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CORPS ENGINEER OPERATIONS SUPPORTING NON-LINEAR BATTLE (CONLIB)

Engineer
Studies
Center

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CORPS ENGINEER OPERATIONS SUPPORTING NON-LINEAR BATTLE (CONLIB)

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13. ABSTRACT (Maximum 200 words)

This report's aim is to assess the combat engineer brigade workload in support of an ALB-F heavy corps. This report assumes the organic brigade engineer units satisfy the engineer workload within the immediate zone of brigade operations. The setting of this concept is a non-linear battlefield. The basic approach identifies engineer workload for a typical period of a scenario. Then, ESC divides the workload by the capability for the same period of a corps engineer battalion. Finally, the Center diverts some of battalion equipment workload to form equipment companies. ESC performed this study using two scenarios. In Europe, ESC calculated a one-day fires phase. In SWA, the Center calculated a four-day maneuver phase. ESC identified tasks with priorities. Tasks also identified the required engineer unit with associated squad and various equipment hours. ESC performed excursions and looked at five alternative structures. The Center compared all alternatives to the base case. The report's findings determine: the future workload for a Corps Combat Engineer Brigade, the capability of a USAES designed Combat Brigade to execute the calculated workload, and the optimal mix and number of units for this brigade within a fixed strength. ESC also offers additional suggestions to improve individual units.

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CORPS ENGINEER OPERATIONS SUPPORTING NON-LINEAR BATTLE (CONLIB)

Prepared by
Engineer Studies Center
U.S. Army Corps of Engineers

June 1991

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ESC prepared this report for publication under the supervision of Ms. Marilyn G. Fleming, Chief, Production Center. Miss Patricia Ann Barnes, Technical Publications Editor, edited the study text and graphics.

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EXECUTIVE SUMMARY

As part of its goal to define the AirLand Battle - Future (ALB-F) concept, the U.S. Army Training and Doctrine Command (TRADOC) is currently conducting the Alternative Corps Design Study (ACORDS). This project tracks the employment of a new and conceptual heavy corps which accentuates its maneuver brigades, each of which has a small organic engineer battalion. The proposed heavy corps has additional engineer assets in the form of a 8,000-9,000-man corps engineer combat brigade which would provide engineer support throughout the corps battle zone and tactical support area. In support of ACORDS, TRADOC tasked the U.S. Army Engineer School (USAES) to provide the engineer doctrine and organization for the entire heavy corps. Because of time and resource constraints, USAES requested the Engineer Studies Center (ESC) analyze (1) the corps engineer combat brigade workload, and (2) capability of alternative brigade structures.

In calculating requirements, ESC analysts applied the basic ACORDS assumptions:

The AirLand Battle-Future operational concept is valid. The U.S. Army has two technological advantages: accurate knowledge of the enemy location; and the ability to effect strong, continuous, highly accurate and lethal long-range fire. ACORDS and this report examine two independent scenarios, one in Europe and the second in Southwest Asia.

EUROPE - Force ratios are equal. A non-linear battle erupts in a neutral developed country. Political constraints limit war damage beyond the neutral country's boundaries.

***SOUTHWEST ASIA - Economic factors* lead to the outbreak of war which prompts the affected SWA nation to request U.S. troop intervention, much like the Desert Shield deployment of August 1990*. SWA conditions are harsh, but offset by considerable host nation support.** (*NOTE: Readers should not confuse the lighter contingency corps, designed for places like Latin America, with this heavy corps concept.*)

Both theaters require engineers to have a surge mobility capability equal to the maneuver force and sustained force mobility capability able to easily accept a number of slower engineer units.

ESC's overall study findings show the engineer force structure needs have changed significantly from the 1970s and 1980s when planners postured their force to meet the defensive needs of a long European war. Near the late 1980s, the Army shortened scenarios, but engineer unit capabilities changed only a little. While unit strengths dropped, roles and missions stayed unchanged.

For the future, offense rules. Combat engineer tasks are the preeminent mission. Breaching enemy minefields, especially air delivered ones, is paramount to success. ESC estimates each volley of enemy Multiple Launch Rocket System (MLRS) scatterable mines over a Corps area will produce work for one engineer corps battalion. Heavy construction missions wait, defer to contracts, or belong to the echelon above corps.

*Desert Shield is the unclassified code name for the actual U.S. deployment to Saudi Arabia that began August 7, 1990. The study scenario has no connection with this real world event.

Due to war's rapid pace, engineer units can only be proficient in one mission. Combat support constitutes the mission for the corps combat engineer brigade. The need for scrapers and rollers building new roads and airfields exists during the mobilization or post-war phases or not at all. The Engineer Command of the Echelon Above Corps (EAC) force now reaches forward when heavy construction jobs are required. Engineer planners should now dedicate their efforts to designing a truly integrated set of combat engineer units. The Combat Mobility Vehicle (CMV) development will be to the 1990s what the Armored Combat Earthmover (ACE) was to the 1980s.

ESC's examination led to final recommendations for a proposed brigade structure shown in **Figure i.**

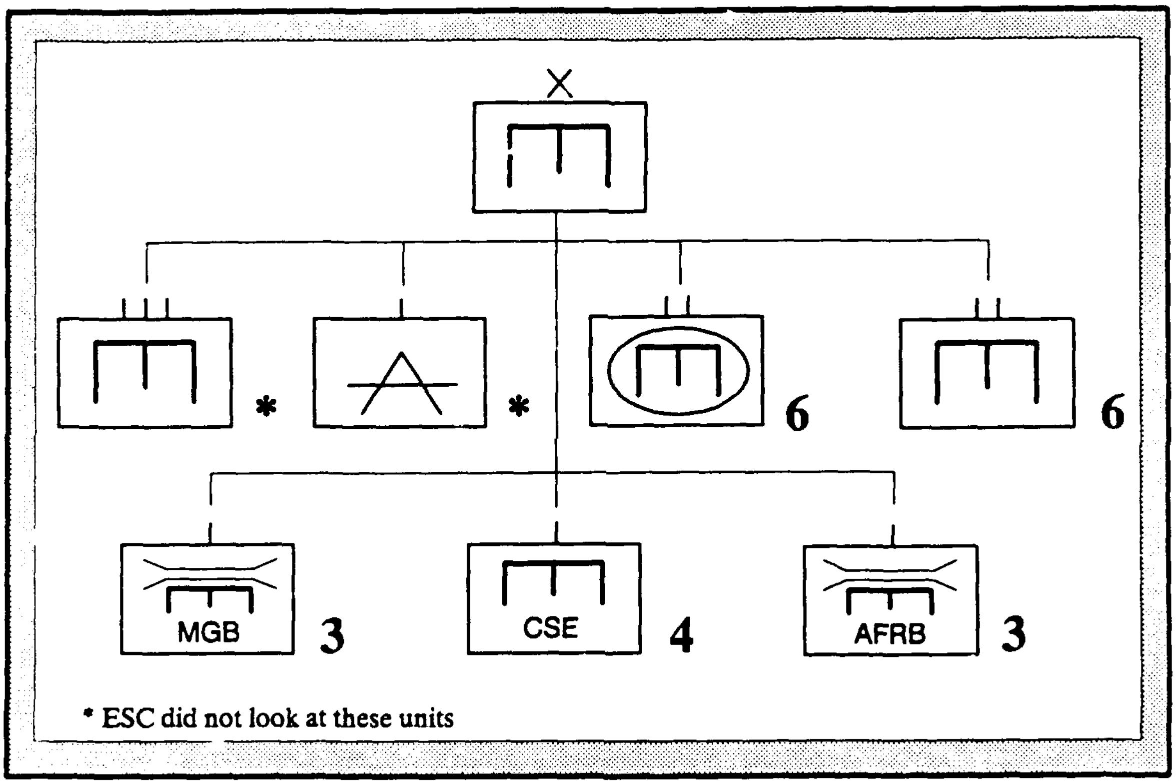

Figure i. PROPOSED ENGINEER COMBAT BRIGADE, CORPS

Emphasis on an offensive posture versus defensive also requires equipment changes. Engineers need less digging equipment. In both study scenarios, major units did not dig in, to include the artillery in the new fire phase and the divisional brigades in the revised maneuver phase. These changes affect both the wheeled and mechanized corps battalions. The changes also affect how the combat support equipment company bolsters the two corps engineer battalions. The two types of corps battalions need similar capabilities. These battalions may have different degrees of mobility and protection within these capabilities.

ESC recommends the mechanized battalion include the 2½-cubic yard loader it does not have now. We also recommend the wheeled battalion contain the MICLIC and other countermine equipment. After these battalion changes, the CSE company needs equipment to backup both types of corps engineer battalions. The company equipment should provide expedient construction and combat support capabilities. Examples of changes to the CSE company include adding more graders, downsizing dump trucks and loaders, and eliminating scrapers and some rollers. The company's three platoons should equally divide all equipment and have the capability to backup either a wheeled or mechanized battalion.

The dominant engineer task for ALB-F is breaching of scatterable minefields. This magnifies the importance of developing the CMV. However, the task is so widespread, the CMV is not enough. ESC recommends development of a laser gun mine neutralizer to give the CMV more versatility and the ACE expanded capability. This gun can add scatterable countermine capability to the wheeled corps battalion and the CSE company. This development, along with the CMV, is mandatory for success.

In summary, ESC recommends the Engineer Corps Combat Brigade be improved as follows:

- Revise equipment levels of ALB-F corps wheeled and mechanized battalions plus the CSE company.
- Pursue development of a laser gun mine neutralizer for the CMV and ACE.
- Authorize corps battalions equally split between mechanized and wheeled corps battalions. Also authorize bridge companies equally between float and fixed.
- Authorize 12 corps battalions per corps with 1 CSE company per 3 battalions.
- Devise allocation rules based on ALB-F firestrike tactics. Examples of recommendations are in **Figure ii**.

EUROPE

1 ribbon bridge company per each heavy corps division.
1 MGB company per each heavy corps division.

EUROPE AND SWA

1½ corps engineer wheeled battalions per each heavy corps artillery brigade.
1½ corps engineer mechanized battalion per each heavy corps artillery brigade.
1 CSE company per 3 corps engineer battalions (wheeled and mechanized).
1 maneuver brigade engineer battalion per corps ACR and divisional brigade.

Figure ii. Proposed ALB-F Allocation Rules (2004 and Beyond)

ABBREVIATIONS AND ACRONYMS

ACE	armored combat earthmover
ACORDS	Alternative Corps Design Study
ADAM	area denial artillery munition
ALB-F	AirLand Battle - Future
APC	armored personnel carrier
Bn	battalion
BRM	bridge and road munition
CACDA	(U.S. Army) Combined Arms Combat Development Activity
CMV	combat mobility vehicle
CONLIB	*Corps Engineer Operations Supporting Non-Linear Battle*
COSCOM	corps support command
CP	command post
CRA	corps rear area
CSE	combat support equipment
CY	cubic yard
EAC	echelon above corps
EH	equipment hours
ERP	engineer regulating point
ESC	Engineer Studies Center
Gra	grader
Grd	ground
HAB	heavy assault bridge
HME	high mobility excavator
IFV	infantry fighting vehicle
IPR	in-process review
Ldr	loader
MECH	mechanized
MF	minefield
MGB	medium girder bridge
MH	man-hours
MICLIC	mine clearing line charge
MLRS	multiple launch rocket system
MOPMS	modular pack mine system
MSR	main supply route

NOFORN .... No Foreign Dissemination or Not Releasable to Foreign Nationals

POL .... petroleum, oils, and lubricants

RAAM .... remote area armor mine system

Sqd .... squad
SWA .... Southwest Asia

TEXS .... tactical explosive system
TOE .... table of organization and equipment
TRADOC .... (U.S. Army) Training and Doctrine Command

USAES .... United States Army Engineer School

WAM .... wide area mine

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CORPS ENGINEER OPERATIONS SUPPORTING NON-LINEAR BATTLE (CONLIB)

I. INTRODUCTION

1. **PURPOSE.** This study determines the combat engineer brigade requirements in support of a heavy corps within the context of a non-linear battlefield.

2. **SCOPE.** This study--

a. Determines the future requirements for a corps combat engineer brigade. ESC uses two postulated 2004 scenarios, one in Europe and the other in SWA.

b. Determines the capability of a U.S. Army Engineer School (USAES) designed combat engineer brigade to execute ESC calculated requirements. For identified shortfalls, ESC assesses the risks.

c. Determines the optimal mix and number of units for the Combat Engineer Brigade within strength limitations. ESC also recommends additional suggestions to improve the Engineer force.

3. **BACKGROUND.**

a. TRADOC tasked the USAES to support the Alternative Corps Design Study (ACORDS).[1] The TRADOC Analysis Command (TRAC) is the sponsor of the ACORDS study. As the Engineer proponent, the USAES is providing the engineer doctrine and organizations. Because of time and resource constraints, the USAES could not specifically analyze all facets of the new concept. For this reason, the USAES requested ESC to estimate the corps engineer requirements above those caused by maneuver brigades.

b. ACORDS supports a larger TRADOC goal. This goal is defining a new concept called AirLand Battle-Future (ALB-F). The lead agency for this conceptual development is the U.S. Army Combined Arms Combat Developments Activity (CACDA). CACDA's work started in September 1989. In December 1989, running through June 1990, a series of general officer and action officer workshops drafted a white paper. CACDA published a series of three papers recording the decisions reached after each workshop.[2]

c. The initial white paper focused on the base case which used a heavy corps in central Europe. TRADOC then modified this heavy corps for employment in SWA. The SWA scenario's purpose was to further confirm the ALB-F concept.

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[1] *Alternative Corps Design Study (ACORDS)*, (TRADOC Analysis Command, 19 January 1990).
[2] *AirLand Battle-Future Alternate Base Case Study*, Phases I, II, & III (U.S. Army Combined Arms Combat Developments Activity, February, March, and April 1990).

d. ESC published a draft report March 1991. The Center sent this report to the sponsor and Study Advisory Group menbers for their review. On 17 May 1991, the USAES, TRAC, and OACE all concurred with no comments.

4. **ASSUMPTIONS/LIMITATIONS AND THEIR SIGNIFICANCE.** The assumptions for this study effort are the same as for the parent ACORDS study. The paragraphs below list the most significant of these assumptions. The USAES directed the single limitation.

a. **Assumption.** The ALB-F operational concept, as defined in ACORDS, is valid.[3] **Significance.** ESC uses two ACORDS scenarios as the model to calculate engineer requirements. Each scenario applies the ALB-F operational concept. Our calculated results, therefore, are only as good as the originally defined concept.

b. **Assumption.** The ACORDS study sets the Army force capabilities for the year 2004. The USAES further defined the engineer capability by designing Unit Reference Sheets and provided these for ESC's use. **Significance.** ESC based its conclusions and recommendations on designs for future units and unpurchased equipment much of which is developmental. Changes in the buying of current developmental systems will either alter findings or delay this study's implementation.

c. **Assumption.** This study uses the threat defined in the ACORDS study. The threat assumptions are further constrained by political implications. **Significance.** ESC uses threat scatterable mining capability to generate engineer mobility requirements, and other threat aspects to define war damage (or its absence) for other engineer mission areas. As with the emerging concept, ESC aligns its results directly to the assumed threat.

d. **Limitation.** ESC assumes the organic brigade engineer unit satisfies the engineer requirements within the immediate zone of operations of maneuver brigades. Each heavy corps has 12 brigades: 9 divisional brigades, 2 ACRs, and 1 separate brigade. **Significance.** ESC will not consider any requirements that *may* be more than organic brigade engineer unit's can accomplish.

5. **METHODOLOGY.** The basic methodology identifies engineer requirements for a representative period of a scenario. Then, ESC divides these requirements by the capability of a corps engineer battalion. The final step diverts excess equipment requirements, from the corps battalions calculated, to form CSE companies.

a. **Scenarios.** ESC used two scenarios -- one in Europe and the second in Southwest Asia -- which applied the AirLand Battle-Future concept. These two scenarios in essence become the major assumption of the study. CACDA classified each source scenario as SECRET to include actual terrain locations. ESC used actual terrain data in computing engineer requirements. Since the concept is a part of the scenarios, some summary concept information is helpful. ESC selected one phase in each theater for a detailed and original analysis. We also performed a short, less accurate, derivative analysis for a second phase in each theater. The study sponsor and ESC agreed that a derivative analysis was necessary to finish the study on time.

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[3] *Ibid.*

(1) **Figure 1** shows the four phases of this proposed doctrine. This figure also shows what type analysis ESC used. Two key assumptions guide the success of these tactical phases. First, we know the location of the enemy with remarkable accuracy. Second, we have highly accurate and lethal long range fires. These fires simultaneously target, hit, and kill large enemy formations. The concept is force oriented and not terrain oriented. There is some parity between forces but not in all areas. Essentially, parity redu s the weighty ratio of Warsaw Pact to NATO forces of the 1980s.

TACTICAL PHASE	DESCRIPTION	TYPE ANALYSIS EUROPE	TYPE ANALYSIS SWA
I	Sensor/Acquisition	--	--
II	Fires	Original	Derivative
III	Maneuver	Derivative	Original
IV	Recovery/Reconstitution	--	--

Figure 1. STUDY SCENARIOS

(2) ***European Scenario.*** The first scenario occurs in central Europe during the winter. CACDA wrote the European scenario only for the first two days of battle. The scenario portrays a single U.S. Corps operating from the fictitious country of Blue Land. The threat operated from the country of Pink Land. The battle zone was Amber Land, a third neutral country between the two belligerents. The threat inserted two airborne brigades and moved a heavy maneuver force into Amber Land. During the one day Fires Phase, the U.S. employed fires, including artillery firestrike tactics, to defeat most of the Pink Land forces. ESC conducted an original analysis of the fires phase. During the Maneuver Phase, the U.S. heavy divisions defeated the rest of Pink Land's forces in Amber Land. The Center conducted a derivative analysis of the maneuver phase. The war continues, but CACDA did not portray the scenario beyond this point.

(3) ***Southwest Asia Scenario.*** The second scenario takes place during summer in SWA. ESC began with a derivative analysis of the fires phase and followed with an original analysis of all four days of the maneuver phase. For the 4-day maneuver phase, U.S. forces have ready 3 divisions, 3 MLRS artillery brigades, 3 aviation brigades, and 1 light cavalry regiment. Armor and mechanized infantry divisions close on enemy flanks the last day. An air assault division and aviation brigades fire on the enemy flanks and rear all 4 days. All units stop during the hottest 6 hours of each day. U.S. forces fight mostly at night. ESC calculated both requirements and capability for all 4 days of battle.

b. **Tasks. Figure 2** shows major tasks calculated for this study. ESC picked the Fire Phase in Europe because it employs Field Artillery brigades in the new firestrike tactic. We picked the Maneuver Phase in SWA to establish a new database that uses future equipment. Each task has variables associated with it. As basic task variables change, ESC creates new and more detailed tasks. For example, Figure 2 lists 27 tasks for Europe but the actual number was 153. The variables causing this expansion include: *Unit Supported* (Branch and Unit); *Priority* (1, 2, or 3); *Terrain Types* (Easy, Moderate, or Difficult); and *Supporting Unit Types* (Mechanized or Wheeled Engineer Battalion, or Bridge Company).

SHORT DESCRIPTION	SCENARIO w/PRIORITY EUROPE Fire Phase	 SWA Maneuver Ph.
MOBILITY		
Initial MSR & Engineer Reconnaissance	2	-
Breach Off-road Minefield	1	1
Breach MSR Minefields	1	1
Enemy Minefield Lane Marking	2	1
Minefield Lane Improvement	2	1
Build Combat Trails and Roads	2	1
COUNTERMOBILITY		
Load Air Volcano Scatterable Mine Canisters	1	2
Emplace 1150mx125m Grd Volcano Minefield	1	-
Friendly Minefield Lane Marking	3	-
Close Ground Volcano Minefield Lane	2	-
Emplace Antitank Ditch w/TEXS	2	-
Construct Antitank Ditch w/ACEs	2	-
Emplace Road Craters w/MOPMS	2	2
Preparation of Demolition on Dam	2	-
Miscellaneous Obstacle Types (log cribs, etc.)	3	-
BRIDGING		
Emplace float bridge w/alternate site	1	-
Operate 2 ERPs per float bridge	2	-
Repair MSR bridge w/45.7m MGB	2	-
Span Gap less than 18m w/HAB	1	-
Span Gap less than 18m w/MGB	1	-
Disable 2x7.5m Bridge w/RBM	1	-
Disable Large MSR Bridge w/C-4	1	-
SURVIVABILITY		
Protect Signal Sites	3	3
Protect FA and ADA Brigade CP Sites	2	3
Protect Corps and Corps FA Tactical Sites	2	3
SUSTAINMENT ENGINEERING		
MSR Rubble Clearance	3	-
Maintain 100km of MSR per Day	3	3

NOTE: Tasks with no rank indicated under scenario were not required.

Figure 2. SCENARIO TASKS AND PRIORITIES

c. **Priorities.** ESC ranked all tasks as priority 1, 2, or 3 (See **Figure 3**). Because of this study's short duration, commanders and planners at USAFS and major commands did not assign these priorities. For the European scenario, we transferred priorities from past ESC studies having similar offensive tactics. Vital tasks became priority number 1, critical tasks number 2, and essential and necessary tasks priority 3. Senior officers in several major commands made the original priority assignments. For SWA, ESC determined priorities using the ACORDS operations order, i.e., mobility tasks comprise priority number 1, countermobility tasks are priority 2, and survivability/sustainment engineering, number 3.

PRIORITY	IMPLICATIONS OF NONSUPPORT
1	High loss of life and early combat defeat.
2	Serious degradation of combat effectiveness, increased vulnerability on the battlefield, increased probability of tactical defeats, and degraded sustainability.
3	Degraded quality of Combat Service Support, long term sustainability degradation, increased equipment/material losses, and have minor impact on tactical operations.

Figure 3. ENGINEER SUPPORT PRIORITIES

d. **Requirements.** For each mission area, ESC used the same approach to generate requirements and then developed planning factors for each task. **Figure 4** shows the three terrain types used in Europe and the characteristics of each type. For SWA, ESC divided the terrain simply by cross-country movement values: (1) *easy* = *go*, (2) *moderate* = *slow-go*, and (3) *difficult* = *no-go*. For SWA, rather than terrain, ESC related planning factors to human environmental factors. Task workload was determined by multiplying each planning factor times the measurement base. Variables impacting these determinations are detailed in this report's annexes. For convenience, ESC placed calculations for bridge mobility and countermobility tasks in a separate bridging annex. We assigned requirements to the battlefield user. For example, in Europe four field artillery brigades primarily execute firestrike. Engineer mobility tasks support movement by both artillery units and logistical resupply vehicles. Both these branches use the same roads. For clarity, ESC divides all the MSR tasks between the zones of influence of only the four artillery brigades.

CHARACTERISTIC	EASY	MODERATE	DIFFICULT
Cross Country Movement (Tanks)	75-95%	55-75%	35-55%
MSR Corridor Widths*	6km	8km	10km
MSR Net per Corridor kilometer	5.2km	8.2km	6.5km
Urban Areas per Kilometer	0.4	0.2	0.15
Intersections per Kilometer	1.0	1.33	1.0
Bridges Less 18m per Kilometer	0.4	0.4	0.4
Bridges 2.7-5m Long	37.5%	78.5%	78.5%
Bridges 5-12m Long	37.5%	17.5%	17.5%
Bridges 12-18m Long	25.0%	4.0%	4.0%

Figure 4. EUROPEAN TERRAIN REGIONS

e. **Capability.** The USAES furnished ESC unit reference sheets for engineer units planned for 2004 (see Annex F). This report uses five engineer units -- two corps battalions, two bridge companies, and the combat support equipment (CSE) company. For the SWA theater, ESC used the percentage of unit effectiveness provided by the USAES (50 percent for personnel and 33.3 percent for equipment) so this report would be consistent with USAES studies. However, for the European theater, ESC changed the wheeled corps battalion effectiveness to 33.3 percent because this unit has limited mobility in a scenario with rapid moves over extended distances. In SWA, planners slowed down the whole pace of battle and USAES capabilities applied to both corps battalions. ESC calculated an 8-man squad for the mechanized corps engineer battalion. For the wheeled battalion, ESC degraded the 8-man squad since one member was also the driver for the squad's 5-ton dump truck. We distributed the dump truck drivers time between 8 hours of driving and 4 hours of sapper duties. ESC tracked capability for the following eight pieces of equipment: Combat Mobility Vehicle (CMV) with Cleared Lane Marking System (CLAMS); 5-ton dump truck; Ground VOLCANO with Wide Area Mine (WAM); Armored Combat Earthmover (ACE)/D-7 Blade; Heavy Assault Bridge (HAB); Road Grader; High Mobility Excavator (HME); and 2½-CY Loader.

f. **Class V.** ESC calculated Class V ammunition and demolition requirements for the following six items: Modular Pack Mine System (MOPMS); Air/Ground VOLCANO; Bridge and Road Munition (BRM); Area Denial Artillery Munition (ADAM); Remote Anti-Armor Mine System (RAAM); Mine Clearing Line Charge (MICLIC). ESC did not estimate Wide Area Mine (WAM) requirements because we assumed the WAM will be part of the future configuration of the VOLCANO system.

g. **Excursions.** ESC calculated a base case for each scenario. Sometimes there were two procedures to solving a particular base case problem. ESC started an excursion whenever a significant difference of opinion existed and shows the excursions calculated by ESC for each scenario (see **Figure 5**). Some excursions provide greater clarity to the base case results. The sponsor or ESC introduced other excursions.

	SCENARIO	
DESCRIPTION	**EUROPE**	**SWA**
Priority 1 & 2 Workload	X	X
CSE Company Equipment Realignment	X	X
Number of Float Bridge Crossing Sites per Division	X	
Maneuver Requirements Moving to Start Line	X	
Breaching MSR Scatterable Mines with MICLIC	X	
Digging Anti-Tank Ditches using Scrapers	X	
Enemy Scatterable Mine Capability		X

Figure 5. SCENARIO EXCURSIONS

h. **Spreadsheets.** ESC calculated study results on two LOTUS 123 spreadsheets. For a complete audit trail, readers will need these spreadsheets. Agencies on the distribution list will receive a form to request a free diskette having these spreadsheets. Others may obtain the spreadsheets by furnishing ESC a blank diskette. Users must have an IBM compatible micro computer (PC). (ESC can copy these programs on a 5¼ inch 3.6k byte or 1.2m diskette or 3½ inch 7.2k diskette.) Each program has a self-contained menu with instructions.

II. FINDINGS

6. **GENERAL.** In this section, ESC presents its findings primarily by scenario. Additional paragraphs explain bridging and excursion results. The final paragraph discusses the combined results of all scenarios and excursions.

7. **EUROPEAN SCENARIO.** The European scenario occurs in winter. In **Figure 6**, a schematic showing the start of the fire phase, the enemy moves the first echelon of an army (corps-size unit) into the battle zone. He also installs two airborne brigades deep in this zone. The U.S. responds with firepower to include four artillery brigades within the battle zone. At the start of the second day the fire phase is almost complete and the maneuver phase starts (see **Figure 7**). The enemy has about one-third his starting strength. The U.S. strikes with two divisions while a third division moves north. During both days, the corps employs its two ACRs in screening missions. Political constraints also limit air damage to both Pink and Blue Lands.

