Engineer

FOR ARMY ENGINEERS

PB 5-87-2 (TEST)

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Let's Improve Engineer Command and Support Relationships

by MAJ Nicholas J. Buechler

Engineers must take a more active role in showing the maneuver commander how engineers can—and cannot—support AirLand Battle. We must understand the different command and support relationships and when to apply them.

Engineers need to know more than by-the-book definitions of each relationship. We can't let the sterile artificiality of war-game environments deceive us—AirLand Battle is certain to be more complex than any game. Yet doctrine in FM 5-100, *Engineer Combat Operations*, doesn't give adequate flexibility to engineers supporting the defense at battalion task force level.

AirLand Battle's prime mandate is this—***seize every opportunity to take the offensive, even in a defensive mission.*** Yet engineer assets are usually placed in a direct-support role for defensive missions. This sets engineers at odds with the offensive spirit of AirLand Battle. Why?—because doctrine says engineers placed in direct support can't be further task organized—and under these conditions, they can't respond flexibly to counterattacks.

The result is that engineers in the field sometimes ignore doctrine and support the maneuver commander as best they can. They do what they are taught to do at the Engineer School—task organize on the basis of METT-T.

This doctrine-flanking maneuver isn't good enough. Engineers must be smarter task organizers; our doctrine must be better defined. We should start by determining task organization according to a prioritized set of critical factors.

1. Serve the commander's intent—know his priority of effort, his concept of operation, his scheme of maneuver, his plan for defeating the enemy. Shape all efforts to his goals.

2. Allocate engineers based on needed effort—prioritize allocations according to critical missions: mobility, countermobility, survivability, and general engineering.

3. Assign missions to engineer units that can best carry them out—units with the right capabilities and equipment.

4. Preserve the engineer unit's normal association with a supported element whenever possible.

5. Consider the needs of follow-on missions—keep task organization simple and clean. Prevent complications in multiple phase operations.

6. Evaluate logistical support—the maneuver unit's ability to support engineers and the benefit gained from that engineer support must be weighed.

The successful maneuver commander applies the ten imperatives of AirLand Battle. The engineers support him. If the maneuver battalion commander is to conduct a successful brigade-directed counterattack or local counterattack, he needs to control engineer assets directly. The engineers must be in a command relationship with the maneuver commander, and allocated attached or under operational control to the task force.

This does not mean that engineer forces must be attached or OPCON to every maneuver battalion. Quite the contrary. If the engineer mission can be accomplished at brigade level, then retain control of engineer forces at that level. Maximum power can be built on the AirLand Battlefield only if direct- or general-support relationships are kept above brigade level.

If we become more proactive in expressing our capabilities, maneuver commanders will quickly stop task-organizing engineers down to squad level or committing vital engineer assets as infantry.

The real problem is that we hamper the maneuver commander by defining support relationships too tightly. Then the commander can't further task organize his engineer forces. We must provide him more flexibility, better guidance, and recommendations on engineer employment.

The advent of E-Force will bring more effective engineer support to the maneuver task force commander. The normal associations built into E-Force promote better command and control relationships and reduce the need to form ad hoc engineer task forces. It will also promote the attachment of engineers at brigade level. Until E-Force is fully implemented, engineers supporting task force level operations must be placed in command relationships.

MAJ Nicholas J. Buechler is a team leader for EOAC at the U.S. Army Engineer School. He has served with the 12th Engineer Battalion in West Germany, and with the 5th Engineer Battalion at Fort Leonard Wood, Missouri. MAJ Buechler holds BS and MS degrees in civil engineering from the South Dakota School of Mines and Technology; he is also an EOBC and EOAC graduate.

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CLEAR THE WAY

by MG Richard S. Kem
Outgoing Commandant, U.S. Army Engineer School

We've covered a lot of ground...

In preparing to leave the U.S. Army Engineer Center and School for my assignment as DCSENGR in USAEUR, I reviewed the goals I set in 1984. My first "Clear the Way" defined our task: "to ensure the effectiveness of combat engineers as members of the combined arms team on the AirLand Battlefield." I'm glad to say that we've steadily progressed toward that goal.

With a focus on warfighting effectiveness, several major actions have evolved. These include E-Force, equipment modernization, the Engineer Command and Control System, and participation in the Army Family of Vehicles.

E-Force embodies our major initiative: restructuring engineer forces to meet the challenge of AirLand Battle. To date, we have redesigned engineer forces in the light divisions and corps and at echelons above corps. Current efforts focus on getting concept approval of E-Force in close combat heavy forces, thus bringing essential engineer support to maneuver commanders.

The "challenging and realistic" engineer training I hoped to see is here. The National Training Center and our growing experience in Latin America have strengthened our active and reserve forces. Training at NTC and in SOUTHCOM have demonstrated our valuable contribution to the Army's warfighting capability.

The Brigade Engineer has been recognized and accepted as a key staff member. Engineer participation on all staffs in TAC, Main, and Rear command posts is now sought to improve maneuver on the dirty, lethal AirLand Battlefield.

During the past few years, we have increased the emphasis we place on leadership training for our officers. We are confident that EOBC and EOAC graduates who become task force engineers are fully capable of offering support essential to the maneuver commander.

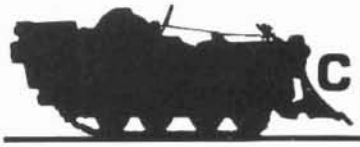
Improved training and E-Force can work only if our soldiers are properly equipped. I have seen the M9 Armored Combat Excavator (ACE) through testing and into production. New commercial construction equipment and small emplacement excavators (SEE) are also about to enter service. Mechanization of Corps Engineer Battalions in Europe is nearing completion. VOLCANO and TEXS development are proceeding.

To ensure engineer responsiveness in AirLand Battle, we have designed the Engineer Command and Control System to become a vital part of the Army's tactical command and control architecture. We have been part of the Army's future look in developing Engineer variants for the Army Family of Vehicles.

Further enhancing the cohesiveness of the Army engineers, we have become part of the Engineer Regimental System, thus strengthening bonds of loyalty and commitment among engineers, and emphasizing the kinship between Active and Reserve Components.

My service as Engineer Proponent has been a great challenge. Like any job that never becomes boring, it is also a job that is never done. I leave the Engineer School and Center knowing that General Reno inherits the potential for a stronger engineer force—and has a long road to travel with you to Fort Leonard Wood and on your missions around the world.

In the past 3 years, we have captured some high ground. But this represents only our intermediate objective. Give General Reno your support, and together we will continue to strengthen our warfighting capability.



CLEAR THE WAY

by MG William Henry Reno
Incoming Commandant, U.S. Army Engineer School

There's a challenging road ahead...

As I assume command of the Engineer Center and School, I eagerly anticipate traveling with you the "long road" General Kem speaks of in his parting remarks. Our road map for the future outlines an exciting journey—it will be up to us to advance toward planned milestones, and open new territory when opportunities arise. Let's look at the landmarks before us:

E-Force implementation: Our immediate goal is to field E-Force. We will work to get early concept approval for the implementation of E-Force in close combat heavy organizations. When it is fully fielded, E-Force will enable us to bring maneuver commanders optimal, flexible battle support.

Expanded training opportunities: We're going to expand the training successes of the NTC in coming years. The Combat Maneuver Training Center at Hohenfels, West Germany, will offer engineers in the European Theater the opportunity to carry out NTC-style maneuvers. The Joint Readiness Training Center at Fort Chaffee affords a realistic training arena where light engineers can execute combined arms maneuvers in low intensity conflict situations.

To extract the maximum benefit from combined arms training, we must work hard for realism, scrutinize our performance, improve what's good, and fix what's broken.

Publications: Current doctrine must support the continuing evolution of the engineer force. You should soon be carrying the new FM 5-34, *Engineer Field Data*, and the coordinating draft of FM 5-116, *Engineer Operations (Echelons Above Corps)*, completed under General Kem's proponency. We plan to revise FM 5-100, *Engineer Combat Operations*, and to field FMs 5-71-100, *Engineer Operations in Support of Close Combat Heavy Forces*, and 5-71-101, *Engineer Operations in Support of Close Combat Light Forces*, in the near future. These manuals will incorporate the lessons we are learning at NTC and in Latin America, bringing engineers to the threshold of a quantum leap forward in combat effectiveness.

New equipment systems: Capable engineer support depends on powerful, effective engineer equipment. Several systems are on deck—I want to see them implemented soon. These include the M9 armored combat earthmover (ACE), the small emplacement excavator (SEE), the VOLCANO scatterable mine emplacement system, the tactical explosive system (TEXS) for rapid antitank ditching, and the counter obstacle vehicle (COV). To enhance training, we aim to field improved mine effects simulators and to open the Battle Command Training Center (BCTC) at Fort Leonard Wood.

Transition to Fort Leonard Wood: We also look down the road toward a geographical landmark—a new regimental home for the engineers. We envision greatly improved engineer training on a site that brings all engineer training together, gives us ample maneuvering room, and offers state-of-the-art facilities.

As I lead you in executing this complex and long-awaited move, keep this in mind: Our destination is not just a new place. Our goal is to move ever closer to combat readiness—perfecting our training, reorganizing the force, fielding new equipment. If we do that, we'll reach our real destination: **Engineers as a fine-tuned combat arm.** *Essayons.*



BRIDGE THE GAP

by CSM Matthew Lee, Jr., U.S. Army Engineer School

Accomplishments come to units that meet high expectations every day, doing it right the first time every time...

Expectations. That word is a mouthful, one we sometimes find is pretty hard to swallow. A major lesson of modern times is that we shouldn't let ourselves be put in a box by expectations. The Army has found out that Americans of all races and origins and of both sexes can work together as good soldiers. That upset a lot of expectations. We hear a lot about stress and learning to get your expectations in line with what you can really do. Stressed-out leaders and followers can destroy themselves and a mission in a hurry.

But expectations have a positive side. This issue of ENGINEER offers evidence that high achievement goes to engineers who have high expectations. The success stories on these pages aren't just about units that experienced the drama of a wartime deployment, or even about units participating in high-intensity training on maneuvers. Accomplishments also come to units that meet high expectations every day, doing it right the first time, every time.

We, the engineers, cannot afford to wait for war to get real training or even to wait for the next field exercise. Training time for us is NOW—in the chow line, in formation, in the barracks. Hip-pocket training must be the tool that we use. We must continue to study and wait; the critical test is sure to come.

Here's what the Army expects of Engineers: We're the people who know how to build whatever needs to be built, and to do it right. We're the people who can cross the gap in the road, knock down the obstacle in the way. When we build, we must build to standard: We're expected to be reliable. Commanders expect our makeshift solutions to be the best available. We must not fail them.

We often meet those expectations as small units where NCO leadership is critical. Look at "*Army Well Drillers in the Rapid Deployment Force,*" p. 23, and "*Engineer Cellular Teams,*" p. 30. These units perform highly specialized tasks. Their NCOs have to be self-reliant experts, able to go ahead and do the job—anywhere, any time, under any conditions. The soldiers in these units must be well trained.

Training works only if it is done by NCOs who set high standards and lead by example (see "*Discipline and Unit Performance,*" p. 44). Training pays off only if you expect to get the most out of every event. "*Repairing Historic Gold Camp Road,*" p. 27, and "*Building a Water Line on Tiger Island,*" p. 19, are good examples of sustainment engineering projects that let units find out if they are what they're expected to be—and how to cope with the unexpected.

And a word to all of you who know we can't always do the job "by the book"—When you can, DO. Strengthen your unit's ability by practicing at peak standards when you have enough time and the right resources. If your soldiers have the habit of producing excellent work (see "*The Three-Phase Inspection System,*" p. 33), they won't be satisfied to do less than their best—even in tough conditions.

Read "*Royal Engineers' Postwar Cleanup in the Falklands,*" p. 13. The author of that article expected his NCOs to rebuild a wind-devastated airfield runway on their own. He wasn't disappointed. That's the engineer tradition in the U.S. Army too. We know our jobs. We're ready for the unexpected. We don't disappoint the units we support—we meet their expectations. It's the engineer way.

— School News —

Noncommissioned Officer Academy (NCOA)

Academy Opens The Fort Belvoir Noncommissioned Officer Academy began operation 1 April, 1987, in order to comply with recent TRADOC guidelines which specify that all NCO training must be conducted in an NCO academy. Previously, advanced NCO training on Fort Belvoir was conducted by the Directorate of Military Engineering, and the administrative aspects were coordinated by the NCO student detachment, according to CSM Frank Gibert, NCO Academy commandant.

Before coming under the auspices of the academy, the POIs focused primarily on the technical aspects of the NCOs' function. "Our intention," said CSM Gibert, "is to emphasize leadership and warfighting in a combat environment."

The academy's history will be a brief one, however, as plans are already under way to move the courses taught at the school to Fort Leonard Wood, Missouri. Currently, only BNCOCs are held at Fort Wood's NCO Academy. The move is scheduled to begin in April, 1988.

Directorate of Combat Developments (DCD)

Idea Program Announced Have you ever found a problem with a fielded engineer system and thought you had a good solution? Have you ever had a suggestion for a change in organization or training that would make your job easier? Have you ever had a good engineer-related idea, but you did not know how or where to get it adopted? DCD has initiated actions for a new program to help your ideas get tested and adopted. It will be called ESSAYONS.

ESSAYONS will provide a fast, low-cost, and informal means for the Engineer School to evaluate your ideas and adopt them if they work. ESSAYONS is not intended to take the place of the Army Suggestion Program, because the Army Suggestion Program will evaluate your idea but may not test and adopt it. ESSAYONS will give your ideas the proper attention from the Engineer perspective, and, if necessary, test your ideas in an operational environment. It is a quick method to improve your equipment, organization, or training.

Anyone may provide an engineer-related idea. Just clearly describe your proposal in writing (if necessary, provide sketch) and send it to—

Commander
U.S. Army Engineer School
ATTN: ATZA—CTD (ESSAYONS)
Fort Belvoir, VA 22060-5281

Be sure to include your name, address, and AUTOVON number for us to contact you in case we have questions regarding your ideas.

Department of Military Engineering (DME)

Training Developments DME is developing field circulars for engineer operation at echelons above corps and for airbase damage repair. Both will be fielded in late fall 1987.

The DME is also developing the ARTEP Mission Training Plan for the engineer battalion (combat) (heavy). The coordinating draft should be fielded in the winter of 1987 for field comment.

Beginning in FY 88, DME will offer weekend courses in horizontal construction, theater of operations (TO) structures, TO utilities, and construction management. Each will be offered twice per year. Check the school course catalog for exact dates.

Directorate of Military Logistics (DML)

Mast Systems Group Course The 52D10 Branch of DML recently began teaching the direct support/general support Hydraulic-pneumatic Mast Groups Repairer (C-9) Course. During the 18-day course, students are trained in the operation of the mast groups systems, DS/GS maintenance procedures, DS/GS troubleshooting of mast groups and related test equipment, and the use of specialized tools.

The course is open to Active Army and Reserve Component Specialists 4, corporals, and sergeants assigned or on orders to a duty position that requires the awarding of ASI C-9. Active Army personnel must have at least 10 months of active duty service time remaining after completing the course. For more information about the course or enrollment requirements, contact SFC Tucker, DML Operations Branch, AV 354-2314/1036.

Engineer Update

Directorate of Evaluation and Standardization (DOES)

Lessons Learned Bulletin The *Lessons Learned Bulletin* summarizes experience gained from worldwide training exercises. An updated bulletin is published each quarter and distributed to active, reserve, and National Guard engineer units (company level and above), DEHs, districts, and major commands.

To assist the Engineer School in collecting relevant lessons learned, field units need to provide after-action reports (AAR) from their training exercises and information concerning doctrine, equipment, and material. Information and AAR's should be sent to: Commandant, U.S. Army Engineer School, ATTN: ATZA-ES, Fort Belvoir, VA 22060-5271.

If your unit is not receiving *The Lessons Learned Bulletin*, contact SFC Kovak at (703) 664-4172 or AV 354-4172.

Engineer Orientation Team (EOT) EOT is currently scheduling visits for FY 88. If you would like to see the EOT presentation or have them schedule a visit with your activity or active duty or reserve component, contact: Commandant, U.S Army Engineer School, ATTN: ATZA-ES (SFC Rexrode), Fort Belvoir, VA 22060-5271 or call (703) 664-4172/1124 or AV 354-4172/1124.

Department of Combined Arms School (DCA)

Engineer Histories Available on Video The Department of Combined Arms, the U.S. Army Engineer School, and the Historical Division, OCE, have jointly sponsored a series of oral histories now available on video tape. Titles include "Engineers in the Battle of the Bulge" and "Engineers in the New Guinea Campaign 1942-1944."

Three more presentations soon will be available, including histories of engineers in the mountains of Italy and in the initial Rhine River crossings during World War II and engineers in the Korean War.

Video tapes of these oral histories are available for loan. Write to ATZA-TA-C, ATTN: Management Branch, U.S. Army Engineer School, Fort Belvoir, VA 22060-5341 or call AV 354-3993.

Engineer School Secretary (ESS)

Publication Cutback The Engineer School, like all TRADOC schools, faces current and projected funding contraints for printing and distribution of student materials. The current mandate is to reduce the number of copies by 15 percent from last year. This policy requires students to turn in texts after completing a course and restricts our ability to satisfy individual field requests for locally printed material and DA publications. We regret the inconvenience.

Directorate of Training and Doctrine (DOTD)

Individual Training Plans Revised A major priority within DOTD this fiscal year is to revise all individual training plans (ITP) for engineer occupations. ITPs lay out strategies and methods used in training. During the first two quarters of FY 87, the Engineer School completed revision of 15 ITPs. Eighteen will be revised during the third and fourth quarters.

General Engineering Manual in Distribution Units should have received FM 5-104, *General Engineering*, through distribution. FM 5-104 provides a doctrinal basis for planning and executing general engineering in the theater of operations. It is primarily concerned with support to noncommitted forces within the Corps and communication zone areas.

Lineman's and Cableman's Handbook Available *The Lineman's and Cableman's Handbook,* which replaced TM 5-765, *Electric Power Transmission and Distribution*, for all personnel holding the 52G MOS, is still available.

To order the book for your unit, send the property book officer's name, Department of Defense activity codes, and document number to: Commandant, U.S. Army Engineer School, ATTN: ATZA-TD-P-CR, Stop 291D, Fort Belvoir, VA 22060-5291.

After initial distribution, units must purchase copies from the publisher, McGraw Hill Book Company, New York.

— Regimental News —

Corps Distinguished Members

On 10 February 1987, letters were forwarded to engineer commanders soliciting nominations for Distinguished Members of the Corps. Nominations received before the 30 March deadline were reviewed by the Regimental Advisory Committee and forwarded to the Chief of Engineers for approval. Since there had not been adequate time for most units to complete their nominations, he decided to await more nominations before further consideration. He did, however, approve the committee's recommendation to designate all living, former Chiefs of Engineers and Corps of Engineers Command Sergeant Majors as Distinguished Members. Honored at Fort Belvoir's annual Engineer Dinner on 8 May were—

LTG Joseph K. Bratton (Ret)
LTG William F. Cassidy (Ret)
LTG Emerson E. Itschner (Ret)
LTG John W. Morris (Ret)
CSM William Leach (Ret)

LTG Fred J. Clarke (Ret), the Corps' Honorary Colonel (also a former Chief), participated with the current Chief, LTG Elvin R. Heiberg, in the designation presentation ceremonies.

These new Distinguished Members join General Bruce C. Clarke (Ret), who was named the Corps' first Distinguished Member earlier this year.

Concerning selection criteria for Distinguished Members, the committee determined that active officers and enlisted should not be eligible for nomination by their respective units. It further determined that any individual serving in a chain-of-command position above a nominating unit, or a currently serving Chief of Engineers or Corps Command Sergeant Major, should not be eligible until reassignment or retirement.

With the nomination procedure firmly in place, units may again begin consideration of Distinguished Members. Each unit may nominate one officer and/or enlisted each year. Later this year, letters will be forwarded to all engineer commanders, soliciting nominations in preparation for the 1988 Engineer Dinner, where new selectees will be recognized.

Commanders having difficulty tracing unit histories may arrange for unit representatives to visit the History Office of the Office of the Chief of Engineers to conduct research. Units needing this assistance should contact Mr. Charles Hendericks, Staff Historian, at (202) 355-3564. Questions regarding the overall selection process may be directed to CPT Jeff Korcan, Corps Adjutant, at the Engineer School's Personnel Proponency Office, (703) 664-2287/3760 (AV: 354-2287/3760).

— Career Notes —

Commissioned Officers Branch

Captain's Promotion Board to Meet MILPERCEN will convene a Captain's Promotion and Conditional Voluntary Indefinite (CVI) board on or about 9 September, 1987. Zones of consideration for promotion to captain consist of all 1st lieutenants with the following dates of rank:

Above the zone: 860331 and earlier
Promotion zone: 860401 thru 861121

All eligible officers should review their Official Military Personnel Record (OMPF) and their Officer Record Brief (ORB) prior to the convening of the board. Administrative and procedural questions may be directed to the Officers' Promotion Section, MILPERCEN, DAPC-MSP-O, 200 Stovall Street, Alexandria, VA 22332-0400, AV 221-9340.

Other than Regular Army (OTRA) officers in the "first time considered" zone for promotion to captain, who desire to remain on active duty past their obligated voluntary (OBV) date, must apply for CVI status for consideration by the September CVI board. Officers cannot apply for CVI after they have been selected for captain. Officers who choose not to apply for CVI when they are in the "first time considered" zone for captain will not be permitted to apply at a later date. Applications should be submitted in original and one copy through the chain-of-command, IAW AR 135-215, to arrive NLT 3 Aug 87 at the Combat Support Arms Career Management Division, MILPERCEN, Attn: DAPC-OPE-P, 200 Stovall Street, Alexandria, VA 22332-0400, AV 221-7815.

