Still other sources are tapped for the potential melding of ideas and needs. Frequent contact is maintained with the Foreign Intelligence and Defense Documentation communities, domestic and foreign literature are screened, and active membership is maintained on invention councils, engineering process and technology panels, and similar professional bodies.

When an idea is believed to have merit, the extent of user interest is explored. For those ideas that stimulate such interest, the availability of funds determines the future course of action. Other organizations which might have a mission interest in the concept are solicited for funding support to prove feasibility.

Taken collectively then, it can be seen that ARRADCOM's Armament Concepts Office is wired into a vast community of ideas. With diligent screening and pursuit of those ideas offering really innovative technology, new weapon ideas are brought to fruition.

An artist's conception of an electromagnetic gun (Figures 1 & 2) has many possibilities for long-range exploitation. Weaponization of such a concept would enable the launching of various payloads, from very high velocity penetrators or multipurpose projectiles of unusual shapes, to

BATTLEFIELD SUPPLY VEHICLE

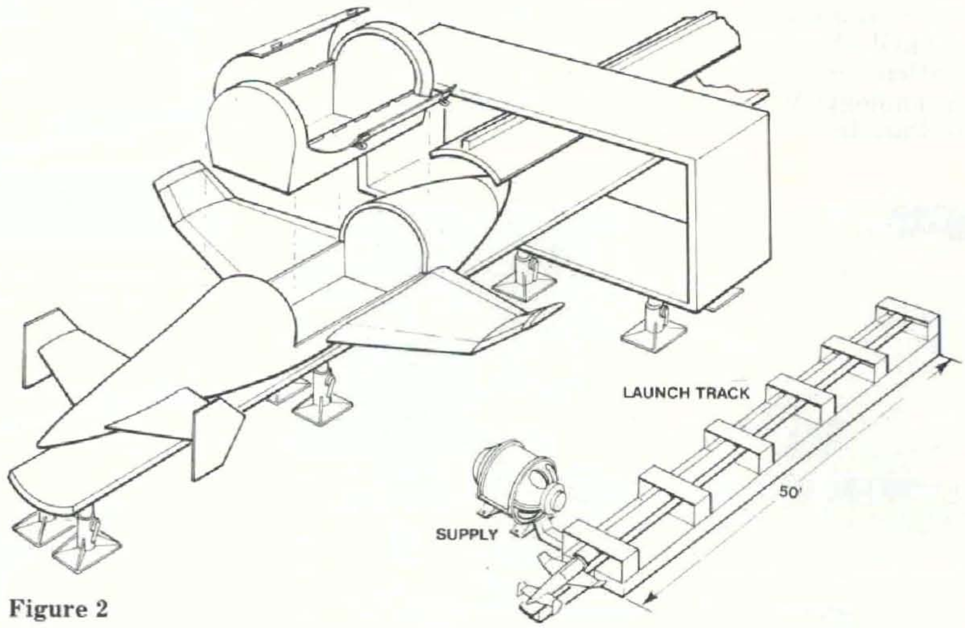


Figure 2

ARMOR DEFEATING

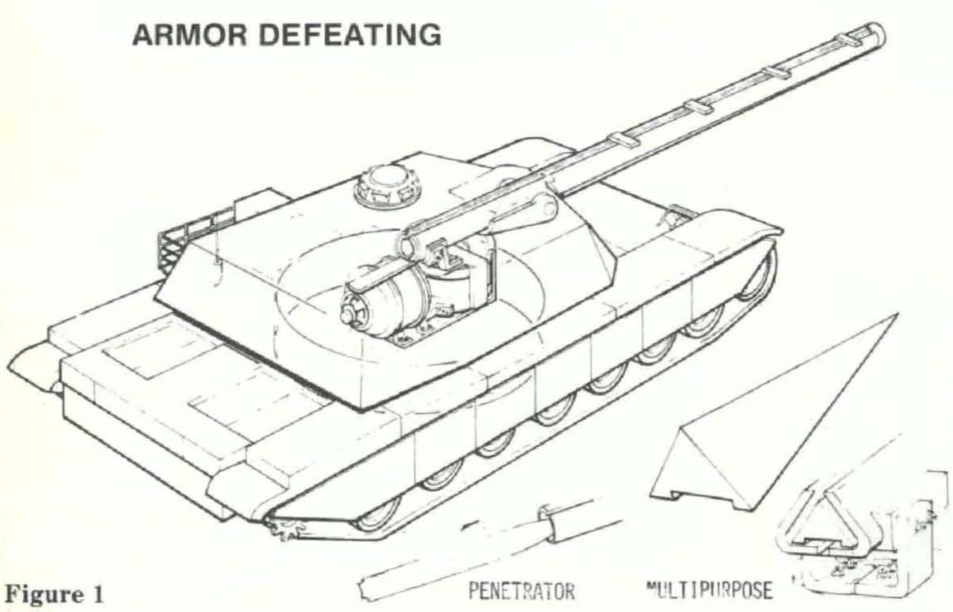


Figure 1

lower velocity launchings for providing inaccessible areas with fuel or supplies or for other lifesaving missions.

Far out, perhaps, is an artist's conception of a robotized army (Figure 3). But considering that man is a scarce and precious resource, the prospect of an automated fighting force that could search, detect, discriminate friend from foe, engage enemy targets, and perform suicide missions, all without human casualties intriguing one.

The technological state of sensors, microprocessors, automation and increased firepower also offers viable project starts that were unthinkable just a few short years ago. The willingness and desire to review such revolutionary concepts as these by the Armament Concepts Office may well result in providing the soldier of the future with superior armaments to win any battle.

Ideas are welcomed from all sources; and should the idea be outside the mission interest of ARRADCOM it is referred to the appropriate government agency. Ideas should be submitted to HQ, ARRADCOM, ATTN: DRDAR-AC, Dover, NJ 07801. The office phone number is commercial (201) 328-6606 or Autovon 880-6606.

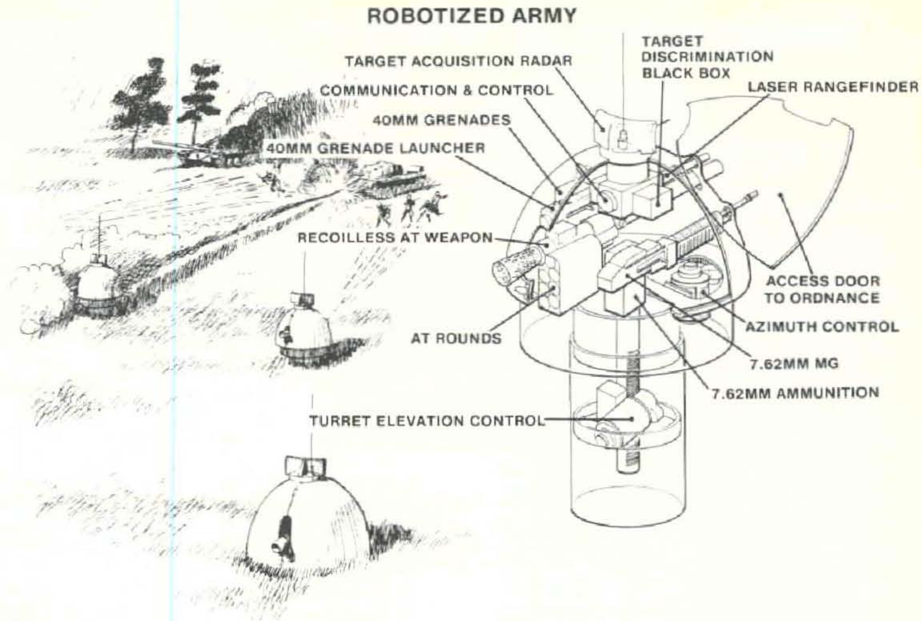


Figure 3

WES Continues Work in Sensor Technology Research

Recent advances in electronics and sensors for detecting potentially hostile actions have created a relatively new field of military research using "electronic intelligence." The field is referred to as sensor technology.

Devices for detecting unwarranted intrusions and for providing military intelligence are being investigated at the U.S. Army Engineer Waterways Experiment Station (WES) in Vicksburg, MS.

WES has been involved in sensor research since 1969. Early systems used in Vietnam relied primarily on seismic waves (ground motion) to detect intruders. Although the systems worked well in some areas, they were not universally applicable. This was because of inadequate sensitivity of the systems in some terrains and because of natural and man-made background noises that caused false alarms.

To address these problems, WES researchers have conducted field programs and developed mathematical techniques for defining environments where various sensor systems could be expected to operate adequately.

Sensor concepts and hardware systems presently under investigation include sensors to protect the perimeter of nuclear storage sites and missile deployment areas against surface and subsurface (tunneling) intrusions by exploiting ground motion induced by the presence of the intruder.

Hardware systems have been tested in media ranging from extremely soft (saturated silts and clays) to rigid (concrete and frozen ground). Responses of the transducers in these systems have also been measured in a wide range of temperature environments.

In addition to investigating the use of ground motion sensor systems, WES researchers have conducted studies of acoustic sensors for detecting and tracking low-flying aircraft.

Conventional systems for aircraft detection rely on radar and are limited to their ability to detect aircraft beneath the horizon or obscured by the natural terrain. Studies are being initiated to determine the effectiveness of electromagnetic wave sensors for intruder detection.

Sensor technology is developing on many levels in several countries. To speed up the technology transfer and eliminate duplication of efforts, WES hosted an international sensor technology symposium last year to promote an exchange of information on sensor concepts and systems that automatically detect, classify, identify and/or locate intruders or targets.

More than 160 delegates from military, industrial, and academic research communities of the United States, Denmark, Germany, United Kingdom, Canada, and The Netherlands attended the 3-day symposium, which was coordinated by CPT Otis Williams, a member of the WES sensor research team.