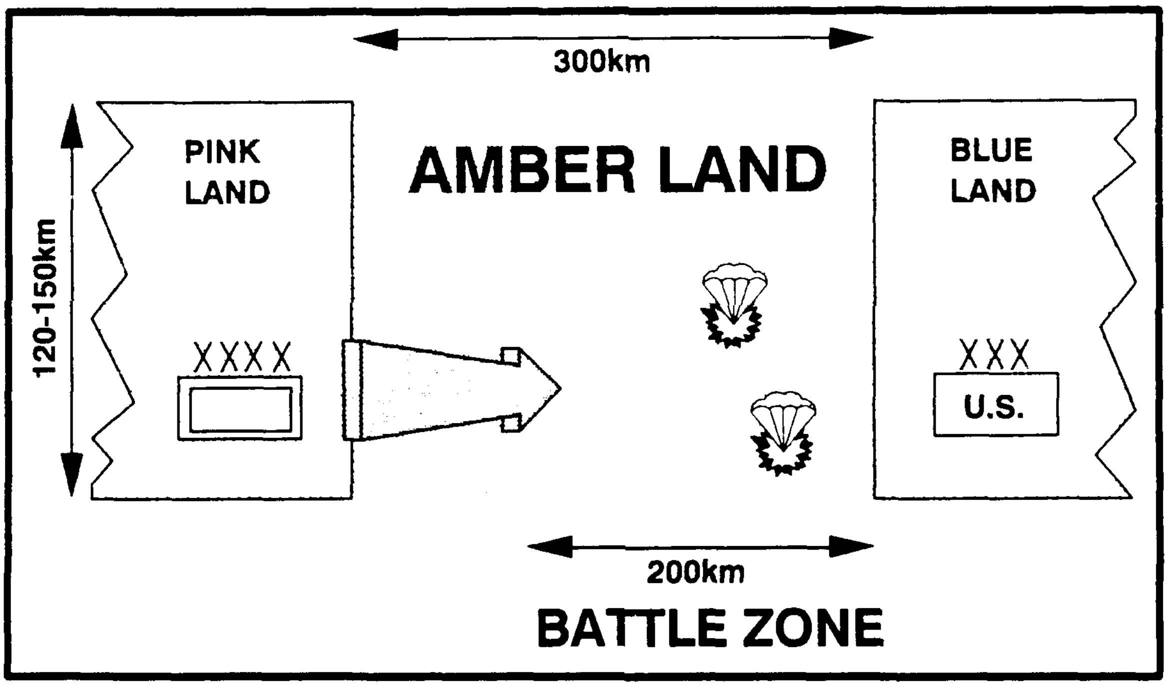


Figure 6. EUROPEAN SCENARIO -- FIRE PHASE

a. **Fire Phase.** For the fire phase, ESC calculated a workload of 21 corps battalions with no CSE companies. If equipment is averaged among the mechanized and wheeled battalions, the workload is reduced to 14. If 7 CSE companies are added and equipment is not averaged among battalions, the workload is equivalent to 13 battalions (6 mechanized and 7 wheeled).

(1) ***Battalion Equivalents.*** **Figures 8 and 9** show workload totals for 14 battalion equivalents with no equipment averaging and no CSE companies.

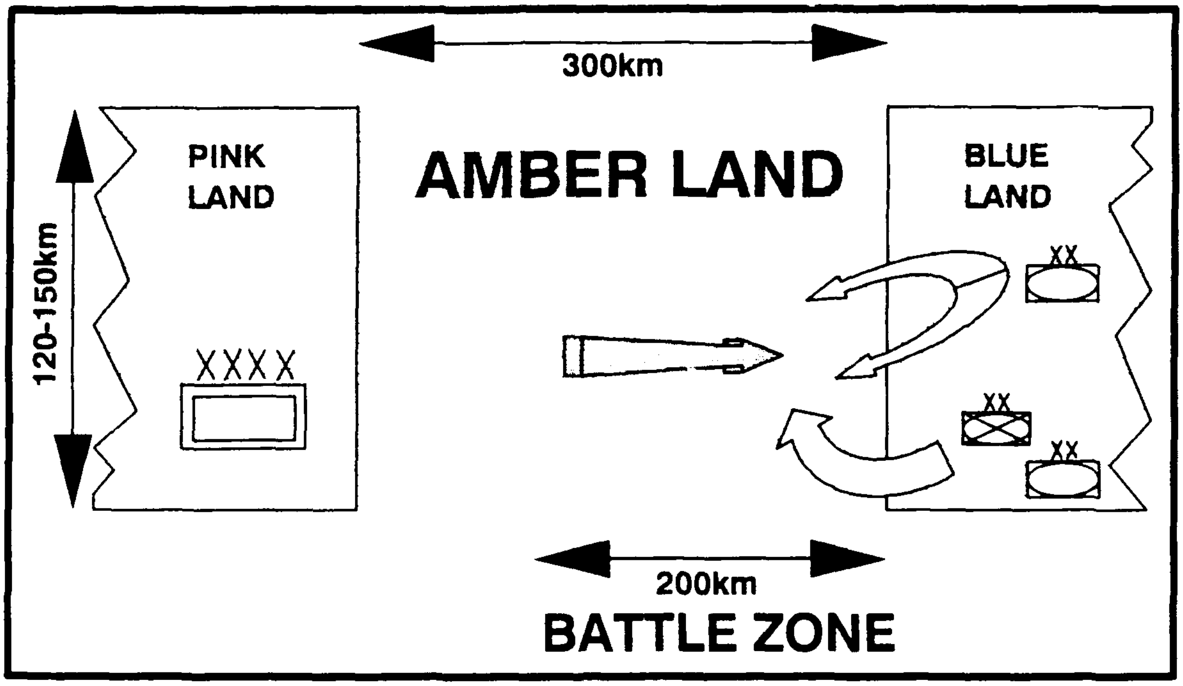
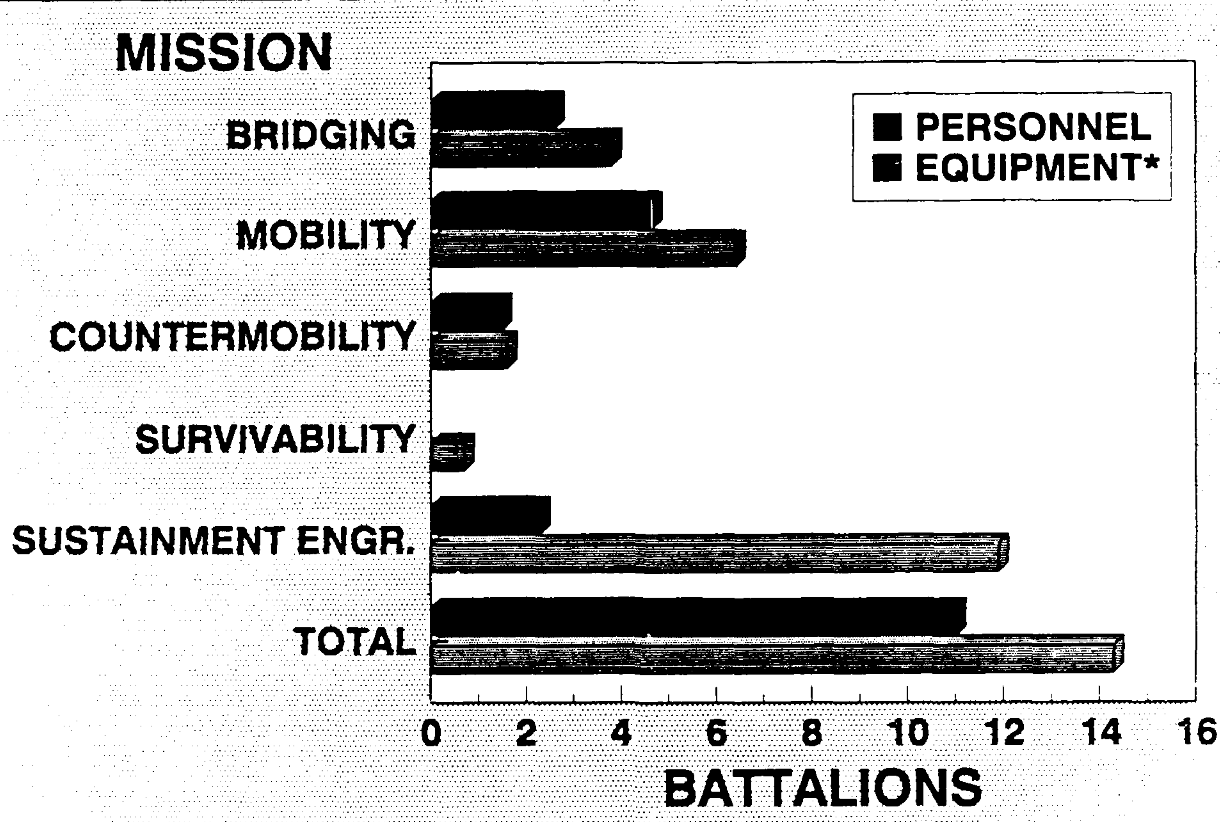


Figure 7. EUROPEAN SCENARIO -- MANEUVER PHASE

(a) *Mission Workload.* The top graph in Figure 8 shows personnel totals for the five missions adding to 11 battalions. Squad-hours (shown in the bottom chart) divided by capability (from Annex F) produce the personnel battalion equivalents. The mobility mission with 4.6 battalions is the largest personnel part of this total. The equipment totals represent the peak use of one of eight equipment types. The equipment workload for sustainment engineering is largest with 12 battalions. The mobility mission is second using the CMV more than any other piece of equipment. The HAB is the peak piece of equipment for the bridging mission. The scenario uses the loader most for sustainment engineering and for all five missions combined. Combined use equals 14 battalions or three battalions more than the personnel workload. Total hours identify peak equipment usage. A division similar to personnel calculations produces the equipment battalion equivalents. (Note: The spreadsheet displays individual scenario capability for the eight equipment types used in this calculation.)

(b) *Priority Workload.* Fourteen battalions are divided among the three priorities (see **Figure 9**). Equipment total is three more battalions than the personnel total. Priority 2 has the largest personnel workload of 4.6 battalion equivalents and priority 3 the largest equipment total with 12 battalions. The loader workload produces these 12 equivalents. Also note the HAB causes the 3.8 battalion equipment workload in priority 1.

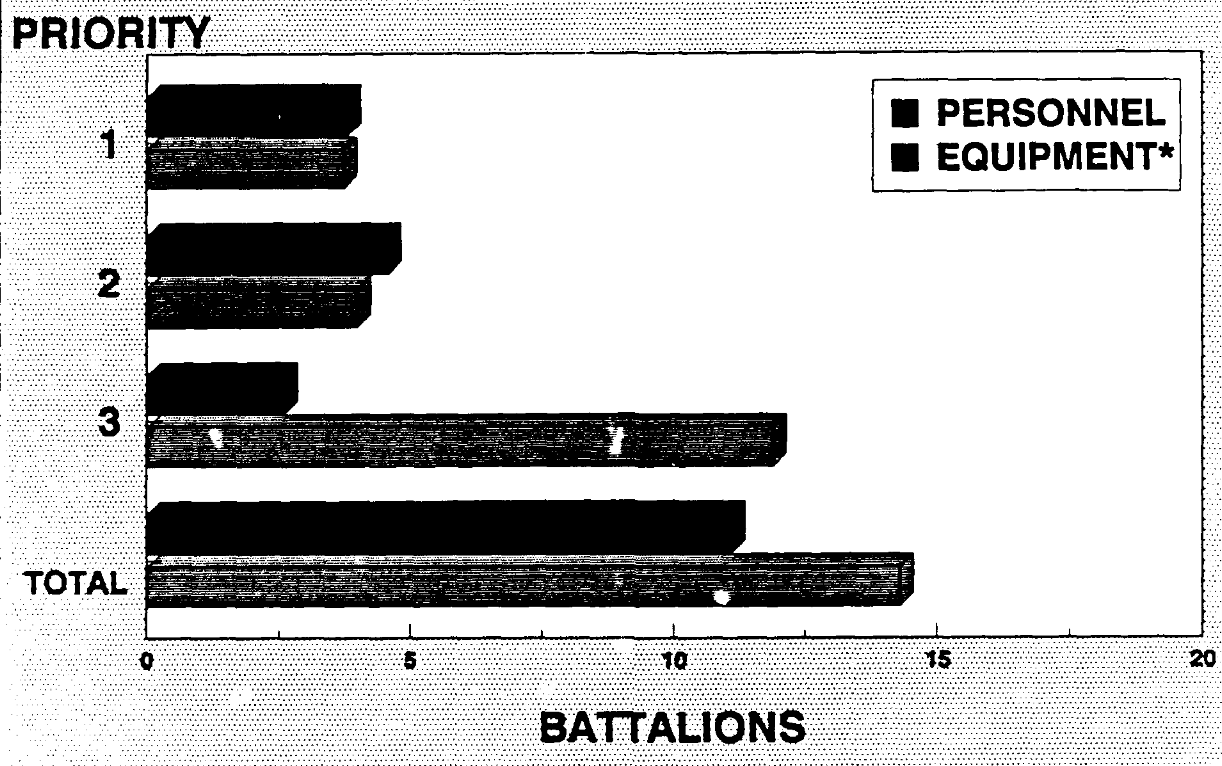
(2) ***CSE Company.*** In **Figure 10**, the top line represents the battalion equivalent workload for each of the eight pieces of equipment. All equipment use is lower than the 11 battalions of personnel required in the scenario except for the loader. By decreasing peak use of the loader we can lower the peak equipment workload . ESC added 7 CSE companies consisting of 7 company equivalents of loaders and lesser equivalents of



HOURS / MISSION	SQUAD	CMV	BLADE	DUMP TRUCK	VOLCANO	GRADER	LOADER	HAB
BRIDGING	498		16	106				676
MOBILITY	883	560	182	214			76	
COUNTERMOBILITY	286		88	86	68			
SURVIVABILITY			31				33	
SUSTAINMENT ENGINEERING	447		318	1,136		409	522	
TOTAL	2,114	560	635	1,542	68	409	631	676

** Individual and total mission equipment levels represent peak use of 1 of 8 types and cannot be added.*

FIGURE 8. EUROPEAN FIRE PHASE RESULTS BY MISSION



HOURS / RANK	SQUAD	CMV	BLADE	DUMP TRUCK	VOLCANO	GRADER	LOADER	HAB
1	730	210	16	106	62			676
2	881	350	286	292	6		109	
3	503		333	1,144		409	522	
TOTAL	2,114	560	635	1,542	68	409	631	676

** Individual and total mission equipment levels represent peak use of 1 of 8 types and cannot be added.*

FIGURE 9. EUROPEAN FIRE PHASE RESULTS BY PRIORITY

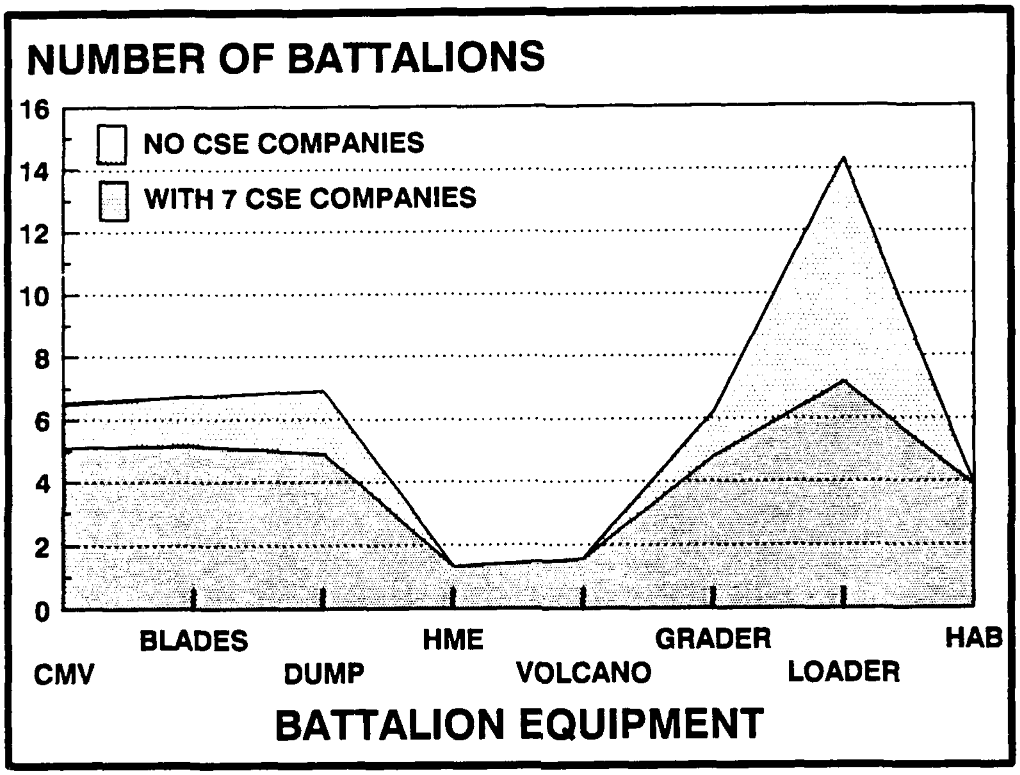


Figure 10. EUROPEAN FIRE PHASE EQUIPMENT DISTRIBUTION

four other items. ESC's methodology maximizes equipment use of corps battalions. The equipment of the CSE company is left uneven for correction at the study end. The CSE company does not contain CMVs so we added 6 for study purposes. In Section III, ESC explores different levels of equipment for the CSE Company. At that time, we look at other places and ways to provide CMV type support. The bottom line of Figure 10 explains the effect of adding these 7 companies. The peak piece of equipment is still the loader with 7 battalions. The CMV, blade, dump truck and grader use now drops to 5 battalion equivalents each. ESC made these reductions to lower the equipment total from 14 to 13 battalions. The same reductions also provide a better mix of corps battalion types.

(3) *Corps Battalion Mix.* **Figure 11** shows the derivation of ESC's final determination of a 13 battalion requirement. For this analysis, ESC estimated the separate impact of the mechanized and wheeled corps battalions. When we consider the two types of battalions and no CSE companies, the equipment total reaches 21 battalions. The mechanized corps battalion has all the CMVs while the wheeled battalion all the loaders. The separate CMV and loader allocations produce this 21 battalion total. When we add 7 CSE companies, the battalion equipment total drops to 13. Personnel requirements determine the mechanized total of 6 battalions. The loader determines the wheeled battalion level of 7. If we only consider the personnel workload, the battalion mix is 55 percent mechanized and 45 percent wheeled. When we add equipment and personnel workload together, the final mix is the reverse at 45 percent mechanized and 55 percent wheeled.

	MECHANIZED	WHEELED	TOTAL*
Personnel	6.0	5.0	11.0
	55%	45%	100%
	--NO CSE COMPANIES--		
Equipment	6.4(CMV)	14.3(Ldr)	20.7
Combined**	6.4	14.3	20.7
	31%	69%	100%
	--WITH 7 CSE COMPANIES--		
Equipment	5.0(CMV)	7.2(Ldr)	12.2
Combined	6.0	7.2	13.2
	45%	55%	100%

* *The sum of both type corps battalions in each row.*
** *The maximum of equipment or personnel in each column.*

Figure 11. EUROPEAN FIRE PHASE CORPS BATTALION MIX

(4) *Class V.* **Figure 12** shows engineer Class V ammunition and explosives workload in loads or rounds versus individual mines. ESC also calculated the aviation and artillery workload. (See **Annex B** for the factors ESC used to obtain these quantities).

LOADS/ ROUNDS	ENGINEER	OTHER	TOTAL
MOPMS	456	0	456
VOLCANO*	71	12	83
MICLIC	728	0	728
BRM	1,408	0	1,408
RAAM	0	1,920	1,920
ADAM	0	240	240

* *Includes WAM*

Figure 12. EUROPEAN FIRE PHASE CLASS V

b. **Maneuver Phase.** ESC applied a derivative methodology to obtain a quick estimate of the maneuver phase to test the hypothesis that the fire phase was more demanding than the maneuver phase. The maneuver analysis showed a 5 battalion workload versus the 13 battalions of the fire phase. This analysis used a current linear offensive battle to simulate a future non-linear concept[4]. **Figure 13** reveals the steps of this analysis.

[4]*Analysis of III Corps Combat Engineer Wartime Requirements* (U.S. Army Corps of Engineers, Engineer Studies Center, December 1984) SECRET-NOFORN

	ARMOR DIVISION		MECH DIVISION		CRA	
	MH#	EH#	MH	EH	MH	EH
Old Workload Hours/Day*	1,751	427	1,727	420	1,834	533
- Technology Savings	876	NC#	864	NC	917	NC
x Factor of Four@	3,504	1,708	3,456	1,682	3,668	2,131
- Old Battalion Capability	8,170	850	10,890	1,112	NA#	NA
New 1-Day Workload	Okay	858	Okay	570	3,668	2,131
New Battalion Capability		414		414	1,534	414
New Battalion Workload		2.1		1.4	2.4	5.1

* III Corps Offensive Operations in Europe
@ Move to Tactical Assembly Area
\# MH = Man-hours, EH = Equipment Hours, NA = Not Applicable & NC = No Change

Figure 13. EUROPEAN MANEUVER PHASE ANALYSIS

(1) Line one of Figure 13 shows the daily requirement for one armor and one mechanized infantry division. The last column displays the workload of a corps rear area (CRA).

(2) Line two applies a 50 percent technological manpower savings. The addition of labor saving bridge, mine, and countermine equipment systems create these savings.

(3) Line three equates four days of battle now to one day in 2004. Conceptual planners envision a much faster pace of war in the future.

(4) Line four subtracts the capability of the organic divisional engineer battalion. The results of this subtraction are on line five. These numbers are the new workload. There is no man-hour workload for the two divisions. However, there is a small equipment workload for the two divisions.

(5) Line six shows the capability of the 2004 corps battalions. Dividing line five by line six obtains workloads in battalion equivalents in line seven. The equipment workload is the highest at 5 battalion equivalents. If the study limitation is not accurate, then the workload is almost 9 battalions (2.1+1.4+5.1=8.6). In either case, this is under the fire phase's 13 battalions.

(6) The III Corps analysis did not separate the battalion workload into wheeled and mechanized battalions. Nor did the former analysis look at both personnel and equipment battalion equivalents. For these reasons, ESC could not break the five battalion workload of this derivative analysis into a battalion mix or separate personnel and equipment battalion equivalents.

8. SOUTHWEST ASIA SCENARIO.

a. **Description.**

(1) The Southwest Asia conflict takes place in summer when the daily temperature high averages 110°F. and the low 80°F. Typically this area hasn't had rain for 30 days. TRADOC envisions this war proceeds at a slower pace than the conflict in Europe. The maneuver phase begins at D+14. Prior to D+14, engineers complete many tasks, including construction of POL and ammunition storage areas, and road repair between the 13th COSCOM and the 47th Air Assault Division area. The 47th's area is separate from the assembly area of our other two heavy divisions. Host nation and heavy battalion support help on road repair and dust palliation. In the desert, road maintenance is a major task. To preserve these roads for wheeled vehicles, tracked vehicles either use available shoulders, or, where there are no shoulders, rough trails cut parallel to existing roads. In this environment, remotely delivered mines are the best obstacle for either side to use, therefore the most important task is to breach minefields.

(2) The ALB-F concept dictates that dispersion and mobility are key to survivability in the desert. Engineers dig in very few tanks and infantry fighting vehicles. Brigade engineers dig in the few vehicles that do need protection. However, the study limitation excludes the work of the brigade engineers from ESC's calculations. This limitation also excludes the workload for route reconnaissance, initial minefield breaches, and obstacles on the division flanks. The 23rd and 53rd U.S. divisions each have three brigades. The engineers have one battalion organic to each brigade. Therefore, six engineer battalions are available to do the work excluded in this analysis.

(3) **Figure 14** shows a schematic plan of the four-day maneuver phase. The enemy moves two armor divisions down into our 13th Corps battle zone. During this movement, the 13th responds with flanking firepower from three aviation brigades. Prior to this phase, our engineers have placed blocking obstacles in front of the lead division. These obstacles, plus aviation support, allow us to move a mechanized and armor division into attack positions. These two divisions move for three days and attack on the fourth day from the opposite flank. Our attack is strengthened with the addition of three artillery brigades. The artillery moves the third day and add their MLRS firepower for the final attack. On the fourth day, divisional cannon artillery fire scatterable mines between the two enemy divisions. The divisional minefields prevent the two enemy divisions from linking up.

(4) A third enemy division, not shown in the figure, but outside and to the top of the area, is attacked by the 47th Air Assault Division of the 13th Corps. Again, prior to this phase, our engineers placed turning obstacles which prevent this third division from moving down to attack towards our 53rd Mechanized Division. Air VOLCANO missions seal off principal routes to the enemy's rear. Engineers provide marginal support to the 47th area because it is primarily an air battle. Additionally, host nation support provides prepared facilities for the 47th Division's base of operations.

b. **Maneuver Phase.** For the maneuver phase, ESC calculated a workload of 13 battalions (6½ mechanized and 6½ wheeled). ESC's methodology went through several steps to arrive at these numbers.

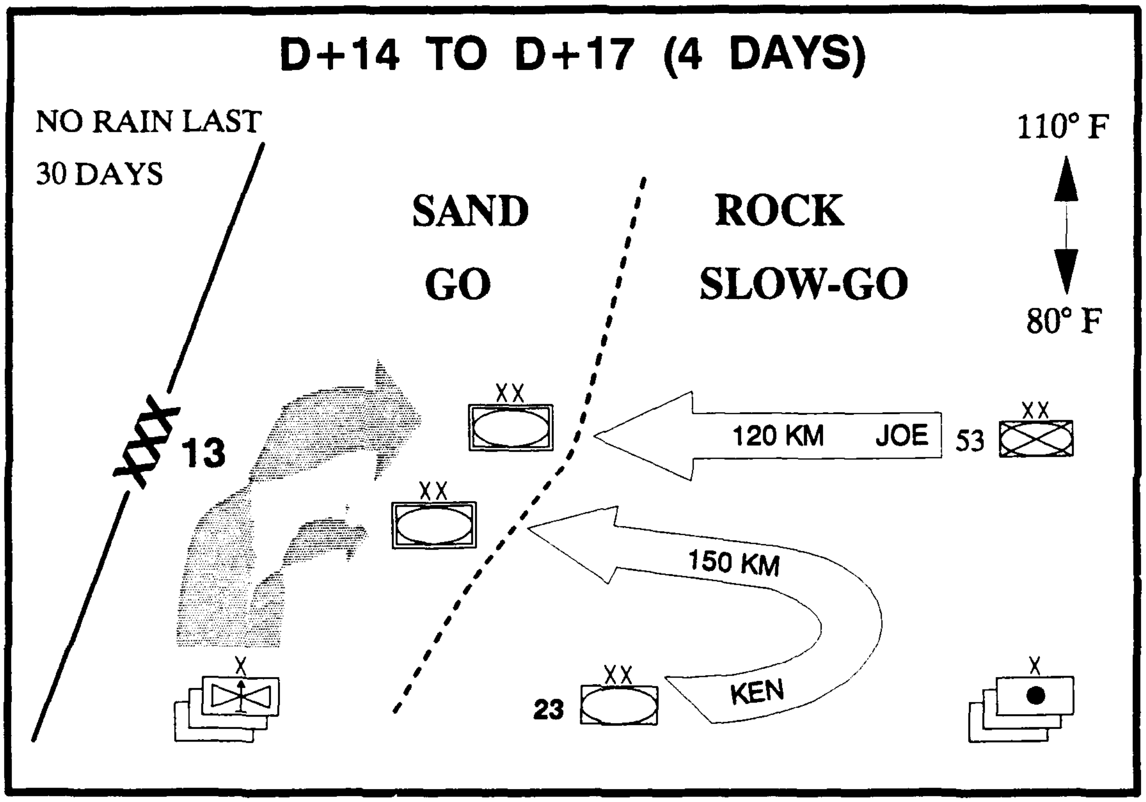


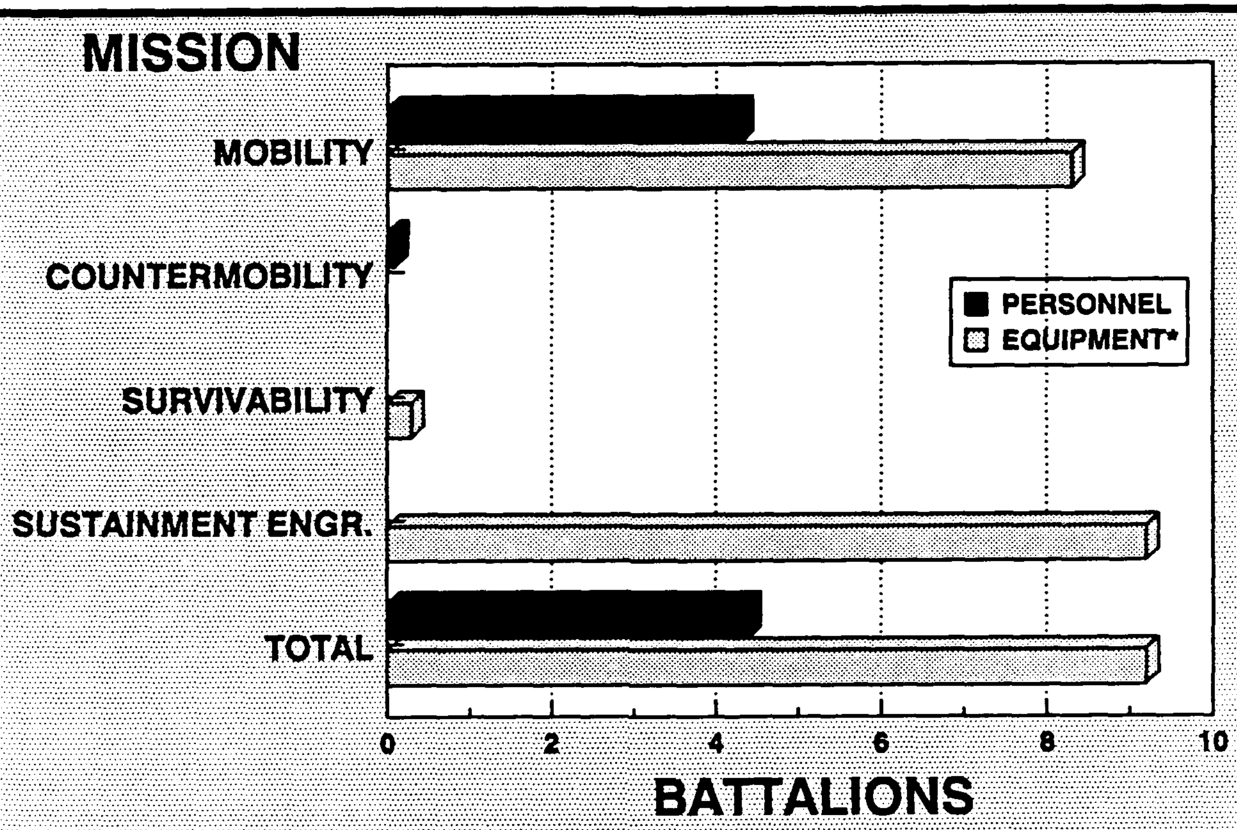
Figure 14. SCHEMATIC OF SOUTHWEST ASIA MANEUVER PHASE

(1) ***Battalion Equivalents.*** **Figures 15 and 16** show the workload for 9 battalion equivalents. These figure totals reflect battalion averaging of equipment and no CSE companies. This averaging process does not account for the fact that the CMV is only in the mechanized battalion and the loader is only in the wheeled battalion.