NCO and Enlisted Soldiers Branch

Appealing Your Enlisted Evaluation Report Officials at HQ Department of the Army believe that NCOs are not using the Army's Appeal System when they believe they were rated inaccurately or unfairly. Last year only 336 appeals reached the Army Deputy Chief of Staff for Personnel Enlisted Special Review Board (ESRB), which is the Army's primary authority for ruling on appeals based on claims of inaccurate or unjust evaluation. There are more than 277,000 active duty NCOs. Only five Reserve Component NCO appeals reached the board.

Appealing is not an act of futility. In 1986 full or partial relief was granted on 38 percent of all appeal cases completed. The guidelines for appeals are contained in Chapter 4 of AR 623-205, *Enlisted Evaluation Reporting Systems*, to which Appendix G has recently been added to provide more definitive guidance for their construction. The staff judge advocates and your personnel services center can also help you.

For additional information concerning appeals, contact the agency listed below which is responsible for your component:

Active Duty NCOs	Commander U.S. Army Enlisted Records and Evaluation Center ATTN: PCRE-RE-A Fort Benjamin Harrison, IN 46249-5301
Reserve NCOs	U.S. Army Reserve Personnel Center ATTN: DARP-PRE-A 9700 Page Boulevard St. Louis, MO 63132-5200
National Guard NCOs	Chief, National Guard Bureau ATTN: NGB-ARP-E Washington, D.C. 20310-2500

— News & Notes —

New Mine-Clearing Developments On 6 April 1987, the Belvoir Research and Development and Engineering (RD&E) Center awarded a $2,185,000 production contract for the Army's new Cleared Lane Marking System (CLAMS) to BMY Corporation of York, Pennsylvania.

CLAMS will be used to help vehicle drivers follow safe paths cleared through minefields. Mounted on the rear of the lead minefield-breaching vehicle, it dispenses colored flags that can be seen easily during the day. Lightsticks are provided for night operations.

A device attached to the vehicle's odometer controls the dispenser, dropping the markers at constant intervals. Units are scheduled for delivery between November 1987 and February 1988.

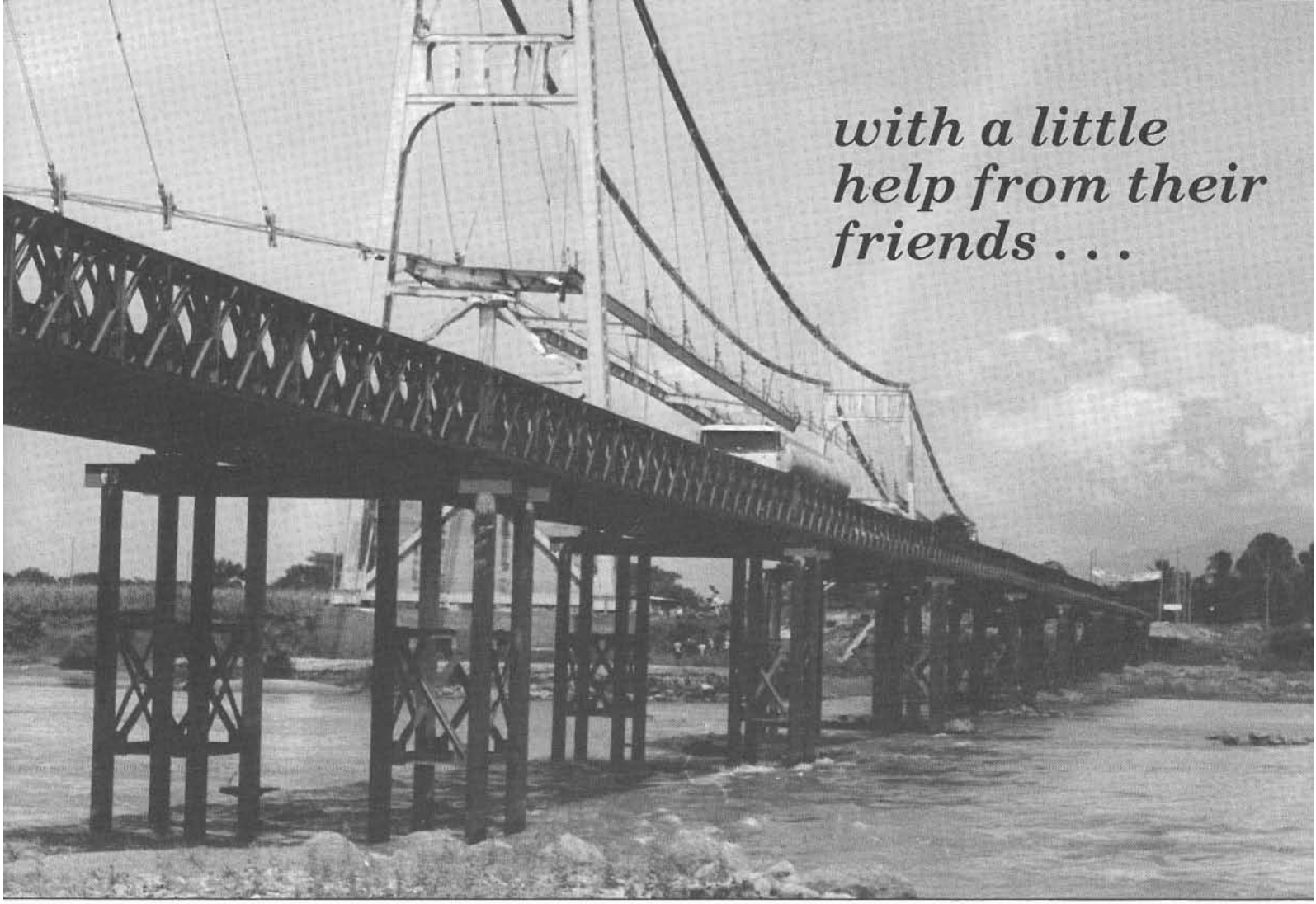
The Belvoir RD&E Center also has evaluated foreign "flail" technology to determine its effectiveness and suitability for clearing safe paths through minefields.

A vehicle designed by Aardvark Mine Ltd, of Aberdeenshire, Scotland, was tested by the U.S. Army Armor and Engineer Board at Fort Knox, Kentucky, to obtain data that could eventually result in a tank-width vehicle mine clearing system for combat engineers.

After reviewing reports of past designs, Aardvark developed a flail that weighs less, costs less, requires less power, lasts longer, and provides a better beat pattern than its predecessors. The Aardvark uses less power to drive its flails, although it employs more chains per foot of rotor than older designs. The tip weight has been matched with the flailing speed to produce a better pattern of contact with the ground. During trials, one Aardvark flail cleared charges of up to 3.6 kilograms of explosive with virtually no damage.

The design evaluated by the center weighs 13½ tons—10 tons for a prime mover and 3½ tons for the flail unit. Mounted on a custom-built, half-track vehicle, the flail unit is a 10-foot-wide rotor with 72 to 79 chains having disc-shaped striker tips. Other features include automatic contouring and depth control, retractable sidearms for air transport, an armored cab, and an optional rotor with 60 heavy chains for use against buried antitank mines.

Data from these tests will be used to design a flail system providing a path as wide as the vehicle selected to perform as its prime mover.



with a little help from their friends . . .

Salvadorans Rebuild Two Bridges

by Joseph T. Cowgill

El Salvador's people have been at war for 8 years, struggling with a guerrilla insurgency that has alternately raged and smoldered. Lives and homes have been destroyed, and the population of this tiny but strategically located country systematically terrorized.

Like many Central American nations, El Salvador has largely undeveloped rural areas and a fragile transportation network. Guerrilla forces have focused many of their destructive efforts on the nation's precious infrastructure, making movement and communication difficult wherever they can. This is the story of one guerrilla attempt to disrupt travel in El Salvador and how U.S. Army Engineers helped to make sure the effort failed.

Rio Lempa crossings destroyed

The Rio Lempa runs through country hotly contested in El Salvador's civil war. Flowing south along the Honduran border, the river crosses the country on its way to the Pacific, severing the eastern third of El Salvador from the west. Two bridges over the river—Puente San Marcos and Puente Cuscatlan—are the sole links between eastern and western El Salvador.

The Salvadoran Army, realizing the importance of these bridges, had manned them with light security forces. But the small guard contingents were easily circumvented by the rebels. In late 1982, they managed to plant demolitions and blow up both spans, making the Rio Lempa a major barrier.

The guerrillas' sabotage, continued ambushes, and harassment failed to halt transportation altogether, but caused significant problems on the routes served by the bridges. To provide a roadway of sorts, the government routed traffic across a hydroelectric power plant dam near Cuscatlan, and converted a railroad bridge to make a roadway at San Marcos. Both these crossings—one of them on the Pan American Highway—were restricted to alternating one-way traffic.

El Salvador seeks Bailey bridges

For more than three years after the destruction of the bridges, the Salvadoran government tried to construct other crossings on the Rio Lempa. These efforts were hampered because the Salvadoran Army had



Salvadoran workers prepare a Bailey bridge span at Cuscatlan.

converted its engineer units to infantry—combating the guerrillas was a top priority. This left reconstruction in the hands of a relatively inexperienced civil works ministry.

Weather and river conditions also thwarted reconstruction work. Attempts were made to push earthen causeways into the river, reducing its normal 600- to 1,000-foot widths to distances that could be easily bridged. But heavy rains and rushing water soon destroyed these structures.

The most feasible solution, the government finally concluded, would be to span the river with Bailey bridges on piers. Through coordination with U.S. agencies, El Salvador obtained some used Bailey bridge sets from the United States. To make the sets serviceable, civilian workers removed paint and rust, primed, painted, and lubricated major parts.

The refurbished bridge equipment was then moved to the two sites by truck—a 2-hour drive from San Salvador on hostile roads.

Army engineers prepare the sites

Mobile District, U.S. Army Corps of Engineers, were called upon in early 1986 to supervise the design, fabrication, and construction of steel pile piers at both sites. This phase of the project took several months—all materials were imported, and heavy equipment, cranes, pile drivers, had to be procured.

Pile driving began in April, but seasonal rains impeded site preparation. High waters and swift currents repeatedly washed away the causeways that were needed for pile emplacement. Because of river bed conditions at Cuscatlan, the last set of piles couldn't be driven in the planned location. Subsurface problems also forced a change in the location of far bank abutments. As a result, the Cuscatlan Bridge's planned length nearly doubled, reinforcing chords had to be used on the far bank span, and the final length of the bridge—usually determined in the design stage—remained unresolved almost to the day the first bridge hit the far bank.

USAES assists in designing bridges

Through USAID, El Salvador requested assistance in constructing the Bailey bridges, and acquired the services of a technical assistant from Bridging Branch, the U.S. Army Engineer School.

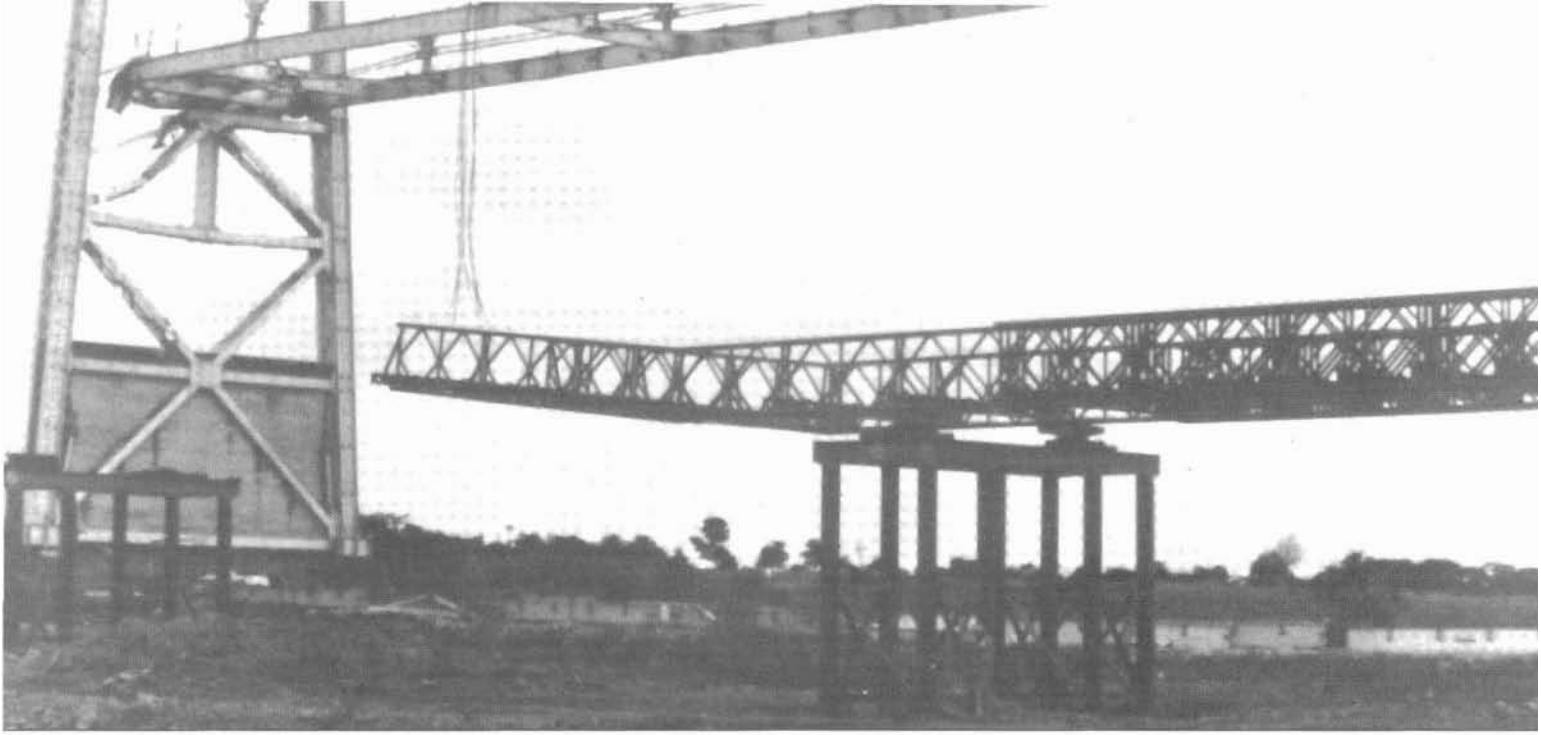
In a 3-day site visit, the advisor determined correct quantities of components, equipment, and manpower, and set up the building sequence. On this occasion and throughout the project, the advisor communicated with his Spanish-speaking counterparts by drawing diagrams and using the universal language of mathematics. Thus, he literally sketched the building sequence for the bridges and drew pictures to recommend solutions to construction problems.

Salvadorans construct San Marcos Bridge

Assisted by the Engineer School advisor, 100 Salvadorans set to work on the San Marcos Bridge. The workers were farmers, construction laborers, steel workers—and one man with Bailey bridge construction experience. On the first 10-hour day only the roller layout, launching nose, and 10 feet of bridge were completed. Training—and the vivid urgings of the host country supervisor—swiftly improved productivity, and 10-hour days soon ended with 100 to 120 feet of bridge constructed and launched.

Construction problems were numerous. Inexperienced Salvadoran workers left leveling bolts out of pile piers 3 and 4. Engineers substituted an epoxy filler, allowing it to cure for a day before extending the launching nose to pier 3.

Crews had to be diverted from bridge construction: one to clean and lubricate parts that arrived on site covered with paint, another to correct problems caused by wrong-sized locally made chess. Gaps between pieces of chess were hammered into the button stringers, and bent pin lugs were repaired.



The damaged Cuscatlan bridge looms above a Bailey span in mid-launch.

Bridge equipment arrived slowly, since most available trucks had to be used to haul rock and fill for the causeway.

Construction speeded up when a cherry picker became available—3, 4, or 5 bridge panels could then be assembled and lifted into place in one move. The cherry picker also eased movement of transoms, stringers, and other heavy components from distant stockpiles to the bridge.

By the end of July, 600 feet of triple-single bridge had been built and 500 feet launched. Bridge-building then halted until the last pier could be finished. Further construction and launching required a dozer pulling the bridge, which could not be done during pier construction.

The final touches on the San Marcos Bridge cost extra effort. During launching across the last four piers, the bridge repeatedly went off the centerline. This was a coordination problem—keeping a pulling and a pushing dozer working together proved tricky.

The final length of the bridge was determined only after both ends were situated over the banks. Errors in the original design and siting put the abutments too far apart. An extra 10 feet of bridge was added to each end span, and chord reinforced. The San Marcos Bridge carried traffic across its 1,140-foot length on 26 August 1986.

Experience speeds construction at Cuscatlan Bridge

The Salvadoran supervisor began the bridge at Cuscatlan in the absence of the USAES advisor. Traveling between sites, he completed and nearly launched one of the bridges at Cuscatlan, while he directed construction at San Marcos.

The supervisor's independent work at Cuscatlan proved to be a mixed blessing. His experience helped him to train his work force at Cuscatlan, putting construction ahead of schedule. But, lacking technical advice, he built and launched the bridge across single rocking rollers rather than using tandem rollers. This created a problem—the bridge was split over the piers. To solve the difficulty, the Salvadoran supervisor and the USAES technical advisor decided to use timbers and plain rollers to replace the missing rocking rollers.

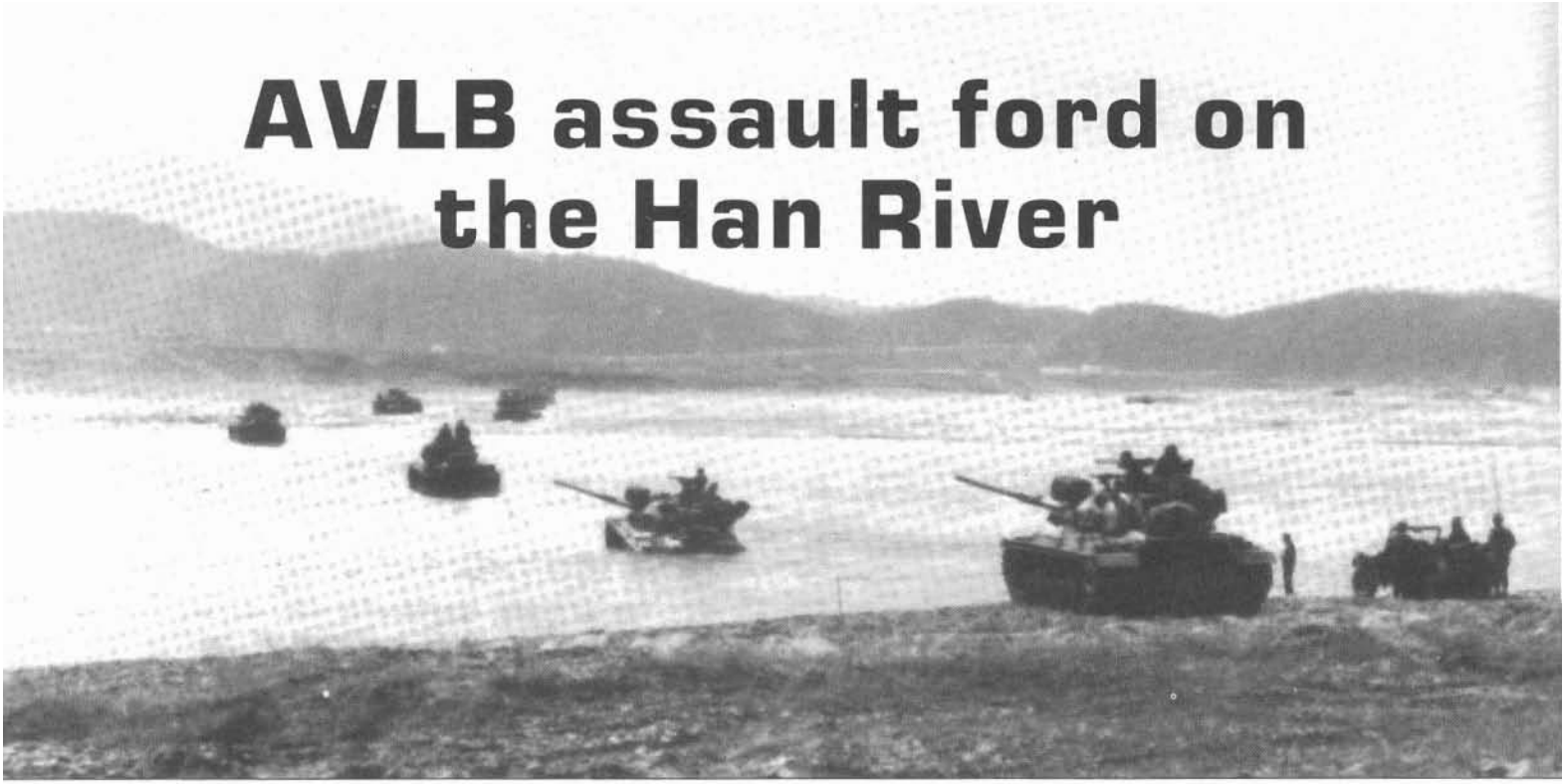
The Cuscatlan Bridge proved harder to launch than the San Marcos Bridge. A comparison of their configurations explains why. San Marcos was over 1,140 feet of triple-single bridge, all spans equal until after final launch. At Cuscatlan, each bridge was over 990 feet long. The launching nose was followed by 190-foot triple-double, chord reinforced, followed by 8 spans of 100-foot triple-single. Launching these bridges was like trying to push a bowling ball with a rope. However, earlier struggles with pulling and pushing dozers had taught workers how to avoid problems.

The complex endeavor at Cuscatlan was made more difficult by guerrilla activity. The guerrillas threatened a 7-day road shutdown on the Pan American Highway, but Salvadoran Army forces provided security for commercial trucks after the second day of the attempted blockade. In the end, guerrillas only succeeded in causing temporary shortages of components.

Construction at Cuscatlan showed how a few months' practice could make cooperative nation building pay off. Salvadoran workers had learned how to work with Bailey bridge under their own supervisor. U.S. engineer expertise stood by to iron out problems. In September 1986, the Salvadorans celebrated—three bridges were opened to traffic, and east-west travel across the Rio Lempa was restored. The Salvadorans, with U.S. cooperation, had thwarted a guerrilla campaign.