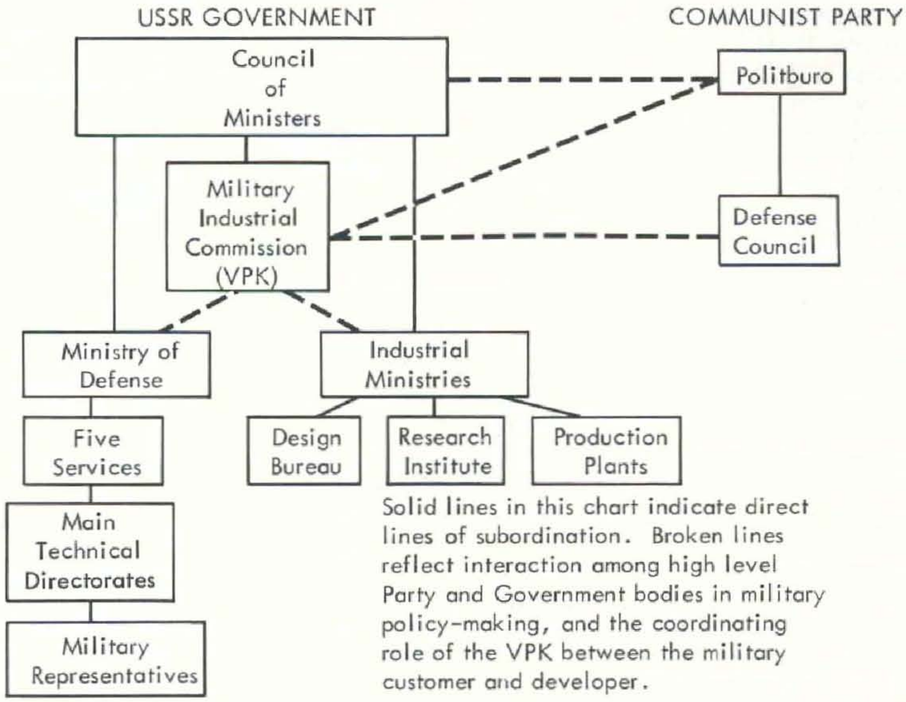
NATO Panel III Research Study Group-11 (RSG-1), a NATO group devoted to military application of seismic and acoustic sensors, met at WES in conjunction with the symposium. Mr. Bob O. Benn, chief of the WES Environmental Systems Division, is chairman of RSG-11.

The opening session of the symposium featured a keynote address by Dr. Jeanne Mintz, from the Office of the Under Secretary of Defense for Research and Engineering, Office of the Assistant for Program Planning. She spoke on "Sensor Development and Application: A Department of Defense Prospective." A summary of her speech appears on page 22 of this issue of the Army RDA Magazine.

Generation of Weapon Requirements in the Soviet Ground Forces

By P. Aileen O'Brien

Much has been written and spoken of the high quality of Soviet military materiel—its simplicity on one hand yet its mission accomplishing capability on the other, its alleged high reliability and its ruggedness of design—its lack of "gold plating." The magazine thought it would be most informative to its reader community if an article could be procured describing the Soviet requirements generation process that has led to the fielding of its excellent materiel. We asked the U.S. Army Foreign Science and Technology Center at Charlottesville, VA, to provide us with such an article. The following by Miss P. Aileen O'Brien describes the basic mechanics of their process in order that we may better understand the criteria of the Soviet Ground Forces as a customer of weapons.



Solid lines in this chart indicate direct lines of subordination. Broken lines reflect interaction among high level Party and Government bodies in military policy-making, and the coordinating role of the VPK between the military customer and developer.

The imposing abundance of arms equipping the Soviet Ground Forces reflects the degree to which leadership in this field is able to articulate and satisfy its demands. Of all branches of the Soviet military, the Ground Forces seems to have the clearest idea of its mission and the freest hand in preparing itself for this mission's accomplishment.

The Ground Forces' effectiveness as a weapons' customer is a product of this clarity of purpose, but it is also tied to its use of certain mechanisms for translating goals into specific weapons requirements, and for maintaining shrewd and determined oversight throughout the entire weapons acquisition cycle.

The mission of the Ground Force derives from the Soviets' concept of combined arms, that is, the total integration of all types of weapons in order to perform a coordinated mission. The task of the Ground Forces within this comprehensive picture is to provide a rapid, overwhelming offensive thrust by land.

In order to fortify itself in anticipation of this task, the leadership of the Ground Forces has focused on building an enormous array of tanks, while recognizing the need for a wide range of accompanying capabilities, including mobile artillery, air cover, and CBR protection, bridging and engineering vehicles, etc.

While there may be differences of opinion within Ground Forces as to the exact operational use of certain pieces of equipment, notably the BMP Mechanized Infantry Combat Vehicle, there is still a remarkable degree of unity in the doctrinal thrust of this force's leadership. This cohesiveness has served them well in presenting their needs to political leadership, and in placing demands upon weapons' producers. Thus, the nature of weapons which equip the Ground Forces is a logical and consistent response to the guidelines of its doctrine.

The link between doctrine and production of equipment is the Tactical Technical Requirement (TTR). The Soviet acronym is TTT (Tatiko-Tekhnicheskye-Trebovaniya). This document, authorized by personnel from the Ground Forces and Ministry of Defense hierarchy, sets in motion the entire weapons acquisition process. It is the reference point used by the military to ensure that the products of industry meet its operational needs.

The generation of weapon requirements can be visualized as a 2-part cycle, beginning at the highest level of power, descending into the rank and file of military personnel and passing back up through the chains of command. This cycle begins with the laying out of broad political and military policy. This is an ongoing process which takes place at the very highest echelon of authority, including the Politburo, Defense Council and of course officers from the Ministry of Defense.

The Ministry is well-represented by its experienced and aggressive Minister, Dmitri Ustinov, along with Deputy Ministers of Defense. Prior to this appointment as Minister of Defense in 1976, Ustinov was the dominant civilian figure in Soviet weapons acquisition dating back to WW II.

It is likely that the Deputy Minister most concerned with broad policies as they relate to weaponry would be N. N. Alekseyev, Deputy Minister of Defense for Armaments.

In addition, military officers of the General Staff, who rank just below deputy minister level, participate in the formulation of overall military goals and assignment of basic operational missions to each service branch.

It is doubtful that specific methods of accomplishing this mission are discussed at this level in the case of the Ground Forces. This is partly because of the relative stability of Ground Force mission and also because few Ground Force weapons, taken individually, have direct impact on the strategic concerns of political leaders. Therefore, the service is given wide latitude in developing the means of executing its mission.

In order to accomplish this, broad policy guidelines are filtered down to institutions at the next lower level within the Ground Forces, the Main Technical Directorate (MTD). In the Ground Forces, historically there have been two Main Technical Directorates, one pertaining to artillery and rocket forces, the other pertaining to armored forces. These Main Technical Directorates have been pinpointed as the actual sources of the TTRs.

The TTR itself, apparently, is a short document requesting that a type of weapon be constructed to meet certain identified operational needs. It spells out the general performance goals of the weapon and specific quality indices up to which it must measure. Very little technical direction is given to the defense industry in this document as to what the finished product should be like or how it should be built.

Yet, the division of responsibility between customer and producer is not quite so neat, for a customer as effective as the Soviet Ground Forces would not carelessly ask for an item without consideration of what industry can in fact produce. The TTR, thus, does not generally call for performance beyond the state of the art of the relevant technologies, reflecting the pragmatic attitude that the developed weapon must be capable of being manufactured and fielded rapidly in large numbers within the known capabilities of Soviet industry.

The workings of the MTD's seem to reflect this dual customer orientation toward identifying operational needs and toward educating itself in the intricacies of weapon technology. The MTD's are responsible for overseeing the training of Ground Forces personnel in military academies. They also coordinate the efforts of their own research institutes, which seem to be the focal point for identifying specific areas of potential improvements in the Ground Force posture.

At this conceptual stage in the weapons acquisition cycle, personnel from military research institutes interact informally with professional design engineers from the defense industrial ministries in making judgments as to the feasibility of various design alternatives. Finally, the MTD's have adjunct Scientific and Technical Committees which appear to play an overseeing role in the creation of the TTR. This stage of requirements generation is perhaps the most difficult to understand.

Nevertheless, it is clear that the rank and file military personnel who write the TTR's are constantly mindful of imposed doctrinal requirements, the changing technological capability of industry, evidence of any deficiencies in operational equipment and, of course, changes in the threat faced by the Ground Forces. In these functions (and subsequent functions) the key MTD participants are the Military Representatives, technically trained officers who spend their entire career in some aspect of weapons acquisition.

With the approval of the TTR at the MTD level, the TTR travels up through the Ground Forces chain of command to the top of the Ministry of Defense hierarchy. Approval at this level is necessary before any formal overtures to industrial ministries are made.

The TTR then reaches the industrial side of the Soviet defense sector. It is assigned to a selected design bureau within a particular industrial ministry, where conceptual plans are formulated.

Next, an appointed project Chief Designer consults with high level customer representatives and personnel from the Military-Industrial Commission (VPK), the government organization officially responsible for smoothing out relations between the military customer and developer. This group attempts to reach initial agreement as to the rough design of the weapon to be built, the organizations responsible for its development, and cost and production estimates. This accomplished, the TTR becomes an official decision of the VPK.

The decision is turned over to the selected defense industrial ministry, which carries the project from design through mass production. At every stage, however, a representative from the military customer is physically present to ensure that the project strictly adheres to the guidelines laid out in the TTR.

The Soviet Ground Forces is adept as a weapons customer because its direction is clear, well-articulated and relatively stable with respect to time and enemy threat. Its effectiveness can also be traced to its behavior throughout the weapons acquisition process. Through the TTR, its needs are formally laid out, thus facilitating communication with government and industrial personnel. These requirements are carefully drawn up by a trained staff and rarely are changes in them interjected during weapons development. While the customer considers feasibility early in the creation of the TTR, it does not constrain the industrial designer with excessively detailed or unrealistic technical demands.

Finally, the military customer follows up on its requests by monitoring the entire development and production of weapons assisted by the mediating efforts of the Military Industrial Commission. These practices, along with other aspects of their overall acquisition process, have allowed the Soviet Ground Forces to field weapons that meet the numerical goals and wide range of operational requirements laid out in their offensive doctrine.

P. AILEEN O'BRIEN is serving as a research specialist in Soviet ground forces weapon acquisition procedures at the Foreign Science and Technology Center in Charlottesville, VA. She received a BA in political science from the University of Virginia.

Sensor Development and Application

By Dr. Jeanne S. Mintz

The following article was originally presented as a keynote address at a Sensor Technology Symposium. It is carried here in an abbreviated format

Unattended ground sensors, developed for Vietnam, have a clear potential for use in a fast-paced European scenario. There, a single foggy day, a day in which we could not detect where the main enemy force was coming from, could permit a critical enemy breakthrough. Unattended ground sensors provide the battlefield commander with the only round-the-clock, passive sensor system that DOD has developed.

After a glamorous debut as one of the most exciting new technologies of the Vietnam War, these sensors are no longer high priority items in DOD budgets. Some of the reasons for this situation are what I would like to address before turning to current trends and possible developments.

Remote sensors proved their worth in Vietnam. They played a key part at Khe Sanh. They had a significant role in blunting the 1972 offensive. In many less well known operations, day after day, they paid their way.

Those with some experience and a modicum of training in the use of sensors found that they worked very well. And they worked when the weather prevented other surveillance systems from functioning.