(a) *Mission Workload.* The top of Figure 15 shows the personnel total for the five missions adds up to 4.4 battalions. The mobility mission uses most of this total with 4.3 battalions. The equipment workload is largest for sustainment engineering with about 9 battalions. The grader causes this workload. The mobility mission is close behind with the CMV using about 8 battalions. The conflict uses the grader most for all five missions combined. The combined use is the same 9 battalions, or 4-5 battalions more than the personnel workload.

(b) *Priority Workload.* Figure 16 shows the 9 battalions divided between the three priorities. Again, equipment total exceeds personnel total by 4-5 battalions. Priority 1, with 4.3 battalion equivalents, has the largest personnel workload. Priority 3 has the largest equipment total with 9 battalions. The grader workload produces these 9 equivalents. NOTE: the CMV in Priority 1 is almost as high with about 8 battalion equivalents. Combined totals do not differ from the mission workload breakdown above.

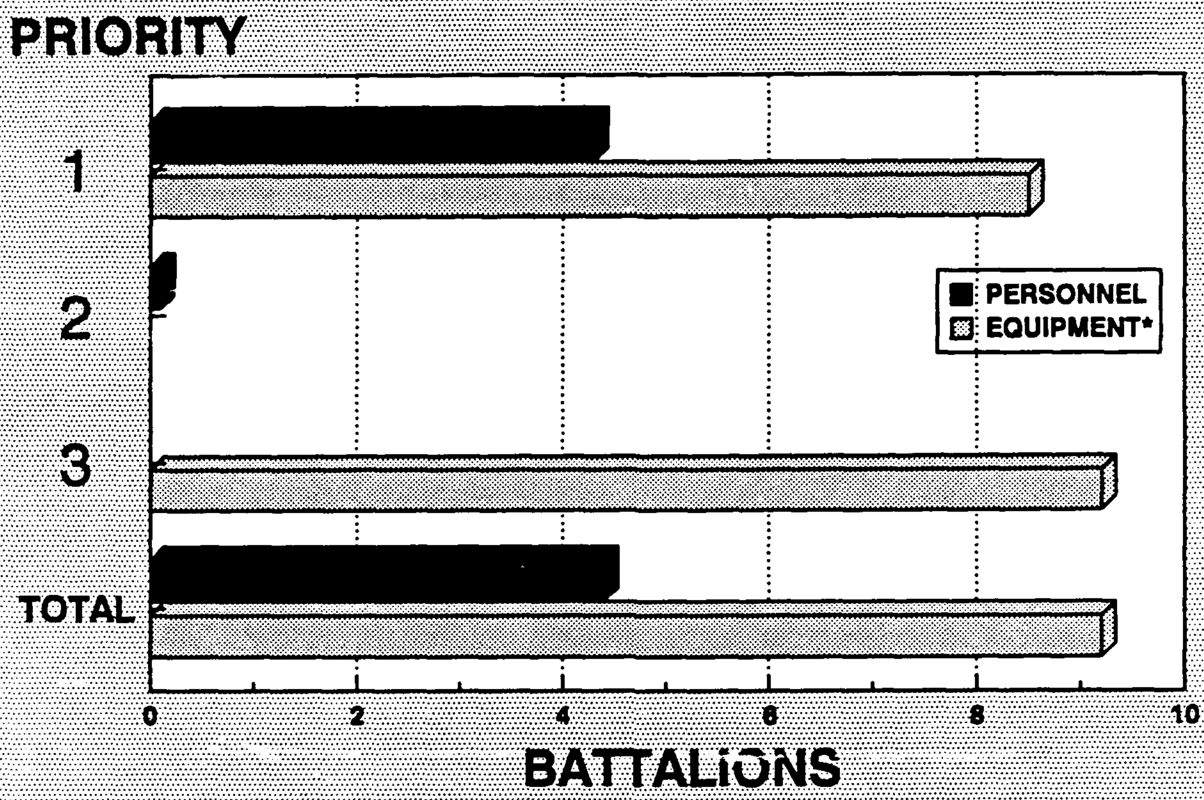
(2) ***CSE Company.*** The top line of **Figure 17** charts the battalion equivalent workload for each of the five pieces of equipment. Equipment use is higher than the 4.4



HOURS (4 DAYS) / MISSION	SQUAD	CMV	BLADE	DUMP TRUCK	GRADER	LOADER
MOBILITY	4,452	3,275	26			
COUNTERMOBILITY	54					
SURVIVABILITY			42			48
SUSTAINMENT ENGINEERING			2,120	2,638	2,638	659
TOTAL	4,506	3,275	2,188	2,638	2,638	707

** Individual and total mission equipment levels represent peak use of 1 of 5 types and cannot be added.*

FIGURE 15. SWA MANEUVER PHASE RESULTS BY MISSION



HOURS (4 DAYS) / PRIORITY	SQUAD	CMV	BLADE	DUMP TRUCK	GRADER	LOADER
1	4,452	3,275	26			
2	54					
3			2,162	2,638	2,638	707
TOTAL	4,506	3,275	2,188	2,638	2,638	707

** Individual and total mission equipment levels represent peak use of 1 of 5 types and cannot be added.*

FIGURE 16. SWA MANEUVER PHASE RESULTS BY PRIORITY

battalions of personnel required in this theater except the dump truck and loader. By decreasing peak use of the blades, CMVs, and graders, we can lower the peak equipment workload. ESC added 4 CSE companies consisting of 4 company equivalents of CMVs and graders plus 2 equivalents of blades. Because the CSE company does not contain CMVs, ESC added 6 for study purposes. The bottom chart line of Figure 17 shows the effect of adding these 4 companies. No longer is the grader the peak piece of equipment. The CMV now equals the grader (6.4 battalion equivalents each).

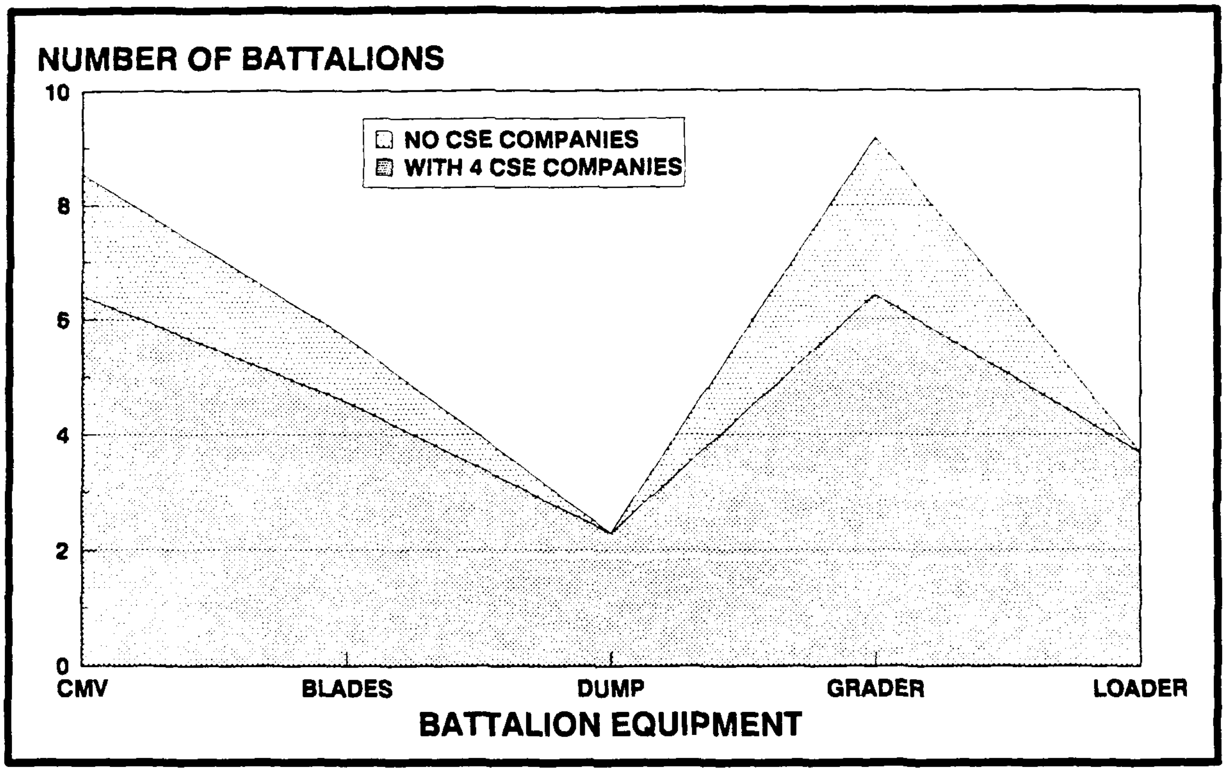


Figure 17. SWA MANEUVER PHASE EQUIPMENT DISTRIBUTION

(3) Corps Battalion Mix. **Figure 18** shows how ESC determined a final requirement of 13 battalions. For this analysis, we estimated the separate impact of the mechanized and wheeled corps battalions. When the two types of battalions and no CSE companies are considered, equipment total reaches 18 battalions. The mechanized corps battalion has all the CMVs while the wheeled battalion all the graders. The separate CMV and grader allocations produce this 18 battalion total. When we add 4 CSE companies, the battalion equipment total drops to 13. The 13 battalion total is more realistic than a 9 battalion total. The 13 battalion total is possible since the CMV and grader are no longer averaged between the two type engineer corps battalions. Equipment determines the mechanized and wheeled totals of 6½ battalions each. The personnel mix is about 75 percent mechanized and 25 percent wheeled. The final mix is an even 50 percent mechanized and 50 percent wheeled.

(4) Class V. **Figure 19** shows the engineer Class V ammunition and explosives workload quantified in loads or rounds versus individual mines. In addition to the engineer workload, ESC calculated the aviation and artillery workload. See Annex B for the factors ESC used to get these quantities.

	MECHANIZED	WHEELED	TOTAL*
Personnel	3.7	1.1	4.8
	77%	23%	100%
	--NO CSE COMPANIES--		
Equipment	8.5(CMV)	9.2(Gra)	17.7
Combined**	8.5	9.2	17.7
	48%	52%	100%
	--WITH 4 CSE COMPANIES--		
Equipment	6.4(CMV)	6.4(Gra)	12.8
Combined	6.4	6.4	12.8
	50%	50%	100%

* The sum of both type corps battalions in each row.
** The maximum of equipment or personnel in each column.

Figure 18. SWA MANEUVER PHASE CORPS BATTALION MIX

c. **Fire Phase.** ESC applied a derivative methodology to make a quick estimate of the fire phase. The only purpose of this analysis was to see if the fire phase was more demanding than the maneuver phase. The SWA fire phase appears the same as the maneuver phase. ESC estimates both phases require 13 corps battalions. The methodology starts with the European results. In Europe the fire phase was 2.6 times more demanding than the maneuver phase. However, the European fire phase had double the artillery brigades as SWA. The European fire phase also had one and one-third more enemy heavy divisions. When the Center calculates these two differences, the 2.6 to 1 ratio for Europe becomes 1 to 1 for SWA[6].

LOADS/ ROUNDS	ENGINEER	OTHER	TOTAL
MOPMS	6	0	6
VOLCANO*	0	7.5	7.5
MICLIC	429	0	429
BRM	15	0	15
RAAM	0	240	240
ADAM	0	30	30

* Includes WAM.

Figure 19. SWA MANEUVER PHASE CLASS V (Average per Day)

[6]European results were 13 battalions in the fire phase and 5 battalions in the maneuver phase. ESC then applied a one-half reduction for artillery and a three-fourths reduction for enemy divisions. Multiplying the two reductions equals a factor of three-eighths. Three-eighths times 13 equals 5. The resulting adjusted European ratio equals 5 fire phase battalions and 5 maneuver phase battalions. ESC then applied the adjusted 5:5 or 1:1 ratio to SWA's 13 maneuver phase battalions to produce an estimated 13 battalion workload for the fire phase.

9. **BRIDGING.**

a. **Figure 20** shows the study's bridging results. ESC estimated this workload using only the European theater. The SWA terrain had no bridge requirements for the surveyed dry season. ESC's calculations equalled a three float bridge and three fixed bridge company workload. Annex C describes in detail the elements of these calculations. Analysis for this annex was mostly derivative with some original terrain investigations.

	MEDIUM GIRDER BRIDGE	**ASSAULT FLOAT RIBBON BRIDGE**
Fire Phase	3+	2-
Maneuver Phase	3+	3-
Scenario Total	3	3

Figure 20. EUROPEAN BRIDGING WORKLOAD

b. This analysis strongly supports a ratio of 1 to 1 float to fixed bridge companies. This ratio translates to an allocation of one bridge company set (1 ribbon bridge + 1 MGB) per heavy division in a heavy corps. ESC estimated this bridging set with a low float bridge risk and a moderated fixed bridge risk. We calculated float bridges with a 95 percent chance of crossing any east-west axis in Central Europe. For fixed bridges, we spanned all gaps over 5 meters. For gaps under 2.7 meters, we assumed the self-crossing capability of tracked vehicles. For gaps 2.7 to 5 meters, ESC assumed the use of fascines or construction of expedient fords. Analysis shows large quantities of fascines are the most cost effective bridging for 2004 and beyond.

c. Our analysis supports the decision to place the HAB in the corps engineer battalion[7]. Engineers need to support the artillery brigades in the fire phase with responsive HABs. Divisional float bridging should either be dropped or placed at corps[8]. The same analysis applies to fixed bridging that has always been at corps.

(1) Engineers need fixed bridging close to, or within the Tactical Support Area during the fire phase. During this phase, engineers use the HAB in the battle zone center.

(2) Engineers also use float bridging in the center of the battle zone during the fire phase. Since mobility is the chief concern during this phase, planners should predict and be able to project corps float bridging forward. Planners also expect to use float bridging as part of the maneuver phase. The ALB-F concept provides plenty of planning time before the maneuver phase begins. This warning is enough to allow corps units to get float bridging up to division areas.

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[7]This analysis carefully compares the ALB-F concept with the scenario conditions. ESC used no quantitative analysis, with times and distances, to support ESC's findings.

[8]*Ibid.*

10. EXCURSIONS.

a. **Priority Workload.** For each scenario, ESC separated total workload for priority 1 and 2 (See **Figures 21 and 22**). Total workload for all three priorities for each scenario is 13 battalions. By removing priority 3 tasks (approximately 30 percent of the total for 4 battalions), the workload decreased to 9 battalions for each theater. This 30 percent includes most of the blade, dump truck, grader and loader requirements. This study cannot answer

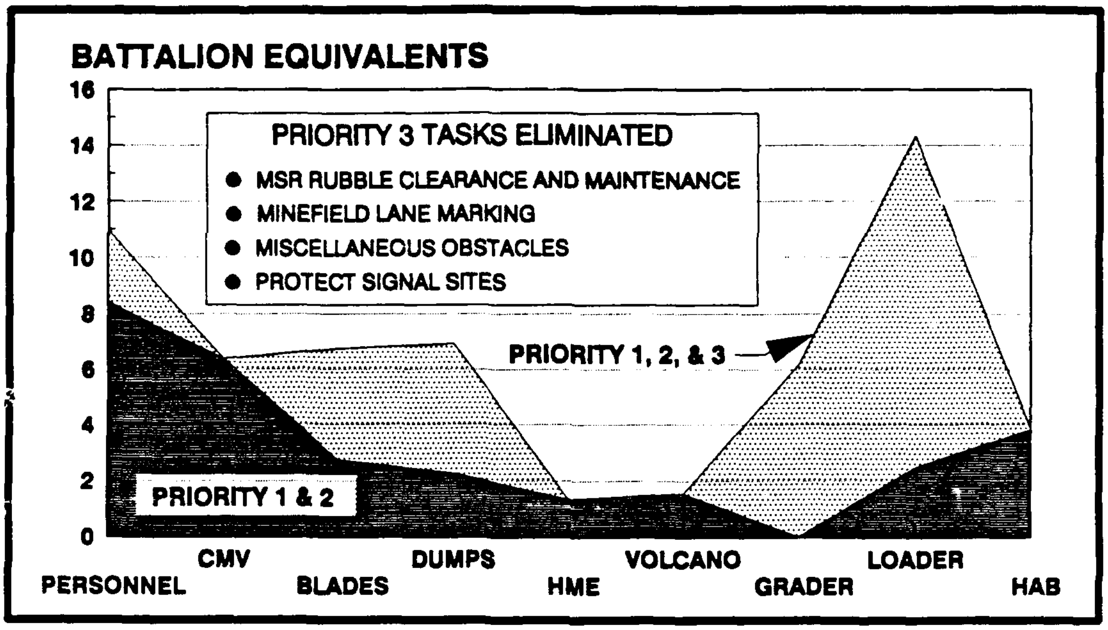

Figure 21. EUROPEAN PRIORITY 1 & 2 WORKLOAD

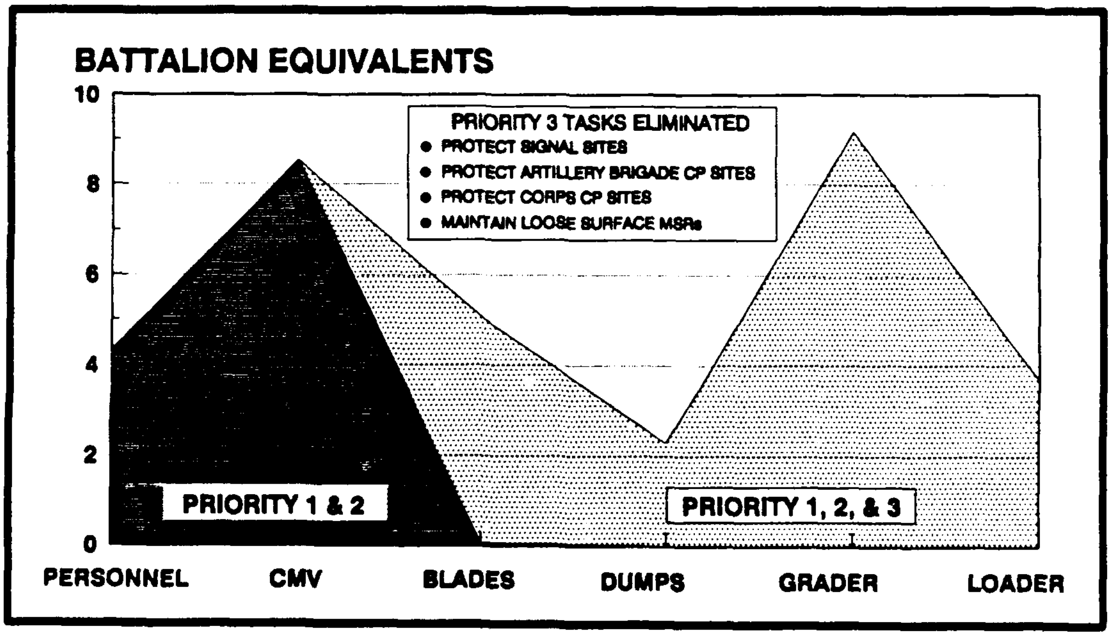

Figure 22. SWA PRIORITY 1 & 2 WORKLOAD

whether our forces could be effective with only 70 percent of the remaining planned capability. In each situation, MSR maintenance is common to the priority 3 workload. Traditionally, MSR maintenance can wait 1 or 2 weeks and not be extremely harmful. However, in the SWA theater, 2 weeks has already elapsed. In the European surroundings the pace is frantic. In one day, the rubble created on MSRs probably equals that of 1-2 weeks of previous battle. For these reasons, ESC considers it highly risky to lower engineer force levels below the total workload of 13 battalions.

b. **CSE Companies.** This excursion tested the impact of changing equipment levels of the CSE Company. The aim of these changes is to decrease the size of the deploying force. ESC measured size by adding the personnel of all units. The Center did not consider deployment weight and cube of units in this excursion. The corps engineer wheeled battalion has 533 personnel, the mechanized battalion 498, and the CSE Company 180. In all cases, the addition of 2 CSE companies and the reduction of 1 battalion results in a net personnel savings.

(1) ***Europe.*** **Figure 23** shows this excursion for Europe's fire phase. This excursion takes 20-55 percent of the battalion equipment workload to form CSE companies. This excursion changed two of the five equipment levels during this process. The first change increased the 2½-CY loader total from 6 to 12. The second change added 6 CMVs to the company. The result of the changes and diversions is 4 CSE companies. The base case had 7 CSE Companies and 13 corps battalions. This excursion does not lower the corps battalion total of 13. This excursion saves 540 personnel. Additionally, deleting 3 CSE companies gives the deploying force an unspecified savings in deployment weight and cube.

	QUANTITY		SCENARIO	
	USAES TOE	STUDY EXCURSION	WORKLOAD DIVERTED	COMPANY EQUIVALENTS
Dozers	6	6	25%	3.1
Loaders*	6	12	55	3.9
CMV	0	6	20	2.5
Dump trucks#	45	45	40	1.7
Graders	6	6	25	2.3
Combined	NA	NA	NA	3.9

IMPACT: CSE Companies reduced from 7 to 4 while corps battalions stay at 13

* 2½-CY equivalents where 1 5-CY = 2 2½-CY
# 5-ton equivalents where 1 20-ton = 3 5-ton

Figure 23. CSE COMPANY EXCURSION (FIRE PHASE)

(2) ***SWA.*** **Figure 24** shows a similar excursion for SWA's maneuver phase. This excursion takes 47-55 percent of the battalion workload for only three items of equipment. One of these items includes the addition of 6 CMVs to the CSE company. The

results of this excursion raised CSE companies from 4 to 8. The same excursion lowered corps battalions from 13 to 9. Theses changes lower deployment strength by 1,342. The impact on deployment weight and cube is unknown.

	QUANTITY		SCENARIO	
	USAES TOE	STUDY EXCURSION	WORKLOAD DIVERTED	COMPANY EQUIVALENTS
Dozers	6	6	50%	5.6
CMV	0	6	47	8.0
Graders	6	6	55	7.6
Combined	NA	NA	NA	8.0

IMPACT: CSE Companies increased from 4 to 8 while corps battalions reduced from 13 to 9

Figure 24. CSE COMPANY EXCURSION (MANEUVER PHASE)

(3) ***Unit Changes***. **Figure 25** shows the impact of combining both scenario changes affects only five equipment types. The consolidation uses but does not change quantity of three equipment items -- dozers, dump trucks and graders. One item -- the loader -- increases from 6 to 12. Last, the excursion adds 6 CMVs. The base case and excursion does not use several CSE company items such as scrapers, SEEs and rollers.

	QUANTITY				
	USAES TOE	EUROPE EXCURSION	SWA EXCURSION	MAXIMUM	CHANGE
Dozers	6	6	6	6	--
Loaders*	6	12	6	12	+6
CMV	0	6	6	6	+6
Dumps#	45	45	45	45	--
Graders	6	6	6	6	--

* 2½-CY equivalents where 1 5-CY = 2 2½-CY
\# 5-ton equivalents where 1 20-ton = 3 5-ton

Figure 25. CSE COMPANY EXCURSION (MAXIMUM QUANTITIES)

c. **Crossing Sites.** At the first IPR on 1 July 10, 1990, the SAG asked ESC to make two bridge excursions. These excursions concern the workload at float bridge crossing sites. Annex C provides details on these excursions. ESC did not use these excursions in the final study results.

(1) *Bridge Losses*. What is the effect on replacing damaged ribbon bridge bays with unit instead of depot stocks? To determine this, ESC calculated 0.74 companies of damaged bridge bays during the maneuver phase. Adding this amount to the base case equals 3.56 or 4 ribbon bridge companies. The effect of this excursion adds one company. The Army now has stocks of replacement ribbon bridge bays in their depots.

(2) *More Crossing Sites*. What is the impact if divisions require four instead of two crossing sites? To determine this, ESC used two crossing sites where a division led with two brigades abreast. The third brigade is in reserve ready to exploit success of either brigade. Using four sites doubles our findings from 2.82 to 5.64 or 6 ribbon bridge companies. Adding the results of the bridge loss excursion these findings, the total companies still round to 6. Future ALB-F units will have more swimming and fording vehicles. This aspect, combined with the use of inserting units by air into the bridgehead, lessens the need for forced bridge crossings. This excursion does show that the number of crossing sites and divisions are the critical workload factors.

d. **Attack Workload.** Does engineer support of attacking divisions require more engineers than the fire phase? In the base case, when the maneuver force moved to the tactical assembly areas, the answer was no. ESC started this excursion to determine if this was true when forces moved from the start line and into the attack. **Figure 26** shows the excursion steps and results (See 7b of our methodology). The maneuver phase takes 11 corps battalions of support. This workload, however, is still lower than the fire phase's 13 battalion level. Of additional note is the high level of overflow equipment requirements for an armor and mechanized infantry division. Formerly, corps engineer units provided this support. The ALB-F concept calls for this support to come from the organic brigade engineers. ESC hopes that either the derivative analysis overstates this workload, or, that the equipment levels of brigade engineer companies are adequate.

	ARMOR DIVISION		MECH DIVISION		CRA	
	MH#	EH#	MH	EH	MH	EH
Old Workload Hours/Day*	3,287	857	4,593	818	419	947
- Technology Savings	1,644	NC#	2,297	NC	210	NC
x Factor of Five@	8,218	4,285	11,483	4,090	1,048	4,735
- Old Battalion Capability	8,170	850	10,890	1,112	NA#	NA
New 1-Day Workload	48	3,435	593	2,978	1,048	4,736
New Battalion Capability	1,584	414	1,485	414	1,534	414
New Battalion Workload	Okay	8.3	0.4	7.2	0.7	11.4

* III Corps Offensive Operations in Europe
@ Move to Start Line and Attack
\# MH = Man-hours, EH = Equipment Hours, NA = Not Applicable & NC = No Change

Figure 26. ATTACK MANEUVER PHASE WORKLOAD

e. **MSR Mine Breaching.** For this study, ESC breached MSR minefields by "sweeping" them with the blade of the CMV. ESC heard criticism of this technique and some doubted its reliability. For this excursion, ESC examined the impact of breaching MSR minefields using the MICLIC (Shown in **Figure 27**). This method adds about 2 battalions of manpower, 4 battalions of CMV use, and a logistical burden of 1,820 MICLICs. Substituting the MICLIC for the CMV is not productive. ESC, however, does not prefer to rely solely on the CMV method either. We believe the German initiative of a laser gun has the most promise[9]. Using vehicular battery power, this gun neutralizes mines without detonation. From an operating distance spanning 5 to 50 meters, the laser burns a hole in the mine casing, and sets fire to the explosive. The addition of this laser gun provides the CMV with a dual scatterable countermine capability and the ACE with a countermine capability.