Mr. Cowgill was the USAES advisor to El Salvador for the San Marcos and Cuscatlan bridge projects. He is a training specialist, Bridging Branch, Combat Operations Division, in the Directorate of Military Engineering, USAES. He has spent 21 years in active service, mostly with various Army float and panel bridge companies.

AVLB assault ford on the Han River



by CPT John Rivenburgh

Cross the water where ***you*** choose, and make the battle yours. Here's how the Orange Force (2d Infantry Division) used a surprise crossing to defeat the Blue Force in 1982's joint ROK-US Exercise, TEAM SPIRIT. Convinced that a flank attack on Blue Force would turn the tide, Orange Force maneuver commander, division engineer, and assistant division engineer planned to cross the South Han River and drive west.

They decided to move a mechanized brigade across a major water obstacle. No fords or fixed bridges were available. The few prepared, deep-water crossing points had been used by the enemy. To surprise the enemy, AVLB assets of the divisional float bridge company (6 launchers with 8 bridges) would construct a hasty AVLB overlapping assault ford at an unexpected site.

Emplacing the assault ford

Two days before the attack, E Company, 2d Engineer Battalion, used SCUBA teams, 3-man reconnaissance boats, and shoreline observation to determine the feasibility of the assault ford. The findings were less than ideal (sandy-silty-rocky bottom; 5.5-foot depth, and 5-foot-per-second current), but the river bottom was flat. The battalion commander consulted with the assistant division commander and gave the order to initiate.

To prepare for the mission, the end curbs were removed from the AVLBs and safety poles were fabricated. The first launcher drove into the river and launched its bridge at maximum fording depth. Before the bridge completely submerged, the AVLB commander placed 8-foot safety poles in the river bottom along the sides of the bridge. After the first launcher retreated, a second came forward, launched its bridge, and formed an interlock by overlapping the first bridge 3 feet. In this way, 5 AVLBs spanned 300 feet.

The attack

The third morning, the battalion bombarded the far shore. Under cover of smoke, 37 armored vehicles crossed the overlapping assault ford with only one minor mishap. This surprise maneuver allowed Orange Force to defeat Blue Force in detail.

The findings of the river reconnaissance proved to be more than adequate for the mission. The 5 AVLBs were recovered without damage to bridges or launchers.

The hasty AVLB overlapping assault ford is not suitable for all river conditions—it works best when a ford's only limiting factor is depth. A rocky bottom can cause point loading and damage the bridges. Bridges may sink into a clay or silt bottom, lowering their surfaces below the crossing vehicles' fording depth. Bottom suction may render bridges unrecoverable. Extensive shore preparation is needed when banks are steep or high. Bridges must be retrievable from the near shore.

All this means that a thorough reconnaissance must be conducted. The division engineer and maneuver commander must ensure the benefits outweigh the risks. AVLB crews must train on land to perfect the overlapping techniques. Clearly, the use of this assault ford is heavily dependent on METT-T.

But like all specialized tools, the hasty AVLB overlapping assault ford can be the perfect instrument in the right circumstances—it can let the maneuver force commander exploit enemy weakness.

CPT John Rivenburgh is a Senior Team Leader in EOAC Division of the Engineer School. He has also served as Commander, E Company, 2d Engineer Battalion; and Project Engineer, Albuquerque District, COE. CPT Rivenburgh holds a BS in Civil Engineering from Clarkson University, an MS in Civil Engineering from the University of Connecticut, and is a registered professional engineer in Virginia.

Royal Engineers' Postwar Cleanup in the Falklands

by LTC Michael H. H. Brooke, RE

"When the bullets stop, there will be a cry for Engineers to get the situation back on its feet. Move your Squadron by sea to the South Atlantic, and be prepared to fight if necessary. Your tasks are—

- Reopen Stanley Airfield.
- Clear mines/explosives.
- Restore water supply and essential services to Port Stanley.
- Construct company base camps for the infantry guard force."

Mobilizing

Such were the orders I received just 10 days before 3 Field Squadron sailed for the Falkland Islands on June 19, 1982. My first job was to prepare the squadron to meet the challenge.

The Squadron had recently returned from a construction project in Kenya, so we were well organized for deployment. Our tradesmen's skills in electrical work and carpentry were at their best.

We had little knowledge, however, of the Aluminum Mat Grade 2 (AM-2) of which Stanley Airfield's main runway would be rebuilt, and no expertise whatever in constructing Portakabins and Pakaway Buildings (portable prefabricated quarters and storage facilities), or operating rock drills and rock crushers. These gaps in training would have to be closed quickly.

Key personnel needed immediate training, particularly on the unfamiliar commercial equipment that we would be using. I dispatched Squadron Officers, NCOs, and Sappers to all the civilian firms who would supply our equipment. Each was responsible for returning to the squadron with operating knowledge of a system, and the ability to pass it on to the troops who would use it.

Our primary challenge was AM-2 airfield mat training—we could only do this in the United States. The morning after I received our orders, my Troop Staff Sergeants (E7 Platoon Sergeant equivalent) were with me at Heathrow Airport, on their way to the U.S. Marine Corps' Bogue Field, Cherry Point, NC. If the squadron's NCOs could gain proficiency in laying AM-2, I thought we had a good chance of success. After 4 days of intensive training at Bogue Field, the men were ready to train the rest of the squadron.

Meanwhile in the United Kingdom, the squadron began to prepare for the possibility of combat. All ranks reclassified on their personal weapons, and found ways to increase our potential firepower. The .5-inch Browning machine guns were taken out of our Ferret Scout Cars, which wouldn't be going with us to the South Atlantic.

By the time the NCO contingent returned from the United States, preparations were reasonably well in hand. The Quartermaster (QM) had obtained the necessary stores and engineer equipment. The squadron had been augmented with additional technical specialists in construction trades, power generation, and quality control. Squadron personnel were completing their private arrangements for leaving the country.

The Squadron sailed from Southampton on the appointed day, bound for the Falkland Islands 8,000 miles away. The precious 3 weeks of transit time was spent in weapons training, physical training, and familiarization with AM-2.

A complex job

We arrived in Port Stanley on a wintry July 11. Initially, there was no accommodation ashore. This meant commuting daily by small boat, in weather that was potentially ferocious and always unpredictable. Gradually, however, we established a Squadron HQ in the Falkland Islands Defense Force Drill Hall, which had been used by the Argentinians during their occupation of the islands.

The aftermath of conflict was everywhere evident. Ten thousand Argentine prisoners of war, some of them ill or injured, had not yet all been repatriated. We were not able to shelter them, but we managed to provide them food, water, and medical assistance until British hospital ships began to transport them back to the mainland about 10 days later.

Parts of Port Stanley and its environs were infested with land mines and booby traps. Water was scarce, since the town's main pumping station had been hit by artillery fire. Damaged ships staggered in the harbor, their supplies and munitions waiting to be unloaded or scuttled.

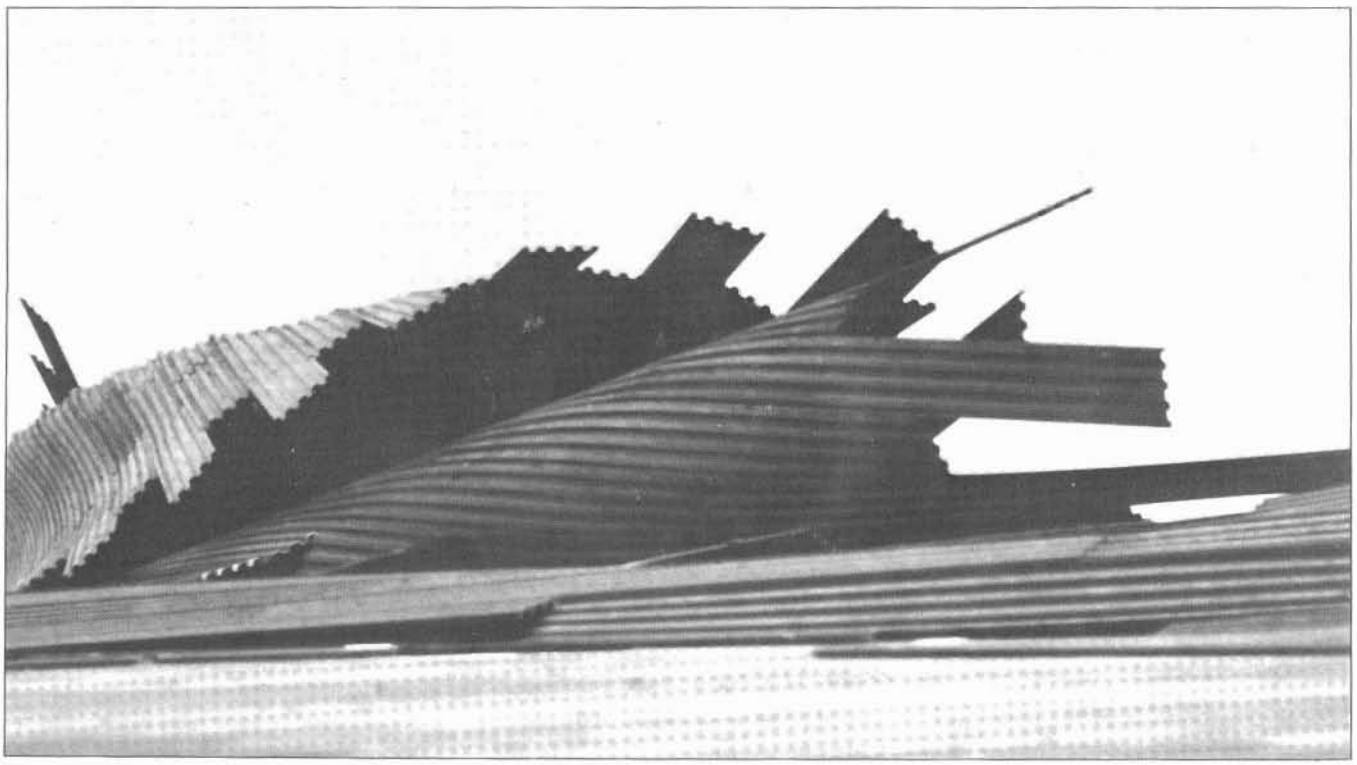
Restoring Port Stanley

Our most urgent task was to restore basic utilities. A military water point was substituted for the damaged main pumping station. Though we had almost no spares for the pumping engines, our Sappers soon managed to bring production to the million-gallon mark.

Meanwhile, the town of Port Stanley was systematically cleared of mines and booby traps. Sappers trained for operations in Northern Ireland conducted the search, dividing the town into small grids and painstakingly combing each square for booby traps and mines.

Rebuilding Stanley Airfield

With 50 Field Squadron, we set about one of our primary objectives—



Hundred mph winds can roll light-weight aluminum airfield mat into a giant tortilla. Panels, visible at edges, are 10 feet by 1 foot and weigh 80 pounds each.

rebuilding Stanley Airfield. Initially, we had expected the airfield to be pitted with deep craters after the Royal Air Force bombing raids by Vulcan bombers. It proved, however, that all but two craters had been illusions. The Argentinians had used large irregularly shaped sheets of vinyl to create a pattern that—from the air—looked like cratering on the runway surfaces. These "craters" were simply moved aside when Argentine aircraft were about to land.

Even though the job to be done proved less heroic than we at first believed, we found it Herculean enough. Grading the airfield surface and filling the craters to strict quality control specifications required full support of quarrying and rock-crushing operations, with which the squadron was not familiar. Clearly, this aspect of engineer support is a critical element in many repair and rehabilitation jobs. I carried away the conviction that cleanup units must be fully prepared to carry out and support quarrying and rock-crushing operations—otherwise the effectiveness of the mission will be impaired.

The goal at Port Stanley was to improve the airfield surface so that it could accept Phantom F-5 fighters, thus releasing the aircraft carrier ***Invincible*** from her standoff station. Because the strip was too short for high-speed fighter aircraft, we also installed runway hydraulic arrestor gear. Day and night, rain and storm, the Sappers labored, and it was a sweet moment to watch the first jet land safely.

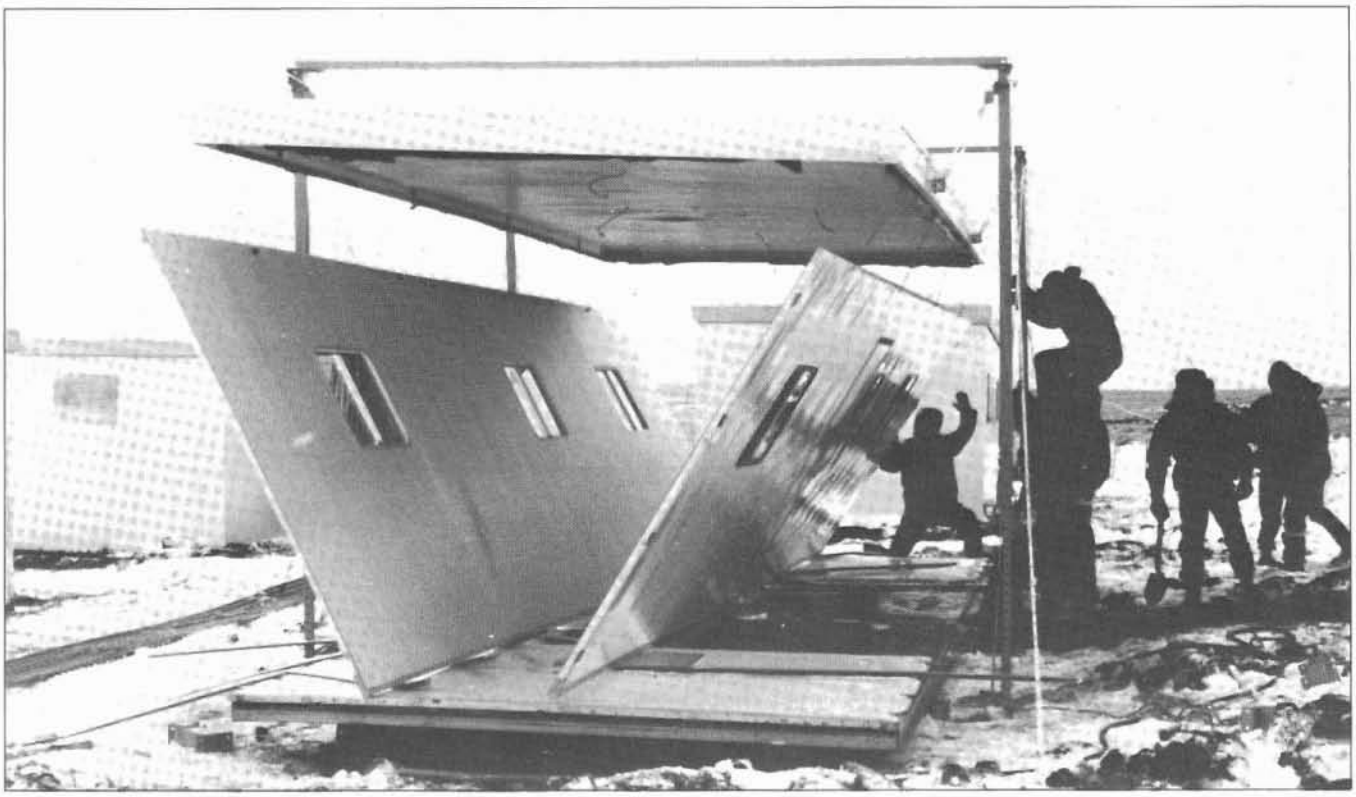
But there was little time for celebration. Soon after the commissioned officers had moved on to supervise other construction operations, the light-weight aluminum airfield mat at Port San Carlos, specifically designed for Harrier Operations, was attacked by ferocious 100-mile-an-hour winds and torn away from its moorings. The junior NCOs who had been left in charge of this forward operating base did a superb job of supervising the repairs, which were completed in just 3 days.

Constructing the garrison

When we left 50 Field Squadron to continue expanding the airfield, we turned our attention to camp construction across the islands for the Battalion Guard Force. Our first job was to unload several ships, a task made difficult by lack of suitable lighterage and stevedore experience. However, engineers have always been an adaptable breed, and we managed our job with ingenuity, inventiveness—and cooperation with the port squadron.

Where there had been grassy areas, Portakabins began sprouting from the earth. Each cabin provided accommodation for 10 soldiers. Again, high winds quickly ripped the first cabins from their foundations, but engineers stabilized and provided floor-level insulation for the buildings by stacking sandbags at the ground line and literally tying the Portakabins down with guy wires attached with Spanish windlasses. The same technique was used to secure the portable lavatories.

The camps were constructed by field troops operating more or less independently. The Squadron's junior leadership flexed its muscles unsupervised, providing housing for a garrison guard force of 1½ infantry battalions, 2 artillery batteries, and elements of the RAF. These facilities



Portakabin kits are designed for rapid installation. Here, soldiers steady side panels which drop out of the roof. Assembly can be completed in less than a half hour.

were expected to last for up to 5 years.

An unexpected duty

The Squadron was also called upon to build a permanent cemetery for those of our dead whose relatives had decided they should rest where they fell in action. These 14, including LTC H. Jones, VC, OBE, who had gallantly commanded 2 Battalion, the Parachute Regiment at Goose Green, had been temporarily buried at Ajax Bay. Sappers from 3 Squadron dug new graves at Blue Beach, where the first British Task Force landings had occurred some 5 months earlier. The Sappers had the honor of acting as bearers when Mr. John Knott, then Secretary of State for Defense, presided over the burial ceremony during his brief visit to the islands.

Lessons learned

Six months after our arrival, we embarked for home knowing that we had met the mission's challenge. In less than 2 weeks, we had prepared ourselves for a number of unfamiliar engineering tasks. We had mobilized, upgraded our combat readiness, and assimilated needed expert personnel. Dispatching our NCOs to sources of expertise for immediate information and training had been critical to our success in carrying out our job after we arrived.

The traditional engineer virtues of flexibility and initiative served us well when we encountered the Falklands' hostile weather conditions and serious resource deficiences. The trials we met taught us—and should remind all those who must be prepared to mobilize to remote and unfamiliar terrain—that small wars operations will inevitably present a set of difficulties which no unit can anticipate.

As we worked with limited personnel and long supply lines, we abandoned the intensive micromanagement we are so often tempted to practice in peacetime. Our NCOs proved that they could accomplish massive tasks at short warning without constant oversight by officers. In sum, the ingredients key to our success were—

- Keep the unit's administration on the ball. If the admin's right, the job will be right.
- Think clearly; make a simple plan but remain flexible. The situation on the ground will always surprise you.
- Trust your subordinates. Allow troop commanders to use their initiative to get on with the job.
- Train hard, even if time is short. Training pays.

LTC Michael H. H. Brooke, RE, was commissioned in the Royal Marines in January 1967, and served in Singapore and at the Commando Training Center. He transferred to the Royal Engineers in 1972 and has seen service in West Germany, Northern Ireland, Cyprus, Kenya, and the Falkland Islands. LTC Brooke was the British Exchange Officer at Fort Belvoir from 1985 to 1987, serving with USAES, Department of Military Engineering, as Chief, Combat Operations Division.

Military Pipeline Operations

by CPT Robert W. Metz

AirLand Battle runs on tracks, rolls on wheels, flies on wings—and feeds on petroleum. How much POL can major conflict eat? In World War II, half the logistical tonnages were petroleum products. Field armies and tactical air forces consumed 3 to 8 hundred thousand gallons of fuel per day.

To feed the need, Army engineers laid over 3 thousand miles of military petroleum pipelines in Europe, along the Mediterranean, and through China-Burma-India.

In Vietnam and Korea, petroleum's share of logistical tonnages rose to over 60 percent. It is likely that POL will become even more vital in the future.

These precious supplies can't be unloaded and picked up in rear areas. Fuel and fuel products must go where the soldier goes—as far forward as the tactical situation dictates.

Engineer, Quartermaster, and Transportation units cooperate to provide bulk petroleum distribution systems. They see that supplies move smoothly from ships to armies by road, rail, air, inland waterway, and above all, by pipeline.

Why pipelines?

Pipelines are relatively time-consuming to build and susceptible to enemy disruption. In Vietnam, the enemy was able to cause losses of over 2.5 million gallons of fuel per month. Slow construction rates may also mean that pipelines lag behind the rate of combat advance, making fuel supply to forward units uncertain.

Despite these disadvantages, pipelines remain the most efficient way to distribute bulk petroleum. They allow a continuous flow of fuel, whatever the weather and terrain. They also keep road and rail networks open for materiel that cannot be moved in any other way.

Who runs the system?

Within the theater of operations, several branches of the Army support petroleum distribution. The Quartermaster Petroleum Group executes the bulk fuel distribution mission. Assigned directly to the Theater Army, the group works with the Theater Army Materiel Management Center and host nation staffs to develop a petroleum distribution plan. This plan is the basis for designing, building, and operating the system, which the petroleum group and its subordinate units then operate and maintain.

Who builds the pipelines?

A combat heavy engineer battalion usually builds the distribution system. The battalion prepares sites and builds bulk storage, pump stations, fuel jetties, and other related pipeline facilities. A pipeline platoon element from a pipeline construction support company often performs part of the construction.

The pipeline construction support companies rarely operate independently. They usually provide technicians and specialized equipment to help engineer battalions with construction, rehabilitation, and repairs. These companies are the inland pipeline experts.