Those who were disappointed with sensors, I think, were those who didn't employ them properly. Those were the units where emplacement was haphazard, no meaningful data collection was recorded, and the personnel at the readouts were not given adequate insight into the significance of the beeps and blips they were observing.

By contrast, there were many units, including a number in the Army's 25th Division and in Naval units ashore and on the rivers, that employed remote sensors successfully. They sharpened and improved their tactics to coordinate sensors with other surveillance means. They relied increasingly on sensors for triggering ambushes, tracking enemy movement at a distance, perimeter security and other uses.

There was also disenchantment among those who expected tactical sensors to do everything, and reacted negatively when they didn't. Sensors are not a panacea. They can make a significant contribution to battlefield surveillance and targeting. However, they, no more than any other system, are not going to find all the targets on the battlefield and win the war singlehanded.

In the early days, unattended ground sensors also suffered on occasion from a problem that frequently afflicts new systems: the desire of some to squeeze the last bit of technological improvement out of the system.

In their enthusiasm, some designers ignored the critical importance of operability. True, at the beginning, tactics may have lagged technology in the use of sensors in Southeast Asia. But good tactics evolved rapidly, and as more and better use was made of the systems deployed, it became clear that it was unnecessary to embellish the system to a degree of sophistication which outstripped battlefield requirements.

Finally, there were bureaucratic reasons for the lukewarm reception accorded remote sensors in some quarters. When the Defense Communications Planning Group (later Defense Special Projects Group) was established in September 1966, not only was it given Brickbat priority and DX rating, carte blanche authority and direct access to the Secretary of Defense, but the funds to support the program were taken from the Services' budgets.

The program was expensive and, to many in the Services, it appeared that they were being forced to fund it. Understandably, this made some of those whose budgets were being raided to finance a program they did not control, uneasy.

With the winding down of the war, DSPG was closed in 1972 and responsibility for further development of sensor systems was split among the Services, with provision for OSD to coordinate developments, requirements and employment.

The Army was given responsibility for developing a tactical system based on equipment inherited from DSPG, a system for the internal aspects of site security, and for the command and control systems for all site security systems.

The Air Force was charged with developing systems for external site security. The Navy and Marine Corps continued development of selected systems also bequeathed them by DSPG. The reason for splitting up responsibility was the decision to return from a wartime footing to business as usual.

These are some of the reasons why today unattended sensors are not always seen as a priority need by the Services, especially when they can hardly afford new weapon systems. Contributing to this is a lack of understanding of the *potential* of sensors.

For those unfamiliar with the system, there is concern about the number of personnel required to deploy and react to the sensors. In fact, as presently conceived in the Army, the number of people dedicated to REMBASS would be very small.

The current state-of-the-art precludes the need for dedicated aircraft for relay. Miniaturization permits loading the required equipment into pods so lightweight that they can be hung on aircraft dedicated to other missions with virtually no effect on the primary mission.

In a world of stringent financial constraints, unattended ground sensors have to compete with a number of other surveillance systems. Some of us may regard sensors as the best way to go for many applications because they don't sleep and they don't bleed—two of the features that made them so popular with their proponents in Vietnam.

But to hold their own in competition with alternative means of surveillance they must pay their own way. By the very nature of their use in tactical situations, unattended ground sensors have to be throw-aways.

This makes dollar cost of overriding importance. The manpower cost of getting the sensors where they are needed is also important. Increasingly, sensors must be designed to mesh with other systems, leading to an integrated surveillance capability.

Ideally, unattended ground sensors will be complementary with other surveillance systems in the true meaning of the word "complementary"—they will enhance the effectiveness of the other systems by cueing them, filling gaps, etc., and their value will in turn be enhanced.

To arrive at that ideal situation, we need several things. We need to test unattended ground sensors against other systems to determine which system performs better for a given task. We need to test them in conjunction with other systems, to get the most out of both.

We need to exploit the potential synergistic effect of sensors used in conjunction with the other new battlefield surveillance systems in development. We need to enhance the capability of sensors to work under a variety of weather and terrain constraints.

The REMBASS program has identified several areas that would benefit from research to enhance the capabilities of future systems. Once such area is finding a means of bridging the gaps to that seismic sensors will operate fairly uniformly in different types of soil. As is well known from the research done thus far, the seismic clutter in an area and the seismic signature of a target vary greatly with the mechanical properties of the soil.

If we could provide the user with a simple sensor which compensates for these differences, we would have gone a long way toward increasing the capabilities of currently fielded hardware.

I am not suggesting one all-purpose seismic sensor which will work in media ranging from bedrock to loose sand but a sensor which can tolerate a much wider variation in soil properties than the present sensors.

On the tactical side, our U.S. sensor program should be more closely identified with operational tactical needs in Europe as was done for a time under the auspices of Project Avid Guardian.

The information developed through Avid Guardian should be provided to the appropriate NATO armaments working groups. This would be particularly timely as NATO's Periodic Armaments Planning System gets under way. Under this system, the emphasis will be on reaching agreement on early establishment of requirements.

The Avid Guardian data is a careful compilation of actual surveillance requirements developed by the military representatives of four countries working together over a period of several years.

We should examine the possibilities for further cooperation among the NATO allies, similar to the Avid Guardian effort. We should consider jointly the potential of unattended ground sensors to do low false alarm sensing of enemy forces.

We should seek and use the opportunity to demonstrate and evaluate the capabilities of sensors in tests side by side with other surveillance techniques in all weather in an operational environment. That last phrase, in an operational environment, is the key one.

I think that much of the scepticism about how sensors perform and much of the pressure for over-elaborate design of new system components would disappear if we could exercise present and projected systems under real-world conditions.

Clearly, one set of applications for tactical sensors that suggests itself is the use of sensors in conjunction with scatterable mines and other artillery-delivered munitions. We need to take another look at the potential of remotely-controlled low light level TV cameras used with seismic and acoustic sensors.

Remote imaging is not a new area for unattended sensors. However, it is one that deserves closer scrutiny in light of technical advances in such fields as pyroelectric vidicons and small, low-power data storage devices.

The role of unattended ground sensor systems should be a recognized and accepted surveillance technique today. In the closing days of the Southeast Asia war, unattended ground sensors were somewhat in the position of radar at the end of World War II or electronic warfare in the mid 50s.

Those who had used the new systems and saw the results were highly enthusiastic. Those unfamiliar with them were sceptical of their achievements. But development and fielding of new radar and EW equipment proceeded apace for a variety of reasons and gradually radar and EW were adopted throughout the Services.

Unattended ground sensors do not yet enjoy the same degree of acceptance or development. However, it is clear that remote sensors have a significant role to play, along with other systems.

With support from the proper quarters and with more meaningful dialogues between the engineers and the people who ultimately must use the products, I have no doubt that these sensor systems can go on to develop their full promise.

DR. JEANNE S. MINTZ is special assistant for Plans and Requirements in the Office of the Under Secretary of Defense for Research and Engineering (International Programs and Technology). Prior to joining OSD, Dr. Mintz spent 10 years in defense research with several organizations, including the Defense Special Projects Group and the Center for Naval Analyses in Washington, DC. Her work in examining the potential of unattended ground sensors for use in tactical operations in Europe led to the establishment of a U.S., U.K., GE program in Europe to pursue that goal.

She holds a PhD from Harvard University where she was the first woman Littauer Fellow.

18th Annual Meeting. . .

AORS Participants Review Priority Problems

Priority problem areas facing the Army and proposed solutions for dealing with them were reviewed by more than 300 military and civilian representatives at the 18th Annual U.S. Army Operations Research Symposium, 14–16 November, at Fort Lee, VA.

Sponsored by the U.S. Army Training and Doctrine Command, the meeting was cohosted for the sixth consecutive year by the U.S. Army Logistics Center, commanded by MG Oren E. DeHaven; the U.S. Army Quartermaster Center and Fort Lee, commanded by MG Fred C. Sheffey; and the U.S. Army Logistics Management Center, commanded by COL James E. Harris.

Symposium arrangements were handled by the TRADOC Systems Analysis Activity (TRASANA), located at White Sands (NM) Missile Range. This year's theme, "Priority Problem Areas," was based on DA's Fiscal Year 1980–81 study planning guidance which identified 13 problem areas the Army will encounter during the next two years.

The Army Operations Research Symposium is designed to provide a stimulating forum for the Army's ORSA community relative to the needs of both the user and the analyst. This year's meeting included general session presentations, working group discussions, a banquet address, and a brief questions and answers review period.

Symposium chairman Mr. Leon F. Goode Jr., who is TRASANA deputy director for Technical Operations, called the meeting to order. He noted that the 18th AORS was structured so as to be more responsive to the announced theme. This, he said, has not always been the case in past years.

He added that the Army does have problems and that the AORS would hopefully bring these problems together so they could be properly viewed. Goode provided a brief review of the Army's posture in the 1940s and its posture today. He stressed that although the Army was not prepared in 1940, it did have the element of time on its side.

We do not really know, he continued, whether we have time on our side again today. The acquisition process is different than it was in the 1940s. At that time, we were able to mobilize quickly, but no one knows for sure if we could do it again. He noted that in the 1940s we were able to develop one particular aircraft, from requirement to production, in only four months.

Mr. Ellwood C. Hurford, scientific advisor to the commander of the Army Logistics Center, welcomed the AORS attendees. He summarized the various activities at Fort Lee and said that it was a pleasure to host the conference.

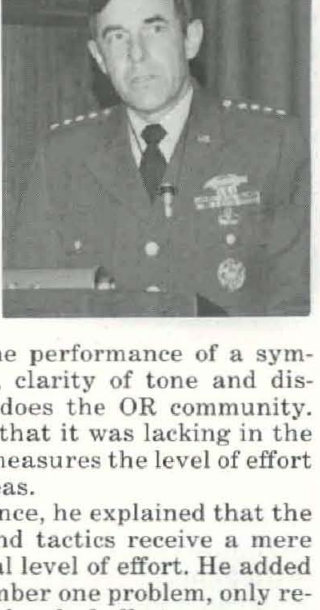
U.S. Army Chief of Staff GEN Edward C. Meyer opened the formal presentations with his keynote address on the institution of Army operations research. He provided an evaluation of where it stands today, and what it must do to be valued by the Army as a whole.

He began by stating that there are too many filters on Army analysis today. These filters, he noted, are "too sensitive," "too political," "too parochial," and "too tough." They are actually used as built-in protection to help us avoid many difficult issues, he added.

GEN Meyer used music as a metaphor to illustrate what he considered to be the operations research communities' greatest needs today. Any good orchestral performance needs musicians and an audience. In the case of operations research, he said, the Army is the audience and operations research practitioners are the musicians.

He praised the Army's OR practitioners by stating that they were talented, sometimes tempermental, but professionally dedicated to their work. "However," he said, "I am very concerned about continued criticism of Army analysis by those outside the Army."