	# of MFs	Breaches	Squad Hours	Breaching CMV Hrs	Improvement CMV Hrs	Total CMV Hrs	# of MICLIC
Base Case	47	140	175	525	0	525	0
Excursion	47	140	525	0	875	875	1,820
Difference (Bn Equiv)			350 (1.8)	-525	875	350 (4.0)	1,820

Figure 27. MSR MICLIC EXCURSION

f. **Anti-tank Ditches.** What equipment engineers should use to dig mechanical anti-tank ditches? At the first IPR, the SAG asked ESC to analyze alternatives.

(1) The study's obstacle plan sited both explosive and mechanical anti-tank ditches. ESC used two ACEs for the mechanical ditches. This excursion explored the use of scrapers. **Figure 28** shows the results of this analysis. The scraper anti-tank ditch takes over 50 percent more time and twice the equipment. The scraper alternative's one advantage is that it does release one blade. However, in our European workload, blade use is not a problem.

TYPE	RESOURCES	TOTAL HOURS	ELAPSED TIME
TEXS	1 Squad 1 HME	20.0 16.0	20.0
Normal Mechanical	2 ACEs	75.0	37.5
Other Mechanical	3 Scrapers 1 dozer	180.0 60.0	60.0

Figure 28. ANTI-TANK DITCH EXCURSION

[9]The Ministry of Defense has contracted this development to a firm in Hamburg. As of September 25, 1990 the firm is registered as JAFO Technologie, a subsidiary company of Blohm + Voss international (BVi).

(2) This excursion reveals an additional option. A TEXS 1500m ditch takes 17.5 less hours to emplace than one using ACEs. However, the TEXS ditch expends 20 squad hours while the ACE none. The TEXS is a difficult system, therefore allowances must be made for loading and hauling times. Is this time savings worth the extra complexity? In the European battle, squad hours are at a premium. As ESC found in our 1985 study, the mechanical ditch is the preferred method[10].

g. **Scatterable Mine Threat.** What is the effect of enemy scatterable mine capability on engineer workload in the SWA desert's maneuver phase? Mine warfare is more important in the desert than in a temperate climate. While the European base case assumed one MLRS shot per day with mines, in the SWA base case we estimated one shot every 6 hours. For this excursion, ESC tested the impact of a mine launch every 2 to 24 hours per day. **Figure 29** shows the excursion results. Each mine launch per day adds or subtracts about 2 battalions effort of CMV equipment. The same daily launch adds or subtracts about 1 battalion of squad effort. CMV hours include hauling the MICLIC, a task the ACE can also perform. Therefore each set of enemy mine launches generates work for one engineer battalion. In Europe, the estimate of two launches results in a workload of one battalion does not consider using CSE companies. Scatterable mine threat capability significantly impacts total engineer effort even after ESC reduces battalion equivalents about one-third for the addition of CSE companies. Factors that make up the threat capability vary. Planners must consider total launchers, percentage of rounds with mines, and attrition of both rounds and launchers. ESC concludes that the CMV's countermine capability is critical. So critical, that planners should consider all effort to increase the CMV's countermine capability. Planners should also consider extending scatterable countermine capability to other engineer vehicles.

Scatterable Mine MLRS Rounds/Day	CMV Hours	CMV Bn Equiv*	Squad Hours	Squad Bn Equiv	Total Corps Battalions
1	819	2	2,096	2	11
2	1,638	4	2,899	3	13
4**	3,275	9	4,506	5	18
8	6,550	17	7,721	9	26
12	9,825	26	10,935	12	35

* No CSE Companies
** Base Case of 1 round every 6 hours

Figure 29. SCATTERABLE MINE THREAT (SWA Excursion)

11. **COMBINED RESULTS.** The most important excursion deals with realignment of equipment of the CSE Company. This paragraph examines the base case of each conflict and

[10] *Engineer Analysis of the 9th Infantry Division (Motorized)* (U.S. Army Corps of Engineers, Engineer Studies Center. December 1985), Annex D.

compares it with this excursion. ESC also summarizes together selected findings from both theaters.

a. **Europe.** **Figure 30** summarizes the European tactical phases. ESC calculated a base case of 13 corps battalions and 7 CSE companies for the fire phase. The maneuver phase in Europe is less. The Center estimates the theater only needs 4 CSE companies by simple changing a few equipment quantities. One excursions lowers the 13 battalion level to 9. However, the Center cannot rate the risk of losing these 4 battalions. ESC's recommends the final allocation be the fire phase's 13 battalions and 4 modified CSE companies.

	TACTICAL PHASE		
	FIRES	MANEUVER	TOTAL
Base Case			
-Corps Battalions	13	5	13
-CSE Companies	7	*	7
Excursions:			
-Corps Battalions			
Priority Tasks	9	*	9
Support to Maneuver Brigades	*	11	11
-CSE Companies			
Equipment Changes	4	*	4

* Not calculated or not applicable

Figure 30. EUROPEAN ENGINEER REQUIREMENT

b. **SWA.** **Figure 31** summarizes the Southwest Asia tactical phases. ESC calculated a base case of 13 battalions and 4 CSE companies for the maneuver phase. A derivative analysis determined the fire phase required the same amount. The top two priorities equal a workload of 9 battalions. As with the European scenario, ESC did not rate this 9 battalion level further because we rejected the 9-battalion/8-company excursion as being too heavy a force to deploy. This excursion also does not use all equipment efficiently. For example, the theater only needs 2 of the 8 companies for the CMV and grader. Therefore, we recommend the base case solution of 13-battalion/4-company.

c. **All Scenarios.** The theaters and tactical phases have similarities and differences.

(1) ***Similarities.*** **Figure 32** shows the similarity of engineer mission workload. Mobility and Sustainment Engineering missions are high for both. Bridging is a medium workload but applicable only to Europe. Countermobility and survivability remain low for both. Survivability is low primarily because of the offensive direction of the ALB-F concept. **Figure 33** shows the similarities of the corps battalion mix. The similarity is so close that ESC recommends a 50-50 percent mix of mechanized and wheeled corps engineer battalions.

	TACTICAL PHASE		
	FIRES	MANEUVER	TOTAL
Base Case			
-Corps Battalions	13	13	13
-CSE Companies	*	4	4
Excursions:			
-Corps Battalions			
Priority Tasks	*	9	9
Equipment Changes#	*	9	9
-CSE Companies			
Equipment Changes#	*	8	8

* Not calculated or not applicable
\# Same excursion

Figure 31. SOUTHWEST ASIA ENGINEER REQUIREMENT

	FIRE PHASE EUROPE	MANEUVER PHASE SOUTHWEST ASIA
Mobility	High	High
Bridging	Medium	----
Countermobility	Low	Low
Survivability	Low	Low
Sustainment Engineering	High	High

Figure 32. AIRLAND BATTLE-FUTURE ENGINEER WORKLOAD

	MECHANIZED	WHEELED
EUROPE		
Fire Phase	45%	55%
SWA		
Maneuver Phase	50	50
ESC RECOMMENDED		
All Phases	50	50

Figure 33. CORPS BATTALION MIX

(2) *Differences.* More than any other factor, the different tactical phases produce different daily rates for Class V ammunition and explosives used by engineers (**Figure 34**) and different quantities for like tasks (**Figure 35**). Divisional engineers

accomplish many tasks in SWA rather than corps engineers. Annexes A to E show more detail on task quantities.

LOADS/ ROUNDS	EUROPE ENGINEER	EUROPE OTHER	SOUTHWEST ASIA ENGINEER	SOUTHWEST ASIA OTHER
MOPMSs	456	0	6	0.0
VOLCANO*	71	12	0	7.5
MICLIC	728	0	429	0.0
BRM	1,408	0	15	0.0
RAAMS**	0	1,920	0	240.0
ADAM***	0	240	0	30.0

* Includes WAM
** 9 mines per round
*** 36 mines per round

Figure 34. CLASS V RESULTS (Average per Day)

TASK	FIRE PHASE EUROPE	MANEUVER PHASE SOUTHWEST ASIA
MSR MF Breaches	140	264
Off-road MF breaches	56	33
Combat Roads (km)	15	17
Ground VOLCANO MF (m)	71,300	0
Antitank Ditch (m)	5,750	0
Road Craters	96	3
Dam Demolitions	6	0
Disable Bridges	82	0
HABs emplaced	45	0
Ribbon Bridges	4	0
MGB (m)	417	0
Protected Sites	39	9
MSRs Maintained (km)	1,637	927

Figure 35. MEASUREMENT BASE TOTALS (Average Per Day)

III. FORCE ALIGNMENT

12. **GENERAL.** In this section, ESC examines alternate force structures and designs for the calculated workload. Our findings in previous sections revealed disparities in equipment distribution which prompted us to add temporarily the CMV to the CSE company in each base case. The European base case was initially 13 corps battalions and 7 CSE companies. The SWA base case was 13 battalions and 4 companies. ESC adjusted the European base case by reducing the CSE requirement from 7 to 4 companies. The Center could drop 3 CSE companies by simply adding 5 to 6 2½-cubic yard loaders to either the CSE company or the mechanized corps battalion. These alternatives represent systematical changes in equipment levels in both theaters.

13. **ALTERNATIVES.** ESC examined the base case and five alternative units designs shown in **Figure 36**. We devised the alternatives from the base case adjustments and the excursion results. For this evaluation, the European base case has 13 battalions and 7 companies. The SWA base case 13 battalions and 4 companies. **Figure 37** shows the equipment changes to each corps battalion and the CSE company.

ALTERNATE	DESCRIPTION
Base Case	Modified USAES ALB-F Unit Designs
A	Adjusted Equipment Levels of USAES ALB-F Unit Designs
B	Adding CMV to CSE Company
C	Balancing Equipment Between the Two Corps Engineer Battalions
D	Adding Laser Gun Mine Neutralizer to CMV and ACE
E	Light CSE Company Plus Elements of Alternatives A to D

Figure 36. ALB-F ALTERNATE STRUCTURES (Engineer Corps Combat Brigade)

a. **Base Cases** are the USAES unit designs with one modification. Annex F shows the full unit designs. The modification adds 6 CMVs to the CSE company. The School designed company has no CMVs.

b. **Alternate** A increases selected quantities of equipment in the USAES designed units, but does not add new equipment or subtract existing equipment. ESC moved the 6 CMVs in the CSE Company to the mechanized corps battalion, increasing the CMVs in this battalion from 12 to 18. We also increased graders by 3 in the CSE company and loaders by 6 in the wheeled battalion.

EQUIPMENT	BASE CASE	A	B	C	D	E
			COMBAT SUPPORT EQUIPMENT COMPANY			
CMV	6*	0	9	0	0	0
2½-CY Loader	6					
Grader	6	9				9
Laser Gun (ACE)	0					3
ACE	0					3
Dozer	6					3
Scraper	6					0
Dump Truck (5T/20T)	9/12					30/0
Bituminous Dist.	0					3
			CORPS MECHANIZED ENGINEER BATTALION			
CMV	12	18				
2½-CY Loader	0			6		6
Laser Gun (ACE/CMV)	0				6	30
			CORPS WHEELED ENGINEER BATTALION			
CMV	0			6		
2½-CY Loader	6	12				
Laser Gun (ACE)	0					6
ACE	0					6
Dozer	12					6

* For Study only. USAES TOE has 0 authorized

Figure 37. UNIT EQUIPMENT CHANGES (ALB-F Alternate Structures)

c. **Alternate B** adds 9 CMVs to the Combat Support Equipment Company. Equipment quantities in both corps battalions stay the same.

d. **Alternate C** balances equipment between the two corps battalions while the CSE company remains unchanged. ESC added 6 loaders to the mechanized battalion and 6 CMVs to the wheeled battalion. The additions represent new equipment for both battalions. However, equipment quantities in the other battalion remain the same.

e. **Alternate D** adds the Laser Gun Mine Neutralizer which the German Army is currently developing. ESC added 6 guns to a third of the mechanized battalion's 18 ACEs to give the mechanized battalion the equivalent of 6 surrogate CMVs. Combined with the battalion's 12 real CMVs, this gives the unit 18 vehicles that can clear scatterable mines.

f. **Alternate E** produces a light CSE company and merges elements of alternatives A through D.

(1) In the CSE company, ESC cut scrapers and downsized dump trucks and loaders as follows: Three 5-CY loaders became 6 2½-CY loaders; 12 20-ton dump trucks were dropped; and 5-ton trucks were increased from 9 to 30. ESC also added 3 new

bituminous distributors and 3 more graders. For this alternative, ESC removed heavy equipment that our analysis did not use. We reduced dozers from 6 to 3 and added 3 new ACEs. ESC would equip the 3 new ACEs with the Laser Gun Mine Neutralizer. Other company changes such as reducing rollers and downsizing water distributors are possible. ESC deferred these changes to the USAES as they do not affect our calculations.

(2) ESC used Alternative C as the basis for battalion improvements. We added 6 loaders to the mechanized battalion. For the wheeled battalion, we reduced dozers from 12 to 6 while adding 6 ACEs. This alternative adds the Laser Gun Mine Neutralizer to all 6 ACEs. The latter gives the same result as adding 6 CMVs, but at much less cost.

14. DISCUSSION.

a. **Figure 38** shows, by theater, the number of battalions and companies calculated for each alternative. This figure also shows the maximum number for each type unit to help rate the alternatives. However, the maximum number is not applicable to the force structuring process because the Army has separate structuring rules for each theater.

	EUROPE		SWA		MAXIMUM	
ALTERNATIVE	**BN**	**CO**	**BN**	**CO**	**BN**	**CO**
Base Case						
-USAES TOE	13	7	13	4	13	7
A						
-USAES Equip changes	11	4	12	3	**12**	**4**
B						
-CMV to CSE Co	13	7	12	4	13	7
C						
-Balance Bn Equip	11	3	12	4	**12**	**4**
D						
-Laser Gun	13	7	10	4	13	7
E						
-Light CSE Co and Combination A-D	11	3	10*	3*	**11**	**3**

* Or 7 battalions & 6 Companies (using graders in 3 extra companies)

Figure 38. ALB-F ALTERNATE STRUCTURE RESULTS

b. ESC dropped the base case and alternatives B and D because these three solutions provide an unneeded extra battalion and three extra companies. The lead alternative is E, with either alternative A and C a close second. These three alternatives provide 12 battalions and 4 companies or less. Alternative E has the lowest total with 11 battalions and 3 CSE companies. NOTE: Alternative F shows a sub-alternative for SWA where 10 battalions and 3 companies have the same capability as 7 battalions and 6 companies. ESC rejected this sub-alternative for excessive command and control.

c. **Figure 39** shows five additional advantages of the alternate ALB-F structures.

	USE 100% SQUADS IN EUROPE	**USE 50% SQUADS IN SWA**	**USE 1 CSE COMPANY/ 3-4 BNs**	**FLEXIBLE IN MINE BREACHING**	**EASY CSE COMPANY TO DEPLOY**
Base Case– USAES TOE	No	No	No	No	No
A– USAES Equipment Changes	YES	No	No	No	No
B– CMV to CSE Co	No	No	YES	YES	No
C– Balance Bn Equipment	YES	No	YES	YES	No
D– Laser Gun	No	YES	No	No	No
E– Light CSE Co & Combined A-D	YES	YES	YES	YES	YES

Figure 39. ALB-F ALTERNATE STRUCTURE ADVANTAGES

(1) In Europe, ESC calculated an 11 battalion workload for personnel. None of the alternatives reduce personnel workload. Those alternatives that use 100 percent of personnel in Europe do not waste squad power. Alternatives A, C, and D all have 11 battalions and meet this criterium.

(2) ESC's calculations for SWA result in 4.4 to 4.8, which when rounded, equates to a personnel workload of 5 battalions. None of the alternatives can reduce battalion equipment workload this low. A reasonable expectation is using at least 50 percent of available personnel. Only Alternatives D and E, each with 10 battalions, do this. (NOTE: If extra engineer squad power is available, commanders would use it. However, this type use is not a priority task of this study. An example task would be sandbag protection of rear area facilities.)

(3) Having 3 platoons allows the CSE company to support three battalions with a platoon each[11]. With individual tasking of equipment, the CSE can support more than three battalions . However, when the company has equipment/platoons in more than four places, command and control is difficult. ESC therefore assumes less than 3, or more than 4 battalions per company is a disadvantage. Alternatives B, C, and E have a good company to battalion support ratio.

(4) In 2004, threat scatterable mine capability is formidable. The enemy can launch scatterable mines over most of the ALB-F battlefield. This battlefield is large with engineer corps battalions dispersed over the entire area. For flexibility in breaching scatterable mines, both the mechanized and wheeled battalions need a strong countermine capability. Capability can be organic as is the case of the USAES designed mechanized battalion. Planners can add countermine capability either to the wheeled battalion (Alternatives C and E), or to the CSE company for further distribution to the wheeled battalion (Alternate B). In summary, Alternatives B, C, and E provide the most flexibility in breaching threat scatterable mines.

(5) Future contingencies will require rapid deployment which will combine factors of air and sea transport plus unit size. In the past, engineer equipment companies had considerable weight and cube to transport. In most cases, a company could equal or exceed battalion size. For ALB-F, the CSE company should be light and easy to deploy. Only Alternate E fulfills this advantage.

d. **CSE Company.** The five alternatives presented hinge on the equipment in the CSE company. Currently, planners can correct any theater workload imbalance by adjusting the equipment makeup of the CSE company. However, ESC would prefer to see this company become lighter. We would always add the 2½-CY loader to the mechanized battalion, and either the CMV or the ACE with Laser Gun Mine Neutralizer to the wheeled battalion. However, planners could still switch both these battalion changes to the CSE company. The above alternatives challenge existing design, upgrade combat capability, and decrease construction capability of the CSE company. ESC appraised three other options:

(1) The CSE company could have two versions, one to support corps mechanized battalion, and the other the wheeled. ESC discarded this option as too complicated because units lose flexibility in deployment and on the battlefield.

(2) The CSE company could add construction personnel to make the company a smaller version of the construction battalion. ESC discarded this option since this rear area mission belongs with the Engineer Command[12].

(3) Planners could drop the CSE company and distribute company equipment

---

[11] This assignment could be attachment or direct support. The type of command and control is outside this study's scope.

[12] The future of the Engineer Command is unknown. In the study's SWA conflict, one was not deployed. However, four heavy battalions did deploy. ESC assumes there will be some engineer headquarters in the rear in 2004. We will not speculate if this is an engineer command, brigade, group or cellular team.

to the two types of corps engineer battalions. ESC discarded this option because it makes the corps battalions too heavy.

15. **EQUIPMENT HISTORIES.** The Army first organized corps mechanized engineer battalions in the mid-1980s. Europe converted six wheeled battalions to form these. The wheeled corps battalion and CSE company organizations go back to WWII. Through the early 1970s, however, engineers called the CSE a light equipment company. **Figure 40** shows equipment levels for the last three decades and compares these levels to the ALB-F units in the fourth column. ESC referred to all these levels when designing Alternate E. Alternate E equipment levels are in the last column.

EQUIPMENT	1960s	1970s	1980s	ALB-F	ALT "E"
			COMBAT SUPPORT EQUIPMENT COMPANY		
2½-CY Loader	4	4	0	0	6
5-CY Loader	-	-	5	3	0
Grader	9	9	9	6	9
Medium Dozer	3-7	4	0	6	6*
Heavy Dozer	1-6	0	8	0	0
5-ton Dump Trk	15	0	0	9	30
20-ton Dump Trk	-	27	30	12	0
Bituminous Dist	1	3	2	0	3
Rock Crusher	1	1	1	0	0
Scraper	9	9	9	6	0
			CORPS MECHANIZED ENGINEER BATTALION		
2½-CY Loader	-	-	8	0	6
Grader	-	-	4	0	-
Medium Dozer	-	-	12	18	18
5-ton Dump Trk	-	-	35	12	12
			CORPS WHEELED ENGINEER BATTALION		
2½-CY Loader	13	6	10	6	6
Grader	4	4	4	9	9
Medium Dozer	7**	10	14	12	12
5-ton Dump Trk	56	56	60	36	36

* 3 of 6 are ACEs
** Late 1960s the unit had 10 HEAVY dozers

Figure 40. EQUIPMENT HISTORIES

IV. CONCLUSIONS AND RECOMMENDATIONS

16. **GENERAL.** This analysis is based on a draft concept which planners wrote for 2004. ESC's conclusions assume the concept is correct. Many changes are likely before 2004. However, as planners revise the ALB-F concept, readers can change or confirm our conclusions. This report lists more conclusions than recommendations and states ESC's findings in general terms for a reason. Commanders should implement recommendations only when within the Army's planning cycle. Our recommendations are very sensitive to the study's assumptions involving engineer equipment. Between now and 2004, equipment developmental capabilities can change. Also, what equipment, what quantity, and when available will surely change.

17. **HIGH MOBILITY IS NOT A CONSTANT CONDITION.** Engineers must keep pace with the maneuver force. However, both theater conflicts confirm the surge mobility needs of the maneuver force are higher than the sustained rates. Therefore mechanizing most or all corps engineer battalions is not necessary. The wheeled corps engineer battalion may have less protection and less mobility, but it is a valuable unit because it currently has and can have even greater equipment capabilities. Conversely, the mechanized battalion can have slow equipment. For example, a loader in a mechanized unit merely has to keep up with each borrow pit location as opposed to attacking tanks.

18. **CONSTRUCTION IS A DIFFICULT TASK.** Having squads perform corps battalion tasks used to be easy. Now these soldiers mainly train and prepare for combat support missions. Combat support includes the typical missions of mobility and countermobility. When commanders added a company to a corps battalion, the unit's new mission was a surrogate heavy battalion. The heavy battalion does the construction tasks for the sophisticated sustainment engineering mission. Corps battalions can still do expedient construction tasks, however, they can no longer easily take on complex construction tasks because personnel need more time to train for combat support missions. Combat engineering is now more complex with advancing technologies. As a result, ESC concludes (1) designers can mix combat support and expedient construction support capabilities in the same unit, but (2) expedient construction and heavy construction capabilities should be in separate units.

19. **SURVIVABILITY MISSIONS ARE REDUCED.** The ALB-F concept is an offensive concept. During firestrike, artillery units constantly move and do not dig in. During the maneuver phase, armor and infantry focus on the enemy. With the absence on seizing terrain, maneuver forces rarely dig in. The USAES states that ALB-F units are 80 percent offensive and 20 percent defensive. Engineers now need less digging equipment in corps battalions. Based on this information, ESC recommends either (1) unit designers return ACE and dozer quantities to levels of 1 per platoon, or (2) designers add new ACE capabilities, such as the Laser Gun Mine Neutralizer, at proposed levels.

20. **COUNTERMINE TASKS PREDOMINATE.** In an offensive doctrine, survivability directly correlates with mobility. In the future, threat scatterable mine capability is of foremost importance. The enemy can launch instant minefields to all parts of the battle zone at any time. Getting the maneuver and support force through these minefields is a formidable task. This mission is the first priority task for engineers. The development of the CMV in the 1990s will be what the ACE was in the 1980s. The principal countermine vehicles will be keys to battlefield success. Unit designers should place these vehicles, and explosives such as the MICLIC, at levels of 2 per platoon or 1 per squad. In 2004, squads may have more than a single squad vehicle. The CMV and ACE equipped with the Laser Mine Gun Neutralizer are candidate vehicles.

21. **ONE MISSION FOR THE CORPS COMBAT ENGINEER BRIGADE.** The ALB-F corps battle zone is over three times the depth and twice the width of the former divisional area (See **Figure 41**). The former engineer brigade could provide support to the entire corps area. The new brigade has only enough capability for the battle zone and a small part of the Tactical Support Area. The engineer unit in the rear, usually the engineer command, has to assume responsibility for the most of the Tactical Support Area. This reality is complimentary to the task of leaving construction an exclusive mission for engineer heavy battalions. Engineers will have to decide how this is done. The area can become the mission of the engineer command. Or, other rear area engineer units can assume the mission. Mission interface will require using direct and general support relationships and controls such as forward working limits and engineer work lines or areas.

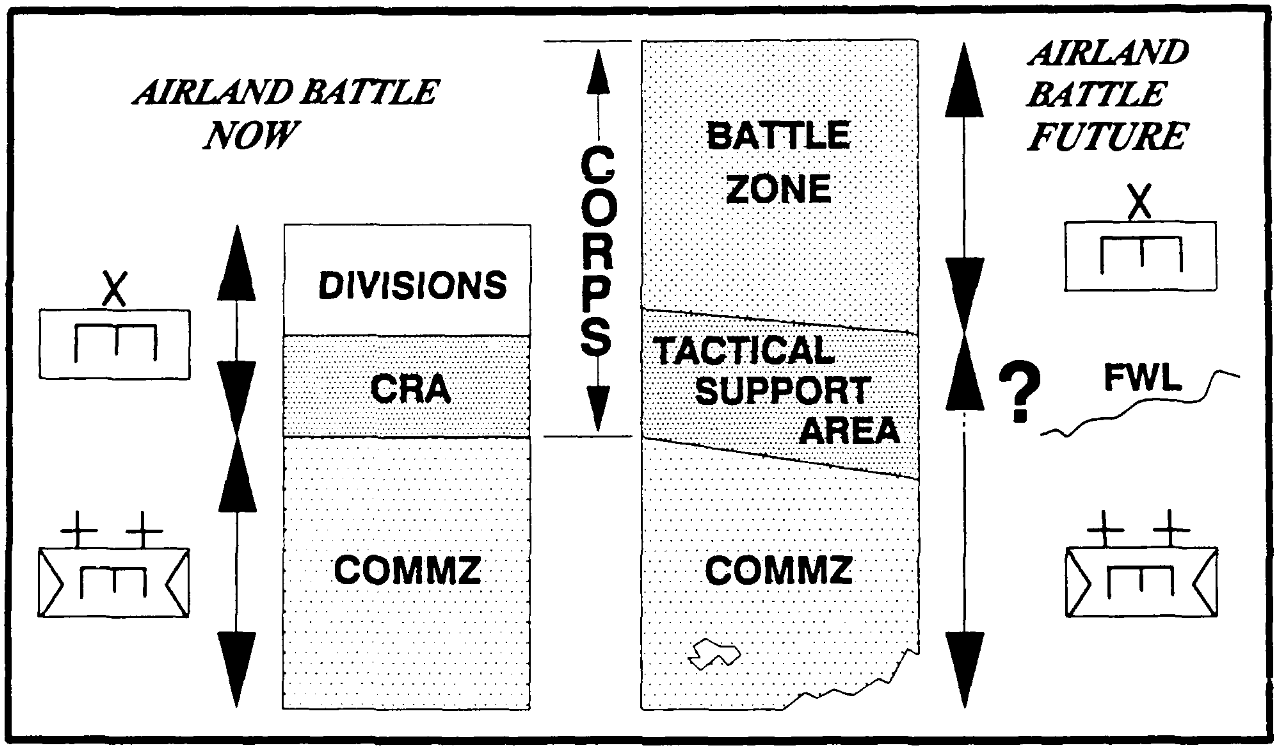

Figure 41. COMPARISON OF AIRLAND BATTLE ZONES – NOW VERSUS FUTURE

22. **WHEELED AND MECHANIZED BATTALIONS SHOULD BE EQUAL PARTNERS.** The wheeled corps battalion's design makes it the weak sister of the mechanized battalion. The two different designs compound support to the maneuver and support force. Part of this problem is the scatterable mine threat. Both types of battalions should have some capability, although capability for each should be different degrees. The different degrees will produce battalions with corresponding differences in mobility and protection which is acceptable. **Figure 42** illustrates this concept.