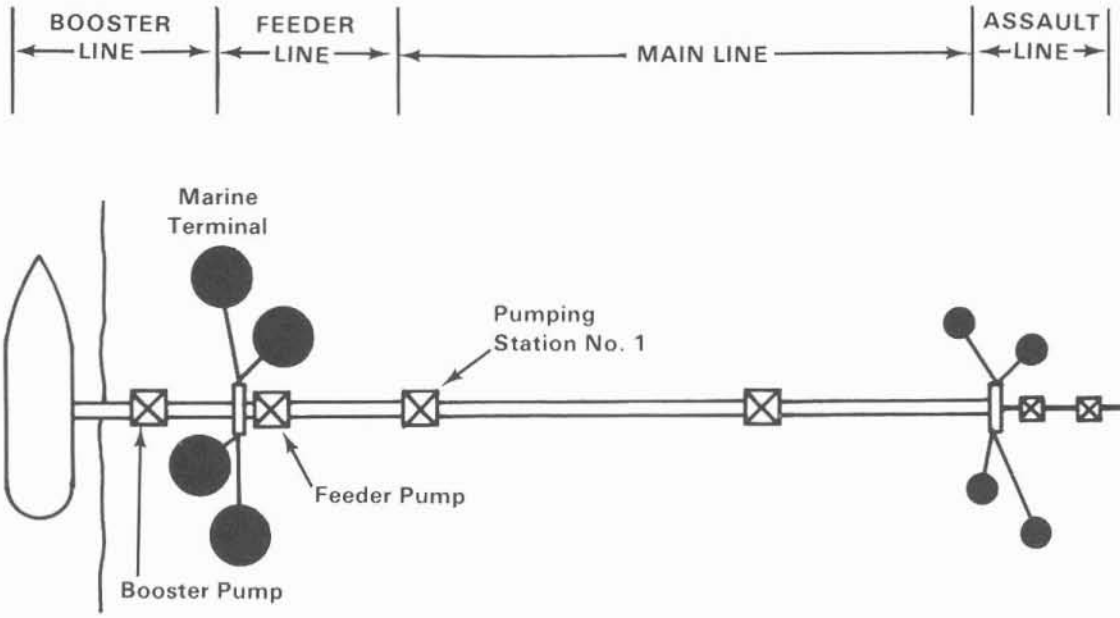
Engineer port construction companies provide expertise for offshore petroleum facilities. These companies can lay offshore assault hose lines and submarine pipelines, and build POL jetties and tanker discharge facilities. Radiographic welding teams and diving teams may be attached to these companies. The teams can test, inspect, and repair pipelines and POL jetties.

How is the system designed?

Theater pipeline systems are designed to be easy to construct, yet meet fuel needs in the theater. The designer must consider the design fuel (the heaviest fuel the line will carry), the mean low temperature in the area, the flow rate needed to meet fuel requirements, and the number and type of pipeline facilities available in the theater.

The engineer officer designs the line in modular form for each of the three types of lines in the system: the booster line, the feeder line, and the main line. Quartermaster Corps handles assault pipelines at the dispensing end of the system.

The booster line transports fuel



	PURPOSE	*RESPONSIBILITY*	*MAIN COMPONENTS*
BOOSTER LINE	Takes fuel from tanker to base terminal tank farm	Engineer Co (PC) ACB Engr Bn (CH)	Submarine pipeline (undeveloped Theater) Docking facility Booster pump station (if required) API steel pipe
FEEDER LINE	Primes 1st main-line pump station	Engr Bn (CH) Pipeline Co	API steel pipe Feeder pump station
MAIN LINE	Majority of pipeline	Engr Bn (CH) with Pipeline Company	Lightweight tubing (LWT) API steel pipe (if required) Main-line pump stations
ASSAULT LINE	Dispenses fuel at receiving end of pipeline	QM	Collapsible hoseline Assault pumps

Schematic design for POL pipeline port facilities

from the offshore tanker to the first or base terminal tank farm. The design of this line depends upon the developmental stage of the theater. In an immature theater, a submarine pipeline may be needed to discharge the fuel, while in a developed theater, a pier facility may be available for direct shoreside discharge. In this line, the design is based upon the flow rate required to unload a tanker, as well as the design fuel and temperature.

A feeder line, usually from ½ to 1 mile long, may be needed to transport fuel to the first main-line pump station. This line's flow rate depends upon the fuel requirements upstream and the operating hours of the feeder pump station. The feeder pump station will provide the priming pressure needed to operate the first main-line pump station.

The longest and the most time consuming line to construct is the main line, which may cover hundreds of miles. The main line has the same flow rate as the feeder line, but is constructed of a lighter weight steel tubing because of the distances it must cross.

The engineer must understand the design parameters of these three lines, as well as all other related storage and supporting facilities addressed in the Army Facilities Components System. With this knowledge, and an understanding of the basics of fluid flow, he can design a pipeline system that supplies fuel throughout the theater.

What's new in military pipelines?

New developments continue to increase the effectiveness of the military pipeline system. The Joint Chiefs of Staff contingency plans require rapid delivery of bulk petroleum in the theater. Construction rates of up to 25 miles of pipeline per

day are needed if these requirements are to be met.

To meet the demand for speed, several systems are being developed. The Automated Pipeline Equipment System's truck-mounted hopper feeds pipe into a joiner—it can connect over 1 thousand feet of pipe in minutes. The Army is also moving to a lighter-weight aluminum pipe that will decrease the rate of manual construction by more than half.

For gap crossings, where the threat of leaks is most critical, the Army has developed the Pipeline Outfit Petroleum (POP) System. The POP System can swedge pipe together, creating a tighter bond over the gap.

These systems can reduce construction time and enhance the reliability of future distribution systems, meeting the needs of the highly mobile AirLand Battle.

Military pipeline systems are the key to the bulk petroleum supply. They can effectively distribute fuel to mechanized forces, enabling them to maintain the offensive in AirLand Battle.

Engineer support to petroleum supply is designed to be an effective combination of both general and specialized skills. Engineers make a critical contribution to designing an efficient system that can be constructed swiftly. The all-round capabilities of the combat heavy engineer battalions are combined with the highly developed skills of small, specialized units to build the pipeline. This pairing of resources minimizes duplication of low density skills, yet provides the manpower and equipment needed to perform the mission. The effectiveness of the operation is ensured by intensively training engineer units in both the Active and Reserve components.

Through management, training, and modernization, engineers have ensured that their part in the petroleum pipeline supply mission will be successfully accomplished. Maneuver commanders can be sure they'll get the fuel they need to win the AirLand Battle.

CPT Robert W. Metz is currently an instructor in Structures and Utilities Branch, Department of Military Engineering, U.S. Army Engineer School. He has also served with the 497th Engineer Company (Port Construction) at Fort Eustis, Virginia. CPT Metz is a 1982 USMA graduate and a graduate of EOBC and EOAC. He is completing a Master's degree in engineering administration at George Washington University.



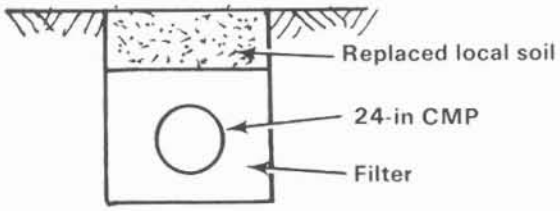
Engineer Problem

You are an assistant S-3 (civil engineer) for a combat heavy battalion. Proper design and construction of a subsurface drain, 2,000 meters long, is essential for the accomplishment of your unit's mission. Available subsurface drainpipe—perforated, 24-inch corrugated metal pipe (CMP) with hole diameters of ⅜ inch—is adequate for your use.

Your materials quality specialist (MQS) obtains the following data from sieve and hydrometer analyses of the soil at the site of the proposed drain:

Size	% Passing	Size	% Passing
⅜ in	100	#80	50
¼ in	98.5	#100	46.5
#4	97	#200	32.5
#10	89	0.04 mm	22
#20	78	0.02 mm	11
#40	67	0.01 mm	3
#50	60		

All of the grains of this soil pass through the pipe perforations, so you know that the drain needs a filter.



The battalion S-2 locates a more coarse-grained soil at another site. He estimates the quantity of soil to be 1,750 bank cubic yards (BCY). Your MQS analyzes the soil as a possible filter for the drain. He determines—

Size	% Passing	Size	% Passing
1½ in	95	#50	18
¾ in	90	#80	13.5
⅜ in	83.5	#100	12.5
¼ in	77	#200	8
#4	72	0.04 mm	5.5
#10	47.5	0.02 mm	3.5
#20	30	0.01 mm	1.5
#40	22		

Questions to Answer

1. Is the more coarse-grained soil suitable as a filter for the drain?
2. If it is suitable and the S-2's estimate is correct, is there enough filter soil to construct the drain?



Building a water line on Tiger Island

by CPT Jim Balocki and 1LT Michael Malsom

Tiger Island rises 2,500 feet above the Gulf of Fonseca, just off the Pacific coast of Honduras. The steep slopes of the island's extinct volcano are littered with reminders of a fiery past. Amapala, the only settlement, is a shadowy ghost town—though in a past life it was a lively port. On this forgotten island, the soldiers of Bravo Company, 52d Engineer Battalion (Combat Heavy), built a pipeline from a well at the base of Tiger Island to a storage tank at its summit. Our goal—to provide water for personnel stationed there.

Our objective was simple—our task difficult. There was no electrical power at the well site. Rough terrain made it impossible to build pump stations along the pipeline route. Parts of the design for the system were beyond the normal capability of the battalion's construction staff.

Reconnaissance

A map reconnaissance yielded two route options: the first went along a road that wound 2½ miles up the mountain's southwestern slope, the second climbed straight up the western side of the island. We sent a small site reconnaissance and survey team to Tiger Island to study the terrain and to locate a centerline for the project.

The team discovered immediately that the island's primitive environment would make construction a challenge. Thick vegetation on the upper slopes made the mountain a hooded monster; the lower slopes were covered with cornfields and open spaces that belonged to local farmers. The "road," nothing more than a donkey trail, offered neither access for construction nor reduced grade. The straight route up the mountainside would be best for the pipeline, we decided.

Omaha District, Corps of Engineers, helps with project design

Shortly after returning from the site visit, we contacted the Omaha District, Corps of Engineers. We explained what we had seen on our reconnaissance and our idea of how the mission might be accomplished.

The partnership we developed with the Omaha District project design team was critical to our success. Deployment training exercise project designs are normally carried out by the unit tasked with the mission or by the staff at Palmerola Air Base on the Honduran mainland. The complexity of this project required expert technical assistance which only the Corps could provide. Our joint effort to design and construct the pipeline yielded lasting benefits to both organizations.

By mid-February, the scope of the pipeline project had become apparent. Just to move water, the system needed an electrical supply system, an electromechanical control system, and hydraulic components. Terrain along the project site did not allow access for construction or maintenance. Multiple pumping facilities would greatly increase the required construction effort and also the potential for future maintenance problems. Therefore, a single pump station near the well site would be the best choice. The consequences of this design decision were unnerving—the static pressure head in our pipeline would be in excess of a thousand pounds per square inch.

The design team, now consisting of engineers from the hydraulic, electrical, mechanical, and structural areas, faced equally perplexing design problems. Our power source was over a mile away from the well site; therefore, an electrical distribution system was required.

Three-phase motors were the optimal choice because of their cooler operating temperature and longer life. These motors dictated the type of power we had to bring to the site. Two options were available—a high voltage system that used 2-gage conductors or a low voltage system incorporating 500 MCM conductors. The lighter weight of 2-gage conductors made a high-voltage distribution system the logical choice.

A control system was needed to



PVT William Walsh and SGT Edward Harris mix and place the pump station foundation. The trough shown served as the mixer for the entire placement. The white pipe protruding on the right temporarily protected the well from being contaminated or accidentally sealed.

operate the pipeline and to prevent or indicate component failure. We designed a system that could provide information on pump and motor status, prevent pump cavitation due to low water conditions, and remotely control the pumping cycle.

Getting supplies—getting there

Getting materials was our next obstacle. Construction materials for deployment training exercise projects are purchased locally in Central America. Most arrangements are made through the contracting officer at Palmerola. Our design efforts had produced a viable bill of materials, but what we needed to carry out the mission was not available anywhere in Honduras. We had to bring it from the United States. The responsibility for that task fell to the 52d's staff.

It took 3 months to write specifications, produce the necessary purchase documents, secure funds from USSOUTHCOM, obtain, and prepare nearly $100,000 worth of construction materials for shipment. We needed help from the Omaha District in preparing the specifications for everything from steel pipe to microprocessor control systems.

Transporting soldiers, materials, and equipment from Fort Carson to Tiger Island was an enormous endeavor. With careful airload planning, we managed to move the 50 tons of mission-essential materials on two C-141B Starlifters.

The materials and equipment were trucked from Palmerola to the small seacoast village of Coyolito. To our dismay, as materials were off-loaded in Coyolito, several 700-pound reels of cable rolled off a truck bed and crashed to the ground. Crates that had been specially constructed to store 21-foot sections of steel pipe were reduced to splinters, and pipe was scattered about the ground. Fortunately, no construction materials were damaged, and we managed to salvage enough packing material to take us over the next leg of our journey.

In Coyolito, our materials and equipment were loaded aboard an old barge operated by the Honduran Navy. We could only do this at high tide, when the barge could move close enough to the pier to be loaded. Even then, the motion of the barge and the narrow gangways proved tricky for our backhoe operator, who narrowly missed a trip into the drink when a plank broke under him.

Our troubles weren't over yet—as the barge neared the pier at Amapala, it ran aground. We rocked all night in the shallow water, waiting for the rising tide to free us. Townspeople lined the shore, curiously wondering what the American soldiers were trying to do.

Building the system

The first job on Tiger Island was to move materials to the work sites. Over the next 2 weeks, we flew about a third of our supplies to the top of the island in a Chinook helicopter. The remainder were stockpiled and secured at the pump station site.

Laying pipe. Placing and connecting the pipe proved to be the most demanding task of the entire mission. The project centerline, which had been surveyed and cleared only 3 months before by the reconnaissance team, was completely overgrown with vegetation. With the aid of a native farmer we reestablished the centerline, working for several days to reclear the route before any pipe could be moved into place.

Every available soldier worked for 3 weeks to place over 6,000 feet of pipe on the treacherous slopes of the



CPL Todd Browning, CPL Dennis Fitzpatrick, SSG James Dixon, and PVT Joseph Lininger begin to lower the submersible well pump and motor into the well casing; they lowered the apparatus 80 feet by hand.

mountain. Each section was moved and placed by hand, using human chains to pass the 70-pound lengths to their designated locations.

Coupling the pipe was a simple process. We used Victualic ® couplings and fittings, which allow about 3 degrees of flexibility in all directions at the point of coupling. The entire system was surface laid, so the couplings had to be flexible on varying terrain.

Laying electrical system. Installing the electrical distribution system also proved to be a challenge. On our initial site reconnaissance, we learned that the local farmers burn their cornfields twice a year to control pests and remove undergrowth. Obviously, the electrical system had to be buried, or the first burn would destroy it. First, all cable was surface laid by hand and spliced by high-voltage exterior electricians from Alpha Company. After the entire cable length was in place, 60 contract laborers spent 2 weeks in burying the cable. The rugged terrain made it impossible to dig in several places; instead, 7,000 sandbags covered the exposed sections.

Splicing the cable was a difficult task in the tropical environment. The cable had to be surgically clean and dry. The splices had to be made with extreme care, and each one tested for capacity to carry the high voltage for which the system was designed. This task, which included carrying heavy test equipment up and down the mountain, took 2 weeks. It was the last major activity necessary to complete the project.

Preparing the well site. Construction at the well site went on for the duration of the 2-month project. First, we removed the well pipe and submerged well pump that had been placed 2 years earlier. Extreme care had to be taken not to damage the well casing or drop the pipe. We then constructed a 15-foot-square concrete pad and foundation on which the pump house structure, pumps, motors, fittings, and controls would stand. There was no ready mix concrete, so we mixed by hand, using the 1:2:3 mix design method. Over the cured foundation, we erected a prefabricated metal building.

Our plumbers and electricians installed pumps, motors, interior electrical components, and the control system. At the same time, a second crew constructed an 8-foot-square structure at the summit to house an additional pump and the master control panel. At first, the control system did not operate properly. Apparently, one of the printed circuit boards in the control panels had been damaged during transport or installation. After several consultations with the manufacturer, we installed new boards, and the system began to function properly.

Lessons learned

Constructing this pipeline and pumping system was a challenge to the soldiers and leaders charged with the mission. Often, four or five separate construction projects would be going on in different places, as the project spread for a mile up and down the mountain. Continuous coordination was essential to

accomplish many tasks because each was dependent upon others.

The ability, experience, and skill of the NCOs assigned to the project, as well as the determination and initiative of every soldier, were paramount in the success of this mission. We learned a great deal about ourselves, construction, and working in foreign environments. The Deployment Training Exercise program provided, without a doubt, the best individual and collective training available to engineer soldiers.

We learned several important points during this project that are worth sharing:

First, there is no substitute for well-conditioned soldiers. The engineer soldier must be physically and mentally conditioned to cope with the hardships that must be endured in adverse environments.

Second, both officers and NCOs must be able to understand the scope of the mission before they can carry out the subtasks so as to ensure the mission's success. Engineer leaders must give mission orders and allow subordinates to be ingenious and creative in their work.

Finally, units working on technically complex projects can benefit from the expertise and experience of members of the area and district Corps of Engineers offices to ensure the successful design, planning and execution of the mission. Engineers who understand the entire system, each subsystem, and the interfaces among them, must be an integral part of the design and system start-up process.

Raising a pipeline to the top of a 2,500-foot mountain may have been a tough job—but planning, cooperation, and the perseverance and dedication of engineer soldiers proved again that we engineers rarely find any job impossible.

CPT Jim Balocki is currently assigned to the 52d Engineer Battalion (Combat Heavy), serving as the Civil Engineer. He holds a BS degree from the University of Washington, and an MS from USC and is a registered professional engineer in Virginia.

1LT Michael Malsom is currently a platoon leader with the 52d Engineer Battalion. He is a graduate of Oregon State University and OCS.

Engineer Solution

Solution to Question #1

The data from the in-situ soil yield a grain size distribution graph (on DD Form 1207) from which you find these critical soil sizes:
D(85) = 1.46 mm; D(50) = 0.17 mm; D(15) = 0.026 mm

The data from the proposed filter soil yield a grain size distribution graph from which you determine these critical soil sizes:
D(85) = 10.7 mm; D(50) = 2.1 mm; D(15) = 0.2 mm

a. Determine whether filter soil is unable to wash through the CMP perforations:
D(85, filter)/hole diameter = 10.7 mm/9.5 mm = 1.1 > 1.0
Answer: Yes.

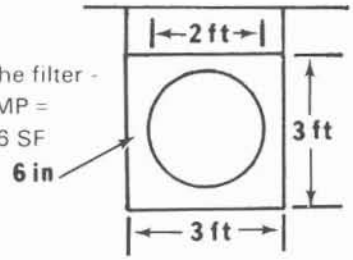
b. Determine whether in-situ soil is unable to wash through the filter:
D(15, filter)/D(85, soil) = 0.2 mm/1.46 mm = 0.14 < 5, and
D(50, filter)/D(50, soil) = 2.1 mm/0.17 mm = 12.4 < 25
Answer: Yes.

c. Determine whether there is sufficient permeability in the filter for free water to reach the pipe:
D(15, filter)/D(15,soil) = 0.2 mm/0.026 mm = 7.7 > 5
Answer: Yes, the proposed filter soil is acceptable.

Solution to Question #2

The thickness of filter material should be a minimum of 6 inches around the circumference of the drainpipe:

The cross-sectional area of the filter materials is calculated as—
Area enclosed by the perimeter of the filter -
Area defined by the 24-inch CMP =
3 ft x 3 ft - $(\pi/4)$ x (2 ft)^2 = 5.86 SF



The volume of the filter material (well-compacted around the drainpipe) is the product of its cross-sectional area and its length:

2,000 m x 3.28 ft/m x 5.86 SF = 38,400 CCF
Since 27 CCF = 1 CCY, 38,400 CCF = 1,420 CCY

Considering losses of filter soil during loading, hauling, and placement, one should add a reasonable waste factor. A value of 10 percent of the volume is a sensible factor, so the project will require 1.1 x 1,420 CCY = 1,560 CCY of filter soil.

The S-2's estimate was for in-place soil. To convert the compacted volume of filter soil to in-place volume, multiply 1.05 x 1,560 CCY = 1,640 BCY.

Answer: You have enough filter soil to properly construct the drain.

Reference: Chapter 4, FM 5-541, *Military Soils Engineering*, May 1986.

Problem submitted by MAJ Randy Rapp, Staff Officer, HQDA, ODCSOPS, Force Development Directorate.

Army Well Drillers in the Rapid Deployment Force

by LTC Bruce A. Malson and CPT David O. Carberry

The Quartermaster Corps can transform foul muck into potable water. But surface water must be available before Quartermaster Corps personnel can go to work, and many areas have none. Desert operations, for example, require massive logistical support if water has to be brought in by pipeline or other means. The best option is to find water in the area of operations—often, well drilling is the right solution. Today's Army can put completely-equipped well-drilling teams on the ground wherever and whenever they are needed.

Reorganizing for rapid deployment

A focussed organization for well drillers has been reactivated in the Army after a post-Vietnam hiatus in service. Three of its active well-drilling detachments originated after 1980 and were assigned to the 548th Engineer Battalion (Combat Heavy) and Fort Bragg in June of 1985. The 6th Detachment is based in Panama.

The 22d Detachment originated at Fort Campbell, Kentucky, in January 1981. The 38th Detachment originated at Fort Riley, Kansas, in December 1983. The 865th Detachment originated at White Sands Missile Range, New Mexico, in October 1982. After attending several schools, including the Navy Well Drilling School, these units deployed to sites in the Continental United States and in Honduras, where they successfully completed numerous wells.

The Army drillers then consolidated at Fort Bragg to train and deploy. The past 15 months have witnessed deployments to four states and two continents. The result has been improved technical skills and ability to sustain operations. The Army's goal is to have three detachments that can deploy independently and sustain well-drilling operations for 15 days. The right repair parts are the key to sustaining operations. Through each training event the list of parts is refined. Simultaneous deployments to New York and Virginia in August 1986 validated the current repair parts over-pack and identified the few additions still needed.

Well-drilling team configuration

Since joining the 548th Engineer Battalion in June 1985, the well drillers have lived the battalion motto—"our jobsite—the world." They are on standby to go anywhere, anytime, to drill wells up to 1,500 feet deep.

Each detachment is authorized five personnel. The central piece of equipment is the drilling machine. The crew's most critical function is maintenance. "We are unique to the Army by virtue of our mission and equipment. We are our own mechanics. Each man must learn to break down every component of the drilling rig and rebuild it. Often isolated while doing our job, we must rely on ourselves," says SFC Wesley Turner, NCOIC.