The General added that the quality of Army analysis can be substantiated. Those who criticize it, he said, are either jealous or just don't understand it. Said he: "Whenever I defend a program, regardless of what it is, I need reasonably solid analytical basis for my arguments. That is one reason I support Army operations research."



U.S. Army
Chief of Staff
GEN Edward C. Meyer

Meyer noted that just as the performance of a symphony score requires balance, clarity of tone and disciplined orchestration, so too does the OR community. Relative to balance, he stated that it was lacking in the Army's Study Program, if one measures the level of effort across the priority problem areas.

As an example of this imbalance, he explained that the important areas of doctrine and tactics receive a mere three to five percent of the total level of effort. He added that personnel, the Army's number one problem, only receives four percent of the total level of effort.

"Here we are," he said, "the most manpower-intensive of the three Services, and it appears that the level of effort outside the Army (Air Force, Navy, OSD) surpasses what we do internally by a wide margin." At the same time, he added, we devote over half of our study effort to things.

Another effort which he said he is concerned about is threat analysis. Some important steps have been taken in this area, but much more remains to be done. The General stressed that too often a lack of good information on the threat limits the use of other study efforts which use that data as a point of departure.

Meyer also noted that there is an unhealthy duplication in the modeling capabilities which blurs the essential focus of each section. For example, the Concepts Analysis Agency, which should deal with issues pertinent to echelons above the Corps, uses models which reach down to the single item level.

The Chief of Staff explained that there should be an appropriate level of overlap to allow for correlation and data transfer. However, every agency cannot have a top-to-bottom, stand alone capability. It's undesirable and too expensive. He called for an integrated hierarchy of models and studies.

Meyer maintained that there will be no studies czar imposed on the operations research community—"I am the studies czar," he quipped. He added that it is the task of the Study Program Management Office to crystallize problems, and act as a catalyst to unify efforts.

The General emphasized greater support from the intelligence community. He specifically wants the intelligence community to focus on future Warsaw Pact trends, and on weaknesses on their new systems. He called for an increased focus on the overall shortcomings of the Soviet Union.

The Chief of Staff summarized four key things which are of concern to him. These are as follows:

- How many separate data bases do we have, and how legitimate is the information in these bases?
- To what degree do we use history for credible information bases?
- To what degree are we creatively gathering data about today's Army?
- To what degree are we hung up on studies searching for the A-plus paper, but ignoring the essential factor of timeliness? Sometimes a C+ paper with original thought, available at the time of decision, can prevent him from making a decision which history will grade an F.

Meyer concluded his remarks by stating that he is now writing a "White Paper" which will discuss the thrust and vision of the Army's analytical requirements. Said he: "As we look to the 1980s, a time of considerable peril, we must redouble our efforts."

Mr. E. B. Vandiver III, technical advisor in the Office of the Deputy Chief of Staff for Operations and Plans, followed the Chief of Staff with a report on a study of Army analysis which was undertaken last year by DCSOPS. Deputy Under Secretary of the Army for Operations Research Mr. David C. Hardison chaired the group which conducted the study.

Office of the
Deputy Chief of Staff
for
Operations & Plans
(Technical Advisor)
E. B. Vandiver III

Vandiver began by stating that the study was necessary because of the growing emphasis in the Army on analysis. There was a perceived need for greater coordination, he said. It's rather difficult to define the analytical community, noted Vandiver, because of its size and the number of people involved in it.

Approximately $137 million is associated with that part of the analysis community that was evaluated in the study. In general, the purpose of the study was to find out what Army analysis should be.

Vandiver explained that some of the questions asked in the study were: How can a given system best be sued? Is a system worth its price? How many of each system should be acquired? "We found," said Vandiver, "that the environment in which systems must work is composed of a complexity of things, and there are many types of systems."

Vandiver indicated that the study group collected a lot of viewpoints of what Army analysis was and how it could be improved. He also said that an inventory was taken of the available resources for conducting analyses. It was found that the distribution of work was evenly divided, except for the area of command and control.

He explained that the study group found a need to improve the centralized management of the Army Studies Program. We proposed, he said, establishment of a 10-man office to manage and coordinate things. He cautioned, however, that the study group does not want as much centralization as there used to be.

Vandiver argued that the study group also found a great need to strengthen the analysis capability at CACDA, Fort Leavenworth, KS. He also indicated a need for greater interface with other organizations, and more emphasis of the control functional area.

Vandiver noted that the study group recommended that practices should be adopted to sharpen the focus of analysts on management issues. Another recommendation was to establish an analytical activity in USAREUR.

He concluded by stating that attempts are now underway to implement some of the recommendations, and that the Army Study Program has already begun considering some of the priority problem areas.

Priority Problem Areas—Background and Utilization was the title of an address by Mr. Dick Lester, chief of the Operations Research Group for Forces and Readiness in the Office of the Deputy Under Secretary of the Army for Operations Research.

Office of the
Deputy Under Secretary
of the Army
for
Operations Research
(Chief, Operations Group
for Forces & Readiness)
Dick Lester

Lester began his address by stating that his remarks would center around a discussion of study planning. This is a new approach to analysis which he said appears to have gained general acceptance. He called on his audience to dedicate its thoughts to this new concept, its organization, and its procedures.

Defining priority problem areas themselves is not an easy task, he remarked. One of the things that must be considered, Lester said, is whether priority problem definitions should be broad or specific. Also, should we only consider those which have the very highest priority, and should more be done relative to cross agency work?

Lester closed by stating that the study program must be balanced. He discussed mission areas and said that there is a need to measure the value and quality of studies, and there must be consistency of management.

MG Willard Latham, deputy commander of VII Corps, U.S. Army Europe, provided a fast-paced presentation on "The Challenges Facing a Corps in Europe." He prefaced his remarks by stating that although there are problems, Europe is in a much improved state of affairs than it was five years ago.

Latham indicated that the goal for VII Corps was recently formalized. The goal is to achieve a well-balanced, properly positioned deployed force ready to accomplish its D-day mission and to enhance the quality of life for the entire VII Corps family.

He stressed that there are several problems facing the VII Corps. The first problem, he said, is the problem of malstationing of tactical and support forces and the supplies they require during the initial stages of the battle.

The General noted specifically that combat brigades are in dispersed locations away from the battle area. Said he: "VII Corps has some combat forces that are over 150 kilometers, by road march, from their battle positions." He expressed a similar concern regarding war reserve material.

U.S. Army Europe
VII Corps
Deputy Commander
MG Willard Latham

Another problem, he emphasized, is that of new command and control systems. He explained that many of the components of these new systems are too large and VII Corps needs an improved capability to hide in the electromagnetic spectrum.

Latham noted also that VII needs more communications assets. We need to provide for an increased number of secure FM radio nets, and there is a long-standing requirement for high-speed tactical teletype equipment.

The VII Corps Deputy Commander, in closing his address, stated that his organization is moving at full speed to overcome its problems. He added that the OR community could provide valuable assistance in solving these identified problems.

Banquet speaker Mr. Andrew Marshall, director of Net Assessment, Office of the Secretary of Defense, provided a highly interesting address titled "Assessing The NATO Warsaw Pact Balance." During the past few years his office has studied the theater nuclear balance.

He noted that his office, in making its assessment, first looked at what the U.S. objective is. It is, he said, to deter an attack by the Soviets on us and on our allies. He stressed that much of his work is on comparative descriptions.

Office of the
Secretary of Defense
Director of
Net Assessment
Andrew Marshall

Marshall explained that the function of his assessments is diagnosis, not therapy. He candidly stated that his office has found little use for much of the analytical communities' apparatus. This, he noted, is because too much emphasis is placed on weapons and procurement.

Initial conditions under which combat starts are very important relative to the outcome of the battle, argued Marshall. Today's analysis community assumes that there will be a big surprise attack by the Soviets, said Marshall. The Soviets, he noted, do not operate this way, they depend largely on disruption and disorganization.

He emphasized that the Soviets do a number of things differently than we do. For example, they don't assume that their pilots will make individual decisions. The way they equip their planes and other weaponry is really a reflection of this philosophy and their culture as a whole.

There are differences also in the way the U.S. and the Soviets conduct their assessment, noted Marshall. Their doctrine is different for one thing. They also put less emphasis on the "surprise attack" and more emphasis on the sequence of time in which events occur.

COL David M. Maddox, director of the Analysis Directorate, Office of the Deputy Chief of Staff for Combat Developments, TRADOC, was the final general session speaker. He spoke on Mission Area Analysis.

He began by stating that the Army has a requirement to perform mission area analysis and that eventually everyone will be touched by it. The purpose of mission area analysis is to identify deficiencies, propose corrective actions, and capitalize on breakthroughs.

Maddox indicated that TRADOC is currently putting a document together that will ultimately serve as a guide on how to conduct a mission area analysis. He explained that there are two types of mission area analyses—phase I and Phase II.

A phase I analysis is basically a quick effort which lasts from 60 to 90 days. Existing data are assembled into usable form and solutions are selected which offer the greatest payoff.

Phase II analyses, said Maddox, do not have a data base immediately available. They are considered "major study" efforts and they require about nine months to complete. External analytical support is also necessary.

Maddox noted that the Department of the Army is now conducting a 6-month study to determine the feasibility of carrying out an Army-wide mission area analysis. One of the goals of the DA mission area analysis would be to aid decision makers in allocating limited resources.

Office of the
Deputy Chief of Staff
for
Combat Developments
HQ, TRADOC
Director of the
Analysis Directorate
COL David M. Maddox

Maddox called for support of the mission area analysis concept. He argued that it can provide an important front-end analysis for materiel programs. It is the first step, he said, to a good family of systems.

The closing session of the 18th AORS featured a 15-minute report on the conclusions of each of the 10 AORS working groups, and a brief questions and answers panel discussion. Titles (problem areas) of the groups were: *Initial Force Effectiveness/Survivability/Coalition Warfare; Force Readiness and Rapid Reinforcement; Tactical, Nuclear and Chemical Warfare; Command, Control, Communication and Intelligence; Air Defense; Manpower Availability, Personnel Management, Quality of Life; Force Design, Planning, Programing and Modernization; Threat Assessment; Support to the Forces in the Field;* and *Training the Force.*

Tooele Activates Prototype Chemical Munitions Disposal System

A new $67 million prototype Chemical Agent Munitions Disposal System (CAMDS), designed to provide large scale demilitarization of obsolete or unserviceable chemical agents and munitions, has been activated at Tooele Army Depot, UT.

During the next six years the system will be tested in 12 different phases of demilitarization operations. Approximately 120,000 rockets, projectiles, bombs, mortars, spray tanks and bulk containers filled with mustard or nerve gas will be destroyed.