MECHANIZED BATTALION		WHEELED BATTALION	
ACTUAL*	**PROPOSED****	**ACTUAL**	**PROPOSED**
ACE	--	Dozer	--
CMV	--	--	ACE w/Laser Gun
APC Sqd Veh	--	5-t Dump Sqd Veh	--
--	Loader	Loader	--
VOLCANO	--	VOLCANO	--
MICLIC	--	--	MICLIC
HAB	--	--	Fascine/M4T6 trestle

* Contained in USAES ALB-F TOE (Annex F)
** ESC suggested changes

Figure 42. CORPS BATTALION CAPABILITIES

23. **BATTALION AND COMPANY MIXES.** ESC determined that the corps combat engineer brigade should have 12 battalions, one half of which are wheeled and the other half mechanized. For every three of these battalions, the brigade needs one CSE company. The heavy corps also needs one ribbon bridge and one MGB company per heavy division. These ratios should not change as planners refine the ALB-F concept. These ratios now equal 6 wheeled and 6 mechanized battalions plus 4 CSE companies. Also, the corps needs a total of 3 ribbon bridge and 3 MGB companies. The brigade may need additional corps mechanized battalions to backup divisional brigades or corps ACRs. However, ESC did not analyze the latter requirement. The study limitation assumed brigades and ACRs had enough organic engineer capability.

24. **THE CSE COMPANY IS TOO HEAVY.** The proposed ALB-F CSE company has both expedient and heavy construction capability. ESC found no requirement for the heavy capability in either theater. The company could use the addition of combat support equipment. Examples of the latter include ACEs and the Laser Gun Mine Neutralizer. The expedient construction mission removes the need for scrapers and some rollers. The mission also directs the downsizing of loaders and dump trucks. However, the expedient construction mission says planners should add more graders. Also, planners should return the bituminous distributor to the CSE company.

25. **MORE COUNTERMINE DEVICES ARE NEEDED.** Designed units depend too much on the CMV and MICLIC. Although these are excellent systems, the fewer the mobility systems, the easier the enemy can produce counter systems. Engineers must add new methods for neutralizing scatterable mines. Currently, engineers use sweeping and blast technologies. Developers are exploring technology to duplicate vehicular magnetic signatures in front of tanks and IFVs. To this, engineers should add using laser technology to neutralize mines. Laser technology is advancing faster than magnetic duplication. The Germany Army has abandoned mine sweepers for the laser methodology. Adding this system to the CMV will provide it with multiple countermine capabilities. Adding the system to the ACE will give it a capability it does not have now. Laser development is only a win-win situation.

26. **RECOMMENDATIONS.**

a. Revise equipment levels of ALB-F corps wheeled and mechanized battalions plus the CSE company.

b. Pursue development of a laser gun mine neutralizer for the CMV and ACE.

c. Authorize 12 battalions per corps with 1 CSE company per 3 battalions, and 2 bridge companies per corps heavy division. An even mix of battalion types (wheel to mechanized) and bridge company types (float to fixed) should exist as shown in **Figure 43**.

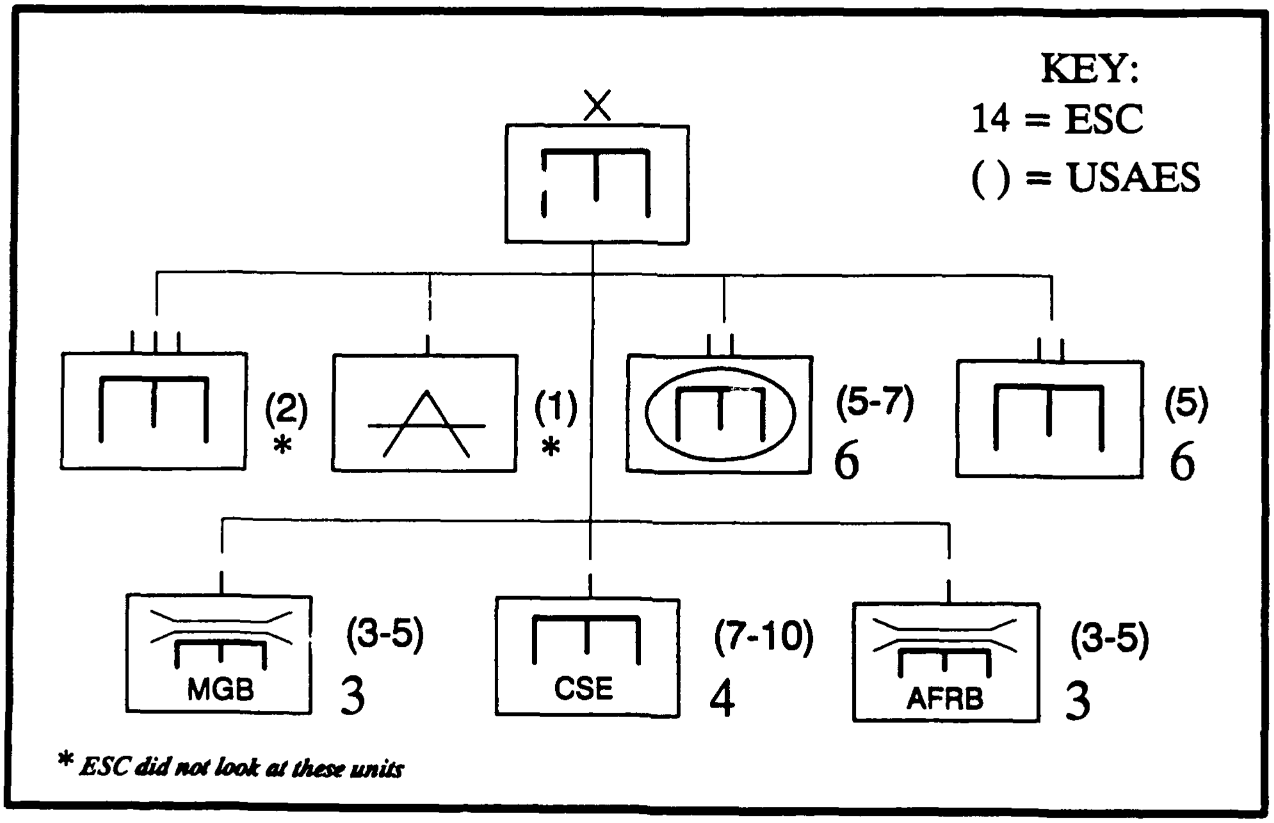

Figure 43. PROPOSED CORPS ENGINEER COMBAT BRIGADE

d. Devise allocation rules based on firestrike tactics. **Figure 44** shows ESC's example recommended rules.

EUROPE

1 ribbon bridge company per each heavy corps division.
1 MGB company per each heavy corps division.

EUROPE AND SWA

1½ corps engineer wheeled battalions per each heavy corps artillery brigade.
1½ corps engineer mechanized battalion per each heavy corps artillery brigade.
1 CSE Company per 3 corps engineer battalions (wheeled and mechanized)
1 maneuver brigade engineer battalion per corps ACR and divisional brigade.

Figure 44. EXAMPLE ALB-F ALLOCATION RULES

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ANNEX A

MOBILITY REQUIREMENTS

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ANNEX A

MOBILITY REQUIREMENTS

1. **PURPOSE.** This annex discusses the methodology ESC used to determine the requirements for the engineer mobility mission.

2. **SCOPE.** This annex:

a. Defines mobility tasks for the study's European and SWA theater scenarios.

b. Explains key points of the methodology for calculating mobility task requirements.

c. Records the mobility task requirements in amounts, total man-hours and equipment-hours, and the equivalent battalion equivalents.

d. Notes observations that pertain only to analysis of this annex.

3. **ASSUMPTIONS AND THEIR SIGNIFICANCE.**

a. **Assumption.** For study purposes, ESC separately calculates the mobility task of bridging (See Annex C). We also calculate MSRs up to the Brigade Support Areas as part of the sustainment engineering mission in Annex E. **Significance.** The doctrinally defined mission of mobility is higher than stated solely in this annex.

b. **Assumption.** ESC used the CMV to clear scatterable mines off of MSRs. We used the MICLIC, towed by the CMV, for off-route mine breaching. After both breaching tasks, ESC used squads to proof lanes and destroy un-detonated mines. **Significance.** If engineers use the ACE to tow the MICLIC, planners can substitute an equal amount of ACE hours for CMV hours. The MICLIC hours do not change with either assumption. If engineers leave un-detonated mines at the edges of breached lanes, this annex overstates the personnel workload.

c. **Assumption.** The CMV has the CLAMS. **Significance.** If the CLAMS is not ready by 2004, then engineers need additional man-hours to mark lanes with the HEMMS.

4. **TASKS. Figure A-1** shows the mobility tasks calculated in this annex along with their priority. In SWA, all mobility tasks were priority one. In Europe, two of the six tasks are priority one and the rest priority two. The SWA theater did not have an initial MSR reconnaissance task.

	RANK		
NUMBER	**EUROPE**	**SWA**	**DESCRIPTION**
M-2	1	1	Breach 1250m MSR Minefield Lane
M-3	1	1	Breach 1250m MICLIC Minefield Lane
M-1	2	-	Initial Engineer/MSR Reconnaissance
M-4	2	1	Improve 1250m of MICLIC Lane Breach
M-5	2	1	Mark 1250m Minefield Lane w/HEMMS
M-6	2	1	Build 1km of Combat Trails & Roads

FIGURE A-1. MOBILITY TASKS

5. **METHODOLOGY.**

a. ESC calculated mobility requirements based on identified tasks in each theater. ESC identified these tasks using OPORDs, maps and terrain analysis reports. Keeping the MSR net open generated most of this mission area. The MSR net and additional combat roads kept pace with the movement of the tactical force. The tactical force movement responded to the enemy's advance. TRADOC estimated the enemy's advance in Europe much faster than in the SWA desert. However, enemy scatterable mining capability broadly determined the mobility workload in both theaters.

b. Basic methodology differed slightly for each theater.

(1) ***Fire Phase***. In Europe, four artillery brigades and two ACRs used most of the available terrain. However, engineers only kept MSRs open to the rear of each of these brigade sized units. ESC kept open both a primary and alternate MSR with connecting laterals to each brigade. **Figure A-2** shows a schematic of this approach. Note, we call the brigade dual MSRs each a MSR corridor. Figure 4 before identified the statistical composition of these corridors.

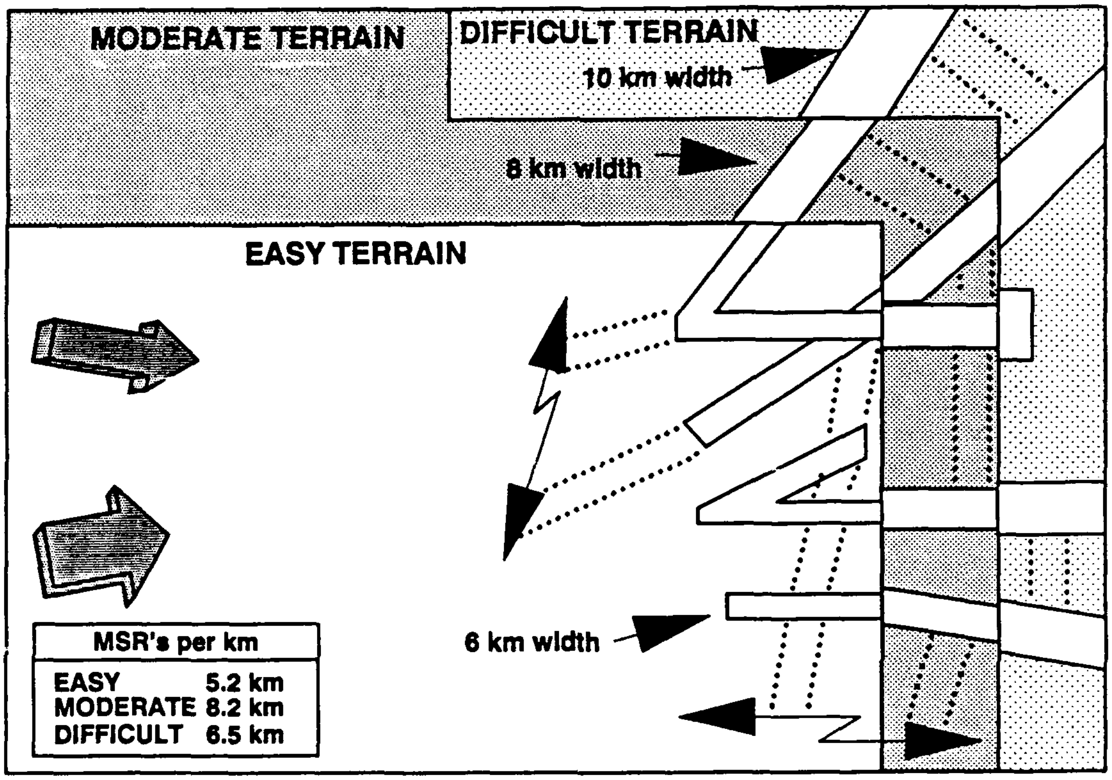

Figure A-2. MSR CORRIDORS

(2) ***Maneuver Phase***. In SWA, the maneuver phase started D+14. This allowed the engineers to do most of the MSR reconnaissance during the fires phase. Additionally, engineers used the fires phase to build parallel trails to MSRs to serve tracked vehicles. During the divisional advances of the maneuver phase, brigade engineers did other tasks. This latter work, dropped certain tasks for corps engineers. The divisional workload included daylight route reconnaissance, building more parallel trails, and the most important task of breaching minefields. However, the scatterable threat included minefields behind the leading divisions that evolve corps engineers.

6. DISCUSSION.

a. **Fire phase.** The top of **Figure A-3** shows the mobility planning factors used for calculating the fire phase requirements. ESC used factors for a standard breaching depth of 1,250 meters per average minefield met. We used different factors in building combat trails.

Task	Hours: Squad	Blade	5T Dptk	CMV	Loader
EUROPEAN FIRE PHASE					
Breach 1250m MSR Minefield Lane	1.25*			0.50	
Breach 1250m off-route MICLIC Minefield Lane	1.25*			2.50	
Improve 1250m off-route MICLIC Minefield Lane	3.75			6.25	
Mark 1250m Minefield Lane with HEMMS	5.00				
Build 1km Combat Trail:					
Easy Terrain	1.50	20.00	8.00		4.00
Moderate Terrain	2.50	25.00	10.00		5.00
Difficult Terrain	3.50	28.00	12.00		5.00
Initial Reconnaissance of MSR:					
32km by Mechanized Engineers	2.00				
48km by Wheeled Engineers	2.00		2.00		
SOUTHWEST ASIA MANEUVER PHASE					
Breach 1250m MSR Minefield Lane	2.03*			1.00	
Breach 1250m off-route MICLIC Minefield Lane	2.03*			4.79	
Improve 1250m off-route MICLIC Minefield Lane in Summan (Rock) Terrain	6.08			12.02	
Mark 1250m Minefield Lane with HEMMS in Summan (Rock) Terrain	9.38				
Build 2.6km of Combat Trail in Summan (Rock) Terrain		1.00			

* *Squads blow un-detonated mines same or following day*

Figure A-3. MOBILITY PLANNING FACTORS

We divided these combat trail factors between easy, moderate and difficult terrain. Finally, ESC used different factors for reconnaissance based on type of squad vehicle.

(1) ***Reconnaissance.*** **Figure A-4** shows the MSR net by unit and type terrain. For these calculations, ESC assumed: This was a squad task using the organic vehicle; engineers would look at only 50 percent of the total 4,464 kilometer (km) distance; and squads would be traveling half of the time and doing the reconnaissance in the remaining half. The squad in the wheeled engineer battalion uses its dump truck at an average speed of 48 km per hour. The mechanized squad would travel at 32 km per hour. The mechanized squad uses its tracked APC which our study equipment calculations does not follow or capture.

UNIT	TERRAIN	DISTANCE (kilometers)
66th Artillery Brigade	Difficult	344
66th Artillery Brigade	Moderate	190
67th Artillery Brigade	Moderate	638
68th Artillery Brigade	Difficult	346
68th Artillery Brigade	Moderate	464
69th Artillery Brigade	Difficult	294
69th Artillery Brigade	Easy	682
South ACR	Difficult	144
South ACR	Moderate	132
South ACR	Easy	526
North ACR	Difficult	52
North ACR	Moderate	230
North ACR	Easy	432
TOTALS:	**Difficult**	**1,180**
	Moderate	**1,654**
	Easy	**1,640**
All Units		**4,474**

Figure A-4. RECONNAISSANCE OF MSRs

(2) ***MSR Breaches***. All minefields across MSRs need breaching. ESC calculated the average 1250 meter depth of a minefield based on threat capabilities. For Europe, we determined that the fire phase capability was an average 65 percent of its D-day capability. We also assumed the threat fires one volley of scatterable mines every 24 hours. ESC calculated the breaching speed of the CMV at 10 km per hour. ESC assumes the CMV initially clears one lane right of the center lane. This lane opens traffic forward on the MSR. CMVs next sweep a second lane left of the center line of mines. Finally, CMVs make two more passes to clear into both route shoulders.

(3) ***Off-route Breaches***. ESC assumed engineers breach off-route lanes for artillery units to use. Engineers breached this type lane using the MICLIC. We calculated the enemy can place minefields in depth every 25 km across the battlefield. We assumed that 57 percent of these minefields needed lanes. We crossed minefields needing breaching with two lanes. Engineers marked all of these lanes using the HEMMS.

(4) ***Combat Trails***. ESC assumed that artillery brigades needed combat roads equal to 4 percent of the width of their operations.

b. **Maneuver Phase.** Figure A-3 also shows the mobility planning factors used to calculate maneuver phase requirements. These factors have decrements due to the hot desert conditions[1]. ESC used the same methodology here as for the fire phase except as noted below.

(1) ***MSR Breaches.*** The scatterable mine threat is higher in SWA than Europe. So ESC assumed the enemy can fire mines every 6 hours. We also figured the enemy was down to only 50 percent of his systems during this tactical phase. Of these minefields, ESC assumed 50 percent were in the divisional zones. The other 50 percent are on MSRs used by corps units and a task for corps engineers.

(2) ***Off-route Breaches.*** In this tactical phase, 25 percent of enemy minefields needed MICLIC lanes. This percentage is lower than Europe. Movement in the desert is primarily over existing routes.

(3) ***Combat Trails.*** ESC assumed the MSRs extend to brigade support areas. These areas move every 24 hours. Where there was no existing road, we assumed engineers would build a combat trail. ESC measured these distances using actual terrain maps. Mappers call the actual terrain *summan*, a type of encrusted rock. Movement over this rock is good so ESC only used the faster ACE. The ACE traveled in 3rd gear and made sporadic improvements.

7. **MEASUREMENT BASE. Figure A-5** shows the measurement base for the mobility tasks. In this figure, ESC averaged the SWA four day total. On a daily basis, SWA engineers breach more minefields on MSRs than off routes. In Europe, engineers breach more off-route minefields than in SWA. In both theaters, engineers build about the same amount of combat roads or trails per day. The CMV marks MSR lanes with CLAMS. The CLAMS marked lanes are therefore the same quantity as the MSR breaches.

Measurement	Base	Europe	SWA
Initial Reconnaissance	Km	2,237	--
Tactical MSR Breaches	Each	140	264
Off-route minefields	Each	28	17
Off-route MICLIC Lanes	Each	56	33
Lanes marked with HEMMS	Each	56	33
Combat Trails	Km	15	17

Figure A-5. MOBILITY MEASUREMENT RESULTS
(Average Per Day)

[1] *Workload Estimates for Combat Engineers in the Desert* (U.S. Army Corps of Engineers, Engineer Studies Center, April 1986), Annex A.

8. RESULTS.

a. **Hours Required.** **Figure A-6** shows the mobility results in hours for the mobility mission. The equipment list and total is higher than squad hours for Europe than in SWA. For squad hours, SWA's are higher than equipment hours while the reverse is true in Europe. Desert conditions in SWA require more man-hours per task than the temperate climate of Europe. The latter explains some of the differences in these results.

	EUROPE (1 Day)	**SOUTHWEST ASIA (4 Days)**
Squad Hours	883	4,452
Equipment Hours:		
CMV	560	3,275
ACE	182	25
5-ton Dump Truck	214	--
Loader	76	--
Total	**1,032**	**3,300**

Figure A-6. MOBILITY RESULTS (Hours Required)

b. **Corps Battalions.** **Figure A-7** shows the mobility workload needed by the two types of corps engineer battalions in both theaters. Both Europe and SWA require a total of four plus battalion equivalents of personnel. The CMV equipment battalion equivalents dominate each theater's equipment total. The CMV equipment equivalent is two to four battalions higher than personnel. However, ESC only used the CMV to haul the MICLIC trailer and improve the blown lane. The ACE can also perform this mission. Planners could transfer up to three-fourths of the CMV battalion equivalents to the ACE which would result in equipment equivalents approaching the personnel total.

Engineer Battalion Equivalent	**Squad**	**Blade**	**5T Dptk**	**CMV**	**Loader**
		EUROPEAN FIRE PHASE			
Mechanized Corps Battalion	3.35			6.37	
Wheeled Corps Battalion	1.19	2.07	0.81		1.73
Total	4.54	2.07	0.81	6.37	1.73
		SOUTHWEST ASIA MANEUVER PHASE			
Mechanized Corps Battalion	4.28	0.06		8.53	
Wheeled Corps Battalion					
Total	4.28	0.06		8.53	

Figure A-7. MOBILITY RESULTS (Corps Battalion)

9. **EXCURSIONS.** ESC conducted two excursions that use data from this annex.

a. ESC offered to show the outcome of breaching mines from MSRs using the MICLIC. The results of the MICLIC excursion are in Figure 27 of the main report. ESC concluded using the CMV is the better method to breach MSRs. However, we also recommended developing the Laser Gun Mine Neutralizer so the CMV has a dual countermine capability.

b. The USAES suggested ESC look at different threat scatterable mine capabilities in SWA. Different levels of threat mining affect four of the five SWA mobility tasks. The results of this excursion are in Figure 29 of the main report. For every enemy mine launch, the engineer workload increases by two battalions of CMVs and one of squad effort. This excursion reinforced the criticality of our own need for countermine capability. Engineers need to add more CMVs or additional countermine items of equipment to their units. Several initiatives are currently underway in the developmental community to solve this need.

10. **OBSERVATIONS.**

a. **Firestrike.** A new tactic, firestrike supports the fire phase of the ALB-F concept. In Europe, movement resembles a delay but the tactical initiative remains offensive. Because of the offense nature of firestrike, the engineer mobility mission is significant.

b. **Countermine Concern.** The scatterable mine threat is the first concern of mobility operations in ALB-F. This enemy capability drives the engineer mobility workload. This threat is even more important in the desert of SWA.

c. **CMV Criticality.** The CMV is essential in combating enemy scatterable minefields, so much so that it should be both enhanced and augmented. Planners can enhance the CMV by the addition of the Laser Gun Mine Neutralizer. Planners can also add this same laser gun to the ACE to give it countermine capabilities. When planners add the ACE to the CMV in the countermine role, engineers have a potent stockpile of mobility options.

d. **Squad Reconnaissance.** By engineer doctrine, reconnaissance is a squad mission. For this mission, wheeled engineers divert a 5-ton squad dump truck. For the same mission, mechanized engineers lose speed using organic APCs. If, in accordance with the ALB-F concept, airborne and space sensors provide route information, the requirement for engineer reconaissance would be lessened. Fewer reconnaissance teams at some other level might then be possible. Planners can examine returning the two or three reconnaissance teams to the S-2 section.

LAST PAGE OF ANNEX A.

ANNEX B

COUNTERMOBILITY REQUIREMENTS

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ANNEX B

COUNTERMOBILITY REQUIREMENTS

1. **PURPOSE.** This annex discusses methodology the Engineer Studies Center (ESC) used to determine requirements for the engineer countermobility mission.

2. **SCOPE.** This annex:

a. Defines countermobility tasks for the study's European and SWA theater scenarios.

b. Explains ESC's methodology for calculating countermobility task requirements.

c. Records countermobility task requirements in amounts, total man-hours and equipment-hours, and battalion equivalents.

d. Notes observations that pertain only to the analysis for this annex.

3. **ASSUMPTIONS AND THEIR SIGNIFICANCE.**

a. **Assumption.** VOLCANO canisters contain the WAM round(s) and the VOLCANO has its own vehicle. **Significance.** This report will underestimate study man-hours when engineers separately emplace the WAM. If planners place the VOLCANO on dump trucks listed in ANNEX F, then ESC underestimated dump truck hours.

b. **Assumption.** For convenience, ESC calculated bridge demolition hours separately *in Annex C.* **Significance.** As stated in this annex, this report doctrinally underestimates countermobility hours.

4. **TASKS.** **Figure B-1** shows the countermobility tasks calculated in this annex along with their priority. In SWA, all countermobility tasks were priority two. In Europe, two of the nine tasks are priority one, two priority three, and the rest priority two. In the SWA theater, offensive operations reduced the countermobility workload. In SWA, brigade engineers accomplished most of the countermobility tasks.

NUMBER	RANK EUROPE	RANK SWA	DESCRIPTION
C-1	1	2	• Load & Replace Air VOLCANO
C-2	1	-	Emplace Ground VOLCANO Minefield
C-4	2	-	Close Ground VOLCANO Minefield Lanes
C-5	2	-	TEXS (HME) Antitank Ditch w/Ground VOLCANO Minefield
C-6	2	-	Mechanical Antitank \ditch w/Ground VOLCANO Minefield
C-7	2	2	Road Crater w/MOPMS
C-9	2	-	Demolition Preparation of Dams
C-3	3	-	Minefield Lane Marking w/HEMMS
C-8	3	-	Miscellaneous Obstacle w/MOPMS

Figure B-1. COUNTERMOBILITY TASKS

5. **METHODOLOGY.**

a. ESC calculated countermobility requirements based on identified tasks in each theater. ESC identified these tasks using OPORDs, maps and terrain analysis reports. Additionally, the USAES furnished us an obstacle plan for each theater. ESC created its own obstacle plan and then verified it using the USAES's plan. Slowing, changing direction, or stopping enemy movement generated most of this mission area. In Europe, obstacles also helped contain and eventually counter two enemy airborne brigade drops. Enemy breaching capabilities determined minefield frontages. ESC used dynamic obstacles to protect friendly movement. TRADOC estimated movement in Europe would be much faster than in the SWA desert. However, terrain variances broadly determined the amount and type of obstacles in both theaters.

b. Basic methodology differed slightly for each theater.

(1) ***Fire Phase.*** In Europe, four artillery brigades and two ACRs responded to enemy division movement. ESC set up obstacles in concert with brigade and regiment operating plans.

(2) ***Maneuver Phase.*** In SWA, the maneuver phase started D+14. This allowed the engineers to pre-emplace extensive minefields during the fire phase. Engineers placed blocking minefields in front of the enemy's lead division. Engineers placed turning minefields on the enemy's left flank. Turning obstacles prevented a reserve division from reinforcing the two lead enemy divisions. During the divisional advances, brigade engineers did most of the countermobility tasks. This latter work, dropped certain tasks for corps engineers. The divisional workload included emplacing obstacles on our own divisional flanks.

6. DISCUSSION.

a. **Fire phase.** The top of **Figure B-2** shows the countermobility planning factors used for calculating the fire phase requirements.

	HOURS				
Task	**Squad**	**Blade**	**5T Dptk**	**HME**	**VOLCANO**
EUROPEAN FIRE PHASE					
Load/Replace 1 Air VOLCANO	0.5				
Lay 1150x125m Ground VOLCANO Minefield*	0.4				1.0
Mark 250m Minefield Lane w/HEMMS	1.0				
Close 125m Ground VOLCANO Minefield Lane	0.6				
Build 300m TEXS Antitank Ditch w/Ground VOLCANO	4.0		2.0	3.0	1.0
Build 500m Mechanical Antitank Ditch w/Ground VOLCANO	0.4	25.0			1.0
Emplace 1 Road Crater w/MOPMS	1.0				
Prepare Dam for Demolition	2.5		1.0		
Construct Miscellaneous Obstacle w/MOPMS	3.0		1.0		
SOUTHWEST ASIA MANEUVER PHASE					
Load/Replace 1 Air VOLCANO	1.0				
Emplace 1 Road Crater w/MOPMS	2.0				

* Includes reloading.

Figure B-2. COUNTERMOBILITY PLANNING FACTORS

(1) ***Air VOLCANO.*** Engineers are responsible for loading and replacing air VOLCANO canisters. This report captures the man-hours for this task. ESC also counts the number of canisters to figure ammunition rates. This report does not calculate aviation hours to emplace these minefields.

(2) ***Ground VOLCANO.*** ESC calculated all VOLCANO minefields with a standard dimension of 1150x125 meters. ESC determined the number of minefields according to the MSRs, maneuver, and enemy airborne brigades. Man-hours includes one complete cycle. A cycle includes firing, removing the spent canister, and replacement with a new one. One-half of all minefields included lanes for maneuvering. Engineers marked all lanes with HEMMS.