The well drillers are organized into a platoon of three detachments. The platoon leader or sergeant accompanies a detachment on deployment. The detachment leader puts his crew to work conducting the actual drilling operations while the platoon sergeant or leader coordinates the mission.

How does the work really go? In a recent deployment to Fort Drum, "It became obvious that we would need additional bearings for the drill rotary table during a maintenance break. 1LT Sullivan was able to obtain them in one day while we carefully sustained the drilling, so no time was lost," explains SSG Dennis Huff, NCOIC of the 38th. "The detachment leader is the technical expert, the man who makes it happen. I keep him properly resourced and the wells go in," added 1LT Tim Sullivan, platoon leader.

Well-drilling operations

The unit's first action on site is to dig mud pits—two holes measuring 6 feet long by 4 feet wide and 4 feet deep. Mud is produced by combining a slurry mix with water. Its purpose is to prevent the well from collapsing during drilling, as well as to bring up debris created by the rotating drill bit at the well bottom. The mud's density is easily adjusted by adding more slurry mix or water.

Next, the soldiers prepare the drill rig and attach a drill bit. The size of the bit depends on mission requirements and geological conditions, but can be over 10 inches in diameter. When drilling begins, the drill rig can exert over 5,000 pounds of pressure to force the bit into the earth with a rotary action. A powerful mud pump pushes mud to the bottom of the hole through the drilling stems, forcing mud to surge up through the hole and then to the mud pits where sediments can settle out. The mud is then cycled back through the pump and into the hole to repeat the process over and over.

As drilling proceeds, soldiers take samples every 5 feet to record the drill's progress. The mud flowing out of the hole is strained for samples of the material that the bit is boring through. "This allows us to identify the aquifers. When we bring up rounded gravel and sand mixtures, it is a pretty good bet we have reached a water-bearing formation," explains SGT Steven Johnston, the 22d's NCOIC. The first sign that a good water source has been reached is often a marked reduction in the density of the mud. This indicates that ground water is diluting the mud.

The full five-man detachment works together to establish drilling operations. Within 12 hours of arriving on site, the soldiers are operating the rig in round-the-clock drilling. Two-man shifts work 12 hours each. The rig stops only for maintenance, which takes up 4 to 6 hours a day. While two men work, the two or three others perform peripheral support tasks—picking up supplies or catching some sleep. Because the current organization is so physically demanding for the crew, the modification table of organization and equipment (MTOE) is currently being reviewed to consider authorizing nine personnel for each detachment.

Finishing the well

An important part of the well drillers' mission is finishing the well. This includes emplacing steel casing through the depth of the hole—a gravel packing around the entire length of the steel casing—emplacing the pump and galvanized steel pipe to carry the water out of the well, and a sanitary cement cap around the top of the well.

First the soldiers ream the hole by blowing air through the drilling stems. The air rises, forcing debris up and out. When the hole is relatively free of debris, the crew puts casing in the hole. The 20-foot sections of steel casing include screens that let water into the well. Next, the soldiers pack pea gravel (⅜-inch-diameter gravel), around the outside of the casing all the way to the bottom. They then set the pump within the casing, and install a sanitary cement cap around the top of the well. Finally, the crew adds electrical power with a generator, and the well is ready to produce water.

The material used to finish wells comes from a well-completion kit. Kits are currently stocked in Pueblo, Colorado, awaiting contingency missions. Each kit requires six to eight tractor-trailer rigs for transportation. Each contains materials to finish almost any size well to a depth of 1,500 feet. Adjunct equipment includes a 30-kilowatt generator and various size water pumps. In the event of a deployment, this kit is shipped to the drilling site.

Finding water

Well-drilling engineers are not trained to select sites for water-producing wells. During Bright Star 85, an Army geologist was responsible for selecting a site location. Geological survey maps are used when possible, but often the most valuable source of information proves to be local inhabitants. By asking about existing wells and their depth, the well drillers have a little more to go on. If no information is available, well drillers make an estimate by studying the local geography and then recon by drilling.

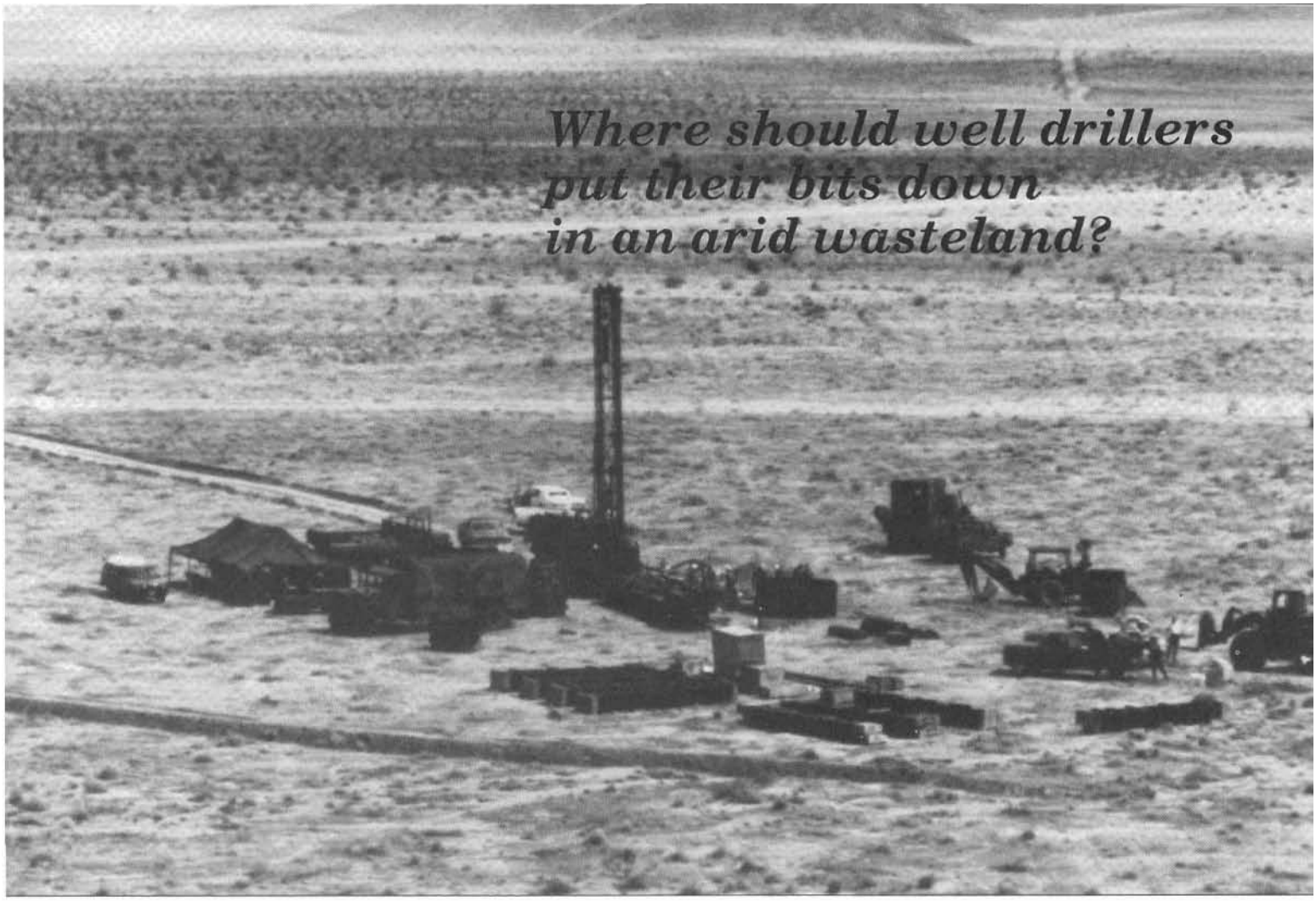
Lighter equipment planned

The future promises new equipment for well drillers. Detachments will be refitted in FY 88. The proposed rigs will be capable of drilling to 600 feet, and will be transportable with C141 aircraft. This provides a significant advantage over current models that drill to 1,500-foot depths, but require C5A aircraft for transport.

Today and every day, the 22d, 38th, and 865th stand ready to go anywhere to perform their mission. Their four reserve counterparts are also available for well-drilling missions. The story of the well drillers is one of increased readiness for arid area operations. After 2 years of training and deploying from Fort Bragg, they can say to the Army: ***We're ready to produce oases on order!***

LTC Bruce A. Malson is the deputy commander of the 20th Engineer Brigade at Fort Bragg, North Carolina. He previously commanded the 548th Engineer Battalion (Combat Heavy). Before attending CGSC, LTC Malson served in the 237th Engineer Battalion in Heilbronn, Germany. He is currently completing a PhD at New York University.

CPT David O. Carberry commands Company A, 548th Engineer Battalion. He served as platoon leader and company Executive Officer with the 82d Engineer Battalion in Bamberg, Germany. He holds a BS in mechanical engineering from Clarkson College of Technology, and is an EOAC graduate.



Water in the desert

by CPT Michael G. Monnett

Gone are the days of "water discipline" when we thought soldiers could teach their bodies to make do with less water. We have learned that soldiers in training and combat need plenty of water to survive, fight, and win.

This is particularly true for soldiers operating in hot, arid environments like the one the U.S. Central Command (USCENTCOM) worked in last summer during Gallant Eagle 86. Held in southern California in July and August, Gallant Eagle 86 gave interservice forces an opportunity to deploy, conduct, and support sustained joint military operations from multiple locations in a desert environment.

Like any other desert operation, this exercise had a big thirst. One way to get water was to drill wells—but where should well drillers put their bits down in an arid wasteland?

THE WATER RESOURCES SUPPORT TEAM

Mr Allen DeWall, team leader for the Water Resources Support Team, Terrain Analysis Center, Engineer Topographic Laboratories, Fort Belvoir, VA, supplied the answer. "We support Army operations by sending a research team to find areas that have a high probability of containing water."

To carry out that mission, the team has a geologist, hydrologist, and geophysicist, and is broken down into four elements. The data base element looks at existing water resources. The remote sensing element analyzes imagery to determine probable water sites. The geophysics element provides the main effort at the location. The fourth element is someone familiar with the local area and the language of the natives.

For Gallant Eagle 86, the team deployed to Fort Irwin, CA. Its mission: find water for a joint drilling operation by the 425th Engineer Detachment, an Army Reserve unit from Dallas, TX, and the 820th Civil Engineer Squadron (USAF), Nellis Air Force Base, Las Vegas, NV.

Imagery survey—

Before the team deployed, its members looked at all available imagery—satellite or aerial photos, maps, and surveys. "Where there's

life, there's water," DeWall said. "We look for drainage patterns, springs, anywhere water might go underground."

In some of these areas the team also looks for indications of fault lines. Water tends to travel down faults, and where they intersect, there's a good chance water has collected.

Resistivity testing—

Once on the ground, the team goes to each likely source of water and conducts electrical or magnetic field resistivity tests. If there is water in a formation, resistance is lower. If the water is salty, it's far lower; if the aquifer is dense—clay, for example—resistivity is higher.

There are two methods of measuring the resistances of strata underground. The older method, called electrical resistivity, consists of sending an electric current through the ground and then recording the return, much the same way a meter can read the amount of current passing through resistors in a circuit board.

The other method, Transient EM, is much newer. "Instead of generating a current through the ground, Transient EM creates a magnetic field," DeWall said. "When the current that creates the field is shut off, the field collapses, generating another current in its wake. We measure that current as it dissipates into the ground."

THE DRILLING SITE

At Gallant Eagle, the team chose a closed basin where the water was likely to flow in from all sides. They felt almost 100 percent sure of hitting water here, since there were two existing wells in the area. The water they expected to find had collected over many years to form an underground lake, or aquifer.

The process of finding water, however, is never a certainty. "All we can deal in is probabilities," DeWall cautioned. "We can say that there's an 80 percent probability that a location has water, but we just don't know unless drilling is successful."

To drill and find nothing is not an infrequent occurrence. As for the team at Gallant Eagle 86 site, the water rising at the desert well was ample evidence that their search techniques could be real thirst quenchers.



The only sure way to find out if a formation holds water—drill for it!

CPT Michael G. Monnett was commissioned as an Air Defense Artillery Officer in 1987. He has served with the 82d Airborne Division at Fort Bragg, North Carolina, and with the 32d Army Air Defense Command in Germany. He is currently commander of the 13th Public Affairs Detachment, Fort Hood, Texas.

Repairing Historic Gold Camp Road

The worst washouts had eaten 25 feet into the road's outer edge; they bottomed out anywhere from 40 to 70 feet below the road

by 1LT Jeffrey P. Lee

Five relentless hours of summer rain pour 8 inches of seething liquid erosion onto a crumbling mountain road—could you repair the damage quickly if that road was a critical line of communication? C Company, 52d Engineer Battalion (Combat Heavy) of Fort Carson, Colorado, found they could.

Seven miles of Gold Camp Road had been closed for nearly a year after just such a storm. At the request of the U.S. Forest Service, C Company repaired the damage and completed a new drainage system in just 3 weeks, reopening the road for travel in August, 1986.

Originally built as a standard gage railroad in 1901, Gold Camp Road hauled the half-billion dollars of gold ore mined at Cripple Creek, Colorado. The 45-mile-long railroad ran to Colorado Springs at a 3.8 percent grade. It boasted 9 tunnels and 31 trestles. This made it the steepest standard gage railroad—and the most expensive—of its time.

The railroad also attracted a booming tourist business. Its most famous rider was Vice President Teddy Roosevelt, who called his scenic passage "the trip that bankrupts the English language."

After the Cripple Creek lode played out and the train stopped running, a Colorado Springs businessman bought the railroad for its tourist potential. He tore out the trestles



The worst washouts had eaten 25 feet into the road's outer edge.



A D-8K dozer built a pioneer road to gain safe access to the bottom of each washout.

and tracks, making the route into a toll road. In 1939, the road became a free highway known as Gold Camp Road.

The U.S. Forest Service and El Paso County have maintained Gold Camp Road ever since. But when they found contract repair of the 1985 washouts would cost an estimated $250,000, it became clear the road would be repaired later—or never. Then the Forest Service turned to the U.S. Army engineers.

Assessing the damage

The damaged section of Gold Camp Road was comprised almost entirely of weathered and disintegrated granite. The road grade rises smoothly, consisting of an unusual amount of cut and fill construction along the contour of the rugged mountains—the railroad's builders chose to work along mountainsides and canyon walls, rather than along a streambed.

The through fills were the most fragile. Eleven washouts—five of them major—had occurred along the road. The worst washouts had eaten 25 feet into the road's outer edge; they bottomed out anywhere from 40 to 70 feet below the road surface. Washouts occurred where the inslope of the road reversed and the outside edge of a through fill eroded, leaving huge chasms in the road (two of these were only passable by trail bike).

It was critical to redirect the drainage—otherwise new washouts would occur.

The culverts had almost all failed. Built perpendicular to the road at a 2 percent slope and at small diameters (18 inches), most were choked with disintegrated granite.

The disintegrated granite had very few fines and was extremely susceptible to erosion. This soil was made up of Pike's Peak granite, a soil that correlates to a Unified Soils Classification System type SP. In its unweathered state, the granite is characterized by large phenocrysts of flesh-pink microline in a ground mass composed of quartz, oligoclase, and abundant biotite, with numerous trace minerals.

Working closely with a U.S. Forest Service Civil Engineer, C Company decided to install 25 culverts, construct 16 rolling dips, grade 7 miles of road, dig ditches, and repair all washouts.

Rebuilding the road

C Company deployed almost all equipment and personnel from the Heavy Equipment Earthmoving Platoon. The company was supported by two general construction squads, two mechanics, a mess section, and a medic. The unit set up a bivouac at the project site.

The Forest Service supplied culvert and explosives. The Forest Service's civil engineer also surveyed borrow sites, culvert locations, and washouts in coordination with the 52d's staff and surveyors.

Work began immediately on the three largest washouts. A D-8K dozer built a "pioneer road" to gain safe access to the bottom of each washout. Once trafficability was established around each work site, the D-8Ks and MW-24 bucket loaders opened borrow sites, and the M-929 5-ton dump trucks began haul and fill operations. Engineers placed boulders carefully to build shelves from the washout bottom upward, filling voids in the shelves with disintegrated granite material. Using a 6,000-gallon water distributor and a K-300 high-speed compactor (BOMAG), they added moisture and compacted the material in layers 1 to 2 feet deep.

The 52d repaired all washouts this way. Soldiers used a nuclear densometer to test compaction. Samples taken at most sites surpassed the 90-percent CE-55 goal, and often reached 100 percent compactive



Soldiers drill 4-foot-deep holes in granite for demolition charges.

effort. The few sites that were below specifications were reworked to meet the 90-percent goal. The unit nearly doubled the road width at each washout and raised the outside shoulder to create an inslope—this would carry water past the repaired washout. Workers also excavated the inside wall to widen the road and create an insloping surface.

Demolition served to loosen more rock at high elevations in the borrow site, to widen the road through solid rock outcroppings, and to open space for a culvert in solid rock. The unit arrived at a suitable charge after initial tests showed that civilian explosives were relatively weak. The unit used two-component explosives ammonium nitrate and nitromethane. Soldiers drilled holes 1¼ inches to 1½ inches in diameter with a 250-cubic-foot-per-minute air compressor and rock drill. The most effective charges were set 4 feet deep and weighed 4 pounds each. These charges were placed along natural joint patterns and in structural deformations, to take advantage of weaknesses in the rock formations. The charges were packed and tamped with moistened soil.

It was critical to redirect the drainage—otherwise, new washouts would occur. The 52d insloped the entire stretch of road to protect the fragile through fills. They used 130-G graders except on the upper, rockier sections, where D-8K dozers cut the initial rough inslope.

The unit installed culverts where existing culverts had failed or where drainage already flowed from the inslope to the outer shoulder. To enhance self-cleaning of disintegrated gravel, the engineers set the new culverts at a 10-percent slope and at an angle instead of perpendicular to the road. The new culverts were also 24 to 36 inches in diameter—wider than their predecessors. The unit placed culverts in stable natural drainage channels. The inlets were covered to a depth of at least half the culvert's diameter, and both inlets and outlets were riprapped with granite. A D-8K dozer with a single ripper dug culvert trenches in rocky areas; otherwise, a backhoe was used. Culverts became the most time-intensive aspect of the project.

The engineers built rolling dips with a 621-B scraper. The scraper excavated the outer shoulder and used the fill to build a berm just below the dip. A grader worked the material into a crest to prevent water from passing the structure. The rolling dip would then act as a culvert, forcing the insloped drainage across the road to exits in level areas that would allow water to dissipate naturally.

Upper stretches, where rough rocky outcroppings were the road surface, were resurfaced using 621-B scrapers to spread lifts of select disintegrated granite material. Final work included leveling and landscaping all borrow sites. Damaged trees were removed and culvert inlets cleaned and widened.

On August 7, 1986, Gold Camp Road reopened. The 52d finished the project on schedule in just 26 days, 23 of which were spent on construction operations. The equipment-intensive project gave operators and supervisors invaluable experience of engineer tasks they'd have to perform in a wartime mountain road construction or repair mission.

1LT Jeffrey P. Lee is currently the Heavy Equipment Earthmoving Platoon Leader for C Company, 52d Engineer Battalion (Combat Heavy). He has worked on projects in Honduras and at Fort Carson, Colorado. He has also given tactical engineer support to brigade-size elements. 1LT Lee holds a BS in geophysical engineering from the Colorado School of Mines.

Engineer Cellular Teams

by CPT Steven R. Steininger

Some specialized tasks are beyond the capability of standard unit organizations. For these tasks, the Army has created the Engineer Cellular Teams (TOE 5-500 series) to be employed on an "as-needed" basis in any theater.

The TOE 5-500 Series

The complete Tables of Organization and Equipment for these units are often hard to obtain in the field. Field Manual 5-100, *Engineer Combat Operations*, describes many of the cellular teams. This article focuses on construction-oriented teams: TOEs 5-520-H and 5-530-H. Several common planning factors affect engineer teams, and should be known to commanders and staffs alike.

Construction team planning

Some engineering missions of the combat heavy battalions will be deleted when they reorganize in mid-FY 88. The Army recognizes the importance of retaining such engineer skills as quarrying and paving, forestry, power distribution, and diving. But we cannot dedicate units to these missions in every brigade or battalion.

Some cells deserve separate discussion, but most share common resource and management needs—especially maintenance, supply and logistics, and personnel and administration. All have some operational limitations. To integrate a detachment successfully, managers must contact the cellular teams and investigate their needs.

Maintenance. Some of the larger detachments have an organic maintenance crew. Often the crew (or mechanic) works only on equipment unique to the team. Repairs to engineer vehicles and equipment (radios, weapons, cargo trucks) must be made by some other element.

The simplest way to deal with maintenance needs is to attach the team to a support or line company. This approach challenges the supporting company—the organizational shop is now responsible for more equipment and vehicles. The prescribed load list (PLL) will be drained faster, so stocks should be beefed up before a team arrives, and needed PLL item lines should be added to accommodate unusual equipment needs.

A bigger workload means the direct-support shop has to alter its scheduled services. Priorities will change (Engineer teams have a high visibility—everyone wants to see them work). Leaders will have to be resourceful to overcome the challenges without seriously hampering operations or affecting morale.

Special detachments can also be sent to the team from the direct-support shop. This works well when the team is away from its support unit. Problems can arise with POL and PLL supply and personnel and tool loss to the direct-support shop.

Logistical support. Since many teams have no organic supply sections, cellular teams are totally dependent on the unit to which they are attached for logistical support. This is true of all classes, especially Classes III, IV, V, and IX. POL is a major item. Heavy equipment burns diesel fuel quickly, and requires quantities of lubricants and fluids, some of which are unusual.

Major end items (Class VII) may also present challenges. If an indispensable element of the team's system becomes a total loss, the whole operation may collapse unless a suitable replacement is available.

Detailed coordination and planning that includes representatives

from operations, logisitics, and maintenance can forestall crises by ensuring that a team and its support unit are not hampered by supply interruptions.