Processes employed by CAMDS include thermal deactivation of explosives and propellants, chemical neutralization of nerve agents, incineration of mustard agents, and thermal decontamination of contaminated metal parts and solid wastes.

Only one type of munition and one type of agent will be processed at any one time. The plant is designed so that it can adapt to a particular munitions process by rearranging special machinery between each demilitarization phase.

All equipment and procedures have been designed for safety and total containment of hazardous materials. Explosives are processed by remote control in special reinforced containment structures. Chemical agents are also processed by remote control under negative pressure.

A new, self-contained demilitarization protective ensemble (protective suit) was specially developed for CAMDS personnel who perform maintenance in chemical agent processing areas. All other individuals are also required to wear protective clothing.

CAMDS represents 11 years of effort, including technology, development, construction, procurement, testing and training. It was developed by the Toxic and Hazardous Materials Agency, Aberdeen Proving Ground.

During the first three months of CAMDS operations, all systems for disposing of agent-filled M55 rockets will be examined. More than 2,000 rockets, each filled with 10.7 pounds of nerve agent GB and 22.5 pounds of explosives and propellants, will be processed during prototype operations with live munitions.

A second phase of operations will be designed to demonstrate the system's capability to conduct full scale demilitarization over an extended period. This 13-month phase calls for the destruction of about 16,000 unserviceable M55 rockets.

CAMDS will be manned by a 163-man crew working on a single, 8-hour shift, five days a week. A second maintenance shift will also operate.

Army Studies 'Copter Wire Strike Protection System

A wire deflector and cutter system, that will reportedly protect low-flying helicopters against damage from in-flight strikes of horizontally strung mechanical and communications wire and cables, is being evaluated by the Army.

Termed the Helicopter Wire Strike Protection System (WSPS), it was successfully tested by the Applied Technology Laboratory (ATL), U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, VA, at the Impact Dynamics Facility, NASA Langley Research Center.

An instrumented OH-58 Kiowa helicopter was equipped with the system. It consisted of upper and lower mechanical wedge type cutters and a windshield center post wire deflector with a saw-tooth cutting edge.

The helicopter was raised by swing cables and pulled back to a 98-foot height. It was then pendulum swung at 40 knots to cut a 3/8-inch steel cable messenger carrying a .85-inch 50 pair communications cable which was strung at about 20 feet above the ground. Successful cuts were made with the upper and lower cutters with no significant helicopter loads or pitch changes measured.

"In-flight wire strikes are a serious threat during all weather daytime and nighttime helicopter operations such as nap-of-the-earth, inclosed area takeoff/landing and confined area maneuvers," explained project engineer Mr. LeRoy T. Burrows. "The Army's growing emphasis on these operations is necessary for helicopter survival in future combats," he said.

He added, "that during the period of 1971 to May 1978, 6.5 percent of Army aviation accidents and 21 percent of Army aviation fatalities resulted from wire strikes. These figures represent peacetime experience, while combat operations will result in more wire strikes.

"The system weighs about 16 pounds and would cost about $2,000 per helicopter. The projected reduction in accidents and Army aviator fatalities would more than cover the expense of retrofitting the Army's OH-58 inventory, and in addition, the Army aviation mission effectiveness would be enhanced," Burrows said.

The WSPS, developed by Bristol Aerospace Ltd for the Canadian National Defense Headquarters, has been qualified and approved for retrofit on their OH-58 (Kiowa) helicopters in January 1980. The long range plan is to retrofit all U.S. Army helicopters with WSPS.

OH-58 Kiowa, equipped with Wire Strike Protection System (SSPS) consisting of upper and lower mechanical wedge-type cutters and a windshield center post wire deflector with a saw-tooth cutting edge, was tested recently by the Applied Technology Laboratory at the Impact Dynamics Facility, NASA Langley Research Center.

ALMC Establishes New Course

Establishment of a new R&D management correspondence course has been announced by the U.S. Army Logistics Management Center, Fort Lee, VA. Designated as Subcourse 72(D), it consists of three lessons and a final exam.

Reserve component students who complete the course can earn a total of 50 credit hours. The course can also be used to satisfy requirements for the resident and on-site R&D Management Course (SL-F3); a portion of the Logistics Executive Development Course and associate LEDC; and Phase One of the R&D Education Program for Reserve Officers.

Interested personnel should submit DA Form 145 to the U.S. Army Logistics Management Center, ATTN: DRXMC-ET-C, Fort Lee, VA 23801. Additional information may be obtained by calling Autovon 687-1839/3378/3601.

Capsules. . .

MERADCOM Vehicles to Test Gasohol

The 115 gasoline powered vehicle fleet of MERADCOM, along with the command's other gasoline powered equipment, has been given the mission of testing gasohol in military tactical vehicles.

Gasohol, which is a trademark of Nebraska Agricultural Products Industrial Utilization Committee, is a blend of 90 percent gasoline and 10 percent ethyl alcohol. MERADCOM will purchase 200 proof, denatured ethyl alcohol and blend it with unleaded gasoline.

The program, which received the go-ahead from Secretary of the Army Clifford L. Alexander, Jr., on 13 December, consists of the fleet test, a laboratory analysis program, materials compatibility tests, military engine static tests, dynamometer tests, and development of a military procurement specification.

The command's Materials Technology Laboratory and the Electrical Power Laboratory will be the labs involved initially. Later, the program will expand to the rest of Fort Belvoir. In 1980, the use of gasohol will be expanded to Letterkenny Army Depot, PA, Fort Lewis, WA, and Red River Army Depot, TX.

The Army's program is designed to identify any problem areas peculiar to the Army, particularly in military vehicles and with fuel handling systems.

The use of gasohol in Army vehicles could reduce its gasoline consumption. Several state and local governments, as well as private industries are currently engaged in evaluating gasohol.

MERADCOM Tests New Diesel Fuel Additive

Field tests of an additive stabilizer package for diesel fuel that prevents fuel breakdown during prolonged storage and improves corrosion resistance in vehicle fuel systems, has been announced by the U.S. Army Mobility Equipment R&D Command, Fort Belvoir, VA.

The M-60 Tank Development Project Manager's Office and Chrysler have received 250 treatments of the additive for use in the latest test phase. The treatment will be used in assembled tanks that are awaiting final equipment fitting, a process that takes up to 12 months to complete.

When completed, the M-60s will be fully fueled and treated with the additive to minimize corrosion, microbiological growth, and fuel deterioration problems. Previous additive tests have involved vehicles at rebuild depots, and some Prepositioned Materiel Configured in Unit Sets equipment in Germany.

Effective additive stabilizers are expected to become more important in the future as the Army is forced to rely on lower quality fuels. Keeping vehicles and equipment combat ready could depend on the ability to stabilize those fuels, and to maintain the integrity of equipment fuel systems.

Army Receives CH-47 'D' Model for Testing

A prototype of the CH-47 D Model Chinook Helicopter has been delivered to the Army by the Boeing-Vertol Co. for development testing at Fort Rucker, AL.

For 15 years the Army has used the Chinook to perform airborne medium lift tasks. At first glance the modernized D-model accepted by the Army appears very similar to the CH-47 A-B-C models in today's inventory. Close inspection of the D-model's capabilities indicates many changes and improvements have taken place.

Major improvements include new and more powerful engines and drive system, new rotor blades, new flight control system, new external cargo handling system and new hydraulic and electrical systems.

During brief ceremonies, the prototype aircraft was accepted on behalf of the Army by LTG Robert J. Baer, deputy commander for Materiel Development, HQ DARCOM. Keys to the aircraft were handed to LTG Baer by Mr. Otis H. Smith, president of the Boeing-Vertol Co.

Currently the CH-47 program is within budget limitations and several months ahead of schedule. The program is estimated to have saved approximately $700 million in research and development costs and another $400 million in production costs. Substantial reductions in operating and supply costs will reportedly be realized because of the modernization program.

Patriot Missile Ready for Operational Testing

Patriot, the Army's most advanced air defense weapon ever developed, is ready for operational tests at White Sands Missile Range, NM, following the recent tactical battalion demonstration and destruction of a pilotless F-86 jet.

Patriot Project Manager MG Oliver D. Street III, said Patriot is now ready for government testing, the final phase of Army missile development that precedes production.

"This tactical flight test was a major milestone for Patriot," the Army's senior air defense officer said, "and I am pleased that we accomplished all our program objectives."

For the test, the Army and Raytheon emplaced three complete Patriot fire units, a command and coordination station, and a launcher in tactical positions on the range. From those positions, the fire units acquired and "located" the target, and fed information to the command and coordination station which then assigned the firing unit in the best location to engage the aircraft.

Seconds later, the Patriot missile, armed with a live warhead, struck and destroyed the high-speed jet flying at low altitude, long range, and in a countermeasures environment.

Patriot, being developed to replace both the Hawk and Nike Hercules missiles, will be so sophisticated and smart that it can diagnose its own problems and tell how to solve them. The highly-mobile, all-weather system is expected to go into production early next year.

Army Developing Arctic Fuel Dispensing System

The U.S. Army Mobility Equipment R&D Command (MERADCOM) has begun advanced development work on a system of Arctic Fuels Dispensing Equipment (AFDE). A new generation of collapsible storage tanks and fuel lines is planned, if they prove to be feasible during preliminary testing.

The AFDE systems will be simple and lightweight and will include air transportable bulk storage and forward area refueling equipment, designed for use in climates between +65 degrees and −65 degrees Fahrenheit.

Collapsible fuel storage tanks and refueling systems currently in use become inflexible and brittle during arctic conditions, resulting in leaks and failures. Other problems include wax and ice particles clogging filter/separator units, viscous fuel, and difficulty in starting pump engines. These problems reduce pumping rates and result in a failure to achieve satisfactory mission performance.

Elastomeric materials in the arctic system will be based upon state-of-the-art technology in low temperature elastomers, such as polyfluorophosphazene. Pumping equipment will be powered by gas turbine engines to insure easy starting, and will have sufficient power to pump the viscous fuel.

Current plans call for the Arctic Fuel System Supply Point collapsible tanks to store up to 120,000 gallons of fuel, with a pumping capability to dispense fuel at a rate of 600 gallons per minute.

The Forward Area Refueling Equipment system will be made up of 500 gallon collapsible tanks, and capable of pumping fuel at a rate of 200 gallons per minute.

Army Gets First Production Stinger Weapon

General Dynamics Corp. has delivered to the Army the first production Stinger air defense weapon. Watching the final assembly and accepting for the Army was COL (P) Phillip Mason, Stinger PM. He directs the program for the Army and Marine Corps at the Army Missile Command, Redstone Arsenal, AL.