(3) ***Antitank Ditches.*** ESC estimated that engineers emplace antitank ditches only in the European theater. Engineers sited these ditches on easy and moderate terrain, emplacing about one-third mechanically. The remaining ditches used the TEXS with the HME. ESC reinforced both types of ditches with ground VOLCANO minefields.

(4) ***Road Craters.*** ESC planned road craters using the BRM reinforced with MOPMS. We selected road locations in difficult terrain for this obstacle. We also created a road crater where roads crossed into our antitank ditches and ground VOLCANO minefields. All craters used 5 BRMs for an average road width of 30 feet.

(5) ***Dam Demolition.*** In estimating the workload to prepare a dam for demolition, ESC did not include the obstacle firing time. We counted the number of dams in the battle zone. We estimated the workload to attack spillway valves (water relief regulator). Or, the workload represents a 2-stage conventional attack on dam edges.

b. **Maneuver Phase.** The bottom of Figure B-2 shows the countermobility planning factors used for calculating the maneuver phase requirements. These factors have decrements due to the hot desert conditions[1]. ESC used the same methodology here as for the fire phase except as noted below.

(1) ***Air VOLCANO.*** ESC assumed commanders emplaced air VOLCANO minefields to interdict enemy escape routes in the rear. The quantity ESC estimated was less than in Europe. Competing tank fighting missions of the helicopters caused this reduction.

(2) ***Road Craters.*** ESC had engineers emplace only a few road craters. These craters interdicted principal MSRs. Engineers moved to all road craters sites by helicopter.

7. **MEASUREMENT BASE.** In **Figure B-3**, the measurement base for countermobility tasks, ESC averaged the SWA four day total. This figure reinforces the commitment of Corps Engineers to the fires phase in EUROPE. Note the contribution of non-engineers in the placement of minefields. On a daily basis, SWA commanders plan less air VOLCANO minefields than in Europe. However, the VOLCANO four-day SWA maneuver total is higher

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[1] *Workload Estimates for Combat Engineers in the Desert* (U.S. Army Corps of Engineers, Engineer Studies Center, April 1986), Annex A.

than Europe's one-day fires phase total. ESC assumed different uses for artillery minefields depending on tactical phase. In Europe's fire phase, we used artillery minefields to entrap two enemy airborne brigades. In SWA's maneuver phase, we placed minefields astride MSRs connecting two enemy armor divisions.

Measurement	**Base**	**Europe**	**SWA**
Air VOLCANO Load/Unload	Canisters	12	7.5
Ground VOLCANO Minefields:			
Separate	Meters	71,300	--
W/Antitank TEXS Ditch	Meters	5,750	--
W/Antitank Blade Ditch	Meters	4,600	--
Minefield Lanes Marked	Each	62	--
Minefield Lanes Closed	Each	62	--
TEXS Antitank Ditch	Meters	3,600	--
Blade Antitank Ditch	Meters	1,750	--
Road Craters	Each	96	3
Dam Demolitions	Each	6	--
Miscellaneous Obstacles	Each	8	--
Non-engineer:			
Aviation Air VOLCANO			
Minefield (400x400)	Meters	19,200	12,000
Artillery 155mm			
Minefield (170x1100)	Meters	16,000	2,000

Figure B-3. **COUNTERMOBILITY MEASUREMENT RESULTS (Daily Average)**

8. RESULTS.

a. **Hours Required. Figure B-4** shows countermobility mission results in hours. In Europe, engineers use about an equal amount of squad-hours as equipment-hours. In SWA, due to the tactical situation, engineers use only a small amount of squad-hours.

	EUROPE (1 Day)	**SOUTHWEST ASIA (4 Days)**
Squad Hours	286	54
Equipment Hours:		
ACE	88	--
HME	39	--
5-ton Dump Truck	86	--
Ground VOLCANO	68	--
TOTAL	281	--

Figure B-4. COUNTERMOBILITY RESULTS (Hours Required)

b. **Corps Battalions.** **Figure B-5** shows the countermobility workload needed by the two types of corps engineer battalions. Readers can directly compare the information for both theaters in this figure. In Europe, engineers need about one-and-a-half battalion equivalents of personnel and equipment. The squad-hour and ground VOLCANO battalion equivalents back this total. In SWA, personnel represent only a fraction of one battalion equivalent.

Engineer Battalion Equivalent	**Squad**	**Blade**	**5T Dptk**	**HME**	**VOLCANO**
			EUROPEAN FIRE PHASE		
Mechanized Corps Battalion	0.88	0.48	0.64	0.89	0.99
Wheeled Corps Battalion	0.60	0.28	0.11	0.45	0.56
Total	1.48	0.76	0.75	1.34	1.55
			SOUTHWEST ASIA MANEUVER PHASE		
Mechanized Corps Battalion	--	--	--	--	--
Wheeled Corps Battalion	0.04	--	--	--	--
Total	0.04	--	--	--	--

Figure B-5. COUNTERMOBILITY RESULTS (Corps Battalions)

9. **EXCURSIONS.** ESC conducted two excursions that use data from this annex.

a. What is the impact of replacing the ACE with scrapers in digging mechanical antitank ditches? Results of the antitank excursion appear in Figure 28 of the *main report*. ESC concluded the ACE is better for constructing ditches. This excursion also exposed the weakness of the explosive ditch or TEXS (NOTE: the TEXS is still a developmental system). ESC recommends planners use mechanical ditches over explosive ones.

b. What is the daily ammunition supply rate for engineer related explosives and mines? ESC looked at five different types of Class V ammunition. **Figure B-6** shows the results of this excursion. ESC looked at four engineer munitions, two artillery and one aviation.

LOADS/	EUROPE		SOUTHWEST ASIA	
ROUNDS	ENGINEER	OTHER	ENGINEER	OTHER
MOPMS	456	--	6	--
VOLCANO*	71	12	--	7.5
MICLIC	728	--	429	--
BRM	1,408	--	15	--
RAAMS**	--	1,920	--	240.0
ADAM***	--	240	--	30.0

* Includes WAM
** 9 mines per round
*** 36 mines per round

Figure B-6. CLASS V RESULTS (Daily Average)

We did not expand our results beyond the fires phase in Europe or the maneuver phase in SWA, nor did we include munitions used by the brigade engineers in SWA. The fires phase, where planners stress countermobility, consumes the most ammunition. In both theaters, the air VOLCANO rates are close together. Munition rates for other theater munitions are far apart.

10. OBSERVATIONS.

a. **ALB-F.** The engineer countermobility mission is low for the ALB-F concept. The mission is low whether in the fires phase or the maneuver phase. Planners could lower the number of ground VOLCANOs in corps battalions. The planned ground VOLCANO quantities support a more conventional defensive tactic. These observations are no surprise. The ALB-F centers on destroying enemy forces. Neither seizing or holding terrain is important. Because of the latter, countermobility missions will always be low.

b. **Antitank Ditches.** The ALB-F concept requires engineers to construct only a few antitank ditches. Engineers can construct the few needed ditches using the ACE or dozer. The ALB-F concept does not require further development of the TEXS. The USAES should drop the TEXS. When planners need extensive antitank ditches, the heavy battalion can come forward.

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ANNEX C

BRIDGING REQUIREMENTS

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ANNEX C

BRIDGING REQUIREMENTS

Paragraph **Page**

Figures

1. **PURPOSE.** This annex discusses the methodology ESC used to obtain requirements for the engineer bridging mission.

2. **SCOPE.** This annex:

a. Defines the European scenario's bridging tasks (SWA has no bridging tasks).

b. Explains the methodology used to calculate bridging task requirements.

c. Records the bridging task requirements in amounts, total man-hours and equipment-hours, and the equivalent battalion equivalents.

d. Notes observations that pertain only to the analysis for this annex.

3. **ASSUMPTIONS AND THEIR SIGNIFICANCE.**

a. **Assumption.** Water and gap conditions allow engineers to cross military load class (MLC) 70 vehicles. This applies to the MGB, ribbon bridge, and the heavy assault bridge (HAB). **Significance.** Developers are designing future bridging for MLC 70 and engineers have specified current bridges for various MLC 70 configurations. However, the

Army has not tested all configurations. If future testing invalidates these assumptions, the annex's findings are inadequate.

b. **Assumption.** ESC estimated war damage to bridges is realistic. **Significance.** ESC had no war game models to estimate war damages. We took damage rates from other studies and models and related them to this study. If actual damage rates run significantly higher or lower, then our results are either under or overstated.

4. **TASKS.** **Figure C-1** shows the bridging tasks calculated in this annex along with their priority. Five of the seven tasks are normally mobility tasks. The two "disable" tasks are normally countermobility tasks. ESC calculated all of these tasks for the European scenario. The SWA scenario had a few bridges over trafficable wadis so no tasks were applicable here.

NUMBER	RANK	DESCRIPTION
B-1	1	Emplace Ribbon Bridge with Alternate Site
B-4	1	Span Gap less than 18m with HAB
B-6	1	Disable 2 Lanes 7.5m Wide with BRM
B-7	1	Disable Large MSR Bridge with C-4
B-2	2	Operate 2 ERPs per Ribbon Bridge Site
B-3	2	Repair MSR Bridge with 45.7m Link Reinforced MGB
B-5	2	Span Gap less than 18m with MGB

Figure C-1. BRIDGING TASKS

5. **METHODOLOGY.**

a. **Fire Phase.** ESC calculated fire phase requirements for large gap requirements based on actual MSR bridges in the scenario. ESC identified these bridges using maps and terrain analysis reports. We generated small gap requirements statically from terrain samples. ESC used the HAB to span gaps in the center of the battle zone. The MGB spanned gaps near or in the tactical support area. ESC estimated war damage to both types of bridges based on location to the enemy. Most of our calculations centered on MSR bridges located within brigade corridors. Annex A provides a detailed explanation of brigade corridors. Finally, ESC averaged bridge lengths based on actual waterway widths.

b. **Maneuver Phase.** ESC calculated maneuver phase bridge requirements using a derivative methodology. This methodology used former ESC studies and river averages based on classic European battlegrounds. This methodology relates linear battle, using today's weaponry, to future non-linear battle and equipment.

6. **DISCUSSION.**

a. **Fire phase.** **Figure C-2** shows the bridge planning factors ESC used to calculate fire phase requirements. ESC used factors for float and fixed bridges (less the HAB)

Task	Hours				Bridging Meters	
	Squad	Blade	5T Dptk	HAB	Ribbon	MGB
Emplace Ribbon Bridge Site		4			1m/Gap m	
Operate 2/ERPs/Hour	0.5					
Emplace 45.7m MGB						1m/Gap m
Span <18m Gap w/HAB				1		
Span <18m Gap w/MGB						1m/Gap m
Disable 2x7.5m Bridge	1.0		1			
Disable Large MSR Bridge	18.0		2			
Daily capability				**176m/Bn**	**213m/Co**	**122m/Co**

Figure C-2. BRIDGE PLANNING FACTORS

depicted in meters of bridge. The total meters calculated divided by these factors gave the bridge workload directly in bridge companies.

(1) *Gap Characteristics.* Figure 4 previously showed the distribution of gaps less than 18 meters wide. ESC also conducted a survey of rivers over 18 meters wide. This survey embraced the classic invasion routes of central Europe. This survey revealed that rivers average 60 meters wide. The survey also measured the number of large rivers for every 100 kilometers of longitude. There are, on the average, no rivers every 100 kilometers on 28 percent of the longitudinal segments, one river on 43 percent, two rivers on 24 percent, and three or more rivers on 5 percent of the segments. This means there is a 95 percent chance there are two rivers or fewer for any segment. Tacticians should be able to avoid the avenues of approach that contain three or more rivers.

(2) *Damage Assessment.* ESC assumed 100 percent damage of large bridges in the center of the battle zone. Ribbon bridges used to replace these disabled bridges suffered losses of two-thirds of the bridge bays per day. We assumed a 50 percent damage factor for large bridges in the Tactical Support Area. For small bridges, ESC assumed only a 4 percent damage factor. For all damage factors, the cause of destruction can vary from local sabotage to threat bombers. ESC did not separate destruction causes by percentages.

(3) *Bridge Demolitions.* ESC divided bridges for demolition into two groups. The center classified bridges with one or two lanes as small bridges. We classified bridges with four or more lanes as large bridges. ESC counted the number of bridges requiring demolitions from a site specific obstacle plan.

b. **Maneuver Phase.** ESC employed a derivative analysis to compute the large bridge workload for the maneuver phase. For this analysis, ESC assumed a scenario with three divisions, each crossing one river. Each division uses two crossing sites. ESC then combined river widths, bridge bay damage estimates and ribbon bridge company capability to calculate float bridge workloads. We estimated fixed bridge workload based on the normal ratio of float to fixed bridges, i.e., 6:4, or total float bridge workload is 60 percent float and

40 percent fixed. The 40 percent of fixed bridges includes the requirement for both large and small gap bridges. We determined this ratio using ESC's 1988 *USAREUR Tactical Bridge Study*.[1]

7. **MEASUREMENT BASE. Figure C-3** shows the measurement base for the bridging tasks. In this figure, ESC averaged the lengths of small MGB bridges as 9.6 and 13.7 meters long. We used a 7.9 meter MGB over 2.7-5 meters gaps, 14.9 meter over 5-12 meter gaps, and 20.4 meter for 12-18 meter gaps. We averaged these lengths using the percent distributions for the two terrain types shown in Figure 4 of the main paper. This figure also shows that two 45.7 meter MGBs use all of a company's 121.5 meters of bridge. The leftover bridge bays are not usable since the company's link reinforcing sets are all in use.

Bridge	Quantity	Size	Meters
	FIRE PHASE		
Small Bridge Demolitions	58	--	--
Large Bridge Demolitions	24	--	--
HAB Bridge Sites	45	--	--
Ribbon Bridges	2	21m	70.0
	2	36m	126.7
Sub-total	4	--	196.7
Large Medium Girder Bridges	2	45.7m	121.5
Small Medium Girder Bridges	15.5	9.6	148.9
	10.7	13.7	146.3
Sub-total	26.2	--	295.2
	MANEUVER PHASE		
Ribbon Bridges	6	60m	600.0
Medium Girder Bridges	--	--	400.0

Figure C-3. BRIDGE MEASUREMENT RESULTS

8. **RESULTS.**

a. **Bridge Companies. Figure C-4** shows the bridge results for ribbon and medium girder bridge companies. ESC recommends three of both type bridge companies. Since the scenario had three divisions, this recommendation represents one set of bridge companies per division. If the number of deployed divisions per corps is higher than three divisions, then the number of sets should increase by the same number. ESC bases this allocation on the worst case of two river lines per scenario. The actual scenario has only one river line. History shows bridging is critical to the success of tactical operations. For this reason, ESC

[1] *USAREUR Tactical Bridge Study* (U.S. Army Corps of Engineers, Engineer Studies Center, September 1988) (SECRET NOFORN-NOCON).

raised the results to cover a 95 percent chance of having the correct amount of bridging available. ESC also lowered the MGB company total by one company. We felt that tracked vehicles could use fascines, temporary fords, or expedient earth/gravel fill for gaps between 2.7 and 5 meters. We did not consider gaps below 2.7 meters as this is the self-crossing capability of tracked vehicles.

	Ribbon Bridge Companies	MGB Companies
FIRE PHASE		
Wet Gaps	0.92	--
Dry Gaps:		
>18 Meters	--	1.00
<18 Meters--	--	2.42
(5-18 Meters)	--	(1.42)
(<5 Meters)	--	(1.00)
Scenario Total	0.92	3.42
Two-river Line Total	1.84	4.42
No MGB <5 Meters	--	3.42
MANEUVER PHASE		
Derivative Analysis	2.82	3.28
TOTAL SCENARIO		
ESC Recommended	3.00	3.00

Figure C-4. BRIDGING RESULTS

b. **Corps Battalions. Figure C-5** shows the bridge demolition workload needed by the corps engineer battalions. Over two corps battalions of bridge effort are actually countermobility results. This figure does not show an additional 0.3 battalions of effort. These 0.3 battalions represent the man-hours needed to operate the equipment regulating points for ribbon bridge operations.

9. **EXCURSIONS.** The Study Advisory Group at IPR #1, 10 July 1990, asked ESC to conduct two excursions.

a. **Bridge Losses.** The first excursion did not replace ribbon bridge bay losses from depot stocks. This excursion equalled a 0.74 additional ribbon bridge company requirement. This 0.74 added to the base case equals a new workload of 3.56 or 4 ribbon bridge companies. ESC believes ribbon bridge bays would be available from depot stocks. We base this belief on the criticality of the MSR net to resupply the artillery brigades with ammunition.

The corps commander normally would support this priority and the bays are within trucking distance.

	Personnel	5-ton Dump Truck
Mechanized Battalion	1.7	1.0
Wheeled Battalion	0.6	0.1
Total Battalions	**2.3**	**1.1**

Figure C-5. BRIDGE DEMOLITION RESULTS

b. **More Crossing Sites.** The base case uses two crossing sites per division. ESC bases this on the locations of the enemy and the favorable attack ratio of our forces. ESC assumes one brigade crossing for each of two brigades of a division. The third brigade would follow one of the lead brigades. The excursion raises the crossing sites from two to four per division. This excursion adds 2.82 ribbon bridge companies. The excursion added to the base case equals 5.64 or 6 ribbon bridge companies. Adding the first excursion to the second excursion equals 6.38 companies. The excursions combined still round to an even 6 company total. The number of bridges per division crossing is the most critical factor of this task. ESC believes that these crossings are more of a hasty nature than deliberate. Hasty crossings normally require less sites. Additionally, if a deliberate crossing is necessary, the Corps Commander would probably cross with only one division versus two.

10. **OBSERVATIONS.**

a. **Bridge Mix.** ESC analysis strongly shows that the float to fixed ratio of bridge companies be 1:1.

b. **Small Gaps.** Terrain studies consistently show more gaps under 12 meters than from 12 to 24 meters. The actual 18-meter capability of the AVLB is excessive. The design capability of the HAB at 24 meters is extravagant unless able to emplace half a bridge in two locations. At the other end of the spectrum, the forces need fascines. Large quantities of fascines are the most cost-effective bridge solution now available.

c. **Bridge Quantity.** AirLand Battle-Future requires one bridge company set (1 Ribbon Bridge + 1 MGB) per heavy division in a corps.

d. **Division Bridging.** This analysis provided corps bridging to support division operations. No evidence supports organic large-gap bridging assets for brigades.

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ANNEX D

SURVIVABILITY REQUIREMENTS

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ANNEX D

SURVIVABILITY REQUIREMENTS

1. **PURPOSE.** This annex discusses the methodology ESC used to determine combat engineering survivability requirements.

2. **SCOPE.** This analysis:

a. Identifies tasks most likely to impact significantly on the corps' ability to survive on the non-linear battlefield.

b. Constructs an algorithm for calculating engineer effort associated with each task.

c. Determines survivability requirements for the fires phase in the European theater scenario and for the maneuver phase in the Southwest Asia theater.

d. Makes observations that pertain only to the analysis of this annex.

3. **ASSUMPTIONS AND THEIR SIGNIFICANCE.**

a. **Assumption.** In the Southwest Asia theater, the division will use the CP evacuated by a brigade. **Significance.** This obviates the need for the engineers to provide protection to division CPs.

b. **Assumption.** Enough host nation support personnel are available to satisfy most of the COSCOM protection requirements. **Significance.** Without this support, the engineer workload would increase in both scope and size.

4. **ENGINEER SURVIVABILITY TASKS.** Survivability on the non-linear battlefield involves protecting key command, control, and communications facilities. The non-linear concept does not require engineers to protect tanks and infantry fighting vehicles. The shoot and scoot concept for artillery and ADA battalions obviates the need for the engineers to provide protection for these weapon systems. Host Nation and COMMZ engineer heavy battalions provide protection for Corps and Corps Arty main CPs plus COSCOM installations. **Figure D-1** lists the major survivability tasks and priorities for the corps engineer brigade. ESC protected 20 signal sites, four artillery brigades, one ADA brigade, the Corps tactical CP, and Corps Artillery tactical CP.

	RANK		
NUMBER	EUROPE	SWA	DESCRIPTION
S2	2	3	Protect Bde CP Sites
S3	2	3	Protect Tactical CP Sites for Corps and Corps Artillery
S1	3	3	Protect Signal Sites

Figure D-1. SURVIVABILITY TASKS

5. **METHODOLOGY.** ESC determined and quantified survivability tasks by looking at several factors. Engineers protected units that stayed in one place a long time. Engineers favored protecting equipment in the battle zone over the tactical support area. Engineers did not protect equipment and supplies that were in low densities or rapidly moved. The short duration of both conflicts kept supplies moving and dispersed. ESC assumed host nation support assets available whenever commanders could use them.

a. **Figure D-2** shows the algorithm derived from the methodology that ESC used to calculate requirements.

Engineer Requirements (Equipment-hours/Man-hours) =

Items to be Protected X Number of Moves X Hours Per Item

Figure D-2. SURVIVABILITY REQUIREMENTS ALGORITHM

b. ESC determined the number and type items engineers would protect. We confirmed this information with the SAG at two IPRs.

6. DISCUSSION.

a. **Planning Factors.** The top of **Figure D-3** shows survivability planning factors for the European theater fires phase, while the bottom lists factors for the SWA maneuver phase.

	BLADE HOURS	LOADER HOURS
EUROPEAN SCENARIO		
Protect Signal Sites	0.75	0.00
Protect Bde CPs	0.86	1.72
Protect Corps/Arty	0.86	1.72
SOUTHWEST ASIA SCENARIO		
Protect Signal Sites	0.93	0.00
Protect Bde CPs	1.70	3.40
Protect Corps/Arty	1.70	3.40

Figure D-3. SURVIVABILITY PLANNING FACTORS

b. **Fires Phase.** In Europe, opportunity exists to find cover and concealment both natural and man-made.

c. **Maneuver Phase.** ESC found that dispersion and mobility are the best solution for desert survivability. In this terrain, logisticians must import materials for engineers to use in constructing protective positions. Commanders place vehicles in natural defilade for it is difficult to dig positions in rocky or sandy desert type terrain. Engineers should remove soil from trenches as berms tend to outline positions. The SWA theater had one less artillery brigade for engineers to protect than Europe.

d. **Movement.** In Europe, ESC assumed engineers protect all communication sites one time. These sites stayed in place for the duration of the fires phase. We set up and moved corps tactical CPs to new protected positions twice. We set up field and air defense artillery brigades three times. In SWA, engineers provided positions for the same number of moves per unit except at corps level. We did not move the corps tactical CPs.

7. ***MEASUREMENT BASE. Figure D-4** shows the measurement base totals for the* European and the Southwest Asia theaters. The survivability task totals are low for reasons distinct to each theater.

TASK	EUROPE	SWA
Protect Communications Sites	20	20
Protect FA & ADA Sites	15	12
Protect Corps/ARTY TAC Sites	4	2

D-4. SURVIVABILITY MEASUREMENT RESULTS

a. The European theater showed the introduction of the fires phase. This phase introduces firestrike, the newest evolution of artillery warfare. During this phase, we will prevent the enemy from massing his forces and moving forward through our RISTA efforts. We will prevent the enemy from detecting and firing on our positions through our counter-RISTA efforts. These efforts include frequent movement preventing the need for engineers to dig artillery positions.

b. The Southwest Asia theater developed the maneuver phase. In this phase, we first gain air superiority, then maneuver elements move rapidly against the enemy. Holding or seizing terrain, the normal generator of a survivability workload, is not an aim.

8. RESULTS.

a. **Figure D-5** incorporates the survivability results for the European theater. ESC calculated a workload of about three-fourths of a wheeled corps battalion. We estimated only one-tenth a battalion workload for the mechanized battalion. We used the mechanized battalion's ACEs to construct the remote signal sites. The wheeled battalion made up the bulk of this workload as it has the only loaders.

	BATTALION EQUIVALENTS		TOTAL HOURS
	BLADES	LOADER	
MECHANIZED	0.10	0.00	15.0
WHEELED	0.19	0.74	49.0
TOTALS	**0.29**	**0.74**	**64.0**

Figure D-5. SURVIVABILITY RESULTS -- EUROPE

b. **Figure D-6** shows the results of the southwest Asia workload calculations. The hours column displays the total hours for the four-day maneuver phase. The other equipment columns show battalion equivalents. ESC estimated an insignificant corps mechanized battalion workload. The workload for a wheeled corps battalion equals one-fourth a battalion.

	BATTALION EQUIVALENTS		TOTAL HOURS
	BLADES	LOADER	
MECHANIZED	0.04	0.00	19.0
WHEELED	0.06	0.25	71.8
TOTALS	**0.10**	**0.25**	**90.8**

Figure D-6. SURVIVABILITY RESULTS -- SWA (4 Day Total)

9. OBSERVATIONS.

a. Artillery and Air Defense require little or no protected positions below brigade headquarters during either tactical phase or theater.

b. Maneuver forces do not expose themselves unnecessarily before striking and, therefore, do not need protected positions.

c. The host nation will provide most of the survivability support in the corps tactical support area.

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ANNEX E

SUSTAINABILITY REQUIREMENTS

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ANNEX E

SUSTAINABILITY REQUIREMENTS

1. **PURPOSE.** This annex presents the methodology ESC used to estimate sustainment engineering requirements for the non-linear battlefield.

2. **SCOPE.** The analysis in this annex:

a. Identifies and compares sustainment engineering tasks and priorities.

b. Determines sustainment engineering requirements for the study's two theaters.

c. Makes observations that pertain only to the analysis of this annex.

3. **ASSUMPTIONS AND THEIR SIGNIFICANCE.** ESC developed several engineer assumptions by applying AirLand Battle-Future doctrine to the two theater scenarios.

a. **Assumption:** As much as possible, U.S. engineers take advantage of existing facilities. This is especially true for the European theater. The host nation will also provide support to the engineers in the rear portion of the tactical support area. **Significance.** The host nation support will offset a large percentage of the U.S. engineer requirement.

b. **Assumption:** In the Southwest Asia theater, host nation contractors or theater heavy battalions provide dust abatement to main supply routes (MSRs). **Significance.** This also reduces the U.S. engineer workload in the corps area.

c. **Assumption:** The new doctrine disperses forward logistics with very little buildup of supply levels. **Significance.** This reduces the task for engineers to construct base infrastructures.

4. **TASKS.** MSR maintenance is the primary sustainment engineering task. For the European theater, engineers also clear rubble from these routes. As an adjunct to this, ESC quantifies construction of combat trails in the mobility annex (Annex A). **Figure E-1** shows the European and Southwest Asia Sustainment Engineering tasks and priorities for non-linear battles.

NUMBER OF TASK	RANK IN THEATER		MSR TASK DESCRIPTION
	EUROPE	SWA	
E1	3	---	Rubble Clearance
E2	3	3	Maintain 100 km

Figure E-1. SUSTAINMENT ENGINEERING TASKS AND PRIORITIES

5. **METHODOLOGY.** ESC considered several factors to calculate the sustainment engineering workload. Location of terrain corridors determined tactical avenues of approach. These avenues then defined MSRs that engineers must maintain. The support area locations provided additional MSR tasks for engineers. For Europe, the amount of war damage determined the rubble engineers need to remove from MSRs. Engineers avoid extensive MSR development and repair by using host nation support. The short duration of the war also lessens the wear and damage by vehicles to the MSR network.

6. **DISCUSSION.**

a. **Fire Phase. Figure E-2** shows the Sustainment Engineering planning factors for the European theater's fire phase. Sustainment engineering tasks include only MSR repair and rubble clearance. Logisticians use host nation facilities for ammunition and storage sites. The enemy does not bomb these storage sites.

b. **Maneuver phase. Figure E-2** also shows planning factors for the Southwest Asia theater's maneuver phase. MSR repair of loose surface roads is the only task. The harsh desert conditions increase engineer planning factors. Engineers direct their support towards the mobility of the two attacking heavy divisions. During the fire phase's preceding 14 days, engineers improve roads to COSCOM and the 47th Air Assault Division areas. Engineers also complete POL and ammunition storage areas before D+14. U.S. and contract engineers also provide helicopter pads with dust palliation before the maneuver phase begins.