Personnel support. Personnel support and administration often get overlooked. Contact between the S-1 (XO/1SGT at company) of the host unit and the inbound attachment is critical. For the duration of an operation, a team is dependent on the unit to which it is attached for finance, replacements, personnel actions, and for legal, mail, religious, medical, and food service. Nothing is so painful as a soldier with a problem. An early list to the S-1 (XO/1SGT) of names, rank, SSN, MOS, and next of kin can avoid trouble later.

Security. Several common threads also run on the operations side. Teams do not have crew-served weapons. Their only self defense is small-arms fire. If a team is to be included in a larger defense plan, remember its limits. If weapons are provided, training must be provided too.

Camouflage and NBC are another grave concern. Only a few teams can conceal themselves. This is partly because they have no screening systems, but mostly because of the nature of their work (quarries are hard to hide). These engineer crews are highly susceptible to attack. Most are equipped to detect NBC weapons and protect their people, but not to decontaminate and/or continue operations in an NBC environment.

Communications. Although some cellular teams have organic communications, many do not. S-3s like teams to have radios. Communication gear and personnel are prized commodities throughout the Corps. It is likely that the supporting unit will have to give up gear, if outside assets are not brought in.

Transportation. Some units have enough vehicles; some can hardly even move their people. Most require assistance—much of the machinery is oversized and has special movement problems. A few items will not fit on any available USAF planes. Transport planning must start early.

Cellular teams

The teams designated under the 5-520H/530H TOE series are built to work in forestry, quarrying, well drilling, concrete paving, equipment support, pipelines, power lines, power plant operation/maintenance, asphalt mixing and paving, diving, utilities, and real estate.

Engineer teams perform many integral unit functions. The tasks that set them apart can be found in ARTEP 5-500, *Engineer Cellular Teams*. Though aging, it still provides good information to the operational planner. ARTEP 5-115, *Engineer Combat Heavy Battalion*, will define quarrying and asphalt missions until a new ARTEP 5-500 is published. Some detachments deserve a closer look.

Forestry. Attached to an engineer group, a service and support battalion, or operating semi-independently, this platoon-size section produces rough lumber and timber piling. It cannot deliver its products without added transportation support. With small maintenance and supply crews, the forestry crew functions better.

Quarry. Only the 225-ton-per-hour (tph) quarry unit is currently organized as a team. Once the combat heavy battalions surrender the remaining 75-tph sets, another quarry team will be created (2 capacities will be available until standard new equipment is in place). Both types are similar to current 75-tph squads found in the combat heavy units. Actual sizes of specific machines vary.

All units require transportation support and need numerous trips to haul everything. The 225-tph crush/screen/wash unit exceeds USAF capacity. Quarry units are normally attached to an engineer group, but can be expected to move down to battalion level in the future.

Well drilling. These are some of the most active teams today. For a complete picture, see "Army Well Drillers," on p. 23.

Concrete mixing and paving. Normally attached to a combat heavy battalion or construction support company (CSC), this team has its own 100- to 125-cubic yard-per-hour (cyh) central mix plant, a 200- to 225-cyh central mix plant, a 200- to 225-cyh slip form finishing machine, and organic maintenance. The team does not, however, have all the laborers needed to run a concrete operation. Added transport is needed to move the finishing machine.

Equipment support. These one- to two-man teams with either a dozer, scoop loader, or grader can be attached to engineer line companies working with maneuver units. All require support because of their size.

Asphalt paving and mixing. Two new cells are now available. One is the asphalt mixing team, built around the 100- to 150-tph asphalt plant, which produces asphalt cement concrete (ACC). It requires significant time, labor, and support to transport and erect.

The second is the asphalt paving team. It primarily places hot mix ACC to yield a quality surface for roads and airfields. The team can place cold mix materials and support bituminous surface treatment operations. Although it is self-mobile, the cell lacks dump-truck assets to move paving material. Both teams will be attached to groups, battalions, or CSCs.

Diving. Diving detachments may be placed almost anywhere, but normal engineer assignment is to a group or brigade involved in major port or underwater pipeline projects. The teams can dive in both SCUBA and deep sea underwater surface-supplied diving equipment in support of numerous tasks. These teams are currently under reorganization—organic sections in fixed units will disappear and become part of the modular concept.

Utilities. These cells sustain base-camp operations and fixed

Hotline Q & A

Q. How can my unit obtain the Engineer regimental crests? How should the crest be worn with the uniform?

A. Corps crests are currently only available through the Army-Air Force Exchange System (AAFES) military clothing sales stores. If a unit desires to purchase crests for its soldiers, it should place a local purchase order with an AAFES clothing store. Units may also contract with private vendors; however, crests may not be purchased with appropriated funds. Ultimately, enlisted personnel will receive the crest as part of their initial issue through the supply system.

Males must wear the crest centered and ⅛ inch above the top of the right pocket flap or ½ inch above unit awards or foreign badges on the Army green, blue, and white uniforms. On the blue mess uniform, the crest is worn centered on the satin facing and ½ inch below the notch in the lapel. On the white mess uniform, it is worn ½ inch below the notch and centered on the lapel. The vertical axis of the crest must be perpendicular to the ground.

Females will wear the crest centered and ½ inch above the nameplate or ½ inch above unit awards or foreign badges on the Army green, white, and blue uniforms. It is worn centered on the right side of the white, blue, and black mess jackets between the lapel and shoulder seam with the top of the crest aligned with the top row of miniature medals. On mess uniforms the crest is not worn on the lapel or the lapel facing. The vertical axis of the crest will be perpendicular to the ground.

All members of the Corps who have completed advanced individual training, warrant officer certification, or engineer officer basic course are authorized to wear the crest. All personnel who held an engineer MOS before 23 June 1986 are automatically members of the Corps and authorized to wear the crest.

Q. How can my unit get an 80-foot timber trestle training bridge? Can this bridge be requested by national stock number?

A. The Engineer School's Department of Military Engineering, Bridging Branch, responds that the costs and national stock numbers for trestle training bridges are available in Army Facility Components System manuals. Although plans for an 80-foot bridge are not available, the costs for a 60-foot span and for two 40-foot spans with intermediate support appear below.

- A 60-foot steel stringer span, military load class 60, timber pile abutments:

#8512OAE	Superstructure	$48,129
#8512OCJ	Abutments (2 ea)	7,872
Total Cost		$56,001

- Two 40-foot glue laminated stringer spans, 2 lanes, military load class 60, timber pile intermediate support abutments:

#8512OBG	Superstructure (2 ea)	$110,656
#8512OEW	Intermediate support 20 feet high	4,720
#8512OCJ	Abutments (2 ea)	7,872
Total Cost		$123,248

These amounts are in 1986 dollars as referenced from TM 5-301-1, *Army Facilities Component System-Planning (Temperate)*, pages 10-56.

Q. When M-1 tanks cross an AVLB 60-foot span bridge, do the curbs have to be removed?

A. The curbs remain on the bridge to guide the vehicles across. The maximum span of the AVLB is 15 meters for support of M-1 tanks.

installations by providing facilities and engineering (FE) support. Three teams—HD, HE, and HF—are designed for installations of up to 2,500, 2,500-4,000, and 4,000-10,000 personnel. The teams have some construction capabilities, though their main mission is to maintain existing systems, health, and welfare. They can also maintain their own equipment. All are found in facilities engineer groups (TOE 5-203J) but may also appear elsewhere.

Power Line. Since the power distribution section of combat heavy support companies is disappearing, this team will take over general engineering tasks such as airfield lighting systems and exterior electrical distribution. Normally allocated to an FE group or power generating plant (often with team HG, Power Plant Generation and Maintenance), these high-voltage specialists may be attached to combat heavy battalions.

Other Construction Teams. Teams HC (Real Estate), HG (Power Plant), and HJ (Welding Inspection) also assist the construction effort. Their contributions are often critical to overall success.

Engineer cellular teams deserve more attention. As the role of the component-like detachments increases, we must learn to integrate them smoothly into other units. The thinking behind the teams is good: If commanders, staffs, and planners manage them correctly, cellular teams can make vital contributions to engineer missions.

CPT Steven R. Steininger is currently assigned to the 54th Engineer Battalion in West Germany. He has also served with the 802d Engineer Battalion in Korea. CPT Steininger holds a BS in mining engineering from the University of Pittsburgh, and is an EOBC and EOAC graduate.

The Three-Phase Inspection System— The Corps Guarantee of Built-in Quality

by CPT Thomas P. Reed

The U.S. Army Corps of Engineers has been in the construction business since the birth of our nation. Fort McHenry and Fort Meigs—sturdy monuments of the Corps' reputation for excellence—date from before the War of 1812.

Today, the Corps of Engineers' work includes a broad variety of civil and military construction projects, and a comprehensive system of quality assurance for its worldwide construction program. Billions of dollars worth of structures now uphold the Corps' standard of excellence in dozens of nations.

The three-phase inspection system is an important part of the Corps' quality assurance program. Common practice in the construction industry, the system is simple to understand and to implement. It can be applied to any construction project regardless of its size or complexity.

The three-phase system

The three-phase inspection system includes a preparatory, initial, and follow-up inspection:

The preparatory inspection. The first and most important phase of the three-phase inspection system is the preparatory inspection. It takes place before each distinct feature of the project is begun. In this phase, the supervisory and quality control personnel agree on the plans and specifications. They review construction methods, and ensure that personnel, equipment, and available materials comply with the project specifications.

Inspectors review plans for quality control tests or samples, and any documentation—such as certifications of the quality of materials to be used. They inspect the work site, and settle all issues surrounding plans, personnel, equipment, and materials before construction begins.

The initial inspection. The second phase takes place as construction begins. Inspectors take samples, perform control testing, and examine the work to ensure that the quality of construction is in accordance with plans and specifications. Construction methods can be adjusted to meet time limitations or other conditions that arise during the initial inspection.

The follow-up inspection. The third phase of the inspection goes on continuously until the construction sequence is complete. The work is inspected daily, using the same procedures established during the initial inspection. Deficiencies are corrected immediately.

A typical project

Here's how the three-phase inspection system is implemented by an engineer squad as they build a concrete tank pad. This project—like many other engineer construction tasks—requires prepared formwork and placement of concrete.

A three-phase inspection has already assured the formwork is adequate. The second sequence will be concrete placement. A day before the ready mix concrete is delivered and placed, the platoon sergeant holds a ***preparatory inspection*** with the squad leader.

During this inspection, the platoon sergeant reviews the requirements for concrete, personnel, and tools. He ensures that the process for placing, finishing, and curing the concrete will be in accordance with the appropriate technical manual (FM 5-742). He decides with the squad leader how many sample cylinders and slump tests are to be taken. Finally, the squad leader and platoon sergeant discuss any questions or doubts either may have about the concrete placement.

The platoon sergeant conducts an ***initial inspection*** during the first concrete placement. He ensures the methods used to place, finish, and cure the concrete are proper. He also checks the concrete's temperature, slump, and drop height. The squad leader takes sample cylinders as planned in the preparatory inspection. This inspection is complete after the methods used to place, finish, and cure the tank pad are verified.

The platoon sergeant conducts a daily ***follow-up inspection,*** continuing to monitor the temperature, slump, drop height, and the quality of the finish for each concrete placement. The squad leader continues to take samples on a regular basis. His test cylinders are broken 7 days and 28 days later to check the strength of the concrete.

The result?—a structure guaranteed to stand up under the wear and tear imposed by heavy loads.

The three-phase inspection system provides a systematic approach for quality control. It assures quality products by requiring detailed preparation, review, and inspection of each step toward a completed structure—whether that structure is as simple as a sidewalk—or as complex as the Grand Coulee Dam.

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Past in Review (continued from page 45)



Rome Plows easily felled trees in the dense Vietnamese jungle.

falling limbs, trees, and brush. This tractor and blade, soon known all over Vietnam as the "Rome Plow," became the mainstay of tactical land-clearing units in Vietnam.

The Rome Plow's blade was supported by shoes mounted on the bottom of the blade. Thus it rode about 6 inches above the ground, eliminating standing vegetation but not pulling up the roots or digging into the earth. The Rome Plow could slice through a 12-inch tree with one pass. Repeated passes by the knife-like stinger mounted on the left side of the blade felled trees up to 48 inches in diameter.

Land-clearing units

The Rome Plow force grew from the original four test plows of 1966 to three platoons, each with thirty plows, by the summer of 1967. In January 1969, the force reached its peak strength—six full companies with thirty plows each. Three of these companies operated independently under the 18th Engineer Brigade and supported I Field Force in the central highlands of Vietnam. The other three companies formed the 62d Engineer Battalion (Land Clearing) under the 20th Engineer Brigade, and supported II Field Force in the lowlands north and northwest of Saigon.

The 62d Engineer Battalion was designed to work in the large tracts of relatively level jungle found in the III Corps Tactical Zone, an area with a well-established road net and a large force of enemy soldiers.

The tactical land-clearing concept directly addressed the need to operate on Vietnamese terrain; its success owed much to the fact that techniques and doctrine were tailored in the field. The Rome Plow companies' organization, for example, was based directly on results of the field tests run in 1966.

These tests showed that platoons had too little maintenance support and too few operators to use an optimal number of plows. Since adequate maintenance was clearly critical for successful operations, the land-clearing companies formed in 1967 were given adequate organizational and direct-support maintenance. The company organization included enough operators to keep thirty tractors functioning.

Tactical operations

Land-clearing operations were of two kinds—area cutting and strip cutting. These operations fit two missions: 1) Clearing extensive areas of vegetation to deny cover where enemy activity was suspected, and 2) Clearing vegetation along roadways, trails, airfields, and installations to provide observation and fields of fire and to reduce the danger of ambush.

Area cutting operations. Area cuts were aimed at enemy supply and base areas and infiltration routes, and were usually conducted by company-size units. Guided by an officer in a helicopter overhead, a plow operator cut an outline of the area to be cleared. The other tractors followed counterclockwise around the delineated area, forcing debris to the outside. Using this method, a land-clearing company could clear 150 to 200 acres a day, depending on enemy action, the terrain, and maintenance problems.

Strip cuts. Strip cuts helped secure lines of communication (LOCs) and installations by clearing the jungle for 200 meters on either side of roads and trails or around base areas.

Security measures. Land-clearing companies had to provide themselves with flexible bases for operation. They established a nightly defensive position (NDP) with centralized maintenance and resupply at each project. New NDPs were cut as work progressed so that the tractors would not have to "walk" more than 4 kilometers to the work site.

The enemy was a constant and formidable problem to land-clearing units, which, lacking defensive manpower, relied on infantry or

armor units to provide work-site security. The 62d Engineer Battalion (L/C) found that land-clearing operations worked best as coordinated engineer-infantry-armor operations. The unit posted two infantrymen on the lead tractor during operations to recon the jungle by fire.

Rome Plow operators often found themselves clearing the jungle far ahead of their infantry security. They carried .45-caliber submachine guns to protect themselves against enemy attack, since the standard issue M16 was too long for the enclosed cab.

Most casualties suffered by land-clearing companies were inflicted by mines, booby traps, and mortar attacks on NDPs. Nearly two-thirds of the men in these companies were wounded by enemy action during their 1-year tours. In a single, 75-day operation, almost 50 percent of one land-clearing unit was wounded. Other hazards included falling trees and limbs, bamboo slivers, snakes, swarms of bees, and extreme heat.

Maintenance and transportation

Maintenance problems abounded. It was common for one-half to two-thirds of the plows to suffer severe damage during an operation. Repair parts were in short supply, and frequently had to be flown in by helicopter. Heavy monsoon rains, thick dust, and constant mortar attacks on the NDPs made maintenance more than a challenge. Most maintenance was done by the company's organizational and direct-support mechanics at the cutting site or in the NDP.

Lack of transportation assets for the Rome Plows limited company mobility. Assigned ten semitrailer lowbeds, a land-clearing company could move only one-third of its plows at a time. In the Mekong Delta, where roads were impassable much of the year and the main supply routes were canals, land-clearing companies used U.S. Navy landing craft and Army M4T6 rafts to move between work sites.

Operation Cedar Falls

Almost immediately, the new units became an innovative assault tool. In the first use of land clearing as direct support of an infantry thrust, they formed the leading edge of the infantry assault in Operation Cedar Falls (January 1967). The 168th Engineer Combat Battalion, with 15 bulldozers and 2 Rome Plows, was joined in the attack by 35 bulldozers and 2 Rome Plows from the 1st, 27th, 86th, and 588th Engineer Battalions.

The operation's mission was to drive the enemy from the Iron Triangle, northwest of Saigon. Tractor teams plunged into the jungle to open a path for mounted and dismounted infantry assault forces. As dozer and infantry columns advanced, the engineers leveled enemy base camps and supply areas and established helicopter landing zones for resupply and casualty evacuation. When Cedar Falls ended, land-clearing companies had cleared 2,711 acres of jungle and had given maneuver commanders an impressive first look at the value of tactical land clearing.

Other operations in which tactical land-clearing teams were part of a maneuver assault force included Junction City (February 1967), in War Zone C, northwest of Saigon, and the Cambodian incursion in May and June 1970. In the Cambodian operation, the 62d led the way with land-clearing operations to provide access to suspected enemy base areas.

Civic action applications

Tactical land-clearing operations provided more than just a means for penetrating the jungle or for making roads and trails safe from ambush. Strip clearing along main supply routes aided villagers on their way to market by eliminating hiding places for the Viet Cong highway "tax collectors."

Besides providing security for military bases, area clearing operations opened heretofore uncultivated land. Vietnamese farmers moved onto cleared land, particularly along roadways, as soon as debris was removed. In one civic action project, the 20th Engineer Battalion cleared more than 2 square miles of forest to make way for Montagnard farmlands and homesites.

Land-clearing units operating near villages had to take care not to disrupt the lifestyle of the inhabitants. The Vietnamese hold land dear, so the U.S. Army learned to avoid unwarranted destruction of wooded areas. Units in the Mekong Delta found that the Vietnamese customarily buried their dead in the woodlines on high ground. Such locations were left undisturbed.

Tactical land-clearing operations were a valuable resource to maneuver commanders in Vietnam, and occasionally benefited the economy of South Vietnam and farmers in the countryside. Tactical planners at first believed that land-clearing operations could deny ambush sites and sanctuaries indefinitely, accomplishing what repeated infantry operations could not.

But the jungle quickly returned, and with it the enemy. A few months after operation Cedar Falls, the jungle and the Viet Cong had returned to the Iron Triangle. Within a year, the enemy used the area as its base for the 1968 TET Offensive attack on Saigon.

For further reading, see: MG Robert R. Ploger, *Vietnam Studies, US Army Engineers, 1965-1970.*

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We the People of the United States, in order to form a more perfect union, establish justice, insure domestic tranquility, provide

for the common defense...

by Penelope Schmitt

Today, the Preamble of the Constitution reads like a catalogue of the excellent habits which our government has steadily improved through practice. Habits. But think—***perfect union*** makes your family's trip from Niagara to Yellowstone a long, unbroken road without border guards. ***Justice*** means that a random inspection stop in your home state is just to check for worn tires, not to scrutinize your identity papers. American nights are ***tranquil***—you travel in your camper, stopping at park after national park with a delicious shiver about bears—but you never worry about roaming guerillas. You calmly share the road with a convoy of National Guardsmen—in another country they might be an army of occupation, or worse, your countrymen engaged in anything BUT the ***common defense***.

It might seem to you that the nightmare possibilities suggested above are purely imaginary. Perhaps you believe that when our founding fathers signed the Declaration of Independence, they merely ratified a way of life Colonial Americans had been living out since the Pilgrims set foot on Plymouth Rock. Not so.

A short tour of the Confederation in the late 1780s shows us the results of government under The Articles. Relations among the states were deteriorating into a series of trade wars. Merchants couldn't send their products across the Hudson from New Jersey to New York without paying import duties. Rhode Island was printing currency that wouldn't buy a glass of water.

Territorial contests abounded. Pennsylvania and Virginia stood nose to nose over ownership of the Pittsburgh area. Vermont blackmailed Congress into granting it statehood by leaking news of secret annexation talks with Canada. Parts of North Carolina and Tennessee seceded, temporarily forming the state of Franklin—a Balkan nation on the outposts of the frontier. So much for a perfect union.

As for justice, domestic tranquility, and the common defense, any feeble illusions the new nation might have had about itself soon shattered. The final blow came when Shays' Rebellion shook New England in early 1787. Cash-poor farmers rose against the state of Massachusetts by the thousands. When neither Congress nor the state could offer them relief, they moved to capture a federal arsenal in Springfield. The uprising was put down by a small cadre of loyal militiamen and a hastily assembled army raised by General Benjamin Lincoln, formerly of the Continental Army.

The incident riveted the determination of leaders who had been pondering the need for a new instrument of government. George Washington and others saw that a congress with no military or fiscal might was powerless to act for order or justice. "Influence," Washington said, "is no government."

In May, 1787, the Constitutional Convention met to begin writing the document which has steered our nation through 200 years of peace, war, prosperity, depression, turmoil, and tranquility.

Twenty-two of the thirty-nine men who would sign the Constitution had served in the Continental Army during the War for Independence. Their conviction of the need to provide for the common defense was founded on a solemn knowledge of the potential for violent disorder. These men, with George Washington as their preeminent leader, ensured that the Constitution was written so as to best protect the people from internal strife, as well as from external intrusion.

The military envisioned by the founding fathers was—and is—a citizen soldiery bound to serve the needs of the nation, obedient to the will of its own people. We came to enjoy perfect union, justice, and tranquility largely because military men saw our need for a common defense. We continue to enjoy those privileges because our Armed Forces still willingly defend and uphold the Constitution of the United States.

Penelope Schmitt is Features Editor for ENGINEER

Revising the Standard Pattern Minefield

by CPT Wayne Whaley

Let's not waste words. We need a standard tactical minefield that reduces time and logistics requirements. Such a minefield has been developed by the 1st Engineer Battalion (Mechanized) at Fort Riley, Kansas.

This minefield can be easily laid from an M113 armored personnel carrier (APC) or a 5-ton dump truck. It is simple to record and clear, though enemy forces find it hard to breach. Adaptable to most terrains, it accommodates both buried and surface-laid mines.