General Dynamics delivered the shoulder fired plane killer in a ceremony at the company's Sycamore Canyon, CA, plant. This initial unit and several subsequent rounds will undergo contractor tests at White Sands (NM) Missile Range, to make sure production hardware meets Army requirements. Later, the government will evaluate missile reliability.

General Dynamics manufactures Stinger components at Pomona, CA, but does final assembly and testing at Sycamore Canyon. Other major team members include Atlantic Research Corp. for the propulsion system; Army Armament R&D Command and Magnavox for the fuze and warhead; and Teledyne Electronics for the belt pack interrogator.

Weighing about 35 pounds, Stinger will be an all arms weapon and will give soldiers and marines immediate air defense against low level aircraft attacking from any direction. It will have improved range and maneuverability, significant countermeasures resistance, and a device to identify aircraft.

Army Fields Initial Shipments of 155mm Howitzers

The first shipments of the Army's new self-propelled 155mm howitzer have been received at Fort Stewart, GA, for fielding by two units there. The 1st Battalion, 35th Field Artillery of the 24th Infantry Division (Mechanized), the first Army unit to take delivery of the new M109A2 howitzers, received 26 of the new weapons.

The M109A2 is being fielded by the U.S. Army Armament Materiel Readiness Command (ARRCOM). ARRCOM has production, maintenance support and management responsibility for the system. Army officials said this new weapon will add significantly to the mobility and firepower capabilities of division artillery.

The new howitzer will be the first new self-propelled 155mm weapon in the U.S. Army inventory since 1969, when the last of the short tube M109s was delivered. More than 500 of the weapons are planned for production over the next three years. The majority will be used to reequip Field Artillery battalions in U.S. Army, Europe.

The new M109A2 howitzer has numerous significant improvements over the M109A1, especially in the areas of effectiveness, efficiency, reliability, and human engineering.

The gun mount design has been improved; hydraulic components have been simplified; on-board ammunition stowage has been increased to 36 rounds, which includes 22 of the newly developed longer rounds; engine monitoring instruments have been added; several new safety features have been incorporated; and a ballistic cover placed over the panoramic telescope sight.

The M109A2 weighs 55,000 pounds, combat loaded. It can reach a maximum speed of 35 miles per hour and has a normal cruising range of 215 miles. The engine is the latest commercial 8V71T diesel built by Detroit Diesel with an Allison XTG 411-2A transmission.

The M185 cannon is manufactured by the Army's Watervliet Arsenal and the M178 Gun Mount is built by the Army's Rock Island Arsenal. The chassis and final assembly are the responsibility of Bowen-McLaughlin-York Co. (Division of HARSCO), York, PA.

Honig Reappointed to Science Advisory Council

Dr. John G. Honig, former member of the Systems Review and Analysis Office, ODCSRDA, and now with the Office of the Director of Cost Analysis, OCOA, DA, was recently reappointed for a 3-year term as a member of the Maryland Governor's Science Advisory Council.

Maryland Governor Harry Hughes noted that Honig had provided valuable services to the State of Maryland during his initial term of membership on the Science Advisory Council. He stated that he was confident that Honig would continue his unselfish devotion to the public interest.

ERADCOM Developing New Air-to-Ground Data Link

Initiation of full-scale development of a new air to ground data link for two major Army weapons systems has been announced by the U.S. Army Electronics Research and Development Command.

Identified as the Modular Integrated Communications Navigation System (MICNS), it will be used on both the Army's Standoff Target Acquisition System (SOTAS), and Remotely Piloted Vehicles (RPV), and with the U.S. Air Force Precision Location System.

The air and ground data link will reportedly use 18 Complementary Metal Oxide Silicon on Sapphire Semiconductors (CMOS/SOS) and eight other high technology custom Large Scale Integration (LSI) circuits used primarily in military applications.

The circuits were developed by industry because they provide high speed data processing using relatively low power. Size, weight, and power problems in the RPV and PLS data terminals dictated their maximum use as well as the application of the LSI and hybrid microwave integrated circuits.

First delivery of MICNS is expected during the later part of 1980. Harris Corp., Melbourne, FL, is the development contractor.

GSRS Renamed Multiple Launch Rocket System

Redesignation of the General Support Rocket System to the Multiple Launch Rocket System (MLRS) has been announced by the U.S. Army Missile Command, Redstone Arsenal, AL. MLRS PM COL Richard Steimle said that the new name conforms with that already established by NATO.

The U.S., Germany, United Kingdom and France signed a memorandum of understanding this past July calling for the cooperative development of a standard NATO rocket. The system is known internationally as the Multiple Launch Rocket System.

Boeing and Vought Corp. are currently competing for the MLRS development and contract. Early next year the Army is expected to select one contractor for final qualifications and initial production. The Army plans to field the rocket system in the early 1980s.

Under the memorandum of understanding, MLRS will be developed and coproduced in both the U.S. and Europe. The joint program and the new weapon will reportedly strengthen the NATO alliance, reduce development costs through the cooperative effort, and enable the four countries to share production benefits.

MLRS will feature a 12-round launcher mounted on a highly mobile, fully-tracked vehicle that can be emplaced quickly and deliver massive firepower. Hardware will be standard except for communications and perhaps the ammunition resupply vehicle.

Wheeled Vehicle Management Offices Established

In June 1979, the Department of the Army directed DARCOM and TRADOC to establish Tactical Wheeled Vehicle Management Offices in order that a single Army position can be established in support of the tactical wheeled vehicle program.

The DARCOM office, which has been functional since June with a skeleton staff, has been established at HQ, Tank-Automotive R&D Command. Authorization for 15 civilian spaces has been received, and manning up to this level has begun. Mr. Melvin Burcz, Autovon 273-2203, is the acting chief of the office.

Within DARCOM headquarters, the director of Materiel Management has been assigned the mission of monitoring this effort, with COL Stanley Levinson (274-9808) the point of contact there.

The establishment of this office will not interfere with, nor be imposed between direct communications or operations of higher headquarters and counterparts in major commands and the functional DARCOM headquarters staff elements.

The TRADOC counterpart office is at Fort Lee, VA.

XM445 Fuze Reportedly Performs Perfect in Tests

In the last two months of testing, the XM445 fuze used in the Multiple Launch Rocket System (MLRS) reportedly performed perfectly and verified its ability to survive the rocket's maximum range flight environment. The rocket firings are at White Sands Missile Range, NM.

The XM445, an electronic, remotely set, time fuze, was designed and developed at the Harry Diamond Laboratories. It is an engineering original, and is the first HDL rocket fuze to be designed with two independent post-launch safety characteristics.

Additionally, solid state electronics replaces the mechanical safety and arming "clockworks" found in previous rocket fuzes. This will also be the first production application of a fluidic generator power supply for fuzes.

Competing system contractors, Boeing and Vought, have completed the contractor portions of the verification test firings. Government tests are now in progress and the operational test of the fuze is scheduled for mid-February 1980.

Conferences & Symposia . . .

96 Papers Chosen for Army Science Conference

Ninety-six technical papers judged to be representative of the high caliber of Army in-house laboratory RDT&E related to national defense, have been selected for presentation, 17–20 June, at the 12th U.S. Army Science Conference, West Point, NY.

Twenty-four supplemental papers involving more than 40 authors and coauthors have also been chosen for possible presentation in case any of the primary papers are withdrawn. All 120 papers will be eligible for honorary awards consideration and all will be published in the conference proceedings.

Authors and coauthors of technical papers judged to be "most outstanding" will receive the Dr. Paul A. Siple Memorial Medallion and share a monetary award. The late Dr. Siple was an internationally renowned scientific advisor to the Director of Army Research.

Large bronze medallions bearing a crest symbolic of Army research will honor authors of other top rated papers, along with \$3,500 to \$4,000 (normal total) in awards funded through the Army Incentive Awards Program.

Seventy-four primary papers selected for presentation this year are representative of research performed at laboratories within the U.S. Army Materiel Development and Readiness Command. Sixteen supplemental papers also represent DARCOM effort.

The remaining papers listed for the 1980 Army Science Conference include 11 primary and four supplemental from the Office of the Surgeon General; nine primary and three supplemental from the Office of the Chief of Engineers; and two primary and one supplemental from other R&D activities.

The Office of the Deputy Chief of Staff for Research, Development, and Acquisition is the sponsoring agency for the Army Science Conference. Administrative details are performed by the U.S. Army Research Office, Research Triangle Park, NC.

Personnel Actions

Burbules Becomes ARRCOM Deputy Commander


BG Peter G. Burbules

BG Peter G. Burbules, former commander of Tooele Army Depot, UT, has succeeded BG Henry H. Harper as deputy commander of the U.S. Army Armament Materiel Readiness Command, headquartered in Rock Island, IL.

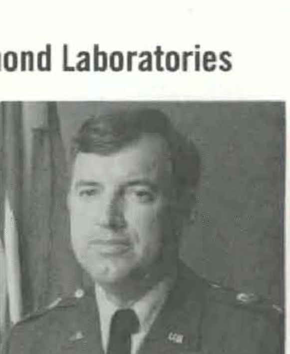
Graduated in 1970 with a master's degree in business administration from Babson College, BG Burbules holds a bachelor's degree from the University of Omaha, and he has completed the Armed Forces Staff College, the Naval War College, and he is a graduate of the Infantry Officers Candidate School.

His earlier assignments included chairman, Joint Fuze Task Group (part of the Fuze Management Organization under the Joint Logistics Commanders); executive officer, Systems Review and Analysis Office, DCSRDA; and executive secretary, Army Systems Acquisition Review Council.

He has served also as a weapon systems analyst in the Office, Army Chief of Staff; commander, Support Battalion of the 172d Arctic Light Infantry Brigade, AK; and overseas tours in Korea, Turkey, and Vietnam.

BG Burbules is a recipient of the Legion of Merit with Oak Leaf Cluster (OLC), Meritorious Service Medal, Joint Service Commendation Medal, and the Army Commendation Medal with OLC.

Benoit Commands Harry Diamond Laboratories


COL William R. Benoit

COL William R. Benoit, deputy director/commander of the U.S. Army Materials and Mechanics Research Center, Watertown, MA, since 1978, has succeeded COL Clifton R. Goodwin as commander of the U.S. Army Electronics R&D Command's Harry Diamond Labs.

Prior to his AMMRC assignment, COL Benoit was deputy director of Procurement and Production at the Troop Support and Aviation Materiel Readiness Command, St. Louis, MO. He has served also as commander of the 67th Maintenance Battalion, Fort Benning, GA, and as commander, Staff and Faculty Battalion, Transportation School, Fort Lee, VA.