MSR TASK	SQUAD HOURS	BLADE HOURS	LOADER HOURS	DMP TRK HOURS	GRADER HOURS
			EUROPEAN SCENARIO		
Rubble Clearance	2.10	2.75	2.75	2.75	---
Maintain 100 km Bituminous Surface	12.50	---	12.50	50.00	25.00
			SOUTHWEST ASIA SCENARIO		
Maintain 100 km Loose Surface	---	76.92	23.92	95.70	95.70

Figure E-2. SUSTAINMENT ENGINEERING PLANNING FACTORS

7. MEASUREMENT BASE.

a. **Fire Phase.** **Figure E-3** shows the sustainment engineering measurement base for the fire phase in the European theater expressed in (1) kilometers of main supply route, (2) kilometers of MSR in urban areas, (3) total number of urban areas, (4) rubble spots as a percentage of the total number of urban areas, and (5) the total area for rear area maintenance. ESC uses this base to calculate needed MSR repair and rubble clearance.

TYPE OF TERRAIN	MSR KMS	URBAN AREAS KM OF MSR	URBAN AREAS	RUBBLE SPOTS*	REAR AREA MAINTENANCE
EASY	1,633	0.40	653	65	668
MODERATE	1,645	0.20	329	33	188
DIFFICULT	1,158	0.15	174	18	781
TOTAL	**4,436**	----	**1,156**	**116**	**1,637**

** = 10% DAMAGE*

Figure E-3. SUSTAINMENT ENGINEERING MEASUREMENT RESULTS (EUROPE)

b. **Maneuver Phase.** **Figure E-4** shows the measurement base for Southwest Asia's maneuver phase. The figure quantifies supply routes for the 23rd Armor Division, the 53rd Mechanized Division, the 47th Air Assault Division and the Corps rear areas. ESC bases calculations on a four-day maneuver plan. As the two heavy divisions advance towards the enemy, their MSR network increases. ESC exclude the 47th Air Assault Division and the Corps rear area from the engineer work load calculations. The host nation and theater engineers repair the excluded MSRs.

	DAY 1	DAY 2	DAYS 3 & 4
23d Armor Div	190	320	489
53d Mech Div	128	264	438
47th AA Div*	392	392	392
Corps Rear Area*	407	407	407
TOTAL	**1,117**	**1,383**	**1,726**

* Support from Host Nation/Heavy Battalions

Figure E-4. SUSTAINMENT ENGINEERING MEASUREMENT RESULTS (SWA)

8. RESULTS.

a. **Figure E-5** incorporates sustainment engineering results for the fire phase in the European theater. The figure shows total hours as well as total battalion equivalents. The equipment workload -- almost 12 battalions -- result from the use of over 500 loader hours. Squad-hours are low, i.e., just over two battalions of effort.

	HOURS	BATTALION EQUIVALENTS
Blades	318	2.89
Loaders	522	11.87
5-Ton Dump Trucks	1,136	6.46
Graders	409	6.20
TOTAL EQUIPMENT	**2,385**	**11.87**
SQUADS	447	2.33

Figure E-5. SUSTAINMENT ENGINEERING RESULTS -- EUROPE

b. **Figure E-6** shows the Southwest Asia sustainment engineering results. In this area, workload is high because of the effort to maintain loose surface secondary roads. Again, the loader is the key piece of equipment, requiring over nine battalion equivalents. No squad-hours are required because there is no rubble to remove. ESC calculates mine removal from MSRs under mobility (Annex A).

	HOURS	BATTALION EQUIVALENTS
Blades	2,120	4.91
Loaders	659	3.43
5-Ton Dump Trucks	2,637	2.29
Graders	2,637	9.16
TOTAL EQUIPMENT	**8,053**	**9.16**

Figure E-6. SUSTAINMENT ENGINEERING RESULTS -- SWA (4-DAY TOTAL)

9. **OBSERVATIONS.**

a. For the European theater, sustainment engineering is about one-half MSR maintenance and one-half rubble clearance.

b. In desert offensive operations, MSR maintenance is the predominant sustainment engineering task because of:

(1) lack of paved roads
(2) use of existing loose surface roads and trails
(3) lack of war damage to other facilities

c. Dust abatement will be a problem in the Southwest Asia theater desert. For this task, engineer units can use either bituminous distributors or dump truck spreaders. However, this report did not calculate the workload for these two types of equipment.

d. The non-linear battlefield creates more requirements for tactical, combat support, and combat service support units to be self-sustained. This will reduce, for engineer units, traditional sustainment engineering tasks.

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ANNEX F

ENGINEER UNIT FUTURE DESIGNS

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ANNEX F

ENGINEER UNIT FUTURE DESIGNS

Paragraph **Page**

Figure

1. **PURPOSE.** This annex shows the engineer unit designs used to calculate capability.

2. **GENERAL.** **Figures F-2 to F-6** show the strength and equipment of the five units calculated in this study. **Figure F-1** shows the structure proposed for these five units (Solid boxes represent the minimum strength configuration proposed by TRADOC. Dotted boxes represent the Engineer School's maximum proposed design). The Engineer School designed all of these future units and structure[1]. As the engineer proponent, the school designed these units to support the ACORDS study.

3. **BATTALION EQUIVALENTS.** ESC used Figures F-2 and F-3 to compute battalion equivalents for each scenario. We combined the number of squads and squad size in these figures with the study's capability assumptions and scenario lengths. ESC examined 22 hours of the European scenario and 4 days in the SWA scenario. In Europe, study capability was 185.6 squad hours for the wheeled corps battalion and 198 hours for the mechanized battalion. The European study's battalion equivalent equalled 191.8 hours. In SWA, the capability was 1,215 squad hours wheeled, 864 mechanized for a 1,039.5 average battalion equivalent.

[1] *Study Plan Engineer Support to Corps Operations, Non-Linear Battlefield Concept* (United States Army Engineer School, 13 July 1990), Appendix 2 to Annex B.

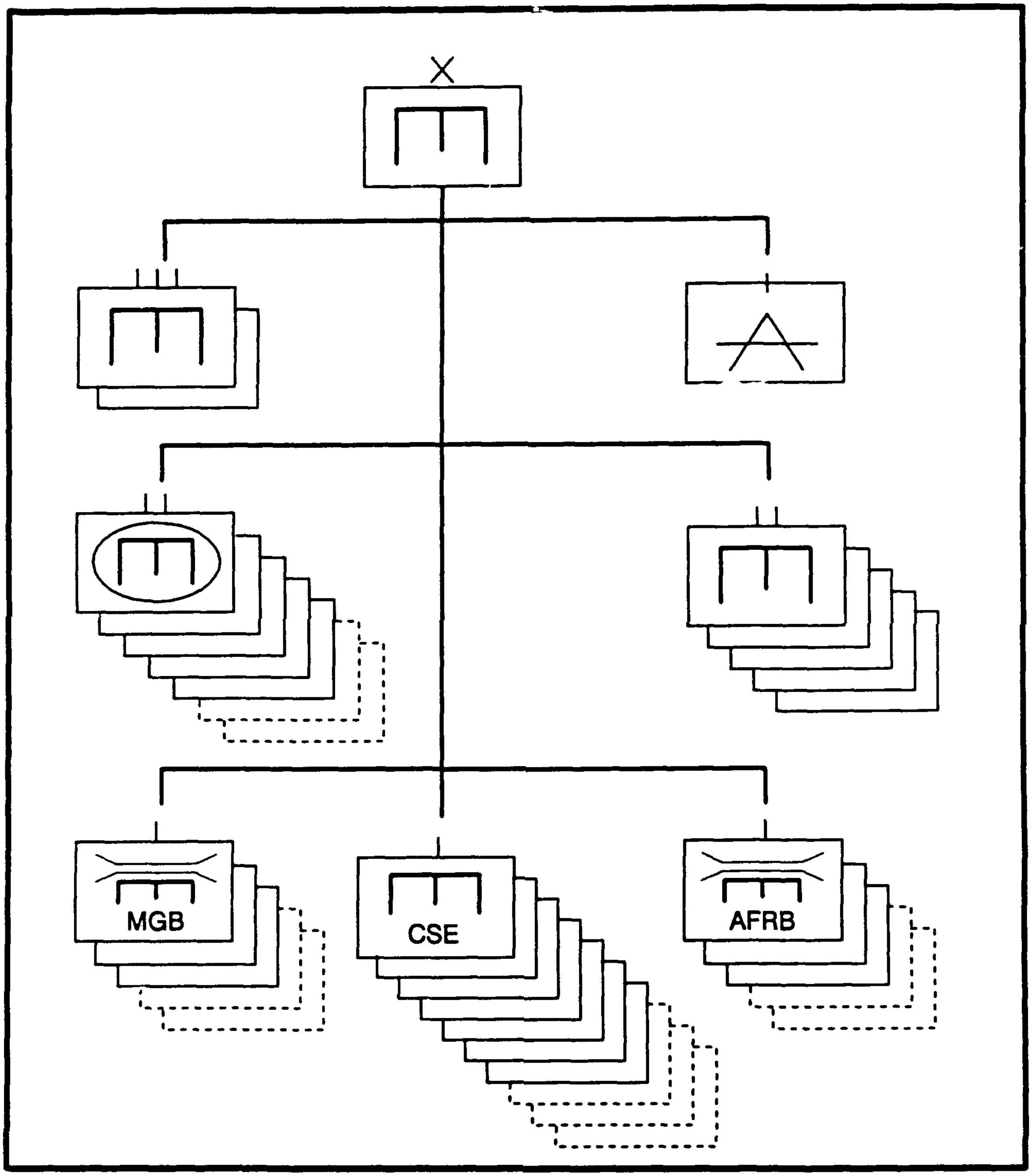
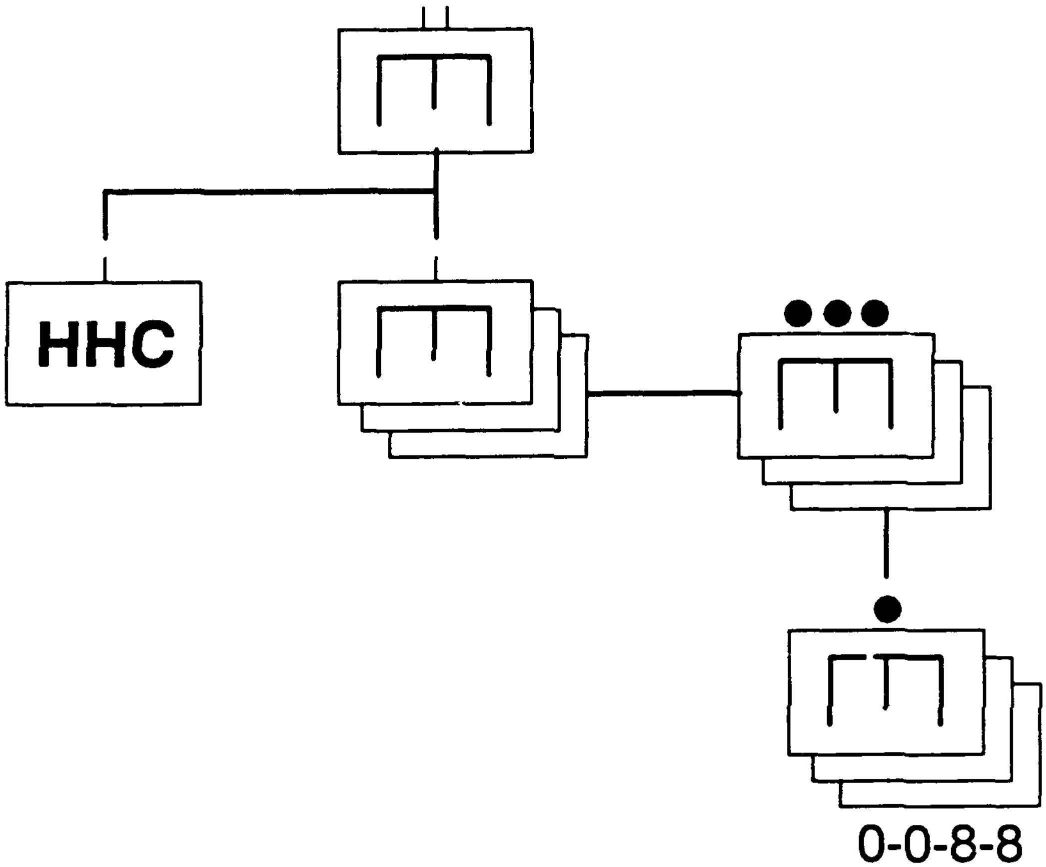


Figure F-1. AIRLAND BATTLE - FUTURE ENGINEER CORPS COMBAT BRIGADE

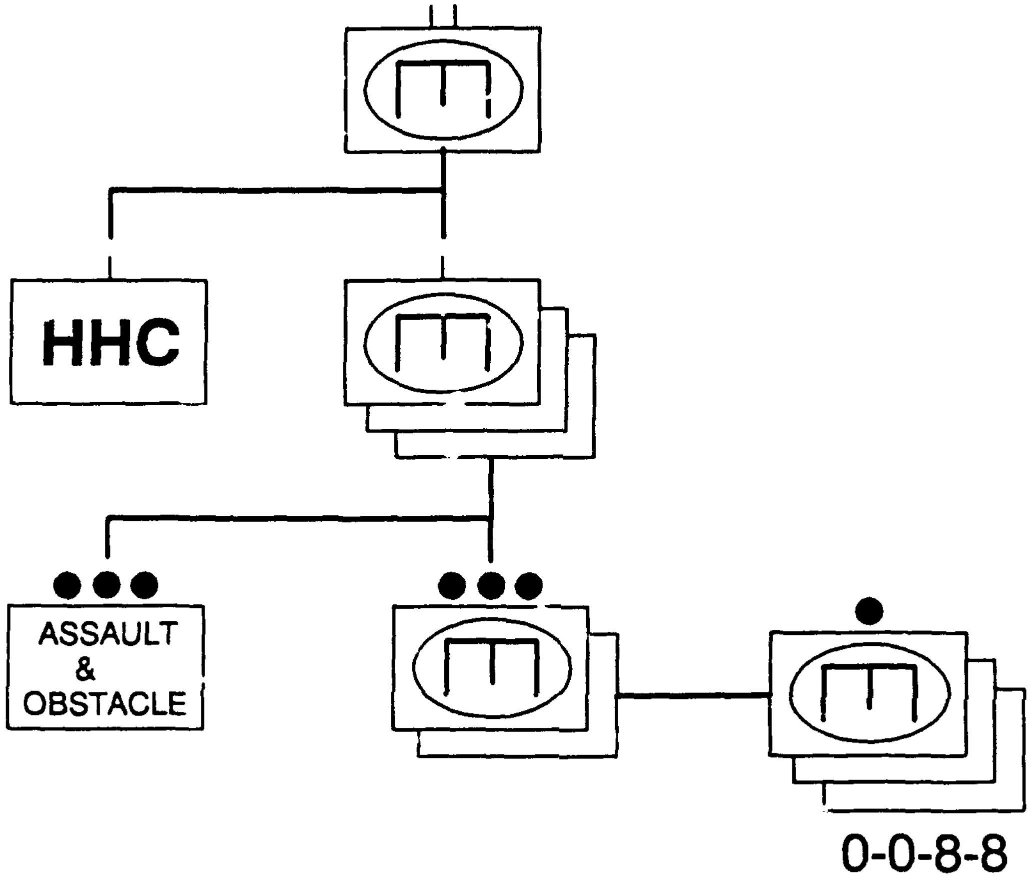


KEY BATTALION EQUIPMENT

36 - 5T DUMP TRUCK
12 - DOZER
9 - GRADER
6 - 2½ CY LOADER
6 - SEE

6- VOLCANO
3- 20T CRANE
3 - WATER DISTRIBUTOR
4 - TEXS W/HME

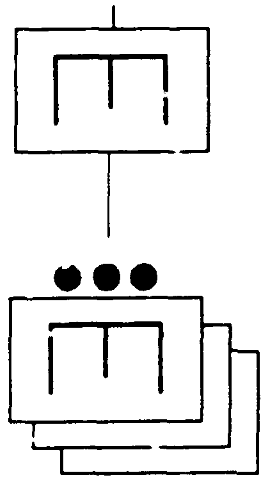
Figure F-2. AIRLAND BATTLE - FUTURE ENGINEER BATTALION, CORPS WHEELED



KEY BATTALION EQUIPMENT

28 - APC	6 - VOLCANO
18 - ACE	12 - MICLIC
12 - CMV	12 - 5T DUMP TRUCK
12 - HAB	4 - TEXS W/HME
6 - SEE	

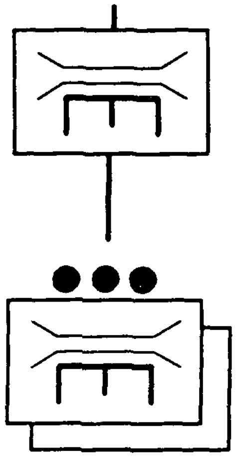
Figure F-3. AIRLAND BATTLE - FUTURE ENGINEER BATTALION, CORPS MECHANIZED



KEY COMPANY EQUIPMENT

6 - DOZER	3 - 25T CRANE
6 - SCRAPER	12 - 20T DUMP TRUCK
6- GRADER	9 - 5T DUMP TRUCK
3 - 5CY LOADER	3 - 2500GAL WATER DISTRIBUTOR
6 - SEE	
1 - VIBRATORY ROLLER SELF PROPELLED	3 - TAMPER ROLLER SELF PROPELLED

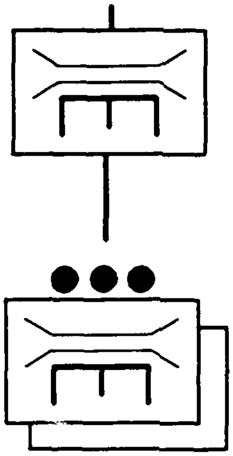
Figure F-4. AIRLAND BATTLE - FUTURE ENGINEER COMBAT SUPPORT EQUIPMENT COMPANY



KEY COMPANY EQUIPMENT

1 - ACE
2 - 20T CRANE
1 - 2½ CY LOADER
30 - BOLSTER TRAILER
32 - 5T DUMP TRUCK
4 - MGB SET (30.5m)
2 - REINFORCEMENT SET

Figure F-5. AIRLAND BATTLE - FUTURE ENGINEER COMPANY MEDIUM GIRDER BRIDGE



KEY COMPANY EQUIPMENT

2 - ACE	12 - RAMP BAY
1 - 20T CRANE	30 - INTERIOR BAY
14 - BOAT BRIDGE	56 - 5T TRANSPORTER
14 - CRADLE BOAT	56 - PALLET CARGO
1 - 16-MAN BOAT	2 - BOLSTER TRAILER
2 - 3-MAN RECON BOAT	6 - TILTBED TRAILER

Figure F-6. AIRLAND BATTLE - FUTURE
ENGINEER COMPANY ASSAULT FLOAT BRIDGE RIBBON

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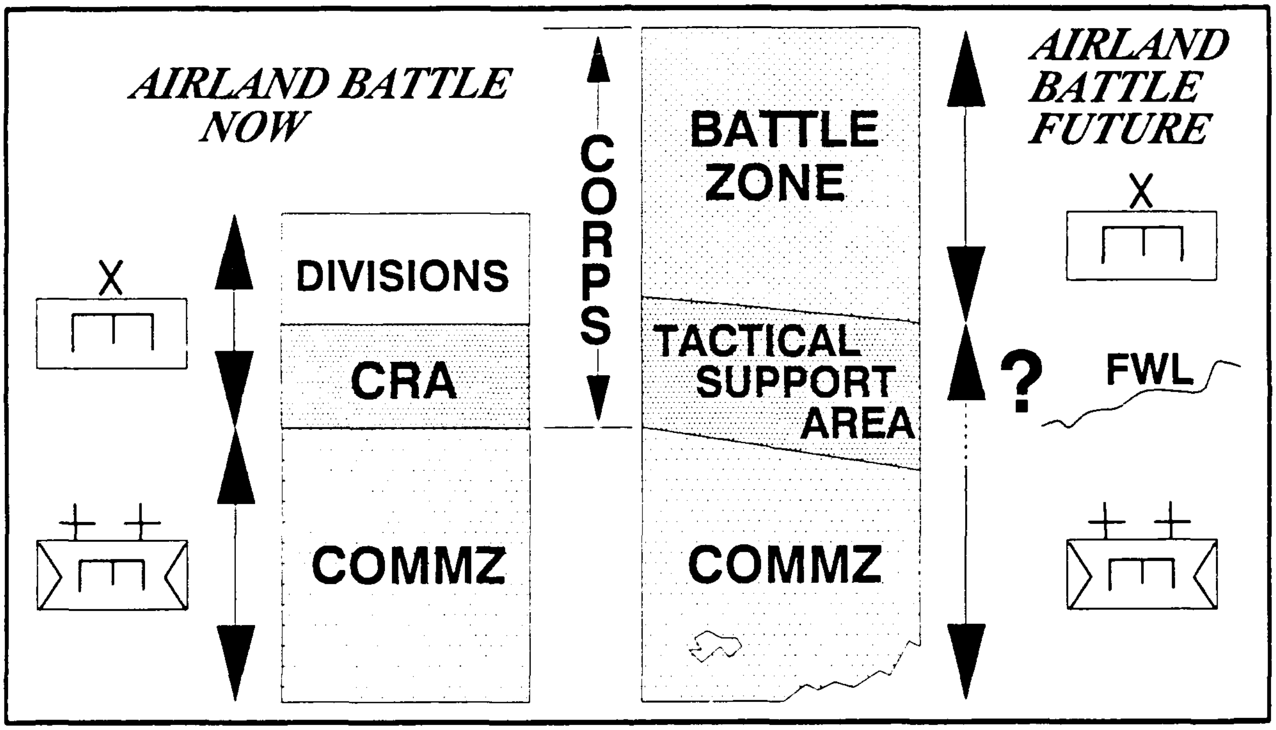
LAST PAGE OF ANNEX F

CORPS ENGINEER OPERATIONS SUPPORTING NON-LINEAR BATTLE (CONLIB)	STUDY GIST CEESC-R-91-18

PRINCIPAL FINDINGS:

(1) The corps engineer combat brigade should concentrate support to the Battle zone. Rear area engineers will have to assume responsibility for the Tactical Support Area. This focuses brigade support for combat support and expedient construction tasks. The United States Army Engineer School (USAES) should remove the brigades's heavy construction capability. This diagram shows the changing role for this brigade:



(2) Revise equipment levels of AirLand Battle-Future (ALB-F) engineer corps wheeled and mechanized battalions. The aim of these changes balances the capability of the two battalions. Engineer Studies Center (ESC) also made additional equipment changes to the Combat Support Equipment (CSE) company. The changes make the company lighter while expanding its capabilities.

(3) Pursue the development of a laser gun mine neutralizer. This gun mounts on the Combat Mobility Vehicle and Armored Combat Earthmover.

(4) Authorize 12 battalions per corps with 1 CSE company per 3 battalions. Corps engineer battalions should be one half wheeled and the other half mechanized. Authorize 2 bridge companies per corps heavy division. Bridge companies should be one half float and the other half fixed.

(5) Devise allocation rules based on firestrike tactics. These rules base corps engineer battalions on artillery brigades rather than maneuver divisions.

MAIN ASSUMPTIONS:

(1) The ALB-F operational concept, as defined by TRADOC, is valid.

(2) Equipment forecasted by TRADOC for 2004 are available as are ALB-F engineer units designed by the USAES.

(3) The study uses the threat defined by TRADOC that includes some political constraints.

PRINCIPAL LIMITATION: This report assumes the organic brigade engineer units satisfy the engineer workload within the immediate zone of brigade operations.

STUDY SCOPE: This report:

(1) Determines the future workload for a Corps Combat Engineer Brigade.

(2) Determines the capability of a USAES designed Combat Brigade to execute the calculated workload.

(3) Determines the optimal mix and number of units for this brigade within a fixed strength. ESC also offers additional suggestions to improve individual units.

STUDY OBJECTIVE: This report's aim is to assess the combat engineer brigade workload in support of an ALB-F heavy corps. The setting of this concept is a non-linear battlefield.

BASIC APPROACH: The basic approach identifies engineer workload for a typical period of a scenario. Then, ESC divides the workload by the capability for the same period of a corps engineer battalion. Finally, the Center diverts some of battalion equipment workload to form equipment companies.

(1) ESC performed this study using two scenarios. In Europe, ESC calculated a one-day fires phase. In SWA, the Center calculated a four-day maneuver phase.

(2) ESC identified tasks with priorities. Tasks also identified the required engineer unit with associated squad and various equipment hours.

(3) ESC performed excursions and looked at five alternative structures. The Center compared all alternatives to the base case.

REASONS FOR PERFORMING THE STUDY. This study is a part of TRADOC's development of the ALB-F concept. TRADOC eventually tasked the USAES to support the Alternate Corps Design Study (ACORDS). The USAES rated the engineer workload for the brigade and ACR structures. The USAES tasked the ESC to do the same for the echelon above brigade. The Center furnished its findings by briefings in July, October and November of 1990. This report provides the complete audit trail of the analysis.

STUDY SPONSOR: Headquarters, US Army Engineer School

PERFORMING ORGANIZATION AND PRINCIPAL AUTHORS: ESC performed this study under the general direction of Mr. Bruce W. Springfield. Mr. Douglas K. Lehmann was the Project Manager. The study team analysts were Dr. Lawrence C. Smith and Mr. Stephan E. Ryeczek.

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START AND COMPLETION DATES OF STUDY: April 1990 and June 1991.

CORPS ENGINEER OPERATIONS SUPPORTING NON-LINEAR BATTLE (CONLIB)
SOFTWARE ORDERING FORM

FROM ______________________________ DATE __________________

ORGANIZATION/OFF!CE ____

ADDRESS ____

____ PHONE ___________

I desire a copy of the LOTUS 123 spreadsheets for:

___ CONLIB1 (European scenario)

___ CONLIB2 (Southwest Asia scenario)

I have an IBM compaticle micro computer (PC) with :

___ 5¼ inch diskette, 3.6k bytes

___ 5¼ inch diskette, 1.2m bytes

___ 3½ inch diskette, 7.2k bytes

___ 3½ inch diskette, 14.4k bytes

Blank, soft-sectored, DS/DD diskettes and two address labels appreciated. (We will place one on the outside of the package mailed to you and the other we will place inside in case the outside address becomes lost or blurred.)