The minefield is more than 100 meters deep, and cannot be breached by standard line charges. It has three belts, and offers the option of variable density without a change in its pattern. It can serve as a building block for longer linear obstacles, and can accommodate a variety of deception patterns. Finally, it is standardized so task-organized units can work together.

Laying the minefield

After a site is selected, break the engineer platoon into teams. Each squad works as a team to lay, bury, and arm mines. The platoon leader and platoon sergeant supervise the operation, record the minefield, make progress reports, and provide local security with the M2 .50-caliber heavy machine gun on the platoon leader's APC.

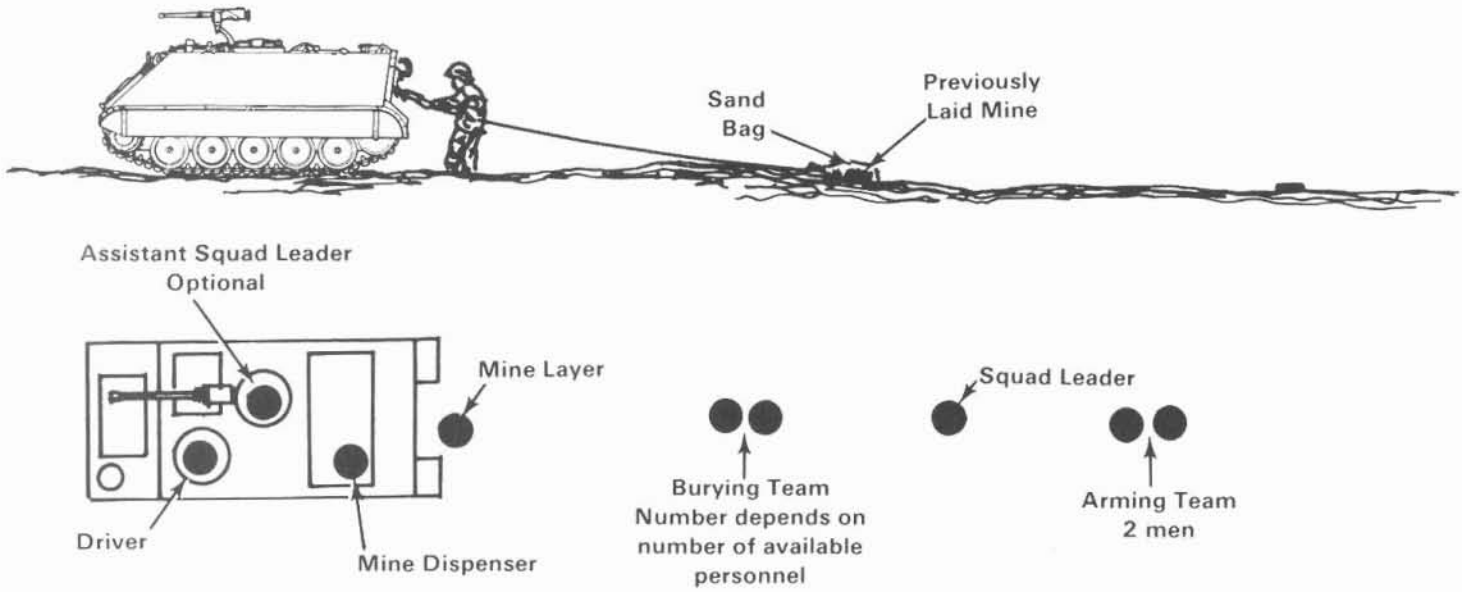
Two squads are broken into subteams as follows: an APC driver, two minelayers (one inside the APC and one outside), a burying team with enough personnel to bury mines, an arming team of two men, and the squad leader. If enough men are available, the assistant squad leader can act as the track commander, man the M2 .50-caliber, and direct the driver and laying team members.

The third squad can provide local security and supplement the working squads, or take the place of working squad members who need to rest or eat. Using the third squad this way enables the platoon to work nonstop, limited only by supplies of fuel and mines. The third squad may also make logistics runs between the work site and the ammunition supply point (ASP) or lay out another minefield under the supervision of the senior squad leader or platoon sergeant.

The direction of layout is decided upon by the OIC or NCOIC, and a base line is established at the starting side of the minefield. A rope 120 meters long, marked with engineer tape at 10, 35, 45, 55, 65, 90, 100, and 110 meters, is laid on the base line and staked down.

The minefield is constructed in three belts. The first belt has two rows; the second and third belts have four rows each. The first squad lays odd-numbered rows, the second lays the even-numbered rows. Rows are 10 meters apart; belts are 25 meters apart. The first mine of the first row of each belt is laid 10 meters from the base line. The second row begins 15 meters from the base line; the third row, 12.5 meters; and the fourth row, 17.5 meters from the base line. Other mines are laid at 10-meter intervals within rows.

To ensure the APC drives in a straight line, the squad leader chooses a landmark as an aiming point. If no landmark is available, the squad leader can erect a u-shaped picket for the driver to sight on. The distance from the base line to the landmark depends on local visibility conditions and the size of the feature. The landmark should be narrow—a building 300 meters away is not a



Equipment and personnel positions during minelaying

good feature to choose, since a variance of 3 to 4 degrees in sightings could lead the driver to veer off course and run into a previously laid row.

To measure distances between mines, attach a rope to the rear of the APC, and tie a sandbag or other weight 10 meters down the rope. As the sandbag passes by the previously laid mine, the mine-dispensing soldier inside the APC hands another mine to the minelayer outside the APC, who can then lay the mine at a 10-meter interval. The minelayer must lay the mine to the side of the rope so that the sandbag does not drag over a previously laid mine. The soldiers proceed in this way until they reach the end of the minefield. At the end of the minefield, the squad leader directs that minelaying stop.

The APC driver moves forward another 20 to 50 meters before returning to the base line to begin another row. He disguises the end of the minefield by varying the location at which he makes his turn. As in all minefields, rows are laid from the enemy side toward the friendly side.

Up to 40 mines may be stored in the APC. After returning to the base line, the squad removes packing material and reloads the APC with mines. A well-trained unit can move with an APC at a speed of between 2 and 4 miles per hour. The platoon can emplace about 200 meters of minefield front per hour, depending on conditions.

The burying team follows the laying team. They dig holes for mines and put the soil in sandbags, to be removed after minelaying is done. Depending on vegetation or snow cover, 10 to 30 percent of the mines are buried. To avoid a pattern of burying every other or third mine, the squad leader decides how many mines per row will be buried, and designates an appropriate number of holes in random sequence.

The arming team arms the mines and installs tilt rods and antihandling devices. They then emplace and camouflage the mines. The squad leader directs the arming team to install antihandling devices in random sequence to avoid creating a detectable pattern. He must let the platoon leader know which mines in the row are buried or equipped with antihandling devices for recording purposes.

Recording procedures

The recording team (platoon leader or platoon sergeant) records the minefield on DA Form 1355, *Minefield Record*. The diagram showing the minefield layout can be preprinted. Mines that are buried and/or have antihandling devices are noted. Since each row holds the same number of mines, the platoon leader need only keep track of which rows are completed to report the percent of minefield complete. Since minefield recording is simplified, the platoon leader and platoon sergeant can spend more time supervising their platoon, and less doing paperwork.

Variations

The minefield can be modified to include turning points, antipersonnel (AP) mines, different densities, and irregular inner rows (IIR), as desired. To include turning points, all rows must turn in the same direction at once, at the same point, and proceed in the same direction for the same distance. If AP mines are to be added, they are emplaced as in the current standard pattern minefield to form clusters. If clusters are added to the minefield, the distance between rows should increase by 10 to 15 meters.

To alter the density of the minefield, the distance between belts should be increased from 25 to 50 meters, or the third belt should be eliminated. The field's density can be decreased where the harassment or protection of unlikely enemy

avenues of approach is intended. Adding mines in an irregular pattern between belts may confuse the enemy. Mines can also be added to the leading edge of the minefield, as in an IIR. This creates an irregular outer edge (IOE). The IIR or IOE should be laid by hand after the minefield is complete. It need not follow any pattern, as long as it is accurately recorded on DA Form 1355. Adding an IOE or IIR slows down the clearing and recovery of the minefield by friendly units.

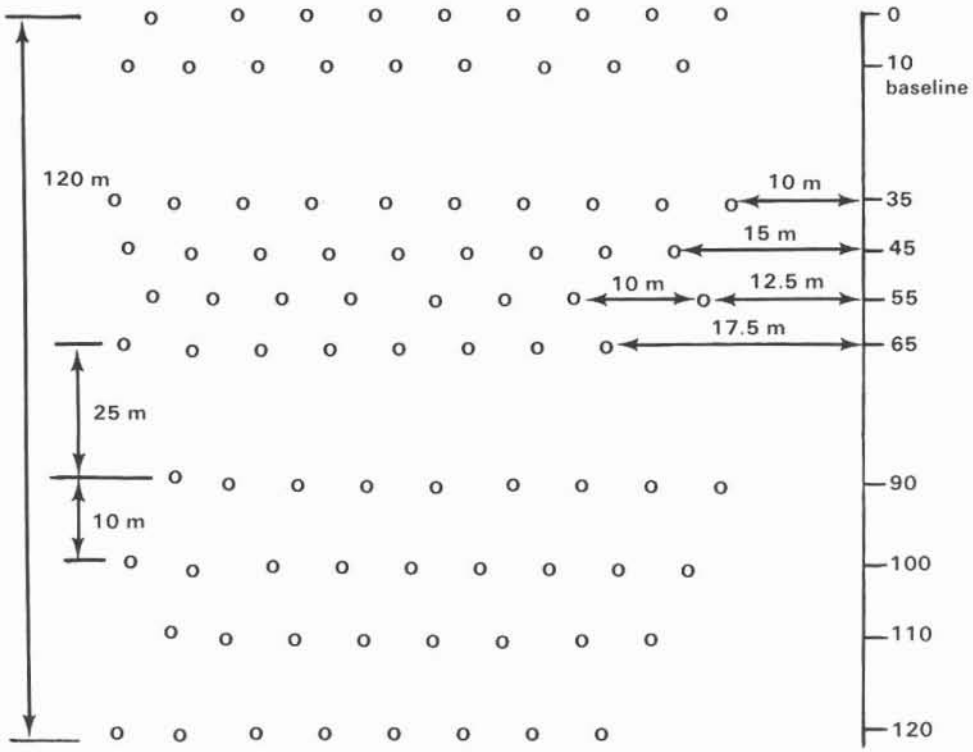
Field experience

The 1st Engineer Battalion minefield has been successfully employed in the field, including at the National Training Center. Several engineer units that have evaluated ARTEPS or have been trained with or evaluated by the 1st Engineer Battalion have decided to adapt this minefield in various degrees into their SOPs. These include the 4th ENG BN at Fort Carson, CO; the 8th and 17th ENG BNs at Fort Hood, TX; the 7th ENG BN at Fort Polk, LA; and the 10th ENG BN in Germany, all of whom are now using this minefield.

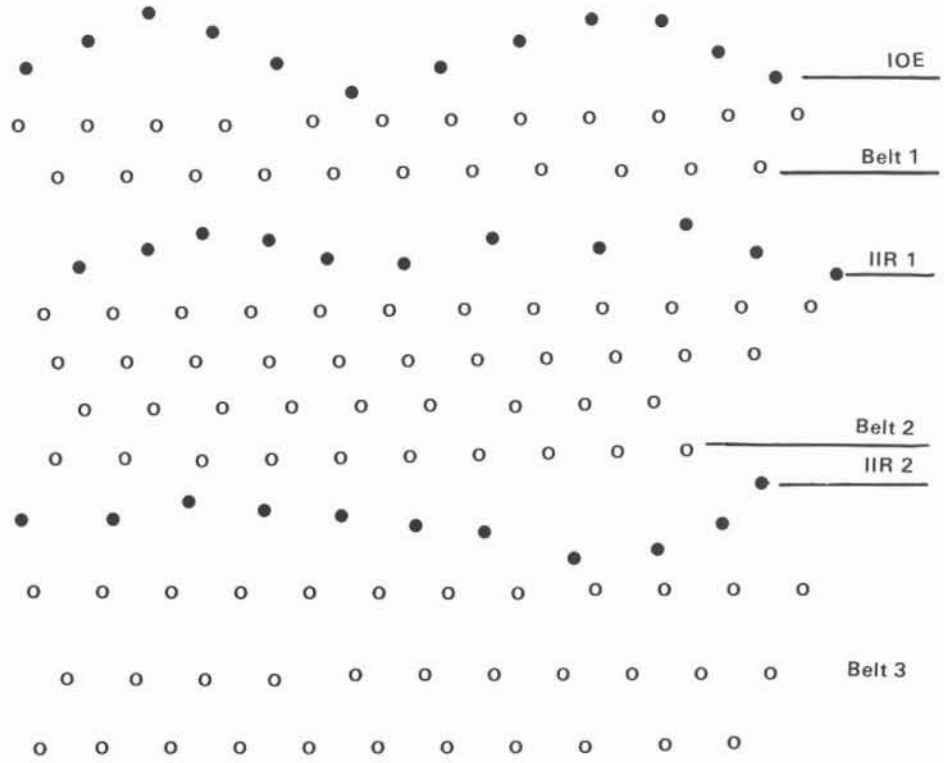
The minefield can be used by both wheeled and mechanized units, although it is more suited to mechanized units, which have better cross-country mobility. It can be emplaced quickly and can be used by engineer units on the move to enhance flank protection.

On the AirLand Battlefield, where speed and time are critical, the 1st Engineer Battalion minefield is superior. The Army should adopt it—now.

CPT Wayne Whaley is currently serving with the 82d Engineer Battalion in West Germany; he has also served with the 1st Engineer Battalion at Fort Riley, Kansas. CPT Whaley holds a BS in architectural engineering from Kansas State University, and is a graduate of EOBC and EOAC.



Configuration of revised standard pattern minefield

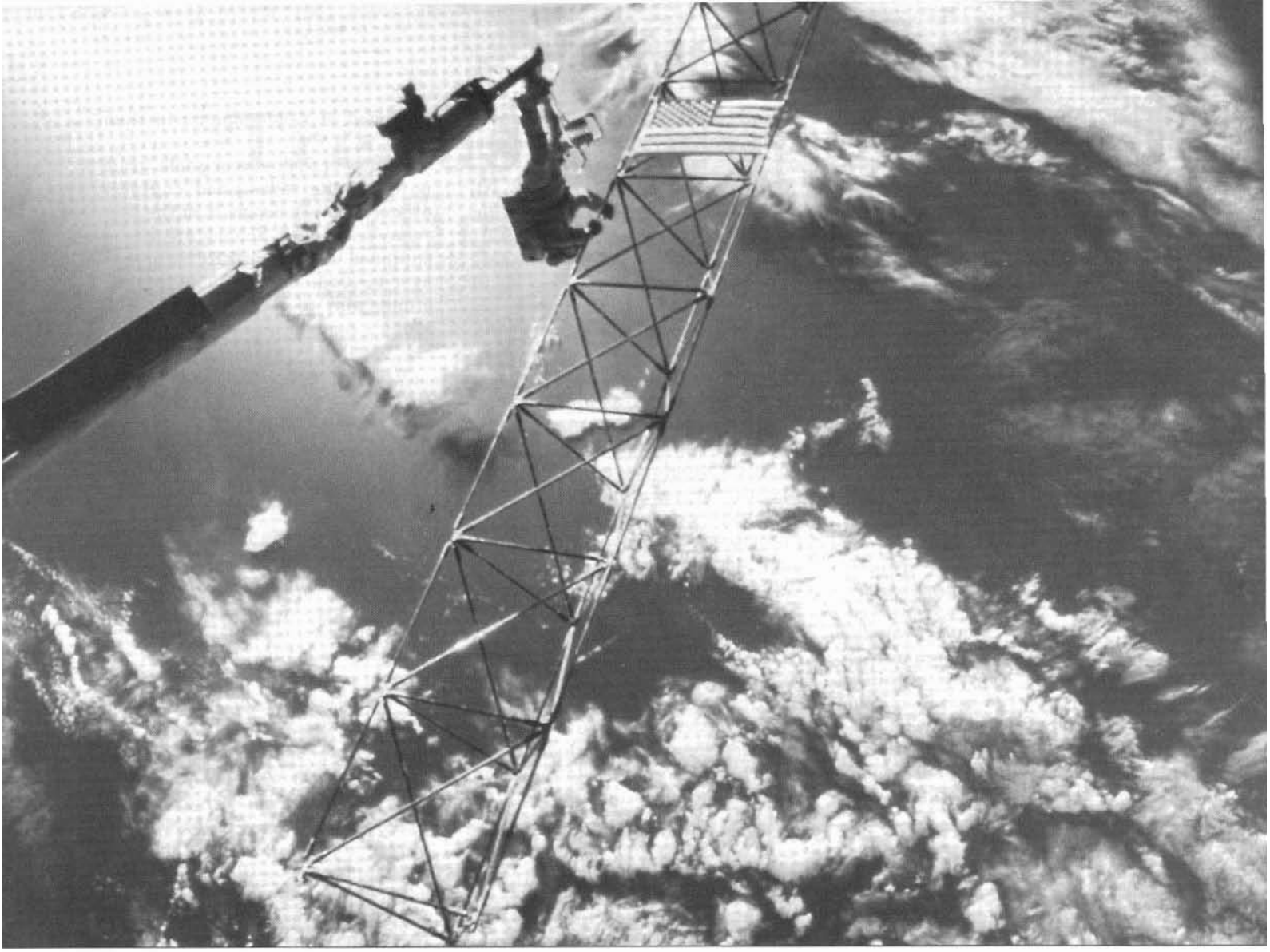


Minefield with irregular inner and outer rows

References:

Field Circular 5-71-2. *Engineers in the Tank and Mechanized Infantry Task Force.* (Coordinating Draft). U.S. Army Engineer School, Fort Belvoir, VA, July 1986.

First Engineer Battalion Battle Drills. Fort Riley, KS, June, 1986.



Space: The new high ground for engineers

by MAJ Thomas C. Suermann

The Army is rapidly expanding its horizons from terrestrial operations to space-based solutions for strategic, operational, and tactical missions. This commitment to space is not new, but renewed—the Army has been active in space programs since the Redstone rocket was developed. America's first satellite, the Explorer I, was built by an Army team and launched aboard a four-stage, modified Army rocket, the Juno.

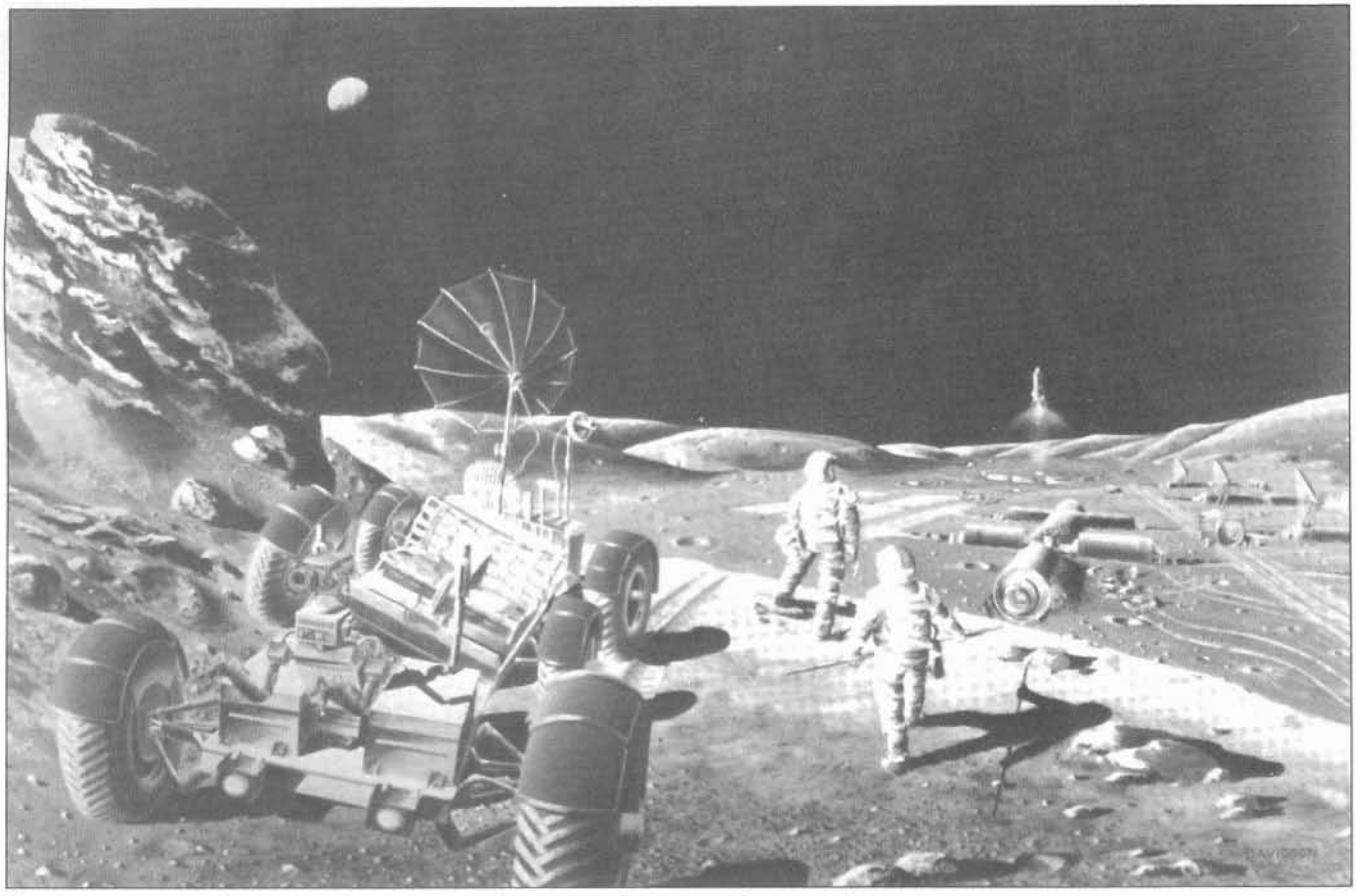
When the National Aeronautics and Space Administration (NASA) was created in 1958, it acquired the Army's launch vehicle program and the Jet Propulsion Laboratory in Pasadena. As a result of this and other program transfers, the Army's leadership role in space programs soon diminished to ballistic missile defense proponency. The Army became a user of systems developed and controlled by other services.