Other key assignments have included test director and deputy commander, Army Aviation Systems Test Activity, Fort Rucker, AL; aide-de-camp to the deputy commander, Eighth U.S. Army, Korea; and flight and academics instructor, Navy Test Pilot School, Patuxent, MD.

Graduated from Officer Candidate School in 1955, COL Benoit earned a BS degree in mathematics from the University of Nebraska under the Army's degree completion program, and has completed requirements of the Army Command and General Staff College.

Qualified in both fixed and rotary wing aircraft, he is a recipient of the Bronze Star Medal with Oak Leaf Cluster, the Meritorious Service Medal with OLC, and the Distinguished Flying Cross.

Sibert Named AMMRC Commander/Deputy Director


COL George W. Sibert

COL George W. Sibert, a 1958 graduate of the U.S. Military Academy, recently assumed duties as commander/deputy director of the Army Materials and Mechanics Research Center, Watertown, MA.

COL Sibert was assigned from 1976 until 1979 to the Office of the Deputy Chief of Staff for Research, Development, and Acquisition. He served as the DA Systems Coordinator for Aircraft Survivability Equipment and the Advanced Scout Helicopter, and on the DA West Point Study Group.

From 1967–70, he served in the R&D Directorate and as an Assistant Secretary of the General Staff at HQ Army Materiel Command (now DARCOM). Vietnam tours were served with the 1st Infantry Division and the 23d Infantry (Americal Division).

COL Sibert holds an MS degree in engineering from Princeton University, has completed the Army Command and General Staff College, the Engineer Officer Basic and Advanced Courses, and Airborne, Ranger, and Aviation training.

Mullens Chosen as Copperhead Product Manager


LTC Fred T. Mullens

LTC Fred T. Mullens, formerly assigned as commander of the Ammunition Complex at Akizuki, Japan, has succeeded LTC Robert A. Nulk as product manager of the Copperhead cannon-launched, laser-guided projectile.

LTC Mullens will report directly to the Project-Manager-Joint Project Manager for Cannon Artillery Weapons Systems/Semi-Active Laser Guided Projectiles at the U.S. Army Armament Research and Development Command.

Commissioned as a second lieutenant in the Ordnance Corps in 1961, LTC Mullens holds a BS degree in business from Florida Southern College, and a master's degree in business administration from Athens College. His military schooling includes the Armed Forces Staff College, and the Defense Systems Management College.

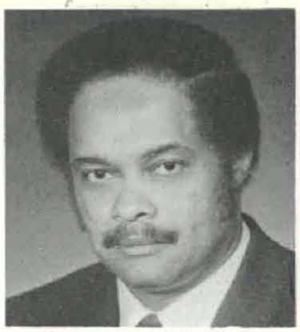
Listed among his earlier assignments are commander, Milan Army Ammunition Depot, Milan, TN; assistant PM for Research and Development in the 2.75 Project Office; and assistant PM for Production, Dragon Project Office, Redstone Arsenal, AL.

LTC Mullens is a recipient of the Bronze Star Medal, the Meritorious Service Medal with Second Oak Leaf Cluster, and the Army Commendation Medal.

Schell Appointed to Federal Executive Service

Mr. James Edward Schell II has been appointed as a member of the Federal Senior Executive Service (SES) and has assumed the position of director for the Tactical Computer Systems Center (CENTACS) at the U.S. Army Communications R&D Command (CORADCOM).

Schell, a recognized technical leader in computer systems engineering and computer science, will serve as technical advisor on tactical computer technology to the commander, CORADCOM, and higher Army and DOD levels.


James E. Schell II

He will direct the CENTACS R&D programs which include the multi-service Military Computer Family of standardized tactical computers and peripherals, diagnostic systems, support software, and software engineering techniques and tools.

Schell formerly served with Litton Systems, Inc., CA. He was program director for Command and Control Systems, and was responsible for the design, development and production of Data Processing and Communication hardware and programing for application in Command and Control systems for military deployment.

Prior to becoming the command and control systems program director at Litton, he was program director for the AN/TTC-39 and program manager for TACFIRE Systems Improvement.

Schell has received numerous citations and commendations for his outstanding government and civic work and has held offices in professional and community organizations. He has a bachelor's degree from Morehouse College, Atlanta, GA, in mathematics and physics and has done graduate work at California State University, Northridge, CA.

Awards . . .

Sedney Chosen as 1979 Kent Award Recipient


Dr. Raymond Sedney

Dr. Raymond Sedney, chief of the Fluid Dynamics Research Group, U.S. Army Armament R&D Command's Ballistic Research Laboratory, Aberdeen (MD) Proving Ground, has been chosen as the 1979 R. H. Kent Award recipient.

The award, which is named in honor of the late Dr. Robert H. Kent, is the highest annual commendation presented by BRL for exceptional professional achievement in science or engineering. It was established in 1956.

Dr. Sedney, who has served at BRL for almost 21 years, is an internationally recognized expert in the fields of high-speed flow, viscous flow and applied mathematics.

A 1975 recipient of an Army R&D Achievement Award, he has authored more than 75 publications, holds a bachelor of science degree in physics, and a master's degree and a doctor of science degree in mathematics, all from Carnegie Institute of Technology.

Bensel Receives Natick Commander's Award

Dr. Carolyn K. Bensel, research psychologist assigned to the Clothing, Equipment and Materials Engineering Laboratory, U.S. Army Natick (MA) Research and Development Command, recently received the Commander's Award for Civilian Service.

Dr. Bensel was cited for innovative human factors research on combat clothing and life support equipment systems which significantly contributed to the solution of clothing design problems affecting the performance and safety of the individual soldier. Her research reportedly made a unique contribution to combat clothing design.

Dr. Bensel, the author of more than a score of technical publications in her chosen field had previously been commended for her outstanding work by the Natick Technical Director's Silver Pin for Engineering in April 1978.

Patent Granted for Integrated Circuit Fabrication

Dr. Robert J. Zeto and Mr. Sidney Marshall, scientists at the U.S. Army Electronics R&D Command's Electronics Technology and Devices Laboratory, Fort Monmouth, NJ, recently received a patent for development of an improved method of fabricating integrated circuits.

The new method reduces integrated circuit processing temperatures by 200 to 400 degrees Celsius from those required in conventional procedures, thus significantly improving device performance and reliability.

Zeto joined the ETDL staff in 1966 and currently heads the Semi-conductor Passivation Team. Marshall, a senior project engineer in ETDL's Microelectronics Division, is currently involved in high speed military circuit technology programs and has published several research papers on integrated circuits.

Klein Gets Second Exceptional Service Award

Mr. Norman L. Klein, the recently retired assistant deputy for Science and Technology, U.S. Army Materiel Development and Readiness Command, has received a second Decoration for Exceptional Civilian Service.

The award was presented to Klein by DARCOM Commander GEN John R. Guthrie in recognition for his introduction of new managerial techniques for research and development activities to support Army systems.

Klein had served at DARCOM, formerly U.S. Army Materiel Command, since its inception in 1962. He was first assigned as chief, Chemistry and Materiels Branch, Research Division and later as chief, Laboratories Administrator before assuming the position of assistant deputy for Science and Technology in March 1973.

He began his civil service career in 1946 following four years of service in the U.S. Army. He was awarded the Legion of Merit in 1946 for outstanding military service. During his civil service career he received the Meritorious Civilian Service Award and five Outstanding Performance Awards.

Klein is a graduate of Georgia Institute of Technology where he earned a BS degree in chemical engineering. He is also a graduate of the Brookings Institute.

Keaton Gets Medal for Outstanding Management

COL Jack L. Keaton, USA (Ret.) was recently presented the Association of Old Crows Management Silver Medal of Electronic Warfare. The presentation was made in Washington, DC, during the Association's 16th National Convention.

AOC President COL A. Brees, USAF, when presenting the award, cited COL Keaton "for his outstanding management in electronic warfare. This is demonstrated in his leadership in forging Tri-Service agreements for aircraft survivability equipment, significantly shortening equipment development, fielding aircraft survivability systems for Army aircraft and introducing these concepts to NATO allies." The cited accomplishments were discharged while COL Keaton was the Army's Project Manager for Aircraft Survivability equipment.

Reader's Guide . . .
Weed Control for Public Health Applications

Weed Control Methods for Public Health Applications is the latest volume in a series of publications edited by Dr. Edward O. Gangstad on the control of aquatic vegetation considered harmful to human health.

Malaria, probably the most ancient and widespread water-related diseases known to man, has been greatly reduced through combined chemo-therapeutic-insectidal programs. However, it is reported that control of the disease has been complicated by development of *Anopheles* strains that have resisted medicines and insecticides.

According to the editor, active malaria cases in the United States were fewer than a dozen before the Vietnam War, but in 1973 the figure was about 700, almost all traceable to returning military personnel.

The editor reports on other diseases whose transmission is indirectly affected by aquatic weed conditions. These include filariasis and various trematodiases caused by shistosomes, Chinese liver fluke, cattle liver fluke, Guinea worm, giant intestinal fluke, Asiatic lung fluke, and broad tapeworm.

The volume includes measures for the control of waterweeds that are breeding grounds for disease-pest arthropods, such as snipe flies, tabanids (horse, gad, deer, and green heads), Clear Lake gnats, May flies, black flies, sand flies and sewage flies.

Herbivorous Fish. During the last decade, research to discover means of controlling obnoxious aquatic plant growth has included evaluation of herbivorous fishes.

Two of the species studied, the white amur fish and the Israeli carp, have shown sufficient efficacy to offer promise for use on controlling aquatic weeds in habitats occupied by established game fish populations.

The Israeli carp was only effective in controlling filamentous algae and is useless for control of rooted aquatic plants. On the other hand, the white amur has shown promise in controlling submersed and emersed plants.

The purpose of this research was to determine the efficiency of the white amur as a biological control agent for aquatic weed populations in natural habitats, with evaluation of the effects of space and plant nutrients resulting from the destruction of weeds in the aquatic ecosystem.

This information provides the basis to establish a system of knowledge for control and operational procedures for use of white amur for aquatic plant control, particularly hydrilla, which is hard to control by other methods.

Utilization in China. In this volume, the fish producing areas in China are divided into five major areas; the Amur River basin, the Yangtze-Yellow River basin, the South China area, the Northwest Area, and the Tsangpu-Lu River basin.

The major fish species are divided into two groups: the herbivores and the carnivores. The carnivores include the Chinese perch, snake-head, sheat fish, sturgeon, yellow catfish, pike and taimen. The herbivores include the carp species, the black roach, the bigheads, Peking bream and the mullet species.

Generally, the herbivores prefer to feed in calm, still waters, while the carnivores feed in either fast or slow waters. The breeding and migration habits vary widely with the individual species.