PLEASE FILL IN AND RETURN THIS PRE-ADDRESSED FORM OR FAX TO (703) 355-2503

(fold)

OFFICIAL BUSINESS

US Army Engineer Studies Center
ATTN: CEESC-SA (Lehmann)
Casey Building 2594
Fort Belvoir, VA 22060-5583

(fold)

	CORPS ENGINEER OPERATIONS SUPPORTING NON-LINEAR BATTLE (CONLIB)	**STUDY GIST** CEESC-R-91-18

PRINCIPAL FINDINGS:

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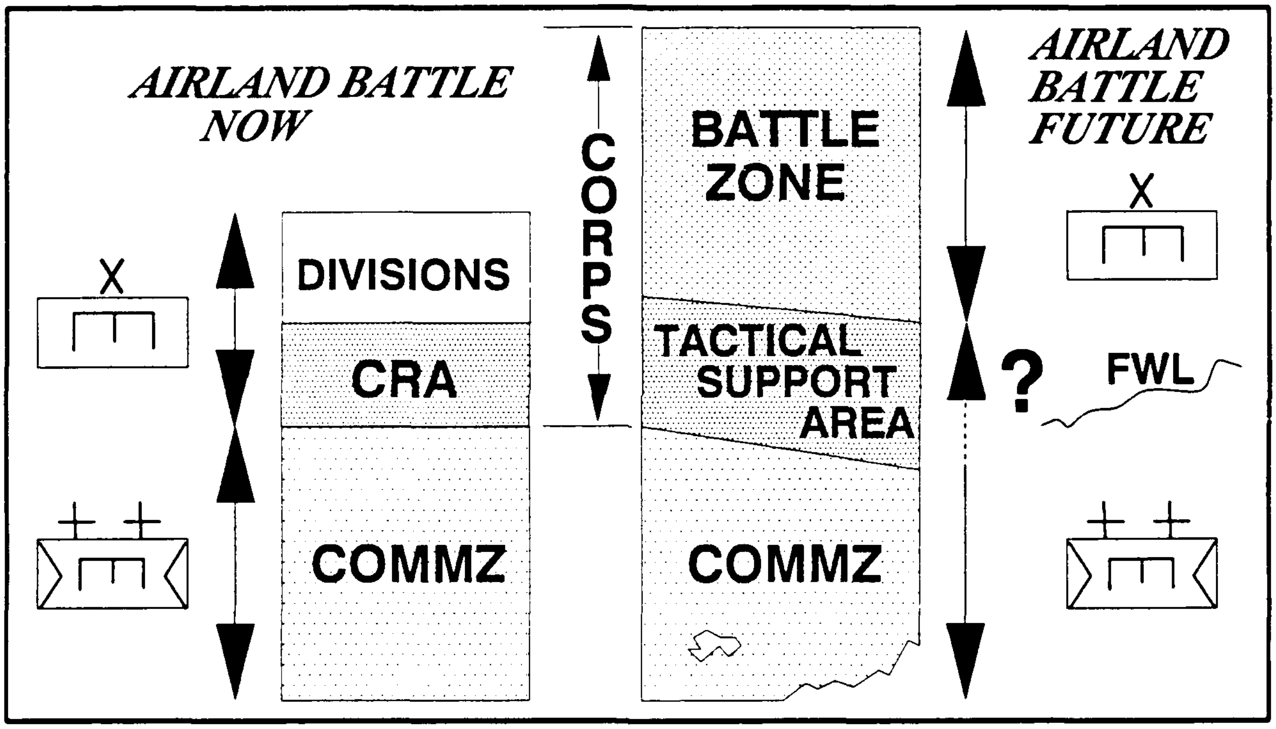

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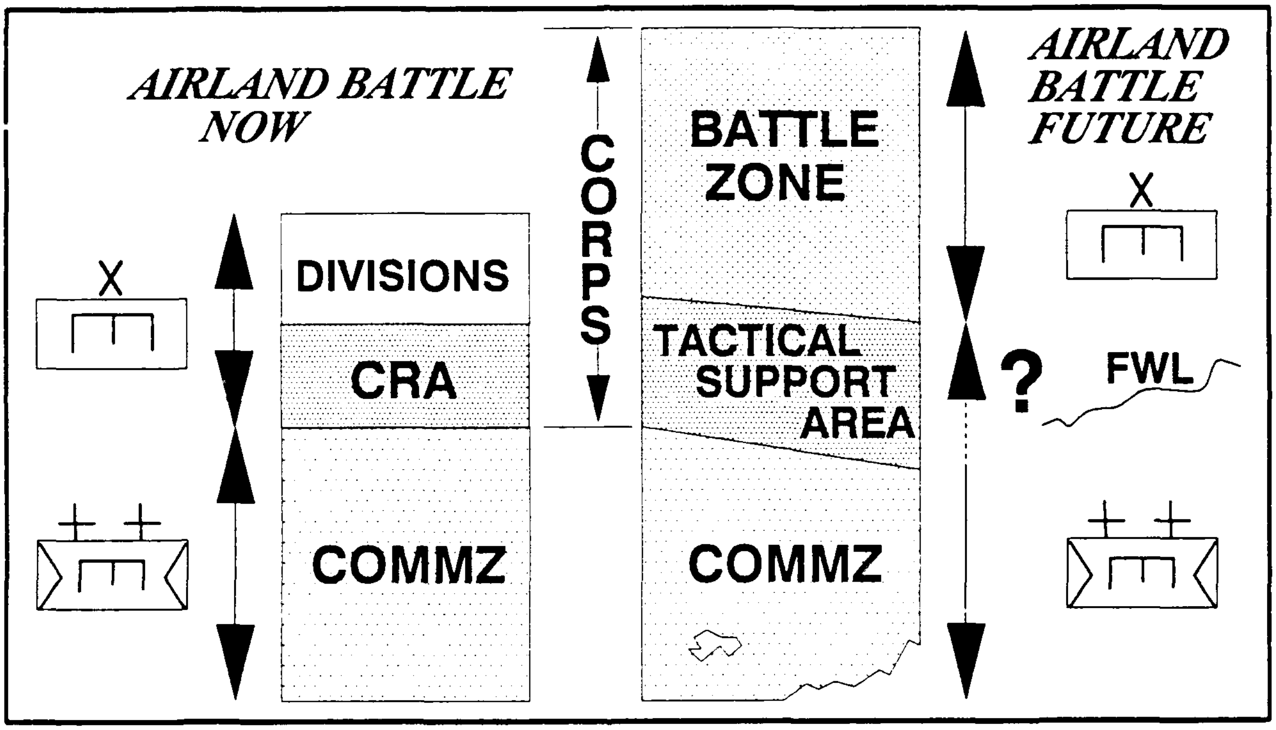

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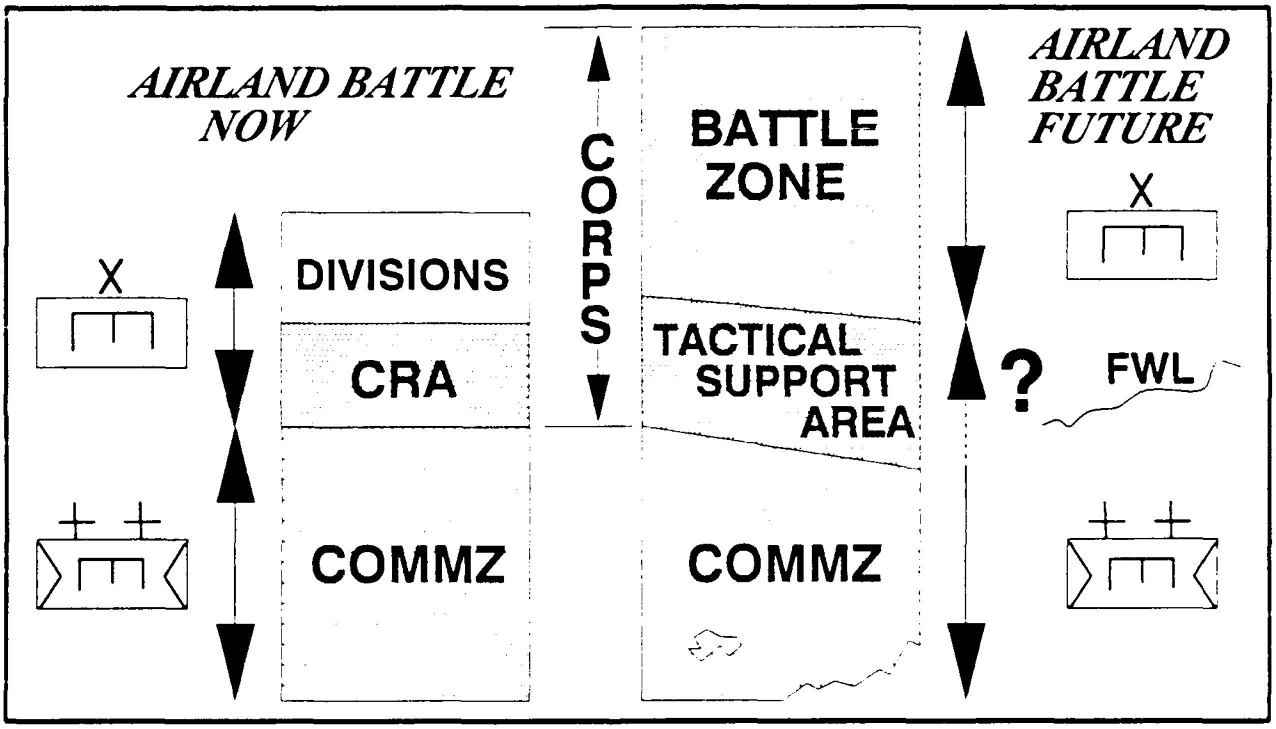

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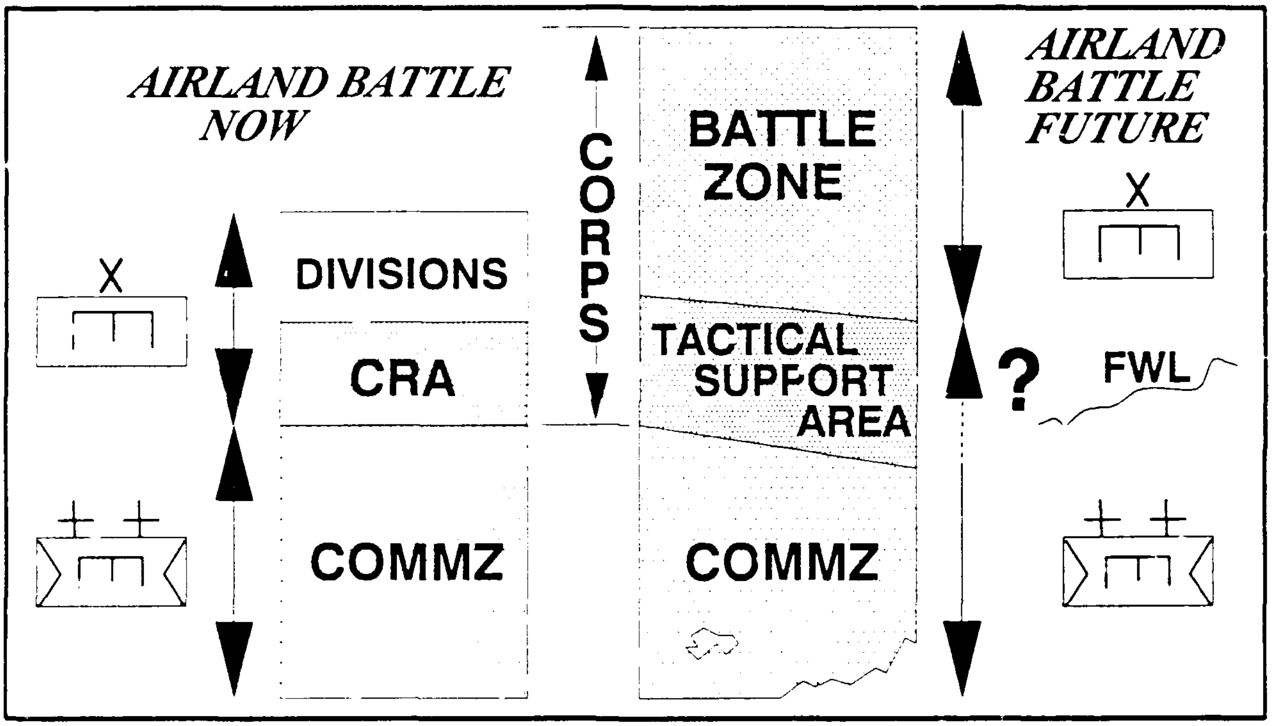

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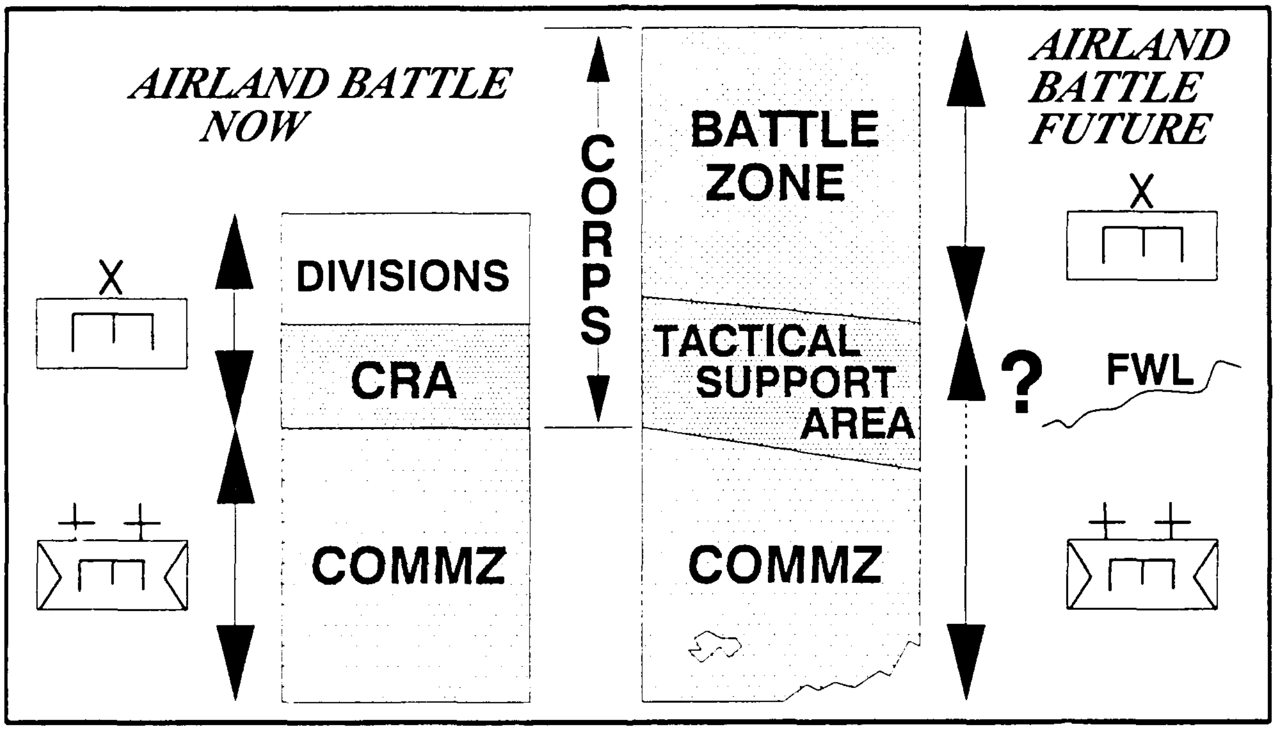

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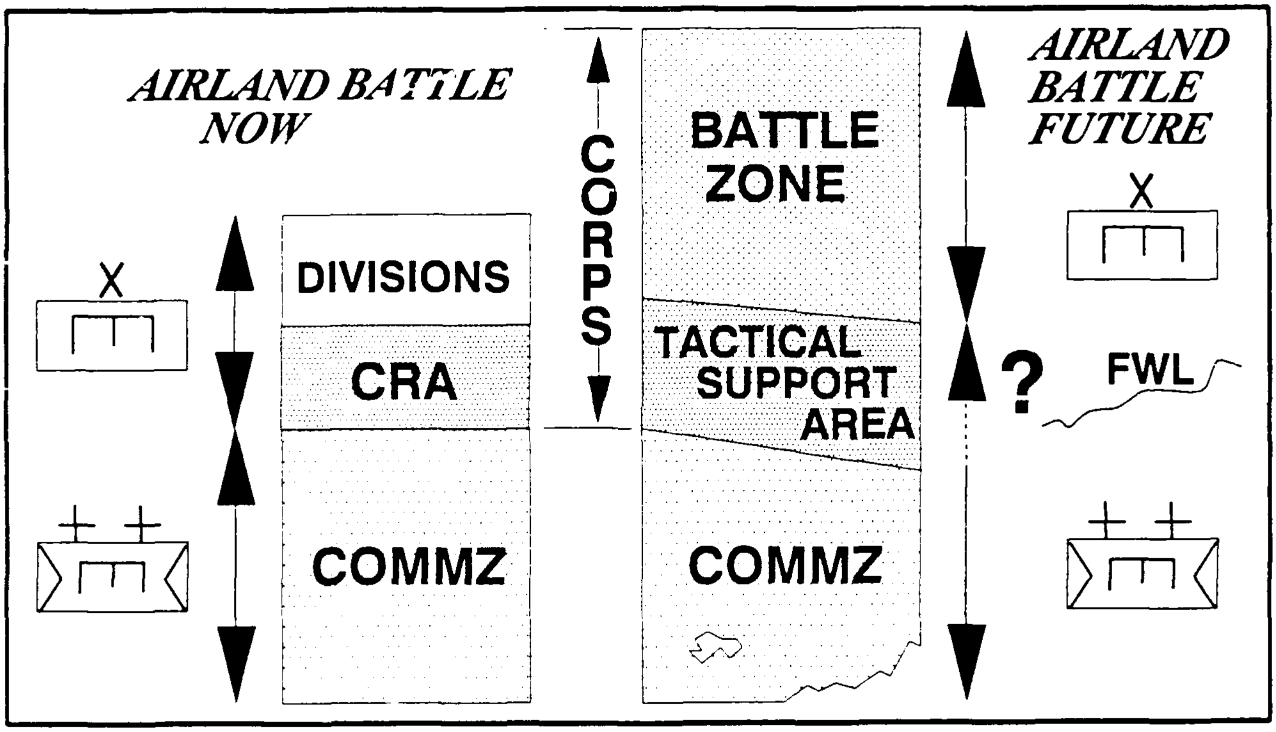

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MAIN ASSUMPTIONS:

(1) The ALB-F operational concept, as defined by TRADOC, is valid.

(2) Equipment forecasted by TRADOC for 2004 are available as are ALB-F engineer units designed by the USAES.

(3) The study uses the threat defined by TRADOC that includes some political constraints.

PRINCIPAL LIMITATION: This report assumes the organic brigade engineer units satisfy the engineer workload within the immediate zone of brigade operations.

STUDY SCOPE: This report:

(1) Determines the future workload for a Corps Combat Engineer Brigade.

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STUDY OBJECTIVE: This report's aim is to assess the combat engineer brigade workload in support of an ALB-F heavy corps. The setting of this concept is a non-linear battlefield.

BASIC APPROACH: The basic approach identifies engineer workload for a typical period of a scenario. Then, ESC divides the workload by the capability for the same period of a corps engineer battalion. Finally, the Center diverts some of battalion equipment workload to form equipment companies.

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REASONS FOR PERFORMING THE STUDY. This study is a part of TRADOC's development of the ALB-F concept. TRADOC eventually tasked the USAES to support the Alternate Corps Design Study (ACORDS). The USAES rated the engineer workload for the brigade and ACR structures. The USAES tasked the ESC to do the same for the echelon above brigade. The Center furnished its findings by briefings in July, October and November of 1990. This report provides the complete audit trail of the analysis.

STUDY SPONSOR: Headquarters, US Army Engineer School

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DTIC ACCESSION NUMBER OF FINAL REPORT: DA accession number DA334759.

COMMENTS AND SUGGESTIONS MAY BE SENT TO: Director, US Army Engineer Studies Center, Casey Building #2594, Fort Belvoir, VA 22060-5583. (703-355-2286, DSN 345-2286.)

START AND COMPLETION DATES OF STUDY: April 1990 and June 1991.

	CORPS ENGINEER OPERATIONS SUPPORTING NON-LINEAR BATTLE (CONLIB)	**STUDY GIST** CEESC-R-91-18

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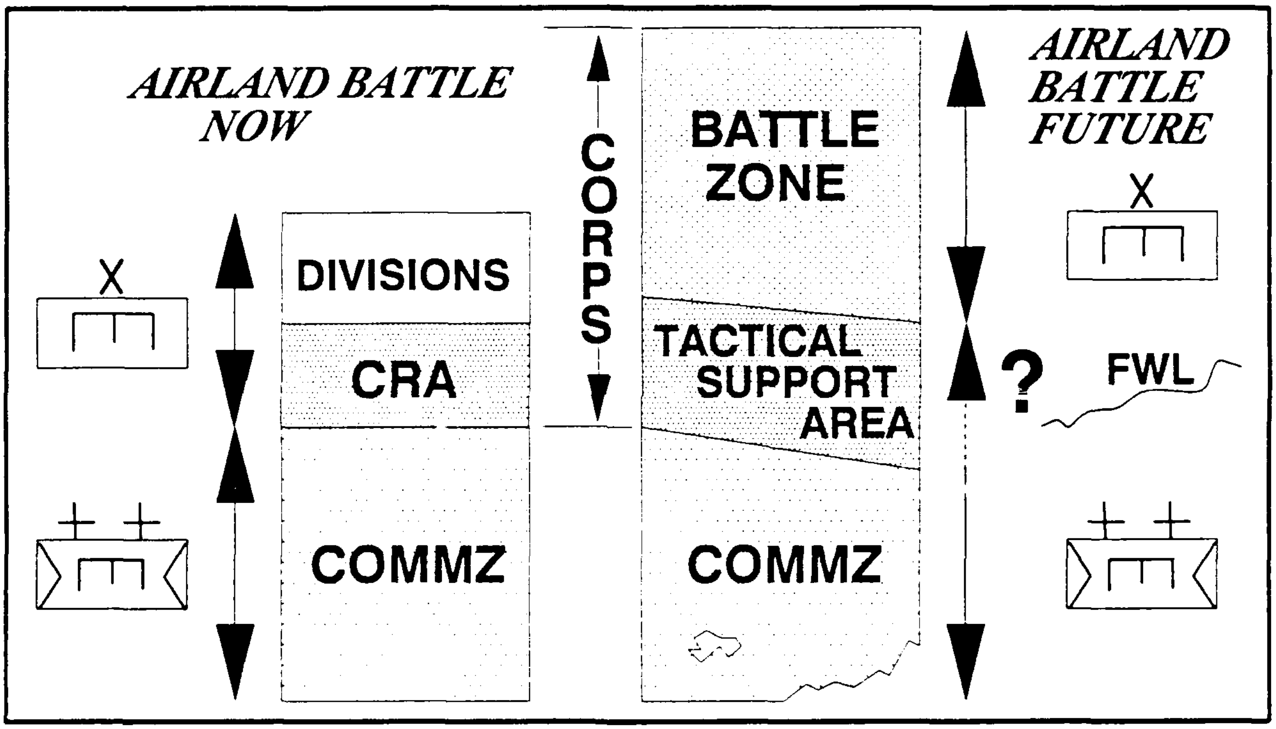

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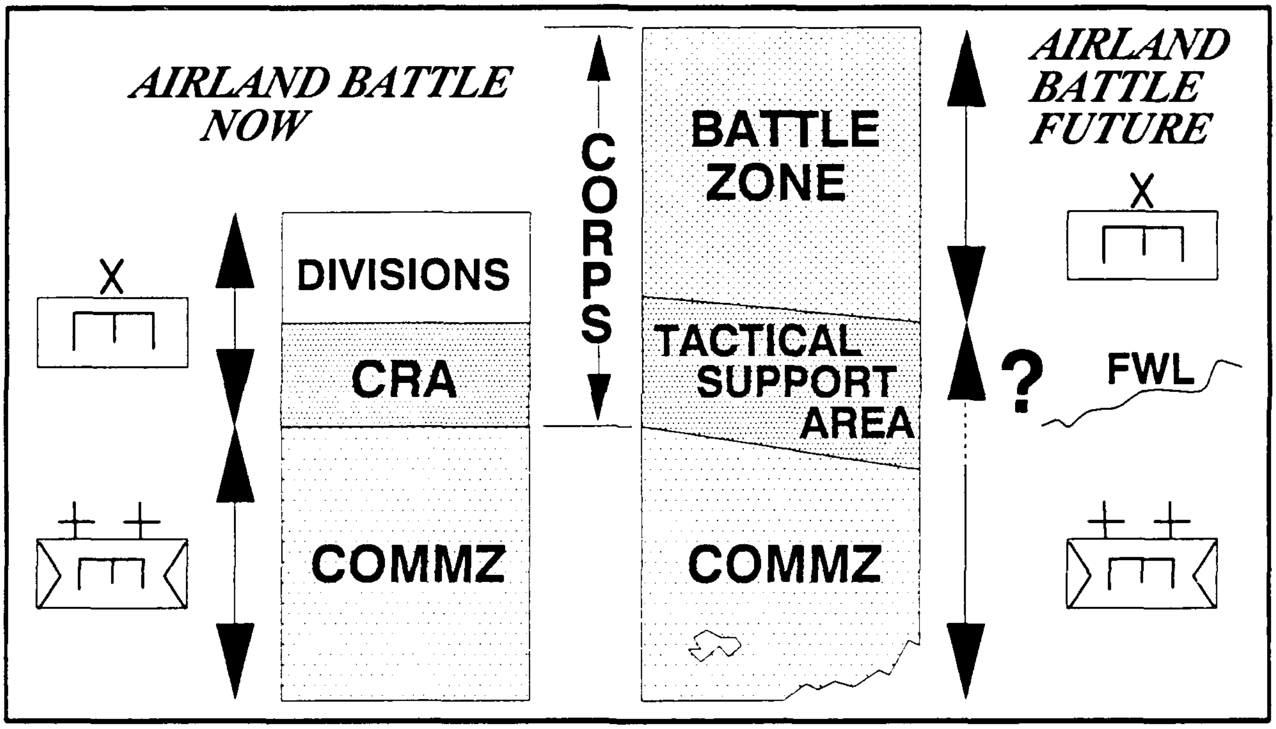

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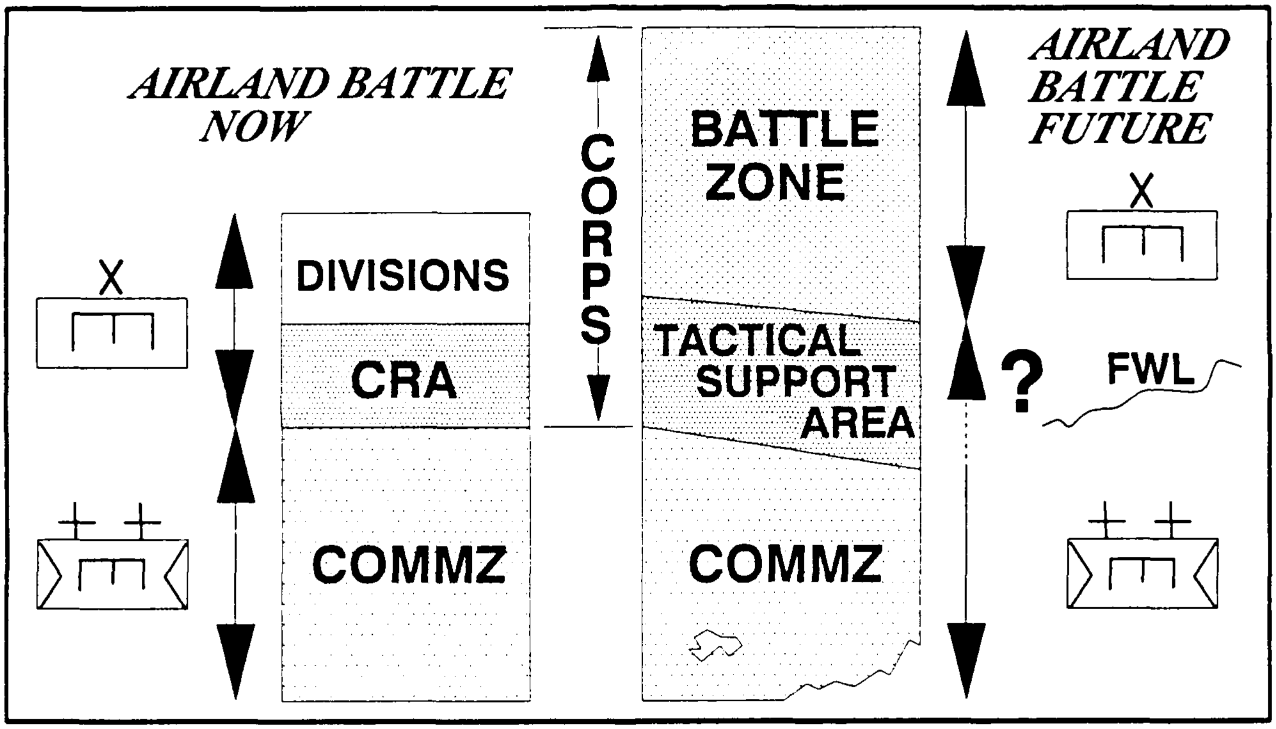

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CORPS ENGINEER OPERATIONS SUPPORTING NON-LINEAR BATTLE (CONLIB) SOFTWARE ORDERING FORM

FROM ____________________ DATE ____________

ORGANIZATION/OFFICE ____________________

ADDRESS ____________________

____________________ PHONE ____________

I desire a copy of the LOTUS 123 spreadsheets for:

___ CONLIB1 (European scenario)

___ CONLIB2 (Southwest Asia scenario)

I have an IBM compaticle micro computer (PC) with :

___ 5¼ inch diskette, 3.6k bytes

___ 5¼ inch diskette, 1.2m bytes

___ 3½ inch diskette, 7.2k bytes

___ 3½ inch diskette, 14.4k bytes

Blank, soft-sectored, DS/DD diskettes and two address labels appreciated. (We will place one on the outside of the package mailed to you and the other we will place inside in case the outside address becomes lost or blurred.)

PLEASE FILL IN AND RETURN THIS PRE-ADDRESSED FORM OR FAX TO (703) 355-2503

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