Recent initiatives

In the mid-1970s, the Army began to reverse this trend by taking the lead in the Tactical Exploitation of National Capabilities Program (TENCAP). This program provides national level systems support to battlefield commanders.

In 1983, the Army took further steps to shape its future in space. In quick succession, the Army formed the Army Space Council, the Army Space Working Group, and the Army Space Office. In 1984 the Army Staff Field Element was created at the U.S. Air Force Space Command. Then in September 1985, this organization became the Army Space Planning Group (ASPG), serving as the Army element in the new unified U.S. Space Command (USSPACECOM).

In July 1986, the U.S. Army Space Institute (USASI) was established at Fort Leavenworth as TRADOC's



Space construction may become an Army engineer task on such sites as this conceptual "lunar colony."

focal point for space training and doctrine development. In August 1986, the U.S. Army Space Agency (USASA) was provisionally activated in Colorado Springs as the Army element of USSPACECOM.

The USASA will provide the Army's perspective on planning for DOD space systems support to land forces and strategic defense. The Agency will integrate Army needs into USSPACECOM planning and operations and—in the future—will provide operational forces for Army space missions.

Current initiatives in the Army Space community include development of an Army Space Master Plan. This plan is the blueprint for Army exploitation of space. It is also the basis for efforts which will support programs such as the Strategic Defense Initiative (SDI), the Air Defense Initiative (ADI), and the theater missile warning and defense system.

Engineers in space

Opportunities for Army engineers are expanding with the Army's growing participation in space programs. The Army's NASA detachment, which is under the supervision of the new Space Agency, already has engineer officers on board at the Johnson Space Center in Houston. They are carrying out valuable geological analysis and space system experimentation. As the Army refines its space operations, demand for topographers, geologists, and structural engineers will increase. The Army will also need more mission specialists familiar with satellite operations and the orbital parameters that affect their specialties.

"Future Army operational doctrine must capitalize on emerging space capabilities."

ARMY SPACE POLICY

The Army and Air Staffs have recently approved assignment of an operational Army detachment to the Consolidated Space Operations Center (CSOC) at Falcon Air Force Station near Colorado Springs. This detachment will operate and manage satellite constellations. Army engineers are likely to be included, but they must begin planning and training for their specialized missions immediately.

Engineer space projects cover a full spectrum of disciplines, including extraterrestrial terrain analysis, digital imagery target recognition, and synthetic aperture radar (SAR) data exploitation. As artificial intelligence (AI) and robotics applications increase, so will the need for engineers who can effectively manage space systems and issue commands to orbital platforms that are capable of increasing the effectiveness of ground forces.

Army space engineers must be prepared to use the NAVSTAR Global Positioning System (GPS), a satellite system that pinpoints location and tracks speed of vehicles, aircraft, and individual soldiers far more accurately than present means.
(continued on page 43)

Trends in Engineer Officer Training

by MAJ Edward Hayes and Penelope Schmitt

The Engineer Officer Basic and Advanced Courses (EOBC and EOAC) have been evolving towards a new format since 1985. Let's look at the program that is shaping the future of the Corps—How do the courses of 1987 differ from the old curriculum? In what roles can we expect graduating officers to be strongest? How can graduates of the new curriculum expect their careers to develop? What can they do to determine the direction of their own career paths?

A changed curriculum

The redesigned curriculum for the EOBC and EOAC courses has intensified training for the combat missions of the Army Engineer. The goal is clear: Make engineers vital players on the combined arms team. Missions primary to AirLand Battle doctrine—mobility, countermobility, and survivability—are also primary in the classroom. Young officers learn to manage the engineer mission interface with other branches of the Army in low-, medium-, and high-intensity conflicts.

The EOBC/EOAC curriculum has been streamlined to eliminate duplication of effort in the two courses. EOAC will no longer repeat material taught in EOBC. Course designers have also excised intensive training in some technical engineering tasks, especially in heavy construction and other general engineering areas. Less time is spent in learning how to lay pipeline, analyze soils, and design drainage. Materials on concrete production and construction management have been reduced by half from the former curriculum.

Reshaping the engineer officer corps

Such changes in the structure of engineer officer training are intended to produce a reshaped officer corps. Let's look at the intentions, and at the near term results.

The Engineer School aims to produce officers who think clearly and solve problems readily in a wide variety of environments. To this end, the technical side of military engineering has been brought into better balance with the needs of a modern army—our engineers can no longer be walking repositories of all the engineering tasks. There's just too much to know. Instead, officers must learn to access, manage, and employ information and resources effectively.

Here's what the changes in curriculum have meant in the EOBC and EOAC courses:

Trends in Engineer Officer Instruction, 1979-1987

	EOBC COURSE				EOAC COURSE			
Content	FY 79 hours	%	FY 87 hours	%	FY 80 hours	%	FY 86 hours	%
Technical*	151	26	159	20	348	33	222	20
Nontechnical**	420	74	656	80	1040	67	1093	80
Total	571		815		1388		1315	

*Technical instruction includes structures and utilities, roads and airfields, and nonstandard fixed bridging.

** Nontechnical instruction covers combat survival skills, logistics, leadership, administration and training, and mobility, countermobility, and survivability missions.

Technical instruction as a proportion of course content has fallen from about a quarter in EOBC and a third in EOAC, to a fifth of the instructional time in both courses. The actual amount of technical instruction has changed very little in EOBC. The main change is that officers in EOBC now receive over 200 hours ***more*** instruction in the nontechnical areas than in the old EOBC course. This new emphasis on combat missions, logistics, leadership, and management skills is creating junior officers who are better prepared for combat missions, yet still competent in the required military engineering skills.

In the EOAC course, however, technical instruction has been cut by 126 hours. This change reflects a conscious effort to excise technical material unneeded by engineers in wartime conditions. Theater of operations construction standards are stressed. Less time is spent on engineering theory and design, and more time on the procedures to adapt to sites and construct from existing designs such as those found in the Army Facilities Components System (TM 5-300 series).

The goal of the EOAC course is to give officers the informational tools to execute combat-critical engineering missions, general engineering missions in the theater of operations (see FM 5-104, *General Engineering*), and the management and leadership skills to solve problems collectively.

In reducing technical instruction, the Army Engineer School has not abandoned high standards—it has recognized that educating experts in an age of rapidly expanding knowledge is a job for universities and technical institutions. (For example, see special training programs de-

scribed in "Space: the New High Ground for Engineers," p. 40.)

There is room for both specialists and generalists in today's Engineer Corps. In FY 1979, almost half the students in EOBC held a degree in engineering. By FY 1986, only 26 percent had an engineering degree. The number of students with degrees unrelated to engineering (liberal arts, psychology, business, and the like) rose from 23 percent to 39 percent. Although the number of students in EOBC who have no degree has risen from 10 to 14 percent, it remains low.

In EOAC, very few students hold no degree—only 7 percent. Among the others, the proportion of degreed engineers is greater than in EOBC—40 percent. Another 22 percent hold engineering-related degrees in physics, math, geology, biology or chemistry. The remaining 38 percent hold degrees in other areas. Ten percent of each class hold MA or MS degrees. Though advanced technical expertise is by no means a prerequisite for success as an engineer officer, EOAC graduates remain a more technically oriented group than the typical EOBC class.

After EOAC—choosing your path

How will the changes in the curriculum affect the military careers of engineer officers? Those who seek careers in troop leadership, staff positions, or in combat engineering will find that EOBC and EOAC dovetail perfectly with their training needs. The EOBC course is a better school for leadership than ever, and EOAC has been redesigned to focus more precisely on solving military engineer problems in the theater of operations.

Engineer officers who plan to specialize in technical areas should seek additional training on their own. Options include professional engineer certification (see ENGINEER, Fall/Winter 1986, pp. 41-42), enrollment in advanced degree programs or locally available seminars and classes, and active membership in professional societies. Regardless of their area of expertise, officers should maintain active reading programs to stay informed of developments in their fields.

Whatever their career goals, graduates of the redesigned engineer officer training program at the U.S. Army Engineer School are better equipped to manage information, to execute combat engineering missions, and to lead effectively in today's Army of excellence.

MAJ Edward Hayes is currently Chief, Structures and Utilities Branch, Department of Military Engineering, U.S. Army Engineer School. He holds a BS from Norwich University, an MS in civil engineering from Purdue, and an MS in systems management from USC; he is also a CGSC graduate. MAJ Hayes has served with the 23d Engineer Battalion in West Germany and the 52d Engineer Battalion at Ft. Carson, Colorado. He has also served as project engineer and Air Force liaison officer for the Europe Division, Corps of Engineers.

Penelope Schmitt is Features Editor for ENGINEER.

Space (continued from page 41)

NAVSTAR will let combat forces record minefields and locate enemy obstacles while performing mobility and countermobility missions in support of tactical commanders.

Space engineers must also be familiar with designing and erecting large space structures capable of satisfying on-orbit logistic functions in support of AirLand Battle doctrine. There are many hurdles to be overcome before such engineering challenges can be met. The Corps, true to its motto, "Essayons," has already begun to explore solutions. The Construction Engineering Research Laboratory (CERL) at Champaign, IL, and the Engineer Topographic Laboratories (ETL) at Fort Belvoir, VA, are exploring ideas that will allow the Army to use space to improve support to ground forces.

Building for the future

As the Space Institute develops its training base requirements and the Space Agency develops operational support planning for Army field forces, personnel managers will be searching their files for qualified people to lead the Army in space. The U.S. Air Force already administers an Undergraduate Space Training (UST) program. Although the Army will use UST as part of a joint training effort, it will still have to develop a program particularly suited to its own needs.

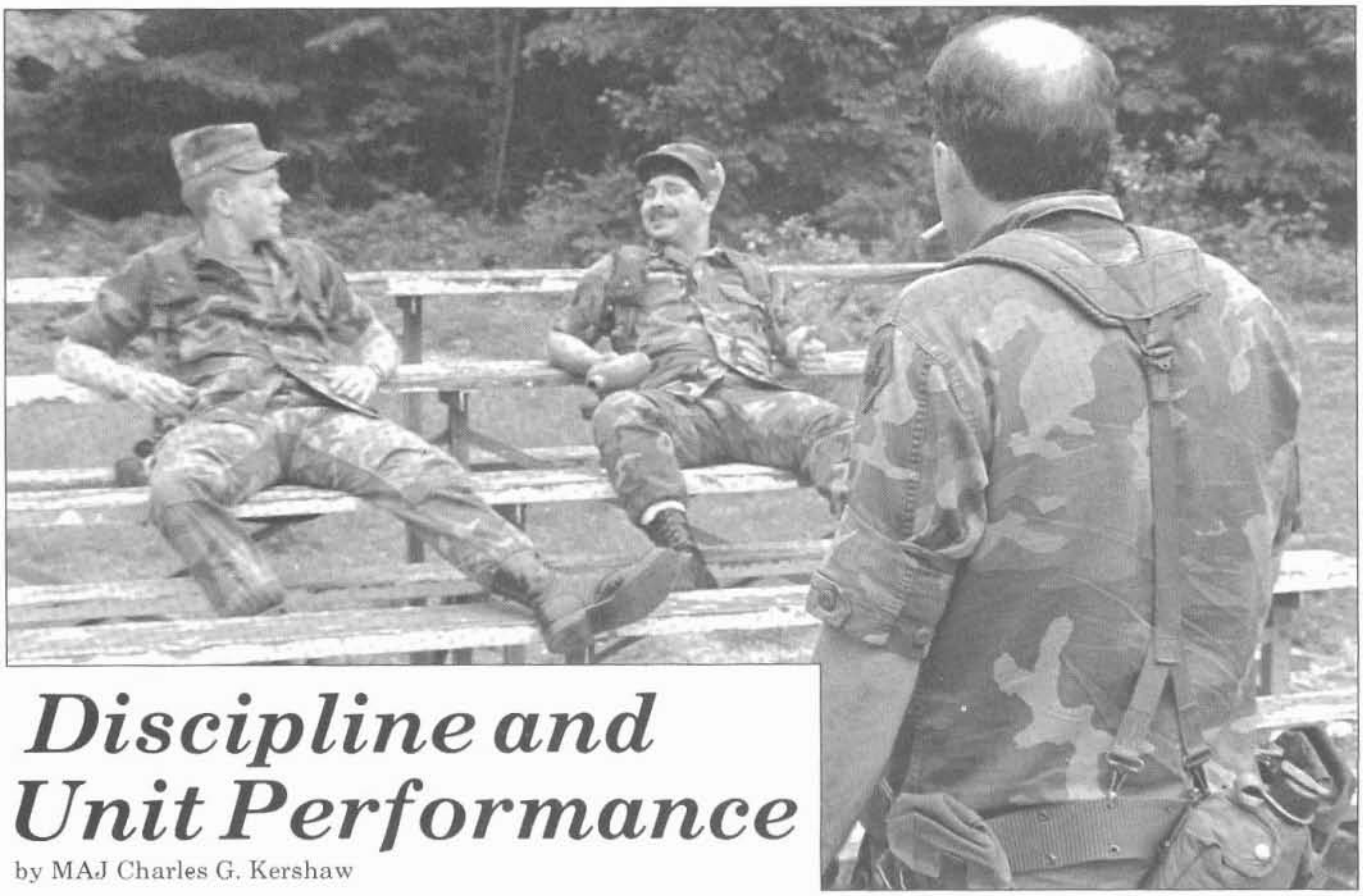
Several civilian and military schools help Army engineers to bridge the professional space education gap. Excellent graduate programs at the Universities of California, Colorado, and Illinois, at Stanford, Texas A&M, Georgia Tech, the Naval Postgraduate School, and the Air Force Institute of Technology are preparing engineers to confront new challenges in space.

The leadership challenge

Our sister services and several hundred defense industries have already begun expanding into space. The Army—particularly the Corps of Engineers—must plan for the future in space now. Army engineers have always been proud to be the "first in and the last out." We have consistently and valiantly helped to secure the high ground.

Space is our new high ground. Destiny beckons us.

MAJ Thomas C. Suermann is a staff officer with the Space Plans and Policy Division, U.S. Army Space Agency. He has served with engineer units in the 82d Airborne Division and in Germany. He has also served as a command engineer in Korea and as an instructor at West Point. Most recently, he was Brigade Operations Officer for HQ Command, XVIII Airborne Corps, during operation Urgent Fury in Grenada; he was also Chief of Operations in the Corps Engineer Section. He holds an MSE in Aeronautical Engineering from Princeton University, and is a 1971 USMA graduate, a graduate of CGSC, and is a registered professional engineer in Virginia.



Discipline and Unit Performance

by MAJ Charles G. Kershaw

Photo by PFC Richard M. Sanborn

Soon after I arrived at my new duty station, I donned my load-carrying equipment (LCE), and headed to the range to requalify with my individual weapon.

At the range, soldiers stood in concrete foxholes, zeroing their weapons. The range NCOIC and two other safety NCOs walked the firing line while small groups of officers, NCOs, and soldiers milled in the background, waiting their turns to fire.

The safety NCOs wore their LCE hanging open and loose as they pried pebbles from the ground with M-16 cleaning rods. A bareheaded master sergeant, whose LCE also draped open, briefed second firing order, as they lounged on the bleachers. Others around me, including a young captain, had not fastened their equipment.

I asked several individuals what the unit policy was regarding wear of the LCE. The captain said he wore his open because everyone else did. The master sergeant grudgingly responded, "Sir, if that's what you want, I'll fasten it."

The sergeant's exasperated reply to my queries bothered me. I expect to see soldiers wearing their uniforms smartly, even in the field. Precision in training fosters success in combat. Soldiers become accustomed to working in an environment of excellence characterized by pride, discipline, and attention to detail.

Military leaders judge units by how well they execute the small details of tactics, gunnery, maintenance, and appearance. In other words, they look at the basics.

According to a study conducted at the Naval Post Graduate School entitled "Excellence in Combat Arms," senior commanders commented that they could not tell if a unit was excellent in just a few minutes, but they could usually determine whether it was good or not. Appearance ranked high as an indicator of discipline.

The Army rests on the foundation of discipline. Units cannot and will not accomplish their missions without it. Discipline trains soldiers to react properly in the absence of leaders and orders. It enforces adherence to unpopular decisions. Tough, demanding tasks become easier to accomplish. Discipline prepares soldiers to endure the confusion and stress of combat.

What disturbed me most about the scene at the zero range was the sloppiness of NCOs and officers charged with responsibility for enforcing policies and standards. Leaders establish standards of performance by what they do, not by what they say. I felt that the standard being set by their example undermined the fabric of unit discipline.

Ardant du Picq wrote that time—a long time—is needed to give leaders the habit of command and confidence in their own authority and to give soldiers confidence in their leaders and in their fellows.

It is not enough to order discipline. The chain of command must continually practice it.

MAJ Charles Kershaw, formerly an instructor in the Command and Leadership Branch, Department of Combined Arms, USAES, is now the brigade S4 of the 193d Infantry Brigade in Panama.

Land Clearing in Vietnam

by CPT Rodney R. Gettig and Dr. James W. Dunn

The Vietnam Conflict only recently became history, yet techniques learned in the rice paddies and jungles are already being forgotten. Hidden in old field manuals and reports, valuable lessons are in danger of gathering dust on back shelves.

The current situation in Central America, U.S. Army contributions to training friendly armies, and our need to be ready to operate in a jungle environment should prevent us from putting these lessons in the archives too soon.

One important engineer story that deserves to be returned to the light is our experience with tactical land-clearing operations in Vietnam from 1966 to 1971.

A key mission in jungle operations

The Army turned to land clearing to deny cover to the Viet Cong and the North Vietnamese Army, who concealed base camps, infiltration routes, and sanctuaries in jungle vegetation. We also needed to combat the jungle itself—modern tools of war can't move through dense rain forest. Eventually, land clearing became the key to mobility and success in many American offensive operations.

We create the Rome Plow

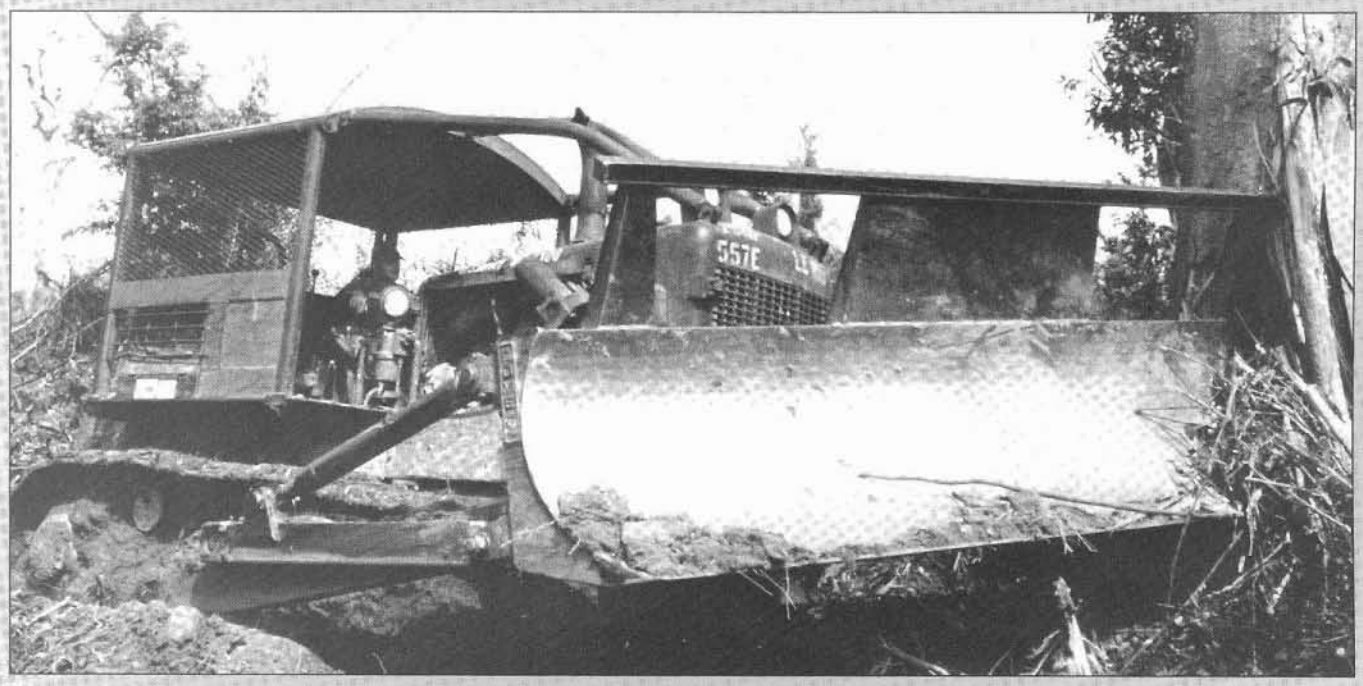
In November 1965, General Westmoreland dispatched an engineer officer to Australia to watch bulldozers towing heavy steel balls and ship anchor chains through the jungle. The officer actually brought a lost art home—our engineers taught the Australians how to do this early in World War II. The dozers proved able to clear trees less than 10 inches in diameter.

The Army also tested a dinosaur called the Transphibian Tactical Tree Crusher, which floated over swampy jungle floor and could fell trees up to 6 feet in diameter. Unfortunately, it was vulnerable to enemy fire, and its complex hydraulic system often broke down.

While the specially-designed Transphibian proved unreliable, a simpler system using a sharpened bulldozer blade realized great success. The blade, made by the Rome Construction Company of Rome, Georgia, was originally designed to clear American farmland. The Army tested four blades with accessories, including a gasoline-powered blade sharpener, in August 1966.

The Army installed the Rome blade on medium tractors, usually the D7E or HD-16M, and added a steel cab to protect operators from

(continued on page 34)



The Rome Plow rapidly became the Army's workhorse for land clearing in Vietnam.

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