The black roach or black amur is considered to be of special significance in China for the control of snails that harbor the liver and lung flukes, and other schistosomes. The editor points out that these studies have particular significance to the status of fish culture throughout the world.

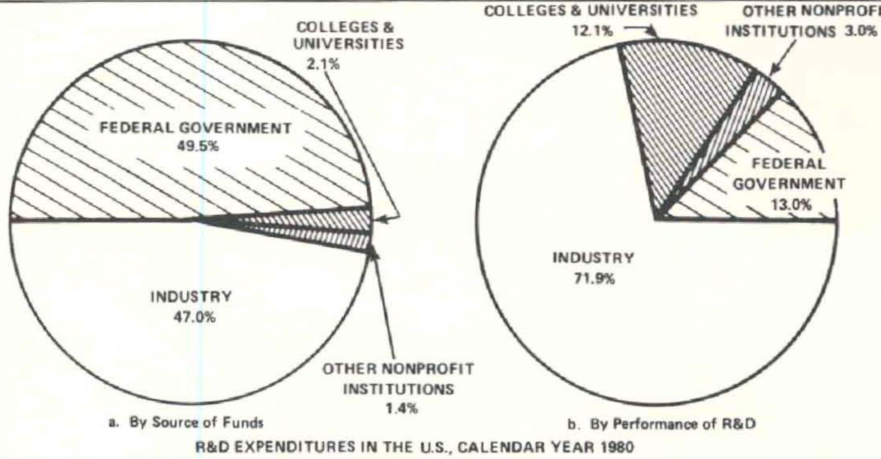
Dr. Gangstad, aquatic plant control botanist, transferred to the Office of the Chief of Engineers in October 1966 from the Texas Research Foundation, Dallas, where he was employed as principal agronomist of the Hoblitzelle Agricultural Laboratory. He graduated from the University of Wisconsin with an MA in biochemistry (1947) and from Rutgers University with a PhD in agronomy (1950) and minors in plant pathology and physiology.

Battelle Forecasts $61.8 Billion for CY 1980 R&D

Federal Government support for R&D during CY 1980 is expected to be about $30.6 billion, an increase of 19.0 percent from 1978. This represents 49.5 percent of the total 1980 national projection of $61.8 billion for R&D.

Industrial R&D funding for 1980 is estimated to be $29.1 billion, up 20.9 percent from 1979. This will account for 47.0 percent of the total R&D funding. Funding by academic institutions is projected at $1.3 billion (2.1 percent of total), and nonprofit organizations at $850 million (1.4 percent).

These estimates were prepared by Drs. W. Halder Fisher and Jules J. Duga of Battelle's Columbus (OH) Laboratories, Department of Resource Management and Economic Analysis. Data were drawn from numerous sources, including the National Science Foundation reports and the McGraw-Hill Annual Survey of Business Plans for R&D Expenditures.



R&D EXPENDITURES IN THE U.S., CALENDAR YEAR 1980

The total forecast by Battelle's Columbus Laboratories is $61.8 billion. Distribution shown here is by source and performance.

A national increase of $10.2 billion (19.7 percent) over the 5.16 billion that the National Science Foundation estimates was actually spent in 1979 is forecast. Although most of the increase will be absorbed by continued inflation, Battelle forecasts about a 7.0 percent real increase in R&D expenditures. This represents a new peak in total real funding of R&D.

The report notes that if a severe recession occurs, it will have offsetting effects on R&D. While industrial commitments may decrease in the short term, federal support may increase in order to maintain stability in the R&D "system" and to guard against a serious decrease in the nation's capacity.

While the Federal Government continues to be the dominant *source* of research funds, industry remains as the dominant *performer*. In 1980, performance of R&D by industry is expected to rise to $44.4 billion, or 71.9 percent of all research performed. This compares with $8.1 billion (13.0 percent) for the Federal Government, $7.5 billion (12.1 percent) for academic institutions, and $1.9 billion (3.0 percent) for nonprofit organizations.

The Battelle forecast notes that federal funding supports research performance in all four sectors. Currently, between one-fourth and one-third goes to support R&D conducted by the government itself; about half goes to industry; approximately one-fifth goes to colleges and universities; and the rest, less than one-twentieth, goes to other nonprofits.

Industry absorbs almost all of its own funds, either performing the R&D in-house or contracting with other industrial performers. Its contracts and grants to colleges and universities slightly exceed those to other nonprofit institutions. Other nonprofits finance both themselves and the academic institutions about equally.

Four government agencies dominate the federal R&D scene and are expected to account for 87.6 percent of total federal R&D funding in 1980. These are the Department of Defense, 45.5 percent; the Department of Energy, 15.2 percent; the National Aeronautics and Space Administration, 14.8 percent; and the Department of Health, Education, and Welfare, 12.1 percent. Creation of a separate Department of Education will alter *apparent* allocations of the R&D budget, even if no change occurs in the functional budgets.

The forecast notes that national security, reflected in the Department of Defense Budget, is a principal driving force in furthering R&D spending. Economic growth, founded upon both basic and applied research, is expected to remain as an objective that requires direct and indirect federal support. The continuing emphasis on energy, and the associated problems of balance of payments and insecure resources, will result in increased efforts on the research, development, demonstration, evaluation, and diffusion of new energy technologies.

R&D will be heavily self-funded in the manufacturing industries where, on the average, only 34.9 percent of the total will be supported by the Federal Government. The non-manufacturing industries do relatively little R&D and support will be divided almost equally between federal and industrial funding.

As a new feature of the R&D forecast, Battelle estimated the federal versus industrial support for the R&D performed by several broad industrial sectors. Battelle expects the aerospace industry to be the leader in total R&D, with funding support of nearly $11.0 billion for 1980. Of that, 78.1 percent will be federally funded. Other industries to be receiving substantial funds from government include electrical machinery and communications and rubber products.

All other broad manufacturing industry classes are expected to be supposed primarily by industry funds. These ratios range from 83.2 percent of industrial support for fabricated metals and ordnance up to 100.0 percent for both the paper industry and the lumber and furniture industry. Other classes in this group include petroleum products; machinery; autos, trucks and parts, and other transportation equipment; chemicals; professional and scientific instruments; nonferrous metals; stone, clay, and galss; iron and steel; other manufacturing; and textile mill products and apparel.

The Battelle report also compares the four performing sectors in terms of their relative costs of R&D. During the interval 1972–1980, costs of all R&D, as an average, are estimated to rise by 74.2 percent. Increases in the individual performing sectors are expected to be: Federal Government, 80.2 percent; industry, 74.7 percent; colleges and universities, 73.6 percent; and other nonprofit organizations, 46.6 percent.

The 1979–80 cost increase for all R&D is estimated to be 12.1 percent. By sectors, the increases are estimated as government, 16.9 percent; industry, 10.7 percent; colleges and universities, 13.5 percent; and other nonprofits, 17.7 percent.

Since 1973, real R&D effort has increased at a 6-year average rate of almost 2.7 percent per year, and the projections for 1980 suggest that the 7-year average rate will increase to about 3.3 percent. Battelle estimates that during the decade of the 1980s real R&D activity will increase at an average annual rate of approximately 3.0 percent.

The forecast also discusses recent proposals made by the President in response to a Domestic Policy Review undertaken by the Department of Commerce. Intended to establish means for improving innovations in the U.S., these proposals include: enhancing the transfer of technical information; increasing technical knowledge; improving industry/university R&D cooperation; strengthening of the patent system; clarifying antitrust policy; fostering the development of small innovative firms; opening federal procurement to innovations; improving the regulatory system; and facilitating adjustment to technical change.

According to the report, these proposals probably will not be implemented in time to significantly affect short-term forecasts of R&D in the U.S., but each may have long-range potential for enhancing both the support and the results of R&D.

As with any change in public policy, there are likely to be winners and losers. But taken as a whole, these recommendations and others that will be proposed by the Administration or the Congress have the potential for improving the overall resource productivity of the country's collective R&D enterprise.

DEPARTMENT OF THE ARMY

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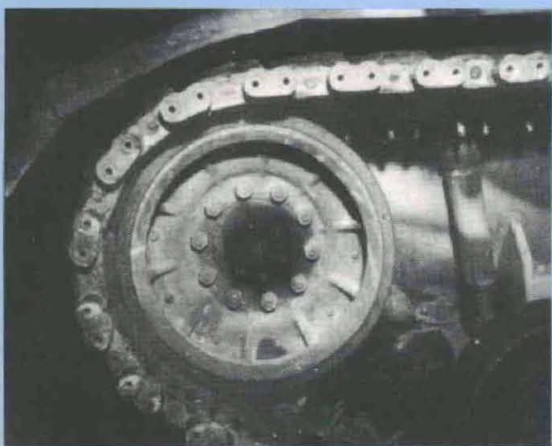

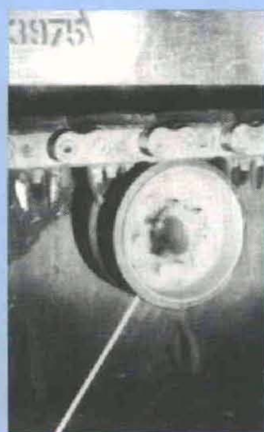

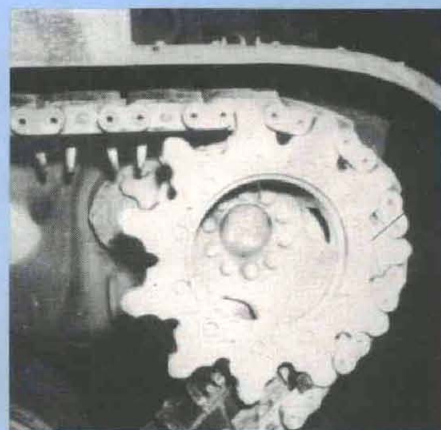

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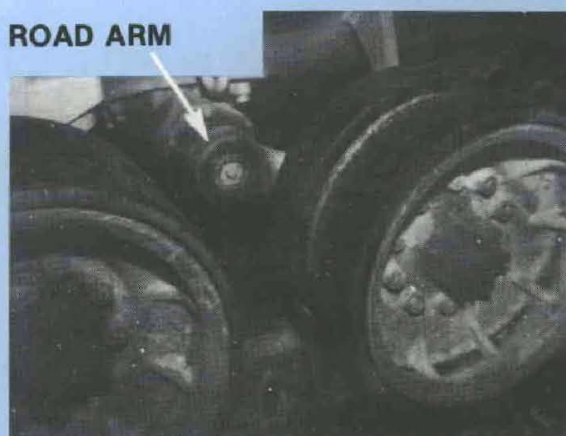
DRIVE WHEEL

M-60 TANK

ROAD ARM



ROAD WHEELS

M-60 TANK - SUSPENSION COMPONENTS